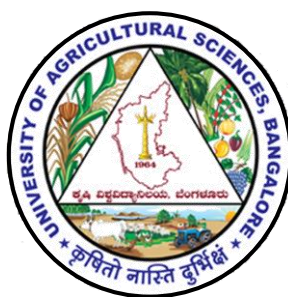


**STUDIES ON ASSOCIATION OF CAPSAICIN AND
OLEORESIN CONTENTS ON INCIDENCE OF
ANTHRACNOSE FRUIT ROT AND SEED QUALITY,
AND VALIDATION OF DNA MARKERS LINKED TO
PUNGENCY IN HOT PEPPER (*Capsicum* spp.)**



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PALB 2084

**DEPARTMENT OF SEED SCIENCE AND TECHNOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
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2015

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Thesis submitted to the
University of Agricultural Sciences, Bengaluru
in partial fulfillment of the requirements
for the award of the Degree of

Doctor of Philosophy

in

Seed Science and Technology

BENGALURU

AUGUST, 2015



DEDICATED TO
MY
TEACHER
AND
ADORABLE PARENTS

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CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON ASSOCIATION OF CAPSAICIN AND OLEORESIN CONTENTS ON INCIDENCE OF ANTHRACNOSE FRUIT ROT AND SEED QUALITY, AND VALIDATION OF DNA MARKERS LINKED TO PUNGENCY IN HOT PEPPER (*Capsicum spp.*)**” submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in **SEED SCIENCE AND TECHNOLOGY** to the University of Agricultural Sciences, Bengaluru, is a record of *bona-fide* research work done by **Mr. NAGARAJU, K. S., I.D. No. PALB 2084** during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bengaluru
August, 2015


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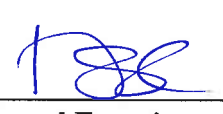


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Bengaluru
August, 2015

[NAGARAJU, K.S.]

“Studies on association of capsaicin and oleoresin contents on incidence of anthracnose fruit rot and seed quality, and validation of DNA markers linked to pungency in hot pepper (*Capsicum* spp.)”

ABSTRACT

NAGARAJU, K. S.

Chilli (*Capsicum annuum*) is a highly valued spice cum cash crop. India is the largest producer of chilli in world. Anthracnose fruit rot caused by *Colletotrichum* Spp. is most serious disease reducing crop yield and quality. The present studies were carried out at the College of Agriculture, UAS, GKVK, Bengaluru. The results revealed that, days to fruiting ranged from (22-92 days), test weight (0.2972-9.74 g), germination (42-96 %), SVI-I (283-1489), seed protein (6.4-17.4 $\mu\text{g g}^{-1}$), capsaicin (27-417 $\mu\text{g g}^{-1}$), oleoresin 3-23 %, ASTA colour value (2-16) and seed infection (0-82 %). The capsaicin content was negatively correlated with anthracnose disease and oleoresin was positively correlated with seed quality. Seed treatment with iprodione+ carbendazim @ 0.4 (%) eliminated anthracnose seed infection and improved seed quality. Storing dry chilli fruits in aluminium foils retained maximum seed germination (%) compared to vapour pervious containers. seed germination, test weight, TDH activity, seed protein, capsaicin and oleoresin decreased and seedling vigour and EC increased with storage period. Genotypes amplified single dominant band at 100 Kb with marker 7F/15R except AR-75, Byadagi Kaddi, Dyavanur Delux, G4, Gouribidanur Local, HMT-1 for pungency. A low pungent parent Paprika from *C. annuum* was hybridized to highly pungent parent *C. chinense* Assam Bhut Jolokia to produce inter specific hybrid and the six generation mean analysis revealed that, higher seedling length and the higher seedling emergence were predominantly under the control of genes with dominance effect and the dominance effect were unidirectional as evidenced by higher magnitudes of dominance gene effects.

August, 2015
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Major Advisor

ಮೆಣಸಿನಕಾಯಿಯಲ್ಲಿ ಹಣ್ಣು ಕೊಳೆಯುವಿಕೆ ಮತ್ತು ಬೀಜ ಗುಣಮಟ್ಟದೊಂದಿಗೆ ಕ್ಯಾಪ್ಸೈಸಿನ್ ಮತ್ತು ಒಲಿಯೋರೈಸಿನ್‌ಗಳ
ಸಂಯೋಜನೆ ಹಾಗೂ ಮೆಣಸಿನಕಾಯಿಯ ಫಾಟಿನ ಗುಣಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಡಿ.ಎನ್.ಎ ಗುರುತುಗಳ ಮೌಲ್ಯಾಂಕನದ
ಅಧ್ಯಯನ

ಪ್ರಬಂಧದ ಸಾರಾಂಶ

ನಾಗರಾಜು, ಕೆ. ಎಸ್.

ಮೆಣಸಿನಕಾಯಿಯು ಒಂದು ಅತ್ಯಮೂಲ್ಯ ಮಸಾಲೆ ಹಾಗೂ ನಗದು ಬೆಳೆಯಾಗಿದ್ದು ಭಾರತವು ಇದರ ಅತಿದೊಡ್ಡ ಉತ್ಪಾದಕ ದೇಶ. ಹಣ್ಣು ಕೊಳೆ ರೋಗವು ಗಂಭೀರ ಕಾಯಿಲೆಯಾಗಿದ್ದು ಬೆಳೆಯ ಇಳುವರಿ ಮತ್ತು ಬೀಜ ಗುಣಮಟ್ಟವನ್ನು ಕಡಿಮೆ ಮಾಡುತ್ತದೆ. ಈ ರೋಗವು ಕೊಲೆಟೊಕ್ಟ್ರಿಕಮ್ ಜಾತಿಯ ರೋಗಕಾರಕ ಸೂಕ್ಷ್ಮಾಣು ಜೀವಿಯಿಂದ ಬರುತ್ತದೆ. ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಜಿ.ಕೆ.ವಿ.ಕೆ. ಬೆಂಗಳೂರಿನಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಅಧ್ಯಯನದ ಫಲಿತಾಂಶಗಳ ಪ್ರಕಾರ ಕಾಯಿ ಕಚ್ಚುವಿಕೆಗೆ 22-92 ದಿನಗಳು, 0.2972-9.74 ಗ್ರಾಂ. ಪರೀಕ್ಷಾ ತೂಕ, ಶೇ. 42-96 ರಷ್ಟು ಬೀಜ ಮೊಳಕೆಯೊಡೆಯುವಿಕೆ, 283-1489 ರಷ್ಟು ಮೊಳಕೆ ಸಾಮರ್ಥ್ಯ, ಪ್ರತಿ ಗ್ರಾಂ. ಬೀಜಕ್ಕೆ 6.4-17.4 ಮೈಕ್ರೋ ಗ್ರಾಂ. ನಷ್ಟು ಪ್ರೋಟೀನ ಪ್ರಮಾಣ, ಪ್ರತಿ ಗ್ರಾಂ. ಬೀಜಕ್ಕೆ 27-417 ಮೈಕ್ರೋ ಗ್ರಾಂ. ನಷ್ಟು ಕ್ಯಾಪ್ಸೈಸಿನ್ ಪ್ರಮಾಣ, ಶೇ. 3-23 ರಷ್ಟು ಒಲಿಯೋರೈಸಿನ್, 2-16 ಎ.ಎಸ್.ಟಿ.ಎ ಬಣ್ಣದ ಮೌಲ್ಯ ಮತ್ತು ಶೇ. 0-82 ರಷ್ಟು ಬೀಜ ಸೊಂಕು ಕಂಡುಬಂದವು. ಹಣ್ಣು ಕೊಳೆ ರೋಗಕ್ಕೆ ಕ್ಯಾಪ್ಸೈಸಿನ್ ಅಂಶವು ಋಣಾತ್ಮಕ ಸಂಬಂಧ ಹಾಗೂ ಬೀಜ ಗುಣಮಟ್ಟಕ್ಕೆ ಒಲಿಯೋರೈಸಿನ್ ಅಂಶವು ಧನಾತ್ಮಕ ಸಂಬಂಧವನ್ನು ಹೊಂದಿವೆ. ಶೇ. 0.4 ರಷ್ಟು ಐಪ್ರೋಡಿನ್ + ಕಾರ್ಬೆಂಡೆತ್ಯಜಿಯಮ್ ಬೀಜೋಪಚಾರವು ಹಣ್ಣು ಕೊಳೆ ರೋಗಾಣುವಿನ ಬೀಜ ಸೊಂಕಿನಿಂದ ಮುಕ್ತಗೊಳಿಸಲು ಉಪಕಾರಿಯಾಗಿದೆ ಹಾಗೂ ಬೀಜ ಗುಣಧರ್ಮಗಳನ್ನು ಹೆಚ್ಚಿಸುವಲ್ಲಿ ಸಹಕಾರಿಯಾಗಿದೆ. ಹಣ್ಣುಗಳೊಟ್ಟಿಗೆ ಬೀಜಗಳನ್ನು ಅಲ್ಯೂಮಿನಿಯಮ್ ಲೋಹದ ತೆಳುಹಾಳೆಯಲ್ಲಿ ಶೇಕರಿಸಿದಾಗ ಹೆಚ್ಚಿನ ಶೇ. ಬೀಜ ಮೊಳಕೆಯೊಡೆಯುವಿಕೆ, ಮೊಳಕೆ ಸಾಮರ್ಥ್ಯ, ಪರೀಕ್ಷಾ ತೂಕ, ಪ್ರೋಟೀನ ಪ್ರಮಾಣ, ಪ್ರತಿ ಗ್ರಾಂ. ಬೀಜಕ್ಕೆ 27-417 ಮೈಕ್ರೋ ಗ್ರಾಂ. ನಷ್ಟು ಕ್ಯಾಪ್ಸೈಸಿನ್ ಪ್ರಮಾಣ, ಶೇ. 3-23 ರಷ್ಟು ಒಲಿಯೋರೈಸಿನ್, 2-16 ಎ.ಎಸ್.ಟಿ.ಎ ಬಣ್ಣದ ಮೌಲ್ಯ ಮತ್ತು ಶೇ. 0-82 ರಷ್ಟು ಬೀಜ ಸೊಂಕು ಕಂಡುಬಂದವು. ಮೆಣಸಿನಕಾಯಿಯ ಫಾಟಿನ ಗುಣಕ್ಕೆ ಡಿ.ಎನ್.ಎ ಗುರುತುಗಳ ಮೌಲ್ಯಾಂಕನದಲ್ಲಿ 7ಎಫ್/15ಆರ್ ಡಿ.ಎನ್.ಎ ಗುರುತಿಗೆ ಎಆರ್-75, ಬ್ಯಾಡಗಿ ಕಡ್ಡಿ, ದ್ಯಾವನೂರ ಡಿಲಕ್ಷ, ಗೌರಿಬಿದನೂರ ಲೋಕಲ್, ಹೆಚ್‌ಎಮ್‌ಟಿ-1 ತಳಿಗಳನ್ನು ಹೊರತುಪಡಿಸಿ ಉಳಿದೆಲ್ಲಾ ತಳಿಗಳು ವಿಶದೀಕರಿಸಿವೆ. ಕಡಿಮೆ ಫಾಟು ಗುಣದ ಪೊಷಕ ತಳಿಯನ್ನು ಹೆಚ್ಚು ಫಾಟು ಪೊಷಕ ತಳಿಯಾದ ಆಸಾಂ ಭೂತ್ ಜೊಲೊಕೀಯಾ ಸಂಕರಿಸಿ ನಿರ್ದಿಷ್ಟಾಂತರ ಸಂಕರ ತಳಿಯನ್ನು ಉತ್ಪಾದಿಸಲಾಯಿತು. ಆರು ತಲೆಮಾರಿನ ವಿಶ್ಲೇಷಣೆಯಲ್ಲಿ ಹೆಚ್ಚಿನ ಮೊಳಕೆ ಉದ್ದ ಮತ್ತು ಕ್ಷೇತ್ರ ಮೊಳಕೆಯೊಡೆಯುವಿಕೆ ಲಕ್ಷಣಗಳನ್ನು ವ್ಯಕ್ತಪಡಿಸುವಲ್ಲಿ ಪ್ರಮುಖವಾಗಿ ಪ್ರಾಧಾನ್ಯ ವಂಶವಾಹಿಗಳ ನಿಗ್ರಹದಲ್ಲಿರುತ್ತವೆ. ಪ್ರಾಧಾನ್ಯ ವಂಶವಾಹಿಗಳ ಪರಿಣಾಮಗಳು ಒಂದೆ ದಿಕ್ಕಿನಲ್ಲಿರಿತ್ತವೆಂದು ಅವುಗಳ ಪ್ರಮಾಣದಿಂದ ಸಾಬಿತಾಗಿದೆ.

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ಪ್ರಧಾನ ಸಲಹೆಗಾರರು

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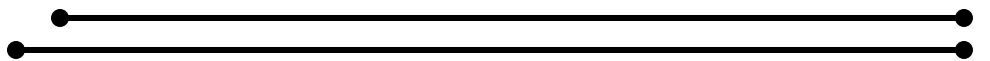
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INTRODUCTION



I INTRODUCTION

Hot pepper (*Capsicum* spp) ($2n=24$) is one of the most important and highly valued vegetable as well as commercial spice crop consumed in India and world. *Capsicum*, a new world genus has richness in diversity but their diversity has not received much attention along with tomato and potato crops. The center of origin is said to be Mexico, with secondary centers in Guatemala and Bulgaria (Salvador, 2002).

The genus *Capsicum* belongs to family solanaceae comprising twenty to thirty species of the new world tropics and subtropics. Modern taxonomists recognize five major cultivated species of hot pepper and mild types as *Capsicum annuum*. The other four species are *Capsicum frutescence* L., *Capsicum chinense* Jacquin, *Capsicum baccatum*, *Capsicum pendulum* Willdenow and *Capsicum pubescence* Ruiz and Pavon (Luboslawa Nowaczyk, *et al.*, 2009).

Christopher Columbus was one of the first Europeans to encounter them (in the Caribbean), and called them "peppers" because they like black and white pepper of the *Piper* genus known in Europe, have a spicy hot taste unlike other foodstuffs. Upon their introduction into Europe, hot peppers were grown as botanical curiosities in the gardens of Spanish and Portuguese monasteries. But the monks experimented with the culinary potential and discovered that their pungency offered a substitute for black peppercorns, which at the time were so costly that they were used as legal currency in some countries (www.indianspices.com/html/s0420sts.htm).

Hot pepper crop can be produced around the year with the benefits of faster, cleaner production and a premium quality end product. Hot pepper is rich source of vitamin 'A', 'C' and numerous chemicals including steam-volatile oil, fatty oils, capsaicinoids, carotenoids, vitamins, protein, fiber, and mineral elements (Bosland and Votava, 2000; Anon. 2003). It is a tropical and subtropical crop grown from almost sea level up to an altitude of 2000 meters. It was first introduced to India from Brazil by the Portuguese towards the end of 15th century subsequently its cultivation became popular in the 17th century (Basu and Amithkirshna De, 2003).

India is the largest producer of hot peppers in the world accounting nearly 90 per cent of world production. Among the major spices, dried hot pepper ranked first in both area and production. In India hot pepper (dried) is cultivated under an area of 0.805 million hectares with production of 1.299 million tons during 2011-12 (FAOSTAT, 2012). India is one of the major exporters of hot pepper oleoresins, the value of which increased from Rs. 74.1 million in 2000-01 to 231.3 million in 2003-04 and hot pepper powder export value increased from 627.6 million in 2000-01 to Rs 890 million in 2001-02. Andhra Pradesh ranked first in hot pepper production with an area of 0.248 million hectares and with the production of 0.804 million tones. Karnataka ranked second in hot pepper production with an area of 0.1008 hectares and with the production of 0.107 million tons (www.indianspices.com/pdf/Major%20spice%20wise%20area%20and%20productionsr.pdf).

The two chemical groups of greatest interest are the capsaicinoids and the carotenoids. Given that roughly a quarter of the world's population consumes hot peppers each day. And capsaicinoids are among the most widely used secondary metabolites in the world. Capsaicin is a unique alkaloid of the plant kingdom restricted to the genus *Capsicum* (Tewksbury, *et al.*, 2006). Capsaicin bioactive molecule of food and of medicinal importance and its analogues called capsaicinoids synthesized in placenta of the fruits are the compounds responsible for the pungency of the fruits. Pepper cultivars vary with respect to their level of pungency because of quantitative and qualitative variation in capsaicinoid content. (Arnon *et al.*, 2006).

Capsaicin is useful as a counterirritant, antiarthritic, analgesic, antioxidant, and anticancer agent. The rich supply of carotenoids contributes to chili peppers nutritional value and colour (Britton and Mendez, 1997). Further, it is a source of commercial preparations of Vitamins A, B, E, P and minerals. Many chili pepper constituents have importance for nutritional value, flavor, aroma, texture, and colour. The ripe fruits are especially rich in vitamin C (Garcia *et al.*, 1998). Russian scientists identified Vitamin P in green hot pepper, which is considered to be important as it gives us protection from secondary radiation.

The hot flavor of hot peppers is due to the presence of a group of seven closely related homologous alkyl vanillylamides called capsaicinoids were responsible for the

heat, or pungency. However, Capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) and dihydrocapsaicin are responsible for approx. 90 per cent of the pungency. Hot pepper hotness is measured in Scoville Heat Units (SHU) (Scoville, 1912) which is originally a subjective measure but today, hot pepper hotness is more frequently determined by HPLC (High Performance Liquid Chromatography), whose results can be correlated to traditional Scoville ratings: the conversion generally accepted is that 15 Scoville units is equal to 1 ppm capsaicin plus capsaicinoids. (Ritesh *et al.*, 2000).

Hot pepper oleoresin is obtained by the extraction of hot peppers (the fruit of red pepper, *Capsicum annuum* L. or *Capsicum frutescens* L.) with approved food grade solvent and subsequent careful removal of the solvent by distillation. Besides intense pungency due to capsaicin and small quantities of allied alkaloids, the hot pepper oleoresin will have dark red colour due to carotenoid pigments. Colour and pungency are important from the point of view of quality of the product (<https://law.resource.org/pub/in/bis/S06/is.15697.1.2006.pdf>).

Mature red peppers are considered as one of the richest natural pigment sources. For this reason, they have been traditionally employed as food colorants and paprika, and more recently as oleoresin. The intense and characteristic red colour of *Capsicum* is due to carotenoid pigments which are massively synthesized during ripening. All carotenoid pigments present in red peppers are isoprenoids of 40 carbon atoms, with 9 conjugated double bonds in the central polyenic chain, with different terminal groups that change the chromophore properties of each pigment. They can be classified into two isochromic families: red and yellow. The red fraction mainly contains capsanthin and capsorubin, considered as exclusive to *Capsicum* genus, and a lower proportion of other red carotenoids, while the yellow one is made up of the rest of the carotenoids, zexanthin β -cryptoxanthin and β -carotene, among others. This last fraction is considered as a biosynthetic precursor of the red one (Concepcion Ayuso *et al.*, 2007).

Seed is a key component among all inputs for sustainable crop production. The importance of quality seed has been realized by mankind long ago. The need for a good viable seed for prosperity of human race is mentioned in Rigveda of ancient India. It is mentioned in the primeval manusmriti as “Subeejam Sukshetre Jayate Sampadyate”

which literally means “A good seed in a good field will win and prosper”. Hot pepper seeds are low volume high value with inputs and seed production practices and techniques are considered (Vkoundinya and Pradeep Kumar, 2014).

Availability of genetic markers such as SCAR and CAPS assist to distinguish pepper genotypes as pungent and non-pungent at molecular level (Claver *et al.*, 2007). Further, association of these markers with phenotypic pungent character in the genotypes of *C. chinense*, *C. baccatum*, *C. frutescens*, *C. galapagoense*, *C. eximium*, *C. tovarii* and *C. cardenasii* offers a faster, cheaper and more reproducible method for identifying pungent peppers. Thus validation of these molecular markers in populations offers precise categorization into pungent and non-pungent genotypes needed for further studies.

To sustain high production and productivity of hot pepper, a large number of high yielding varieties and hybrids have been developed as a result of intensive crop improvement programme. In spite of this, the importance of local cultivars, which are selected and domesticated over a period of time and generations by the farmers for their adaptation to different climatic conditions, preferences in quality, biotic and abiotic stresses, cultural values, medicinal properties and yield are also to be emphasized. Out of which many cultivars are now in seed production chain. However, basic understanding of the capsaicin and oleoresin content in relation to hot pepper seed quality and incidence of fruit rot (*Colletotrichum* sp.) are the emphasis of the moment.

Among all diseases of hot pepper, fruit rot anthracnose caused by *Colletotrichum capsici* (Sydow) Butler and Bisby is a major problem in India and one of the more significant economic constraints for production worldwide, especially in tropical and subtropical regions (Than *et al.*, 2008). *Colletotrichum* species can survive in and on seeds as acervuli and micro-sclerotia (Pernezny *et al.*, 2003). The pathogen readily colonizes the seed coat and peripheral layers of the endosperm even in moderately colonized seeds. Heavily colonized seeds had abundant inter and intracellular mycelia and acervuli in the seed coat endosperm and embryo, showing disintegration of parenchymatous layers of the seed coat and depletion of food material in endosperm and embryo (Chitkara *et al.*, 1990).

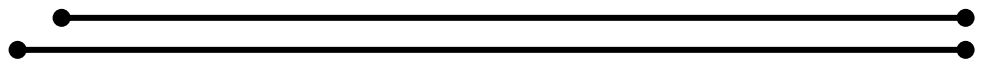
Storage and preservation of quality seeds is an essence until next season and is as essential as producing quality seeds. Seeds of many plant species are extremely tolerant to storage conditions in a state of desiccation. The metabolism in dry state activity is drastically reduced to a very low level (quiescence) while retaining their ability to germinate for considerable periods. The unique principle compounds of hot pepper, colour and pungency offer a new arena to identify their effects on seed longevity in view of their major ecological, agronomical and economical importance.

Seeds in particularly plant species belong to the most spectacular examples of organism longevity in eukaryotes. Due to this property, the seed system provides an appropriate model to study longevity and aging, which is of paramount interest for human health. However, our knowledge of the exact mechanisms underlying extreme longevity of dry seeds is still in its infancy (Loic and Isabelle, 2008).

With this endeavor the present investigation, entitled “**Studies on association of capsaicin and oleoresin contents on incidence of anthracnose fruit rot and seed quality, and validation of DNA markers linked to pungency in hot pepper (*Capsicum spp.*)**” was envisaged to study the effect of principle compounds capsaicin and oleoresin on the seed quality, storability, anthracnose fruit rot incidence, severity, seed treatments to control anthracnose fruit rot and to validate molecular markers linked to pungency with the following objectives:

- 1) To study the variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality.
- 2) To study the anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin.
- 3) To study the seed quality attributes as influenced by capsaicin and oleoresin during seed storage.
- 4) To assess the efficacy of seed treatments to control seed borne anthracnose.
- 5) Validation of trait specific DNA markers linked to pungency.

REVIEW OF LITERATURE



II REVIEW OF LITERATURE

Hot pepper (*Capsicum sp.*) is highly valued as a vegetable and spice, as well as commercial crop and becoming increasingly important in terms of production and consumption. It is crops can be produced year round with the benefits of faster, cleaner production and a premium quality end product. At the same time hot peppers are rich source of vitamin 'A' and 'C'. Hot pepper comprises numerous chemicals including steam-volatile oil, fatty oils, capsaicinoids, carotenoids, vitamins, protein, fiber, and mineral elements (Bosland and Votava, 2000).

The two chemical groups of great interest are the capsaicinoids and the carotenoids. Fruit capsaicin content has an international commercial prime rate. Capsaicin is a unique alkaloid of the plant kingdom restricted to the genus *Capsicum*. Capsaicin is the pungency factor, a bioactive molecule of food and of medicinal importance. Capsaicin is useful as a counter irritant, antiarthritic, analgesic, antioxidant, and anticancer agent. The rich supply of carotenoids contributes to hot peppers nutritional value and colour (Britton and Mendez, 1997).

The literature related to the present investigation is reviewed under following heads.

- 2.1 To study the variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality
- 2.2 To study the anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin
- 2.3 To study the seed quality attributes as influenced by capsaicin and oleoresin during storage
- 2.4 To assess the efficacy of seed treatments to control seed borne anthracnose
- 2.5 Validation of trait specific DNA markers linked to pungency

2.1 Variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality

2.1.1 Variability, heritability and genetic advance

Manju and Srilathakumari (2002) studied the thirty-two accessions of hot pepper (*Capsicum chinense* Jacq.) were to estimate the variability, heritability and genetic advance in randomized block design with three replications. Higher phenotypic and genotypic coefficients of variation were observed for fruits per plant, yield per plant, seeds per fruit and fruit weight. High estimates of heritability coupled with high genetic advance were also observed for these characters, indicating that they can be effectively improved through selection.

Malikarjun *et al.* (2003) reported that, hot pepper (*Capsicum annuum* L) is an indispensable condiment in the Asian continent because of the colouring matter obtained from the fruits which is used as a natural colourant in food-stuffs in place of synthetic dyes, which are harmful. There are 20 carotenoids contributing to the colour of matured fruits, and capsanthin contributes as much as 36 per cent of total carotenoid content in the fruits. Therefore, there is need to develop varieties with higher content of capsanthin in the fruits

Sheela *et al.* (2004) evaluated twenty five bird pepper accessions for morphological and biochemical traits in Kerala. Observed wide range of variability among accessions for all morphological traits. The contents of ascorbic acid, capsaicin, oleoresin and carotenoids in mature green fruits ranged from 21.0 to 77.6 (mg g⁻¹), 0.21 to 1.57 (%), 4.5 to 14.25 (%), and 0.14 to 0.5 (%) respectively, with the highest values being recorded in accessions CF 15, CF 5, CF 23 and CF 138, respectively.

Mishra *et al.* (2004) conducted an investigation on genetic variability including mean, genotypic and phenotypic variances, coefficients of variation, heritability, genetic advance and genetic gain with 22 genotypes of capsicum (*Capsicum annuum*) in the mid-hills of Uttaranchal, India. Significant differences among the genotypes were observed for all 18 characters studied. High phenotypic and genotypic coefficients of variation,

heritability and genetic gain were observed for ascorbic acid content, number of fruits per plant, fruit yield per plant, seed yield per fruit and fruit length.

Mini and Khader (2004) assessed genetic variability, heritability and genetic advance for number of seeds per fruit, 100-seed weight, fruiting span and crop duration in 25 genotypes of hot pepper during 2002-03 in Kerala, India. Analysis of variance revealed significant differences among genotypes for all traits. High heritability coupled with high genetic advance was observed for 100-seed weight.

Verma *et al.* (2004) conducted an experiment on 12 hot pepper [*Capsicum annuum*] genotypes to determine the extent of genetic variability, genetic coefficient of variation, heritability, genetic advance as percent of mean and correlation of different characters. Data were recorded for days to 50(%) germination, days to 50(%) flowering, days to 50(%) fruiting, plant height, plant canopy, number of branches per plant, leaf length, leaf width, pod length, pod width and number of fruits per plant. The phenotypic coefficient of variation was higher than the genotypic coefficient of variation in all the characters. Plant canopy, number of fruits per plant, days to 50(%) fruiting, plant height, days to 50(%) flowering and pod length showed high heritability. The number of fruits per plant, plant canopy, pod length and plant height also showed high estimates of genetic advance as percent of mean coupled with high heritability suggesting additive genetic variance. High heritability along with moderate genetic advance as per cent of mean was observed for number of branches per plant, leaf width and pod width indicating the predominance of both additive and non-additive gene action. High heritability associated with low genetic advance as per cent of mean was observed for days to 50(%) flowering and days to 50 (%) fruiting indicating a non-additive gene action.

Yudhvir Singh and Madhu Sharma (2008) observed, sufficient variability for all horticultural and quality traits studied; that is, days to 50 (%) flowering, days to first harvest, primary structural branches per plant, secondary branches per plant, fruit length, fruit diameter, average fruit weight, number of seeds per fruit, 100-seed weight, pericarp:seed ratio, number of marketable fruits per plant, number of total fruits per plant, plant height, total soluble solids, and oleoresin, capsanthin, and capsaicin content. High

phenotypic (PCV) and genotypic coefficients of variation (GCV) were observed for seed weight per fruit, and oleoresin and capsaicin content. Moderate PCV and GCV were recorded for number of seeds per fruit, 100-seed weight, pericarp seed ratio, ascorbic acid, and capsanthin. High heritability coupled with high genetic advance was noted for oleoresin and capsaicin content, which indicated the role of additive gene action for the inheritance of these traits. Correlation and path analysis studies indicated that, capsanthin was significantly and positively correlated with yield. Ascorbic acid and capsaicin content were positively associated with total soluble solids at green and red fruit stage, respectively.

Sarkar *et al.* (2009) evaluated forty-nine hot pepper genotypes to study genetic variability as well as association for 12 growth and fruit characters. There was significant variation among the genotypes. Number of fruits/plant, fruit length (cm), placenta length (cm), fruit weight (g) and number of seeds/fruit showed high values of GCV and PCV. High heritability in broad sense coupled with high GA in (%) grand mean was recorded for number of fruits/plant, fruit length, days to 50 (%) flowering and plant height indicating such characters were controlled by additive gene action. The phenotypic path coefficient analysis revealed that number of fruits / plant, fruit weight and 1000 seed weight had positive and high direct effect on fruit yield indicating their reliability as selection criteria to improve yield of hot pepper.

Variability and association analysis was studied by Hedau *et al.* (2008) among 42 genotypes of hot pepper (*Capsicum annum* L.). The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits under study and difference between GCV and PCV was not high, indicating that these quality traits were not much influenced by the environmental factors. Heritability ranged from 38.8(%, for manganese $\mu\text{g g}^{-1}$) to 99.9 (%, for capsaicin). High heritability and high genetic advance were observed for ascorbic acid, total phenols, iron (Fe) and beta carotene content in fruits indicating involvement of additive gene action.

Balvir Kaur and Daljit Singh (2009) recorded significant genotypic differences among genotypes Punjab Lal and S-12-1 were resistant to fruit rot and virus complex

while Punjab Guchhedar, S-99-3 and S-103 were resistant to fruit rot and moderately resistant to virus complex. Genotypes S-2530, S-2, S-5, S-99-3 and S-30 were significantly superior to check varieties for colouring matter. Similarly, S-99-3 and S-5 were also identified for high capsaicin. They also reported presence of wide variability in the study material.

Maga *et al.* (2012) evaluated hot pepper genotypes using descriptive statistics and cluster analysis. They revealed that, first principal component accounted for 54.69 (%) and 65.96 (%) of the total variations in 2009 and 2010, respectively. Based on the traits defined by the PCA, the genotypes were classified into three clusters. The correlations indicated that total fruits yield per plant, number of leaves per plant, number of nodes per plant, fruit length, single fruit weight, days to first flowering and fruit girth were highly significant.

Naresh *et al.* (2012) screened thirty accessions using colorimetric method and considerable variability was observed for total capsaicinoids (0-1.65 %). Results revealed that abundant indel (insertion and deletion events) and SNP (single nucleotide polymorphisms) in the cloned AT₃ partial sequence. Both AT₃-1 and AT₃-2 are present in many cultivars that suggest paralogous gene lineages. They also, opined that, the capsaicinoids are the alkaloids responsible for pungency in hot pepper fruits. Estimates of capsaicinoids obtained by colorimetric method and HPLC were highly correlated ($R_2=0.996$) suggesting that colorimetric method is an effective means for estimating total capsaicinoids in extracts of fresh hot pepper fruits.

Tilahun *et al.* (2013) experimented the capsaicin and ascorbic acid contents of seven Indian peppers varieties/accessions from *Capsicum annuum* (CA 97, CCH, K1, KTPL19, Arka Abhir and Bayadagi Kaddi) and *C. frutescens* (CF1) species were determined using High Performance Liquid Chromatography (HPLC). The accession CF1 showed the highest concentration of capsaicin (445 mg 100 g⁻¹ DW) with corresponding pungency value of 71,200 SHUs and Arka Abhir variety showed the lowest capsaicin concentration (29 mg 100 g⁻¹ DW) with 4,672 SHUs of pungency value. Similarly, Bayadaggi Kaddi variety showed the highest ascorbic acid content (189

mg/100 FW) and the accession CA 97 showed the lowest ascorbic acid contents (55.3 mg/100 FW)., CF1 and Bayadagi Kaddi can be used as a potential source for capsaicin and vitamin C, respectively.

Naresh *et al.* (2013) studied genetic variability of 103 hot pepper genotypes for major fruit qualitative characters, viz., total capsaicinoids, total carotenoids, red and yellow carotenoids and they revealed total carotenoids content exhibited positive correlation with the fruit colour, while the total capsaicinoids exhibited negative and significant correlation with total carotenoids content. A wide range of variation was noticed in the contents of total capsaicinoids (0-1.67%), total carotenoids (8.6-357.9 ASTA), red carotenoids (0-0.27%) and yellow carotenoids (0-0.2%). These major fruit quality traits showed high values for GCV, PCV and heritability coupled with high GAM suggesting predominance of additive gene action and low influence of environmental factors in the trait expression.

Faria *et al.* (2013) aimed to evaluate 49 accessions of pepper and four characteristics that confer quality to its fruit. Analysis of variance revealed a significant effect of genotypes on capsaicin total soluble solids, vitamin C and extractable colour. Based on the Scott Knott test at 5 per cent probability, the total capsaicin content was presented the greatest diversity among the accessions. However, access 27 (BGH 4733-56) recorded the highest value of soluble solids and colour extracting, standing out among the other accesses.

Datta and Das (2013) reported a wide range of variation among *Capsicum annuum* L genotypes for several morphological, fruit and quality characters. Variability studied revealed that there was a wide range of variability for all the characters studied. High heritability along with higher genetic advance (as a percentage of mean) was found in capsaicin content in fruit, number of fruits per plant, yield per plant and primary branches per plant. These characters may be considered as reliable selection indices as they are possibly governed by additive gene effect.

Amit *et al.* (2014b) examined the twenty three genotypes for genetic variability, heritability, genetic advance and correlation for growth and yield contributing characters in hot pepper under Kashmir conditions. Significant variations were observed for all the characters studied except for days to flowering and crop duration [mature (green) as well as dry (red)]. High phenotypic coefficient variation (PCV) and genotypic coefficient variation (GCV) were recorded for number of fruits per plant, fruit weight and dry (red) yield. All the characters showed high heritability estimates. However, number of the fruits plant⁻¹, green fruit yield plant⁻¹, dry (red) yield plant⁻¹, number of seeds plant⁻¹ and plant height exhibited high genetic advance as percentage of mean indicating additive gene effect.

Tasso *et al.* (2014) evaluated 30 hot pepper (*Capsicum annuum* L.) genotypes for twelve quantitative characters and noticed considerable variability among the genotypes for the characters studied. The capsaicin content and ascorbic acid contributed maximum towards divergence.

Surya Kumari *et al.* (2014) evaluated ninety four paprika accessions for seventeen different characters for variability, heritability, genetic advance as percent of mean and genetic divergence. Plant height, plant spread, and fruit diameter exhibited moderate PCV and GCV estimates suggesting the possible role of environment in expression of these characters. They reported significant GCA effects for number of fruits per plant, 100 seed weight, and number of seeds per fruit, capsanthin content. Suggesting, a significant GCA effect in desired direction for number of seeds per fruit and 100 seed weight and capsanthin content.

Shiva *et al.* (2014) assessed the variability in paprika alike hot peppers (26 indigenous germplasm) and paprika lines (18 exotic collections) and reported highly significant variation among the genotypes. And revealed that, among the various characters, maximum coefficient of variation (15.25%) was recorded for capsaicin content in both indigenous and exotic germplasm and minimum variation for colour value (0.46%) in the indigenous germplasm and weight of pericarp (6.78%) in the exotic collections.

Raj *et al.* (2014) evaluated the twenty (20) isolates of *C. capsici* collected from conventional hot pepper growing areas of Tamil Nadu. In culture, most of the isolates produced cottony, fluffy or suppressed colonies. However, no significant differences were noticed in shape and size of conidia. The reaction of the 20 isolates on an indigenously developed differential set of *Capsicum* cultivars indicated the existence of different virulences in Tamil Nadu hot pepper populations. The genetic relationship between 20 morphological groups recognized within *C. capsici* was investigated using random amplified polymorphic DNA (RAPD) analysis. Molecular polymorphism generated by RAPD confirmed the variation in virulence of *C. capsici* and different isolates were grouped into two large clusters. The pathological and RAPD grouping of isolates suggested no correlation among the test isolates.

Bae *et al.* (2014) examined the impacts of cultivar, fruit maturity stage (mature versus immature), and growing season (2008, 2009) on the concentration of bioactive compounds in diverse pungent and non-pungent peppers. Mature peppers generally had the highest capsaicinoids content ($115.5\text{--}338.9\ \mu\text{g g}^{-1}$ in 2008 and $93.8\text{--}326.3\ \mu\text{g g}^{-1}$ FW in 2009) compared to immature peppers. Paprika-type peppers generally had the highest contents of ascorbic acid in mature fruits, while capsaicinoids were higher in all mature stage peppers. Total phenolics were also significantly higher in mature fruits compared to immature peppers in both years. They reported positive correlation between total phenolics and DPPH radical scavenging activity was observed. The genetic variability in bioactive compounds found in this study constitutes a useful genetic base for improving the nutrient quality of peppers. And also opined that, the content and types of bioactive compounds vary based on genetic and environmental factors.

Robi and Sreelatha Kumary (2004) estimated capsaicin and ascorbic acid contents at 3 stages of maturity, i.e. colour changing stage red ripe and withering stage. Significant variation was observed among genotypes for capsaicin content at the colour changing (1.26 to 3.02 %), red ripe (1.32 to 3.18 %) and withering stages (1.48 to 3.36 %), with the genotype CC3 giving the highest contents at all stages. Indicating that, genotypes had the highest capsaicin content at the withering stage and the highest ascorbic acid content at the red ripe stage.

Claver *et al.* (2007) studied the liquid chromatography electrospray ionization time of flight mass spectrometry [HPLC-ESI/MS (TOF)] method to identify and quantify capsaicin and dihydrocapsaicin in extracts of pepper fruits. Capsaicin and dihydrocapsaicin contents varied largely among families, and families did not respond similarly in producing these capsaicinoids when their fruits were grown in spring and summer, with some families showing no increase, whereas in others, the increase was more than 2 fold. Heterosis for the pungency trait, assessed by the capsaicin and dihydrocapsaicin contents in fruits, was found, indicating the existence of epistasis, over-dominance, or dominance complementation. Non-pungent parent alleles contributed to the capsaicin and dihydrocapsaicin contents since transgressive segregation did occur. They opined that, the type of gene action varied between capsaicin and dihydrocapsaicin, and a seasonal effect during fruit development could affect gene action.

Balvir Kaur and Daljit Singh (2009) assessed thirty three genotypes of hot pepper collected from Punjab, Rajasthan and AVRDC (Asian Vegetable Research and Development Centre), Taiwan for various horticultural characters. Punjab Lal and S-12-1 were resistant to fruit rot and virus complex while Punjab Guchhedar, S-99-3 and S-103 were resistant to fruit rot and moderately resistant to virus complex. Genotypes S-2530, S-2, S-5, S-99-3 and S-30 were significantly superior to check varieties for colouring matter. Similarly, S-99-3 and S-5 were also identified for high capsaicin coupled with high yield and could be utilized for the genetic improvement of hot pepper for yield and quality characters.

2.1.3 Trait inter relationship in hot pepper

Gadal *et al.* (2003) established correlation between capsanthin content and other traits of *C. annuum* in 36 genotypes. At the phenotypic and genotypic levels, ascorbic acid (red) content had a positive correlation with capsanthin content. The positive association of plant spread, number of fruits per plant, fruit length, fruit yield and ascorbic acid (green) content with capsanthin content was mainly due to indirect effects through ascorbic acid (red). Fruit rot was negatively correlated with capsanthin content due to its indirect effect through ascorbic acid (red). Seed weight showed direct and indirect positive correlation with capsanthin content. Plant height showed positive

indirect effect, whereas pericarp weight exhibited positive direct effect, and negative and positive indirect effects. Fruit weight exhibited negative direct effect, and high to moderate positive indirect effect through seed weight and pericarp weight at the genotypic level. Numbers of seeds per fruit were not significantly correlated with capsanthin content.

Hanson *et al.* (2004) evaluated 46 *Capsicum* accessions for five carotenoids, ascorbic acid, tocopherols, and total phenolics. And revealed the existence of ample genetic diversity within *C. annuum* for increases ANTI Oxidant (AO) content. Based on dry weight values, non-pungent *C. annuum* were significantly greater than pungent ones for contents of β -cryptoxanthin (36 %), ascorbic acid (65 %), total phenolics (36 %) and α -tocopherol (11 %). Brown fruited accessions exceeded the means of red fruited ones for capsanthin (34 %), zeaxanthin (37 %), lutein (36 %), β -cryptoxanthin (71 %), β -carotene (82 %), ascorbic acid (19 %) and α -tocopherol (40 %). They also stated that, inhibition of lipid peroxidation (ILP) assay could be adopted for AO characterization. ILP was positively correlated with phenolics (r^2 0.72**) and ascorbic acid (r^2 0.58**) contents. Significant positive correlations were detected between most carotenoids as well as a significant positive correlation between ascorbic acid and total phenolics contents (r^2 0.78**).

Hari *et al.* (2005) estimated the association of paprika and the magnitude of their interrelationship. A positive and significant correlation was exhibited by number of primary and secondary branches, plant spread and seed weight with dry fruit yield per plant. The association of number of seeds per fruit, oleoresin content and ascorbic acid content (AAC) with dry fruit yield per plant was also positive but non-significant.

Arkadiusz Szterk and Lewicki (2010) measured peroxide value (PV) of several vegetable oils oxidized at 70 °C spectrophotometrically using a new chemiluminescence (CL) method. The reaction in CL was based on lipid hydroperoxides decomposition with HO⁻ ions in two different medium. The first reaction was carried out in a DMF/KOH/oil mixture, while in the second reaction acridine was used in addition. A linear correlation between PVs determined spectrophotometrically and measured with the CL method.

Jamiolkowska (2014) studied the role of some phenolic compounds on health status of sweet pepper plants for flavonoids and phenol acids using isocratic HPLC method. The fungi most frequently isolated from pepper were *Alternaria alternata*, *Fusarium* spp., *Botrytis cinerea* and *Sclerotinia sclerotiorum*. Flavonoids content in plant parts was positively correlated with the intensity of colonization by pathogenic fungi.

Golubkina *et al.* (2014) revealed direct correlation between capsaicin concentrations in placenta, seeds, and pericarp and between fruit mass and capsaicin placenta (seeds)/ pericarp ratios. Accessions with the highest content of biologically active compounds are indicated: with vitamin C up to 2652 mg 100 g⁻¹ of dry wt, ASTA up to 150 units, capsaicin content in pericarp up to 47 mg 100 g⁻¹ of dry wt, and dry matter up to 18.4 per cent.

2.1.4 Direct and indirect effects in hot pepper

Dipendra Gogoi and Gautam (2003) carried out correlation and path coefficient analyses using 52 hot pepper genotypes comprising local collections. They established that, cultivars and advanced breeding lines to find out the association among 20 characters and their direct and indirect effects on yield. Fresh fruit yield per plant exhibited significant and positive correlation with dry yield, fruits per plant, flowers per plant, fresh fruit weight, leaves per plant, fruiting percentage, dry fruit weight, 1000-seed weight and seeds per fruit.

Sreelathakumary and Rajamony (2004) studied 15 accessions of hot pepper and correlation analysis showed that yield had highly significant and positive correlation with fruits per plant, fruit length, fruit girth and fruit weight. Path analysis revealed that fruits per plant, fruit weight and fruit girth had positive direct effects on yield. Fruit length had a negative direct effect on yield, but its indirect effect through fruits per plant, fruit girth and fruit weight was high and positive. These results suggest that selection for fruits per plant, fruit weight, fruit length and fruit girth might lead to an increase in the yield of hot pepper.

Deepu Mathew *et al.* (2004) evaluated fifty-six *Capsicum* accessions, consisting of 48 hot peppers (*C. annuum*), two bell peppers (*C. annuum* var. *grossum*) and one accession each of *C. chinense*, *C. frutescens* and *C. praetermissum* [*C. baccatum* var. *praetermissum*], 2 accessions of *C. baccatum* subsp. *baccatum* and one accession of *C. baccatum* subsp. *baccatum* × *C. baccatum* subsp. *pendulum* [*C. baccatum* var. *pendulum*]. Results of correlation and path analyses indicated that selection for fruit number; length and width as well as plant height and canopy length was significantly correlated with yield. They also concluded that, seed recovery ratio and 1000 seed weight should selection criteria for improvement of yield in hot peppers.

Mini and Khadher (2004) revealed that genetic correlation analysis for oleoresin yield was positively correlated with number of fruits per plant, and negatively associated with number of days to fruit set, flowering and harvesting. Path analysis indicated that the number of days to flowering had a positive direct effect on oleoresin yield. The number of days to harvesting and number of fruits per plant had negative direct effects on oleoresin yield.

Singh and Singh (2004) studied the association in 10 selected local hot pepper cultivars/lines and revealed the importance of correlation among yield per plant, fruits per plant, fruit diameter and plant height in determining high fruit yield in hot pepper. The path coefficient analysis brought out the number of fruits per plant, fruit weight and fruit diameter as major yield components, which might be considered as selection indices for improvement of hot pepper.

Jayashree *et al.* (2007) studied correlation and path analyses for yield and yield components for 17 genotypes of hot pepper (*Capsicum annuum*). The analysis of variance showed the highly significant variation among the genotypes for all traits except number of days to fifty per cent flowering and 1000-seed weight. The wet red hot pepper yield showed a positive and highly significant correlation with number of branches per plant, fruit girth, 1000-seed weight, seed percentage, plant height, fruit length and number of fruits per plant, but exhibited a significant negative association with number of days to fifty per cent flowering. Fruit girth was highly and directly correlated with yield,

whereas plant height, die back incidence, number of fruits per plant, seed percentage and fruit rot incidence were highly but indirectly correlated with yield.

Jogi *et al.* (2013) Character association and path analysis in fifty genetically diverse indigenous and exotic genotypes of hot pepper were studied for 16 important characters. The phenotypic and genotypic association of fruit yield was significantly positive with all the characters except days to first flowering and ten fruit weight. Early fruit yield and late fruit yield per plant were found highly significant and positive correlation with total fruit yield. The genotypic path co-efficient analysis revealed that ascorbic acid and chlorophyll content had high direct positive effect on total fruit yield.

Yudhvir Singh *et al.* (2009) evaluated thirty genotypes of hot pepper (*Capsicum annuum* L.) randomized block design with three replications to study the extent of association and to understand the direct and indirect effects of component traits on yield. Genotypic correlations were higher than the corresponding phenotypic ones for most of the traits indicating the existence of inherent association among these traits. Correlation and path analysis studies indicated that average fruit weight, number of total and marketable fruits per plant and fruit length contributed considerably for the marketable green yield. Among quality traits, ascorbic acid exhibited significant and positive association with TSS.

Reddy *et al.* (2008) conducted an experiment with 14 genotypes of hot pepper and revealed that genotypic correlation coefficients were higher than phenotypic correlation coefficients. At the genotypic level yield displayed significant and positive association with number of fruits per plant, number of primary branches, plant height, number of secondary branches and average fruit weight and at phenotypic level yield displayed significant and positive association with the number of fruits per plant. At the genotypic level, number of fruits per plant, fruit length, fruit width, average fruit weight, pedicel length and number of seeds per fruit showed positive direct effect on yield and at phenotypic level days to 50 per cent flowering, plant height, number of primary branches, plant spread, number of fruits per plant, average fruit weight, pedicel length and number of seeds per fruit had positive direct effect on green fruit yield. Seed weight per fruit,

number of fruits per plant *via* plant height, number of primary branches, number of seeds per fruit and seed weight per fruit, fruit width through average fruit weight, average fruit weight through fruit width, pedicel length, number of secondary branches, pericarp thickness and number of primary branches, number of fruits per plant, number of seed per fruit and seed weight per fruit and seed weight through number of secondary branches and fruit width were recorded positive and high.

Surya Kumari *et al.* (2011) conducted correlation studies in 94 diverse genotypes of paprika (*Capsicum annuum*) grown at Lam (Andhra Pradesh) indicated that dry fruit yield plant⁻¹ showed significant and positive association with plant height, plant spread and number of fruits plant⁻¹, fruit girth, seeds fruit⁻¹ and capsanthin content. Path coefficient studies revealed that number of fruits plant⁻¹ had the highest positive direct effect on dry fruit yield plant⁻¹. Number of fruits plant⁻¹, plant height, plant spread, number of seeds fruit⁻¹, days to maturity and capsanthin content (in the given order) were important yield and quality components having direct bearing on dry fruit yield and hence can be considered while breeding for improved yield in paprika.

Amit *et al.* (2014a) studied the genetic correlations and path coefficients among twenty traits in hot pepper. Capsaicinoid content showed positive association with number of fruits per plant while average green and dry fruit weight had negative effect on capsaicinoid content in hot pepper. Positive and significant associations between capsaicinoid content in green and dry hot pepper, ascorbic acid content in green and red ripe hot pepper indicated continuous increase in capsaicinoid and ascorbic acid contents with the maturity. Path analysis towards dry yield per plant revealed the importance of average dry fruit weight, number of fruits per plant, fruit length, green yield per plant and α -carotene content in improvement of dry yield per plant.

2.1.5 Variation and inter relationship for anthracnose in hot pepper

Reddy *et al.* (2008) reviewed hot pepper breeding research in India and opined that germplasm sources resistant to hot pepper anthracnose have been identified and used in current breeding programs. The North-East region has emerged as having a novel diversity in the cultivated species of the genus *Capsicum*.

Akhilesh Mishra *et al.* (2001) studied 22 genotypes of *C. annuum* and reported that, fruit yield per plant was positively and significantly correlated with number of fruits per plant and number of pickings, but was negatively associated with days to fifty per cent flowering and days to first harvest. High pericarp thickness and fruit diameter increased the fruit weight at edible maturity but had negative or little effect on the number of fruits and yield per plant. A low degree of association was observed between ascorbic acid content, and seed yield per fruit and 1000-seed weight.

Tenaya *et al.* (2001) reported higher capsaicin content in anthracnose resistant cultivars, while the content was lower in susceptible cultivars of hot pepper. Whereas, Deshmukh and Kurundkar (2002), studied the anthracnose [*Glomerella cingulata*] disease intensity on the leaves, branches and fruits of hot pepper (cv. Parbhani Tejas) and reported that it is correlated with fruit yield. A linear relationship was obtained between disease intensity and fruit yield of hot pepper. The disease intensity on the leaves (leaf spots), branches (dieback) and fruits (fruit rot) was negatively and significantly correlated with green fruit yield.

Prasath and Ponnuswami (2008) opined that, and development of high colour hot pepper varieties for extracton of paprika oleoresin in particularly in *Capsicum* breeding to enhance quality was evolved through pure line selection of local varieties and hybrid development.

Ahmed *et al.* (2008) observed variations in seed quality of paprika hot pepper for 1000 seed weight, germination percentage, shoot length, root length, seedling vigour index, seedling dry weight, electric conductivity and per cent infection. Significantly maximum 1000 seed weight (5.55 g), germination percentage (83.30%), shoot length (6.57 cm), root length (9.41 cm), seedling vigour index (1502) and seedling dry weight (6.365 mg) with lower electrical conductivity (1.807 dS/m) and percent infection (2.11 %) in after ripening fruits comapred to seeds obtained immediately after harvest without ripening period recording lower 1000 seed weight, germination percentage, shoot length, root length, seedling vigour index and seedling dry weight with higher electrical conductivity and percent infection.

Naveen Kumar (2009) reported that oleoresin had significant negative correlation with lesion diameter caused by *C. capsici* both at genotypic and phenotypic levels while capsaicin and ascorbic acid showed negative non significant correlation with reaction to anthracnose disease of both *C. capsici* and *C. gloeosporioides* both at genotypic and phenotypic level.

Nayeeema Jabeen *et al.* (2009) estimated phenols and phenolic enzymes under both uninoculated and inoculated conditions at different growth stages among two *Fusarium* wilt resistant, 6 susceptible and their twelve F₁ hot pepper hybrids and observed a positive correlation between the host resistance and the amount of phenols and increased enzyme activities while it was almost the opposite in susceptible lines.

2.1.6 Amylase activity in hot pepper

Young In Kwon *et al.* (2007) investigated nine types of pepper for inhibitory activity against Angiotensin I-Converting Enzyme (ACE). Several pepper extracts had high α -glucosidase inhibitory activity, which was not correlated to total phenolic content and free radical scavenging-linked antioxidant activity. Select extracts such as green pepper and long hot pepper had less or no inhibitory effect on the α -amylase activity. Among various water extracts, yellow, cubanella and red pepper had the highest ACE inhibitory activity.

Menichini *et al.* (2009) evaluated the influence of fruit ripening on total phenols, flavonoids, carotenoids and capsaicinoids content and antioxidant, hypoglycaemic and anticholinesterase activities of *Capsicum chinense* Jacq. cv Habanero. The concentration of carotenoids and capsaicinoids increased as the peppers reached maturity, whereas the concentration of phenols declined. The immature fruits showed the highest radical scavenging activity (IC₅₀ of 97.14 micro g ml⁻¹). On the contrary, the antioxidant activity evaluated by the beta-carotene bleaching test showed a significant activity for mature peppers (IC₅₀ value of 4.57 micro g ml⁻¹ after 30 min of incubation). Mature peppers inhibited α -amylase with an IC₅₀ of 130.67 micro g ml⁻¹. The lipophilic fractions of both mature and immature peppers exhibited an interesting and selective inhibitory activity against α -amylase with IC₅₀ values of 29.58 and 9.88 micro gm⁻¹ respectively.

Oboh *et al.* (2011) studied aqueous extracts (1:100 w/v) of *Capsicum annuum* var. *grossum*, *C. annuum* var. *abbreviatum*, and *C. annuum* var. *accuminatum* and a combination of the 3 varieties (1:1:1) were assayed for phenolic content (total phenol and flavonoid), antioxidant activities (reducing power and 1,1-diphenyl-2-picrylhydrazyl radical scavenging abilities), inhibitory effect on Fe^{2+} induced lipid peroxidation *in vitro*, and the ability of the extracts to inhibit key enzymes α -amylase and α -glucosidase. The combination of peppers showed additive effects in their phenolic content and displayed antioxidant properties. However, the inhibition of pancreatic α -amylase activity showed an additive effect, whereas α -glucosidase inhibitory activity was antagonistic with the combination. *C. annuum* var. *accuminatum* contributed most to the activities of the combined peppers. Suggesting hot pepper could be used in the prevention and management of type 2 diabetes.

2.2 Anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin

2.2.1 Anthracnose disease incidence and severity in hot pepper

Lin *et al.* (2007) studied fruit of F_1 , F_2 , BC_1 , P_1 , F_1 , and BC_1 , P_2 , F_1 generations by micro injection with isolate Coll-153 (*C. acutatum*) at two positions on each green and red fruit and measured lesion diameter five days later. At the green fruit stage, seven out of ten F_1 plants evaluated were resistant. Segregation ratio in the F_2 generation fit a 9R:7S model, and in the BC_1 , P_2 , F_1 generation, a 1R:3S segregation suggests control by two complementary dominant genes. However, backcross to the resistant parent (BC_1 , P_1 , F_1) failed to fit the predicted 1R:0S ratio. The ratio of resistant to susceptible plants in the F_2 generation approximated a 7R:9S ratio, and almost all the BC_1 , P_2 , F_1 progeny were susceptible (4R:96S plants), suggesting that the resistance may be controlled by duplicate recessive genes, and concluded that, the genes conferring resistance at the immature green fruit stage appears to be distinct, and independent of those controlling resistance in mature red fruit.

Wilawan Kraikruan *et al.* (2008) analysed the different varieties of cultivated hot peppers (*Capsicum* spp.) producing varied amounts of capsaicin *in vitro*. They,

germinated conidia on potato dextrose agar media supplemented with 40 per cent methanol/aqueous capsaicin solution in final concentrations of 0, 25, 50, 100 and 200 mg l⁻¹. Each plate was inoculated with a solution containing approximately 400 conidia of *C. capsici*, then incubated at 25 °C and 70 per cent relative humidity under continuous light for 5, 6 and 7 hours. Approximately 96 per cent of conidia germinated on the capsaicin free medium after six hours of incubation, but only 53 per cent germinated on PDA containing 25 mg l⁻¹ capsaicin. Subsequently, conidia germination increased to 91 per cent after 7 hours on plates containing 25 mg l⁻¹ capsaicin. Germination of *C. capsici* conidia was completely inhibited on the PDA with 100 and 200 mg l⁻¹ of capsaicin. Revealing role of capsaicin in preventing conidial germination of the anthracnose-causing fungus *Colletotrichum capsici*.

Rodeva *et al.* (2009) studied three species of *Capsicum annum* cultivars and lines, *C. baccatum* var. *pendulum* accessions and interspecific hybrid progenies for natural attack by *Colletotrichum* spp. All studied *C. baccatum* var. *Pendulum* accessions and most of *C. annum* × *C. frutescens* hybrids showed high field resistance. The symptoms of *Colletotrichum* spp first appeared as small, water soaked lesions that expanded rapidly. Fully expanded lesions were usually round and sunken and ranged in colour from dark red to tan to black. Often multiple lesions formed on individual fruit. During warm and wet periods, conidia were splashed by rain or irrigation water from diseased to healthy fruit. Diseased fruit acted as a source of inoculum, allowing the disease to spread from plant to plant within the field.

Vinaya *et al.* (2009) examined the anthracnose of hot pepper caused by *Colletotrichum capsici* (Sydow) Butler and Bisby is an economically important disease of hot pepper affecting both fruit and seed quality. Hot pepper seed samples collected from different hot pepper growing districts of northern Karnataka revealed fungi viz., *Colletotrichum capsici*, species of *Cercospora*, *Alternaria*, *Penicillium* and *Aspergillus*. *Colletotrichum capsici* were the most predominant fungi encountered (71.24 %). Seed samples collected from Haveri district showed maximum infection of *Colletotrichum capsici*. Among the different seed health testing methods tested, Standard Blotter Method

was found to be most efficient for the quick and accurate diagnosis of *Colletotrichum capsici*.

Ranbir Singh and Chowdury (2010) studied the natural incidence of anthracnose of hot pepper (*C. capsici*) and reported maximum percentage (43.37 %) of die back incidence during 2003 was observed in Cv. Suryamukhi and minimum (27.77 %) in CH-3, while the varieties like Pusa Jwala, Pant C-1 and CH3 did not differ significantly on die back incidence. They also reported maximum and minimum incidence, 45.93 and 26.66 per cent, was observed in Suryamukhi and Akashi, respectively, and it differed significantly during 2002. Whereas, in 2003, maximum and minimum incidence of fruit rot infection varied from 41.83 (Suryamukhi) to 17.09 per cent (Akashi). While, maximum intensity of fruit rot was observed in Suryamukhi (40.39 %) and minimum in Akashi (17.51 %) during 2004.

Nsabiyeera *et al.* (2012) revealed presence of highly significant genotypic differences ($P < 0.001$) existed in most scored disease traits. Highly significant genotype by season ($P < 0.001$) interactions were observed for both disease incidences and severity indices, except for *Phytophthora* blight severity index. Field disease correlation stability analysis cross seasons indicated significant virus and *Phytophthora* blight severity indices implying some stability in these scores across seasons with virus severity index being the most consistent scored disease trait. Anthracnose incidence and severity contributed more to yield loss.

Anamika *et al.* (2012) conducted a survey to assess the incidence of anthracnose of hot pepper in five locations. The percentage incidence of anthracnose affected fruits under field conditions was more on green fruits which the outcome indicated the incidence ranged from 55.53 to 71.10 per cent. It was revealed the predominance presence of the anthracnose disease which is the major constraints to profitable cultivation of hot pepper.

Susheela (2012) evaluated the methods of screening for resistance to hot pepper anthracnose. Using puncture method, conidia of *Colletotrichum capsici* germinated and

differentiated into appresoria on fruit surfaces in both green and ripened red fruits and the lesion area was more in green fruits compared to red fruits, which is not common under field conditions. Further, the green fruits which were tolerant towards anthracnose were certainly tolerant at ripened red stage, whereas if fruits were found susceptible at green stage, ripened red fruits were found to be either tolerant or susceptible. Glomeralla, which is sexual stage of *Colletotrichum* sp. is known to produce more appresoria on the surface of immature fruits than on fully ripened fruits. In contrast, ripened red fruits were found to be more susceptible with large lesion areas under field conditions, while green fruits were showing initial symptoms only at the colour changing stage. The percentage incidence of anthracnose affected fruits under field conditions employing the spray inoculation is found to be the ideal method to identify resistant hybrids.

Prathibha *et al.* (2013) assessed the extent of loss in fruit quality parameters upon infection by anthracnose, capsaicin, oleoresin and phenol contents were estimated in both healthy and anthracnose infected fruits (with 40 per cent disease severity) in 15 varieties. capsaicin, oleoresin and phenol contents reduced significantly in anthracnose infected fruits as compared to healthy fruits in all the 15 varieties. Reduction in phenol content in infected fruits was relatively high as compared to capsaicin and oleoresin. Reduction in phenol content varied from 16 to 69 per cent, while reduction in capsaicin varied from 20 to 60 per cent and oleoresin from 17 to 55 per cent.

Hyi Jin Kim *et al.* (2014) examined the inhibitory efficacy of this strain against anthracnose by *Colletotrichum gloeosporioides* in infections of pepper and cherry tomato and the degree of anthracnose injury to pepper are in the following order: untreated control eugenol (sopra extract) > tebuconazol (a chemical fungicide) > azoxystrobin (a chemical fungicide) strain A1022 SC. Also had an inhibitory effect against anthracnose on cherry tomato. In a field test, azoxystrobin (10,000 ppm active ingredient; 1,000-fold dilution) and strain A1022 SC (2×10^4 colony forming unit mL⁻¹; 500-fold dilution) had inhibitory effects of 68.0 and 61.6 per cent against pepper anthracnose, respectively. Our results suggest that strain A1022 SC can be an alternative to chemical fungicides, at least for pepper and cherry tomato anthracnose infections caused by *C. gloeosporioides*.

Hema Ramdial *et al.* (2015) conducted a study to identify and characterize the pathogens responsible for anthracnose disease in bell peppers (*C. annuum* L.) in Trinidad. Seventy two per cent of all isolates were *Colletotrichum truncatum* and 28 (%) were *C. gloeosporioides*. Pathogenicity tests demonstrated different levels of resistance to anthracnose in various *Capsicum* genotypes. *C. gloeosporioides* sensu lato isolates caused significantly greater damage than *C. truncatum* isolates regardless of pepper cultivar. PCR with taxon- and species-specific primers produced amplicons of expected band sizes for all *Colletotrichum* species and only for *C. gloeosporioides*, respectively.

2.2.2 Symptomatology of fruit rot anthracnose (*Colletotrichum* spp.)

Chowdary (1957) described the symptoms of anthracnose of hot pepper as appearance of a small black circular spot sharply defined but at times diffused. The disease spread was more in the direction of long axis of the fruit, so that original circular spot becomes elliptical. As the infection progressed, the spots showed either diffused black, greenish black or dirty gray in colour, markedly delimited by a thick sharp black outline enclosing a dark lighten black or straw coloured area. Two or more spots coalesced to form bigger spots. Diseased fruits tend to lose their normal red colour and turned straw coloured or in some cases turned white. When diseased fruit was cut open, the lower surface of the skin was found to be covered with minute, black, spherical elevations. In advanced cases, seeds were covered by a mat of mycelium.

Typical anthracnose symptoms on hot pepper fruit include sunken necrotic tissues, with concentric rings of acervuli. Fruits showing blemishes with reduced marketability (Manandhar *et al.*, 1995).

Khodke and Gahukar (1995) Isolated *Colletotrichum gloeosporioides* (*Glomerella cingulata*) from ripe hot pepper fruits in pure culture and its pathogenicity was confirmed. This was considered to be the first record of this species occurring on hot pepper in Maharashtra, India.

Oh *et al.* (1998) observed initial anthracnose symptoms on some green fruits at two days after inoculation resulting in typical sunken necrosis within five days after

inoculation. Concentric rings of the acervuli within the fruit spots were common symptoms. In some cases, the lesions were brown, not orange, and then turned black from the formation of setae and sclerotia.

Singh *et al.* (1993) evaluated nineteen varieties of hot pepper against *C. capsici* under laboratory condition. Red ripe fruits were pinpricked and sprayed with 8000 conidia ml⁻¹ of suspension of *C. capsici* and held in moist chamber at 28 °C for 24 hours. The lesion spread in the first six days was lowest in varieties BG₁ and Lorai (5.75 and 6.0 mm, respectively) and were the only two varieties graded as resistant to fruit rot.

Ekbote *et al.* (1997) reported maximum radial growth of 90 mm by *C. gloeosporioides* isolates on Richard's, Brown's and Potato dextrose agar medium followed by Czapek's agar (89.6 mm). Richard's medium also supported good sporulation. The maximum dry mycelia weight of the fungus was recorded on the 12th day after seeding *i.e.*, 426 mg in potato dextrose broth.

Khodke and Wankhede (2000) noticed more growth and sporulation of *Colletotrichum gloeosporioides* in Richard's agar, potato dextrose agar and oat meal agar. Moderate growth and sporulation were observed in Asthana and Hawker's medium, whereas no growth was observed in plain agar medium.

Hegde and Anahosur (2001) evaluated fifty two hot pepper genotypes against fruit rot fungus, *C. capsici* under natural condition. LCA-301, LCA-324, K-1 and Byadagikaddi were found resistant. Whereas, KDSC-210-10 and S-32 were found to be highly susceptible. Resistant genotypes contained higher capsaicin, ascorbic acid and lower amount of total sugars than susceptible ones.

Hegde and Kulkarni (2001a) conducted a study to determine the stage of infection of *Colletotrichum capsici* to hot pepper (*Capsicum annuum*) in two cultivars (Byadagi Kaddi and Byadagi Dabbi) and the maximum per cent disease index (PDI) was observed in red fruits of Byadagi Dabbi (49.67) than Byadagi Kaddi (40.33).

Than *et al.* (2008) described symptoms of hot pepper anthracnose disease as circular or angular sunken lesions, with concentric rings of acervuli that were often wet and produced pink to orange conidial masses which under severe disease pressure, lesions coalesced. Conidial masses might also occur scattered or in concentric rings on the lesions.

2.2.3 Relationship of fruit chemical constituents with response to fruit rot anthracnose

Chew (1987) suggested that resistance to anthracnose disease was due to higher fruit capsaicin content rather than small fruit surface area.

Azad (1991) analyzed anthracnose resistant, moderately resistant and susceptible *Capsicum* cultivars and found that in infected plants sugars, ascorbic acid, nitrogen and sulfur contents were reduced; phenolic compounds decreased with increasing fruit maturity which was correlated with disease severity.

Ou *et al.* (1999) studied the effect of hot pepper fruit cuticular wax on infection by *C. gleosporioides* and their research revealed that removal of cuticular wax layer of hot pepper fruits produced larger lesions upon infection with *C. gleosporioides* compared to the lesion produced on fruits with intact cuticular wax layer.

Jeyalakshmi and Seetharaman (1999) Reported 50 per cent reduction in capsaicin content in diseased hot pepper fruit due to die-back. Ascorbic acid content was less in diseased hot pepper fruit. Khodke and Wankhede (2000) revealed less ascorbic acid content, total sugar and capsaicin in fruits heavily infected due to dieback

Hegde and Kulkarni (2001b) screened fifty two hot pepper genotypes against fruit rot of hot pepper (*C. capsici*) under natural conditions. Analysis of biochemical constituents of field resistant genotypes revealed that resistant genotypes contained higher capsaicin, ascorbic acid and lower total sugars than susceptible ones.

Hegde and Anahosur (2001) evaluated fifty two hot pepper genotypes against fruit rot fungus, *C. capsici* under natural condition. LCA-301, LCA324, K-1 and Byadagi

Kaddi were resistant whereas, KDSC-210-10 and S-32 were highly susceptible. Resistant genotypes contained higher capsaicin, ascorbic acid and lower amount of total sugars than susceptible ones.

Prasad *et al.* (2000) capsaicin content in hot pepper fruits was determined by using acetone extraction method and capsaicin was estimated colorimetrically. Similarly, maximum oleoresin yield of 16.25 per cent was obtained when acetone was used as extraction solvent and this was on par with ethyl alcohol. (Rajinder *et al.*, 2003). The capsaicin content of 2.15 and 2.06 per cent were obtained by using acetone and ethyl alcohol as solvent respectively.

Kim *et al.* (2004) examined post harvest (detached) and in planta (attached) fruits of pepper plants, *Capsicum annuum* cv. Jejujaerae (susceptible) and *Capsicum baccatum* cv. PBC80 (resistant), inoculated with the anthracnose pathogen *Colletotrichum gloeosporioides* using light, confocal laser scanning, and electron microscopy to compare the cytological differences. They revealed that, nonwound inoculation of postharvest pepper fruit, resistant pepper tissues showed a significant increase in the thickness of the cuticle layer compared with that of the susceptible and noninoculated fruit. Cytological features of programmed cell death (PCD) were observed in the resistant pepper fruit with post harvest inoculation. They also observed nuclear modifications and structural changes of hypersensitivity in the resistant fruit, including separation of the plasma membrane from the cell wall, dilation of the endoplasmic reticulum, accumulation of electron-dense inclusions in vacuoles, and cytoplasmic vacuolization accompanying fragmentation of the cytoplasm.

Mesta *et al.* (2007a) conducted an experiment to determine the fruit growth stage (green fruit, green fruit turning to red and red fruit) most susceptible to fruit rot (*Colletotrichum capsici*) infection and to evaluate the role of different biochemical constituents on the level of fruit rot resistance in hot pepper. They revealed that, Red fruits showed 150 per cent more fruit infection and 128 per cent more percentage area of fruit infection than green fruits and concluded that the stage at which fruits turn from green to red was prone to anthracnose fruit rot infection.

Ruchi Garg *et al.* (2012) opined that, pre and post-harvest anthracnose fruit rot is a main disease of hot pepper (*Capsicum* spp.). Among *Colletotrichum* species causing anthracnose, *C. capsici* is the most common in India. A total of 41 *Capsicum* genotypes were screened for anthracnose resistance under field conditions. Bhut Jolokia, PBC-380 and IC-383072 were found symptomless. In vitro inoculation of the selected set of genotypes with *C. capsici* revealed that 9 days after inoculation was appropriate to record observations on disease resistance. They compared, field and in vitro evaluations, nine lines (BS-35, BS-20, BS-28, Punjab Lal, Bhut Jolokia, Taiwan-2, IC-383072, Pant C-1 and Lankamura collection) showed consistent resistance in field as well as in vitro to the disease.

Mikulic Petkovsek *et al.* (2013) evaluated the role of soluble phenolic compounds in plant's defence mechanism in three distinct parts were analysed on pepper fruit: healthy tissue, anthracnose lesion, and bordering tissue and identified individual phenolic compounds with the use of HPLC-MS system. They determined 21 phenolic compounds in pepper fruit pericarp the prevalent apigenin, quercetin and luteolin glycosides, chlorogenic acid and one chrysoeriol glucoside. *C. coccodes* infection increased the accumulation of chlorogenic acid, chrysoeriol glucoside, quercetin and luteolin glycosides in infected bordering tissue of both analysed pepper cultivars compared to healthy pepper tissue or symptomatic spot. Intense phenolic synthesis was characteristic for the bordering zone between the healthy and infected plant tissue resulting in higher total phenolic content which might hinder the fungus to spread from the infected cells into the healthy tissue.

2.2.4 Estimation capsicin by High Performance Liquid Chromatography (HPLC)

Collera *et al.* (2005) employed normal and reverse phase high-performance liquid chromatography to identify and separate the carotenoid pigments present in varieties ancho, guajillo and mulato of *Capsicum annum*. In the reverse phase 13 common carotenoids out of 24 were found. In normal phase there were 14 common carotenoids out of 22. They reported considerable variation in carotenoid composition and identified major carotenoids β -carotene and β -cryptoxanthin which have provitamin-A activity.

Nirala *et al.* (2014) opined that, *Capsicum* species commonly known as hot peppers are economically important group of plants belonging to the Solanaceae family. Of the 38 species reported, only six species namely, *Capsicum annuum*, *C. assamicum*, *C. baccatum*, *C. frutescence*, *C. chinense* and *C. pubescens* are cultivated. They are very important component of the human beings as peppers are used as vegetables, spices, and a colouring agent and for medicinal purposes. Based on pungency trait which is due to the presence of a group of compounds known as capsaicinoids, cultivated capsicums are classified into sweet peppers and hot peppers.

2.2.5 Capsicin and its effect of on anthracnose fruit rot

Garciglia and Alejo (1990) described a colorimetric method for determination of capsaicin in capsicum fruits. The acetone or ethyl acetate extract (prepared at room temperature) is purified on a basic alumina (Brockmann Grade I) column and pure capsaicin is eluted with methanol-acetone-water (75:25:1) the capsaicin content is determined after colour development with Folin-Ciocalteu reagent, the absorbance being measured at 760 nm.

Masood *et al.* (1994) evaluated effect of capsanthin and capsaicin, the colouring and pungent principles of red hot pepper *Capsicum annuum* respectively, against the growth and aflatoxin producing potentials of *Aspergillus flavus*. Capsanthin completely checked both the growth and toxin production at all the concentrations viz. 0.2, 0.6 and 1.0 mg ml⁻¹.

Collins *et al.* (1995) assessed high performance liquid chromatography (HPLC) method for analysis of capsaicinoids in dried *Capsicum* fruit powder, involving changes in extraction, mobile phase, flow rate, and excitation and emission spectra and resulting in reduced analysis time, increased sensitivity, and safety, is reported. Extraction of *Capsicum* fruit powder using acetonitrile proved to be the best capsaicinoid extractor in the shortest time interval. They developed two analytical methods, one method determines total amount of heat units in seven (7) minutes, while the other provides total amount of heat units as well as separation of all present major and minor capsaicinoids in 20 minutes. These improved techniques provide inexpensive and rapid methods for

quantitative and qualitative analysis of capsaicinoids in *Capsicum* fruit samples along with good sensitivity and no interference or confounding peaks.

Molina Torres *et al.* (1999) reported the antimicrobial activity of capsaicin, high concentrations of capsaicin retarded the growth of *E. coli* and *P. solanacearum*. The lowest concentrations of capsaicin 25 mg mg⁻¹ completely inhibited *P. solanacearum* growth. They also reported that, capsaicin inhibited the growth of *B. subtilis* strongly.

Jeanne *et al.* (1999) opined that capsaicinoids, the alkaloids responsible for pungency in chilli fruit, are synthesized from phenylpropanoid intermediates and short-chain branched-fatty acids. Transcript levels of enzymes on the capsaicinoid pathway were monitored in *Capsicum annuum* and *C. chinense* fruit as a function of development, tissue type and genotype. Transcript levels for all three genes were positively correlated with degree of pungency in placental tissue; habanero, the most pungent chilli fruit, had the highest transcript levels, California Wonder, a non-pungent fruit, had the lowest levels. These genes are expressed in a placental-specific manner, and transcript levels are positively correlated with fruit pungency.

The hot flavor of hot peppers is due to the presence of a group of seven closely related compounds called capsaicinoids, but capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) and dihydrocapsaicin are responsible for approximately 90 (%) of the pungency 1–3. Hot pepper hotness is measured in Scoville Heat Units (SHU) (Scoville, 1912) which is originally a subjective measure but today, hot pepper hotness is more frequently determined by HPLC (high performance liquid chromatography), whose results can be correlated to traditional Scoville ratings the conversion generally accepted is that 15 Scoville units is equal to 1 ppm capsaicin plus capsaicinoids. (Ritesh *et al.*, 2000)

Yayeh Zewdie and Bosland (2000) studied the capsaicinoid content, of chile (*Capsicum annuum* L.) genotypes to different environments. Double haploid lines, an F₁ hybrid, and an open-pollinated cultivar estimated the genotype, environment, and genotype-by-environment interaction effect on the total capsaicinoids and on individual

capsaicinoids. Significant differences were observed among the genotypes and among genotype-by-environment interactions over the environments. Among the genotypes in an environment, the within-genotype variances were also significantly different. The double haploid line, HDA 207, had low within-genotype variance for individual and total capsaicinoids, with the exception of the isomer of dihydrocapsaicin. Also for HDA 270, the genotype-by-environment interaction was negligible for individual and total capsaicinoids, indicating stability across environments.

Two important quality attributes of hot pepper is pungency imparted by the presence of capsaicinoids and the colour due to carotenoids. Capsaicin is a unique alkaloid of the plant kingdom restricted to the genus *Capsicum*. Capsaicin is the pungency factor, a bioactive molecule of food and of medicinal importance. Capsaicin is used as a counter irritant, anti-arthritic, analgesic, antioxidant, and anticancer agent. The rich supplies of hot pepper carotenoids contribute to food nutritional value and colour (Anon, 2003).

Tewksbury and Nabhan (2001) opined the biological properties of capsaicin its evolutionary significance in the plants has not been examined completely. The HPLC method was optimized by defining how composition of the mobile phase affected retention times. Both identification and quantification were based on retention times and the following criteria: linearity of the UV response at 229 nm in HPLC, recoveries from spiked samples, and observed individual molecular ions in the mass spectra of the extracts determined by liquid chromatography-mass spectrometry. This method, with a limit of detection of ~15-30 mg, was used to quantify the distribution of capsaicinoids in whole peppers. Total capsaicinoid levels of whole peppers ranged from 1.21 $\mu\text{g g}^{-1}$ for the PR Gang ja variety to 121.1 $\mu\text{g g}^{-1}$ for the Chung yang variety. (Choi *et al.*, 2006) revealed that, the chemical responsible for the fruit's pungency selectively discourages vertebrate predators without deterring more effective seed dispersers.

Tewksbury *et al.* (2008) showed that chemical defence of hot pepper ripe fruit reflects variation in the risk of microbial attack in *Capsicum chacoense*. In population producing varied contents of capsaicinoids in naturally polymorphic proportion, showed

that variation is directly linked to variation in the damage caused by *Fusarium* fungal pathogen on hot pepper seeds and experimentally demonstrated that capsaicinoids protect hot pepper seeds from *Fusarium*. They also opined that pungency in hot peppers may be an adaptive response to selection by a microbial pathogen.

Bharathi *et al.* (2011) reported that native variety of hot pepper from Andaman & Nicobar Islands (IC 553688), was characterized and the capsaicinoids content were estimated in terms of parts per million of heat (ppmH) by high performance liquid chromatography. One way ANOVA indicated that all the hot pepper accessions differed significantly in their capsaicin ($p < 0.01$). Among the varieties, IC 553688 was found to be more pungent with high capsaicinoids content (29,140.63 ppmH) and pungency value at 4, 37,109.52 Scoville Heat Unit (SHU) as compared to that of *C. chinense* cv. Tezpur Local (10,170.60 ppmH and 1, 52,558.99 SHU), *C. frutescens* cv. Pusa Sadabahar (3,922.47 ppmH and 58,837.10 SHU) and *C. annuum* cv. Pusa Jwala (2,778.86 ppmH and 41,682.95 SHU) respectively. The genotype IC 553688 has become well adapted to hot and humid climate of Andaman and Nicobar islands where it has potential to be grown commercially for the extraction of nutraceuticals.

Zeid *et al.* (2011) studied that capsaicin and dihydrocapsaicin content in *Capsicum* samples collected at Riyadh (Saudi Arabia), calculate their pungency in Scoville heat units (SHU). The limit of detection (LOD) of the method was 0.09 and 0.10 $\mu\text{g g}^{-1}$ for capsaicin and dihydrocapsaicin, respectively, while the limit of quantification (LOQ) was 0.30 and 0.36 $\mu\text{g g}^{-1}$ for capsaicin and dihydrocapsaicin, respectively. Hot peppers showed the highest concentration of capsaicin ($4249.0 \pm 190.3 \mu\text{g g}^{-1}$) and the highest pungency level (67984.60 SHU), whereas green peppers had the lowest detected concentration ($1.0 \pm 0.9 \mu\text{g g}^{-1}$); green peppers, red peppers and yellow peppers were non pungent. The mean consumption of peppers for Riyadh city population was determined to be 15.5 g/person/day while the daily capsaicin intake was 7.584 mg/person/day.

Naresh *et al.* (2012) examined the capsaicinoids are the alkaloids responsible for pungency in hot pepper fruits. Estimates of capsaicinoids obtained by colorimetric method and HPLC were highly correlated ($R_2 = 0.996$) and suggested that colorimetric

method an effective means for estimating total capsaicinoids in extracts of fresh hot pepper fruits. Thirty accessions were screened using colorimetric method and considerable variability was observed for total capsaicinoids (0-1.65 %). In order to see sequence polymorphism associated with pungency level, they cloned and sequenced part of AT₃ gene, anacyltransferase belonging to the BAHD family of acyltransferases. Results revealed that abundant indel (insertion and deletion events) and SNP (single nucleotide polymorphisms) in the cloned AT₃ partial sequence. Both AT₃-1 and AT₃-2 are present in many cultivars that suggest paralogous gene lineages.

Sanju *et al.* (2014) reported that hot pepper varieties ‘Naga hot pepper’ or ‘Bhoot Jolokia’ (*Capsicum chinense* Jacq.) are indigenous to the northeast region of India and has been recognized as one of the hottest hot pepper in the world. In the Scoville organoleptic test, the highest Scoville Heat Unit (SHU) value was found in September 15 sowing fruits and the lowest in the February 15 sowing fruits. Fruit produced from spacing 105 cm × 105 cm showed highest Scoville Heat Unit. In High Performance Liquid Chromatography analysis, highest amount of capsaicinoid was also found in September 15 sowing while fruits produced from spacing 105 cm × 105 cm showed highest amount of capsaicinoid.

2.2.6 Anthracnose and changes in hot pepper quality

Jeyalakshmi *et al.* (1994) reported the changes in chemical constituents of hot pepper fruits infected by *C. capsici*. Diseased fruits had reduced quantities (50 per cent) of capsaicin and oleoresin. Surface wax as well as the protein and ascorbic acid content were depleted in diseased fruits.

Biles *et al.* (1997) studied developmental regulation and organ-specific expression of shikimate dehydrogenase in seedlings of *Capsicum annuum* L, during their early development. The results obtained suggest that there is both a developmental regulation and an organ-specific expression of shikimate dehydrogenase in seedlings of *C. annuum*, seen mainly in the cotyledons. The amounts of shikimate dehydrogenase were compared with the end-products of the shikimate pathway, chlorogenic acid and lignins. And it was observed that the fall in shikimate dehydrogenase activity in cotyledons coincided with a

decrease in the concentrations of phenolics during primary leaf development. However, this did not seem to be the case with the hypocotyls, where the fall in phenolics was not related to the amount of shikimate dehydrogenase but rather to an increase in lignin deposition, supporting the view that chlorogenic acid might act as a precursor of the aromatic moiety of cinnamoyl alcohols during cell wall lignification.

Khodke and Wankhede (2000) revealed less content of ascorbic acid, total sugar and capsaicin in fruits heavily infected due to dieback and studied the biochemical changes in hot pepper [*Capsicum annuum*] in fruits infected with *Alternaria alternata*, *Colletotrichum dematium* and *Rhizoctonia bataticola* [*Macrophomina phaseolina*]. Fruit samples from healthy and diseased hot pepper plants showing ≥ 50 (%) infection were analysed for various chemical constituents. The ascorbic acid, total sugar, reducing sugar, non-reducing sugar and capsaicin contents were lower in infected fruits than in healthy fruits.

Prasanna Kumar (2001) reported that *Colletotrichum gloeosporioides* fungus were grayish white to dark gray on Potato dextrose agar (PDA) and may produce aerial mycelium ranging from a thick mat to sparse or tufts of mycelium. Conidia were hyaline, unicellular and either cylindrical with obtuse ends or on hyaline brown conidiophores in acervuli that were irregular in shape and about 500 μm in diameter. Setae were $4\text{--}8 \times 200 \mu\text{m}$, one to four septate, brown and slightly swollen at the base and tapered at the apex. Orange slimy conidial masses could be formed as the acervulus matures.

Wanshou *et al.* (2002) studied alkaloids in the fruit are the active constituents responsible for analgesia, anti-inflammation and for stimulating fat metabolism, sneezing and lachrymation. They extracted components responsible for the pungent flavour in the fruits capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin, homodihydrocapsaicin I, homodihydrocapsaicin II, nonoyl vanillylamide, decoyl vanillylamide, capryl vanillylamide, cryptoxanthin, capsanthin, capsorubin and carotene. They also revealed that, presence of alkaloids in the seed *Viz.*, solanine, solanidine, solamargine, solasodine and solasonine in *Fructus capsici* (hot pepper); the fruit of plants *Capsicum frutescens*.

Estrada *et al.* (2002) carried out quantitative analysis of capsaicin and dihydrocapsaicin content in the pericarp, placenta, and seeds of seven cultivars of hot peppers belonging to *Capsicum annuum* L. var. *annuum*), maax (*Capsicum annuum* L. var. *aviculare*) xkatik, and habanero orange and habanero white (*Capsicum chinense* Jacq.) by gas chromatography. They recorded higher capsaicin content in the fruits of habanero orange and habanero white, followed by sukurre, chawa, xkatik, and maax. Dihydrocapsaicin content did not follow the same scheme, being higher in the fruits of sukurre, followed by chawa, habanero white, habanero orange, and maax. And reported that capsaicinoids are a group of 12 or more related alkaloids responsible of the pungent sensation in fruits of the genus *Capsicum*. capsaicin [(E)-N-(4-hydroxy-3-methoxybenzyl)-8-methyl-6-nonenamide] and dihydrocapsaicin are responsible for more than 90 (%) of the pungency.

Patil *et al.* (2003) evaluated hot pepper (*Capsicum annuum*) genotypes against fruit rot caused by *Colletotrichum capsici*. They recorded data on the incidence of fruit rot at each picking and observed that cultivars Jayanti and Phule Jyoti appeared to be resistant and 11 cultivars, namely Jwala, Phule Suryamukhi, Arka Lohit, KAC-86-25, Agni Rekha, AKC-BC-89-11, Parbhani tall, X-235, AKC-BC-89-8, G-4 and Surkta, were found to be moderately resistant.

Khirbhat *et al.* (2006) inoculated hot pepper fruits with the isolates of *Colletotrichum capsici* and measured length and breadth of the lesions produced by various isolates after 10 days of inoculation. The fungal isolates were divided into four groups based on their virulence: group I (CC-9, capability of producing susceptible reaction in all *Capsicum cultivars*); group II (CC-8, capable of producing susceptible reaction in Sadabahar, Hisar Shakti and Kiran and resistant reaction in Hisar Vijay); group III (CC-6, capability of producing susceptible reactions in Sadabahar, Hisarvijay and kiran and resistant reaction in Hisar Shakti); and group IV (CC-1, CC-2, CC-3, CC-4, CC-5 and CC-7, incapable of producing susceptible reaction in all *Capsicum cultivars*).

Mistry *et al.* (2008) have carried out biochemical analysis of the capsaicin content in hot pepper fruit was greatly reduced in the diseased hot pepper fruits, which was

732.05 $\mu\text{g g}^{-1}$ as against 1429.65 $\mu\text{g g}^{-1}$ in healthy fruits. The loss of ascorbic acid from the hot pepper fruit due to die-back disease infection was quite large and directly related to the disease intensity which was found 2505.82 $\mu\text{g g}^{-1}$ in diseased fruits, whereas it was 6260.31 $\mu\text{g g}^{-1}$ in healthy fruits.

Arora *et al.* (2011) assessed the capsaicin which is a pungent highly domesticated fat soluble alkaloid having its origin from Bolivia and Brazil. It is biosynthesized via phenylpropanoid pathway and branched chain fatty acid pathway. Its pungent analogues are synthesized using amidation reactions catalyzed by lipases and non-pungent analogues using acyl chain lengths and different substituent in aromatic ring. It acts by binding TRPV1 and shows wide applications in relief from pain, breast and prostate cancer, obesity, heart diseases and hair losses.

2.2.7 Effect of Peroxidase on seed quality and fruit rot disease

Sunga and Chiub (1995) evaluated the effect of natural aging on germination and several physiological characteristics related to peroxidation in the seeds of two edible soybean cultivars. Natural ageing was achieved by sealing the seeds in aluminum foil bags coated with polyethylene and storing the seeds at 5 or 25 °C for 3, 6, 9, and 12 months. The results indicate that at both 5 and 25 °C, ageing inhibited seed germination and enhanced lipid peroxidation, but with more rapid seed deterioration and a greater extent of lipid peroxidation at the latter temperature. Ageing also inhibited the activity of peroxidase, catalase, ascorbate peroxidase, superoxide dismutase and lipoxygenase. The seeds harvested from the spring crop were more susceptible to aging than the seeds harvested from the autumn crop. The changes in germination and physiological activities, expressed as a function of growing season and ageing condition, were similar in the two cultivars.

Estrada *et al.* (2000) studied changes in capsaicinoids, lignin, and free phenolics of pepper fruits of *Capsicum annuum* cv. Padron, during the maturation process. They reported that, although capsaicinoids increase with development, the maximal levels of free phenolics and lignin are observed during the early stages of development. A decrease of peroxidase activity was observed during maturation, and this was related with a

decrease in other physiological parameters studied, namely chlorophylls and pH. Subcellular fractionation studies reveal that most peroxidase activity is localized in the soluble fraction throughout development. The changes in the peroxidase activity were accompanied by changes in the different isoenzymes. Acidic isoenzymes increased whereas the basic isoenzymes decreased over the same period, and the changes in these isoenzymes were related with capsaicin metabolism.

Diaz *et al.* (1997) described the evolution of capsaicinoids during the development, maturation, and senescence of the fruit in three varieties of hot chile peppers [Habanero (*Capsicum chinense* Jacq.), De arbol (*C. annuum* var. *annuum*), and Piquin (*C. annuum* var. *aviculare*)] and its relation with the activity of peroxidases in these fruits. Capsaicinoids were more abundant in the fruit of Habanero, followed by De arbol and then by Piquin. Capsaicin was higher than dihydrocapsaicin in the three varieties. Capsaicinoids, capsaicin and dihydrocapsaicin increased continuously and reached a peak after 45-50 days from fruit set (DFFS) in Habanero and De arbol and after 40 DFFS in Piquin and then declined. Peroxidase activity increased at the time when the concentration of capsaicinoids started to decrease. They also reported an inverse relationship between the evolution of capsaicinoids and peroxidase activity that might indicate that this enzyme is involved in capsaicinoid degradation.

Gannett *et al.* (1998) opined that enzymatic levels of peroxidases were found to increase in chile pepper fruit during ripening. Fruit harvested at intervals throughout the growing season showed incremental increases in total peroxidase enzyme levels and increased intensity in the activity of an acidic isozyme form of $pI = 4.0$ in polyacrylamide gels. Fast protein liquid chromatography on an anion-exchange column yielded an acidic peroxidase enzyme activity in both green and red chile fruits. These results indicate that alternate forms of chile fruit peroxidases vary during fruit ripening, are stable at elevated temperatures, and demonstrate broad pH optima during the ripening stages.

Douglas *et al.* (2003) evaluated horse radish peroxidase compound I and II reduction by two prominent capsaicinoids (25 °C, pH 7.0) using transient-state methods. They determined rate constants approaching 2107 and $5105 M^{-1} s^{-1}$ for compound

I and compound II reduction, respectively. And also determined k_{app} values for steady-state capsaicinoid oxidation approaching $8.105 \times 10^{-5} \text{ s}^{-1}$ (25 °C, pH 7.0). Accounting for stoichiometry, these are in excellent agreement with constants for compound II reduction, suggesting that this reaction governs capsaicinoid-dependent peroxidase turnover. Besides, ascorbate also rapidly reduced capsaicinoid radicals, assisting in the determination of the kinetic constants reported. And concluded that, peroxidases catalyze capsaicinoid oxidation and may play a central role in their metabolism. However, key kinetic aspects of peroxidase-catalyzed capsaicinoid oxidation remain unresolved.

Moreno *et al.* (2003) studied the change and physiological and biochemical indicators (catalase, peroxidase, aconitase [aconitate hydratase] and ascorbic acid oxidase [ascorbate oxidase] activities; phenolic compounds by several micronutrients (Fe, Mn, Cu, Zn and B) in mature leaves of red pepper (*Capsicum annuum* cv. Lamuyo). Thus, comparisons between biochemical indicators determined at standard conditions against those indicators induced with a given nutrient, as catalase and peroxidase with Fe and Mn, as well as ascorbic acid oxidase with Cu, revealed hidden insufficiency situations.

Coluccia *et al.* (2004) used a rapid and reliable method for the determination of Sudan colourings in food products containing hot pepper is described. HPLC/MS/MS analysis was used on the samples after extraction from the food matrix using acetonitrile and reported higher accuracy with HPLC method for capsaicin estimation.

2.3 Seed quality attributes as influenced by capsaicin and oleoresin during storage

2.3.1 Hot pepper quality attributes and seed quality parameters during storage

Barton (1953) reported that high viability of low moisture content vegetable, flower and tree seeds was maintained during two years of sealed storage at -4 °C.

Martin *et al.* (1960) reported that okra seeds having 12 per cent moisture content gave 90 per cent germination after storing for 11 years in sealed glass jar at 2 to 4 °C.

Seed borne pathogens play an important role in deterioration of seeds. Christensen and Kaufman (1969) divided the fungi invading seeds into two groups *i.e.* field fungi and

storage fungi. These fungal pathogens can be a major cause of quality losses in seed storage.

Pillayarsamy *et al.* (1973) reported that hot pepper seeds of cv. K-1 treated with thiram @ 2 g kg⁻¹ and stored in plastic containers produced superior germination over the control during storage.

Dhawale and Kodmelwar (1978) reported that seed germination decreased with length of storage due to invasion of storage fungi (*Colletotrichum capsici*) in capsicum.

Aspergillus glaucas, *Aspergillus Condidus* and *Pencillium* spp are important storage fungi on tomato seeds and were found to accelerate the rate of deterioration (Kononkov and Dudina, 1986).

Doijode (1990) observed that seed moisture plays an important role in germination and seed longevity. Seed moisture is to be satisfactory and at safe level before put for storing the seed material.

Anujagupta *et al.* (1994) revealed that the chilli seeds of Cv Pusa Jwala treated with fungicides and stored in cloth bag and tin container. The viability lost within 10 months when the seeds stored in cloth bag. Whereas seeds stored in tin container retained viability up to 19 months. Seeds treated with fungicides like thiram, captan, bavistin and dithane M-45 and stored in cloth bag maintained viability more than 10 months above prescribed standard. Only Thiram treated seeds and stored in tin container maintained 73 per cent germination after 19 months of storage.

Thaigarajan (1994) observed that hot pepper seeds dried to a moisture content of 8 per cent recorded 73 per cent germination after 30 months storage, seed germination decreased as storage prolonged.

Values of EC measured in seed soaking solutions are directly related to the cellular membrane integrity. Disorganized membranes affected by insects, mechanical

injury and/or long storage periods, are usually associated with seed deterioration processes and consequently to lower seed vigour (Bewley and Black, 1994).

Angamuthu (1996) observed that superiority of paddy seeds stored in polythene bag for seed quality parameters was due to slow rate of deterioration, as the polythene bags are moisture impervious, which might not have allowed the movement of moisture from the environment and hence not allowing the seeds to deteriorate at faster rate.

Ochi *et al.* (2003) isolated a new non pungent capsaicin derivative, 6",7"-dihydro-5',5""-dicapsaicin (1), and a known capsaicin metabolite, omega-hydroxycapsaicin (2) from the fruit of *Capsicum annuum*. Their structures were established on the basis of spectroscopic evidence and revealed that 6", 7"-dihydro-5', 5""-dicapsaicin and revealed that it has the nearly same antioxidant activity as capsaicin.

Topuz and Ozdemir (2003) studied the effects of drying methods, gamma-irradiation, and storage on the carotenoids (capsanthin, capsorubin, zeaxanthin, capsolutein, violaxanthin, beta-carotene, and beta-cryptoxanthin) of paprika by reverse phase HPLC. Sun-dried and dehydrated paprika samples were irradiated in a (60) Co gamma-irradiator at five doses (0, 2.5, 5.0, 7.5, and 10 kGy) in polyethylene bags and stored for 10 months at ambient temperature. Higher irradiation doses and a longer storage period resulted in a significant reduction of all the carotenoids, except capsorubin. The decrease of red carotenoids, for all irradiation treatments, was less than that of the storage period. Even the highest irradiation dose, 10 kGy, caused a 11.1 (%) capsanthin reduction; however, 10 months of storage at the ambient temperature caused a 42.1 (%) reduction of capsanthin. The most significant pigment reduction was realized in the processing and storage conditions of paprika, rather than in the irradiation process.

Vijayalakshmi *et al.* (2003) studied mycoflora associated with seeds of hot pepper (*Capsicum annuum*) cv. Sindhur and the effects of *Aspergillus flavus* and *A. niger* on the seed germination and mitotic cell division in hot pepper and pearl millet. The mycoflora associated with the hot pepper seeds include *Alternaria alternata*, *Aspergillus candidus*, *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus tamarii*, *Aspergillus terreus*, *Curvularia*

lunata [*Cochliobolus lunatus*], *Drechslera rostrata* [*Setosphaeria rostrata*], *Fusarium oxysporum*, *Rhizopus nigricans* [*Rhizopus stolonifer*] and *Trichothecium roseum*. Seed germination was inhibited by *Aspergillus flavus* and *Aspergillus niger*.

Aleksandra and Biserka (2004) studied the powders of pepper stored at ambient temperature, exposed to daylight. The final quality was evaluated by measuring the extractable colour by the American Spice Trade Association (ASTA). Also, the possibility of using surface colour measurement, as a supplement to extractable colour measurement was investigated. The use of the chromatic attributes L, a and b, suggested by CIELAB, made it possible to find the correlation between ASTA and apparent colour of paprika.

Ute Schweiggert *et al.* (2006) studied changes in capsaicinoid contents of hot pepper powders after thermal treatment and during storage of major pungent principles capsaicin, dihydrocapsaicin and nordihydrocapsaicin. Heating and drying resulted in (21.7 to 28.3) degradation of the initial capsaicinoid content, the three major capsaicinoids showing similar heat susceptibility. During storage at ambient temperature over 6 months with and with out illumination, further degradation of the pungent principles by 6.8-11.9 (%) was observed. Since residual enzyme activities were assumed to cause capsaicinoid losses, soluble peroxidase (POD) activity was investigated. It was shown that immediate thermal treatment of the plant material did not result in a complete POD inactivation even under rigorous temperature-time regimes. In contrast, a regeneration of about 30 % of initial POD activity was found in those samples which were first blanched at 80°C for 5 and 10 min and then minced. However, no correlation between POD activity and capsaicinoid losses could be established.

Ravi Hunje *et al.* (2007a) conducted experiment to study the seed storability of Byadagi kaddi hot pepper and Dyavanur local variety. Among the halogen treatments, seeds treated with potassium iodide (10⁻³ M) concentration and calcium chloride (4g kg⁻¹ of seed) recorded significantly maximum seed germination (71.66 and 70.00 %), field emergence (60.34 and 59.46 %), root length (5.92 and 7.00 cm), shoot length (5.00 and

4.82 cm), vigour index (784 and 832) and lower electrical conductivity of seed leachate (2.136 and 2.179 dSm⁻¹) at the end of 20 months storage period.

Venkatasubramanian and Umarani (2007) conducted storage studies to compare four different methods of priming viz., hydropriming, halopriming, sand matricpriming and osmopriming accomplished for two durations. The results revealed that viability of primed seeds were dependent on the method as well as duration of priming however; irrespective of method and duration all the priming methods were superior to untreated seeds through out the storage period.

Jerlin *et al.* (2008) studied storability of seeds of hot pepper [*Capsicum* sp.] pelleted and packed in cloth bag, 400-gauge polythene bag and aluminium foil bag. And evaluated for 100-seed weight, number of days to emergence, germination percentage, seedling length and vigour index, and they reported that, aluminium foil bag registered the highest values for the seed quality characters, followed by the 400-gauge polythene bag and cloth bag.

Manjunatha *et al.* (2008) studied the effect of seed coating with polymer, fungicide and container on seed quality of hot pepper cv. Byadgi Kaddi during storage. Among the different treatment combinations, they recorded significantly higher germination and field emergence with 2.0 g thiram kg⁻¹ seed bed treatment compared to the control at the end of 12 months of storage. Seedling length and vigour index of hot pepper were significantly higher in seeds coated with thiram. Among the seed treatments, significantly lower electrical conductivity of seed leachate (2.023 dSm⁻¹) was recorded in seeds treated with thiram at the end of 12 months of storage. They also reported the presence of fungi *Aspergillus*, *Penicillium*, *Rhizopus*, *Colletotrichum* and *Alternaria* spp during storage. The seed treatments, significantly lowered seed infection by (8.01 %) in the seeds coated with thiram to untreated control (9.99 %).

Umajyothi *et al.* (2008) studied the effects of storage conditions and post harvest chemical treatments on the germination and vigour index of hot pepper (*Capsicum*) cv. LCA 334. However, the germination percentage of seeds treated with chemicals and

stored recorded a gradual decline during storage. They recorded higher seed germination (70 %) and seed germination loss (9.09 %) with sodium chloride (2 %) and stored in cold storage showed extended viability up to the end of the storage period (9 months). The seeds obtained from fruits that had been treated with sodium chloride (2 %) recorded lower germination (55.13 %). However, they also reported that, seeds after treatment with chemicals and kept under cold storage were superior to seeds stored under ambient conditions.

Kavitha *et al.* (2009) conducted storage experiment under the ambient (25 degrees C and 70 % RH) and cold conditions (4 degrees C and 50 % RH) for a period of ten months (July 2006-May 2007) of hot pepper seeds cv. Byadagi Dabbi pelleted with botanicals, chemicals in comparison with unpelleted seeds as control and stored in 700 gauge polythene bags. Seeds pelleted with captan (3 g kg⁻¹) + imidachloprid (2g kg⁻¹) stored in cold condition recorded higher germination (80.3 %), root length (8.26 cm), shoot length (4.66 cm), vigour index (1033), seedling dry weight (0.172 g) and lower EC (0.845 dSm⁻¹) followed by seeds pelleted with neem leaf powder at the end of the 10th month of storage period.

Khayatnezhad (2010) studied the effects of PEG stress on corn cultivars (*Zea mays* L.) at germination stage and revealed the most effective levels in reducing physiological characters due to increased sensitivity of genotype to ageing process. Thus, affecting metabolism in terms hydrolysis of stored products which are utilized for cell expansion, seedling tissue synthesis, radicle and plumule elongation.

Qumer Iqbal *et al.* (2011) studied total mold counts and *Aspergillus* during storage of hot pepper fruits and reported that *Aspergillus* counts increased with storage duration, but all counts were significantly lower in peppers stored in polyethylene bags. A gradual increase in temperature during prolonged storage of hot peppers in combination with aeration may be the main reasons for increases in fungal biomass and *Aspergillus* proliferation with the subsequent aflatoxin production.

Samira *et al.* (2013) noticed significant ($P < 0.05$) differences among cultivars of five green hot pepper varieties for pungency with storage conditions and reported changes in quality of pepper. Storage at ambient conditions resulted in high weight loss and rapid deterioration in chemical composition. The highest and lowest moisture contents were recorded in Melka Eshet and PBC 600, respectively. The highest pungency level was observed in ambient storage environment.

Deepa *et al.* (2013) carried out studies were to find out the influence of vacuum packaging on physical parameters of whole hot pepper and biochemical constituents in hot pepper seeds. Hot pepper fruits were stored in vacuum packed and jute bags stored at room temperature ($25 \pm 2^\circ\text{C}$), cold storage ($4 \pm 1^\circ\text{C}$) under both light and dark conditions for a period of 24 months. At the end of the storage period, seeds were separated from fruits and various parameters viz., moisture content, capsaicin content, ascorbic acid, carbohydrates, protein and mineral elements like Fe, P, Na and K were analyzed. It was observed that the samples stored in vacuum packed bags maintained the quality with least deterioration in all the quality parameters compared to samples stored in jute bags.

Caixeta *et al.* (2014) aimed to assess the dormancy of hot peppers in three maturity stages during storage, in order to determine the best point of reaping and sowing and also enzymatic changes during the process of seed germination processed in different stages of maturation during storage. They revealed that dormancy in seeds of hot peppers especially when newly stored and is surmounted by four months of storage. Enzyme changes are evident in the germination process and the different stages of maturation during storage.

Mahadev *et al.* (2014) studied the influence of vacuum packaging and long term storage on quality in chilli fruits stored in vacuum packs and jute bags at two moisture levels (10 and 12 %) in room and cold storage under both light and dark conditions for a period of 24 months. It was observed that the vacuum packed hot peppers under cold storage were found to have the least per cent decline in various quality parameters. Hot peppers with 12 per cent moisture and stored in vacuum packaged bags recorded better quality parameters over 10 per cent moisture.

Panayotov and Aladjadjiyan (2014) investigated the changes in viability and thermodynamic parameters of peppers seeds during storage under ambient (uncontrolled) conditions for 132 months. They found that the viability potential deteriorated more rapidly after 4-5 years of storage. Thermodynamic parameters differential enthalpy and entropy, and free energy decreased with decline of germination. Therefore these parameters can be used as means for better understanding of ageing processes and this is of great importance in prediction of the deterioration of pepper seeds during long-term storage.

Ramya Addala *et al.* (2015) determined the effect of storage conditions on rate of colour degradation of paprika based products. The study was conducted on seven paprika, three hot and two hot peppers powder up to six months at four different storage conditions. Results showed that samples with ethoxyquin shown lower extractable colour loss than samples without ethoxyquin. Further, samples that had been irradiated shown higher surface colour loss than samples that had not been irradiated. Samples stored at high temperature-humidity degraded rapidly compared to samples stored in room conditions. Refrigerated and freezer stored samples showed minimal extractable and visual colour loss.

Qumer Iqbal *et al.* (2015) studied the effects of different temperatures, packaging materials and storage time on the stability of capsaicinoids and antioxidants viz., total carotenoids, ascorbic acid and total phenolic compounds in dry whole pods packed in jute bags and low density polyethylene bags (LDPE), stored for five months under controlled conditions at 20, 25 or 30°C. They reported significant differences with respect to their capsaicinoids and antioxidant concentrations, and with the increase in storage temperature and time, a gradual and steady decrease in these levels. Overall, mean concentrations after five months reduced by 22.6 %, ascorbic acid, 19 % for phenolic compounds, 17 % for carotenoids and 12.7 % for capsaicinoids.

2.3.2 Effect of seed storage on seed quality parameters

From the physical appearance it is impossible to test whether a seed is viable and vigorous, unless it is allowed to germinate in favorable conditions. Seed vigour is also an

important parameter in assessing seed quality, particularly for raising the crop for seed production (Heydecker, 1969 and 1972, Woodstock, 1973).

Sen (1977) reported that loss in membrane permeability under unfavorable conditions of storage leading to increased leaching of seed constituents and thus loss in seed viability.

Seed ageing is known to cause appreciable changes in viability and genetic status of crops and is quite effective in producing large number of changes in the qualitative and quantitative characters (Purkar, 1980).

Viability of pepper seeds dropped to 59 per cent when stored in polythene bag and to zero per cent in cloth bag at the end of seven years of storage under ambient conditions (Popovska *et al.*, 1981).

The storage potential of seed is greatly affected by their quality at the time they enter seed storage or their pre-storage history. Seeds of a given lot, size, chronological age and germination level do not maintain viability equally well in storage under identical conditions (Vanagamudi, 1988). It is not clear what the critical factors are and by what mechanisms loss of viability occurs.

Verma *et al.* (1991) reported that cauliflower and tomato seeds stored in laminated bags recorded higher germination (65.3 and 67.6 %, respectively) compared to unsealed polythene bag (52 and 43 %, respectively) at the end of 11 months.

Saxena (1994) reported that stored vegetable seeds like onion, tomato, okra and cabbage at different moisture contents in different packing materials and reported that seeds with six to eight per cent moisture content could be stored for a longer period in polythene bags (700 gauge).

Fisher (1994) reported that the seeds of *Capsicum annuum* stored in sealed plastic flask and glass jar have maintained high germination even 20-22 years, while seed stored

in cloth bags showed marginal decrease in germination after three years at room temperature.

Doijode (1997) reported that storage of okra cv. Pusa Sawani seeds under ambient condition at Bengaluru and packaging in paper bag, polythene bag, glass and aluminum foil has retained the seed germination above the certification standard up to four years.

Sharma *et al.* (1998) observed the superiority of chilli seeds stored in aluminium foil and polythene bag for germination and field emergence was due to lower rate of deterioration as these containers are moisture impervious which did not allow movement of vapour form of moisture from the environment and thus seeds did not deteriorate at faster rate.

Kato Nogucgi and Tanaka (2003) reported capsaicin as an allelochemical, causing growth inhibition of roots and shoots of alfalfa, cress, lettuce, crabgrass, timothy and ryegrass besides suppressing their germination. Increasing the dose of capsaicin increased inhibition. Germination percentage was inhibited to 50 per cent at capsacin concentration of 82, 88, 68, 4.8, 3.2 and 11mM for alfalfa, cress, lettuce, crabgrass, timothy and ryegrass respectively. Suggesting that capsaicin may act as an allelochemical on other plants.

Padma and Muralimohan Reddy (2004) dried the fresh seeds of okra cv. Parbani Kranti to 10 and 7.14 per cent seed moisture and stored in cloth bag, poly pouch, cikatainer, polythene bag and aluminum foil pouch under ambient conditions. The seeds with 10 and 7.14 per cent seed moisture could be stored for 22 and 32 months in cloth bag respectively. The same seed could be stored in cikatainer and poly pouch for 30 and 32 months, respectively and up to 50 months in polythene bag and aluminum foil pouch.

Sandhya and Singh (2004) carried out experiment on storage of peas (variety Pb-87) with the objective to enhance their shelf life. The shelf life of shelled peas packaged in high-density polyethylene was 4, 7, 17 and 45 days, when stored at the temperatures of ambient, 15, 5 and -11°C, respectively. Among organoleptic characteristics, loss of protein content was higher in pervious bag which could be mainly attributed to property

of protein chains forming loose mesh when the moisture content is more and upon loss in moisture content they become disorganized.

Natesh *et al.* (2005) conducted an experiment to determine the suitable growth regulator and their concentration for increasing seed yield and quality of hot pepper [*Capsicum annuum*] cv. Byadagi Kaddi. A higher seed yield per plant and per ha was recorded with GA₃ at 100 ppm (11.95 g and 195.5 kg), followed by GA₃ at 50 ppm (9.71 g and 189.7 kg) and NAA at 20 ppm (7.27 g and 190.6 kg, respectively), with better quality seeds, compared to other treatments.

Ravi Hunje *et al.* (2007b) reported that chilli seeds stored for 20 months in sealed aluminium foil recorded significantly higher seed germination (82.83%), field emergence (76.67%), root length (6.85cm), shoot length (6.38cm), vigour index (1076) and lower seed leachate values (1.579 dSm⁻¹) followed by the seeds stored in 700 gauge polythene bag compared to the seeds stored in fruit form, cloth bag, paper bag and polythene bag (400 gauge) throughout the storage period. The storing of seeds in fruit form also recorded higher seed quality parameters at the end of storage period.

Zhang Zhen *et al.* (2008) studied the changes in capsaicin, flavonoid, free phenolic content, and PAL, CS and POD activities during development of hot pepper (*Capsicum annuum* L.) in fruit. They established that during fruit development, capsaicin content increased and reached a maximum at day 50 after flowering, but decreased later. Maximal levels of free phenolics and flavonoids were observed during the early stage of development, after wards their contents decreased with fruit ripening. From 22 to 60 days after flowering, PAL activity increased rapidly during 29 to 36 days after flowering reaching a peak at day 36 after flowering, CS activity remained at very low values during the first 15 days after flowering, then increased, and followed by a sharp increase to attain a maximum in both in placenta and pericarp at day 36 after flowering, before decreasing during the later developmental stages. The POD activity decreased with fruit development, but the activity increased during 50-60 days after flowering.

Koraddi and Sumangala (2008) studied effect of different packing materials and revealed that the mean sensory evaluation index (SEI) score was highest in polyethylene (55.77) followed by LDPE bag (53.32) and plastic container (50.82). Plastic container is suitable for fenugreek, hot pepperes, beans, carrot and tomato while polyethylene bag for coriander and for cucumber and LDPE bag for lady's finger.

Pugliese *et al.* (2014) conducted an experiment to determine the carotenoid content of 20 varieties of red, orange or yellow coloured sun-dried hot pepper belonging to four *Capsicum* species (*C. annuum*, *C. baccatum*, *C. chinense* and *C. chacoense*). They revealed that, red peppers had a higher carotenoid content and bioaccessibility than either the orange or yellow pepper. *Xanthophylls* showed greater bioaccessibility than carotenes. They confirmed that dried hot pepper are a good source of carotenoids and excellent source of antioxidants as they are rich in bioactive phytochemicals such as carotenoids.

Nguyen and Minh (2014) revealed that, cooling preservation and packaging maintains the colour appearance and reduce cayenne pepper weight loss is more effective at normal room temperature. The cost of applying this technique is relatively low. This simple technique is easy to apply at the household and small-scale production in the rural area of Tra Vinh province (Vietnam), and steady improvement of living conditions of the local level.

2.3.3 Oleoresin

Cooper *et al.* (1991) capsaicin, the pungent ingredient in many varieties of *Capsicums* has recently been implicated as a possible carcinogen and reported mutagenicity data for 1b and an extract of red pepper as measured by the Ames assay and the V-79 mammalian cell assay. And observed that 1b is always accompanied by a number of related homologues when obtained from natural sources. They isolated seven of these homologues, characterized and synthesized by a general and unique route developed.

An analogue of capsaicin, dimethoxybenzylmethyloctamide (DMBMO), was synthesized for use as an internal standard and used for quantification of capsaicin, nordihydrocapsaicin, and dihydrocapsaicin. This novel internal standard has a retention time between that of capsaicin and dihydrocapsaicin and is nonpungent. A pre-collaborative test was used to check the robustness of the procedure for variations in instrumentation by using HPLC (Thomas *et al.* 1991).

Hundal *et al.* (2003) conducted an experiment to evaluate 17 parents and 42 hybrids of hot pepper (*C. annuum*) for oleoresin and related traits. The highest dry matter content was recorded for MS 12 × Punjab Lal (35.6 %). Punjab Lal recorded the highest capsaicin concentration in powder (0.7 %) and capsaicin level in oleoresin (3.05 %), while S 2529 exhibited the maximum colouring matter in powder (185.18 ASTA units) and colouring matter in oleoresin (883.86 ASTA units). The oleoresin content was highest in MS 12 × 2529 (17.06%).

Liljana *et al.* (2013) assessed the possibilities of utilization of *Capsicum annuum* ssp. *Microcarpum* L. for extracting capsaicin and its use as a biopesticide against the green peach aphid *Myzus persicae* sulz. in pepper culture are summarized. The content of capsaicin was evaluated spectrophotometrically, and the ability of capsaicin for acting as biopesticide was calculated according to Abbott. Results showed that oleoresin from *Capsicum annuum* ssp. *microcarpum* L. and its dilution 1:20 are the most efficient as a biopesticide. From these results we can say that this kind of peppers can be used as a raw material for extraction of capsaicin, because of its high concentration and efficiency.

2.3.4 ASTA colour units

Perva *et al.* (2004) studied colour intensities of residue material and extracts of hot pepper variety Byedige as given by ASTA (American Spice Trade Association) and CU (Colour Unit) value, respectively. The highest extraction yield for total solids of 12.8 (%) was obtained at 400 bar and 40 degrees C, where almost 96 (%) of capsaicinoids and 80 (%) of colour components were removed from the raw material. The highest CU value of hot pepper extract, obtained by a single step extraction at 40 degrees C and 400 bar, was approximately 15,000 CU. Calculated mass transfer coefficients of hot pepper

extract from solid material varied from 2×10^{-7} to $11 \times 10^{-7} \text{ m s}^{-1}$ in the pressure range of 100-400 bar and temperature range 40-80 °C.

Eissa *et al.* (2007) analyzed pasteurized hot pepper samples for the contents of capsaicin. Capsaicin was highest in the fresh hot green ($226.2 \text{ mg } 100 \text{ g}^{-1}$) and red coloured ($175.7 \text{ mg } 100 \text{ g}^{-1}$) compared with the respective figures obtained with the sweet peppers. The superior level of capsaicin in the hot pepper varieties was maintained after acid-brining in the pasteurized purees. Brining in the presence of acetic acid (0.25 - 0.7 %) resulted in the highest scoring compared with respective scores obtained with the other treatments.

Alfonso *et al.* (2012) investigated phenolic compounds, carotenoids content (red and yellow), extractable colour (total pigments) and antioxidant activity in fruits from Chiltepin and Habanero pepper. The Habanero pepper had significantly had higher total phenolic content ($5.92 \pm 0.47 \text{ mg/g GAE}$) than the Chiltepin pepper ($4.85 \pm 0.23 \text{ mg/g GAE}$). On the other hand, the highest content of total antioxidant activity was found in Chiltepin hot peppers ($11.10 \pm 1.6 \text{ mg of GAE /g of dry weight}$). In contrast, Habanero hot peppers showed the lowest values of total antioxidant activity. In this way, the Habanero hot pepper has the lowest content ($14 \text{ mg g}^{-1} \text{ dry weight}$) of carotenoids (yellow isochromic fraction) while the Chiltepin hot pepper had higher levels of yellow isochromic fraction ($36 \text{ mg g}^{-1} \text{ dry weigh}$). Finally, the Chiltepin showed the highest value of extractable colour (80 ASTA units) than Habanero (40 ASTA units).

Vijaya Bhaskara and Sasikalap (2013) examined twelve different hot pepper varieties at three different stages green, red ripe and red dry for the estimation and extraction of capsaicin and colour. The hot pepper sample which has the highest pungency was subjected for the extraction of capsaicin. From the pericarp of the hot pepper the colour was extracted and the higher colour intensity was found according to the ASTA (American Spice Trade Association) and CU (Colour Units).

Naima Zaki *et al.* (2013) analysed quality parameters of paprika powder (*Capsicum annum* L.) collected from three localities in Morocco from three localities

for colour, total capsaicinoids, total carotenoid, fat content and fatty acid composition. The oil contents of paprika powder among localities varied relatively from 7.55 g to 8.67 g per 100 g. The main fatty acids oils were linoleic acid (60.1 - 0.9 %), oleic acid (12.1-16.1 %) and palmitic acid (7.7-14.5 %). Remarkable amounts of capsaicinoids were found in the different locations, with a maximum obtained for Elkalaa des Sraghna paprika (184.97 mg kg⁻¹). Total carotenoid content values averaged from 2323.66 to 3025.05 mg kg⁻¹ dry weight with the high content obtained for the Tadla paprika. The ASTA Values differ significantly between the three localities; the high value of ASTA 20 was obtained for Tadla paprika.

Velazquez *et al.* (2014) studied quality parameters of smoked, oven-dried and sun-dried paprikas. Sun-dried paprikas showed the highest (American Spice Trade Association, ASTA) pigment concentrations, whereas oven-dried paprikas showed the best browning index and red/yellow pigment ratio, and sun-dried paprikas had the highest redness for reflected colour. The colour stability results showed drastic colour change and decreased redness and ASTA units of the sun-dried and oven-dried paprikas after two and five days of UV exposure. Degradation of the smoked paprika colour parameters was progressive, and they showed less degradation even after 30 days. The evaluation of the antioxidant activity showed higher DPPH radical scavenging capacity in the smoked samples. The profiles of volatile phenolic compounds of the smoked samples are responsible for the differences in the antioxidant capacity.

2.3.5 Antioxidant activite in hot pepper

Axel *et al.* (1996) evaluated the widely used TBA assay for lipid peroxidation to minimize artefactual oxidative degradation of lipids during the assay. Formation of the TBA-MDA condensation product was studied with and without exclusion of oxygen, and the concentration effect of BHT addition was examined. Oxygen was depleted from the reaction mixture by extensive argon gassing. Exclusion of oxygen resulted in decreased TBARS production in plasma but not in standard solutions. High BHT concentrations resulted in a similar effect.

Zulfugarov *et al.* (2011) assessed the reduction of molecular oxygen or water oxidation, Reactive Oxygen Species (ROS) produced by a variety of enzymes and redox reactions in almost every compartment of the plant cell. In addition to causing cellular damage, these ROS play a role in signaling networks. Many factors contribute and simultaneously control their metabolism, and opined it is difficult to detect individual ROS accurately. As several challenges inherent to ROS their relatively short half lives, low intracellular concentrations, enzymatic and non-enzymatic scavenging capacity of the cells, and the absence of absolutely selective probes for ROS.

Małgorzata Materska (2012) examined the phenolic compound fractions (PCF) from hot pepper and characterised their composition and antiradical activity from fruits of hot pepper *Capsicum annuum*. Total phenolics content was assessed by Folin-Ciocalteu method. Antioxidant activity was measured according to superoxide radical, generated in NADH/PMS model and DPPH radical. The separation yielded three subfractions with different composition. In fraction 1, the predominant component was quercetin 3-O-rhamnoside-7-O-glucoside. The presence of luteolin 7-O-apiosyl-glucoside was observed in fraction 2, and the key component of fraction 3 was quercetin 3-O-rhamnoside. The highest antioxidant activity was noted for fraction 2, both in reducing superoxide radicals ($IC_{50}=97 \mu g cm^{-3}$) and $DPPH^+$ ($IC_{50}=43 \mu g cm^{-3}$).

2.4 Efficacy of seed treatments to control seed borne anthracnose

2.4.1 Effect of seed borne anthracnose on seed quality in hot pepper

Siddiqui *et al.* (1974) have identified and detected seed borne fungi in hot pepper, brinjal, tomato bhendi, radish, carrot and onion. The important fungi observed were *Alternaria tenuis*, *Aspergillus sp.*, *Cladosporium cladosporioides*, *Colletotrichum capsici*, *Curvularia lunata*, *Pencillium sp.* and *Phoma sp. etc.*

Thind and Jhooty (1985) reported that losses due to anthracnose of chilli varied between 66-84 per cent. The market value and nutritive value is degraded in infected fruits resulting in poor quality seed.

Perane and Joi (1988) studied seed borne infection of fruit rot and dieback of chillies. They reported that, the disease is both seed borne and air borne and affects seed germination and vigour to a greater extent.

Asalmol *et al.* (2001) noticed fruit rot upto 32 per cent and dieback upto 29 per cent have been noticed. Seedling decay and seed rot upto 21 per cent were recorded in chilli.

Solanke *et al.* (2001) reported that *Colletotrichum capsici*, *Curvularia lunata*, *Aspergillus flavus*, *Fusarium moniliforme*, and *Rhizopus stolonifer* were found to be associated with the untreated seeds of chilli which significantly reduced germination.

Kulkarni *et al.* (2005) conducted an experiment to determine the effects of chemical seed treatments and pelleting on the viability of hot pepper (cv. Jwala) seeds. The dried hot pepper (cv. Jwala) seeds were treated with bavistin [carbendazim] at 2 g kg⁻¹ seeds, quintal at 2 g kg⁻¹ seeds, gauchho [imidacloprid] at 5 g kg⁻¹ seeds. These treated seeds were pelleted with maida and another set was pelleted with plaster of paris and the above mentioned chemicals. The results indicated the superiority of maida + goucho seed pelleting compared to all other treatments for different parameters such as seed germination (63.8 %), shoot length (4.45 cm), root length (8.62 cm), vigour index (859) and dry weight of seedlings (4.37 g).

Padghan and Belge (2009) reported that, *Colletotrichum dematium* was found to reduce the germination of almost all test cultivars of hot pepper (*Capsicum annuum*). Among them, G-4 was reported as the least susceptible, with germination and mortality values of 76 (%) and 32 (%), respectively. Seed treatment with the fungicide combination of TMTD [thiram] + carbendazim (0.2 % and 0.1 %) increased the germination up to 86 (%) and reduced the total mortality to 14 %. Metalaxyl recorded the least efficacy against the pathogen with 75 % germination and 25 % mortality. Among the bioagents, maximum germination and minimum total mortality was found in *Trichoderma viridae*, while minimum germination and maximum mortality rate was recorded with *Pseudomonas fleuroscens* compared to the absolute control.

Uzma and Hasan (2011) isolated 19 genera and 38 species of fungi by using standard blotter and deep freezing method from hot pepper seeds. *Aspergillus flavus*, *A. niger*, *A. fumigatus*, *Alternaria alternata*, *Drechslera hawaiiensis*, *Fusarium moniliformae*, *F. oxysporum* and *F. solani* were more frequently isolated. Seed treatment with fungicide ridomyl gold @ 0.15 & 0.25 (%) inhibited the growth of all fungi whereas asafetida and nigella sativa powder @ 0.25 (%) were found to be more effective however showed little fungicidal activity toward *Fusarium moniliformae*.

Choudhary *et al.* (2013) studied the efficacy of various chemical and biocidal agents on the germination and seedling vigour of *C. capsici* infected hot pepper seeds. Among different seed treatments, Thiram, Captan and Bavistin were found superior and significantly higher seed germination as compared to other treatments and control. Among different bioagents used seed germination (82.35 %) was recorded in seed treated with *T. viridae*. Bavistin was most effective with 93 per cent (68 % in control) seed germination with no pre or post emergence mortality and increased seedling vigour index of 506.85 which was 306 in control.

Chauhan *et al.* (2014) studied the efficacy of different plant extracts, systemic, non-systemic and compound (systemic + non-systemic) fungicides tested as seed treatment against pathogenic isolate I-13 (*C. capsici*) under in vivo condition. Among the four effective ephyto-extracts, *Datura stramonium* extract seed treatment @ 10 ml/kg seed gave maximum seed germination (85.28 %), reduced pre-and post-emergence mortality (14.59 % and 9.64 %, respectively) and highest root (11.57 cm) and shoot length (9.27 cm) under in vivo condition. Among eight different systemic, non-systemic and compound fungicides, carbendazim seed treatment @ 2 g kg⁻¹ seed gave maximum seed germination (90.10 %), reduced pre-and post-emergence mortality (9.96 % and 2.72 %, respectively) and increased root (13.77 cm) and shoot length (21.03 cm) followed by mancozeb @ 3 g⁻¹ kg seed and carbendazim + mancozeb @ 2.5 g⁻¹ kg seed.

Alam *et al.* (2014) studied the bio-fungicide as seed treating agents and results of seed health testing showed that, five different seed borne fungi viz. *Colletotrichum capsici*, *Curvularia lunata*, *Rhizopus stolonifer*, *Aspergillus flavus* and *Fusarium*

moniliformae were found to be associated with hot peppers seed samples. Among these fungi, *Curvularia lunata* was the most prevalent followed by *Rhizopus stolonifer*, *Colletotrichum capsici*, *Fusarium moniliformae* and *Aspergillus flavus*. The highest percentage of germination (93.33 %) was recorded when the seeds were treated with BAU Bio-fungicide, whereas the lowest percentage of germination (61.33 %) was recorded in untreated seeds. The highest percentage of healthy seedling (95.33 %) was recorded when the seeds were treated with BAU Bio-fungicide and allamonda leaf extracts, whereas the lowest percentage of healthy seedling (59.00 %) was recorded in case of untreated seeds. The highest vigour index (681.59) was recorded when the seeds were treated with neem leaf extracts, whereas the lowest vigour index (214.66) was recorded in case of untreated seeds

Santosh Reddy *et al.* (2014) studied that the seed borne nature of fungi by standard blotter method which revealed the presence of *Colletotrichum capsici*, *C. gloeosporioides* and *C. acutatum* also *Alternaria alternata*, *Fusarium sporotrichioides* and *F. oxysporum*. Seed treatment with eleven chemical fungicides and four bio fungicides in different combinations tested in nursery which revealed that carboxin 37.5 % + thiram 37.5 % WS (Vitavax power) @ 0.2 % and metalaxyl 4 % + mancozeb 64 % WP (Ridomil gold) @ 0.2 % showed least infection (7.25 % and 10.09 %) with highest seedling vigour index (932.02 and 871.70). Among four bio fungicides tested alone and in combination @ 10g kg⁻¹ seed treatment, combination of *Trichoderma harzianum* + *Pseudomonas fluorescens* and *P. fluorescens* alone showed least seedling infection (14.89 % and 14.94 %) with highest vigour index (930.74 and 915.27) compared to untreated control (351.77).

2.4.2 Effect of seed treatment on seed quality parameters in hot pepper.

Mutuswamy *et al.* (1983) reported that hot pepper seeds treated with captan @ 4 g kg⁻¹, sulphur dust @ 4 g kg⁻¹, bavistin @ 2 g kg⁻¹ carboxin @ 2 g kg⁻¹ and benlate @ 4 g kg⁻¹ of seeds controlled seed borne fungi effectively besides improving germination percentage. Out of different fungicides tried, seed treatment with captan was found to be the best.

Ramakrishna and Vaprakasam (1994) reported that hot pepper seeds cv. Co-1 treated with thiram or captan @ 0.4 per cent improved the germination percentage and vigour index.

Prasanna and Lennard (2001) observed that seed treatment with thiram, captan and iprodione substantially reduced *Alternaria* infection in brassica seed and hot water treatment at 55 °C for 15 min gave complete control of *A. brassicae* and *A. brassicicola* seed infection.

Ramesh and Prasanna (2001) reported that cauliflower seeds soaked in fungicides solution at 40-50 °C for 10-20 minutes completely eliminated seed infection of *Alternaria brassicicola* and improved seed germination.

Yenjerappa *et al.* (2002) evaluated the efficacy of 13 fungicides and two biological control agents against fruit rot of hot pepper (caused by *Colletotrichum capsici*). Hexaconazole recorded the least disease incidence followed by benomyl, ziram and propiconazole. These fungicides were on par with each other and showed significantly superior efficacy to other fungicides and biological control agents. The two biological control agents were found ineffective, recording higher fruit rot incidence. The most commonly used fungicides, such as wettable sulfur (40.12 %), carbendazim (37.10 %), penconazole (36.40 %) and copper oxychloride (35.71 %) were not effective against the fruit rot.

Tamil Vajnan *et al.* (2004) studied efficacy of *Trichoderma viridae* and *T. harzianum* against 9 isolates of *Colletotrichum capsici*, collected from fresh red pepper (*Capsicum annum* var. *longum*) fruits showing characteristic symptoms of fruit rot disease from different locations in Haryana, India, and assayed by the dual plate technique using oat meal agar medium. The degree of inhibition of *Colletotrichum capsici* isolates by *T. viridae* was significantly higher than *T. harzianum*. Isolates CC-2 and CC-7 were most sensitive to *T. viridae*, while isolate CC-3 was most sensitive to *T. harzianum*.

Pratibha Sharma *et al.* (2004) evaluated the three different pest management modules including biological, chemical and IPM based on the epidemiology of hot pepper die-back and fruit rot on two cultivars of hot pepper viz. Pusa sadabhar (local) and Navjyoti (Hybrid). IPM module was found superior to biological and chemical module for managing the disease by 63.98 and 68.66 (%) for die-back and fruit rot, respectively in Pusa sadabhar followed by chemical module with the disease control of 53.58 and 45.58 %, for die-back and fruit rot. The disease reduction was highest in IPM module followed by chemical module and biological but was significantly superior to control. In the variety Pusa sadabhar the percent disease control was higher than variety Navjyoti.

Rahman *et al.* (2004) determined efficacy of bion (0.005 %), azoxystrobin and carboxin in inducing systemic resistance to anthracnose (*Colletotrichum capsici*) in hot pepper (*Capsicum annuum*) cultivars Pabna and Mymensingh in a field experiment. Azoxystrobin and carboxin increased seed germination and effectively controlled seed borne fungi in hot pepper. All the tested chemical reduced seedling mortality compared to control. Die-back symptoms were not observed in bion treated seeds but was recorded in azoxystrobin and carboxin treated seeds. Lesion size, leaf infection and leaf area damage were less in plants grown from bion and azoxystrobin treated seeds.

Mesta *et al.* (2007b) observed the *Colletotrichum capsici* in all the samples with or without surface sterilization by 0.1 % HgCl₂. In some samples *Alternaria*, *Cercospora*, *Curvularia* and *Fusarium* were also detected. However, these fungi were eliminated by surface sterilization in majority of the seed and fruit samples. In vitro evaluation of fungicides revealed that captan (0.1 %) and thiram (0.1 %) were effective against *C. capsici*. All these fungicide were proved effective when tested in pots in glasshouse.

Anil Kasyap *et al.* (2008) assessed six fungicides viz. calixin (0.2 %), copper hydroxide (XL-77 and XL-57) (0.3 %), chlorothalonil (0.3 %) and mancozeb (0.3 %) to test their efficacy on growth, sporulation of *Colletotrichum capsici* and development of fruit rot of hot pepper *in-vitro* condition. Complete inhibition of mycelial growth of *C. capsici* was recorded by calixin, copper hydroxide (XL-77 and XL-57) and mancozeb. No sporulation of *C. capsici* was observed in calixin, copper hydroxide and mancozeb,

whereas calixin, copper hydroxide (XL-77), copper hydroxide (XL-57) and mancozeb were highly effective to inhibit the disease development.

Raj and Christopher (2009) treated four cultivars of hot pepper infected by *Colletotrichum capsici* with bio-control agents and fungicides. *Pseudomonas fluorescens* and *Trichoderma harzianum* pure cultures 1×10^8 cfu g⁻¹ and their talcum based formulations (28×10^7 cfu g⁻¹ & 19×10^7 cfu g⁻¹) 5 g kg⁻¹ and 10 g kg⁻¹ of seeds were used, respectively. The treated seeds were evaluated for per cent reduction of *C. capsici*, seed germination and vigour index. It was found that the pure culture of *P. fluorescens* was most effective in reducing *C. capsici* infection followed by *T. harzianum* than the fungicides treated and untreated seeds. Formulations of *P. fluorescens* were also effective in increasing the seed germination.

Belge and Padghan (2009) studied the effect of fungicide and bioagents against *Colletotrichum dematium* causing fruit rot of hot pepper (*Capsicum annuum* L). *Trichoderma viridae* inhibited maximum of 40.89 (%) growth of *C. demantium*, whereas *Pseudomonas fluorescence* restricted 38 (%) of mycelial growth. The treatment of TMTD showed maximum germination of 87.33 (%) and seedling vigour index of 1268.90. While highest SVI was recorded in Alliete as 1304.70 and germination of 85.33 (%). Among bioagents highest germination of 89 (%) and SVI of 1515 were found in treatment with *Trichoderma viridae* as compared to inoculated and uninoculated controls.

Theerthagiri and Ramanujam (2009) revealed that, antagonistic microorganisms *P. fluorescens* (2 %) were very effective in reducing the disease intensity (35.70 PDI). However, the leaf extracts and antagonistic organisms only ranked next to the fungicide (carbendazim @ 0.1 % with 18.05 PDI).

Islam *et al.* (2010) evaluated six fungicides and five plant extracts against anthracnose disease of hot pepper. The highest seed germination (80 %) was obtained from ginger extract and neem leaf extract treated seeds in the laboratory, while the germination was 78.8 (%) and 74 (%), respectively in the field. Application of Tilt 250

EC increased fruit yield of hot pepper by (195.9 %) followed by Proud 250 EC (177.5 %) and Bavistin 50 WP (159.5 %).

Marinus Ngullie *et al.* (2010) conducted experiment to control *Colletotrichum gloeosporioides* causal agent of anthracnose fruit rot disease in the Naga king hot pepper. In vitro studies indicated that *Trichoderma viridae* and *Pseudomonas fluorescens* were very effective in inhibiting mycelial growth of the pathogen. Field evaluation of effective plant extracts and antagonists and fungicide, revealed that spraying with *T. viridae* (2 %) showed a maximum disease reduction of 61.41 (%) followed by *P. fluorescens*, (58.10 %). However, the fungicide (bavistin 0.1 %) with 80.84 (%) disease reductions ranked first.

Kanse *et al.* (2011) conducted a study to evaluate the effects of biological control agents against anthracnose. The highest germination rate (77.75 %) was found in 0.15 % TMTD + 0.05 % carbendazim. The lowest mortality (1.87 %) was observed in *T. harzianum* + *P. fluorescens* at 20 DAS. *T. harzianum* + *P. fluorescens* increased the root and shoot lengths and the number of leaves at 35 DAS.

Ahiladevi and Prakasam (2013) studied the effect of azoxystrobin 25 SC at the rate of 100, 125, and 150g a.i ha⁻¹ along with other fungicides on anthracnose disease of hot pepper caused by *Colletotrichum capsici*. Maximum control of *C. capsici* (PDI of 4.44 and 2.78 on leaves and fruit respectively) was recorded with 150 g a.i.

Chigoziri and Ekefan (2013) investigated seed borne diseases of hot pepper (*Capsicum frutescens*) on naturally infected pepper seeds extracted from pepper fruits. Using agar plate method a total of 20 genera and 36 species from three classes of fungi were isolated and identified from 800 seed samples of pepper. *Colletotrichum capsici*, *Aspergillus niger* and *A. flavus* were the most frequently isolated fungi with 54.75 (%), 44 (%) and 29.75 (%) occurrence respectively. *Phoma* spp., *Humicola fuscoatra*, *Humicola dimorphospora*, *Bispora betulina*, *Phomopsis* spp., *Botryotrichum piluferum*, *Periconi abyssoides*, *Coniothyrium fuckelii*, *Fumago* spp., *Septonema chaetospora* and

Syncephalotrichum racemosum are being reported on pepper seeds for the first time in Benue State

Haq *et al.* (2013) conducted *in vitro* studies to evaluate the efficacy of different fungicides (dithane M-45, alliet, carbendazim, acrobit and antracol) against *C. capsici* at different concentrations. All fungicides exhibited differential effects in inhibiting the mycelial growth of *C. capsici*. Among these fungicides, carbendazim was the most effective in inhibiting the mycelial growth after 4, 8 and 12 days followed by acrobit, dithan M-45 and antracol and least effective fungicide was Allied.

Suwan and Lampang (2013) studied resistance to the carbendazim fungicides by measuring radial growth on the series of PDA plates amended with 0, 0.1, 1, 10, 100, 500 and 1000 $\mu\text{g ml}^{-1}$ of carbendazim. They revealed that, highly resistant (CarHR), one isolate was moderately resistant (CarMR), two isolates were susceptible (CarWR) and three isolates were sensitive (CarS). The *Colletotrichum* spp. isolates which expressed CarHR, CarWR, CarMR and CarS phenotype were proved and confirmed for pathogenicity on fruits of long cayenne pepper. In order to gain further information on pathogenicity test, the *C. gloeosporioides* isolate TPCMCg60 (CarHR) was exhibit very high virulence on pepper fruit.

Shiferaw *et al.* (2014) conducted a survey in seven districts of Southern Ethiopia to determine the occurrence, distribution and the status of hot pepper diseases in the region. Results indicated that 55 (%) of seed beds were infected by seedling diseases. The highest seedling infection (73 %) was recorded at Hawassa zuria district followed by Halaba, Lanfro and Dalocha districts (60, 56 and 54 %, respectively). Similarly survey results showed that 229 (75 %) of samples were infected atleast by one disease. The frequency of pathogen growth depicted that 30 (%) of the associated pathogens were different bacteria, while 21, 12, 9 and 3.0 (%) belong to the fungal genera *Fusarium*, *Colletotrichum*, *Cercospora* and *Alternaria* spp respectively.

Ananthi *et al.* (2014) revealed that, bio-priming with *T. viridae* at 60 % (w/v) for three hours gave the highest rate of germination (9.8), the germination percentage (93 %),

mean root length (80 mm), mean shoot length (63 mm), biomass production (4.3 mg seedling⁻¹), and seedling vigour index (1,330) compared to non-primed seed (SVI=855). *P. fluorescens* treatment at 60% (w/v) for 12 hour also increased the rate of germination (10.8), the germination (95%), mean root length (82 mm), mean shoot length (70 mm), biomass production (4.7 mg seedling⁻¹) and SVI (1,406) compared to non-primed seed (SVI=855). Seed bio-priming with 60% (w/v) preparations of *T. viride* or *P. fluorescens* for 3 h or 12 h, respectively, can therefore be adopted to improve seed germination and seedling vigour in hot pepper.

Meena *et al.* (2014) conducted in vitro studies to evaluate the efficacy botanicals and chemicals against *Alternaria solani* and *Fusarium solani* [*Haematonectria haematococca*] in hot pepper fruits. The minimum *Alternaria* rot incidence of 7.8, 8.0 and 8.1 in pre-inoculation treatment was recorded with carbendazim at 1000 ppm, cow urine at 1000 ppm and bitter temru at 1000 ppm; the control had 54 (%). During post-inoculation treatment, carbendazim at 1000 ppm had the lowest disease incidence of 9 (%), followed by cow urine at 1000 ppm (10.3 %) and bitter temru at 1000 ppm (10.4 %); the control had 56 (%) disease incidence. In the case of *Fusarium* rot, the minimum disease incidence in pre-inoculation treatment was recorded with carbendazim at 1000 ppm, cow urine at 1000 ppm and bitter temru at 1000 ppm (8.0, 8.1 and 8.2 %, respectively); the control had 55 (%).

2.5 Validation of DNA markers linked to pungency

2.5.1 Molecular markers in hot pepper

Huh *et al.* (2001) revealed that the colour of mature pepper fruit is determined by the composition of carotenoids. The fruit colour of red pepper is genetically determined by three loci, *y*, *c1*, and *c2*. The colour of the ripe fruit of TF68 is red and Habanero is orange. QTL analysis of the pigment content of F₂ individuals quantified by HPLC also indicated that phytoene synthase is the locus responsible for the development of fruit colour. The colour, pigment content and genetic behaviour of Habanero also suggest that phytoene synthase may be responsible for the *c2* gene discriminating between red and orange cultivars.

Choong *et al.* (2005) reported that capsaicinoid synthetase (CS) gene cosegregated perfectly with the C locus, which controls the presence of pungency, in 121 F₂ individuals from a cross between 'ECW123R' and 'CM334', both of *Capsicum annuum*. It found that CS and C are tightly linked. Sequence analysis of the genes of four pungent and four non-pungent pepper lines showed that the non-pungent peppers had a 2,529 bp-deletion in the 5' upstream region of CS. They have developed molecular markers of the C locus to detect pungency at the seedling stage. Based on the deleted sequence, they developed five SCAR markers, two of them being codominant. These SCAR markers will be useful for easy, accurate, and early detection of non-pungent individuals in breeding programs.

Pungency or "heat" found in *Capsicum* fruit results from the biosynthesis and accumulation of alkaloid compounds known as capsaicinoids in the dissepiments, placental tissue adjacent to the seeds. Pepper cultivars vary with respect to their level of pungency because of quantitative and qualitative variation in capsaicinoid content. A total of six different main effect QTL affecting capsaicinoid content were identified that are mapped to chromosomes 3, 4 and 7 (Arnon Brand, 2006).

Claudinei *et al.* (2006) studied genetic variation for dormancy in the parents, F₁ and 300 F₂ lines derived from the cross Frontana OR1 and its reciprocal. The germination/dormancy sprouted grains were evaluated on fifty seeds per replication, germinated in paper towel rolls at 20 °C for 5 days. A bimodal distribution for dormancy occurred in the Frontana/OR1 and OR1/Frontana derived F₂ populations. The mean ratio of dormant and non-dormant seeds of the cross and its reciprocal was 85:1115, fitting a digenic model of 1:15 (P < 0.05). In fact, all non after-ripened F₁ seeds germinated. The F₂ distribution indicates that two major genes, here called A, a and B, b, control seed dormancy, which it appears to be recessive to dormancy. Only the homozygous aabb is dormant in the absence of maternal tissue effect.

Claver *et al.* (2007) validated SNP marker for pungency by tetra-primer amplification refractory mutation system-PCR (tetra-primer ARMSPCR) and Cleaved Amplified Polymorphic Sequence (CAPS) distinguishing 29 pungent and non-pungent

cultivars of *Capsicum annuum*. In addition they also reported that these SNP was also associated with phenotypic pungent character in the tested genotypes of *C. chinense*, *C. baccatum*, *C. frutescens*, *C. galapagoense*, *C. eximium*, *C. tovarii* and *C. cardenasi*. The SNP marker is a faster, cheaper and more reproducible method for identifying pungent peppers than other techniques such as panel tasting, and allowed rapid screening of the trait related to pungency in early growth stages.

Charles Stewart Jr *et al.* (2007) revealed that, capsaicinoid biosynthesis is restricted to the genus *Capsicum* and results from the acylation of the aromatic compound, vanillylamine, with a branched chain fatty acid. The presence of capsaicinoids is controlled by the Pun1 locus, which encodes a putative acyltransferase. In its homozygous recessive state, pun1/pun1, capsaicinoids are not produced by the pepper plant. HPLC analysis confirmed that capsaicinoids are only found in the interlocular septa of pungent pepper fruits. Genetic analysis revealed that pun12 co-segregated exactly with the absence of blisters, non-pungency, and a reduced transcript accumulation of several genes involved in capsaicinoid biosynthesis. Collectively, these results establish that blister formation requires the Pun1 allele and that pun12 is a recessive allele from *C. Chinense* that results in non-pungency.

Stellari *et al.* (2010) examined an unreported null allele of Pun1 from a non-pungent accession of *Capsicum frutescens*, the third species in the *annuum chinense frutescens* complex of domesticated *Capsicums*. The loss of pungency phenotype in *C. frutescens* maps to Pun₁ and co-segregates with a molecular marker developed to detect this allele of Pun₁, pun₁₃. Loss of transcription of pun₁₃ is correlated with loss of pungency. Although this mutation is allelic to pun₁ and pun₁₂, the mutation causing loss of pungency in the undomesticated *Capsicum chacoense*, pun₂, is not allelic to the Pun1 locus as shown by mapping and complementation studies. The different origins of nonpungency in pepper are discussed in the context of the phylogenetic relationship of the known loss of pungency alleles.

Cesar *et al.* (2011) reported that capsicum species produce fruits that synthesize and accumulate unique hot compounds known as capsaicinoids in placental tissues.

Capsaicinoids are synthesized through the convergence of two biosynthetic pathways the phenylpropanoid and the branched-chain fatty acid pathways, which provide the precursors phenylalanine, and valine or leucine, respectively. Capsaicinoid biosynthesis and accumulation is a genetically determined trait in hot pepper fruits as different cultivars or genotypes exhibit differences in pungency furthermore, this characteristic is also developmentally and environmentally regulated. The establishment of cDNA libraries and comparative gene expression studies in pungent and non-pungent hot pepper fruits has identified candidate genes possibly involved in capsaicinoid biosynthesis.

Julia *et al.* (2012) studied 53 hot pepper accessions from different areas of this north eastern region for genetic diversity using various morphological characters and 50 simple sequence repeat (SSR) markers. It was found that erect and campanulate fruit types are grouped in separate clusters. The number of alleles per locus ranged from 3 to 9 with an average of 5.36. The average polymorphic information content value was 0.52. Percentage variation among populations, within individuals of population and within individuals was found to be 34, 57.9 and 8.05 %, respectively, indicating diversity in the landraces sampled. Allele mining across acyltransferase 3 (AT3) genes in a set of landraces led to identification of new single nucleotide polymorphisms (SNPs). Sequence analysis of the 2,349 bp AT3 region revealed the presence of a total of 79 SNPs and 3 indels.

Arnon Brand *et al.* (2012) studied on the genetic control of pigment content in pepper fruit focused mainly on monogenic mutations leading to changes in fruit colour. The quantitative variation in pigment content was studied in a cross between a dark green *Capsicum annuum* pepper and a light-green *C. chinense* pepper. Two major pigment content QTLs that control chlorophyll content was identified, pc8.1 and pc10.1. The major QTL pc8.1, also affected carotenoid content in the ripe fruit.

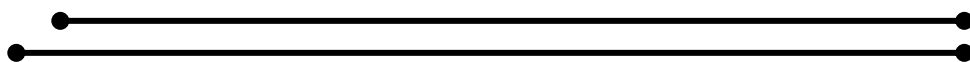
Ved Prakash Rai *et al.* (2013) studied the genomic simple sequence repeats (SSRs) and random amplified microsatellite polymorphism (RAMPO) markers analyse diversity and relationships among 48 pepper (*Capsicum* spp.) genotypes. Out of 106 SSR markers, 25 polymorphic SSR markers (24 %) detected a total of 76 alleles (average,

3.04; range, 2-5). The average polymorphic information content (PIC) was 0.69(range, 0.29-0.92). Seventeen RAMPO markers produced 87 polymorphic fragments with average PIC of 0.63 (range, 0.44-0.81). Genetic variations with in non-annuum genotypes were greater than the *C. annuum* genotypes. Revealing, dstinctness of interspecific derivative landraces grown in northeast.

2.5.2 Joint Scaling Test in hot pepper

Dhal and Hundal *et al.* (2010) evaluated six generations of hot pepper by single plant randomization to find out the nature and magnitude of gene effects for dry matter content in hot pepper. In all the crosses, the F_1 means were intermediate between their corresponding parental means but higher than their respective mid-parental means suggesting partial dominance towards the higher parent (P_1). From the ABC scaling test and three parameter joint scaling test, the presence of epistasis was detected in only three crosses of PBC 830 with S-2530, Pb Lal and Pepsi-7 but second-degree statistics indicated the absence of epistasis. They also revealed that, among gene effects, additive effects were more than non-additive effects. The significance of only additive component of variance also confirms the predominance of additive effects. They concluded that additive effects with partial dominance has more influence on the inheritance of dry matter content of hot pepper fruits, which may be improved through simple selection.

MATERIAL AND METHODS



III MATERIAL AND METHODS

The details of the methods adopted and materials used during the course of the investigation are described in this chapter. The present investigation entitled “Studies on association of capsaicin and oleoresin contents on incidence of anthracnose fruit rot and seed quality, and validation of DNA markers linked to pungency in hot pepper (*Capsicum* spp.)” was taken up with five experiments. The study included both field and laboratory experiment in order to determine the effect of principle compounds capsaicin and oleoresin on the seed quality, storability, fruit rot incidence and severity and seed treatment to control anthracnose fruit rot and to validate molecular markers linked to pungency.

3.1 Location of the experimental site

The field experiments were conducted in E-block, Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bengaluru, Karnataka, India.

Laboratory experiments were conducted in Department of Seed Science & Technology, The Kirkhouse Trust (UK) laboratory and Hot Pepper Improvement Unit, Department Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru.

3.2 Climatic conditions

The monthly weather data during the period of investigation and mean over the years recorded at the meteorological observatory of Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bengaluru, are presented in Appendix-I.

Experimental Details

3.3 Experiment I: To study the variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality

The field experiment was conducted during *Kharif* 2008 at Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bengaluru.

3.3.1 Seed material

For the present study 88 genotypes belonging to three *Capsicum* species viz., *Capsicum annum* var. *longum*, *Capsicum frutescens* and *Capsicum chinense* were collected from the various sources and parts of Karnataka and India during field survey (Appendix-II) and were grown in main field to assess uniformity. The 47 genotypes showing consistent morphological characters confirming the true to type were subjected to self-pollination and the resulted seeds were used for further studies (Table 3.1 and plate 3.1).

Date of sowing	: 3-6-2008
Date of transplanting	: 4-7-2008
Design	: CRD
Replication	: Three

3.3.2 Cultural operations

Nursery: The seeds were treated with Thiaram @ 2g/kg and were sown in poly plug trays with coir pith as media with shade net house, K-Block, Department of Genetics and Plant Breeding. Thirty day old seedlings were transplanted to main field at Plot No. E-6 of Department of Seed Science and Technology. UAS, GKVK, Bengaluru (Plate. 3.1).

3.3.3 Collection of experimental data

3.3.3.1 Sampling procedure

Five plants per plot were randomly selected in each treatment and labeled and following observations were recorded on the tagged plants.

- i. Days to flower initiation
- ii. Days to fruiting
- iii. Days to maturity
- iv. Fruit length (cm)
- v. Fruit width (cm)
- vi. Fresh fruit weight (g)
- vii. Dry fruit weight (g)



Plate 3.1. Some of hot pepper genotypes evaluated for the study

1	Aparna	6	Assam Bhut Jolokia	11	CO-3	16	HMT-1	21	LCA206	26	Paparika	31	Majjige Menasu-1
2	A. Abhir	7	Bayadagi Dabba	12	Chikkaballapur	17	JCA283	22	LCA235	27	Phule Jothi	32	Majjige Menasu-2
3	A. Lohith	8	Bayadagi orange	13	Dyavanur Delux	18	Kashi Anmol	23	LCA245	28	Pusa Sadabahar	33	Cherry pepper
4	A. Suphul	9	Bayadagi Kaddi	14	Dyavanur Delux	19	KDC-1	24	LCA960	29	Samrudhi	34	Sooji Menasu
5	AR-75	10	CO-2	15	G4	20	Lavanga	25	PBC-613	30	Sankeshwara	-	-

Table 3.1. List of selected hot pepper genotypes evaluated to study the variability for capsaicin and oleoresin content and to assess their role on seed quality

Sl. No.	Genotypes	Source
1	Arka Abhir	IIHR, Bengaluru, Karnataka
2	Arka Lohith	IIHR, Bengaluru, Karnataka
3	Arka Suphal	IIHR, Bengaluru, Karnataka
4	Aparna	HRS, LAM farm, Guntur, Andhra Pradesh
5	AR-75	IIHR, Bengaluru, Karnataka
6	Assam Bhut Jolokia	Local collection from Assam
7	Bayadagi Dabba	Popular local variety, Karnataka
8	Bayadagi Kaddi	Popular local variety, Karnataka
9	Bayadagi orange selection	Chilli research station Devihosur, Karnataka
10	CA-6	AVRDC Taiwan
11	Chikkaballapur Local	Popular local variety, Karnataka
12	CO-1	TAU, Coimbatore, Tamil Nadu
13	CO-2	TAU, Coimbatore, Tamil Nadu
14	CO-3	TAU, Coimbatore, Tamil Nadu
15	Coorg local	Local collection from Coorg, Karnataka
16	Dyavanur Delux	Popular local variety, Karnataka
17	G4	HRS, LAM farm, Guntur, Andhra Pradesh
18	Gouribidanur Local	Popular local variety, Karnataka
19	HMT-1	UAS, Dharwad, Karnataka
20	JCA283	IIHR, Bengaluru, Karnataka
21	Kashi Anmol	IVRC, Varanasi, Uttar Pradesh
22	KDC-1	UAS, Dharwad, Karnataka
23	Lavanga	Local collection from Assam
24	LCA206	HRS, LAM farm, Guntur, Andhra Pradesh
25	LCA235	HRS, LAM farm, Guntur, Andhra Pradesh
26	LCA245	HRS, LAM farm, Guntur, Andhra Pradesh
27	LCA 334	HRS, LAM farm, Guntur, Andhra Pradesh
28	LCA353	HRS, LAM farm, Guntur, Andhra Pradesh
29	LCA960	HRS, LAM farm, Guntur, Andhra Pradesh
30	Minchalli Betta	Green foundation, Varthur, Bengaluru, Karnataka
31	Panth C-1	PAU, Ludhiana, Panjab
32	Paprika	HRS, LAM farm, Guntur, Andhra Pradesh
33	PBC-142	AVRDC, Taiwan
34	PBC-613	AVRDC, Taiwan
35	Phule Jothi	MPUAT, Udaipur, Rajasthan
36	Pusa Sadabahar	IARI, New Delhi
37	Rona	Local collection from Rona, Karnataka
38	Samrudhi	ZARS, GKVK, Bengaluru, Karnataka
39	Sankeshwara	ZARS, Devihossur, Byadgi, Karnataka
40	Sahyadri wonder hot	Local collection from Shivamogga, Karnataka
41	Shivani	East West Company, Bengaluru, Karnataka
42	Sooji Menasu	Local collection from Shivamogga, Karnataka
43	Majjige Menasu-1	Local collection from Shivamogga, Karnataka
44	Majjige Menasu-2	Local collection from Shivamogga, Karnataka
45	Tiwari	PAU, Ludhiana, Panjab
46	TMR-23	TAU, Coimbatore, Tamil Nadu
47	Utkal Awa	PAU, Ludhiana, Panjab

- viii. Fruit rot disease incidence (Hegde and Kulkarni, 2001& Ekbote, 2005)
- ix. Fruit rot severity (%) (Ekbote, *et al.*, 2002)
- x. No. of seed/fruit
- xi. 1000 seed weight (g) (ISTA, 1996)
- xii. Electrical conductivity ($\text{mS cm}^{-1} \text{ g}^{-1}$) (ISTA, 1985)
- xiii. Total dehydrogenase activity (TDH) ($\text{A}^\circ 480 \text{ nm}$) (Perl *et al.*, 1978)
- xiv. Standard germination (%) (ISTA, 2010)
- xv. Fresh ungerminated seeds (%)
- xvi. Seedling length (cm)
- xvii. Seedling dry weight (mg)
- xviii. Vigour index I & II (Abdul Baki and Anderson, 1973)
- xix. α -amylase activity ($\mu\text{g /ml/min.}$) (Sadasivam and Manickam, 1996)
- xx. Total soluble seed protein content ($\mu\text{g /g}$) (Lowry *et al.*, 1951)
- xxi. Capsaicin ($\mu\text{g/g}$) (Sadasivam and Manickam, 1996)
- xxii. Oleoresin (%) (Ranganna, 1996)
- xxiii. Seed health (ISTA, 1996)
- xxiv. ASTA color value (Rosebrook *et al.*, 1968)

3.3.5 Methodology

- i. Days to flower initiation:** Average number of days taken by labelled plants to bear at least one completely open flower.
- ii. Days to maturity:** Number of days taken by replicated and labelled plants to have at least one completely mature fruit and averaged and expressed in days.
- iii. Fruit length (cm):** Five fruits in each treatment plant were selected randomly and measured for length from the calyx margin to the tip of the fruit and fruit length was expressed in cm.
- iv. Fruit width (cm):** Five fruits in each treatment plant were selected randomly and measured for width using vernier calipers and fruit width was expressed in cm.
- v. Fresh fruit weight (g):** Five fruits in each treatment plant were selected randomly and weighed in an electronic balance and fruit weight was expressed in gram.

- vi. Dry fruit weight (g):** Five fruits in each treatment plant were selected randomly and dried in oven till attain constant weight and weighed in electronic balance and dry fruit weight was expressed in gram.
- vii. Fruit rot disease incidence:** The genotypes were screened for the natural infection at the experimental plots during *Kharif* with three replications in a Complete Randomized Block Design. The severity of the anthracnose disease most common during rainy season. The anthracnose fruit rot symptoms were scored using 0 to 9 scale (Hegde and Kulkarni, 2001; Ekbote, 2005) as described below.

<u>Per cent area of fruit infected</u>	<u>Disease score</u>
< 1 per cent	0
1 to 10 per cent	1
11 to 25 per cent	3
26 to 50 per cent	5
51 to 75 per cent	7
> 75 per cent	9

Percent disease incidence was calculated by using the formula

$$\text{Per cent disease incidence} = \frac{\text{No. of infected fruits}}{\text{Total number of fruits}} \times 100$$

- viii. No. of seed/fruit:** Number of seeds in five randomly selected red ripe fruits were counted and expressed in whole number.
- xi. 1000 seed weight (g):** Seeds were extracted from sun dried fruits and dried further in hot air oven at 30 °C to reduce the moisture content to six percent. One thousand seeds were counted manually and weighed in eight replicates and mean weight expressed in grams (ISTA, 2010).
- xii. Electrical conductivity of seed leachate (mS cm⁻¹ g⁻¹):** As per ISTA (1985) one gram of seeds were taken randomly from each treatment in three replications and soaked in 100 ml of double distilled water for 18 hour at 25 ± 1 °C. After incubation, the seed leachate was decanted and the electrical conductivity was

measured using digital conductivity meter (Model DI-909) and expressed in ($\mu\text{S cm}^{-1} \text{ g}^{-1}$).

- ix. Standard germination (%):** The seed germination was conducted in the laboratory using between paper method as per ISTA (2010). One hundred seeds of four replications were placed on moist germination paper; the rolled towels were incubated in a germination chamber maintained at 25 ± 1 °C and 90 per cent RH. The germinated seedlings were evaluated on 14th day and the germination per cent was expressed based on normal seedlings.
- x. Fresh ungerminated seeds (%):** The ungerminated seeds with imbibitions and showing no sign of radical emergence after 14 days on final count. were counted as Fresh Ungerminated Seeds (FUG) and expressed in per cent.
- xi. Seedling length (cm):** Among the germinated seedlings, ten normal seedlings were selected at random in each replication on 14th day. The shoot length was measured from the base of primary leaf to the base of hypocotyl. Similarly, the root length was measured from the base of the hypocotyl to the tip of the primary root. The mean seedling length was computed by adding both shoot and root lengths and expressed in centimeters.
- xii. Seedling dry weight (mg):** The ten seedlings used for shoot and root length measurement was used for estimating dry weight. They were dried in a hot air oven maintained at 8 ± 2 °C for 24 hours. After drying and cooling over silica gel for one hour the weight of dry seedlings was recorded and the mean seedling dry weight was calculated and expressed in milligrams.
- xiii. Seedling vigour index:** The germination, mean seedling length and dry weight recorded as above were used for the estimation of Seedling Vigour Index (SVI) I and II, respectively as per Abdul Baki and Anderson (1973) and expressed as whole number.

SVI - I = Mean seedling length (cm) $\times$ Germination (%) and

SVI - II = Mean seedling dry weight (mg) $\times$ Germination (%)

- xiv. Total dehydrogenase activity (TDH)(A° 480nm) :** One gram of seeds selected randomly was imbibed for 24 hours at 20 ± 1 °C in between two moist filter papers. The seeds were given a horizontal cut and soaked with one per cent 2,3,5-triphenyl tetrazolium chloride. These are incubated under dark at 30 ± 1 °C for a period of 6 h and they were washed with distilled water. The red coloured formazan was eluted from the stained embryos by soaking in 10ml of 2-methoxy ethanol for 6 to 8 hours in an air tight screw capped vials. The extract was decanted and the colour intensity was measured with the help of Spectrophotometer (Model Mini Spec-17) at 480 nm. The total dehydrogenase activity (TDH) was expressed in terms of Absorbance (Perl *et al.*, 1978)
- xv. Seed health:** Detection of seed mycoflora was done by standard blotter method (Top of paper) as per ISTA (2010). Ten seeds of ten replications were placed equidistantly in sterile glass petridishes of 9cm diameter lined with three moist blotter papers (Whatman No. 1). Then the petridishes were incubated at alternating temperature of 20-30 °C for 7 days with 12 hours light and 12 hours dark cycles. After incubation, seeds were examined under stereo-binocular and compound research microscope for the presence of seed mycoflora and the percentage of infection was calculated.
- xvi. α -amylase activity:** The α -amylase activity in developing seeds were estimated according to the method of Sadasivam and Manickam (1996). The enzyme was extracted by grinding 0.5 g of seeds in 1ml of 0.1M phosphate buffer pH 7.2. The ground material was left at 4 °C for one hour and centrifuged at 10000 rpm at 4 °C for 15 minutes. The supernatant was used as an enzyme source. To 0.5ml of enzyme extract, 0.5 ml of starch solution was added and incubated at room temperature for 15 minutes. Immediately after incubation, 1 ml of DNS reagent was added boiled for 5 minutes over a water bath and 0.5 ml of 40 per cent sodium potassium tartarate was added to stop the reaction. The solution was cooled at room temperature and 2.5ml of distilled water was added. Blank was prepared without adding starch solution and control without incubation for 15 minutes. The enzyme activity was calculated by measuring OD at 560 nm. α -amylase activity was expressed as μg maltose released/ml/min.

xvii. Estimation of total soluble seed protein ($\mu\text{g g}^{-1}$)

The total soluble seed protein was estimated as per the method prescribed by Lowry *et al.* (1951). The procedure followed is as follows.

a) Preparation of acetone powder

The seed samples were homogenized with chilled acetone in a pestle and mortar. The slurry was filtered immediately under suction pump using Whatman No. 1 filter paper and washed with excess chilled acetone to remove the pigments. The acetone powder was air-dried overnight and stored in sealed containers at 4 °C until further analysis.

b) Preparation of reagents

Solution A: 20g of anhydrous sodium carbonate + 4g of sodium hydroxide were dissolved in 1000ml of water.

Sodium potassium tartarate solution (1.35 %) 8: 1.35g of sodium potassium tartarate was dissolved in water and diluted to 100ml.

Copper sulphate solution (5.5 %): 5.5 g of copper sulphate was dissolved in water and diluted to 100 ml.

Solution B: 1.0 ml of 1.35 % sodium potassium tartarate + 0.1 ml of 5.5 % copper sulphate solutions were mixed together.

Solution C: 50 ml of solution 'A' was mixed with 1 ml of solution 'B', just before use.

Folin ciocalteau reagent (FCR): Commercial grade reagent was diluted 1:1 (V/V) before use.

Standard bovine serum albumin (BSA) solution: 2 mg of BSA was dissolved in distilled water and diluted to 10 ml to get a working standard solution containing 200 mg/ml.

c) Sample extraction: One gram of oven-dried seed sample (acetone powder) was extracted in 10 ml of 0.1 M sodium phosphate buffer (pH 7.0) for one hour on a

magnetic stirrer at room temperature. The extract was centrifuged at 10,000 rpm for 15 min. The supernatant was used for the estimation of total soluble seed protein content.

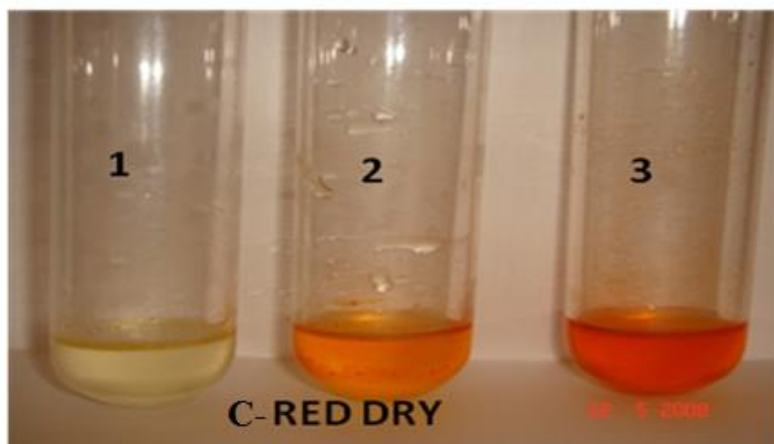
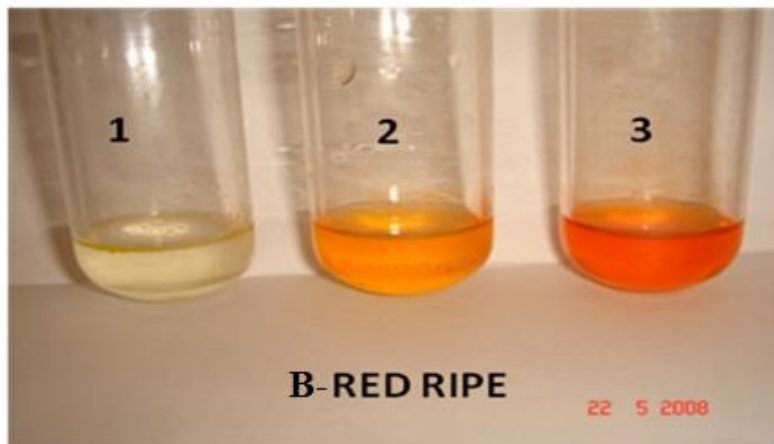
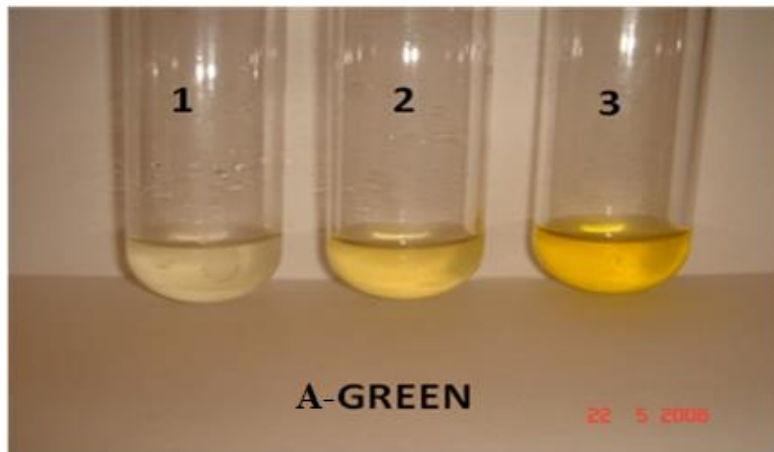
d) Estimation of protein: The required quantity (0.1ml) of supernatant was diluted in one ml water. Five ml of solution C was added and mixed. After 10 minutes, 0.5 ml of FCR was added and mixed immediately. After incubation for 30 minutes under dark, the absorbance of the solution was measured at 660 nm against a reagent blank.

A standard graph was constructed with BSA, with the concentration of 10 to 120 mg. The standard curve was used to estimate the protein content of the sample and expressed in $\mu\text{g g}^{-1}$ dry weight.

xviii. Capsaicin ($\mu\text{g g}^{-1}$): Capsaicin was estimated by following the colorimetric method (Sadasivam and Manickam, 1996). Phenolic group in capsaicin reduces phosphomolybdic acid to lower acids of molybdenum. The resulting component in blue colour was read at 650 nm. The colour intensity is directly proportional to the concentration of capsaicin (Plate 3.2a)

Procedure :

- Weigh 0.5 gm of dry chilli powder into a glass stoppered test tube or volumetric flask.
- Pipette out 10 ml dry acetone into the flask and shake it for 3 hour in a mechanical shaker.
- Let the contents settle down or centrifuge (10,000 rpm for 10 min).
- Pipette out 1 ml of the clear supernatant into a test tube and evaporate to dryness in a hot water bath.
- Dissolve the residue in 5 ml of 0.4% NaOH solution. Add 3 ml of 3% phosphomolybdic acid.
- Shake the contents and let stand for 1 hour.



A- Green Chilli Fruit Extract

B- Red Chilli Fruit Extract

C- Red Dry Fruit Extract

1- Seeds

2- Placenta

3- Pericarp

Plate 3.2a. Estimation of capsaicin by colorimetric method

- Filter the solution quickly into centrifuge tubes to remove any floating debris. Centrifuge at about 5000 rpm for 10 to 15 minutes.
- Transfer the clear blue coloured solution directly into the cuvette and read the absorbance at 650 nm.
- Run a reagent blank along with test samples.
- Prepare a standard graph using 1-200 µg capsaicin simultaneously i.e. pipette out 0.2, 0.4, 0.6, 0.8 and 1 ml of working standard solution and processed as above.
- By using standard graph capsaicin is read and expressed in µg.

xix. Oleoresin (%): Oleoresin of hot pepper is the products obtained by solvent extraction methods with subsequent removal of the solvent (Plate 3.2b). Oleoresin was extracted by cold acetone percolation of finely powdered sample of dried hot peppers and removal of solvent by evaporation over water bath. Oleoresin content was determined by gravity (Ranganna, 1996)

To estimate oleoresin glass column and mounted with porous silica mesh of 0.01 mm were specially designed and fabricated from Merck India Ltd.

Procedure :

- ◆ A known amount of (10g) finely powdered hot pepper sample was transferred into this column and taped it.
- ◆ After fixing this column to an iron stand vertically, sodium carbonate saturated cold acetone (chilled by using refrigerator) was added in the ratio of 1:10 by weight to volume.
- ◆ It was added slowly from the top and regulated the rate of flow of extract from the column so that it takes 2 hour 15 minute to 2 hour 30 minutes for 100 ml cold acetone to pass out of the column and extract was collected in porcelain dishes.
- ◆ The extract was evaporated over water bath at 70 °C till the sample attains constant weight.

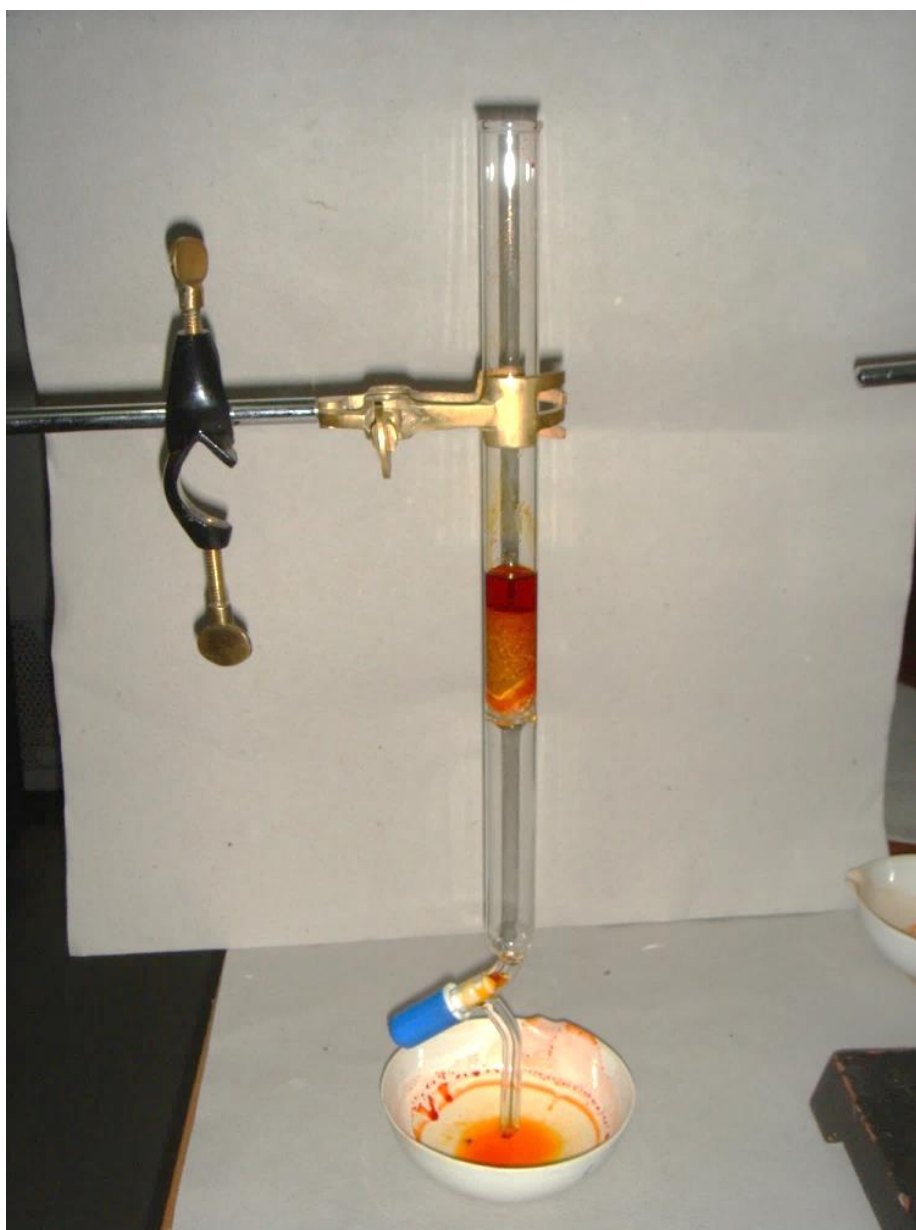


Plate 3.2b. Estimation of oleoresin by solvent extraction method

The amount of oleoresin was calculated estimated as

$$\text{Oleoresin (\%)} = (W_3 - W_2) / W_1 \times 100$$

W_1 : weight of sample (g)

W_2 : weight of empty porcelain dish

W_3 : weight of empty porcelain dish + weight of sample after evaporation

xx. ASTA colour value: The ASTA value of hot pepper samples was evaluated according to the ASTA 20 method (Rosebrook *et al.*, 1968). Known weight of hot pepper was weighed into a 100 ml volumetric flask; acetone was added to the mark, the mixture stirred and, after 16 h of extraction at room temperature in the dark, an aliquot of the transparent decanted extract was taken. The absorbance (A°) of the solution was measured at 460 nm in comparison to a standard glass reference. The absorbance was measured by UV-MS spectrophotometer 117 (Systronics, India). The ASTA colour value was calculated from the following equation

$$\text{ASTA colour value units} = \frac{A \times 164 \times If}{\text{Sample weight (g)}}$$

Where,

A = Absorbance at 460 nm

164 = American Spice Trade Association (ASTA) conversion factor to express oleoresin content.

If = a correction factor for the apparatus, calculated from the absorbance of potassium dichromate, ammonium sulphate and cobalt sulphate. The absorbance of each sample solution was measured three times in two parallel trials.

3.3.6 Biometrical analysis

The biometrical analysis of the data (by following the methods explained below) on individual characters was performed using normal statistical package and statistical methods employed for the analysis are given below.

3.3.7 Genetic variability parameters

(i) Analysis of variance (ANOVA)

Analysis of variance (ANOVA) was carried out as per the method suggested by Cochran and Cox (1959). Accordingly, the variance table was set up as given below to test the significant differences among the treatments and replications.

Source	df	Sum of squares	Mean sum of squares	Expected sum of squares
Replication	(r-1)	Rss	Mssr	Mssg/Msse
Treatments (genotypes)	(g-1)	Gss	Mssg	
Error	(r-1)(g-1)	Ess	Msse	

Where,

- r = Number of replications
- g = Number of genotypes
- Rss = Sum of squares due to replication
- Gss = Sum of squares due to genotypes
- Ess = Sum of squares due to error
- Mssr = Mean sum of squares due to replication
- Mssg = Mean sum of squares due to genotypes
- Msse = Mean sum of squares due to error
- σ^2_g = Genotypic variance
- σ^2_e = Phenotypic variance

(ii) Phenotypic and genotypic coefficient of variation (PCV and GCV)

The phenotypic and genotypic coefficient of variation was computed as per Burton and Dewane (1953) for low moisture stress.

$$PCV = \frac{P}{X} \times 100$$

$$GCV = \frac{G}{X} \times 100$$

Where;

P = Phenotypic standard deviation

G = Genotypic standard deviation

X = Grand mean of character

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

PCV and GCV were classified according to Robinson *et al.* (1949). 0-10 % was considered as low, 10-20 % as moderate and 20% and above as high.

(iii) Heritability (h^2)

Heritability estimate was calculated using the formula (Hanson *et al.*, 1956) as per cent mean

$$h^2 = \frac{V_g}{V_p} \times 100$$

Where,

$h^2(\%)$ = Heritability percentage

V_g = Genotypic variance

V_p = Phenotypic variance

Heritability percentage was categorized as follows (Robinson *et al.*, 1949)

0-30% was considered as low,

30-60% was considered as moderate

60% and above as high

(iv) Genetic advance (GA)

Genetic advance was calculated by using formula given by Johnson *et al.* (1955) and was expressed as per cent of mean.

$$\text{Genetic advance (GA)} = h^2 \times \sigma_p \times K$$

Where,

h^2 = Heritability (Broad sense)

σ_p = Phenotypic standard deviation

K = selection differential which is 2.06 at 5 % intensity of selection (Lush, 1949).

3.3.8 Estimation of correlation coefficients

To estimate the degree of association between the traits studied, phenotypic correlation was computed by using the formula given by Sundararaj *et al.* (1972).

$$r_{Pxy} = \frac{\text{Cov.}Pxy}{\sqrt{Px \times Py}}$$

Where,

r_{xy} = correlation co-efficient between x and Y .

$\text{COV}(X, Y)$ = Covariance of x and Y .

$V(X)$ and $V(Y)$ = Variances of x and Y .

Phenotypic and Genotypic correlations were calculated using the formula (Singh and Choudary, 1985). The significance of correlation co-efficient was tested by referring to the table value at $n-2$ d. f. given by Fisher and Yates at 5 % and 1 % significant level.

3.3.9 Path coefficient analysis

Path coefficient analysis was carried out as suggested by Wright (1921) and illustrated by Dewey and Lu (1957) in F_2 generations. Standard path coefficients, which are standardized partial regression coefficients, were obtained by solving the following sets of 'P' simultaneous equation by "DOOLITTLE TECHNIQUE" as described by Goulden (1959) using SPAR-1 computer programme as described below.

$$\begin{aligned} P_{01} + P_{01}r_{12} + \dots + P_{0p}r_{1p} &= r_{01} \\ P_{01}r_{12} + P_{02} + \dots + P_{0p}r_{2p} &= r_{02} \\ \cdot & \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ P_{01}r_{1p} + P_{02}r_{2p} + \dots + P_{0p} &= r_{0p} \end{aligned}$$

Where, $P_{01}, P_{02}, \dots, P_{0p}$ are the direct path coefficients of the variables, 1, 2, $\dots$, p on the dependent variable 0, $r_{12}, r_{13}, \dots, r_{1p}, \dots, r_{p(p-1)}$ are possible correlation coefficients between various independent variables and $r_{01}, r_{02}, \dots, r_{0p}$ are the correlations between dependent and independent variables.

The indirect effect of i^{th} variable via j^{th} variable is obtained as $P_{oj}r_{ij}$. The contribution of remaining unknown factors was measured as residual factor (r_{ox}), which was calculated as given below.

$$r_{oxs} = \sqrt{1 - (P_{01}^2 + 2P_{01}P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \dots + P_{02}^2 + 2P_{02}P_{03}r_{13} + \dots + P_{0p}^2)}$$

3.4 Experiment II: To study the anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin

Based on results obtained on estimation of capsaicin and oleoresin in red ripe fruits of experiment-I, two hot pepper genotypes each with low, medium and high capsaicin and low, medium and high oleoresin contents respectively (Table 3.2) were raised in Randomized Complete Block Design (Fig. 3.1) at main field with recommended package of practices (Anon., 2006).

Table 3.2: Genotypes selected to assess fruit rot in relation to capsaicin and oleoresin content

Sl. No.	Genotype	Principal components and category			
		Capsaicin ($\mu\text{g/g}$)	Category	Oleoresin (%)	Category
G ₁	Rona	42	Low	12.98	High
G ₂	Paprika	57	Low	13.12	High
G ₃	Shivani	74	Low	5.67	Low
G ₄	Byadagi Orange Selection	122	Medium	5.67	Low
G ₅	Byadagi Dabba	136	Medium	16.58	High
G ₆	Aparna	143	Medium	6.48	Low
G ₇	LCA206	198	Medium	14.86	High
G ₈	Chikkaballapur Local	265	High	15.61	High
G ₉	G ₄	204	High	11.40	Medium
G ₁₀	Panth C-1	221	High	12.46	Medium
G ₁₁	Majjige Menasu-1	302	High	3.97	Low
G ₁₂	Assam Bhut Jolokia	317	High	15.00	High

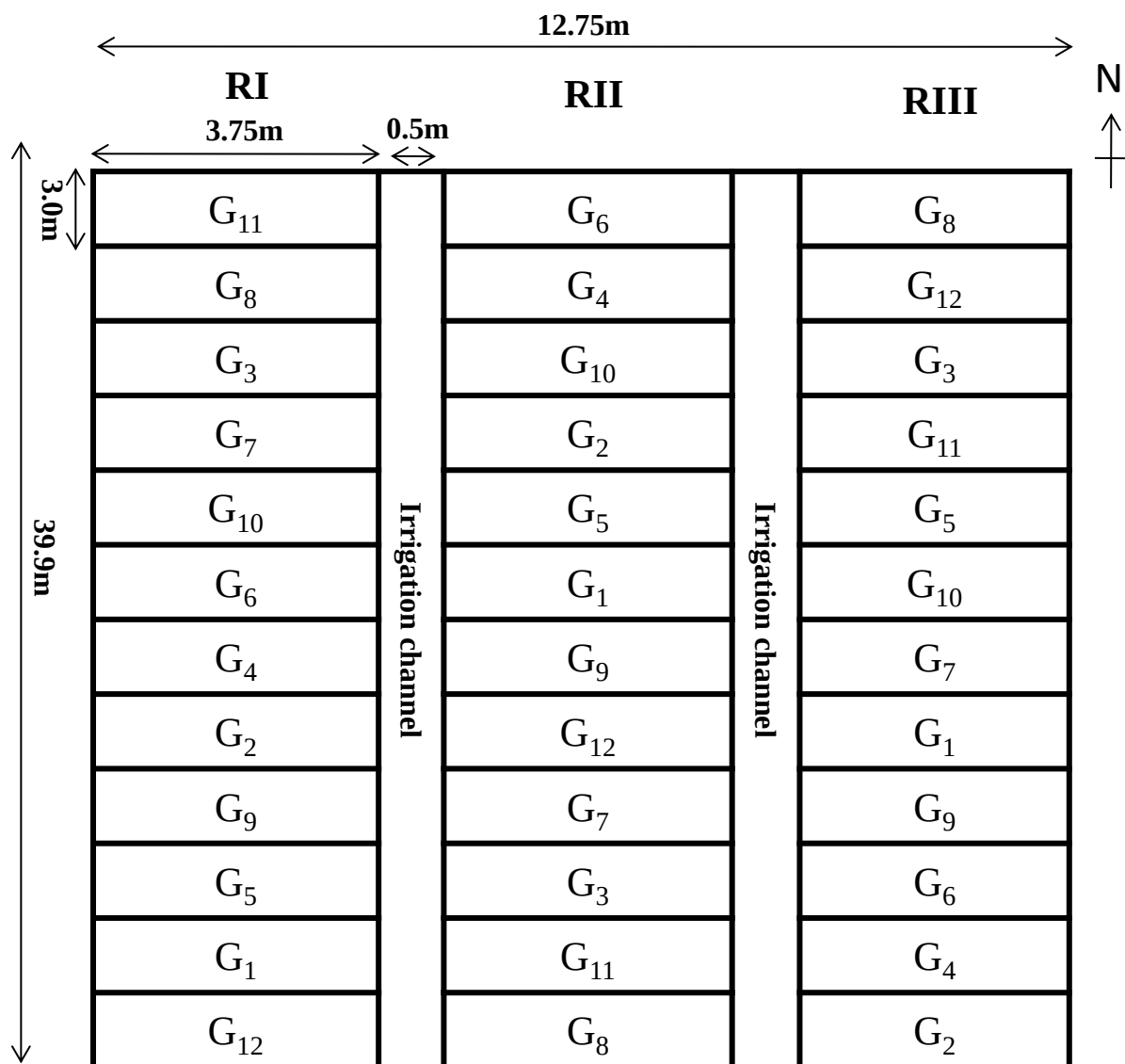


Fig. 3.1. Plan and layout to study the anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin in hot pepper

Genotypes (G)

G₁ : Assam Bhut Jolokia	G₇ : Byadagi Dabba
G₂ : Majjige Menasu-1	G₈ : LCA206
G₃ : Chikkaballapur local	G₉ : G4
G₄ : Panth C-1	G₁₀ : Paprika
G₅ : Rona	G₁₁ : Aparna
G₆ : Shivani	G₁₂ : Byadagi Orange Selection

Design: RCBD

Varieties:12,

Replication : 3

Spacing :75cm X 75cm

No. of plants in each row = 5,

No. of rows = 4

Plot Size: 12.75m X 39.9m = 508.725m²

Length:

Plot: 3 m X 12 = 36m

Bund: 0.3mX 13 = 3.9m

Total Length= 36m + 3.9m=39.9m

Breadth :

Plot: 3.75 m X 3= 11.25m

Irrigation channel: 0.5mX 3=1.5m

Total Breadth = 11.25m + 1.5m=12.75m

Genotypes	: 12
Season	: <i>Kharif</i> (June-July 2009)
Experimental Design	: 12 × 3 RCBD
Replication	: Three (3)

Hot pepper fruits of uniform size at red ripe stage were selected, surface sterilized with one percent Sodium hypochlorite solution and then washed with sterile water. Thereafter, the fruits were inoculated with homogenized spore suspension containing 5×10^5 spores/ml at two spots on the fruit (one μ ml/spot) using Hamilton micro syringe (AVRDC, 2003).

Microinjection method: The genotypes were artificially inoculated using the micro syringe method. The Hamilton micro syringe was made available for screening work by Kirkhouse Trust, UK (the funding agency) at hot pepper improvement unit, Department of Genetics and Plant Breeding, GKVK, Bengaluru.

The inoculated fruits were incubated in plastic boxes. Moist sterilized filter papers were placed at the bottom of the fruits and covered with the lid to maintain ° relative humidity of 90 per cent and incubated at $27 \pm 1^\circ\text{C}$ for eight days. Upon infection by the pathogen, anthracnose disease develops in the form of depressed, circular sunken lesions. The disease reaction on inoculated fruits as indicated by the lesion diameter was measure using a specialized scale in millimeters and expressed in centimeters.

The development of anthracnose fruit rot disease was recorded on naturally infected (Hegde and Kulkarni, 2001; Ekbote, 2005) and artificially inoculated fruits (AVRDC, 2002). Later the seeds extracted from the infected dried fruits and evaluated for the presence of anthracnose inoculums using Standard Blotter method (ISTA, 1996).

Observations recorded

- i. Fruit rot infection plant⁻¹ (%)
- ii. Fruit rot disease incidence on green fruit and on ripe fruits
- iii. No. of fruits infected plant⁻¹

- iv. Number of infected seeds/fruit
- v. True lesion diameter (cm)
- vi. No. of lesions per fruit
- vii. Standard germination (%) (ISTA, 2010)
- viii. Standard blotter Test, (ISTA, 2010)
- ix. Fresh ungerminated seeds (%)
- x. Seedling length (cm)
- xi. Vigour index I & II (Abdul Baki and Anderson,1973)
- xii. Capsaicin content (by HPLC) and ($\mu\text{g g}^{-1}$)
- xiii. Oleoresin content (%).

The methods and procedures outlined for determining the above parameter are detailed as above in experiment-I except for the following

- i. No. of lesions per fruit:** Number of anthracnose lesions developed on fruits in field by natural infection was enumerated on 10 fruits from five sample plants.
- ii. True lesion diameter (mm):** Average diameter of the lesion from the 10 representative fruits was measured using a specialized scale in millimeters and expressed in centimeters.
- iii. Capsaicin content (SHU) :**

Technique : High Performance Liquid Chromatography (HPLC)

Procedure :

- For the extraction of capsaicinoids, 5 g of ground hot pepper fruit and seed samples was weighed into a 100 ml volumetric flask.
- The volume is made up to the mark with saturated and cold acetone and was shaken for 8 hours.
- The extract was filtered through a 0.45-mm filter (Millex-HN, Millipore) and stored at 4 °C until processed.

- This sample was then analyzed by HPLC [Waters 2487, dual wavelength detector, 515 HPLC pump, IN-LINE degasser, pump control module 2.], the symmetry C18 column [250 mm length, 0.25 mm *i.e.*, 250 μ particle size] was used, with the combination of acetonitrile and methanol in water (60:40 v/v).
- The HPLC was monitored at 280 nm and the injection volume was 20 μ l.
- For peak identification, solution of reference standards were analyzed under similar conditions and their retention time were compared to those of samples.
- Capsaicin external standard (Sigma, M2028) were prepared as 1000 ppm stocks in absolute ethanol and was kept as a stock solution in amber colored standard flask.
- The working standard was prepared by adding 10 ml of stock and was made up to 100 ml with rectified spirit and was stored in refrigerator.
- The contribution of each identified compound was expressed as the percentage of its peak area.
- The samples were analyzed by Empower-2 software. The capsaicin in the fruit and seed sample was calculated in Scoville Heat Units (SHU) (Scoville, 1912) as follows,

$$\text{Capsaicin in SHU} = (C/A) \times (C_S / W_X) \times (H_C/R_C)$$

Where,

C: Average peak area of capsaicin

A: Average peak area of standard

C_S: Concentration of standard (mg/ml)

W_X: Weight of sample (mg/ml)

H_C: Heat factor for capsaicin

R_C: Response factor for capsaicin relative to standard

3.5 Experiment III: To study the seed quality attributes as influenced by capsaicin and oleoresin during storage

Fruits of two genotypes each with low, medium and high capsaicin and low, medium and high oleoresin contents raised in Experiment II (Table 3.2) were sun dried to 8 per cent moisture content to extract the seeds and further the seeds were dried to reduce

the moisture content to 6 per cent. The dried seeds and fruits were packed on March 2010 and stored for 24 months (Plate 3.3) after testing for initial seed quality parameters. The seed lots were evaluated for seed quality parameters and at an interval of three months in Department of Seed Science and Technology, UAS, GKVK, laboratory.

Experimental design : $12 \times 2 \times 3$ FCRD

Genotypes : 12

Material (M) : **M₁**: Fruits
M₂: Seeds

Storage containers : 3

P₁ : Vapour previous container (Brown paper cover)

P₂ : 700 gauge vapour proof poly pouches

P₃ : Aluminium foil pouches

No. of replications : 3

The following observation were recorded

- i. Seed moisture content (%) (ISTA, 1996)
- ii. Electrical conductivity ($\mu\text{S cm}^{-1} \text{g}^{-1}$) (ISTA, 1985)
- iii. Total dehydrogenase activity (TDH) (Perl *et al.*, 1983) ($A^\circ 480 \text{ nm}$)
- iv. Standard germination (%) (ISTA, 2010)
- v. Seedling length (cm)
- vi. Vigour index I & II (Abdul Baki and Anderson, 1973)
- vii. Field emergence (%)
- viii. Total soluble seed protein content ($\mu\text{g g}^{-1}$) (Lowry *et al.*, 1951) ($\mu\text{g/g}$)
- ix. Capsaicin content ($\mu\text{g g}^{-1}$)
- x. Oleoresin content (%) (in fruits)
- xi. ASTA color value (Rosebrook *et al.*, 1968)

The methods and procedures outlined for determining the above parameter are detailed as above in experiment-I except for the following



Treatment details

Material (M)

- M₁ : Whole fruits
M₂ : Seed

Genotypes (G)

- G₁ : Assam Bhut Jolokia
G₂ : Majjige Menasu-1
G₃ : Chikkaballapur local
G₄ : Panth C-1
G₅ : Rona
G₆ : Shivani

Packaging (P)

- P₁ : Vapour previous container
P₂ : 700 gauge vapour proof poly pouches
P₃ : Aluminum foil pouches

- G₇ : Byadagi Dabba
G₈ : LCA206
G₉ : G₄
G₁₀ : Paprika
G₁₁ : Aparna
G₁₂ : Byadagi Orange Selection

Plate 3.3. Fruits, seeds and packaging materials used to study the seed quality attributes as influenced by capsaicin and oleoresin during storage

i. Seed moisture content (%)

Seed moisture content was determined by low constant temperature oven method as per International Seed Testing Association Rules (ISTA, 1996). From each sample, five grams of seed was taken at random after thorough mixing and transferred to a stainless steel cup with lid. The cup with lid open was kept in a hot air oven and dried at $103 \pm 1^\circ\text{C}$ for a period of 17 hour. Later the cup was removed from oven after covering with lid and cooled for thirty minutes in a desiccator. Then dry weight of seed was recorded. The seed moisture content was determined by using the following formula and expressed in per cent.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = Weight of the container without seed (g)

M_2 = Weight of the container + seed before drying (g)

M_3 = Weight of the container + seed after drying (g)

ii. Field emergence (%)

One hundred seeds from each variety were sown in three replications on a well prepared, raised seed bed of red soil and the soil moisture was maintained by regular watering. The numbers of emerged seedlings were counted at 14 days after sowing and per cent field emergence was calculated and expressed in per cent.

iii. Accelerated ageing

The seeds were subjected for accelerated ageing by incubating seeds at $40 \pm 1^\circ\text{C}$ at 90 ± 2 per cent RH (Delouche and Baskin, 1973) for 2, 4, 6 and 8 days in an ageing chamber. The seed samples were then removed at different intervals of time with respect to their ageing period and were shade dried until original weight was obtained.

3.6 Experiment IV: To assess the efficacy of seed treatments to control seed borne anthracnose

For this study hot pepper growing areas of North Karnataka (Annigeri) and Andhra Pradesh (Guntur) were surveyed to obtain suitable infected fruit lots of variety Byadagi Dabba and G₄ with fruit rot (*Colletotrichum* Spp.) respectively. Seeds were extracted from 50 per cent fruit rot severity based on the presence of fruit rot symptoms, dried to six percent moisture content and tested for initial seed quality parameters.

Seeds of these lots were treated with seed treatment chemicals listed below and untreated seeds (from healthy fruits as control) were evaluated for seed quality parameters.

Varieties : 2 (Byadagi Dabba and G₄)

Treatments : 9

T₁: Kavach (g kg⁻¹)

T₂: Quintal (g kg⁻¹)

T₃: Propiconazole (ml kg⁻¹)

T₄: Hexaconazole (ml kg⁻¹)

T₅: Hot water treatment (min@ 55 °C)

T₆: *Trichoderma viride* (10⁵ CFU/ml)

T₇: Bavistin (g kg⁻¹)

T₈: Thiram (g kg⁻¹)

T₉: Captan (g kg⁻¹)

Concentration/ Duration : 4

0.2(%) 0.3(%) 0.4(%) 0.5(%) (Except for hot water treatment 5, 10, 15 and 20 min. duration at 55 °C)

Experimental design : 2 × 9 × 4 FCRD

No. of replications : 4

The following observation were recorded

- i. Standard germination (%) (ISTA, 2010)
- ii. Abnormal seedlings (%)
- iii. Fresh ungerminated seeds (%)
- iv. Seed infection (%) (Standard blotter method, ISTA, 2010)
- v. Vigour index I & II (Abdul Baki and Anderson,1973)
- vi. Post germination infected seedlings (%)
- vii. Post germination infected survival seedlings (%)

The methods and procedures outlined for determining the above parameter are detailed as above in experiment-I except for the following

- i. Post germination infected seedlings (%):** Seedlings showing infected symptoms of anthracnose were enumerated on 14th day with a 10X magnifying hand lenses and expressed in per cent age.
- ii. Post germination infected survival seedlings (%):** Post germination infected seedlings were enumerated after 21 days after sowing and the seedlings which survived the infection were counted and expressed in percentage.

3.7 Experiment V: Validation of trait specific DNA markers linked to pungency.

3.7.1 Plant materials

A low pungent parent Paprika from *C. annuum* was hybridized to highly pungent parent *C. chinense* ‘Assam Bhut Jolokia’ (world hottest pepper variety) to produce inter specific hybrid (Plate 3.4). The combined numbers of plants per family (574, 450, 500, 90, 90, and 60 for F₂, BCP₂, BCP₁, P₁, P₂, and F₁, respectively were sown in the plug tray nursery during February, 2012 and seedlings were transplanted in April, 2012 in main field.

Trait specific DNA markers identified as linked to pungency were used for validation in selected genotypes/population as suggested by Lee *et al.*, 2004, Claver *et al.*, 2007, and Truong, *et al.*, 2009.



Plate 3.4. Female (Paprika) and male (Assam Bhut Jolokia) genotypes chosen for the development of inter specific hybrid (*C. annuum* × *C. Chinense*)

3.7.2 Genomic DNA extraction

The genomic DNA of 47 hot pepper genotypes was extracted using Remya *et al.*, 2004. The list of reagent used and the protocol is briefly envisaged under Appendix-I. The concentration and quality of DNA was estimated using 0.8 percent agarose gel. 20 µl of DNA aliquot was diluted in 1980 µl of 1x TE. The DNA concentration was calculated using the formula mentioned below and the purity of DNA sample was determined by the ratio of A₂₆₀ to A₂₈₀ nm.

$$\text{DNA (mg/ml)} = \frac{A_{260} \times 50 \times \text{dilution factor}}{1000}$$

1.	EDTA 0.5 M, pH 8	4ml
2.	Sarkozyl 5 %	5ml
3.	Phenol	5 ml
4.	Sodium Bi-Sulphate	0.2g

3.7.3 Marker analysis

i) SCAR MARKERS

Primer name	Oligo	AT (°C)
BF ₆	5'-GAA AGA TCC GAC CTC GAC AA-3'	53.7
BR ₈	5'-TAG CAC CAA TAA GTG GAG TGC T-3'	53.4
BF ₅	5'-CCA TGA CCA CAT CAT TTT GC-3'	53.0
CSF ₁	5'-ATG GCT TTT GCA TTA CCA TCA -3'	54.4
CSR ₄	5'-TCA AAC ACC ACA AAA GAC TTG G-3'	54.0
CSR ₂	5'-CCT TCA CAA TTA TTC GCC CA -3'	55.2
BF ₇	5'-GGG GTT GGG TAG AGG TTG TT -3'	54.0
BR ₉	5'-GAC AAA CAA TAA TGG ACG ACG ATG G -3'	53.2

Lee *et al.*, 2005

Primer Combination: BF₅ and BR₈, BF₆ and BR₈-codominat
CSF₁ and CSR₄, CSR₄ and CSR₂, BF₇ and BR₉- Dominat

PCR specifications:

PCR mixture:

Template DNA: 50 ng
Primer: 5 pmol
dNTPs: 200 µM
1x *Taq* polymerase buffer
1unit *Ex Taq* polymerase

PCR amplification:

PCR: PTC-200
Pre amplification: 94 °C 5 min
Denaturation : 1 min 94 °C 35 cycles
Annealing: 1 min 62 °C and 2 min extension at 72 °C followed by final extension at 72 °C for 10 min.

ii) CAPS MARKERS

Primer name	Oligo	AT (°C)	Reference
SB2-66F	5'-ATTTTGGATGGGGAAG-3'	51	Claver <i>et al.</i> , 2007
PC-RI	5'-CCCTCTTCAATCAAACATCCA-3'	51	

PCR specifications:

Total volume: 25 µl
DNA: 40 ng template
0.2 µM dNTPs
3.0mM MgCl₂
1x buffer
0.5 unit *Taq* polymerase

PCR amplification:

PCR system 9700

Annealing: 94 °C for 2 min, 35 cycles of 45 s at 94 °C, 1 min at 51 °C

Extension: 2 min at 72 °C ending with 5 min at 72 °C

Digestion: 2.5 U of *Van91* I and 2.5 µl of 10x SuRE/Cut buffer B in total volume of 25 µl incubated for 1 hr at 37 °C and 15min at 65 °C

Product Separation: 2.5 % agarose gel

iii) TETRA-PRIMER ARMS-PCR

Primer name	Oligo nucleotide	AT (°C)	Reference
TPA-P1	5'-GTGATGTTGCACAAGCAACA-3'	59	Claver <i>et al.</i> , 2007
TPA-P2	5'-TTATTGCCTAATTAATTCCAAGTCTG-3'	59	
TPA-P3	5'-GACCGTAAACTTCCGTTGAAA-3'	59	
TPA-P4	5'-TTCAATCAAACATCCAGTTACTTCA-3'	59	

TETRA-PRIMER ARMS-PCR specifications:

Total volume: 10 µl

Template DNA: 30g

Inner forward and outer reverse primers: 0.75 µM

Inner reverser and outer forward primers: 1.75 µM

dNTPs: 200 µM

MgCl²: 3.5mM

1x buffer

Taq: 0.5U (Invitrogen)

PCR amplification:

Annealing: 95 °C for 1 min, 35 cycles of 1 min at 95 °C, 1 min at 54 °C

Extension: 1 min at 72 °C ending with 2 min at 72 °C

Product separation: 2.5 % agarose gel

iv) Genic SSR markers

Primer name	Oligo nucleotide	AT (°C)	Reference
2F	GGGCTTGGGTAGAGGTTGTT	54.0	Truong, <i>et al.</i> , 2009
2R	CTGCAACAGATGCATCAGGA	53.3	
3F	CCTCGGGTCTACGAACAGAA	53.9	
3R	AGAGGGGGTGAGAGAGGAAG	53.5	
7F	GGTTCTCTCATTACGCCACAAATATT	57.7	
12R	ACAACCTTCAGCCCTTGTTGG	53.8	
15R	ACACCAATAAGTGGAGTGCT	48.2	
16R	TTCATTTTCGAAAACTACAA	49.3	
17R	TTTGATGGTAGCATTGATGA	48.4	
Primer Combination: 5NF/11NR; 5NF/5NR; 2F/2R; 3F/3R; 7F/12R; 7F/15R; 7F/16R; 7F/17R			

PCR specifications:

PCR mixture:

Template DNA: 12-20 ng

Primer: 0.25 µM

dNTPs: 200 µM

1X TBE buffer

1unit *Taq* polymerase

PCR amplification:

Denaturation : 5 min 94 °C for 35 cycles

Annealing : 1 min 40-65 °C (depending on the melting temperature of primers) and 1 min of elongation at 72 °C followed by final incubation at 72 °C for 5min for prime extension; gel electrophoresis at 120 V

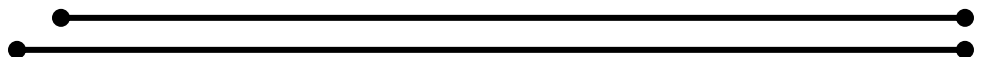
3.7.4 Gel electrophoresis

Agarose gel was prepared using electrophoresis grade agarose in a volume of electrophoresis buffer (1x TAE) sufficient for constructing a gel (300 ml for 18 × 30 cm gel). Ethidium bromide was added at concentration of 0.5µg/ml of gel. The gel was allowed to set fully before removing the comb and loading the samples. Five µl of loading dye was added to 20 µl of PCR products and mixed well before loading into the wells. Care was taken to prevent mixing of samples between wells. A voltage of 1-5 v/cm was given for a period of three hours for separation of PCR fragments. Later electrophoresis gel was viewed under UV light and the DNA banding pattern was recorded and photographed.

Statistical analysis

The data obtained from the experiment were statistically analyzed by using appropriate ANOVA by WINDOWSTAT version 9.1 from INDOSTAT services, Hyderabad licensed to Agriculture Knowledge Management Unit, GKV, UAS, Bengaluru. The critical differences between the treatments were worked out at five per cent significance (Snedecor and Cochran, 1967).

RESULTS



IV EXPERIMENTAL RESULTS

4.1 Experiment I: To study the variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality

The results obtained in the present study are presented under the following headings

4.1 Analysis of variance

4.2 Genetic variability

4.3 Association studies

4.3.1 Correlations

4.3.2 Path coefficient analysis

4.1.1 Analysis of variance (ANOVA)

The mean sum of squares due to genotypes for different characters is presented in Table 4.1. From the data it is evident that the 47 genotypes differed significantly for all the characters studied.

4.1.2 Genetic variability

The results with regards to overall mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and expected genetic advance as per cent mean (GAM) for all 17 characters are furnished in Table 4.2. The details of these variability parameters are presented below.

Range

In general, there was wide range for all 17 characters studied. The highest range was noticed in vigour index I followed by vigour index-II.

PCV and GCV

GCV ranged from 13.12 per cent (seedling dry weight) to 144.13 per cent (Electrical conductivity). The characters such as number of seed/fruit (48.99 %), 1000

Table 4.1. Analysis of variance

Characters	Source of variation	Degrees of freedom	Mean sum of squares
X ₁ : Number of seed fruit ⁻¹	Replication	2	1665.411***
	Treatments	46	6126.63***
	Error	92	109.984
X ₂ : Test weight (g)	Replication	2	3.83094***
	Treatments	46	7.06741***
	Error	92	0.14244
X ₃ : Electrical conductivity (mS cm ⁻¹ g ⁻¹)	Replication	2	0.01141***
	Treatments	46	28.8516***
	Error	92	0.00051
X ₄ : Total dehydrogenase activity (A° 480 nm)	Replication	2	0.05289***
	Treatments	46	1.14172***
	Error	92	0.00009
X ₅ : Germination (%)	Replication	2	7.34752
	Treatments	46	491.227***
	Error	92	6.42723
X ₆ : Fresh ungerminated seeds (%)	Replication	2	0.04847
	Treatments	46	18.874***
	Error	92	0.03823
X ₇ : Seedling length (cm)	Replication	2	1.78158
	Treatments	46	23.332***
	Error	92	0.68994
X ₈ : Seedling vigour index-I	Replication	2	4240.56
	Treatments	46	292899***
	Error	92	5179.97
X ₉ : Seedling dry weight (mg)	Replication	2	0.32102***
	Treatments	46	6.81166***
	Error	92	0.00013
X ₁₀ : Seedling vigour index-II	Replication	2	61743.1***
	Treatments	46	148306***
	Error	92	3036.43
X ₁₁ : Seed infection (%)	Replication	2	22.726***
	Treatments	46	1386.86***
	Error	92	1.5632
X ₁₂ : Fruit rot disease incidence on ripe fruits (%)	Replication	2	41.492***
	Treatments	46	2571.44***
	Error	92	3.21235
X ₁₃ : α -amylase activity ($\mu\text{g ml}^{-1} \text{ min}^{-1}$.)	Replication	2	23.5469***
	Treatments	46	128.027***
	Error	92	0.75442
X ₁₄ : Total soluble seed protein content ($\mu\text{g g}^{-1}$)	Replication	2	0.33938***
	Treatments	46	34.825***
	Error	92	0.00063
X ₁₅ : Capsaicin ($\mu\text{g g}^{-1}$)	Replication	2	1269.5***
	Treatments	46	28502***
	Error	92	44.953
X ₁₆ : Oleoresin (%)	Replication	2	4.23601***
	Treatments	46	52.3526***
	Error	92	0.16469
X ₁₇ : ASTA color value	Replication	2	53.0394***
	Treatments	46	6944.61***
	Error	92	0.55074

Table 4.2. Genetic variability parameters in hot pepper

Characters	Range		Grand mean	GCV (%)	PCV (%)	h ² (%) (Broad sense)	GAM
	Highest	Lowest					
X ₁ : Number of seed fruit ⁻¹	242.33	17.67	91.41	48.99	50.32	95	98.26
X ₂ : Test weight (g)	9.74	0.3	5.49	27.65	28.49	94	55.28
X ₃ : Electrical conductivity (mS cm ⁻¹ g ⁻¹)	13.48	0.33	2.15	144.13	144.14	100	296.91
X ₄ : Total dehydrogenase activity (A° 480 nm)	3.18	0.88	2.17	28.44	28.44	100	58.57
X ₅ : Germination (%)	96.33	38.67	77.2	16.47	16.79	96	33.27
X ₆ : Fresh ungerminated seeds (%)	9.73	0.71	1.83	136.81	137.23	99	280.98
X ₇ : Seedling length (cm)	17.88	5.87	12.81	21.44	22.4	92	42.28
X ₈ : Seedling vigour index-I	1488.67	283.33	1015.63	30.49	31.31	95	61.18
X ₉ : Seedling dry weight (mg)	14.69	8.11	11.48	13.12	13.12	100	27.03
X ₁₀ : Seedling vigour index-II	1235.67	344.67	901.43	24.41	25.17	94	48.78
X ₁₁ : Seed infection (%)	82	0	31.57	68.06	68.18	100	139.97
X ₁₂ : Fruit rot disease incidence on ripe fruits (%)	94.53	0	41.3	70.84	70.97	100	145.66
X ₁₃ : α -amylase activity (μ g ml ⁻¹ min ⁻¹ .)	37.03	12	26.68	24.42	24.63	98	49.85
X ₁₄ : Total soluble seed protein content (μ g g ⁻¹)	18.05	6.38	11.65	29.24	29.24	100	60.24
X ₁₅ : Capsaicin (μ g g ⁻¹)	417	27	178.95	54.43	54.55	100	111.85
X ₁₆ : Oleoresin (%)	22.58	3.2	11.65	35.82	35.99	99	73.43
X ₁₇ : ASTA color value	165.1	2.43	68.96	69.77	69.77	100	143.7

seed weight (g) (27.65 %), electrical conductivity (144.13 %), total dehydrogenase activity (28.44 %), fresh ungerminated seeds (136.81 %), seedling length (21.44 %), vigour index I (30.49 %), seedling vigour Index-II (24.41 %) seed Infection (68.06 %), fruit rot disease incidence on ripe fruits (70.84 %), α -amylase activity (24.42 %), total soluble seed protein content (29.24 %), capsaicin (54.43 %), oleoresin (35.82 %), ASTA color value (69.77 %) manifested higher level of GCV while germination (16.47 %), seedling dry weight (13.12 %) manifested moderate level of GCV.

PCV ranged from 13.12 per cent (Seedling dry weight) to 144.13 per cent (Electrical conductivity). The characters such as number of seed/fruit (50.32 %), 1000 seed weight (28.49 %), electrical conductivity (144.14 %), total dehydrogenase activity (28.44 %), fresh ungerminated seeds (137.23 %), Seedling length (22.40 %), vigour index I (31.31 %), seedling vigour index-II (25.17 %), Seed Infection (68.18 %), Fruit rot disease incidence on ripe fruits (70.97 %), α -amylase activity (24.63 %), Total soluble seed protein content (29.24 %), capsaicin (54.55 %), oleoresin (35.99 %), ASTA color value (69.77 %) manifested higher level of PCV while germination (16.79 %), Seedling dry weight (13.12 %) manifested moderate level of PCV.

Heritability

The heritability (broad sense) ranged 92 per cent (seedling length) to 100 per cent (Electrical conductivity, total dehydrogenase activity, seedling dry weight, Seed Infection, Fruit rot disease incidence on ripe fruits, Total soluble seed protein content, Capsaicin and ASTA color value). All the characters manifested higher heritability such as electrical conductivity (100 %), total dehydrogenase activity (100 %), seedling dry weight (100 %), seed infection (100 %), fruit rot disease incidence on ripe fruits (100 %), Total soluble seed protein content (100 %), Capsaicin (100 %), ASTA color value (100 %), number of seed/fruit (95 %), 1000 seed weight (94 %), germination (96 %), fresh ungerminated seeds (99 %), seedling length (92 %), seedling vigour index-I (95 %), vigour index II (94 %), α -amylase activity (98 %) and oleoresin (99 %).

Genetic advance as per cent mean (GAM)

The GAM ranged 27.03 per cent (seedling dry weight) to 296.91 per cent (Electrical conductivity). All the characters manifested higher GAM such as Electrical conductivity (296.91 %), fresh ungerminated seeds (280.98 %), Fruit rot disease incidence on ripe fruits (145.66 %), ASTA color value (143.70 %), seed Infection (139.97 %), Capsaicin (111.85 %), number of seed/fruit (98.26 %), oleoresin (73.43 %), vigour index I (61.18 %), total soluble seed protein content (60.24 %), total dehydrogenase activity (58.57 %), 1000 seed weight (55.28 %), α -amylase activity (49.85 %), seedling vigour Index-II (48.78 %), seedling length (42.28 %), germination (33.27 %) and seedling dry weight (27.03 %).

4.1.3 Association of characters

4.1.3.1 Correlation studies

The data pertaining to phenotypic correlation coefficients for all possible pairs involving 17 characters are presented in Table 4.3 and the details are presented below:

i. Germination (%)

The characters such as number of seed fruit⁻¹ (0.2816), 1000 seed weight (0.2997), total dehydrogenase activity (0.6566), seedling length (0.7296), vigour index I (0.8694), vigour index II (0.8991) seed infection (0.5309), fruit rot disease incidence on ripe fruits (0.4458), α -amylase activity (0.6895), total soluble seed protein content (0.6082), oleoresin (0.2786), ASTA color value (0.4885) and seedling dry weight (0.6276) showed significant positive correlation with germination per cent while electrical conductivity (-0.8125), fresh ungerminated seeds (-0.8890), capsaicin (-0.7482) showed significant negative correlation with germination per cent.

ii. Seedling vigour index-I

The characters such as number of seed fruit⁻¹ (0.5320), 1000 seed weight (0.4475), total dehydrogenase activity (0.6764), germination (0.8694), seedling length (0.9682), seedling dry weight (0.8212), seedling vigour index II (0.9106), Seed Infection

Table 4.3. Genetic variability parameters in hot pepper

Characters	Range		Grand Mean	GCV (%)	PCV (%)	h ² (%) (Broad Sense)	GAM
	Highest	Lowest					
X ₁ : Number of seed fruit ⁻¹	242.33	17.67	91.41	48.99	50.32	95	98.26
X ₂ : Test weight (g)	9.74	0.3	5.49	27.65	28.49	94	55.28
X ₃ : Electrical conductivity (mS cm ⁻¹ g ⁻¹)	13.48	0.33	2.15	144.13	144.14	100	296.91
X ₄ : Total dehydrogenase activity (A° 480 nm)	3.18	0.88	2.17	28.44	28.44	100	58.57
X ₅ : Germination (%)	96.33	38.67	77.2	16.47	16.79	96	33.27
X ₆ : Fresh ungerminated seeds (%)	9.73	0.71	1.83	136.81	137.23	99	280.98
X ₇ : Seedling length (cm)	17.88	5.87	12.81	21.44	22.4	92	42.28
X ₈ : Seedling vigour index-I	1488.67	283.33	1015.63	30.49	31.31	95	61.18
X ₉ : Seedling dry weight (mg)	14.69	8.11	11.48	13.12	13.12	100	27.03
X ₁₀ : Seedling vigour index-II	1235.67	344.67	901.43	24.41	25.17	94	48.78
X ₁₁ : Seed infection (%)	82	0	31.57	68.06	68.18	100	139.97
X ₁₂ : Fruit rot disease incidence on ripe fruits (%)	94.53	0	41.3	70.84	70.97	100	145.66
X ₁₃ : α -amylase activity (μ g ml ⁻¹ min ⁻¹)	37.03	12	26.68	24.42	24.63	98	49.85
X ₁₄ : Total soluble seed protein content (μ g g ⁻¹)	18.05	6.38	11.65	29.24	29.24	100	60.24
X ₁₅ : Capsaicin (μ g g ⁻¹)	417	27	178.95	54.43	54.55	100	111.85
X ₁₆ : Oleoresin (%)	22.58	3.2	11.65	35.82	35.99	99	73.43
X ₁₇ : ASTA color value	165.1	2.43	68.96	69.77	69.77	100	143.7

(0.6211), fruit rot disease incidence on ripe fruits (0.4953), α -amylase activity (0.6966), total soluble seed protein content (0.6840), oleoresin (0.2824), ASTA color value (0.5484) showed significant positive correlation with seedling vigour index I while electrical conductivity (-0.7374), fresh ungerminated seeds (-0.8100), capsaicin (-0.7993) showed significant negative correlation with vigour index I (Table 4.4).

iii. Seedling vigour index-II

The characters such as number of seed fruit⁻¹ (0.4577), 1000 seed weight (0.4772), total dehydrogenase activity (0.7158), germination (0.8991), seedling length (0.8227), seedling dry weight (0.8757), vigour index I (0.9106), seed infection (0.5901), fruit rot disease incidence on ripe fruits (0.4927), α -amylase activity (0.7373), Total soluble seed protein content (0.7078), oleoresin (0.2715), ASTA color value (0.5541) showed significant positive correlation with vigour index II while electrical conductivity (-0.7284), fresh ungerminated Seeds (-0.7905), capsaicin (-0.7832) showed significant negative correlation with vigour index-II (Table 4.5).

iv. Seed infection (%)

The characters such as number of seed fruit⁻¹ (0.5743), 1000 seed weight (0.3692), total dehydrogenase activity (0.6073), germination (0.5309), seedling length (0.6161), vigour index I (0.6211), seedling dry weight (0.5520), vigour index II (0.5901), fruit rot disease incidence on ripe fruits (0.8712), α -amylase activity (0.6106), Total soluble seed protein content (0.4627), oleoresin (0.2012), ASTA color value (0.5425) showed significant positive correlation with seed infection while Electrical conductivity (-0.5370), fresh ungerminated seeds (-0.5763), capsaicin (-0.7655) showed significant negative correlation with seed infection (Table 4.6).

v. Fruit rot disease incidence on ripe fruits

The characters such as number of seed fruit⁻¹ (0.4477), 1000 seed weight (0.3435), Total dehydrogenase activity (0.5414), germination (0.4458), seedling length (0.4852), vigour index I (0.4953), seedling dry weight (0.4550), vigour index II (0.4927), seed infection (0.8712), α -amylase activity (0.5462), total soluble seed protein content

Table 4.5. Estimation of phenotypic correlation coefficients between seed quality attributes and seedling vigour index-I

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₈
X ₁	1	0.6053**	-0.3062**	0.5047**	0.2816**	-0.3291**	0.6084**	0.5887**	0.4577**	0.5743**	0.4477**	0.4876**	0.4061**	-0.5051**	0.1868**	0.5139**	0.532**
X ₂		1	-0.3445**	0.3995**	0.2997**	-0.2952**	0.4838**	0.5547**	0.4772**	0.3692**	0.3435**	0.3764**	0.2829**	-0.3989**	0.1383	0.2495**	0.4475**
X ₃			1	-0.5398**	-0.8125**	0.8228**	-0.6637**	-0.5517**	-0.7284**	-0.537**	-0.4623**	-0.5984**	-0.4037**	0.678**	-0.0686	-0.336**	-0.7374**
X ₄				1	0.6566**	-0.627**	0.6094**	0.6517**	0.7158**	0.6073**	0.5414**	0.9876**	0.7862**	-0.7846**	0.2855**	0.762**	0.6764**
X ₅					1	-0.889**	0.7296**	0.6276**	0.8991**	0.5309**	0.4458**	0.6895**	0.6082**	-0.7482**	0.2786**	0.4885**	0.8694**
X ₆						1	-0.7278**	-0.5762**	-0.7905**	-0.5763**	-0.4733**	-0.6519**	-0.4447**	0.7141**	-0.2492**	-0.4027**	-0.81**
X ₇							1	0.8302**	0.8227**	0.6161**	0.4852**	0.6241**	0.6225**	-0.7477**	0.245**	0.5025**	0.9682**
X ₉								1	0.8757**	0.552**	0.455**	0.665**	0.6581**	-0.6961**	0.1717**	0.4966**	0.8212**
X ₁₀									1	0.5901**	0.4927**	0.7373**	0.7078**	-0.7832**	0.2715**	0.5541**	0.9106**
X ₁₁										1	0.8712**	0.6106**	0.4627**	-0.7655**	0.2012**	0.5425**	0.6211**
X ₁₂											1**	0.5462**	0.423**	-0.6076**	0.2813**	0.4788**	0.4953**
X ₁₃												1	0.7786**	-0.7982**	0.2585**	0.7454**	0.6966**
X ₁₄													1	-0.6283**	0.3724**	0.6853**	0.684**
X ₁₅														1	-0.1467	-0.6213**	-0.7993**
X ₁₆															1	0.5346**	0.2824**
X ₁₇																1	0.5484**

R²= 0.9974

Residual effect = 0.0513

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

Table 4.4. Estimation of phenotypic correlation coefficients between seed quality attributes and germination

	X ₁	X ₂	X ₃	X ₄	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₅
X ₁	1	0.6053**	-0.3062**	0.5047**	-0.3291**	0.6084**	0.532**	0.5887**	0.4577**	0.5743**	0.4477**	0.4876**	0.4061**	-0.5051**	0.1868**	0.5139**	0.2816**
X ₂		1	-0.3445**	0.3995**	-0.2952**	0.4838**	0.4475**	0.5547**	0.4772**	0.3692**	0.3435**	0.3764**	0.2829**	-0.3989**	0.1383	0.2495**	0.2997**
X ₃			1	-0.5398**	0.8228**	-0.6637**	-0.7374**	-0.5517**	-0.7284**	-0.537**	-0.4623**	-0.5984**	-0.4037**	0.678**	-0.0686	-0.336**	-0.8125**
X ₄				1	-0.627**	0.6094**	0.6764**	0.6517**	0.7158**	0.6073**	0.5414**	0.9876**	0.7862**	-0.7846**	0.2855**	0.762**	0.6566**
X ₆					1	-0.7278**	-0.81**	-0.5762**	-0.7905**	-0.5763**	-0.4733**	-0.6519**	-0.4447**	0.7141**	-0.2492**	-0.4027**	-0.889**
X ₇						1	0.9682**	0.8302**	0.8227**	0.6161**	0.4852**	0.6241**	0.6225**	-0.7477**	0.245**	0.5025**	0.7296**
X ₈							1	0.8212**	0.9106**	0.6211**	0.4953**	0.6966**	0.684**	-0.7993**	0.2824**	0.5484**	0.8694**
X ₉								1	0.8757**	0.552**	0.455**	0.665**	0.6581**	-0.6961**	0.1717**	0.4966**	0.6276**
X ₁₀									1	0.5901**	0.4927**	0.7373**	0.7078**	-0.7832**	0.2715**	0.5541**	0.8991**
X ₁₁										1	0.8712**	0.6106**	0.4627**	-0.7655**	0.2012**	0.5425**	0.5309**
X ₁₂											1	0.5462**	0.423**	-0.6076**	0.2813**	0.4788**	0.4458**
X ₁₃												1	0.7786**	-0.7982**	0.2585**	0.7454**	0.6895**
X ₁₄													1	-0.6283**	0.3724	0.6853**	0.6082**
X ₁₅														1	-0.1467**	-0.6213**	-0.7482**
X ₁₆															1	0.5346**	0.2786**
X ₁₇																1	0.4885**

R²= 0.9859

Residual effect = 0.1186

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

Table 4.6. Estimation of phenotypic correlation coefficients between seed quality attributes and seedling vigour index-II

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₀
X ₁	1	0.6053**	-0.3062**	0.5047**	0.2816**	-0.3291**	0.6084**	0.532**	0.5887**	0.5743**	0.4477**	0.4876**	0.4061**	-0.5051**	0.1868**	0.5139**	0.4577**
X ₂		1	-0.3445**	0.3995**	0.2997**	-0.2952**	0.4838**	0.4475**	0.5547**	0.3692**	0.3435**	0.3764**	0.2829**	-0.3989**	0.1383	0.2495**	0.4772**
X ₃			1	-0.5398**	-0.8125**	0.8228**	-0.6637**	-0.7374**	-0.5517**	-0.537**	-0.4623**	-0.5984**	-0.4037**	0.678**	-0.0686	-0.336**	-0.7284**
X ₄				1	0.6566**	-0.627**	0.6094**	0.6764**	0.6517**	0.6073**	0.5414**	0.9876**	0.7862**	-0.7846**	0.2855**	0.762**	0.7158**
X ₅					1	-0.889**	0.7296**	0.8694**	0.6276**	0.5309**	0.4458**	0.6895**	0.6082**	-0.7482**	0.2786**	0.4885**	0.8991**
X ₆						1	-0.7278**	-0.81**	-0.5762**	-0.5763**	-0.4733**	-0.6519**	-0.4447**	0.7141**	-0.2492**	-0.4027**	-0.7905**
X ₇							1	0.9682**	0.8302**	0.6161**	0.4852**	0.6241**	0.6225**	-0.7477**	0.245**	0.5025**	0.8227**
X ₈								1	0.8212**	0.6211**	0.4953**	0.6966**	0.684**	-0.7993**	0.2824**	0.5484**	0.9106**
X ₉									1	0.552**	0.455**	0.665**	0.6581**	-0.6961**	0.1717**	0.4966**	0.8757**
X ₁₁										1	0.8712**	0.6106**	0.4627**	-0.7655**	0.2012**	0.5425**	0.5901**
X ₁₂											1	0.5462**	0.423**	-0.6076**	0.2813**	0.4788**	0.4927**
X ₁₃												1	0.7786**	-0.7982**	0.2585**	0.7454**	0.7373**
X ₁₄													1	-0.6283**	0.3724**	0.6853**	0.7078**
X ₁₅														1	-0.1467	-0.6213**	-0.7832**
X ₁₆															1	0.5346**	0.2715**
X ₁₇																1	0.5541**

Where,

X₁ : Number of seed fruit⁻¹
 X₂ : Test weight (g)
 X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
 X₄ : Total dehydrogenase activity (A° 480 nm)
 X₅ : Germination (%)
 X₆ : Fresh ungerminated seeds (%)
 X₇ : Seedling length (cm)
 X₈ : Seedling vigour index-I
 X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
 X₁₁ : Seed infection (%)
 X₁₂ : Fruit rot disease incidence on ripe fruits (%)
 X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
 X₁₄ : Total soluble seed protein content (µg g⁻¹)
 X₁₅ : Capsaicin (µg g⁻¹)
 X₁₆ : Oleoresin (%)
 X₁₇ : ASTA color value

(0.4230), oleoresin (0.2813), ASTA color value (0.4788) showed significant positive correlation with fruit rot disease incidence on ripe fruits while electrical conductivity (-0.4623), fresh ungerminated Seeds (-0.4733), capsaicin (-0.6076) showed significant negative correlation with fruit rot disease incidence on ripe fruits (Table 4.7).

4.1.3.2 Path coefficient analysis

Path coefficient analysis were carried out at both genotypic and phenotypic levels taking germination per cent, seedling vigour index I, seedling vigour index II, seed infection per cent and fruit rot disease incidence on ripe fruits as dependent characters. The results pertaining to the path coefficient analyses are presented below

i. Direct effect of different characters on germination per cent at phenotypic level

At the phenotypic level, vigour index I (1.8408) recorded the highest positive direct effect on germination per cent, followed by vigour index II (0.1831) which was of considerable magnitude. Number of seed fruit⁻¹ (0.0038), 1000 seed weight (0.0056), fruit rot disease incidence on ripe fruits (0.0429), α -amylase activity (0.0725), total soluble seed protein content (0.0046) and ASTA color value (0.0051) recorded positive direct effects on germination per cent but their magnitude were low. However, seedling length (-1.3034) recorded the highest negative direct effect on germination per cent followed by fresh ungerminated seeds (-0.2268), seedling dry weight (-0.1182), total dehydrogenase activity (-0.1147). Electrical conductivity (-0.0773), seed infection (-0.0557), capsaicin (-0.0156) and oleoresin (-0.0083) recorded negative direct effect on germination per cent but their magnitude were low (Table 4.8).

ii. Direct effect of different characters on vigour index-I at phenotypic level

At the phenotypic level, seedling length (0.7297) recorded the highest positive direct effect on vigour index I, followed by germination per cent (0.3452) which were of considerable magnitude. Electrical conductivity (0.0230), total dehydrogenase activity (0.0288), fresh ungerminated seeds (0.0793), vigour index II (0.1004), seed infection (0.0132), total soluble seed protein content (0.0070) and oleoresin (0.0055) recorded positive direct effects on vigour index I but their magnitude were low. However, Number

Table 4.7. Estimation of phenotypic correlation coefficients between seed quality attributes and seed infection

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₁
X ₁	1	0.6053**	-0.3062**	0.5047**	0.2816**	-0.3291**	0.6084**	0.532**	0.5887**	0.4577**	0.4477**	0.4876**	0.4061**	-0.5051**	0.1868**	0.5139**	0.5743**
X ₂		1	-0.3445**	0.3995**	0.2997**	-0.2952**	0.4838**	0.4475**	0.5547**	0.4772**	0.3435**	0.3764**	0.2829**	-0.3989**	0.1383	0.2495**	0.3692**
X ₃			1	-0.5398**	-0.8125**	0.8228**	-0.6637**	-0.7374**	-0.5517**	-0.7284**	-0.4623**	-0.5984**	-0.4037**	0.678**	-0.0686	-0.336**	-0.537**
X ₄				1	0.6566**	-0.627**	0.6094**	0.6764**	0.6517**	0.7158**	0.5414**	0.9876**	0.7862**	-0.7846**	0.2855**	0.762**	0.6073**
X ₅					1	-0.889**	0.7296**	0.8694**	0.6276**	0.8991**	0.4458**	0.6895**	0.6082**	-0.7482**	0.2786**	0.4885**	0.5309**
X ₆						1	-0.7278**	-0.81**	-0.5762**	-0.7905**	-0.4733**	-0.6519**	-0.4447**	0.7141**	-0.2492**	-0.4027**	-0.5763**
X ₇							1	0.9682**	0.8302**	0.8227**	0.4852**	0.6241**	0.6225**	-0.7477**	0.245**	0.5025**	0.6161**
X ₈								1	0.8212**	0.9106**	0.4953**	0.6966**	0.684**	-0.7993**	0.2824**	0.5484**	0.6211**
X ₉									1	0.8757**	0.455**	0.665**	0.6581**	-0.6961**	0.1717**	0.4966**	0.552**
X ₁₀										1	0.4927**	0.7373**	0.7078**	-0.7832**	0.2715**	0.5541**	0.5901**
X ₁₂											1	0.5462**	0.423**	-0.6076**	0.2813**	0.4788**	0.8712**
X ₁₃												1	0.7786**	-0.7982**	0.2585**	0.7454**	0.6106**
X ₁₄													1	-0.6283**	0.3724**	0.6853**	0.4627**
X ₁₅														1	-0.1467	-0.6213**	-0.7655**
X ₁₆															1	0.5346**	0.2012**
X ₁₇																1	0.5425**

R²= 0.8807

Residual effect = 0.3453

Where,

X₁ : Number of seed fruit⁻¹
 X₂ : Test weight (g)
 X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
 X₄ : Total dehydrogenase activity (A° 480 nm)
 X₅ : Germination (%)
 X₆ : Fresh ungerminated seeds (%)
 X₇ : Seedling length (cm)
 X₈ : Seedling vigour index-I
 X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
 X₁₁ : Seed infection (%)
 X₁₂ : Fruit rot disease incidence on ripe fruits (%)
 X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
 X₁₄ : Total soluble seed protein content (µg g⁻¹)
 X₁₅ : Capsaicin (µg g⁻¹)
 X₁₆ : Oleoresin (%)
 X₁₇ : ASTA color value

Table 4.8. Estimation of phenotypic correlation coefficients between seed quality attributes and anthracnose fruit rot disease incidence

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₂
X ₁	1	0.6053**	-0.3062**	0.5047**	0.2816**	-0.3291**	0.6084**	0.532**	0.5887**	0.4577**	0.5743**	0.4876**	0.4061**	-0.5051**	0.1868**	0.5139**	0.4477**
X ₂		1	-0.3445**	0.3995**	0.2997**	-0.2952**	0.4838**	0.4475**	0.5547**	0.4772**	0.3692**	0.3764**	0.2829**	-0.3989**	0.1383	0.2495**	0.3435**
X ₃			1	-0.5398**	-0.8125**	0.8228**	-0.6637**	-0.7374**	-0.5517**	-0.7284**	-0.537**	-0.5984**	-0.4037**	0.678**	-0.0686	-0.336**	-0.4623**
X ₄				1	0.6566**	-0.627**	0.6094**	0.6764**	0.6517**	0.7158**	0.6073**	0.9876**	0.7862**	-0.7846**	0.2855**	0.762**	0.5414**
X ₅					1	-0.889**	0.7296**	0.8694**	0.6276**	0.8991**	0.5309**	0.6895**	0.6082**	-0.7482**	0.2786**	0.4885**	0.4458**
X ₆						1	-0.7278**	-0.81**	-0.5762**	-0.7905**	-0.5763**	-0.6519**	-0.4447**	0.7141**	-0.2492**	-0.4027**	-0.4733**
X ₇							1	0.9682**	0.8302**	0.8227**	0.6161**	0.6241**	0.6225**	-0.7477**	0.245**	0.5025**	0.4852**
X ₈								1	0.8212**	0.9106**	0.6211**	0.6966**	0.684**	-0.7993**	0.2824**	0.5484**	0.4953**
X ₉									1	0.8757**	0.552**	0.665**	0.6581**	-0.6961**	0.1717**	0.4966**	0.455**
X ₁₀										1	0.5901**	0.7373**	0.7078**	-0.7832**	0.2715**	0.5541**	0.4927**
X ₁₁											1	0.6106**	0.4627**	-0.7655**	0.2012**	0.5425**	0.8712**
X ₁₃												1	0.7786**	-0.7982**	0.2585**	0.7454**	0.5462**
X ₁₄													1	-0.6283**	0.3724**	0.6853**	0.423**
X ₁₅														1	-0.1467	-0.6213**	-0.6076**
X ₁₆															1	0.5346**	0.2813**
X ₁₇																1	0.4788**

R² = 0.8094 Residual effect = 0.4365

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

of seed fruit⁻¹ (-0.0071), 1000 seed weight (-0.0094), seedling dry weight (-0.0441), fruit rot disease incidence on ripe fruits (-0.0189), α -amylase activity (-0.0055), capsaicin (-0.0068) and ASTA color value (-0.0030) recorded the negative direct effect on vigour index I but their magnitude were low (Table 4.9).

iii. Direct effect of different characters on vigour index II at phenotypic level

At the phenotypic level, vigour index-I (0.8574) recorded the highest positive direct effect on vigour index II, followed by Seedling dry weight (0.5431) and germination per cent (0.2931) which were of considerable magnitude. 1000 seed weight (0.0575), Electrical conductivity (0.0156), seed infection (0.0340), total soluble seed protein content (0.0453), capsaicin (0.0097) and ASTA color value (0.0378) recorded positive direct effects on vigour index II but their magnitude was low. However, number of seed fruit⁻¹ (-0.0120), total dehydrogenase activity (-0.0156), fresh ungerminated seeds (-0.0715), seedling length (-0.7362), fruit rot disease incidence on ripe fruits (-0.0040), α -amylase activity (-0.0743) and oleoresin (-0.0053) recorded the negative direct effect on vigour index II but their magnitude were low (Table 4.10).

iv. Direct effect of different characters on seed infection at phenotypic level

At the phenotypic level, fruit rot disease incidence on ripe fruits (0.6334) recorded the highest positive direct effect on seed infection, followed by vigour index I (0.5975) which were of considerable magnitude. Number of seed fruit⁻¹ (0.1750), total dehydrogenase activity (0.0274), vigour index II (0.1800) and ASTA color value (0.0710) recorded positive direct effects on seed infection but their magnitude were low. However, germination per cent (-0.4725) recorded the highest negative direct effect on seed infection followed by seedling length (-0.4137), capsaicin (-0.3895) which were of considerable magnitude. 1000 seed weight (-0.0657), electrical conductivity (-0.0054), fresh ungerminated seeds (-0.2225), seedling dry weight (-0.1184), α -amylase activity (-0.1978), total soluble seed protein content (-0.0071) and oleoresin (-0.0699) recorded the negative direct effect on seed infection but their magnitude were low (Table 4.11).

Table 4.9. Estimation of phenotypic path coefficients between seed quality attributes and germination

	X ₁	X ₂	X ₃	X ₄	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₅
X ₁	0.0038	0.0023	-0.0012	0.0019	-0.0012	0.0023	0.002	0.0022	0.0017	0.0022	0.0017	0.0018	0.0015	-0.0019	0.0007	0.0019	0.2816
X ₂	0.0034	0.0056	-0.0019	0.0022	-0.0016	0.0027	0.0025	0.0031	0.0027	0.0021	0.0019	0.0021	0.0016	-0.0022	0.0008	0.0014	0.2997
X ₃	0.0237	0.0266	-0.0773	0.0417	-0.0636	0.0513	0.057	0.0427	0.0563	0.0415	0.0357	0.0463	0.0312	-0.0524	0.0053	0.026	-0.8125
X ₄	-0.0579	-0.0458	0.0619	-0.1147	0.0719	-0.0699	-0.0776	-0.0748	-0.0821	-0.0697	-0.0621	-0.1133	-0.0902	0.09	-0.0328	-0.0874	0.6566
X ₅	0.0747	0.067	-0.1866	0.1422	-0.2268	0.1651	0.1837	0.1307	0.1793	0.1307	0.1074	0.1479	0.1009	-0.162	0.0565	0.0913	-0.889
X ₆	-0.7929	-0.6306	0.865	-0.7943	0.9487	-1.3034	-1.2619	-1.0822	-1.0723	-0.8031	-0.6325	-0.8135	-0.8114	0.9745	-0.3193	-0.655	0.7296
X ₇	0.9793	0.8237	-1.3574	1.2451	-1.491	1.7822	1.8408	1.5117	1.6762	1.1432	0.9118	1.2822	1.2592	-1.4714	0.5198	1.0095	0.8694
X ₈	-0.0696	-0.0656	0.0652	-0.077	0.0681	-0.0981	-0.097	-0.1182	-0.1035	-0.0652	-0.0538	-0.0786	-0.0778	0.0823	-0.0203	-0.0587	0.6276
X ₉	0.0838	0.0874	-0.1334	0.1311	-0.1447	0.1506	0.1667	0.1604	0.1831	0.1081	0.0902	0.135	0.1296	-0.1434	0.0497	0.1015	0.8991
X ₁₀	-0.032	-0.0206	0.0299	-0.0338	0.0321	-0.0343	-0.0346	-0.0307	-0.0329	-0.0557	-0.0485	-0.034	-0.0258	0.0426	-0.0112	-0.0302	0.53
X ₁₁	0.0192	0.0147	-0.0198	0.0232	-0.0203	0.0208	0.0212	0.0195	0.0211	0.0374	0.0429	0.0234	0.0181	-0.0261	0.0121	0.0205	0.4458
X ₁₃	0.0354	0.0273	-0.0434	0.0716	-0.0473	0.0453	0.0505	0.0482	0.0535	0.0443	0.0396	0.0725	0.0565	-0.0579	0.0187	0.054	0.6895
X ₁₄	0.0019	0.0013	-0.0019	0.0036	-0.002	0.0029	0.0031	0.003	0.0033	0.0021	0.0019	0.0036	0.0046	-0.0029	0.0017	0.0031	0.6082
X ₁₅	0.0079	0.0062	-0.0106	0.0122	-0.0111	0.0116	0.0125	0.0108	0.0122	0.0119	0.0095	0.0124	0.0098	-0.0156	0.0023	0.0097	-0.7482
X ₁₆	-0.0015	-0.0011	0.0006	-0.0024	0.0021	-0.002	-0.0023	-0.0014	-0.0022	-0.0017	-0.0023	-0.0021	-0.0031	0.0012	-0.0083	-0.0044	0.2786
X ₁₇	0.0026	0.0013	-0.0017	0.0039	-0.0021	0.0026	0.0028	0.0025	0.0028	0.0028	0.0024	0.0038	0.0035	-0.0032	0.0027	0.0051	0.4885

R²= 0.9859

Residual effect = 0.1186

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

Table 4.10. Estimation of phenotypic path coefficients between seed quality attributes and seedling vigour index-I

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₈
X ₁	-0.0071	-0.0043	0.0022	-0.0036	-0.002	0.0023	-0.0043	-0.0042	-0.0032	-0.0041	-0.0032	-0.0034	-0.0029	0.0036	-0.0013	-0.0036	0.532
X ₂	-0.0057	-0.0094	0.0032	-0.0038	-0.0028	0.0028	-0.0046	-0.0052	-0.0045	-0.0035	-0.0032	-0.0035	-0.0027	0.0038	-0.0013	-0.0023	0.4475
X ₃	-0.007	-0.0079	0.023	-0.0124	-0.0187	0.0189	-0.0153	-0.0127	-0.0167	-0.0123	-0.0106	-0.0138	-0.0093	0.0156	-0.0016	-0.0077	-0.7374
X ₄	0.0145	0.0115	-0.0155	0.0288	0.0189	-0.018	0.0175	0.0188	0.0206	0.0175	0.0156	0.0284	0.0226	-0.0226	0.0082	0.0219	0.6764
X ₅	0.0972	0.1034	-0.2805	0.2266	0.3452	-0.3068	0.2518	0.2166	0.3103	0.1832	0.1539	0.238	0.2099	-0.2583	0.0961	0.1686	0.8694
X ₆	-0.0261	-0.0234	0.0652	-0.0497	-0.0705	0.0793	-0.0577	-0.0457	-0.0627	-0.0457	-0.0375	-0.0517	-0.0352	0.0566	-0.0198	-0.0319	-0.81
X ₇	0.4439	0.353	-0.4843	0.4447	0.5324	-0.5311	0.7297	0.6058	0.6003	0.4496	0.3541	0.4554	0.4543	-0.5456	0.1788	0.3667	0.9682
X ₈	-0.026	-0.0245	0.0243	-0.0287	-0.0277	0.0254	-0.0366	-0.0441	-0.0386	-0.0243	-0.0201	-0.0293	-0.029	0.0307	-0.0076	-0.0219	0.8212
X ₉	0.046	0.0479	-0.0732	0.0719	0.0903	-0.0794	0.0826	0.088	0.1004	0.0593	0.0495	0.0741	0.0711	-0.0787	0.0273	0.0557	0.9106
X ₁₀	0.0076	0.0049	-0.0071	0.008	0.007	-0.0076	0.0081	0.0073	0.0078	0.0132	0.0115	0.0081	0.0061	-0.0101	0.0027	0.0072	0.621
X ₁₁	-0.0084	-0.0065	0.0087	-0.0102	-0.0084	0.0089	-0.0092	-0.0086	-0.0093	-0.0164	-0.0189	-0.0103	-0.008	0.0115	-0.0053	-0.009	0.4953
X ₁₃	-0.0027	-0.0021	0.0033	-0.0054	-0.0038	0.0036	-0.0034	-0.0036	-0.004	-0.0033	-0.003	-0.0055	-0.0043	0.0044	-0.0014	-0.0041	0.6966
X ₁₄	0.0029	0.002	-0.0028	0.0055	0.0043	-0.0031	0.0044	0.0046	0.005	0.0033	0.003	0.0055	0.007	-0.0044	0.0026	0.0048	0.684
X ₁₅	0.0034	0.0027	-0.0046	0.0053	0.0051	-0.0048	0.0051	0.0047	0.0053	0.0052	0.0041	0.0054	0.0043	-0.0068	0.001	0.0042	-0.7993
X ₁₆	0.001	0.0008	-0.0004	0.0016	0.0015	-0.0014	0.0014	0.001	0.0015	0.0011	0.0016	0.0014	0.0021	-0.0008	0.0055	0.003	0.2824
X ₁₇	-0.0015	-0.0007	0.001	-0.0023	-0.0014	0.0012	-0.0015	-0.0015	-0.0016	-0.0016	-0.0014	-0.0022	-0.002	0.0018	-0.0016	-0.003	0.548

R²= 0.9974

Residual effect = 0.0513

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α -amylase activity (μ g ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (μ g g⁻¹)
X₁₅ : Capsaicin (μ g g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

Table 4.11. Estimation of phenotypic path coefficients between seed quality attributes and seedling vigour index-II

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₀
X ₁	-0.012	-0.0072	0.0037	-0.006	-0.0034	0.0039	-0.0073	-0.0064	-0.007	-0.0069	-0.0054	-0.0058	-0.0049	0.006	-0.0022	-0.0062	0.4577
X ₂	0.0348	0.0575	-0.0198	0.023	0.0172	-0.017	0.0278	0.0257	0.0319	0.0212	0.0198	0.0216	0.0163	-0.0229	0.008	0.0143	0.4772
X ₃	-0.0048	-0.0054	0.0156	-0.0084	-0.0127	0.0128	-0.0103	-0.0115	-0.0086	-0.0084	-0.0072	-0.0093	-0.0063	0.0106	-0.0011	-0.0052	-0.7284
X ₄	-0.0079	-0.0062	0.0084	-0.0156	-0.0103	0.0098	-0.0095	-0.0106	-0.0102	-0.0095	-0.0085	-0.0154	-0.0123	0.0123	-0.0045	-0.0119	0.7158
X ₅	0.0825	0.0878	-0.2382	0.1925	0.2931	-0.2606	0.2138	0.2548	0.184	0.1556	0.1307	0.2021	0.1783	-0.2193	0.0817	0.1432	0.8991
X ₆	0.0235	0.0211	-0.0589	0.0449	0.0636	-0.0715	0.0521	0.0579	0.0412	0.0412	0.0339	0.0466	0.0318	-0.0511	0.0178	0.0288	-0.7905
X ₇	-0.4479	-0.3562	0.4886	-0.4487	-0.5371	0.5358	-0.7362	-0.7128	-0.6112	-0.4536	-0.3572	-0.4595	-0.4583	0.5504	-0.1804	-0.3699	0.8227
X ₈	0.4562	0.3837	-0.6323	0.58	0.7454	-0.6945	0.8301	0.8574	0.7042	0.5325	0.4247	0.5972	0.5865	-0.6854	0.2421	0.4702	0.9106
X ₉	0.3197	0.3013	-0.2997	0.3539	0.3409	-0.3129	0.4509	0.4461	0.5431	0.2998	0.2471	0.3612	0.3575	-0.3781	0.0932	0.2697	0.8757
X ₁₀	0.0195	0.0125	-0.0182	0.0206	0.018	-0.0196	0.0209	0.0211	0.0187	0.034	0.0296	0.0207	0.0157	-0.026	0.0068	0.0184	0.59
X ₁₁	-0.0018	-0.0014	0.0019	-0.0022	-0.0018	0.0019	-0.0019	-0.002	-0.0018	-0.0035	-0.004	-0.0022	-0.0017	0.0024	-0.0011	-0.0019	0.4927
X ₁₃	-0.0362	-0.0279	0.0444	-0.0733	-0.0512	0.0484	-0.0463	-0.0517	-0.0494	-0.0453	-0.0406	-0.0743	-0.0578	0.0593	-0.0192	-0.0554	0.7373
X ₁₄	0.0184	0.0128	-0.0183	0.0356	0.0275	-0.0201	0.0282	0.031	0.0298	0.021	0.0192	0.0353	0.0453	-0.0284	0.0169	0.031	0.7078
X ₁₅	-0.0049	-0.0039	0.0066	-0.0076	-0.0073	0.0069	-0.0073	-0.0078	-0.0068	-0.0074	-0.0059	-0.0077	-0.0061	0.0097	-0.0014	-0.006	-0.7832
X ₁₆	-0.001	-0.0007	0.0004	-0.0015	-0.0015	0.0013	-0.0013	-0.0015	-0.0009	-0.0011	-0.0015	-0.0014	-0.002	0.0008	-0.0053	-0.0028	0.2715
X ₁₇	0.0194	0.0094	-0.0127	0.0288	0.0184	-0.0152	0.019	0.0207	0.0188	0.0205	0.0181	0.0281	0.0259	-0.0235	0.0202	0.0378	0.554

R²= 0.9775

Residual effect = 0.1500

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

v. Direct effect of different characters on fruit rot disease incidence on ripe fruits at phenotypic level

At the phenotypic level, seed infection (1.0122) recorded the highest positive direct effect on fruit rot disease incidence on ripe fruits, followed by seedling length (0.9352) and germination per cent (0.5813) which were of considerable magnitude. 1000 seed weight (0.0641), fresh ungerminated seeds (0.2404), Seedling dry weight (0.0505), α -amylase activity (0.2425), total soluble seed protein content (0.0234), capsaicin (0.2045) and oleoresin (0.1570) recorded positive direct effects on fruit rot disease incidence on ripe fruits. However, vigour index I (-1.3644) recorded the highest negative direct effect on fruit rot disease incidence on ripe fruits. Number of seed fruit⁻¹ (-0.1266), electrical conductivity (-0.0627), total dehydrogenase activity (-0.0312), vigour index II (-0.0339) and ASTA color value (-0.0872) recorded the negative direct effect on fruit rot disease incidence on ripe fruits (Table 4.12).

4.2 Experiment II: To study the anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin

The results pertaining to effect of capsaicin and oleoresin on anthracnose fruit rot are presented in table (Table 4.16-4.20).

The fruit quality attributes such as capsaicin and oleoresin contents was estimated in healthy, naturally fruit rot infected fruits and artificially inoculated hot pepper fruits among 12 varieties to assess the extent of deterioration of quality attribute due to anthracnose infection.

In general, the seed quality parameters, capsaicin and oleoresin contents of hot pepper fruits such as was reduced in infected fruits as compared to healthy fruits in all the varieties.

The genotypes recorded significant differences for fruit width and fruit length (cm). Genotype Shivani recorded highest fruit width (4.25 cm) and fruit length (12.37 cm). Whereas, Chikkaballapur local recorded lowest fruit width and fruit length (0.90 cm and 3.93 cm).

Table 4.12. Estimation of phenotypic path coefficients between seed quality attributes and seed infection

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₁
X ₁	0.175	0.1059	-0.0536	0.0883	0.0493	-0.0576	0.1065	0.0931	0.103	0.0801	0.0784	0.0853	0.0711	-0.0884	0.0327	0.0899	0.5743
X ₂	-0.0398	-0.0657	0.0226	-0.0262	-0.0197	0.0194	-0.0318	-0.0294	-0.0364	-0.0313	-0.0226	-0.0247	-0.0186	0.0262	-0.0091	-0.0164	0.3692
X ₃	0.0017	0.0019	-0.0054	0.0029	0.0044	-0.0044	0.0036	0.004	0.003	0.0039	0.0025	0.0032	0.0022	-0.0037	0.0004	0.0018	-0.537
X ₄	0.0138	0.0109	-0.0148	0.0274	0.018	-0.0172	0.0167	0.0185	0.0179	0.0196	0.0148	0.0271	0.0215	-0.0215	0.0078	0.0209	0.6073
X ₅	-0.133	-0.1416	0.3839	-0.3102	-0.4725	0.42	-0.3447	-0.4108	-0.2965	-0.4248	-0.2106	-0.3258	-0.2874	0.3535	-0.1316	-0.2308	0.5309
X ₆	0.0732	0.0657	-0.1831	0.1395	0.1978	-0.2225	0.162	0.1803	0.1282	0.1759	0.1053	0.1451	0.099	-0.1589	0.0555	0.0896	-0.5763
X ₇	-0.2517	-0.2001	0.2745	-0.2521	-0.3018	0.3011	-0.4137	-0.4005	-0.3435	-0.3403	-0.2007	-0.2582	-0.2575	0.3093	-0.1013	-0.2079	0.6161
X ₈	0.3179	0.2674	-0.4406	0.4042	0.5195	-0.484	0.5785	0.5975	0.4907	0.5441	0.296	0.4162	0.4087	-0.4776	0.1687	0.3277	0.6211
X ₉	-0.0697	-0.0657	0.0653	-0.0771	-0.0743	0.0682	-0.0983	-0.0972	-0.1184	-0.1037	-0.0539	-0.0787	-0.0779	0.0824	-0.0203	-0.0588	0.552
X ₁₀	0.0824	0.0859	-0.1311	0.1288	0.1618	-0.1423	0.1481	0.1639	0.1576	0.18	0.0887	0.1327	0.1274	-0.1409	0.0489	0.0997	0.59
X ₁₁	0.2836	0.2176	-0.2928	0.343	0.2824	-0.2998	0.3074	0.3137	0.2882	0.3121	0.6334	0.346	0.268	-0.3849	0.1782	0.3033	0.8712
X ₁₃	-0.0964	-0.0744	0.1183	-0.1953	-0.1364	0.1289	-0.1234	-0.1377	-0.1315	-0.1458	-0.108	-0.1978	-0.154	0.1578	-0.0511	-0.1474	0.6106
X ₁₄	-0.0029	-0.002	0.0029	-0.0056	-0.0043	0.0031	-0.0044	-0.0048	-0.0047	-0.005	-0.003	-0.0055	-0.0071	0.0044	-0.0026	-0.0048	0.4627
X ₁₅	0.1967	0.1554	-0.2641	0.3056	0.2914	-0.2782	0.2912	0.3113	0.2711	0.305	0.2367	0.3109	0.2447	-0.3895	0.0571	0.242	-0.7655
X ₁₆	-0.0131	-0.0097	0.0048	-0.02	-0.0195	0.0174	-0.0171	-0.0197	-0.012	-0.019	-0.0197	-0.0181	-0.026	0.0103	-0.0699	-0.0374	0.2012
X ₁₇	0.0365	0.0177	-0.0238	0.0541	0.0347	-0.0286	0.0357	0.0389	0.0352	0.0393	0.034	0.0529	0.0486	-0.0441	0.0379	0.071	0.5425

R²= 0.8807

Residual effect = 0.3453

Where,

X₁ : Number of seed fruit⁻¹
 X₂ : Test weight (g)
 X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
 X₄ : Total dehydrogenase activity (A° 480 nm)
 X₅ : Germination (%)
 X₆ : Fresh ungerminated seeds (%)
 X₇ : Seedling length (cm)
 X₈ : Seedling vigour index-I
 X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
 X₁₁ : Seed infection (%)
 X₁₂ : Fruit rot disease incidence on ripe fruits (%)
 X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
 X₁₄ : Total soluble seed protein content (µg g⁻¹)
 X₁₅ : Capsaicin (µg g⁻¹)
 X₁₆ : Oleoresin (%)
 X₁₇ : ASTA color value

Table 4.13. Estimation of phenotypic path coefficients between seed quality attributes and anthracnose fruit rot disease incidence

	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₂
X ₁	-0.1266	-0.0766	0.0388	-0.0639	-0.0356	0.0417	-0.077	-0.0674	-0.0745	-0.0579	0.0727	-0.0617	-0.0514	0.0639	-0.0237	-0.0651	0.4477
X ₂	0.0388	0.0641	-0.0221	0.0256	0.0192	-0.0189	0.031	0.0287	0.0356	0.0306	0.0237	0.0241	0.0181	-0.0256	0.0089	0.016	0.3435
X ₃	0.0192	0.0216	-0.0627	0.0339	0.051	-0.0516	0.0416	0.0463	0.0346	0.0457	0.0337	0.0375	0.0253	-0.0425	0.0043	0.0211	-0.4623
X ₄	-0.0158	-0.0125	0.0169	-0.0312	-0.0205	0.0196	-0.019	-0.0211	-0.0203	-0.0223	-0.019	-0.0308	-0.0245	0.0245	-0.0089	-0.0238	0.5414
X ₅	0.1637	0.1742	-0.4724	0.3817	0.5813	-0.5168	0.4241	0.5054	0.3649	0.5227	0.3086	0.4008	0.3536	-0.435	0.1619	0.284	0.4458
X ₆	-0.0791	-0.071	0.1978	-0.1508	-0.2138	0.2404	-0.175	-0.1948	-0.1385	-0.1901	-0.1386	-0.1567	-0.1069	0.1717	-0.0599	-0.0968	-0.4733
X ₇	0.5689	0.4525	-0.6206	0.5699	0.6823	-0.6807	0.9352	0.9054	0.7764	0.7694	0.5762	0.5837	0.5822	-0.6992	0.2291	0.4699	0.4852
X ₈	-0.7259	-0.6106	1.0061	-0.9229	-1.1862	1.1052	-1.321	-1.3644	-1.1205	-1.2424	-0.8474	-0.9504	-0.9333	1.0906	-0.3853	-0.7483	0.4953
X ₉	0.0297	0.028	-0.0278	0.0329	0.0317	-0.0291	0.0419	0.0415	0.0505	0.0442	0.0279	0.0336	0.0332	-0.0351	0.0087	0.0251	0.455
X ₁₀	-0.0155	-0.0162	0.0247	-0.0243	-0.0305	0.0268	-0.0279	-0.0309	-0.0297	-0.0339	-0.02	-0.025	-0.024	0.0265	-0.0092	-0.0188	0.4927
X ₁₁	0.5813	0.3738	-0.5436	0.6147	0.5374	-0.5834	0.6236	0.6286	0.5588	0.5974	1.0122	0.618	0.4684	-0.7749	0.2036	0.5491	0.8712
X ₁₃	0.1183	0.0913	-0.1451	0.2395	0.1672	-0.1581	0.1514	0.1689	0.1613	0.1788	0.1481	0.2425	0.1888	-0.1936	0.0627	0.1808	0.5462
X ₁₄	0.0095	0.0066	-0.0094	0.0184	0.0142	-0.0104	0.0145	0.016	0.0154	0.0165	0.0108	0.0182	0.0234	-0.0147	0.0087	0.016	0.423
X ₁₅	-0.1033	-0.0816	0.1387	-0.1605	-0.153	0.146	-0.1529	-0.1635	-0.1424	-0.1602	-0.1566	-0.1632	-0.1285	0.2045	-0.03	-0.1271	-0.6076
X ₁₆	0.0293	0.0217	-0.0108	0.0448	0.0437	-0.0391	0.0385	0.0443	0.027	0.0426	0.0316	0.0406	0.0585	-0.023	0.157	0.0839	0.2813
X ₁₇	-0.0448	-0.0218	0.0293	-0.0665	-0.0426	0.0351	-0.0438	-0.0478	-0.0433	-0.0483	-0.0473	-0.065	-0.0598	0.0542	-0.0466	-0.0872	0.4788

R²= 0.8094 Residual effect = 0.4365

Where,

X₁ : Number of seed fruit⁻¹
X₂ : Test weight (g)
X₃ : Electrical conductivity (mS cm⁻¹ g⁻¹)
X₄ : Total dehydrogenase activity (A° 480 nm)
X₅ : Germination (%)
X₆ : Fresh ungerminated seeds (%)
X₇ : Seedling length (cm)
X₈ : Seedling vigour index-I
X₉ : Seedling dry weight (mg)

X₁₀ : Seedling vigour index-II
X₁₁ : Seed infection (%)
X₁₂ : Fruit rot disease incidence on ripe fruits (%)
X₁₃ : α-amylase activity (µg ml⁻¹ min⁻¹)
X₁₄ : Total soluble seed protein content (µg g⁻¹)
X₁₅ : Capsaicin (µg g⁻¹)
X₁₆ : Oleoresin (%)
X₁₇ : ASTA color value

Table 4.14. Correlation for the dependent and independent characters in hot pepper genotypes

Traits	Germination (%)	Seedling vigour index-I	Seedling vigour index-II	Seed Infection (%)	Fruit rot incidence (%)
X ₁ : Number of seed fruit ⁻¹	0.2816**	0.532**	0.4577**	0.5743**	0.4477**
X ₂ : Test weight (g)	0.2997**	0.4475**	0.4772**	0.3692**	0.3435**
X ₃ : Electrical conductivity (mS cm ⁻¹ g ⁻¹)	-0.8125**	-0.7374**	-0.7284**	-0.5370**	-0.4623**
X ₄ : Total dehydrogenase activity (A° 480 nm)	0.6566**	0.6764**	0.7158**	0.6073**	0.5414**
X ₅ : Germination (%)	1	0.8694**	0.8991**	0.5309**	0.4458**
X ₆ : Fresh ungerminated seeds (%)	-0.889**	-0.8100**	-0.7905**	-0.5763**	-0.4733**
X ₇ : Seedling length (cm)	0.7296**	0.9682**	0.8227**	0.6161**	0.4852**
X ₈ : Seedling vigour index-I	0.8694**	1	0.9106**	0.6211**	0.4953**
X ₉ : Seedling dry weight (mg)	0.6276**	0.8212**	0.8757**	0.5520**	0.455**
X ₁₀ : Seedling vigour index-II	0.8991**	0.9106**	1	0.5901**	0.4927**
X ₁₁ : Seed infection (%)	0.5309**	0.6211**	0.5901**	1	0.8712**
X ₁₂ : Fruit rot disease incidence on ripe fruits (%)	0.4458**	0.4953**	0.4927**	0.8712**	1
X ₁₃ : α -amylase activity (μ g ml ⁻¹ min ⁻¹)	0.6895**	0.6966**	0.7373**	0.6106**	0.5462**
X ₁₄ : Total soluble seed protein content (μ g g ⁻¹)	0.6082**	0.6840**	0.7078**	0.4627**	0.423**
X ₁₅ : Capsaicin (μ g g ⁻¹)	-0.7482**	-0.7993**	-0.7832**	-0.7655**	-0.6076**
X ₁₆ : Oleoresin (%)	0.2786**	0.2824**	0.2715**	0.2012**	0.2813**
X ₁₇ : ASTA color value	0.4885**	0.5484**	0.5541**	0.5425**	0.4788**

Table 4.15. Path analysis for the dependent and independent characters in hot pepper genotypes

Traits		Germination (%)	Seedling vigour index-I	Seedling vigour index-II	Seed Infection (%)	Fruit rot Incidence (%)
X ₁	: Number of seed fruit ⁻¹	0.0038	-0.0071	-0.012	0.175	-0.1266
X ₂	: Test weight (g)	0.0056	-0.0094	0.0575	-0.0657	0.0641
X ₃	: Electrical conductivity (mS cm ⁻¹ g ⁻¹)	-0.0773	0.023	0.0156	-0.0054	-0.0627
X ₄	: Total dehydrogenase activity (A° 480 nm)	-0.1147	0.0288	-0.0156	0.0274	-0.0312
X ₅	: Germination (%)	-	0.3452	0.2931	-0.4725	0.5813
X ₆	: Fresh ungerminated seeds (%)	-0.2268	0.0793	-0.0715	-0.2225	0.2404
X ₇	: Seedling length (cm)	-1.3034	0.7297	-0.7362	-0.4137	0.9352
X ₈	: Seedling vigour index-I	1.8408	-	0.8574	0.5975	-1.3644
X ₉	: Seedling dry weight (mg)	-0.1182	-0.0441	0.5431	-0.1184	0.0505
X ₁₀	: Seedling vigour index-II	0.1831	0.1004	-	0.18	-0.0339
X ₁₁	: Seed infection (%)	-0.0557	0.0132	0.034	-	1.0122
X ₁₂	: Fruit rot disease incidence on ripe fruits (%)	0.0429	-0.0189	-0.004	0.6334	-
X ₁₃	: α -amylase activity (μ g ml ⁻¹ min ⁻¹)	0.0725	-0.0055	-0.0743	-0.1978	0.2425
X ₁₄	: Total soluble seed protein content (μ g g ⁻¹)	0.0046	0.007	0.0453	-0.0071	0.0234
X ₁₅	: Capsaicin (μ g g ⁻¹)	-0.0156	-0.0068	0.0097	-0.3895	0.2045
X ₁₆	: Oleoresin (%)	-0.0083	0.0055	-0.0053	-0.0699	0.157
X ₁₇	: ASTA color value	0.0051	-0.003	0.0378	0.071	-0.0872

Under natural field conditions number of infected fruits per plant recorded significant differs among the genotypes. The lowest fruit rot infected fruits was recorded in Majjige Menasu-1 (0) whereas, highest was recorded in Rona (108.7).

Fruit rot disease incidence under natural field conditions differed significantly among the genotypes. The highest fruit rot disease incidence was recorded in Rona (95 %) followed by Paprika and Shivani (93 % each). However, no symptom of fruit rot disease incidence was recorded on genotype Majjige Menasu-1.

The fruit rot severity (%) under natural field conditions differed significantly among the genotypes. The highest fruit rot disease severity was recorded in Shivani (87.47 %) followed by Aparna (87.09 %). However, no symptom of fruit rot severity was recorded on genotype Majjige Menasu-1.

Number of seeds per fruit recorded significant differences among the genotypes studied. The highest number of seeds per fruit was recorded in Shivani (188.1) followed by Byadagi Dabba (137). Whereas, lowest was recorded in Rona (61.7). (Table 4.16)

Naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose genotypes showed significant differences for number of infected seeds per fruit. None of the seeds in genotype Majjige Menasu-1 recorded seed infection in naturally infected fruits (NIF), where as lowest of 4 (%) was observed in AIF. However, the genotype Byadagi Dabba recorded highest number of infected seeds per fruit both under NIF and AIF (104.18 and 107.7 %, respectively). (Table 4.16)

True lesion diameter (cm) of naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose showed significant differences among genotypes. Lowest true lesion diameter was recorded in genotypes Assam Bhut Jolokia, Majjige Menasu-1 and Panth C-1 (0.77, 0.80 and 0.77 cm, respectively) in NIF. Whereas, the highest true lesion diameter was recorded in Shivani (2.87 cm) and was on Par with Aparna (2.63 cm) followed by LCA 206(2.33 cm). AIF of genotypes Assam Bhut Jolokia and Majjige Menasu-1 recorded lower true lesion diameter of 0.8 cm each. However, genotypes LCA 206 recorded highest (3.1 cm) followed by Shivani (2.9 cm).

Table 4.16. Fruit rot incidence and severity in relation to capsaicin and oleoresin content

Sl. No.	Genotypes	Fruit width (mm)	Fruit length (cm)	Number of infected fruits per plant	Fruit rot disease incidence (%)	Fruit rot severity (%)	Number of seeds per fruit	Number of infected seeds per fruit		Per cent change	True lesion diameter (cm)		Per cent change	No. of lesions/ fruit
								NIF	AIF		NIF	AIF		
1	Assam Bhut Jolokia	1.80	5.88	14.7*	7.0*	55.98*	69.5	4.69	14.0	66.50	0.77	0.80	4.17	1.2
2	Majjige Menasu-1	0.98	4.67	0.00	0.0	0.00	66.3	0.00	4.0	100.00	0.80	0.80	0.00	0.7
3	Panth C-1	1.11	5.90	15.7	25	46.03	69.7	25.15	28.9	12.98	0.77	0.90	14.81	1.2
4	Chikkaballapur local	0.90	3.93	57.0	13	55.88	83.1	34.24	40.9	16.28	1.00	1.20	-16.67	1.2
5	Rona	0.84	9.77	108.7	95	58.58	61.7	55.50	59.8	7.19	1.77	2.30	23.19	1.6
6	Shivani	4.25	12.37	28.3	93	87.47	188.1	90.38	119.6	24.43	2.87	2.90	1.15	1.9
7	Byadagi Dabba	1.90	9.67	21.3	73	68.60	137.1	80.10	83.7	4.30	2.10	2.30	8.70	1.2
8	LCA 206	1.60	7.47	33.0	73	61.78	89.0	104.18	107.7	3.27	2.33	3.10	24.73	1.3
9	G4	1.05	8.50	49.0	38	29.13	70.1	54.66	57.8	5.43	1.40	2.00	30.00	1.2
10	Paprika	1.73	10.80	33.0	93	64.61	98.7	89.80	90.7	0.99	1.67	2.17	23.08	2.0
11	Byadagi orange	1.93	9.85	25.0	63	38.68	70.4	66.15	67.8	2.43	2.07	2.20	6.06	1.2
12	Aparna	0.93	6.19	7.9	68	87.09	106.0	55.12	71.0	22.37	2.63	2.83	7.06	1.2
	Mean	1.585	7.915	32.79	53.21	54.49	92.46	55.00	62.16		1.68	1.96		1.3
	S.Em±	0.138	0.458	0.477	0.179	0.583	5.738	0.288	0.787		0.144	0.067		0.046
	C.D (<0.05P)	0.405	1.343	1.399	0.524	1.710	16.829	0.846	2.309		0.423	0.197		0.135
	CV (%)	15.09	10.02	16.026	4.75	14.51	10.749	8.070	2.193		14.85	5.95		5.965

Note: *values are square root transformed for analysis

NIF: Naturally infected fruits

AIF: Artificially inoculated fruits

The genotypes recorded significant differences for No. of lesions/ fruit. Genotype Majjige Menasu-1 recorded lowest number. of lesions/ fruit (0.7). Paprika genotype recorded highest number of lesions/ fruit (2.0). (Table 4.17).

Fresh ungerminated seeds (%) recorded significant differences among the genotypes studied. The highest fresh ungerminated seeds was recorded in Majjige Menasu-1 (63 %) followed by Assam Bhut Jolokia (56 %). followed by Panth C-1 (27) and G₄ (24). While, fresh ungerminated seeds was absent in the genotypes Chikkaballapur local, Rona, Shivani, Byadagi Dabba, LCA 206, Paprika, Byadagi orange and Aparna.

Germination (%) of naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose genotypes showed significant differences. In NIF the highest germination (%) was recorded in Byadagi Dabba (95 %). While among the artificially inoculated fruits, Chikkaballapur local (76 %) recorded highest germination (%). The lowest seed germination Majjige Menasu-1 (37 and 27 %, respectively) was recorded in both NIF and AIF.

In naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose genotypes showed significant differences for seedling length (cm). For both NIF and AIF highest was recorded in Byadagi Dabba (18 and 16.35 cm, respectively). Whereas, for both NIF and AIF lowest seedling length was recorded in Assam Bhut Jolokia (7.67 and 6.48 cm, respectively).

In naturally infected and artificially inoculated fruits of anthracnose genotypes showed significant differences for vigour index-I. Among naturally infected and artificially inoculated highest vigour index-I was recorded in Byadagi Dabba (1706 and 984, respectively). The lowest vigour index-I among NIF and AIF was recorded in Majjige Menasu-1 (307 and 205, respectively).

The Seedling vigour index-II of naturally infected and artificially inoculated fruits of anthracnose genotypes showed significant differences. In NIF the highest vigour index-II was recorded in Byadagi Dabba (1404) whereas the lower vigour index-II was

Table 4.17. Seed quality parameters in relation to capsaicin and oleoresin content

Sl. No.	Genotypes	Fresh ungerminated seeds (%)	Germination (%)		Per cent change	Seedling length (cm)		Per cent change	Seedling vigour index-I		Per cent change	Seedling vigour index-II		Per cent change
			NIF	AIF		NIF	AIF		NIF	AIF		NIF	AIF	
1	Assam Bhut Jolokia	56*	44	35	20.45	7.67	6.48	15.5	341	227	33.48	376	256	32.08
2	Majjige Menasu-1	63	37	27	27.03	8.00	7.58	5.3	307	205	33.37	419	269	35.68
3	Panth C-1	27	73	72	1.37	10.00	9.17	8.3	721	676	6.28	814	727	10.75
4	Chikkaballapur local	0	85	76	10.59	12.00	11.37	5.3	1042	862	17.29	1088	874	19.60
5	Rona	0	89	55	38.20	11.67	10.77	7.7	1040	596	42.74	1116	624	44.03
6	Shivani	0	81	54	33.33	16.33	10.37	36.5	1331	560	57.92	1109	675	39.11
7	Byadagi Dabba	0	95	60	36.84	18.00	16.35	9.2	1706	984	42.31	1404	814	42.00
8	LCA 206	0	90	68	24.44	13.00	11.17	14.1	1211	756	37.59	1118	754	32.55
9	G4	24	76	72	5.26	14.00	12.56	10.3	1049	900	14.15	872	729	16.31
10	Paprika	0	90	68	24.44	13.33	11.76	11.8	1205	796	33.92	993	666	32.94
11	Byadagi orange	0	87	62	28.74	15.33	12.46	18.7	1329	769	42.17	1104	709	35.75
12	Aparna	0	91	69	24.18	15.67	13.36	14.7	1450	917	36.73	1239	846	31.71
	Mean	14	78	60		12.92	11.12		1061	687		971	662	
	S.Em±	0.053	1.377	0.907		0.645	0.406		64.68	24.84		25.04	17.54	
	C.D (<0.05P)	0.155	4.039	2.660		1.892	1.192		189.71	72.85		73.45	51.45	
	CV (%)	4.02	3.05	2.62		8.60	6.33		10.56	6.26		4.47	4.59	

Note: *values are square root transformed for analysis **NIF:** Naturally infected fruits **AIF:** Artificially inoculated fruits

recorded in Assam Bhut Jolokia (376). In AIF the highest vigour index-II was recorded in Chikkaballapur local (874) whereas, lower was recorded in Assam Bhut Jolokia (256).

Among healthy fruits, naturally infected (NIF) and artificially inoculated (AIF) fruits with anthracnose showed significant differences for capsaicin content in Scoville Hot Unit (SHU) among the hot pepper genotypes under study (Table 4.18).

The genotype Assam Bhut Jolokia recorded highest capsaicin content in placenta, seed and pericarp (1201385, 1178999 and 1016960 SHU, respectively). The lowest was recorded in genotype Shivani (2274, 1384 and 1360 SHU) in placenta, seed and Pericarp, respectively. Whereas, NIF of genotype Assam Bhut Jolokia recorded highest capsaicin content (1113963, 1078003, and 882100 SHU) in placenta, seed and Pericarp, respectively. The lowest was recorded in genotype Shivani (1779, 1362, and 1138 SHU) in placenta, seed and pericarp, respectively. While, AIF of genotype Assam Bhut Jolokia recorded highest capsaicin content (1078003, 1066025, and 811130 SHU) in placenta, seed and Pericarp, respectively. The lowest was recorded in genotype Shivani (1665, 1587, and 975 SHU) in placenta, seed and Pericarp, respectively.

Oleoresin of Healthy fruits, naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose fruits differed significantly among the genotypes studied. Highest per cent oleoresin was recorded in Byadagi Dabba (21.14, 16.37 and 18.57 %, respectively) followed by Paprika (19.02, 14.52 and 16.74 %, respectively). While, the lowest oleoresin content was recorded in Majjige Menasu-1 (4.29, 3.25 and 3.76 %).

4.3 Experiment III: To study the seed quality attributes as influenced by capsaicin and oleoresin during storage

In the present study, the retention of seed quality attributes of hot pepper genotypes (seeds and whole fruits) stored in three packaging was studied. Further, to assess the causes for loss of seed germination, seedling length and SVI-I, vigour constituent changes like loss of electrolytes, total dehydrogenase activity were studied. Besides, amylase activity, capsaicin content and oleoresin content during storage have been recorded and the results are presented under following headings.

Table 4.18. Capsaicin content (SHU) and oleoresin content (%) in relation to fruit rot incidence

Genotypes	Capsaicin content (SHU)														
	Healthy fruits			Naturally infected fruits					Artificially inoculated fruits						
	Placenta	Seed	Pericarp	Placenta	Per cent change	Seed	Per cent change	Pericarp	Per cent change	Placenta	Per cent change	Seed	Per cent change	Pericarp	Per cent change
Assam Bhut Jolokia	1201385	1178999	1016960	1113936	7.28	1078003	8.57	882100	13.26	1078003	10.27	1066025	9.58	811130	20.24
Majjige Menasu-1	1007312	924328	832028	913904	9.27	893818	3.30	721693	13.26	903861	10.27	883775	4.39	663626	20.24
Panth C-1	821008	740601	732364	671207	18.25	663021	10.48	554927	24.23	654836	20.24	646651	12.69	481910	34.20
Chikkaballapur local	824098	753837	730456	747679	9.27	731247	3.00	611742	16.25	657301	20.24	624436	17.17	538916	26.22
Rona	81012	56718	44721	70269	13.26	67846	19.62	32994	26.22	58154	28.22	55731	1.74	28090	37.19
Shivani	2274	1384	1630	1779	21.77	1632	17.92	1138	30.18	1665	26.78	1587	14.67	975	40.18
Byadagi Dabba	21957	592549	7798	18607	15.26	17732	97.01	6220	20.24	17513	20.24	17075	97.12	5442	30.21
LCA 206	632663	581346	343295	561381	11.27	548766	5.60	273812	20.24	523535	17.25	504612	13.20	215627	37.19
G4	675809	625616	542817	626617	7.28	613141	1.99	487070	10.27	539025	20.24	579452	7.38	395068	27.22
Paprika	17948	16852	5983	13957	22.24	12884	23.55	4176	30.20	12526	30.21	12168	27.79	4176	30.20
Byadagi orange	20939	16609	3446	18162	13.26	17327	4.32	2749	20.23	15657	25.23	14196	14.53	2302	33.20
Aparna	18291	13933	6281	13409	26.69	12218	12.31	3757	40.18	11597	36.60	11124	20.16	3256	48.16
Mean	443725	458564	355648	397576	15	388136	17	298532	22	372806	22	368069	20	262543	32
S.Em±	2723	2552	1408	1737		1694		1179		2325		1639		1042	
C.D (<0.05P)	7985	7484	4130	5094		4968		3457		6818		4806		3056	
CV (%)	1.06	1.07	0.873	0.757		0.756		0.878		1.080		0.771		0.895	

Table 4.19. Oleoresin (%) content in relation to fruit rot incidence

Sl. No.	Genotypes	Oleoresin content (%)				
		Healthy fruit	NIF	Per cent Reduction	AIF	Per cent Reduction
1	Assam Bhut Jolokia	14.02	12.78	8.84	13.38	4.57
2	Majjige Menasu-1	4.29	3.25	24.24	3.76	12.24
3	Panth C-1	11.17	9.17	17.86	10.15	9.08
4	Chikkaballapur local	15.67	12.76	18.58	14.19	9.44
5	Rona	13.08	11.31	13.57	12.17	6.93
6	Shivani	6.08	4.61	24.26	5.33	12.28
7	Byadagi Dabba	21.14	16.37	22.55	18.57	12.16
8	LCA 206	14.94	13.38	10.41	14.13	5.36
9	G4	9.81	5.91	39.76	8.06	17.83
10	Paprika	19.02	14.52	23.69	16.74	11.99
11	Byadagi orange	5.82	4.79	17.81	5.30	9.05
12	Aparna	7.25	4.19	42.21	5.71	21.25
	Mean	11.86	9.42		10.63	
	S.Em±	0.370	0.153		0.326	
	C.D (<0.05P)	1.085	0.448		0.956	
	CV (%)	5.405	2.810		5.313	

Table 4.20. Initial seed quality parameters of hot pepper genotypes selected to evaluate seed quality parameters in relation to capsaicin and oleoresin for seed storage

Parameters	Genotypes														
	G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
Electrical conductivity (mS cm ⁻¹ g ⁻¹) of seed leachate	30.24	18.24	15.28	11.35	17.19	14.34	13.28	10.51	17.58	15.78	9.34	11.23	0.39	1.14	4.4
Germination per cent	40	44	76	79	88	80	82	86	80	81	82	86	1.73	5.06	4.0
Mean seedling length (cm)	7.32	7.81	8.72	12.00	11.28	17.28	17.21	15.88	13.23	13.56	15.23	15.62	0.29	0.85	3.9
Seedling vigour index-I	287	349	664	924	1001	1384	1412	1377	1094	1100	1250	1344	46.13	134.64	7.9
Total soluble seed protein (µg g ⁻¹)	6.33	7.21	13.88	12.33	12.88	18.33	19.27	17.42	11.11	17.11	14.2	15.21	0.32	0.94	4.0
Field emergence (%)	38	42	75	77	86	76	78	83	74	79	78	83	1.68	4.90	4.0
Total dehydrogenase activity (A ⁰ 480 nm)	0.913	1.413	1.813	1.783	2.714	3.115	3.44	2.931	1.923	2.963	1.936	2.653	0.05	0.16	4.1
Oleoresin content (%)	14.15	5.31	12.11	15.88	14.12	7.54	22.16	16.1	11.33	20.14	6.33	8.88	0.32	0.94	4.3
α-amylase activity (µg g ⁻¹ ml ⁻¹ min ⁻¹)	13.44	21.11	24.61	25.15	35.13	38.11	35.66	33.18	24.16	34.15	25.16	36.36	0.67	1.96	4.0
Capsaicin content (µg g ⁻¹)	468	321	218	382	42	76	138	204	201	48	142	118	5.99	17.49	5.3

Genotypes (G)

G₁ : Assam Bhut Jolokia
G₂ : Majjige Menasu-1
G₃ : Chikkaballapur local
G₄ : Panth C-1
G₅ : Rona
G₆ : Shivani

G₇ : Byadagi Dabba
G₈ : LCA206
G₉ : G4
G₁₀ : Paprika
G₁₁ : Aparna
G₁₂ : Byadagi Orange Selection

4.3.1 Moisture (%): The data on seed moisture as influenced by genotypes, packaging, materials and their interaction effects are presented in Table (4.21).

Genotypes: Significant differences were recorded between the genotypes for moisture content throughout storage period except six and nine months of storage periods. The higher seed moisture content was recorded in G₉ (7.61 %) followed by G₁ (7.47 %), G₇ (7.46 %) and lower seed moisture was recorded in G₁₁ (7.18 %) followed by G₈ (7.27 %) and G₁₂ (7.33 %) at the end of three months of storage period. The 12th month storage, the G₇ (7.32 %) followed by G₉ (7.23 %), G₁₀ (7.20 %) and lower seed moisture was recorded in G₆ (6.81 %) followed by G₁₁ (6.96 %) and G₈ (7.09 %, respectively. During 15th month storage, higher seed moisture was recorded in G₇ (7.22 %) followed by G₉ (7.13 %), G₁₀ (7.11 %) and lower seed moisture was recorded in G₆ (6.71 %) followed by G₁₁ (6.86 %) and G₈ (7.0 %), respectively, and at the end 18th months of storage, The higher seed moisture was recorded in G₇ (7.71 %) followed by G₉ (7.62 %) and lower seed moisture was recorded in G₆ (7.18 %) followed by G₁₁ (7.35 %) and G₈ (7.48 %), respectively. During 21st month storage, the higher seed moisture was recorded in G₇ (7.96 %) followed by G₉ (7.87 %), G₁₀ (7.84 %) and lower seed moisture was recorded in G₆ (7.44 %) followed by G₁₁ (7.60 %) and G₈ (7.72 %), respectively, at end of 24 months of storage higher seed moisture was recorded in G₇ (7.78 %) followed by G₉ (7.70 %), G₁ (7.69 %), respectively. The lower seed moisture was recorded in G₃ (7.06 %) followed by G₆ (7.25 %) and G₁₁ (7.42 %), respectively.

Fruit and seed materials: Moisture (%) differed significantly among the materials during the storage period. Whole fruits (M₁) recorded the highest moisture (%) content throughout the storage period. At three months of storage, the higher seed moisture (%) was recorded in M₁ (8.43 %) and M₂ (6.33 %). At six months storage the M₁ (8.28%) and M₂ (6.22 %), at nine months M₁ (8.33 %) and M₂ (6.20 %). The 12, 15, 18 21 and 24th months storage, the M₁ was recorded significantly over M₂, the higher seed moisture content was (7.74 %, 7.74%, 8.43 %, 8.91 % and 8.68 %) and (6.49 %, 6.29 %, 6.59 %, 6.60 % and 6.39% in M₂), respectively.

Table 4.21. Moisture content (%) of seed as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	7.48	7.26	7.24	6.62	7.02	7.5	8.25	7.4
G ₂	7.39	7.29	7.28	6.66	7.04	7.55	8.29	7.43
G ₃	7.41	7.3	7.26	6.63	7.03	7.51	8.26	7.41
G ₄	7.34	7.23	7.2	6.6	7	7.48	8.23	7.38
G ₅	7.34	7.31	7.26	6.63	7.03	7.52	8.27	7.42
G ₆	7.38	7.31	7.28	6.31	6.71	7.19	7.94	7.09
G ₇	7.45	7.41	7.39	6.82	7.22	7.7	8.45	7.6
G ₈	7.27	7.24	7.22	6.6	7	7.48	8.23	7.38
G ₉	7.62	7.4	7.37	6.74	7.14	7.63	8.38	7.53
G ₁₀	7.36	7.32	7.3	6.7	7.1	7.59	8.34	7.49
G ₁₁	7.18	7.13	7.09	6.47	6.87	7.35	8.11	7.25
G ₁₂	7.32	7.27	7.24	6.63	7.03	7.51	8.26	7.41
S.Em ±	0.066	0.064	0.064	0.058	0.062	0.066	0.073	0.065
CD (<0.05P)	0.183	NS	NS	0.162	0.172	0.184	0.203	0.182
M ₁	8.43	8.36	8.33	7.24	7.74	8.41	9.41	8.4
M ₂	6.33	6.22	6.2	5.99	6.29	6.59	7.09	6.39
S.Em ±	0.027	0.026	0.026	0.024	0.025	0.027	0.03	0.027
CD (<0.05P)	0.075	0.073	0.073	0.066	0.07	0.075	0.083	0.074
P ₁	7.85	7.08	7.07	6.56	6.96	7.61	8.36	7.51
P ₂	7.22	7.58	7.53	6.75	7.15	7.55	8.3	7.45
P ₃	7.07	7.2	7.19	6.54	6.94	7.34	8.09	7.24
S.Em ±	0.033	0.032	0.032	0.029	0.031	0.033	0.036	0.033
CD (<0.05P)	0.092	0.09	0.09	0.081	0.086	0.092	0.102	0.091
G ₁ M ₁	8.73	8.34	8.32	7.3	7.79	8.46	9.45	8.46
G ₁ M ₂	6.23	6.18	6.16	5.95	6.25	6.54	7.04	6.34
G ₂ M ₁	8.48	8.47	8.46	7.44	7.9	8.61	9.6	8.57
G ₂ M ₂	6.3	6.11	6.09	5.88	6.18	6.48	6.98	6.28
G ₃ M ₁	8.38	8.28	8.24	7.19	7.69	8.35	9.35	8.35
G ₃ M ₂	6.44	6.32	6.28	6.07	6.37	6.67	7.17	6.47
G ₄ M ₁	8.26	8.16	8.13	7.13	7.62	8.29	9.28	8.29
G ₄ M ₂	6.42	6.3	6.28	6.07	6.37	6.67	7.17	6.47
G ₅ M ₁	8.37	8.35	8.3	7.24	7.74	8.41	9.41	8.41
G ₅ M ₂	6.32	6.27	6.23	6.03	6.33	6.63	7.13	6.43
G ₆ M ₁	8.41	8.39	8.35	6.62	7.12	7.79	8.79	7.79
G ₆ M ₂	6.35	6.23	6.2	5.99	6.29	6.59	7.09	6.39
G ₇ M ₁	8.47	8.52	8.5	7.48	7.98	8.64	9.64	8.64
G ₇ M ₂	6.42	6.3	6.28	6.16	6.46	6.76	7.25	6.56
G ₈ M ₁	8.24	8.16	8.15	7.1	7.61	8.27	9.27	8.27
G ₈ M ₂	6.31	6.31	6.29	6.09	6.39	6.69	7.19	6.49
G ₉ M ₁	8.89	8.61	8.58	7.51	8.02	8.69	9.69	8.69
G ₉ M ₂	6.36	6.2	6.17	5.96	6.26	6.56	7.06	6.36
G ₁₀ M ₁	8.38	8.45	8.42	7.44	7.94	8.6	9.6	8.6
G ₁₀ M ₂	6.33	6.19	6.18	5.97	6.27	6.57	7.07	6.37

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	8.22	8.18	8.15	7.12	7.62	8.29	9.3	8.29
G ₁₁ M ₂	6.15	6.08	6.02	5.81	6.11	6.41	6.91	6.21
G ₁₂ M ₁	8.34	8.35	8.32	7.3	7.8	8.47	9.47	8.47
G ₁₂ M ₂	6.29	6.19	6.16	5.95	6.25	6.55	7.05	6.35
S.Em $\pm$	0.093	0.091	0.091	0.082	0.087	0.093	0.103	0.092
CD (<0.05P)	0.259	0.254	0.253	0.229	0.243	0.261	0.287	0.258
M ₁ P ₁	8.96	8.09	8.08	7.1	7.59	8.6	9.6	8.59
M ₁ P ₂	8.26	8.67	8.61	7.33	7.83	8.33	9.33	8.33
M ₁ P ₃	8.07	8.31	8.29	7.29	7.79	8.29	9.29	8.29
M ₂ P ₁	6.73	6.08	6.05	6.02	6.32	6.62	7.12	6.42
M ₂ P ₂	6.19	6.49	6.45	6.17	6.47	6.77	7.27	6.57
M ₂ P ₃	6.06	6.1	6.09	5.79	6.09	6.39	6.89	6.19
S.Em $\pm$	0.046	0.045	0.045	0.041	0.044	0.047	0.051	0.046
CD (<0.05P)	0.13	NS	0.127	0.114	0.122	0.13	0.144	0.129
G ₁ P ₁	8.21	6.96	6.94	6.46	6.85	7.5	8.24	7.4
G ₁ P ₂	7.2	7.67	7.62	6.91	7.31	7.71	8.46	7.61
G ₁ P ₃	7.03	7.16	7.15	6.5	6.9	7.3	8.05	7.2
G ₂ P ₁	7.89	7.07	7.08	6.59	6.94	7.66	8.39	7.5
G ₂ P ₂	7.2	7.53	7.49	6.78	7.18	7.58	8.33	7.48
G ₂ P ₃	7.09	7.28	7.26	6.61	7.01	7.41	8.16	7.31
G ₃ P ₁	7.94	7.14	7.14	6.6	7	7.65	8.4	7.55
G ₃ P ₂	7.32	7.73	7.66	6.95	7.35	7.75	8.5	7.65
G ₃ P ₃	6.97	7.03	7	6.36	6.75	7.15	7.89	7.05
G ₄ P ₁	7.72	7.01	7	6.51	6.91	7.55	8.3	7.45
G ₄ P ₂	7.24	7.59	7.53	6.85	7.25	7.65	8.4	7.55
G ₄ P ₃	7.05	7.11	7.09	6.44	6.84	7.24	7.99	7.14
G ₅ P ₁	7.72	7.08	7.05	6.58	6.98	7.63	8.39	7.53
G ₅ P ₂	7.24	7.68	7.61	6.84	7.24	7.64	8.39	7.54
G ₅ P ₃	7.07	7.16	7.13	6.48	6.88	7.28	8.03	7.18
G ₆ P ₁	7.86	7.11	7.11	6.54	6.94	7.59	8.34	7.49
G ₆ P ₂	7.24	7.67	7.6	5.91	6.31	6.71	7.46	6.61
G ₆ P ₃	7.06	7.17	7.13	6.48	6.88	7.28	8.03	7.18
G ₇ P ₁	7.96	7.16	7.14	6.63	7.03	7.68	8.43	7.58
G ₇ P ₂	7.24	7.74	7.7	7.14	7.54	7.94	8.69	7.84
G ₇ P ₃	7.14	7.34	7.33	6.68	7.08	7.48	8.23	7.38
G ₈ P ₁	7.55	7.07	7.06	6.53	6.93	7.58	8.34	7.48
G ₈ P ₂	7.2	7.49	7.46	6.76	7.16	7.56	8.31	7.46
G ₈ P ₃	7.08	7.15	7.15	6.5	6.9	7.3	8.05	7.2
G ₉ P ₁	8.51	7.27	7.24	6.68	7.09	7.75	8.51	7.65
G ₉ P ₂	7.26	7.63	7.58	6.88	7.28	7.68	8.43	7.58
G ₉ P ₃	7.11	7.32	7.3	6.65	7.05	7.45	8.2	7.35
G ₁₀ P ₁	7.74	7.07	7.05	6.62	7.02	7.67	8.42	7.57
G ₁₀ P ₂	7.24	7.6	7.55	6.86	7.26	7.66	8.41	7.56
G ₁₀ P ₃	7.09	7.3	7.29	6.64	7.04	7.44	8.19	7.34
G ₁₁ P ₁	7.4	7.03	6.96	6.44	6.84	7.49	8.24	7.39
G ₁₁ P ₂	7.14	7.23	7.19	6.5	6.9	7.31	8.07	7.21
G ₁₁ P ₃	7.02	7.13	7.11	6.46	6.86	7.26	8.01	7.16

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₁	7.65	7.06	7.02	6.54	6.94	7.59	8.34	7.49
G ₁₂ P ₂	7.17	7.42	7.37	6.67	7.07	7.47	8.22	7.37
G ₁₂ P ₃	7.13	7.33	7.33	6.68	7.08	7.48	8.23	7.38
S.Em $\pm$	0.114	0.111	0.111	0.1	0.107	0.114	0.126	0.113
CD (<0.05P)	0.317	NS	NS	0.28	0.298	0.319	0.352	0.316
G ₁ M ₁ P ₁	9.9	7.97	7.96	7.02	7.51	8.5	9.49	8.5
G ₁ M ₁ P ₂	8.24	8.76	8.72	7.6	8.1	8.6	9.6	8.6
G ₁ M ₁ P ₃	8.05	8.3	8.27	7.27	7.77	8.27	9.27	8.27
G ₁ M ₂ P ₁	6.52	5.95	5.93	5.9	6.2	6.49	6.98	6.29
G ₁ M ₂ P ₂	6.16	6.57	6.51	6.21	6.51	6.81	7.31	6.61
G ₁ M ₂ P ₃	6	6.02	6.03	5.73	6.03	6.33	6.83	6.13
G ₂ M ₁ P ₁	9.01	8.07	8.11	7.17	7.56	8.69	9.66	8.57
G ₂ M ₁ P ₂	8.35	8.93	8.89	7.76	8.26	8.76	9.76	8.76
G ₂ M ₁ P ₃	8.08	8.42	8.39	7.39	7.89	8.39	9.39	8.39
G ₂ M ₂ P ₁	6.78	6.07	6.05	6.02	6.32	6.62	7.12	6.42
G ₂ M ₂ P ₂	6.04	6.12	6.09	5.79	6.09	6.39	6.89	6.19
G ₂ M ₂ P ₃	6.09	6.13	6.13	5.83	6.13	6.43	6.93	6.23
G ₃ M ₁ P ₁	8.94	8.16	8.18	7.13	7.63	8.63	9.63	8.63
G ₃ M ₁ P ₂	8.29	8.69	8.6	7.48	7.98	8.48	9.48	8.48
G ₃ M ₁ P ₃	7.91	7.98	7.95	6.96	7.45	7.95	8.93	7.95
G ₃ M ₂ P ₁	6.94	6.12	6.09	6.06	6.36	6.66	7.16	6.46
G ₃ M ₂ P ₂	6.34	6.76	6.71	6.41	6.71	7.01	7.51	6.81
G ₃ M ₂ P ₃	6.04	6.07	6.05	5.75	6.05	6.35	6.85	6.15
G ₄ M ₁ P ₁	8.57	7.91	7.89	6.95	7.44	8.43	9.41	8.43
G ₄ M ₁ P ₂	8.19	8.49	8.42	7.36	7.86	8.36	9.36	8.36
G ₄ M ₁ P ₃	8.01	8.09	8.07	7.07	7.57	8.07	9.07	8.07
G ₄ M ₂ P ₁	6.87	6.1	6.1	6.08	6.38	6.68	7.18	6.48
G ₄ M ₂ P ₂	6.29	6.68	6.63	6.33	6.63	6.93	7.43	6.73
G ₄ M ₂ P ₃	6.09	6.12	6.11	5.81	6.11	6.41	6.91	6.21
G ₅ M ₁ P ₁	8.75	8.07	8.04	7.11	7.62	8.62	9.62	8.62
G ₅ M ₁ P ₂	8.26	8.73	8.64	7.4	7.9	8.4	9.4	8.4
G ₅ M ₁ P ₃	8.09	8.24	8.21	7.21	7.71	8.21	9.21	8.21
G ₅ M ₂ P ₁	6.69	6.09	6.07	6.05	6.35	6.65	7.15	6.45
G ₅ M ₂ P ₂	6.22	6.63	6.58	6.28	6.58	6.88	7.38	6.68
G ₅ M ₂ P ₃	6.04	6.08	6.05	5.75	6.05	6.35	6.85	6.15
G ₆ M ₁ P ₁	8.84	8.09	8.1	7	7.5	8.5	9.5	8.5
G ₆ M ₁ P ₂	8.29	8.79	8.71	5.62	6.12	6.62	7.62	6.62
G ₆ M ₁ P ₃	8.1	8.29	8.25	7.25	7.75	8.25	9.25	8.25
G ₆ M ₂ P ₁	6.87	6.12	6.11	6.08	6.38	6.68	7.18	6.48
G ₆ M ₂ P ₂	6.18	6.54	6.49	6.19	6.49	6.79	7.29	6.59
G ₆ M ₂ P ₃	6.01	6.04	6.01	5.71	6.01	6.31	6.81	6.11
G ₇ M ₁ P ₁	8.93	8.13	8.13	7.17	7.67	8.67	9.67	8.67
G ₇ M ₁ P ₂	8.32	8.92	8.87	7.75	8.25	8.75	9.75	8.75
G ₇ M ₁ P ₃	8.17	8.52	8.51	7.51	8.01	8.51	9.51	8.51
G ₇ M ₂ P ₁	6.99	6.18	6.15	6.09	6.39	6.69	7.19	6.49
G ₇ M ₂ P ₂	6.17	6.56	6.54	6.54	6.83	7.13	7.62	6.93
G ₇ M ₂ P ₃	6.11	6.16	6.15	5.85	6.15	6.45	6.95	6.25
G ₈ M ₁ P ₁	8.62	8.12	8.13	7.08	7.59	8.59	9.59	8.59

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₂	8.09	8.28	8.23	7.13	7.63	8.13	9.13	8.13
G ₈ M ₁ P ₃	8	8.09	8.1	7.1	7.6	8.1	9.1	8.1
G ₈ M ₂ P ₁	6.48	6.02	6	5.98	6.28	6.58	7.08	6.38
G ₈ M ₂ P ₂	6.31	6.7	6.68	6.38	6.68	6.98	7.48	6.78
G ₈ M ₂ P ₃	6.15	6.21	6.2	5.9	6.2	6.5	7	6.3
G ₉ M ₁ P ₁	10.12	8.39	8.38	7.29	7.8	8.81	9.83	8.81
G ₉ M ₁ P ₂	8.38	8.9	8.83	7.73	8.23	8.73	9.73	8.73
G ₉ M ₁ P ₃	8.17	8.54	8.52	7.52	8.02	8.52	9.52	8.52
G ₉ M ₂ P ₁	6.91	6.15	6.11	6.08	6.38	6.68	7.18	6.48
G ₉ M ₂ P ₂	6.13	6.35	6.33	6.03	6.33	6.63	7.13	6.43
G ₉ M ₂ P ₃	6.04	6.09	6.08	5.78	6.08	6.38	6.88	6.18
G ₁₀ M ₁ P ₁	8.73	8.06	8.05	7.19	7.69	8.69	9.69	8.69
G ₁₀ M ₁ P ₂	8.3	8.81	8.74	7.65	8.15	8.65	9.65	8.65
G ₁₀ M ₁ P ₃	8.11	8.49	8.47	7.47	7.97	8.47	9.47	8.47
G ₁₀ M ₂ P ₁	6.74	6.08	6.05	6.04	6.34	6.64	7.14	6.44
G ₁₀ M ₂ P ₂	6.19	6.39	6.37	6.07	6.37	6.67	7.17	6.47
G ₁₀ M ₂ P ₃	6.07	6.11	6.11	5.81	6.11	6.41	6.91	6.21
G ₁₁ M ₁ P ₁	8.42	8.03	8.01	7	7.5	8.5	9.5	8.5
G ₁₁ M ₁ P ₂	8.2	8.29	8.25	7.16	7.67	8.17	9.19	8.17
G ₁₁ M ₁ P ₃	8.03	8.21	8.2	7.2	7.7	8.2	9.2	8.2
G ₁₁ M ₂ P ₁	6.38	6.02	5.9	5.88	6.18	6.48	6.98	6.28
G ₁₁ M ₂ P ₂	6.07	6.17	6.14	5.84	6.14	6.44	6.94	6.24
G ₁₁ M ₂ P ₃	6	6.05	6.02	5.72	6.02	6.32	6.82	6.12
G ₁₂ M ₁ P ₁	8.69	8.06	8.03	7.09	7.59	8.59	9.59	8.59
G ₁₂ M ₁ P ₂	8.16	8.47	8.42	7.31	7.81	8.31	9.31	8.31
G ₁₂ M ₁ P ₃	8.17	8.51	8.51	7.51	8.01	8.51	9.51	8.51
G ₁₂ M ₂ P ₁	6.61	6.05	6.01	5.98	6.28	6.58	7.08	6.38
G ₁₂ M ₂ P ₂	6.17	6.36	6.32	6.02	6.32	6.62	7.12	6.42
G ₁₂ M ₂ P ₃	6.09	6.15	6.14	5.84	6.14	6.44	6.94	6.24
S.Em ±	0.161	0.158	0.157	0.142	0.151	0.162	0.178	0.16
CD (<0.05P)	NS	NS	NS	0.396	0.422	0.452	0.498	0.447
CV (%)	3.768	3.745	3.743	3.71	3.723	3.73	3.738	3.743

Initial moisture content (MC): Fruits – 8 % MC

Seeds – 6 % MC

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

Packaging: The effect of packaging on moisture (%) was significantly differed throughout storage period. The higher seed moisture content was recorded in P₁ (7.85 %) followed by P₂ (7.22 %) and P₃ recorded (7.07 %) at the end of 3 months storage. At 6th month storage, P₁ (7.51 %), P₂ (7.21 %) and P₃ (7.03 %) and during 9th month P₁ (7.53%), P₂ (7.18 %) and P₃ (7.07 %) recorded higher seed moisture content. At the end of 12th, 15th, P₁ (7.25 %, 7.16 %) recorded significantly higher seed moisture content over P₂ (7.06 %, 6.95 %) and P₃ (7.04 % and 6.93 %), respectively. At 18th, 21st and 24th month's after storage, P₁ recorded significantly over P₂ and P₃. The higher seed moisture content was recorded in P₁ (7.64 %, 7.86 % and 7.92%), in P₂ (7.56 %, 7.80 % and 7.46 %) and lower seed moisture content was recorded in P₃ (7.34 %, 7.59 % and 7.24 %) at 18th, 21st and 24th month's after storage.

Genotypes × Fruit and seed materials: Genotypes × Materials interaction for moisture (%) content was significant throughout the storage period. The higher seed moisture (%) content was recorded in G₉M₁ (8.87 %) followed by G₁M₁ (8.72 %), G₂M₁ (8.49 %) and lower moisture was recorded in G₁₁M₂ (6.13 %) followed by G₁M₂ (6.21 %) and G₁₂M₂ (6.30 %) at the end of three months of storage. The higher seed moisture (%) content was recorded in G₉M₁ (8.62 %) followed by G₇M₁ (8.53 %) and lower moisture content was recorded in G₁₁M₂ (6.09 %), G₂M₂ (6.10 %) at the end of six months of storage. At the end of nine months storage, the higher seed moisture (%) content was recorded in G₉M₁ (8.58 %) followed by G₇M₁ (8.51 %) and G₂M₁ (8.47 %) and lower moisture content was recorded in G₁₁M₂ (6.02 %) followed by G₂M₂ (6.10 %), respectively. The higher seed moisture content was recorded in G₉M₁ (8.00 %) followed by G₇M₁ (7.98 %) and G₂M₁ (7.94 %) and lower moisture content was recorded in G₁₁M₂ (6.30 %) followed by G₂M₂ (6.38 %), respectively during 12th month of storage. At 15th month storage period, the higher seed moisture content was recorded in G₉M₁ (8.00%) followed by and G₇M₁ (7.98 %) and G₁₀M₁ (7.94 %) and lower moisture content was recorded in G₁₁M₂ (6.11 %) followed by G₂M₂ (6.19 %) and G₁M₂ (6.23 %), respectively. At the end of 18th month storage period, the higher seed moisture content was recorded in G₂M₁ (8.73 %) followed by G₉M₁ (8.69 %) and G₇M₁ (8.66 %) and lower moisture content was recorded in G₁₁M₂ (6.41 %) and G₂M₂ (6.49 %), respectively. Whereas, at

the end of 21st month storage period, the higher seed moisture content was recorded in G₉M₁ (9.19 %) followed by G₇M₁ (9.16 %) and G₂M₁ (9.12 %) and lower moisture content was recorded in G₁₁M₂ (6.41 %) followed by G₂M₂ (6.48 %) and G₁M₂ (6.53 %), respectively. At end of 24 months of storage period the higher seed moisture content was recorded in G₁M₁ (9.06 %) followed by G₉M₁ (9.03 %), G₇M₁ (9.00 %) and lower moisture content was recorded in G₁₁M₂ (6.21 %) followed by G₂M₂ (6.29 %) and G₁M₂ (6.33 %), respectively.

Fruit and seed materials × Packaging: The data on pertaining on Materials × Packaging interaction for moisture content (%) was significant throughout storage period except six months storage. The higher seed moisture content was recorded in M₁P₁ (8.96 %) followed by M₁P₂ (8.25 %) and lower moisture content was recorded in M₂P₃ (6.06%) and M₂P₂ (6.19 %) during three months of storage. At the end of nine months storage, the higher seed moisture content was recorded in M₁P₁ (8.61 %) followed by M₁P₂ (8.28 %) and lower moisture content was recorded in M₂P₃ (6.06 %) followed by M₂P₂ (6.09 %), respectively. The higher seed moisture content was recorded in M₁P₁ (7.83 %) followed by M₁P₃ (7.79 %) and lower moisture content was recorded in M₂P₃ (6.29 %) followed by M₂P₂ (6.52 %) and M₂P₁ (6.68 %) during 12th month of storage. At 15th month storage period, the higher seed moisture content was recorded in M₁P₁ (7.84 %) followed by M₁P₃ (7.78 %) and M₁P₂ (7.59 %) and lower moisture content was recorded in M₂P₃ (6.09 %) followed by M₂P₂ (6.32 %), respectively. At 18th month storage period, the higher seed moisture content was recorded in M₁P₁ (8.66 %) and M₁P₂ (8.34 %) and lower moisture content was recorded in M₂P₃ (6.39 %) followed by M₂P₁ (6.61%) and M₂P₂ (6.78 %), respectively. At 21st month storage period, the higher seed moisture content was recorded in M₁P₁ (9.11 %) followed by M₁P₂ (8.83 %) and lower moisture content was recorded in M₂P₃ (6.39 %) followed by M₂P₁ (6.62 %) and M₂P₂ (6.78 %), respectively. At the end of 24th month storage period, the higher seed moisture content was recorded in M₁P₁ (9.43 %) followed by M₁P₂ (8.34 %) and lower moisture content was recorded in M₂P₃ (6.19 %) followed by M₂P₁ (6.42 %) and M₂P₂ (6.58 %), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for moisture content (%) was significant throughout storage period except six and ninth month storage. The higher seed moisture was recorded in G_9P_1 (8.48 %) followed by G_1P_1 (8.22 %), G_7P_1 (7.97 %), G_3P_1 (7.93 %) and lower moisture content was recorded in G_3P_3 (6.98%) followed by G_1P_3 (7.00 %) which is on par with $G_{11}P_3$ (7.00 %) during three months of storage. The higher seed moisture content was recorded in G_7P_1 (7.67 %) followed by G_3P_1 (7.45 %) and G_1P_1 (7.43 %) and lower moisture content was recorded in G_6P_1 (6.40 %) and G_3P_3 (6.87 %) during 12th month of storage. At the end of 15th month storage period, the higher seed moisture content was recorded in G_7P_1 (7.55 %) followed by G_3P_1 (7.35 %) and lower moisture content was recorded in G_6P_1 (6.32 %) followed by G_3P_3 (6.75 %), respectively. At 18th month storage period, the higher seed moisture content was recorded in G_7P_2 (7.95 %) followed by G_2P_1 (7.83 %) and G_9P_1 (7.73 %) and lower moisture content was recorded in G_6P_2 (6.72 %) followed by G_3P_3 (7.13 %) and G_4P_3 (7.25 %), respectively. At the end of 21st month storage period, the higher seed moisture content was recorded in G_7P_2 (8.20 %) followed by G_9P_1 (8.02 %) and lower moisture content was recorded in G_6P_2 (6.95 %) followed by G_3P_3 (7.40 %) and G_4P_3 (7.48 %), respectively. At the end of 24th month storage period, the higher seed moisture content was recorded in G_1P_1 (8.30 %) followed by G_1P_9 (8.16 %) $G_{10}P_1$ (8.09 %) and lower moisture content was recorded in G_3P_1 (6.50 %) followed by G_6P_2 (6.62 %) and G_3P_3 (7.03 %), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of Genotypes × Materials × Packaging moisture content (%) was non-significantly during 3, 6 and 9th months storage period and was significantly differed rest of the storage period. At the end of 12th month storage, the maximum seed moisture content was recorded in $G_2 \times M_1 \times P_1$ (8.27 %) which is on par with $G_7 \times M_1 \times P_1$ (8.27 %) and lower moisture content was recorded in $G_6 \times M_1 \times P_1$ (6.10 %) and $G_6 \times M_2 \times P_3$ (6.20 %), respectively. At 15th month storage, the maximum seed moisture content was recorded in $G_2 \times M_1 \times P_1$ (8.27 %) and $G_7 \times M_1 \times P_1$ (8.27 %) and lower moisture content was recorded in $G_6 \times M_2 \times P_3$ (6.00 %) and $G_{11} \times M_2 \times P_3$ (6.03 %), respectively. At the end of 18th month storage, the maximum seed moisture content was recorded in $G_2 \times M_1 \times P_1$ (9.03 %) and $G_1 \times M_1 \times$

P_1 (8.90 %) and lower moisture content was recorded in $G_6 \times M_2 \times P_3$ (6.30 %) and $G_{11} \times M_2 \times P_3$ (6.33 %), respectively. At 21st month storage, the maximum seed moisture content was recorded in $G_9 \times M_1 \times P_1$ (9.37 %) and $G_2 \times M_1 \times P_2$ (9.30 %) and lower moisture content was recorded in $G_6 \times M_2 \times P_3$ (6.30 %) and $G_{11} \times M_2 \times P_3$ (6.33 %), respectively. At end of the storage period, the maximum seed moisture content was recorded in $G_1 \times M_1 \times P_1$ (10.33 %) and $G_9 \times M_1 \times P_1$ (9.82 %) and lower moisture content was recorded in $G_6 \times M_2 \times P_3$ (6.10 %) and $G_{11} \times M_2 \times P_3$ (6.13 %), respectively.

4.3.2 Germination (%)

The results on germination per cent as influenced by genotypes, packaging, materials and their interaction effects are presented (Table 4.22).

Genotypes: There was a significant difference between the genotypes for germination per cent throughout storage period. Irrespective of the genotypes, there was a decline in germination per cent during storage. Maximum germination was recorded in genotype G_9 (92 %) followed by G_5 (88 %). The higher seed germination per cent was recorded in G_5 (86 %) followed by G_8 (85 %), G_{12} (83 %) and lower seed germination was recorded in G_1 (37 %) followed by G_2 (44 %) and G_3 (75 %). At the end of six months storage, the higher seed germination was recorded in G_5 (80 %) followed by G_{12} (76 %), G_{10} (75 %) and lower seed germination was recorded in G_1 (30 %) followed by G_2 (35 %) and G_3 (70 %), respectively and during the periods of nine months G_5 (79 %), G_8 (78 %), G_{12} (75 %) and lower seed germination was recorded in G_1 (26 %) and G_2 (34 %). The 12th month storage, The G_5 (76 %) followed by G_8 (75 %), G_{12} (72 %) and lower seed germination was recorded in G_1 (20 %) followed by G_2 (28 %) and G_3 (68 %), respectively. During 15th storage, the higher seed germination was recorded in G_5 (73 %) on par with G_8 (73 %), G_{12} (69 %) and lower seed germination was recorded in G_1 (18 %) followed by G_2 (26 %) and G_3 (65 %), respectively and during 18th month storage, the higher seed germination was recorded in G_5 (71 %) followed by G_{12} (67 %) and lower seed germination was recorded in G_1 (16 %) followed by G_2 (24 %) and G_3 (66 %), respectively. During 21st storage, the higher seed germination was recorded in G_8 (69%) followed by G_{12} (66 %) and lower seed germination was recorded in G_1 (14 %) followed

Table 4.22. Germination (%) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	37 (22)*	30 (18)	26 (15)	20 (11)	18 (10)	16 (9)	14 (8)	11 (6)
G ₂	44 (26)	35 (20)	34 (20)	28 (16)	26 (15)	24 (14)	22 (13)	17 (10)
G ₃	75 (49)	70 (45)	69 (44)	68 (43)	65 (41)	63 (39)	61 (38)	61 (38)
G ₄	79 (52)	74 (48)	73 (47)	70 (44)	67 (42)	65 (41)	63 (39)	62 (39)
G ₅	86 (59)	80 (54)	79 (52)	76 (50)	73 (47)	71 (46)	69 (44)	69 (44)
G ₆	78 (51)	73 (47)	71 (45)	68 (43)	66 (41)	64 (40)	62 (38)	61 (38)
G ₇	81 (54)	75 (49)	74 (48)	71 (45)	68 (43)	66 (42)	65 (40)	64 (40)
G ₈	85 (59)	80 (53)	78 (52)	75 (49)	73 (47)	71 (45)	69 (44)	68 (43)
G ₉	76 (50)	71 (45)	69 (44)	66 (42)	63 (40)	62 (38)	60 (37)	59 (36)
G ₁₀	81 (54)	75 (48)	73 (47)	70 (45)	67 (43)	66 (41)	64 (40)	63 (39)
G ₁₁	81 (55)	75 (49)	74 (48)	71 (45)	68 (43)	66 (42)	64 (40)	64 (40)
G ₁₂	83 (56)	76 (50)	75 (49)	72 (46)	69 (44)	67 (43)	66 (41)	65 (41)
S.Em ±	0.63	0.54	0.52	0.49	0.46	0.44	0.42	0.41
CD (<0.05P)	1.77	1.52	1.47	1.37	1.29	1.22	1.17	1.16
M ₁	75 (50)	69 (45)	69 (44)	65 (41)	62 (39)	59 (37)	58 (36)	57 (36)
M ₂	73 (48)	66 (42)	64 (41)	61 (39)	59 (37)	57 (36)	55 (34)	54 (33)
S.Em ±	0.26	0.22	0.21	0.2	0.19	0.18	0.17	0.17
CD (<0.05P)	0.72	0.62	0.6	0.56	0.52	0.5	0.48	0.47
P ₁	73 (48)	63 (40)	61 (39)	58 (36)	52 (32)	50 (30)	48 (29)	46 (28)
P ₂	75 (50)	68 (44)	67 (43)	63 (40)	62 (39)	60 (38)	58 (36)	57 (36)
P ₃	74 (49)	72 (47)	71 (46)	68 (44)	66 (43)	65 (42)	64 (40)	63 (40)
S.Em ±	0.32	0.27	0.26	0.25	0.23	0.22	0.21	0.21
CD (<0.05P)	0.89	0.76	0.73	0.69	0.64	0.61	0.59	0.58
G ₁ M ₁	39 (23)	33 (19)	31 (18)	25 (14)	23 (13)	21 (12)	19 (11)	14 (8)
G ₁ M ₂	35 (20)	27 (16)	20 (12)	15 (8)	13 (7)	11 (6)	9 (5)	7 (4)
G ₂ M ₁	45 (27)	38 (22)	38 (22)	33 (19)	31 (18)	29 (17)	27 (15)	21 (12)
G ₂ M ₂	42 (25)	32 (19)	30 (18)	23 (14)	21 (12)	19 (11)	17 (10)	12 (7)
G ₃ M ₁	75 (49)	74 (48)	73 (47)	70 (44)	66 (42)	64 (40)	63 (39)	62 (39)
G ₃ M ₂	76 (50)	67 (42)	65 (41)	66 (41)	64 (40)	62 (38)	60 (37)	59 (36)
G ₄ M ₁	80 (53)	76 (50)	75 (49)	72 (46)	68 (44)	66 (42)	65 (41)	64 (40)
G ₄ M ₂	78 (51)	72 (46)	70 (45)	68 (43)	65 (41)	64 (40)	61 (38)	60 (37)
G ₅ M ₁	87 (60)	82 (55)	81 (54)	77 (51)	74 (48)	72 (46)	70 (45)	70 (45)
G ₅ M ₂	84 (58)	79 (52)	77 (50)	74 (48)	72 (46)	70 (45)	68 (43)	67 (42)
G ₆ M ₁	79 (53)	74 (48)	73 (47)	70 (45)	67 (42)	64 (40)	63 (39)	62 (39)
G ₆ M ₂	77 (50)	71 (46)	69 (44)	67 (42)	65 (40)	63 (39)	61 (38)	60 (37)
G ₇ M ₁	82 (56)	77 (50)	76 (49)	72 (46)	69 (44)	67 (42)	65 (41)	65 (41)
G ₇ M ₂	80 (53)	74 (48)	72 (46)	70 (44)	67 (42)	66 (41)	64 (40)	63 (39)
G ₈ M ₁	87 (60)	81 (54)	80 (53)	76 (50)	73 (48)	71 (46)	70 (45)	69 (44)
G ₈ M ₂	84 (58)	78 (52)	76 (50)	74 (48)	72 (46)	70 (45)	68 (43)	67 (42)
G ₉ M ₁	78 (51)	72 (46)	71 (45)	67 (42)	64 (40)	62 (38)	60 (37)	60 (37)
G ₉ M ₂	75 (49)	69 (44)	68 (43)	65 (41)	63 (39)	61 (38)	59 (36)	58 (36)
G ₁₀ M ₁	82 (55)	75 (49)	74 (48)	71 (46)	68 (43)	66 (41)	64 (40)	64 (40)
G ₁₀ M ₂	80 (53)	74 (48)	72 (46)	70 (44)	67 (42)	65 (41)	63 (39)	62 (39)

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	83 (56)	76 (50)	75 (49)	72 (46)	68 (44)	66 (42)	65 (41)	64 (40)
G ₁₁ M ₂	80 (53)	75 (48)	73 (47)	70 (45)	68 (43)	66 (41)	64 (40)	63 (39)
G ₁₂ M ₁	84 (57)	77 (50)	76 (49)	73 (47)	69 (44)	67 (42)	66 (41)	65 (41)
G ₁₂ M ₂	82 (55)	76 (50)	74 (48)	71 (46)	69 (44)	68 (43)	66 (41)	65 (40)
S.Em $\pm$	0.9	0.77	0.74	0.7	0.65	0.62	0.59	0.59
CD (<0.05P)	NS	NS	2.07	1.94	1.82	1.73	1.65	1.64
M ₁ P ₁	76 (50)	65 (41)	64 (41)	58 (36)	51 (31)	48 (29)	47 (28)	45 (27)
M ₁ P ₂	75 (50)	70 (46)	70 (45)	65 (42)	64 (41)	62 (39)	60 (38)	60 (37)
M ₁ P ₃	75 (50)	73 (48)	72 (47)	71 (46)	70 (45)	68 (44)	67 (43)	66 (42)
M ₂ P ₁	70 (45)	61 (39)	59 (37)	57 (36)	53 (33)	51 (32)	49 (30)	47 (29)
M ₂ P ₂	74 (49)	66 (42)	64 (40)	61 (39)	60 (38)	58 (36)	56 (35)	54 (34)
M ₂ P ₃	74 (49)	71 (46)	69 (45)	65 (42)	63 (40)	62 (39)	60 (38)	60 (37)
S.Em $\pm$	0.45	0.38	0.37	0.35	0.33	0.31	0.3	0.29
CD (<0.05P)	1.25	NS	1.04	0.97	0.91	0.86	0.83	0.82
G ₁ P ₁	32 (19)	20 (12)	14 (8)	12 (7)	10 (6)	8 (5)	6 (4)	2 (1)
G ₁ P ₂	38 (23)	33 (19)	29 (17)	17 (10)	15 (8)	13 (7)	11 (6)	8 (5)
G ₁ P ₃	40 (24)	37 (21)	34 (20)	30 (17)	28 (16)	26 (15)	24 (14)	22 (13)
G ₂ P ₁	43 (26)	26 (15)	27 (16)	23 (13)	21 (12)	19 (11)	17 (10)	10 (5)
G ₂ P ₂	50 (30)	37 (22)	35 (21)	27 (16)	25 (15)	23 (13)	21 (12)	15 (9)
G ₂ P ₃	38 (22)	42 (25)	40 (24)	34 (20)	32 (18)	30 (17)	28 (16)	26 (15)
G ₃ P ₁	76 (49)	68 (42)	66 (41)	62 (38)	56 (34)	53 (32)	51 (31)	50 (30)
G ₃ P ₂	77 (50)	74 (48)	73 (47)	71 (45)	70 (44)	68 (43)	66 (41)	65 (41)
G ₃ P ₃	74 (48)	69 (44)	69 (44)	71 (45)	70 (44)	69 (43)	67 (42)	67 (42)
G ₄ P ₁	78 (51)	69 (44)	67 (42)	63 (39)	57 (35)	54 (33)	53 (32)	52 (31)
G ₄ P ₂	79 (52)	76 (50)	74 (48)	72 (46)	71 (46)	69 (44)	67 (42)	67 (42)
G ₄ P ₃	80 (53)	78 (51)	76 (50)	74 (47)	72 (46)	71 (45)	69 (44)	69 (43)
G ₅ P ₁	84 (58)	76 (50)	75 (48)	71 (45)	65 (40)	62 (38)	60 (37)	59 (36)
G ₅ P ₂	86 (59)	81 (54)	79 (53)	77 (51)	76 (50)	74 (48)	72 (46)	72 (46)
G ₅ P ₃	87 (60)	84 (57)	83 (56)	80 (53)	78 (52)	77 (51)	76 (49)	75 (49)
G ₆ P ₁	77 (50)	68 (43)	67 (42)	63 (39)	57 (35)	54 (33)	53 (32)	52 (31)
G ₆ P ₂	78 (52)	73 (47)	71 (46)	69 (44)	68 (43)	66 (42)	64 (40)	64 (40)
G ₆ P ₃	79 (52)	77 (50)	75 (49)	73 (47)	71 (46)	70 (45)	69 (43)	68 (43)
G ₇ P ₁	80 (53)	72 (46)	70 (44)	66 (41)	60 (37)	57 (35)	56 (34)	55 (33)
G ₇ P ₂	81 (54)	75 (49)	73 (47)	71 (46)	70 (45)	68 (43)	66 (42)	66 (41)
G ₇ P ₃	82 (55)	80 (53)	78 (52)	76 (49)	74 (48)	73 (47)	72 (46)	71 (45)
G ₈ P ₁	84 (57)	76 (49)	74 (48)	70 (45)	65 (40)	62 (38)	60 (37)	59 (36)
G ₈ P ₂	86 (59)	79 (52)	78 (51)	76 (49)	75 (48)	73 (47)	71 (45)	70 (45)
G ₈ P ₃	87 (60)	84 (57)	82 (56)	80 (53)	78 (52)	77 (51)	76 (49)	75 (49)
G ₉ P ₁	75 (49)	68 (42)	66 (41)	62 (38)	56 (34)	53 (32)	51 (31)	50 (30)
G ₉ P ₂	77 (50)	70 (44)	68 (43)	66 (41)	65 (41)	63 (39)	61 (38)	61 (37)
G ₉ P ₃	77 (51)	75 (48)	74 (47)	71 (45)	70 (44)	69 (43)	67 (42)	67 (42)
G ₁₀ P ₁	80 (53)	71 (46)	70 (44)	66 (41)	60 (37)	57 (35)	55 (34)	54 (33)
G ₁₀ P ₂	81 (54)	74 (47)	72 (46)	70 (45)	69 (44)	67 (42)	65 (41)	65 (40)
G ₁₀ P ₃	82 (55)	79 (53)	78 (51)	75 (49)	74 (48)	73 (47)	71 (45)	71 (45)
G ₁₁ P ₁	80 (54)	72 (46)	71 (45)	67 (42)	60 (37)	57 (35)	56 (34)	55 (33)
G ₁₁ P ₂	82 (55)	74 (48)	73 (47)	71 (45)	70 (44)	68 (43)	66 (41)	65 (41)
G ₁₁ P ₃	82 (55)	80 (53)	78 (52)	76 (49)	74 (48)	73 (47)	72 (46)	71 (46)

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₁	82 (55)	73 (47)	72 (46)	68 (43)	62 (38)	59 (36)	57 (35)	56 (34)
G ₁₂ P ₂	83 (56)	75 (48)	73 (47)	71 (45)	70 (44)	68 (43)	66 (41)	65 (41)
G ₁₂ P ₃	84 (57)	81 (54)	80 (53)	77 (51)	76 (49)	75 (49)	73 (47)	73 (47)
S.Em ±	1.1	0.94	0.91	0.85	0.8	0.76	0.73	0.72
CD (<0.05P)	NS	2.62	2.54	2.38	2.23	2.11	2.03	2.01
G ₁ M ₁ P ₁	39 (23)	24 (14)	18 (10)	17 (10)	15 (9)	13 (7)	11 (6)	2 (1)
G ₁ M ₁ P ₂	39 (23)	36 (21)	35 (21)	22 (13)	20 (12)	18 (11)	16 (9)	13 (7)
G ₁ M ₁ P ₃	39 (23)	37 (22)	39 (23)	35 (20)	33 (19)	31 (18)	29 (17)	27 (16)
G ₁ M ₂ P ₁	25 (15)	16 (9)	10 (6)	8 (4)	6 (3)	4 (2)	2 (1)	2 (1)
G ₁ M ₂ P ₂	37 (22)	30 (18)	22 (13)	11 (6)	9 (5)	7 (4)	5 (3)	3 (2)
G ₁ M ₂ P ₃	41 (24)	36 (21)	30 (17)	25 (14)	23 (13)	21 (12)	19 (11)	17 (10)
G ₂ M ₁ P ₁	48 (29)	32 (19)	36 (21)	31 (18)	29 (17)	27 (16)	25 (15)	13 (7)
G ₂ M ₁ P ₂	43 (26)	39 (23)	38 (23)	32 (18)	30 (17)	28 (16)	26 (15)	24 (14)
G ₂ M ₁ P ₃	43 (26)	41 (24)	40 (24)	35 (20)	33 (19)	31 (18)	29 (17)	27 (15)
G ₂ M ₂ P ₁	38 (23)	20 (11)	18 (10)	15 (9)	13 (7)	11 (6)	9 (5)	6 (3)
G ₂ M ₂ P ₂	56 (34)	34 (20)	32 (19)	23 (13)	21 (12)	19 (11)	17 (10)	7 (4)
G ₂ M ₂ P ₃	33 (19)	42 (25)	40 (24)	32 (19)	30 (18)	28 (16)	26 (15)	24 (14)
G ₃ M ₁ P ₁	77 (51)	68 (43)	67 (42)	61 (38)	54 (32)	50 (30)	48 (29)	48 (29)
G ₃ M ₁ P ₂	77 (51)	78 (52)	79 (52)	74 (48)	73 (47)	71 (46)	69 (44)	69 (44)
G ₃ M ₁ P ₃	70 (44)	75 (49)	74 (48)	73 (47)	72 (46)	71 (46)	70 (45)	69 (44)
G ₃ M ₂ P ₁	74 (47)	67 (42)	64 (40)	62 (39)	58 (36)	56 (34)	54 (33)	52 (32)
G ₃ M ₂ P ₂	77 (50)	70 (44)	68 (43)	67 (42)	66 (41)	64 (40)	62 (38)	61 (37)
G ₃ M ₂ P ₃	78 (51)	63 (39)	64 (40)	69 (43)	67 (42)	66 (41)	64 (40)	64 (40)
G ₄ M ₁ P ₁	80 (53)	69 (44)	68 (43)	62 (39)	54 (33)	51 (30)	50 (30)	50 (30)
G ₄ M ₁ P ₂	80 (53)	81 (54)	80 (53)	77 (50)	76 (49)	74 (47)	72 (46)	71 (46)
G ₄ M ₁ P ₃	80 (53)	78 (51)	77 (50)	76 (49)	75 (49)	74 (48)	73 (47)	72 (46)
G ₄ M ₂ P ₁	75 (49)	68 (43)	66 (42)	64 (40)	60 (37)	58 (35)	56 (34)	54 (33)
G ₄ M ₂ P ₂	78 (51)	71 (45)	69 (44)	68 (43)	67 (42)	65 (41)	63 (39)	62 (38)
G ₄ M ₂ P ₃	80 (53)	77 (50)	75 (49)	71 (45)	69 (44)	68 (43)	65 (41)	65 (41)
G ₅ M ₁ P ₁	87 (60)	77 (50)	76 (50)	70 (44)	62 (38)	58 (35)	57 (35)	57 (35)
G ₅ M ₁ P ₂	87 (60)	83 (57)	83 (56)	80 (53)	79 (52)	77 (50)	75 (48)	75 (48)
G ₅ M ₁ P ₃	87 (60)	85 (58)	84 (57)	83 (56)	82 (55)	81 (54)	80 (53)	79 (52)
G ₅ M ₂ P ₁	82 (55)	75 (49)	73 (47)	71 (45)	67 (42)	65 (41)	63 (39)	61 (37)
G ₅ M ₂ P ₂	85 (58)	78 (51)	76 (49)	75 (48)	74 (47)	72 (46)	70 (44)	69 (43)
G ₅ M ₂ P ₃	86 (60)	83 (57)	81 (54)	77 (50)	75 (49)	74 (48)	72 (46)	72 (46)
G ₆ M ₁ P ₁	79 (53)	69 (44)	68 (43)	63 (39)	55 (33)	51 (30)	50 (30)	50 (30)
G ₆ M ₁ P ₂	79 (53)	75 (49)	74 (48)	71 (46)	70 (45)	68 (43)	66 (42)	66 (42)
G ₆ M ₁ P ₃	79 (53)	77 (51)	77 (50)	76 (49)	75 (48)	74 (47)	73 (47)	71 (46)
G ₆ M ₂ P ₁	75 (48)	67 (42)	65 (41)	63 (39)	60 (37)	58 (35)	56 (34)	54 (32)
G ₆ M ₂ P ₂	77 (51)	70 (45)	68 (43)	67 (42)	66 (42)	64 (40)	62 (39)	61 (38)
G ₆ M ₂ P ₃	79 (52)	76 (49)	74 (48)	70 (44)	68 (43)	67 (42)	65 (40)	65 (40)
G ₇ M ₁ P ₁	82 (56)	73 (47)	72 (46)	65 (41)	57 (35)	53 (32)	52 (32)	52 (32)
G ₇ M ₁ P ₂	82 (56)	77 (51)	76 (50)	73 (47)	72 (46)	70 (45)	68 (43)	68 (43)
G ₇ M ₁ P ₃	82 (56)	80 (54)	79 (53)	78 (51)	77 (50)	76 (50)	75 (49)	74 (48)
G ₇ M ₂ P ₁	78 (51)	70 (45)	68 (43)	67 (42)	63 (39)	61 (37)	59 (36)	57 (35)
G ₇ M ₂ P ₂	79 (53)	72 (46)	70 (45)	69 (44)	68 (43)	66 (42)	64 (40)	63 (39)
G ₇ M ₂ P ₃	82 (55)	79 (52)	77 (50)	73 (47)	71 (45)	70 (44)	68 (43)	68 (43)
G ₈ M ₁ P ₁	87 (60)	77 (50)	76 (50)	70 (44)	62 (39)	58 (36)	57 (35)	57 (35)

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₂	87 (60)	81 (54)	80 (53)	77 (50)	76 (49)	74 (47)	72 (46)	72 (46)
G ₈ M ₁ P ₃	87 (60)	85 (58)	84 (57)	83 (56)	82 (55)	81 (54)	80 (53)	79 (52)
G ₈ M ₂ P ₁	82 (55)	75 (48)	73 (47)	71 (45)	67 (42)	65 (41)	63 (39)	61 (38)
G ₈ M ₂ P ₂	85 (58)	78 (51)	76 (49)	75 (48)	74 (47)	72 (46)	70 (44)	69 (43)
G ₈ M ₂ P ₃	86 (60)	83 (56)	81 (54)	77 (50)	75 (49)	74 (48)	72 (46)	72 (46)
G ₉ M ₁ P ₁	78 (51)	69 (44)	68 (43)	62 (38)	54 (32)	50 (30)	49 (29)	49 (29)
G ₉ M ₁ P ₂	78 (51)	71 (45)	70 (44)	67 (42)	66 (41)	64 (40)	62 (38)	61 (38)
G ₉ M ₁ P ₃	78 (51)	76 (49)	75 (48)	74 (47)	73 (47)	72 (46)	71 (45)	70 (44)
G ₉ M ₂ P ₁	73 (47)	66 (41)	64 (40)	62 (38)	58 (35)	56 (34)	54 (32)	52 (31)
G ₉ M ₂ P ₂	76 (49)	68 (43)	66 (42)	65 (41)	64 (40)	63 (39)	61 (37)	60 (37)
G ₉ M ₂ P ₃	77 (50)	74 (48)	72 (46)	68 (43)	66 (42)	65 (41)	63 (39)	63 (39)
G ₁₀ M ₁ P ₁	82 (55)	72 (46)	71 (46)	65 (41)	57 (35)	53 (32)	52 (32)	52 (32)
G ₁₀ M ₁ P ₂	82 (55)	74 (48)	73 (47)	70 (45)	69 (44)	67 (42)	65 (41)	65 (41)
G ₁₀ M ₁ P ₃	82 (55)	80 (53)	79 (52)	78 (51)	77 (50)	76 (49)	75 (49)	74 (48)
G ₁₀ M ₂ P ₁	77 (51)	70 (45)	68 (43)	67 (42)	62 (38)	60 (37)	58 (35)	56 (34)
G ₁₀ M ₂ P ₂	80 (53)	73 (47)	71 (45)	70 (44)	69 (44)	67 (42)	65 (41)	64 (40)
G ₁₀ M ₂ P ₃	82 (55)	79 (52)	77 (50)	72 (46)	70 (45)	69 (44)	67 (42)	67 (42)
G ₁₁ M ₁ P ₁	83 (56)	73 (47)	72 (46)	66 (41)	58 (35)	54 (32)	53 (32)	53 (32)
G ₁₁ M ₁ P ₂	83 (56)	75 (48)	74 (47)	71 (45)	70 (44)	68 (43)	66 (41)	66 (41)
G ₁₁ M ₁ P ₃	83 (56)	81 (54)	80 (53)	79 (52)	78 (51)	77 (50)	76 (49)	75 (48)
G ₁₁ M ₂ P ₁	78 (51)	71 (45)	69 (44)	67 (42)	63 (39)	61 (37)	59 (36)	57 (35)
G ₁₁ M ₂ P ₂	81 (54)	74 (47)	72 (46)	71 (45)	70 (44)	68 (43)	66 (41)	65 (40)
G ₁₁ M ₂ P ₃	82 (55)	79 (52)	77 (50)	73 (47)	71 (45)	70 (44)	68 (43)	68 (43)
G ₁₂ M ₁ P ₁	84 (57)	74 (48)	73 (47)	67 (42)	59 (36)	55 (34)	54 (33)	54 (33)
G ₁₂ M ₁ P ₂	84 (57)	74 (48)	73 (47)	70 (45)	69 (44)	67 (42)	65 (41)	65 (40)
G ₁₂ M ₁ P ₃	84 (57)	82 (55)	81 (54)	80 (53)	79 (52)	78 (51)	77 (50)	76 (50)
G ₁₂ M ₂ P ₁	79 (53)	72 (46)	70 (44)	68 (43)	64 (40)	62 (39)	60 (37)	58 (36)
G ₁₂ M ₂ P ₂	82 (55)	75 (49)	73 (47)	72 (46)	71 (45)	69 (44)	67 (42)	66 (41)
G ₁₂ M ₂ P ₃	84 (57)	81 (54)	79 (52)	75 (48)	73 (47)	72 (46)	70 (44)	70 (44)
S.Em ±	1.55	1.33	1.28	1.2	1.13	1.07	1.03	1.02
CD (<0.05P)	NS	3.71	3.59	3.37	3.15	2.99	2.87	2.84
CV (%)	5.5	5.25	5.23	5.22	5.14	5.07	5.04	5.11

Initial	G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
Germination (%)	40	44	76	79	88	80	82	86	80	81	82	86	1.73	5.06	4.0

*Arcsign transformed value for statistical analysis

Treatment details

Materials (M)

M₁ : Fruits
M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover
P₂ : 700 gauge poly pouches
P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia
G₂ : Majjige Menasu-1
G₃ : Chikkaballapur local
G₄ : Panth C-1
G₅ : Rona
G₆ : Shivani
G₇ : Byadagi Dabba
G₈ : LCA206
G₉ : G4
G₁₀ : Paprika
G₁₁ : Aparna
G₁₂ : Byadagi Orange Selection

by G₂ (22 %) and G₃ (61 %), respectively. At the end of the 24th storage month, the higher seed germination was recorded in G₅ (69 %) followed by G₈ (68 %), G₁₂ (65 %), G₇ (61 %) on par with G₁₀ (63 %) and lower seed germination was recorded in G₁ (11 %) followed by G₂ (17 %), respectively.

Fruit and seed materials: Germination (%) differed significantly among the materials during the storage period. Whole fruits (M₁) recorded the highest germination (%) throughout the storage period. At the end of three months storage, the higher seed germination was recorded in M₁ (75 %) and M₂ (73 %). At six months storage, the higher germination was recorded in M₁ (69 %) and M₂ (66 %). At nine months, the higher germination was recorded M₁ (69 %) and M₂ (64 %). At the end of 12, 15, 18 21 and 24 months storage, M₁ recorded significantly higher germination (%) compared to M₂. The higher seed germination (65, 62, 59, 58 and 57 per cent in M₁, respectively) and (61, 59, 57, 55 and 54 per cent in M₂), respectively

Packaging: The effect of packaging on germination per cent was significantly differed throughout storage period. The higher seed germination was recorded in P₂ (75 %) followed by P₃ (74 %) and P₁ (73 %) during 3rd month storage. Similarly at the end of six months storage, the higher seed germination was recorded in P₃ (72 %), P₂ (68 %) and P₁ (63 %) and at the end of nine months, the higher seed germination was recorded in P₃ (71 %), P₂ (67 %) and P₁ (61 %). At the end of 12, 15, 18, 21 and 24 months storage, P₃ was recorded significantly higher compare to P₂ and P₁. The higher seed germination was recorded in P₃ (68, 66, 65, 64 and 63 per cent, respectively) and P₂ recorded (63, 62, 60, 58 and 57 per cent, respectively) whereas, lower seed germination was recorded in P₁ (58, 52, 50, 48 and 46 per cent). the end of 12, 15, 18, 21 and 24 months storage, respectively,

Genotypes × Fruit and seed materials: Genotypes × Materials interaction for germination (%) was non-significant during three months and was significant for rest of the storage period. The higher seed germination (%) was recorded in G₅M₁ (82 %) followed by G₈M₁ (81 %), G₅M₂ (79 %) and G₈M₂ (78 %) and lower germination was recorded in G₁M₂ (27 %) followed by G₂M₂ (32 %) and G₁M₁ (33 %) during six months

of storage. At the end of nine months storage, the higher seed germination (%) was recorded in G_5M_1 (81 %) followed by G_8M_2 (77 %) and G_2M_2 (76 %) and lower germination was recorded in G_1M_2 (20 %) followed by G_2M_2 (30 %) and G_1M_1 (31 %), respectively. The higher seed germination was recorded in G_5M_1 (77 %) followed by G_8M_2 (74 %) and $G_{12}M_1$ (73 %) and lower germination was recorded in G_1M_2 (15 %) followed by G_1M_1 (25 %) and G_2M_1 (33 %), respectively during 12th month of storage. At the end of 15th month storage period, the higher seed germination was recorded in G_5M_1 (74 %) followed by G_8M_1 (73 %) and G_8M_2 (72 %) and lower germination was recorded in G_1M_2 (13 %) followed by G_2M_2 (21 %) and G_1M_1 (23 %) respectively. At 18th month storage period, the higher seed germination was recorded in G_5M_1 (72 %) followed by G_8M_1 (71 %) and G_8M_2 (72 %) and lower germination was recorded in G_1M_2 (11 %) followed by G_2M_2 (19 %) and G_1M_1 (21 %), respectively. At the end of 21st month storage period, the higher seed germination was recorded in G_5M_1 (70 %) followed by G_8M_2 (68 %) and $G_{12}M_1$ (66 %) and lower germination was recorded in G_1M_2 (9 %) followed by G_2M_2 (17 %) and G_1M_1 (19 %), respectively. At end of the 24th month storage period, the higher seed germination was recorded in G_5M_1 (70 %) followed by G_8M_1 (69 %), G_5M_2 (67 %) and lower germination was recorded in G_1M_2 (9 %) followed by G_1M_2 (7 %) and G_2M_2 (12 %), respectively.

Fruit and seed materials × Packaging: Materials × Packaging interaction for germination was significant throughout storage period except for six months storage. The higher seed germination (%) was recorded in M_1P_1 (76 %) followed by M_1P_3 (75 %) and was on par with M_1P_2 (75 %) and lower germination was recorded in M_2P_1 (70 %) during three months of storage. At the end of nine months storage, the higher seed germination per cent was recorded in M_1P_3 (72 %) followed by M_1P_2 (70 %) and M_2P_3 (69 %) and lower germination was recorded in M_2P_1 (59 %) followed by M_1P_1 (64 %) and on par with M_2P_2 (64 %) respectively. The higher seed germination was recorded in M_1P_3 (71 %) followed by M_2P_3 (65 %) and M_1P_1 (65 %) and lower germination was recorded in M_1P_1 (58 %) followed by M_2P_1 (57 %) and M_2P_2 (61 %) during 12th month of storage. At the end of 15th month storage period, the higher seed germination was recorded in M_1P_3 (70 %) followed by M_1P_2 (64 %) and M_2P_3 (63 %) and lower germination was recorded

in M₁P₁ (51 %) followed by M₂P₁ (53 %) respectively. At 18th month storage period, the higher seed germination was recorded in M₁P₃ (68 %) followed by M₁P₂ (62 %) and M₂P₃ (62 %) and lower germination was recorded in M₁P₁ (48 %) followed by M₂P₁ (51 %) and M₂P₂ (58 %), respectively. At the end of 21st month storage period, the higher seed germination was recorded in M₁P₃ (67 %) followed by M₂P₃ (60 %) and on par with M₁P₂ (60 %) and lower germination was recorded in M₁P₁ (47 %) followed by M₂P₁ (49 %) and M₂P₂ (56 %) respectively. At end of 24th month storage period, the higher seed germination was recorded in M₁P₃ (66 %) followed by M₁P₂ (60 %) on par with M₂P₃ (60 %) and lower germination was recorded in M₁P₁ (45 %) followed by M₂P₁ (47 %) and M₂P₂ (54 %), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for germination was significant throughout storage period except for three months storage. The higher seed germination per cent was recorded in G₈P₃ (84 %) followed by G₁₂P₃ (81 %) and was on par with G₇P₃ (80 %), G₁₀P₃ (79 %) and was on par with G₈P₂ (79 %) and lower germination was recorded in G₁P₁ (20 %) followed by G₂P₁ (26 %), G₁P₃ (33 %) and was on par with G₁P₂ (74 %) during six months of storage. At nine months storage, the higher seed germination per cent was recorded in G₅P₃ (83 %) followed by G₈P₃ (82 %) and G₁₂P₃ (80 %) and lower germination was recorded in G₁P₁ (14 %) followed by G₂P₁ (27 %) and G₁P₂ (29 %), respectively. The higher seed germination was recorded in G₈P₃ (80 %) followed by G₁₂P₃ (77 %) and was on par with G₅P₂ (77 %) and lower germination was recorded in G₁P₁ (12 %) followed by G₁P₂ (17 %) and G₁P₂ (23 %) during 12th month of storage. At 15th month storage period, the higher seed germination was recorded in G₈P₃ (78 %) followed by G₁₂P₃ (76 %) and G₁₁P₃ (74 %) and was on par with G₁₀P₃ (78 %) and lower germination was recorded in G₁P₁ (10 %) followed by G₁P₂ (15 %), G₂P₂ (25 %), respectively. At 18th month storage period, the higher seed germination was recorded in G₈P₃ (77 %) followed by G₁₂P₃ (75 %) and G₁₀P₃ (73 %) and was on par with G₁₀P₃ (73 %) and lower germination was recorded in G₁P₁ (8 %) followed by G₁P₂ (13 %), G₁P₃ (26 %) and G₂P₃ (30 %), respectively. At the end of 21st month storage period, the higher seed germination was recorded in G₈P₃ (76 %) followed by G₁₂P₃ (73 %) and lower germination was recorded in G₁P₁ (6 %) followed by G₁P₂ (11 %) and G₁P₃ (24 %).

Table 4.23. Mean seedling length (cm) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	6.62	6.02	5.18	4.60	4.38	4.47	4.32	3.69
G ₂	7.12	6.97	6.24	5.57	5.17	4.80	4.72	4.28
G ₃	8.71	8.45	7.89	7.33	6.93	6.59	6.45	5.85
G ₄	11.04	10.74	10.18	9.61	9.21	8.88	8.76	8.17
G ₅	10.66	10.37	9.79	9.23	8.82	8.50	8.36	7.79
G ₆	15.65	15.36	14.31	13.96	13.49	13.28	13.13	12.35
G ₇	16.73	16.21	15.45	14.99	14.66	14.21	13.97	13.71
G ₈	12.35	12.04	11.49	10.93	10.51	10.17	10.03	9.46
G ₉	12.73	12.43	11.86	11.28	10.88	10.54	10.39	9.82
G ₁₀	12.39	12.09	11.51	10.93	10.54	10.21	10.06	9.44
G ₁₁	14.32	14.01	13.46	12.88	12.49	12.15	12.01	11.26
G ₁₂	14.81	14.51	13.60	13.32	12.49	12.64	12.36	11.88
S.Em ±	0.121	0.119	0.124	0.108	0.096	0.089	0.105	0.091
CD (<0.05P)	0.338	0.332	0.346	0.301	0.267	0.250	0.293	0.256
M ₁	12.21	11.98	11.15	10.58	10.10	9.90	9.71	9.10
M ₂	11.65	11.22	10.67	10.19	9.82	9.51	9.39	8.85
S.Em ±	0.049	0.048	0.051	0.044	0.039	0.037	0.043	0.037
CD (<0.05P)	0.138	0.135	0.141	0.123	0.109	0.102	0.119	0.104
P ₁	11.08	10.81	10.81	8.74	8.09	7.93	7.73	7.21
P ₂	12.05	11.84	11.33	11.02	10.72	10.39	10.15	9.57
P ₃	12.65	12.15	11.58	11.39	11.08	10.79	10.76	10.15
S.Em ±	0.060	0.059	0.062	0.054	0.048	0.045	0.052	0.046
CD (<0.05P)	0.169	0.166	0.173	0.151	0.134	0.125	0.146	0.128
G ₁ M ₁	7.37	6.76	5.80	5.19	4.89	5.10	4.54	4.04
G ₁ M ₂	5.87	5.29	4.56	4.01	3.88	3.84	4.09	3.34
G ₂ M ₁	7.53	7.14	6.49	5.82	5.33	5.09	5.01	4.34
G ₂ M ₂	6.70	6.79	5.99	5.32	5.00	4.51	4.42	4.21
G ₃ M ₁	8.82	8.71	8.06	7.41	6.94	6.67	6.59	5.89
G ₃ M ₂	8.59	8.19	7.72	7.26	6.92	6.51	6.31	5.81
G ₄ M ₁	11.21	11.01	10.37	9.70	9.22	8.96	8.89	8.27
G ₄ M ₂	10.88	10.47	9.99	9.52	9.19	8.81	8.62	8.08
G ₅ M ₁	10.88	10.68	10.00	9.33	8.86	8.60	8.52	7.89
G ₅ M ₂	10.44	10.06	9.58	9.12	8.78	8.40	8.20	7.70
G ₆ M ₁	16.04	15.86	14.21	14.12	13.60	13.39	13.30	12.14
G ₆ M ₂	15.26	14.86	14.40	13.80	13.39	13.17	12.97	12.56
G ₇ M ₁	16.93	16.98	15.66	15.39	14.84	14.73	13.72	14.04
G ₇ M ₂	16.53	15.44	15.24	14.59	14.48	13.69	14.22	13.38
G ₈ M ₁	12.56	12.34	11.69	11.03	10.54	10.27	10.20	9.58
G ₈ M ₂	12.14	11.74	11.29	10.82	10.47	10.07	9.87	9.34
G ₉ M ₁	12.97	12.76	12.09	11.39	10.93	10.66	10.57	9.91
G ₉ M ₂	12.49	12.10	11.63	11.17	10.82	10.42	10.22	9.72
G ₁₀ M ₁	12.60	12.40	11.71	11.04	10.59	10.32	10.22	9.57
G ₁₀ M ₂	12.19	11.78	11.31	10.82	10.50	10.10	9.90	9.31

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	14.56	14.34	13.70	13.02	12.56	12.29	12.21	11.54
G ₁₁ M ₂	14.09	13.68	13.21	12.73	12.42	12.01	11.80	10.97
G ₁₂ M ₁	15.01	14.81	14.06	13.48	12.93	12.76	12.70	12.00
G ₁₂ M ₂	14.61	14.21	13.14	13.17	12.04	12.53	12.02	11.77
S.Em $\pm$	0.171	0.168	0.175	0.152	0.135	0.126	0.148	0.129
CD (<0.05P)	0.478	0.470	0.489	0.426	0.378	0.354	0.414	0.361
M ₁ P ₁	11.20	10.99	9.57	8.23	7.32	7.31	7.19	6.87
M ₁ P ₂	12.53	12.45	11.76	11.53	11.22	10.81	10.61	9.84
M ₁ P ₃	12.89	12.51	12.13	11.98	11.78	11.58	11.32	10.60
M ₂ P ₁	10.96	10.63	10.07	9.26	8.87	8.54	8.28	7.56
M ₂ P ₂	11.57	11.23	10.91	10.52	10.21	9.97	9.68	9.29
M ₂ P ₃	12.41	11.79	11.04	10.80	10.39	10.00	10.20	9.70
S.Em $\pm$	0.085	0.084	0.088	0.076	0.068	0.063	0.074	0.065
CD (<0.05P)	0.239	0.235	0.245	0.213	0.189	0.177	0.207	0.181
G ₁ P ₁	5.05	4.65	3.98	2.52	2.53	2.58	2.33	1.72
G ₁ P ₂	6.85	6.53	5.77	5.12	4.65	5.17	5.05	4.35
G ₁ P ₃	7.95	6.88	5.78	6.17	5.97	5.67	5.57	5.02
G ₂ P ₁	5.90	6.10	5.15	3.67	3.03	2.63	2.62	2.57
G ₂ P ₂	7.25	7.37	6.63	6.42	6.03	5.63	5.50	4.83
G ₂ P ₃	8.20	7.43	6.93	6.63	6.43	6.13	6.03	5.43
G ₃ P ₁	8.05	7.75	6.95	5.73	5.13	4.83	4.63	4.18
G ₃ P ₂	8.82	8.65	8.27	8.07	7.67	7.25	7.13	6.38
G ₃ P ₃	9.25	8.95	8.45	8.20	8.00	7.68	7.58	6.98
G ₄ P ₁	10.23	9.93	9.18	7.98	7.38	7.08	6.90	6.43
G ₄ P ₂	11.23	10.92	10.52	10.32	9.90	9.52	9.42	8.72
G ₄ P ₃	11.67	11.37	10.83	10.53	10.33	10.05	9.95	9.37
G ₅ P ₁	9.92	9.63	8.85	7.65	7.03	6.75	6.55	6.08
G ₅ P ₂	10.83	10.53	10.10	9.90	9.50	9.13	9.02	8.33
G ₅ P ₃	11.23	10.93	10.42	10.13	9.92	9.62	9.52	8.97
G ₆ P ₁	14.73	14.43	13.40	12.28	11.73	11.50	11.30	10.98
G ₆ P ₂	15.63	15.32	14.63	14.68	14.33	13.92	13.78	13.10
G ₆ P ₃	16.58	16.32	14.88	14.92	14.42	14.42	14.32	12.97
G ₇ P ₁	16.08	15.78	13.52	13.72	12.52	12.87	12.23	11.57
G ₇ P ₂	16.52	16.77	16.13	14.95	15.53	15.13	13.98	14.33
G ₇ P ₃	17.60	16.08	16.70	16.30	15.93	14.63	15.70	15.23
G ₈ P ₁	11.65	11.30	10.52	9.33	8.70	8.40	8.20	7.73
G ₈ P ₂	12.50	12.23	11.83	11.63	11.22	10.80	10.68	10.00
G ₈ P ₃	12.90	12.60	12.12	11.82	11.60	11.30	11.22	10.65
G ₉ P ₁	12.07	11.77	10.97	9.72	9.10	8.80	8.60	8.17
G ₉ P ₂	12.85	12.55	12.15	11.95	11.57	11.17	11.03	10.35
G ₉ P ₃	13.27	12.97	12.47	12.17	11.97	11.65	11.55	10.93
G ₁₀ P ₁	11.67	11.37	10.55	9.32	8.73	8.43	8.23	7.68
G ₁₀ P ₂	12.55	12.25	11.85	11.65	11.27	10.87	10.72	10.02
G ₁₀ P ₃	12.97	12.65	12.13	11.83	11.63	11.33	11.23	10.62
G ₁₁ P ₁	13.57	13.25	12.47	11.23	10.65	10.35	10.13	9.22
G ₁₁ P ₂	14.57	14.25	13.85	13.65	13.25	12.85	12.73	12.02
G ₁₁ P ₃	14.83	14.53	14.05	13.75	13.57	13.25	13.15	12.53

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₁	14.08	13.78	12.28	11.77	10.57	10.88	11.08	10.22
G ₁₂ P ₂	14.98	14.68	14.28	13.93	13.67	13.27	12.70	12.37
G ₁₂ P ₃	15.37	15.07	14.23	14.27	13.23	13.78	13.30	13.07
S.Em $\pm$	0.209	0.206	0.214	0.187	0.166	0.155	0.181	0.158
CD (<0.05P)	0.585	0.575	NS	0.522	0.463	0.433	0.507	0.443
G ₁ M ₁ P ₁	5.90	5.70	3.87	2.93	2.13	3.37	1.93	1.93
G ₁ M ₁ P ₂	7.33	7.13	6.57	5.87	5.97	5.57	5.53	4.60
G ₁ M ₁ P ₃	8.87	7.43	6.97	6.77	6.57	6.37	6.17	5.60
G ₁ M ₂ P ₁	4.20	3.60	4.10	2.10	2.93	1.80	2.73	1.50
G ₁ M ₂ P ₂	6.37	5.93	4.97	4.37	3.33	4.77	4.57	4.10
G ₁ M ₂ P ₃	7.03	6.33	4.60	5.57	5.37	4.97	4.97	4.43
G ₂ M ₁ P ₁	6.40	6.17	5.00	3.40	2.53	2.40	2.43	2.03
G ₂ M ₁ P ₂	7.67	7.63	7.03	6.83	6.43	6.03	5.97	5.07
G ₂ M ₁ P ₃	8.53	7.63	7.43	7.23	7.03	6.83	6.63	5.93
G ₂ M ₂ P ₁	5.40	6.03	5.30	3.93	3.53	2.87	2.80	3.10
G ₂ M ₂ P ₂	6.83	7.10	6.23	6.00	5.63	5.23	5.03	4.60
G ₂ M ₂ P ₃	7.87	7.23	6.43	6.03	5.83	5.43	5.43	4.93
G ₃ M ₁ P ₁	8.03	7.83	6.63	5.03	4.23	4.03	4.03	3.70
G ₃ M ₁ P ₂	9.17	9.23	8.67	8.47	8.07	7.63	7.60	6.53
G ₃ M ₁ P ₃	9.27	9.07	8.87	8.73	8.53	8.33	8.13	7.43
G ₃ M ₂ P ₁	8.07	7.67	7.27	6.43	6.03	5.63	5.23	4.67
G ₃ M ₂ P ₂	8.47	8.07	7.87	7.67	7.27	6.87	6.67	6.23
G ₃ M ₂ P ₃	9.23	8.83	8.03	7.67	7.47	7.03	7.03	6.53
G ₄ M ₁ P ₁	10.17	9.97	8.83	7.23	6.43	6.23	6.23	5.93
G ₄ M ₁ P ₂	11.73	11.53	10.93	10.73	10.30	9.90	9.90	8.97
G ₄ M ₁ P ₃	11.73	11.53	11.33	11.13	10.93	10.73	10.53	9.90
G ₄ M ₂ P ₁	10.30	9.90	9.53	8.73	8.33	7.93	7.57	6.93
G ₄ M ₂ P ₂	10.73	10.30	10.10	9.90	9.50	9.13	8.93	8.47
G ₄ M ₂ P ₃	11.60	11.20	10.33	9.93	9.73	9.37	9.37	8.83
G ₅ M ₁ P ₁	9.93	9.73	8.57	6.97	6.17	5.97	5.97	5.57
G ₅ M ₁ P ₂	11.37	11.17	10.50	10.30	9.90	9.53	9.50	8.60
G ₅ M ₁ P ₃	11.33	11.13	10.93	10.73	10.50	10.30	10.10	9.50
G ₅ M ₂ P ₁	9.90	9.53	9.13	8.33	7.90	7.53	7.13	6.60
G ₅ M ₂ P ₂	10.30	9.90	9.70	9.50	9.10	8.73	8.53	8.07
G ₅ M ₂ P ₃	11.13	10.73	9.90	9.53	9.33	8.93	8.93	8.43
G ₆ M ₁ P ₁	14.73	14.53	12.87	11.73	10.77	10.70	10.70	10.33
G ₆ M ₁ P ₂	16.13	15.90	14.73	15.13	14.73	14.33	14.27	13.33
G ₆ M ₁ P ₃	17.27	17.13	15.03	15.50	15.30	15.13	14.93	12.77
G ₆ M ₂ P ₁	14.73	14.33	13.93	12.83	12.70	12.30	11.90	11.63
G ₆ M ₂ P ₂	15.13	14.73	14.53	14.23	13.93	13.50	13.30	12.87
G ₆ M ₂ P ₃	15.90	15.50	14.73	14.33	13.53	13.70	13.70	13.17
G ₇ M ₁ P ₁	16.10	15.90	13.20	13.43	11.83	12.07	11.20	11.70
G ₇ M ₁ P ₂	16.83	17.73	16.67	15.87	16.07	15.67	13.70	14.73
G ₇ M ₁ P ₃	17.87	17.30	17.10	16.87	16.63	16.47	16.27	15.70
G ₇ M ₂ P ₁	16.07	15.67	13.83	14.00	13.20	13.67	13.27	11.43
G ₇ M ₂ P ₂	16.20	15.80	15.60	14.03	15.00	14.60	14.27	13.93
G ₇ M ₂ P ₃	17.33	14.87	16.30	15.73	15.23	12.80	15.13	14.77
G ₈ M ₁ P ₁	11.67	11.40	10.23	8.67	7.80	7.60	7.60	7.27

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₂	13.00	12.83	12.23	12.03	11.63	11.20	11.17	10.23
G ₈ M ₁ P ₃	13.00	12.80	12.60	12.40	12.20	12.00	11.83	11.23
G ₈ M ₂ P ₁	11.63	11.20	10.80	10.00	9.60	9.20	8.80	8.20
G ₈ M ₂ P ₂	12.00	11.63	11.43	11.23	10.80	10.40	10.20	9.77
G ₈ M ₂ P ₃	12.80	12.40	11.63	11.23	11.00	10.60	10.60	10.07
G ₉ M ₁ P ₁	12.17	11.97	10.77	9.07	8.27	8.07	8.07	7.73
G ₉ M ₁ P ₂	13.37	13.13	12.53	12.33	11.97	11.57	11.50	10.60
G ₉ M ₁ P ₃	13.37	13.17	12.97	12.77	12.57	12.33	12.13	11.40
G ₉ M ₂ P ₁	11.97	11.57	11.17	10.37	9.93	9.53	9.13	8.60
G ₉ M ₂ P ₂	12.33	11.97	11.77	11.57	11.17	10.77	10.57	10.10
G ₉ M ₂ P ₃	13.17	12.77	11.97	11.57	11.37	10.97	10.97	10.47
G ₁₀ M ₁ P ₁	11.67	11.47	10.23	8.63	7.83	7.63	7.63	7.27
G ₁₀ M ₁ P ₂	13.07	12.87	12.27	12.07	11.70	11.30	11.20	10.33
G ₁₀ M ₁ P ₃	13.07	12.87	12.63	12.43	12.23	12.03	11.83	11.10
G ₁₀ M ₂ P ₁	11.67	11.27	10.87	10.00	9.63	9.23	8.83	8.10
G ₁₀ M ₂ P ₂	12.03	11.63	11.43	11.23	10.83	10.43	10.23	9.70
G ₁₀ M ₂ P ₃	12.87	12.43	11.63	11.23	11.03	10.63	10.63	10.13
G ₁₁ M ₁ P ₁	13.57	13.33	12.17	10.53	9.73	9.53	9.53	9.20
G ₁₁ M ₁ P ₂	15.17	14.97	14.37	14.17	13.77	13.37	13.33	12.40
G ₁₁ M ₁ P ₃	14.93	14.73	14.57	14.37	14.17	13.97	13.77	13.03
G ₁₁ M ₂ P ₁	13.57	13.17	12.77	11.93	11.57	11.17	10.73	9.23
G ₁₁ M ₂ P ₂	13.97	13.53	13.33	13.13	12.73	12.33	12.13	11.63
G ₁₁ M ₂ P ₃	14.73	14.33	13.53	13.13	12.97	12.53	12.53	12.03
G ₁₂ M ₁ P ₁	14.10	13.90	12.43	11.07	10.07	10.10	10.90	9.73
G ₁₂ M ₁ P ₂	15.47	15.27	14.67	14.50	14.07	13.67	13.67	12.70
G ₁₂ M ₁ P ₃	15.47	15.27	15.07	14.87	14.67	14.50	13.53	13.57
G ₁₂ M ₂ P ₁	14.07	13.67	12.13	12.47	11.07	11.67	11.27	10.70
G ₁₂ M ₂ P ₂	14.50	14.10	13.90	13.37	13.27	12.87	11.73	12.03
G ₁₂ M ₂ P ₃	15.27	14.87	13.40	13.67	11.80	13.07	13.07	12.57
S.Em ±	0.296	0.291	0.303	0.264	0.234	0.219	0.257	0.224
CD (<0.05P)	NS	NS	NS	NS	NS	0.61	NS	NS
CV (%)	4.3	4.4	4.8	4.4	4.1	3.9	4.7	4.3

Initial Mean seedling length (cm)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
7.32	7.81	8.72	12.00	11.28	17.28	17.21	15.88	13.23	13.56	15.23	15.62	0.29	0.85	3.9

Treatment details

Materials (M)

M₁ : Fruits
M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover
P₂ : 700 gauge poly pouches
P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia
G₂ : Majjige Menasu-1
G₃ : Chikkaballapur local
G₄ : Panth C-1
G₅ : Rona
G₆ : Shivani
G₇ : Byadagi Dabba
G₈ : LCA206
G₉ : G4
G₁₀ : Paprika
G₁₁ : Aparna
G₁₂ : Byadagi Orange Selection

%), respectively. At end of the 24th month storage period, the higher seed germination was recorded in G_5P_3 (75 %) followed by $G_{12}P_3$ (73 %), $G_{11}P_3$ (71 %) and lower germination was recorded in G_1P_1 (2 %) followed by G_1P_2 (8 %) and G_2P_1 (10 %), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of Genotypes × Materials × Packaging was significantly differed throughout the storage period. During third month storage, the maximum seed germination was recorded in $G_8 \times M_1 \times P_2$ (87 %) and was on par with $G_5 \times M_1 \times P_2$ (87 %), $G_5 \times M_1 \times P_3$ (87 %) and lower germination was recorded in $G_1 \times M_1 \times P_1$ (25 %) and $G_1 \times M_2 \times P_2$ (37 %), respectively. At the end of six months storage, the maximum seed germination was recorded in $G_5 \times M_1 \times P_3$ (85 %) and $G_5 \times M_1 \times P_2$ (83 %) and lower germination was recorded in $G_1 \times M_2 \times P_1$ (16 %) and $G_1 \times M_1 \times P_1$ (24 %), respectively. During ninth month storage, the maximum seed germination was recorded in $G_5 \times M_1 \times P_3$ (84 %) and $G_8 \times M_1 \times P_2$ (80 %) and lower germination was recorded in $G_1 \times M_2 \times P_1$ (8 %) and $G_5 \times M_1 \times P_2$ (80 %), respectively. At twelfth month storage, the maximum seed germination was recorded in $G_5 \times M_1 \times P_3$ (83 %) and $G_8 \times M_1 \times P_2$ (80 %) and lower germination was recorded in $G_1 \times M_2 \times P_1$ (10 %) and $G_1 \times M_2 \times P_2$ (11 %), respectively. At fifteen month storage, the maximum seed germination was recorded in $G_8 \times M_1 \times P_3$ (83 %) and $G_5 \times M_1 \times P_3$ (82 %) and lower germination was recorded in $G_1 \times M_2 \times P_1$ (6 %) and $G_1 \times M_2 \times P_2$ (9 %), respectively. At eighteen month storage, the maximum seed germination was recorded in $G_5 \times M_1 \times P_3$ (81 %), $G_{11} \times M_1 \times P_3$ (75 %) and $G_7 \times M_1 \times P_2$ (74 %) and lower germination was recorded in $G_1 \times M_2 \times P_1$ (4 %) and $G_1 \times M_2 \times P_2$ (7 %), respectively.

4.3.3 Mean seedling length (cm)

The results on mean seedling length in centimeter as influenced by genotypes, packaging, materials and their interaction effects are presented (Table 4.23).

Genotypes: There was significant difference between the genotypes for mean seedling length (cm) throughout the storage period. Irrespective of the genotypes, there was a decline in mean seedling length (cm) during storage. The higher mean seedling length was recorded in G_7 (16.73 cm) followed by G_6 (15.65 cm), G_{12} (14.81 cm) and

lower seed mean seedling length was recorded in G₁ (6.62 cm) followed by G₂ (7.12 cm) and G₃ (8.71 cm) during three months storage period. At six months storage, the higher seed mean seedling length was recorded in G₇ (16.21 cm) followed by G₆ (15.36 cm), G₁₂ (14.51 cm) and lower seed mean seedling length was recorded in G₁ (6.02 cm) followed by G₂ (6.97 cm) and G₃ (8.45 cm), respectively and during nine months, the maximum seedling length was recorded in G₇ (15.45 cm), G₆ (14.31 cm), G₁₂ (13.60 cm) and lower seed mean seedling length was recorded in G₁ (5.18 cm) followed by G₂ (6.24 cm) and G₃ (7.89 cm), respectively. At the end of 12th month storage, G₇ (14.99 cm) followed by G₆ (13.96 cm), G₁₂ (13.32 cm) recorded higher mean seedling length and lower mean seedling length was recorded in G₁ (4.60 cm) followed by G₂ (5.57 cm) and G₃ (7.33 cm), respectively. During 15th storage, the higher mean seedling length was recorded in G₇ (14.66 cm) followed by G₆ (13.49 cm), G₁₂ (12.49 cm) and lower mean seedling length was recorded in G₁ (4.38 cm) followed by G₂ (5.17 cm) and G₃ (6.93 cm), respectively and during 18th month storage, the higher mean seedling length was recorded in G₇ (14.21 cm) followed by G₆ (13.28 cm) and lower mean seedling length was recorded in G₁ (4.47 cm) followed by G₂ (4.80 cm) and G₃ (6.59 cm), respectively. During 21st storage, the higher mean seedling length was recorded in G₇ (13.97 cm) followed by G₆ (13.13 cm), G₁₂ (12.36 cm) and lower mean seedling length was recorded in G₁ (4.32 cm) followed by G₂ (4.72 cm) and G₃ (6.45 cm), respectively. At end of the 24th storage month, the higher mean seedling length was recorded in G₇ (13.71 cm) followed by G₆ (12.35 cm), G₁₂ (11.88 cm), G₇ (61 cm) and lower mean seedling length was recorded in G₁ (3.69 cm) and G₂ (4.28 cm), respectively.

Fruit and seed materials: Mean seedling length (cm) differed significantly among the materials during the storage period. Whole fruits (M₁) recorded the highest mean seedling length throughout the storage period. At three months storage, the higher mean seedling length was recorded in M₁ (12.21 cm) and M₂ (11.65 cm). At six months storage, the M₁ (11.98 cm) and M₂ (11.22 cm), at nine months M₁ (11.15 cm) and M₂ (10.67 cm). After 12, 15, 18, 21 and 24th month storage, the M₁ recorded significantly higher mean seedling length over M₂. The higher mean seedling length (10.58, 10.10, 9.90, 9.71 and 9.10 cm in M₁, respectively) and (10.19, 9.82, 9.51, 9.39 and 8.85 cm in M₂, respectively).

Packaging: The effect of packaging on mean seedling length (cm) was significantly differed throughout storage period. The higher mean seedling length was recorded in P₃ (12.65 cm) followed by P₂ (12.05 cm) and P₁ recorded 11.08 cm during 3rd month storage. At six months storage, the P₃ (12.15 cm) followed by P₂ (11.84 cm) and P₁ recorded 10.81 cm and during nine months P₃ (11.58 cm), P₂ (11.33 cm) and P₁ (61 cm). At the end of 12, 15, 18, 21 and 24 months storage, the P₃ was recorded significantly higher seed mean seedling length over P₂ and P₁. The higher mean seedling length (11.39, 11.08, 10.79, 10.76 and 10.15 cm in P₃, respectively) and (11.02, 10.72, 10.39, 10.15 and 9.57 cm in P₂, respectively and lower seed mean seedling length was recorded in P₁ 8.74, 8.09, 7.93, 7.73 and 7.21 cm, respectively).

Genotypes × Fruit and seed materials: Genotypes × Materials interaction for mean seedling length was non-significant during three months storage and significant throughout rest of the storage period. The higher mean seedling length was recorded in G₇M₁ (16.93 cm) followed by G₇M₂ (16.53 cm), G₆M₁ (16.04 cm) and lower mean seedling length was recorded in G₁M₂ (5.87 cm) followed by G₂M₂ (6.70 cm) during 3rd month of storage period. At six months of storage, the higher mean seedling length was recorded in G₇M₁ (16.98 cm) followed by G₆M₁ (15.86 cm) and on par with G₇M₁ (15.86 cm) and lower mean seedling length was recorded in G₁M₂ (5.29 cm) followed by G₁M₁ (6.76 cm). At nine months storage, the higher mean seedling length was recorded in G₇M₁ (15.66 cm) followed by G₇M₂ (15.24 cm) and lower mean seedling length was recorded in G₁M₂ (4.56 cm) followed by G₁M₁ (5.80 cm) and G₂M₂ (5.99 cm), respectively. The higher mean seedling length was recorded in G₇M₁ (15.39 cm) followed by G₈M₂ (14.59 cm) and G₆M₁ (14.12 cm) and lower mean seedling length was recorded in G₁M₂ (4.01 cm) followed by G₁M₁ (5.19 cm) and G₂M₂ (5.32 cm), respectively, during 12th month of storage. At 15th month storage period, the higher mean seedling length was recorded in G₇M₁ (14.84 cm) and G₇M₂ (14.48 cm) and lower mean seedling length was recorded in G₁M₂ (3.88 cm) followed by G₁M₁ (5.19 cm) and G₂M₂ (5.00 cm), respectively. At 18th month storage period, the higher mean seedling length was recorded in G₇M₁ (14.73 cm) and G₇M₂ (13.69 cm) and lower mean seedling length was recorded in G₁M₂ (3.84 cm) followed by G₁M₁ (5.10 cm) and G₂M₂ (4.51 cm), respectively. At 21st

month storage period, the higher mean seedling length was recorded in G₇M₂ (14.22 cm) followed by G₈M₁ (13.72 cm) and G₆M₁ (13.30 cm) and lower mean seedling length was recorded in G₁M₁ (4.54 cm) followed by G₂M₁ (5.01 cm) and G₃M₁ (6.59 cm), respectively. At end of the 24th month storage period, the higher mean seedling length was recorded in G₇M₁ (14.04 cm) followed by G₇M₂ (13.38 cm), G₄M₁ (8.27 cm) and lower mean seedling length was recorded in G₁M₂ (3.34 cm) followed by G₁M₁ (4.04 cm) and G₂M₂ (4.21 cm), respectively.

Fruit and seed materials × Packaging: Materials × Packaging interaction for mean seedling length was significant throughout storage period. The higher mean seedling length was recorded in M₁P₃ (12.89 cm) followed by M₁P₂ (12.53 cm) and lower mean seedling length was recorded in M₂P₁ (10.96 cm) and M₁P₁ (11.20 cm) during three months of storage. At six months storage, the higher mean seedling length percentage was recorded in M₁P₃ (12.51 cm) and M₁P₂ (12.45 cm) and lower mean seedling length was recorded in M₂P₁ (10.63 cm) and M₁P₁ (10.99 cm), respectively. The higher mean seedling length was recorded in M₁P₃ (12.13 cm) and M₁P₂ (11.76 cm) and lower mean seedling length was recorded in M₁P₁ (9.57 cm) followed by M₂P₁ (10.07 cm) and M₂P₂ (10.91 cm) during 9th month of storage. At 12th month storage period, the higher mean seedling length was recorded in M₁P₃ (11.98 cm) followed by M₁P₂ (11.53 cm) and M₂P₃ (10.80 cm) and lower mean seedling length was recorded in M₁P₁ (8.23 cm) followed by M₂P₁ (9.26 cm), respectively during 12th month storage. At 15th month storage period, the higher mean seedling length was recorded in M₁P₃ (11.78 cm) followed by M₁P₂ (11.22 cm) and M₂P₃ (10.39 cm) and lower mean seedling length was recorded in M₁P₁ (7.32 cm) followed by M₂P₁ (8.87 cm) and M₂P₂ (10.21 cm), respectively. At 18st month storage period, the higher mean seedling length was recorded in M₁P₃ (11.58 cm) and M₁P₂ (10.81 cm) and lower mean seedling length was recorded in M₁P₁ (7.31 cm) followed by M₂P₁ (8.54 cm) and M₂P₂ (9.97 cm), respectively. At 21st month storage period, the higher mean seedling length was recorded in M₁P₃ (11.32 cm) and M₁P₂ (10.61 cm) and lower mean seedling length was recorded in M₁P₁ (7.19 cm) followed by M₂P₁ (8.28 cm) and M₂P₂ (9.68 cm), respectively. At end of the 24th month storage period, the higher mean seedling length was recorded in M₁P₃ (10.60 cm) followed by

M₁P₂ (9.84 cm) on par with M₂P₃ (9.70 cm) and lower mean seedling length was recorded in M₁P₁ (6.87 cm) followed by M₂P₁ (7.56 cm) and M₂P₂ (9.29 cm), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for mean seedling length was significant throughout storage period except 6th month storage. The higher mean seedling length was recorded in G₈P₃ (18.4 cm) followed by G₇P₃ (17.60 cm) and G₆P₃ (16.58 cm) and lower mean seedling length was recorded in G₁P₁ (5.05 cm) followed by G₂P₁ (5.90 cm) and G₁P₁ (6.85 cm) during 3rd month of storage. The higher mean seedling length was recorded in G₆P₃ (16.32 cm) and G₇P₃ (16.08 cm) and lower mean seedling length was recorded in G₁P₁ (4.65 cm) and G₂P₁ (6.10 cm) during 6th month of storage. At 12th month storage period, the higher mean seedling length was recorded in G₇P₃ (16.30 cm) and G₆P₃ (14.92 cm) and lower mean seedling length was recorded in G₁P₁ (2.52 cm) and G₂P₁ (3.67 cm). At 15th month storage period, the higher mean seedling length was recorded in G₇P₃ (15.93 cm) and G₆P₃ (14.42 cm) lower mean seedling length was recorded in G₁P₁ (2.53 cm) and G₂P₁ (3.03 cm). At 18th month storage period, the seed mean seedling length was recorded in G₇P₂ (15.13 cm) and G₇P₃ (14.63 cm) and lower mean seedling length was recorded in G₁P₁ (2.58 cm) followed by G₂P₂ (2.63 cm), respectively. At 21st month of storage period (24th), the higher mean seedling length was recorded in G₇P₃ (15.03 cm) and G₆P₃ (14.42 cm) and lower mean seedling length was recorded in G₁P₁ (2.32 cm) and G₂P₁ (2.62 cm), respectively. At end of the 24th month storage period, the higher mean seedling length was recorded in G₇P₃ (15.23 cm) and G₇P₂ (14.33 cm) and lower mean seedling length was recorded in G₁P₁ (1.72 cm) and G₂P₁ (2.57 cm), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of genotypes × materials × packaging was significantly differed in 18th month of storage and rest of the storage period showed non-significant. The maximum mean seed seedling length was recorded in G₇ × M₁ × P₃ (16.27 cm) and G₇ × M₁ × P₂ (15.67 cm) and lower mean seedling length was recorded in G₁ × M₂ × P₁ (1.80 cm) and G₂ × M₁ × P₁ (2.40 cm), respectively.

4.3.4 Seedling vigor index-I

The results on SVI-I as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.24)

Genotypes: There was significant difference between the genotypes for SVI-I throughout storage period. Irrespective of the genotypes, there was a decline in SVI-I during storage. The higher SVI-I was recorded in G₇ (1357) followed by G₁₂ (1229), G₆ (1223) and lower SVI-I was recorded in G₁ (250) followed by G₂ (323) and G₃ (668 cm) during three months storage period. At six months storage, the higher SVI-I was recorded in G₇ (1223) followed by G₆ (1118), G₁₂ (1110) and lower SVI-I was recorded in G₁ (190) followed by G₂ (247) and G₃ (596), respectively and during nine months, G₇ (1146), G₆ (1020) and on par with G₁₂ (1020) and lower SVI-I was recorded in G₁ (140) followed by G₂ (217) and G₃ (551, respectively). The 12th month storage, the G₇ (1069) followed by G₁₂ (964), G₆ (961) and lower SVI-I was recorded in G₁ (104) followed by G₂ (161) and G₃ (503), respectively. During 15th storage, the higher SVI-I was recorded in G₇ (1010) followed by G₆ (896), G₁₂ (873) and lower SVI-I was recorded in G₁ (90) followed by G₂ (139) and G₃ (461), respectively and during 18th month storage, the higher SVI-I was recorded in G₇ (950) followed by G₁₂ (861) and lower SVI-I was recorded in G₁ (81) followed by G₂ (121) and G₃ (427), respectively. During 21st storage, the higher SVI-I was recorded in G₇ (913) followed by G₆ (824), G₁₂ (818) and lower SVI-I was recorded in G₁ (69) followed by G₂ (110) and G₃ (407), respectively. At the end of the 24th storage month, the higher SVI-I was recorded in G₇ (887) followed by G₁₂ (780), G₆ (763) and lower SVI-I was recorded in G₁ (51) and G₂ (79), respectively.

Fruit and seed materials: SVI-I was differed significantly among the materials during the storage period. Whole fruits (M₁) recorded the highest SVI-I throughout the storage period. At three months storage, the higher SVI-I was recorded in M₁ (951) and M₂ (889). At six months storage, the M₁ (869) and M₂ (785), at nine months M₁ (803) and M₂ (727). The 12th, 15th, 18th, 21st and 24th month of storage, the M₁ was recorded significantly over M₂. The higher SVI-I (730, 673, 638, 613 and 570, respectively) and (673, 627, 592, 565 and 525 in M₂, respectively).

Table 4.24. Seedling vigour index-I as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	250	190	140	104	90	81	69	51
G ₂	323	247	217	161	139	121	110	79
G ₃	668	596	551	503	461	427	407	365
G ₄	874	799	743	677	627	589	565	521
G ₅	913	834	774	706	654	615	590	545
G ₆	1223	1118	1020	961	896	856	824	763
G ₇	1357	1223	1146	1069	1010	950	913	887
G ₈	1056	962	901	828	772	729	702	655
G ₉	974	880	823	753	699	659	632	589
G ₁₀	1003	906	846	775	721	679	653	606
G ₁₁	1168	1058	996	920	860	813	783	728
G ₁₂	1229	1110	1020	964	873	861	818	780
S.Em ±	14.9	14.9	14.5	13.7	12.5	11.9	11.7	10.9
CD (<0.05P)	41.7	41.6	40.4	38.3	35	33.3	32.8	30.6
M ₁	951	869	803	730	673	638	613	570
M ₂	889	785	727	673	627	592	565	525
S.Em ±	6.1	6.1	5.9	5.6	5.1	4.9	4.8	4.5
CD (<0.05P)	17	16.9	16.5	15.6	14.2	13.6	13.4	12.4
P ₁	846	729	729	552	465	434	411	375
P ₂	934	841	790	740	711	666	630	588
P ₃	980	912	857	813	775	745	725	679
S.Em ±	7.5	7.4	7.2	6.9	6.3	6	5.9	5.5
CD (<0.05P)	20.9	20.8	20.2	19.2	17.5	16.6	16.4	15.3
G ₁ M ₁	290	225	184	139	123	114	97	72
G ₁ M ₂	211	155	95	68	57	48	41	30
G ₂ M ₁	337	272	249	191	165	148	135	102
G ₂ M ₂	309	223	186	130	113	94	84	57
G ₃ M ₁	678	648	596	527	479	447	432	382
G ₃ M ₂	657	545	506	480	443	407	382	347
G ₄ M ₁	900	841	783	707	650	614	597	549
G ₄ M ₂	848	758	702	647	603	564	533	492
G ₅ M ₁	943	875	812	733	674	637	619	570
G ₅ M ₂	882	794	736	679	635	593	562	521
G ₆ M ₁	1271	1176	1042	997	923	880	855	770
G ₆ M ₂	1175	1061	999	925	868	833	793	755
G ₇ M ₁	1395	1306	1192	1120	1041	1002	917	928
G ₇ M ₂	1319	1139	1100	1019	978	899	909	846
G ₈ M ₁	1088	1000	936	852	788	746	727	678
G ₈ M ₂	1024	924	865	804	755	711	677	632
G ₉ M ₁	1007	917	859	775	715	676	655	607
G ₉ M ₂	940	843	788	731	684	643	609	571
G ₁₀ M ₁	1033	938	876	795	734	695	674	626
G ₁₀ M ₂	973	874	816	756	708	664	632	586
G ₁₁ M ₁	1204	1094	1032	943	875	829	807	758

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₂	1132	1022	960	898	845	797	760	698
G ₁₂ M ₁	1262	1140	1069	986	910	871	843	795
G ₁₂ M ₂	1195	1081	972	943	836	851	792	766
S.Em $\pm$	21.1	21	20.5	19.4	17.7	16.8	16.6	15.5
CD (<0.05P)	NS	NS	NS	NS	NS	NS	NS	NS
M ₁ P ₁	879	752	650	516	406	374	364	345
M ₁ P ₂	977	907	847	791	757	709	674	625
M ₁ P ₃	995	949	910	885	857	832	800	739
M ₂ P ₁	812	706	645	587	524	495	458	405
M ₂ P ₂	890	775	733	690	664	623	586	551
M ₂ P ₃	964	874	803	742	693	658	650	619
S.Em $\pm$	10.6	10.5	10.2	9.7	8.9	8.4	8.3	7.7
CD (<0.05P)	29.5	29.4	28.6	27.1	24.7	23.5	23.2	21.6
G ₁ P ₁	169	98	55	33	24	25	13	4
G ₁ P ₂	263	220	170	90	76	68	57	36
G ₁ P ₃	318	252	194	188	170	151	137	113
G ₂ P ₁	258	159	137	83	60	49	43	23
G ₂ P ₂	357	272	236	176	154	132	118	76
G ₂ P ₃	354	311	280	223	204	182	167	139
G ₃ P ₁	608	524	457	355	290	259	240	212
G ₃ P ₂	691	643	608	571	535	491	470	415
G ₃ P ₃	705	621	588	584	558	530	511	467
G ₄ P ₁	795	685	619	506	425	389	367	335
G ₄ P ₂	892	831	785	749	708	662	637	581
G ₄ P ₃	934	882	825	777	747	716	691	646
G ₅ P ₁	837	733	660	541	458	418	394	359
G ₅ P ₂	929	851	802	766	725	679	653	599
G ₅ P ₃	972	919	861	811	779	746	724	678
G ₆ P ₁	1135	987	895	775	674	626	598	569
G ₆ P ₂	1225	1118	1044	1020	981	925	889	838
G ₆ P ₃	1309	1250	1122	1089	1032	1017	986	881
G ₇ P ₁	1288	1129	945	905	753	737	683	631
G ₇ P ₂	1336	1257	1185	1068	1094	1036	927	943
G ₇ P ₃	1447	1282	1308	1234	1183	1078	1129	1087
G ₈ P ₁	980	858	782	657	565	521	496	459
G ₈ P ₂	1072	970	921	881	839	787	756	702
G ₈ P ₃	1117	1057	999	946	911	877	854	805
G ₉ P ₁	908	795	724	601	510	468	442	411
G ₉ P ₂	986	874	828	790	753	707	678	627
G ₉ P ₃	1027	972	918	866	835	803	777	729
G ₁₀ P ₁	930	812	737	616	522	481	456	417
G ₁₀ P ₂	1017	902	855	818	780	731	699	649
G ₁₀ P ₃	1062	1005	946	892	860	827	802	752
G ₁₁ P ₁	1091	955	880	750	645	595	566	504
G ₁₁ P ₂	1190	1057	1007	965	923	870	836	784
G ₁₁ P ₃	1222	1161	1102	1045	1011	975	948	896
G ₁₂ P ₁	1150	1009	882	797	653	643	637	577

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₂	1246	1095	1042	990	958	905	840	809
G ₁₂ P ₃	1289	1227	1138	1106	1009	1035	976	954
S.Em ±	25.8	25.7	25.1	23.7	21.7	20.6	20.3	18.9
CD (<0.05P)	NS	NS	70.1	66.3	60.6	57.7	56.8	52.9
G ₁ M ₁ P ₁	232	137	69	50	32	44	21	5
G ₁ M ₁ P ₂	288	259	232	132	121	102	90	60
G ₁ M ₁ P ₃	348	278	251	236	216	197	178	151
G ₁ M ₂ P ₁	106	58	41	16	17	7	5	3
G ₁ M ₂ P ₂	238	180	108	48	30	33	23	12
G ₁ M ₂ P ₃	288	226	137	139	124	105	95	75
G ₂ M ₁ P ₁	310	200	178	107	74	66	62	26
G ₂ M ₁ P ₂	332	301	270	216	191	167	153	120
G ₂ M ₁ P ₃	370	316	300	251	230	210	190	158
G ₂ M ₂ P ₁	207	119	96	59	46	32	25	19
G ₂ M ₂ P ₂	383	243	202	136	116	98	84	32
G ₂ M ₂ P ₃	338	306	259	195	177	154	143	120
G ₃ M ₁ P ₁	622	536	447	309	228	201	195	179
G ₃ M ₁ P ₂	721	724	682	630	592	545	527	451
G ₃ M ₁ P ₃	692	683	659	641	617	595	572	515
G ₃ M ₂ P ₁	594	511	468	401	352	318	285	244
G ₃ M ₂ P ₂	661	563	533	512	478	438	412	379
G ₃ M ₂ P ₃	717	560	518	527	498	465	451	419
G ₄ M ₁ P ₁	813	692	605	452	350	316	310	295
G ₄ M ₁ P ₂	946	931	871	823	780	730	710	640
G ₄ M ₁ P ₃	939	900	873	847	821	795	770	713
G ₄ M ₂ P ₁	777	677	633	560	501	461	424	375
G ₄ M ₂ P ₂	838	732	698	674	637	594	563	522
G ₄ M ₂ P ₃	929	864	776	706	673	638	613	578
G ₅ M ₁ P ₁	861	751	652	488	383	347	341	318
G ₅ M ₁ P ₂	986	932	869	822	780	732	710	643
G ₅ M ₁ P ₃	983	943	915	888	858	831	805	748
G ₅ M ₂ P ₁	813	716	668	593	533	490	448	401
G ₅ M ₂ P ₂	872	769	734	710	671	626	595	554
G ₅ M ₂ P ₃	962	895	806	735	701	662	644	608
G ₆ M ₁ P ₁	1168	1009	879	736	589	543	532	514
G ₆ M ₁ P ₂	1279	1199	1095	1081	1038	981	948	886
G ₆ M ₁ P ₃	1367	1321	1153	1174	1144	1116	1087	911
G ₆ M ₂ P ₁	1102	966	912	814	759	710	663	624
G ₆ M ₂ P ₂	1171	1037	994	959	925	869	830	790
G ₆ M ₂ P ₃	1251	1179	1091	1004	920	918	886	852
G ₇ M ₁ P ₁	1326	1156	945	878	678	644	588	613
G ₇ M ₁ P ₂	1386	1371	1273	1165	1163	1103	937	1003
G ₇ M ₁ P ₃	1472	1392	1359	1318	1283	1258	1227	1168
G ₇ M ₂ P ₁	1249	1103	945	933	827	830	779	649
G ₇ M ₂ P ₂	1285	1143	1097	972	1025	969	918	883
G ₇ M ₂ P ₃	1423	1172	1256	1150	1082	897	1031	1006
G ₈ M ₁ P ₁	1010	879	779	608	487	444	436	417
G ₈ M ₁ P ₂	1126	1036	975	923	881	825	801	734

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₃	1128	1085	1055	1026	997	969	944	884
G ₈ M ₂ P ₁	951	837	785	707	644	598	555	501
G ₈ M ₂ P ₂	1017	904	866	840	796	749	711	671
G ₈ M ₂ P ₃	1106	1030	943	866	826	785	764	725
G ₉ M ₁ P ₁	945	826	732	559	444	401	393	376
G ₉ M ₁ P ₂	1037	929	874	823	787	737	714	651
G ₉ M ₁ P ₃	1039	997	969	941	914	889	858	794
G ₉ M ₂ P ₁	871	764	716	644	577	535	491	445
G ₉ M ₂ P ₂	935	819	782	757	719	676	642	603
G ₉ M ₂ P ₃	1015	946	867	791	755	718	696	664
G ₁₀ M ₁ P ₁	957	830	731	565	447	408	400	381
G ₁₀ M ₁ P ₂	1070	953	897	850	812	762	733	676
G ₁₀ M ₁ P ₃	1072	1030	999	971	943	915	888	822
G ₁₀ M ₂ P ₁	903	793	743	667	598	554	513	454
G ₁₀ M ₂ P ₂	963	850	813	787	748	700	666	621
G ₁₀ M ₂ P ₃	1052	979	893	813	777	738	717	683
G ₁₁ M ₁ P ₁	1122	974	877	696	565	512	502	485
G ₁₁ M ₁ P ₂	1254	1118	1058	1001	959	905	876	814
G ₁₁ M ₁ P ₃	1235	1189	1161	1131	1101	1071	1042	974
G ₁₁ M ₂ P ₁	1060	936	882	805	726	678	631	522
G ₁₁ M ₂ P ₂	1127	997	956	929	888	835	797	753
G ₁₁ M ₂ P ₃	1209	1133	1043	960	921	878	853	819
G ₁₂ M ₁ P ₁	1184	1034	912	746	594	559	593	529
G ₁₂ M ₁ P ₂	1301	1131	1072	1021	977	921	894	822
G ₁₂ M ₁ P ₃	1301	1254	1222	1191	1160	1133	1042	1032
G ₁₂ M ₂ P ₁	1117	985	851	848	711	728	680	625
G ₁₂ M ₂ P ₂	1190	1059	1011	959	939	889	786	795
G ₁₂ M ₂ P ₃	1278	1200	1053	1021	858	937	911	876
S.Em ±	36.6	36.4	35.4	33.6	30.7	29.2	28.7	26.8
CD (<0.05P)	NS	NS	NS	NS	85.7	81.5	80.3	NS
CV (%)	6.9	7.6	8	8.3	8.2	8.2	8.5	8.5

Initial Seedling vigour index-I														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
287	349	664	924	1001	1384	1412	1377	1094	1100	1250	1344	46.13	134.64	7.9

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

Packaging: The effect of packaging on SVI-I was significantly differed throughout storage period. The higher SVI-I was recorded in P₃ (980) followed by P₂ (934) and (P₁) recorded (846) during 3rd month storage. At six months storage, the P₃ (912) followed by P₂ (841) and (P₁) recorded 729 and during nine months P₃ (857), P₂ (790) and P₁ (729). The 12, 15, 18, 21 and 24th months storage, the P₃ was recorded significantly over P₂ and P₁. The higher SVI-I (813, 775, 745, 725 and 679 in P₃, respectively) and (740, 711, 666, 630 and 588 in P₂, respectively and lower SVI-I was recorded in P₁ 552, 465, 434, 411 and 375, respectively).

Genotypes × Fruit and seed materials: Genotypes × materials interaction for SVI-I was none significantly differed throughout storage period.

Fruit and seed materials × Packaging: Materials × Packaging interaction for SVI-I was significant throughout storage period. The higher SVI-I was recorded in M₁P₃ (995) followed by M₁P₂ (977) and lower SVI-I was recorded in M₁P₁ (879) and M₂P₂ (890) during three months of storage. At six months storage, the higher SVI-I was recorded in M₁P₃ (949) and M₁P₂ (907) and lower SVI-I was recorded in M₂P₁ (706) and M₁P₁ (752), respectively. The higher SVI-I was recorded in M₁P₃ (910) and M₁P₂ (847) and lower SVI-I was recorded in M₂P₁ (645) followed by M₁P₁ (650) and M₂P₂ (733) during 9th month of storage. At the end of 12th month storage period, the higher SVI-I was recorded in M₁P₃ (885) followed by M₁P₂ (791) and M₂P₃ (742) and lower SVI-I was recorded in M₁P₁ (516) followed by M₂P₁ (587), respectively during 12th month storage. At 15th month storage period, the higher SVI-I was recorded in M₁P₃ (857) and M₁P₂ (757) and lower SVI-I was recorded in M₁P₁ (406) and M₂P₁ (524), respectively. At 18th month storage period, the higher SVI-I was recorded in M₁P₃ (832) and M₁P₂ (709) and lower SVI-I was recorded in M₁P₁ (374) followed by M₂P₁ (495) and M₂P₂ (623), respectively. At 21st month storage period, the higher SVI-I was recorded in M₁P₃ (800), and M₁P₂ (674) and lower SVI-I was recorded in M₁P₁ (364) followed by M₂P₁ (458) and M₂P₂ (586), respectively. At the end of 24th month of storage period, the higher SVI-I was recorded in M₁P₃ (739) followed by M₁P₂ (625) on par with M₂P₃ (9.70 cm) and lower SVI-I was recorded in M₁P₁ (345) followed by M₂P₁ (405) and M₂P₂ (9551), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for SVI-I was significant throughout storage period except 3rd and 6th month of storage. The higher SVI-I was recorded in G₈P₃ (1308) and G₇P₂ (1185) and lower SVI-I was recorded in G₁P₁ (55) followed by G₂P₁ (137). During the 9th month of storage, the higher SVI-I was recorded in G₇P₃ (1234) and G₁₂P₃ (1106) and lower SVI-I was recorded in G₁P₁ (33) and G₂P₁ (83) during 12th month of storage. At 15th month storage period, the higher SVI-I was recorded in G₇P₃ (1183) and G₇P₂ (1094) and lower SVI-I was recorded in G₁P₁ (24) and G₂P₁ (60). At 18th month storage period, the higher SVI-I was recorded in G₇P₃ (1078) and G₇P₂ (1036) and lower SVI-I was recorded in G₁P₁ (25) and G₂P₁ (49). At 21st month of storage period, the higher SVI-I was recorded in G₇P₃ (1129) and G₆P₃ (986) and lower SVI-I was recorded in G₁P₁ (13) followed by G₂P₁ (43), respectively. At end of the 24th month of storage period, the higher SVI-I was recorded in G₇P₃ (1087) and G₁₂P₃ (954) and lower SVI-I was recorded in G₁P₁ (4) and G₂P₁ (23), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of Genotypes × Materials × Packaging was significantly differed during 15th, 18th, 21st and 24th month of storage and rest of the storage period and showed non-significant during storage period. At 15th month of the storage, the maximum SVI-I was recorded in G₇ × M₁ × P₃ (1283) and G₇ × M₁ × P₂ (1163) and lower SVI-I was recorded in G₁ × M₂ × P₁ (17) and G₁ × M₂ × P₂ (30), respectively. At 18th month storage, the maximum SVI-I was recorded in G₇ × M₁ × P₃ (1258) and G₁ × M₂ × P₃ (1133) and lower SVI-I was recorded in G₁ × M₂ × P₁ (7) and G₁ × M₁ × P₁ (32), respectively.

At 21st month storage, the maximum SVI-I was recorded in G₇ × M₁ × P₃ (1227) and G₆ × M₁ × P₂ (1087) and lower SVI-I was recorded in G₁ × M₂ × P₁ (5) and G₁ × M₁ × P₁ (21), respectively. At the end of the 24th storage month, the maximum SVI-I was recorded in G₇ × M₁ × P₃ (1168) and G₆ × M₁ × P₂ (1032) and lower SVI-I was recorded in G₁ × M₂ × P₁ (3) and G₁ × M₁ × P₁ (5), respectively.

4.3.5 Total dehydrogenase activity (A° 480 nm) :

The results on Total dehydrogenase activity as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.25).

Table 4.25. Total dehydrogenase activity (A° 480 nm) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	0.859	1.006	0.590	0.481	0.411	0.198	0.096	0.129
G ₂	1.391	1.383	1.122	0.922	0.859	0.439	0.277	0.222
G ₃	1.628	1.618	1.359	1.259	1.179	0.842	0.640	0.381
G ₄	1.607	1.597	1.337	1.238	1.158	0.843	0.618	0.358
G ₅	2.703	2.607	2.433	2.333	2.253	1.972	1.712	1.453
G ₆	3.030	3.027	2.762	2.663	2.581	2.302	2.041	1.781
G ₇	3.335	3.070	2.948	2.964	2.885	2.606	2.347	2.012
G ₈	2.632	2.622	2.321	2.263	2.183	1.902	1.642	1.383
G ₉	1.747	1.737	1.477	1.376	1.295	1.016	0.754	0.494
G ₁₀	2.663	2.653	2.392	2.294	2.213	1.932	1.672	1.412
G ₁₁	1.736	1.726	1.466	1.366	1.286	1.005	0.745	0.483
G ₁₂	2.752	2.706	2.362	2.381	2.301	2.039	1.762	1.502
S.Em ±	0.020	0.050	0.026	0.017	0.016	0.015	0.013	0.014
CD (<0.05P)	0.056	0.138	0.073	0.048	0.046	0.041	0.037	0.039
M ₁	2.192	2.184	1.915	1.822	1.743	1.448	1.219	0.991
M ₂	2.155	2.108	1.846	1.768	1.691	1.401	1.166	0.943
S.Em ±	0.008	0.020	0.011	0.007	0.007	0.006	0.005	0.006
CD (<0.05P)	0.023	0.056	0.030	0.019	0.019	0.017	0.015	0.016
P ₁	1.978	1.889	1.889	1.580	1.508	1.226	1.020	0.783
P ₂	2.251	2.263	1.967	1.881	1.801	1.485	1.256	1.038
P ₃	2.292	2.285	2.005	1.923	1.843	1.563	1.301	1.082
S.Em ±	0.010	0.025	0.013	0.009	0.008	0.007	0.007	0.007
CD (<0.05P)	0.028	0.069	0.037	0.024	0.023	0.020	0.019	0.020
G ₁ M ₁	0.879	1.183	0.608	0.508	0.429	0.216	0.143	0.148
G ₁ M ₂	0.839	0.829	0.572	0.454	0.392	0.180	0.048	0.110
G ₂ M ₁	1.408	1.470	1.139	1.032	0.962	0.438	0.360	0.237
G ₂ M ₂	1.374	1.297	1.104	0.811	0.757	0.440	0.194	0.208
G ₃ M ₁	1.640	1.630	1.372	1.272	1.193	0.914	0.656	0.394
G ₃ M ₂	1.616	1.606	1.347	1.246	1.166	0.769	0.624	0.367
G ₄ M ₁	1.620	1.611	1.351	1.252	1.172	0.894	0.634	0.376
G ₄ M ₂	1.593	1.582	1.322	1.223	1.143	0.791	0.602	0.340
G ₅ M ₁	2.720	2.644	2.451	2.352	2.272	1.991	1.730	1.472
G ₅ M ₂	2.686	2.569	2.414	2.313	2.233	1.953	1.694	1.434
G ₆ M ₁	3.047	3.093	2.779	2.681	2.599	2.319	2.058	1.798
G ₆ M ₂	3.013	2.960	2.744	2.644	2.563	2.284	2.023	1.764
G ₇ M ₁	3.359	2.996	3.008	2.989	2.910	2.630	2.369	2.110
G ₇ M ₂	3.311	3.144	2.889	2.940	2.860	2.582	2.326	1.914
G ₈ M ₁	2.651	2.641	2.383	2.282	2.202	1.921	1.660	1.400
G ₈ M ₂	2.613	2.603	2.258	2.244	2.163	1.883	1.623	1.367
G ₉ M ₁	1.769	1.760	1.498	1.396	1.317	1.036	0.774	0.512
G ₉ M ₂	1.724	1.714	1.457	1.356	1.273	0.996	0.734	0.476
G ₁₀ M ₁	2.682	2.672	2.410	2.313	2.232	1.952	1.691	1.429
G ₁₀ M ₂	2.643	2.633	2.374	2.274	2.193	1.912	1.653	1.394
G ₁₁ M ₁	1.760	1.750	1.488	1.388	1.308	1.026	0.767	0.502

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₂	1.712	1.702	1.444	1.344	1.264	0.984	0.723	0.463
G ₁₂ M ₁	2.770	2.760	2.499	2.398	2.319	2.040	1.780	1.520
G ₁₂ M ₂	2.734	2.652	2.224	2.364	2.283	2.039	1.744	1.483
S.Em $\pm$	0.029	0.070	0.037	0.024	0.023	0.021	0.019	0.020
CD (<0.05P)	NS	NS	0.103	0.068	0.065	0.057	0.053	0.056
M ₁ P ₁	1.983	1.879	1.693	1.611	1.535	1.251	1.031	0.809
M ₁ P ₂	2.293	2.347	2.023	1.923	1.844	1.521	1.294	1.076
M ₁ P ₃	2.299	2.328	2.031	1.931	1.851	1.572	1.331	1.090
M ₂ P ₁	1.972	1.900	1.648	1.549	1.481	1.200	1.009	0.757
M ₂ P ₂	2.208	2.180	1.910	1.839	1.758	1.449	1.217	1.000
M ₂ P ₃	2.285	2.243	1.980	1.915	1.835	1.554	1.272	1.073
S.Em $\pm$	0.014	0.035	0.019	0.012	0.012	0.010	0.009	0.010
CD (<0.05P)	0.040	0.098	NS	0.034	0.033	0.029	0.027	0.028
G ₁ P ₁	0.657	0.647	0.392	0.263	0.213	0.133	0.092	0.058
G ₁ P ₂	0.940	1.197	0.670	0.570	0.487	0.208	0.055	0.133
G ₁ P ₃	0.980	1.175	0.708	0.610	0.532	0.252	0.140	0.195
G ₂ P ₁	1.193	1.078	0.923	0.527	0.498	0.222	0.172	0.187
G ₂ P ₂	1.468	1.570	1.200	1.098	1.020	0.313	0.310	0.218
G ₂ P ₃	1.512	1.502	1.242	1.140	1.060	0.782	0.350	0.262
G ₃ P ₁	1.435	1.425	1.165	1.065	0.985	0.532	0.445	0.187
G ₃ P ₂	1.713	1.703	1.442	1.342	1.262	0.982	0.722	0.460
G ₃ P ₃	1.735	1.725	1.472	1.370	1.292	1.012	0.753	0.495
G ₄ P ₁	1.403	1.392	1.133	1.037	0.958	0.570	0.420	0.160
G ₄ P ₂	1.687	1.677	1.417	1.317	1.235	0.957	0.697	0.437
G ₄ P ₃	1.730	1.722	1.460	1.360	1.280	1.002	0.738	0.477
G ₅ P ₁	2.510	2.242	2.238	2.138	2.058	1.778	1.517	1.258
G ₅ P ₂	2.778	2.768	2.508	2.410	2.330	2.048	1.788	1.530
G ₅ P ₃	2.820	2.810	2.552	2.450	2.370	2.090	1.832	1.572
G ₆ P ₁	2.833	2.908	2.563	2.467	2.387	2.105	1.843	1.583
G ₆ P ₂	3.108	3.098	2.840	2.740	2.658	2.378	2.118	1.860
G ₆ P ₃	3.148	3.073	2.882	2.782	2.698	2.422	2.160	1.900
G ₇ P ₁	3.147	2.473	2.750	2.773	2.695	2.417	2.157	1.668
G ₇ P ₂	3.392	3.382	2.983	3.025	2.945	2.667	2.410	2.153
G ₇ P ₃	3.467	3.355	3.112	3.095	3.015	2.735	2.475	2.215
G ₈ P ₁	2.438	2.428	2.170	2.068	1.988	1.707	1.447	1.190
G ₈ P ₂	2.708	2.698	2.440	2.338	2.260	1.980	1.718	1.460
G ₈ P ₃	2.750	2.740	2.352	2.383	2.300	2.020	1.760	1.500
G ₉ P ₁	1.558	1.548	1.288	1.183	1.103	0.825	0.560	0.300
G ₉ P ₂	1.820	1.810	1.552	1.450	1.368	1.088	0.832	0.570
G ₉ P ₃	1.862	1.853	1.592	1.493	1.413	1.133	0.872	0.612
G ₁₀ P ₁	2.465	2.455	2.193	2.095	2.015	1.733	1.475	1.213
G ₁₀ P ₂	2.743	2.733	2.473	2.373	2.293	2.013	1.752	1.492
G ₁₀ P ₃	2.780	2.770	2.510	2.413	2.330	2.050	1.790	1.530
G ₁₁ P ₁	1.537	1.527	1.265	1.165	1.085	0.805	0.547	0.285
G ₁₁ P ₂	1.822	1.812	1.553	1.452	1.372	1.088	0.827	0.563
G ₁₁ P ₃	1.850	1.840	1.580	1.482	1.402	1.122	0.862	0.600
G ₁₂ P ₁	2.557	2.547	1.962	2.183	2.105	1.880	1.567	1.305
G ₁₂ P ₂	2.828	2.712	2.522	2.458	2.378	2.098	1.838	1.578

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₃	2.872	2.860	2.602	2.502	2.420	2.140	1.882	1.622
S.Em $\pm$	0.035	0.086	0.045	0.030	0.029	0.025	0.023	0.024
CD (<0.05P)	NS	0.240	0.127	0.083	0.080	0.070	0.065	0.068
G ₁ M ₁ P ₁	0.667	0.657	0.397	0.297	0.220	0.137	0.130	0.093
G ₁ M ₁ P ₂	0.980	1.503	0.710	0.607	0.527	0.247	0.070	0.140
G ₁ M ₁ P ₃	0.990	1.390	0.717	0.620	0.540	0.263	0.230	0.210
G ₁ M ₂ P ₁	0.647	0.637	0.387	0.230	0.207	0.130	0.053	0.023
G ₁ M ₂ P ₂	0.900	0.890	0.630	0.533	0.447	0.170	0.040	0.127
G ₁ M ₂ P ₃	0.970	0.960	0.700	0.600	0.523	0.240	0.050	0.180
G ₂ M ₁ P ₁	1.197	1.180	0.927	0.810	0.757	0.237	0.210	0.180
G ₂ M ₁ P ₂	1.507	1.720	1.240	1.137	1.060	0.283	0.340	0.260
G ₂ M ₁ P ₃	1.520	1.510	1.250	1.150	1.070	0.793	0.530	0.270
G ₂ M ₂ P ₁	1.190	0.977	0.920	0.243	0.240	0.207	0.133	0.193
G ₂ M ₂ P ₂	1.430	1.420	1.160	1.060	0.980	0.343	0.280	0.177
G ₂ M ₂ P ₃	1.503	1.493	1.233	1.130	1.050	0.770	0.170	0.253
G ₃ M ₁ P ₁	1.440	1.430	1.170	1.070	0.990	0.710	0.450	0.190
G ₃ M ₁ P ₂	1.750	1.740	1.477	1.377	1.300	1.020	0.760	0.497
G ₃ M ₁ P ₃	1.730	1.720	1.470	1.370	1.290	1.013	0.757	0.497
G ₃ M ₂ P ₁	1.430	1.420	1.160	1.060	0.980	0.353	0.440	0.183
G ₃ M ₂ P ₂	1.677	1.667	1.407	1.307	1.223	0.943	0.683	0.423
G ₃ M ₂ P ₃	1.740	1.730	1.473	1.370	1.293	1.010	0.750	0.493
G ₄ M ₁ P ₁	1.397	1.387	1.130	1.033	0.957	0.677	0.420	0.163
G ₄ M ₁ P ₂	1.727	1.717	1.457	1.357	1.273	0.997	0.737	0.477
G ₄ M ₁ P ₃	1.737	1.730	1.467	1.367	1.287	1.010	0.747	0.487
G ₄ M ₂ P ₁	1.410	1.397	1.137	1.040	0.960	0.463	0.420	0.157
G ₄ M ₂ P ₂	1.647	1.637	1.377	1.277	1.197	0.917	0.657	0.397
G ₄ M ₂ P ₃	1.723	1.713	1.453	1.353	1.273	0.993	0.730	0.467
G ₅ M ₁ P ₁	2.517	2.310	2.247	2.147	2.067	1.787	1.523	1.267
G ₅ M ₁ P ₂	2.817	2.807	2.547	2.450	2.370	2.087	1.827	1.570
G ₅ M ₁ P ₃	2.827	2.817	2.560	2.460	2.380	2.100	1.840	1.580
G ₅ M ₂ P ₁	2.503	2.173	2.230	2.130	2.050	1.770	1.510	1.250
G ₅ M ₂ P ₂	2.740	2.730	2.470	2.370	2.290	2.010	1.750	1.490
G ₅ M ₂ P ₃	2.813	2.803	2.543	2.440	2.360	2.080	1.823	1.563
G ₆ M ₁ P ₁	2.837	2.997	2.567	2.473	2.393	2.110	1.847	1.587
G ₆ M ₁ P ₂	3.147	3.137	2.877	2.780	2.697	2.417	2.157	1.897
G ₆ M ₁ P ₃	3.157	3.147	2.893	2.790	2.707	2.430	2.170	1.910
G ₆ M ₂ P ₁	2.830	2.820	2.560	2.460	2.380	2.100	1.840	1.580
G ₆ M ₂ P ₂	3.070	3.060	2.803	2.700	2.620	2.340	2.080	1.823
G ₆ M ₂ P ₃	3.140	3.000	2.870	2.773	2.690	2.413	2.150	1.890
G ₇ M ₁ P ₁	3.150	2.037	2.633	2.777	2.700	2.420	2.160	1.900
G ₇ M ₁ P ₂	3.457	3.447	3.190	3.090	3.010	2.730	2.467	2.210
G ₇ M ₁ P ₃	3.470	3.503	3.200	3.100	3.020	2.740	2.480	2.220
G ₇ M ₂ P ₁	3.143	2.910	2.867	2.770	2.690	2.413	2.153	1.437
G ₇ M ₂ P ₂	3.327	3.317	2.777	2.960	2.880	2.603	2.353	2.097
G ₇ M ₂ P ₃	3.463	3.207	3.023	3.090	3.010	2.730	2.470	2.210
G ₈ M ₁ P ₁	2.447	2.437	2.180	2.077	1.997	1.713	1.453	1.197
G ₈ M ₁ P ₂	2.747	2.737	2.477	2.377	2.300	2.020	1.757	1.497
G ₈ M ₁ P ₃	2.760	2.750	2.493	2.393	2.310	2.030	1.770	1.507
G ₈ M ₂ P ₁	2.430	2.420	2.160	2.060	1.980	1.700	1.440	1.183

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₂ P ₂	2.670	2.660	2.403	2.300	2.220	1.940	1.680	1.423
G ₈ M ₂ P ₃	2.740	2.730	2.210	2.373	2.290	2.010	1.750	1.493
G ₉ M ₁ P ₁	1.577	1.567	1.303	1.197	1.117	0.837	0.570	0.307
G ₉ M ₁ P ₂	1.860	1.850	1.590	1.487	1.410	1.127	0.873	0.610
G ₉ M ₁ P ₃	1.870	1.863	1.600	1.503	1.423	1.143	0.880	0.620
G ₉ M ₂ P ₁	1.540	1.530	1.273	1.170	1.090	0.813	0.550	0.293
G ₉ M ₂ P ₂	1.780	1.770	1.513	1.413	1.327	1.050	0.790	0.530
G ₉ M ₂ P ₃	1.853	1.843	1.583	1.483	1.403	1.123	0.863	0.603
G ₁₀ M ₁ P ₁	2.470	2.460	2.200	2.100	2.020	1.740	1.480	1.220
G ₁₀ M ₁ P ₂	2.787	2.777	2.513	2.417	2.337	2.057	1.793	1.530
G ₁₀ M ₁ P ₃	2.790	2.780	2.517	2.423	2.340	2.060	1.800	1.537
G ₁₀ M ₂ P ₁	2.460	2.450	2.187	2.090	2.010	1.727	1.470	1.207
G ₁₀ M ₂ P ₂	2.700	2.690	2.433	2.330	2.250	1.970	1.710	1.453
G ₁₀ M ₂ P ₃	2.770	2.760	2.503	2.403	2.320	2.040	1.780	1.523
G ₁₁ M ₁ P ₁	1.543	1.533	1.270	1.170	1.090	0.810	0.553	0.290
G ₁₁ M ₁ P ₂	1.877	1.867	1.603	1.503	1.423	1.137	0.877	0.607
G ₁₁ M ₁ P ₃	1.860	1.850	1.590	1.490	1.410	1.130	0.870	0.610
G ₁₁ M ₂ P ₁	1.530	1.520	1.260	1.160	1.080	0.800	0.540	0.280
G ₁₁ M ₂ P ₂	1.767	1.757	1.503	1.400	1.320	1.040	0.777	0.520
G ₁₁ M ₂ P ₃	1.840	1.830	1.570	1.473	1.393	1.113	0.853	0.590
G ₁₂ M ₁ P ₁	2.560	2.550	2.290	2.187	2.110	1.833	1.570	1.310
G ₁₂ M ₁ P ₂	2.867	2.860	2.597	2.497	2.417	2.137	1.877	1.617
G ₁₂ M ₁ P ₃	2.883	2.870	2.610	2.510	2.430	2.150	1.893	1.633
G ₁₂ M ₂ P ₁	2.553	2.543	1.633	2.180	2.100	1.927	1.563	1.300
G ₁₂ M ₂ P ₂	2.790	2.563	2.447	2.420	2.340	2.060	1.800	1.540
G ₁₂ M ₂ P ₃	2.860	2.850	2.593	2.493	2.410	2.130	1.870	1.610
S.Em ±	0.049	0.121	0.064	0.042	0.040	0.036	0.033	0.035
CD (<0.05P)	NS	NS	0.179	0.117	0.113	0.099	0.092	0.097
CV (%)	3.9	9.8	5.9	4.0	4.1	4.3	4.8	6.2

Initial Total dehydrogenase activity (A ⁰ 480 nm)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (^{<} 0.05P)	CV (%)
0.913	1.413	1.813	1.783	2.714	3.115	3.44	2.931	1.923	2.963	1.936	2.653	0.05	0.16	4.1

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

Genotypes: There was significant difference between the genotypes for total dehydrogenase activity throughout storage period. The higher total dehydrogenase activity was recorded in G₇ (3.335 A° 480 nm) and G₆ (3.030 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.859 A° 480 nm) and G₂ (1.319 A° 480 nm) during three months of storage period. The higher total dehydrogenase activity was recorded in G₇ (3.070 A° 480 nm) and G₆ (3.027 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (1.006 A° 480 nm) and G₂ (1.383 A° 480 nm) during 6th month of storage period. The higher total dehydrogenase activity was recorded in G₇ (2.948 A° 480 nm) and G₆ (2.76 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.590 A° 480 nm) and G₂ (1.122 A° 480 nm) during 9th month of storage period. The higher total dehydrogenase activity was recorded in G₇ (2.964 A° 480 nm) and G₆ (2.663 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.481 A° 480 nm) and G₂ (0.922 A° 480 nm) during 12th month of storage period. The higher total dehydrogenase activity was recorded in G₇ (2.885 A° 480 nm) and G₆ (2.581 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.481 A° 480 nm) and G₂ (0.859 A° 480 nm) during 15th month of storage period. The higher total dehydrogenase activity was recorded in G₇ (2.606 A° 480 nm) and G₈ (2.302 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.198 A° 480 nm) and G₂ (0.439 A° 480 nm) during 18th month of storage period. The higher total dehydrogenase activity was recorded in G₇ (2.347 A° 480 nm) and G₆ (2.041 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.096 A° 480 nm) and G₂ (0.277 A° 480 nm) during 21st month of storage period. At end of the storage period, the higher total dehydrogenase activity was recorded in G₇ (2.012 A° 480 nm) and G₆ (1.781 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁ (0.129 A° 480 nm) and G₂ (0.222 A° 480 nm), respectively.

Fruit and seed materials: Total dehydrogenase activity differed significantly among the materials throughout storage period. Whole fruits (M₁) recorded the highest total dehydrogenase activity throughout the storage period.

At three months storage, the higher total dehydrogenase activity was recorded in M₁ (2.192 A° 480 nm) and M₂ (2.155 A° 480 nm). At six months storage, the M₁ (2.184

A° 480 nm) and M₂ (2.108 A° 480 nm). At nine months, M₁ (1.915 A° 480 nm) and M₂ (1.846 A° 480 nm). The 12, 15, 18 21 and 24 months storage, the M₁ was recorded significantly over M₂. The higher total dehydrogenase activity (1.822, 1.743, 1.478, 1.219 and 0.991 A° 480 nm, respectively) and (1.768, 1.691, 1.401, 1.166 and 0.943 and 480 A° 480 nm in M₂, respectively).

Packaging: The effect of packaging on total dehydrogenase activity was significantly differed throughout storage period. The higher total dehydrogenase activity was recorded in P₃ (2.292 A° 480 nm) followed by P₂ (2.271 A° 480 nm) and P₁ recorded 1.978 A° 480 nm during 3rd month storage. At six months storage, the higher total dehydrogenase activity was recorded in P₃ (2.285 A° 480 nm) followed by P₂ (2.263 A° 480 nm) and (P₁) recorded 1.889 A° 480 nm during 6th month storage. At 9th month storage, the higher total dehydrogenase activity was recorded in P₃ (2.005 A° 480 nm) followed by P₂ (1.967 A° 480 nm) and (P₁) recorded 1.889 A° 480 nm during 9th month storage. At 12th month storage, the higher total dehydrogenase activity was recorded in P₃ (1.923 A° 480 nm) followed by P₂ (1.881 A° 480 nm) and (P₁) recorded 1.580 A° 480 nm during 12th month storage. At 15th month storage, the higher total dehydrogenase activity was recorded in P₃ (1.843 A° 480 nm) followed by P₂ (1.801 A° 480 nm) and P₁ (1.508 A° 480 nm) recorded during 15th month storage. At 18th month storage, the higher total dehydrogenase activity was recorded in P₃ (1.563 A° 480 nm) followed by P₂ (1.485 A° 480 nm) and (P₁) recorded 1.226 A° 480 nm during 18th month storage. At 21st month storage, the higher total dehydrogenase activity was recorded in P₃ (1.301 A° 480 nm) followed by P₂ (1.256 A° 480 nm) and (P₁) recorded 1.020 A° 480 nm during 21st month storage. At 24th month storage, the higher total dehydrogenase activity was recorded in P₃ (1.082 A° 480 nm) followed by P₂ (1.038 A° 480 nm) and (P₁) recorded 0.783 A° 480 nm during 24th month storage.

Genotypes × Fruit and seed materials: the interaction of genotypes × materials showed non-significant difference in 3rd and 6th month of storage period and rest of the storage period showed significant difference. At 9th month of storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in G₇M₁ (3.008 A° 480 nm) and G₇M₂ (2.889 A° 480 nm) and lower total dehydrogenase activity was recorded in G₁M₂ (0.572

$A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.608 A^\circ 480 \text{ nm}$). At 12th month of storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($2.989 A^\circ 480 \text{ nm}$) and G_7M_2 ($2.940 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($0.454 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.508 A^\circ 480 \text{ nm}$). At 15th month of storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($2.910 A^\circ 480 \text{ nm}$) and G_7M_2 ($2.860 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($0.392 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.429 A^\circ 480 \text{ nm}$). At 18th month of storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($2.630 A^\circ 480 \text{ nm}$) and G_7M_2 ($2.582 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($0.180 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.216 A^\circ 480 \text{ nm}$). At 21th month of storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($2.369 A^\circ 480 \text{ nm}$) and G_7M_2 ($2.326 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($0.048 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.143 A^\circ 480 \text{ nm}$). At 24th month of storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($2.110 A^\circ 480 \text{ nm}$) and G_7M_2 ($1.914 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($0.110 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($0.148 A^\circ 480 \text{ nm}$). At 12th month storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($15.7 A^\circ 480 \text{ nm}$) and G_6M_1 ($14.46 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($4.3 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($4.6 A^\circ 480 \text{ nm}$), respectively. At 15th month storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($15.6 A^\circ 480 \text{ nm}$) and G_6M_1 ($14.4 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($3.8 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($3.9 A^\circ 480 \text{ nm}$), respectively. At 18th month storage, the higher total dehydrogenase activity was recorded in G_7M_2 ($14.4 A^\circ 480 \text{ nm}$) and G_1M_7 ($14.3 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($3.7 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($3.9 A^\circ 480 \text{ nm}$), respectively. At 21st month storage, the higher total dehydrogenase activity was recorded in G_7M_1 ($15.2 A^\circ 480 \text{ nm}$) and G_6M_1 ($14.00 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($3.4 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($3.7 A^\circ 480 \text{ nm}$), respectively. At end of the storage month, the higher total dehydrogenase activity was recorded in G_6M_1 ($14.3 A^\circ 480 \text{ nm}$) and G_7M_1 ($14.30 A^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in G_1M_2 ($3.1 A^\circ 480 \text{ nm}$) followed by G_1M_1 ($3.3 A^\circ 480 \text{ nm}$), respectively.

Fruit and seed materials × Packaging: Materials × Packaging interaction for total dehydrogenase activity was significant throughout storage period except at 6th month storage the total dehydrogenase activity was non-significant. The higher total dehydrogenase activity was recorded in M₁P₃ (2.299 A° 480 nm) followed by M₁P₂ (2.293 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.972 A° 480 nm) and M₁P₁ (1.983 A° 480 nm) during three months of storage. At 9th month storage, the higher total dehydrogenase activity was recorded in M₁P₃ (2.031 A° 480 nm) followed by M₁P₂ (2.023 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.648 A° 480 nm) followed by M₁P₁ (1.693 A° 480 nm), respectively. At 12th month storage, the higher total dehydrogenase activity was recorded in M₁P₃ (1.931 A° 480 nm) followed by M₁P₂ (1.923 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.549 A° 480 nm) followed by M₁P₁ (1.611 A° 480 nm), respectively. At 15th month storage, the higher total dehydrogenase activity was recorded in M₁P₃ (1.851 A° 480 nm) followed by M₁P₂ (1.844 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.481 A° 480 nm) followed by M₁P₁ (1.535 A° 480 nm), respectively. At 18th month storage, the higher total dehydrogenase activity was recorded in M₁P₃ (1.572 A° 480 nm) followed by M₂P₃ (1.554 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.200 A° 480 nm) followed by M₁P₁ (1.251 A° 480 nm), respectively. At 21st month storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in M₁P₃ (1.331 A° 480 nm) followed by M₁P₂ (1.294 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (1.009 A° 480 nm) followed by M₁P₁ (1.031 A° 480 nm), respectively. At 24th month storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in M₁P₃ (1.090 A° 480 nm) followed by M₁P₂ (1.076 A° 480 nm) and lower total dehydrogenase activity was recorded in M₂P₁ (0.757 A° 480 nm) followed by M₁P₁ (0.809 A° 480 nm), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for total dehydrogenase activity was significant throughout storage period except 3rd month of storage. At 6th month storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in G₇P₂ (3.382 A° 480 nm) and G₇P₃ (3.355 A° 480 nm), and lower total dehydrogenase activity was recorded in G₁P₁ (0.647 A° 480 nm) and G₂P₁ (1.078 A° 480

nm) during three months of storage. At 9th month storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in G_7P_3 (3.112 A° 480 nm) and G_7P_2 (2.983 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_1 (0.392 A° 480 nm) and G_2P_1 (0.670 A° 480 nm) during three months of storage. At 12th month storage, the higher total dehydrogenase activity (A° 480 nm) was recorded in G_7P_3 (3.095 A° 480 nm) and G_7P_2 (3.025 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_1 (0.263 A° 480 nm) and G_2P_1 (0.527 A° 480 nm) during three months of storage. At 15th month storage, the higher total dehydrogenase activity was recorded in G_7P_3 (3.015 A° 480 nm) and G_7P_2 (2.945 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_1 (0.213 A° 480 nm) and G_2P_1 (0.487 A° 480 nm) during three months of storage. At 18th month storage, the higher total dehydrogenase activity was recorded in G_7P_3 (2.735 A° 480 nm) and G_7P_2 (2.667 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_1 (0.133 A° 480 nm) and G_1P_2 (0.208 A° 480 nm) during three months of storage. At 21st month storage, the higher total dehydrogenase activity was recorded in G_7P_3 (2.475 A° 480 nm) and G_7P_2 (2.410 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_2 (0.055 A° 480 nm) and G_1P_1 (0.092 A° 480 nm) during three months of storage. At end of the storage month, the higher total dehydrogenase activity (A° 480 nm) was recorded in G_7P_3 (2.215 A° 480 nm) and G_7P_2 (2.153 A° 480 nm), and lower total dehydrogenase activity was recorded in G_1P_1 (0.058 A° 480 nm) and G_1P_2 (0.133 A° 480 nm) during three months of storage.

Genotypes $\times$ Fruit and seed materials $\times$ Packaging: Interaction of genotypes $\times$ materials $\times$ packaging was non-significant during 3, and 6th storage period and there was significant difference rest of the storage period.

At 9th month storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (3.200 A° 480 nm) and $G_7 \times M_1 \times P_2$ (3.190 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_1$ (0.387 A° 480 nm) and $G_1 \times M_1 \times P_1$ (0.397 A° 480 nm), respectively. At 12th month storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (3.100 A° 480 nm) and $G_7 \times M_1 \times P_2$ (3.090 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_1$ (0.230 A° 480 nm) and $G_2 \times M_2 \times P_1$ (0.243 A° 480 nm), respectively. At 15th month

storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (3.020 A° 480 nm) and $G_7 \times M_2 \times P_2$ (3.010 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_1$ (0.207 A° 480 nm) and $G_1 \times M_1 \times P_1$ (0.220 A° 480 nm), respectively. At 18th month storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (2.740 A° 480 nm) and $G_7 \times M_1 \times P_2$ (2.730 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_1$ (0.130 A° 480 nm) and $G_1 \times M_1 \times P_1$ (0.137 A° 480 nm), respectively. At 21st month storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (2.480 A° 480 nm) and $G_7 \times M_2 \times P_3$ (2.470 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_2$ (0.040 A° 480 nm) and $G_1 \times M_2 \times P_3$ (0.050 A° 480 nm), respectively. At 24th month storage, the maximum total dehydrogenase activity was recorded in $G_7 \times M_1 \times P_3$ (2.220 A° 480 nm) and $G_7 \times M_2 \times P_3$ (2.210 A° 480 nm) and lower total dehydrogenase activity was recorded in $G_1 \times M_2 \times P_1$ (0.023 A° 480 nm) and $G_1 \times M_1 \times P_1$ (0.093 A° 480 nm), respectively.

4.3.6 Electrical conductivity ($\text{mS cm}^{-1} \text{ g}^{-1}$): The results on electrical conductivity as influenced by genotypes, packaging, materials and their interaction effects are presented (Table.4.26).

Genotypes: There was significant difference between the genotypes for electrical conductivity throughout storage period. The lower electrical conductivity was recorded in G_6 ($11.75 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($12.71 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($13.83 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($34.71 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($26.75 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($20.81 \text{ mS cm}^{-1} \text{ g}^{-1}$) during three months of storage period. The 6th month storage, lower electrical conductivity was recorded in G_6 ($19.29 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($20.23 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($21.34 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($43.46 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($34.25 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($28.33 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. During 9th storage, lower electrical conductivity was recorded in G_6 ($29.00 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($29.92 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($31.03 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($51.13 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($44.06 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($38.02 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively and during 12th month storage, lower electrical conductivity was recorded in G_6 ($37.19 \text{ mS cm}^{-1} \text{ g}^{-1}$)

Table 4.26. Electrical conductivity (dS cm⁻¹ g⁻¹) of seed leachate as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	34.72	42.22	44.26	57.33	66.71	76.52	88.61	93.91
G ₂	26.75	34.26	37.99	50.10	59.52	68.54	80.68	85.97
G ₃	19.24	26.72	36.35	44.49	53.88	63.50	75.79	78.29
G ₄	14.99	22.48	32.18	40.22	49.53	58.74	70.98	74.10
G ₅	20.81	28.33	38.02	46.19	55.63	62.72	74.86	80.16
G ₆	17.00	24.52	34.20	42.37	51.80	58.88	71.02	76.32
G ₇	15.88	23.37	33.04	41.18	50.60	57.66	69.77	75.06
G ₈	12.71	20.23	29.92	38.09	47.53	54.62	66.76	72.06
G ₉	20.17	27.70	37.42	45.60	55.06	62.18	74.33	79.64
G ₁₀	18.21	25.73	35.42	43.59	53.03	60.12	72.26	77.56
G ₁₁	11.75	19.29	29.00	37.19	46.65	53.76	65.92	71.23
G ₁₂	13.83	21.34	31.03	39.19	48.63	55.71	67.84	73.14
S.Em ±	0.179	0.239	0.308	0.390	0.474	0.542	0.647	0.687
CD (<0.05P)	0.500	0.669	0.860	1.089	1.324	1.515	1.809	1.920
M ₁	21.00	27.26	36.60	45.98	55.29	64.25	74.34	79.14
M ₂	16.68	25.43	33.20	41.61	51.14	57.91	72.13	77.10
S.Em ±	0.073	0.098	0.126	0.159	0.193	0.221	0.264	0.280
CD (<0.05P)	0.203	0.272	0.350	0.444	0.539	0.617	0.736	0.782
P ₁	19.43	26.82	26.82	43.51	52.77	64.97	74.78	78.34
P ₂	16.55	25.60	32.51	42.26	51.01	62.35	70.17	76.87
P ₃	20.53	26.63	34.18	45.62	55.86	55.91	74.76	79.15
S.Em ±	0.089	0.120	0.154	0.195	0.237	0.271	0.324	0.344
CD (<0.05P)	0.250	0.334	0.430	0.545	0.662	0.757	0.904	0.960
G ₁ M ₁	36.76	42.99	48.14	61.62	70.90	79.06	89.79	94.60
G ₁ M ₂	32.67	41.45	40.38	53.04	62.53	73.98	87.43	93.21
G ₂ M ₁	28.83	35.07	41.15	53.72	63.01	71.12	81.93	86.74
G ₂ M ₂	24.67	33.44	34.83	46.49	56.04	65.97	79.43	85.20
G ₃ M ₁	21.41	27.66	37.68	46.32	55.63	68.91	74.56	79.38
G ₃ M ₂	17.07	25.78	35.02	42.65	52.14	58.09	77.01	77.19
G ₄ M ₁	17.15	23.35	33.46	41.87	50.97	63.38	70.50	74.91
G ₄ M ₂	12.83	21.60	30.90	38.57	48.10	54.10	71.47	73.30
G ₅ M ₁	22.99	29.27	39.35	48.02	57.37	65.55	76.39	81.22
G ₅ M ₂	18.63	27.40	36.70	44.37	53.90	59.90	73.33	79.10
G ₆ M ₁	19.17	25.43	35.50	44.17	53.50	61.67	72.50	77.33
G ₆ M ₂	14.83	23.60	32.90	40.57	50.10	56.10	69.53	75.30
G ₇ M ₁	18.07	24.33	34.40	43.07	52.40	60.57	71.40	76.23
G ₇ M ₂	13.69	22.40	31.67	39.30	48.80	54.75	68.15	73.88
G ₈ M ₁	14.89	21.16	31.24	39.91	49.26	57.44	68.28	73.12
G ₈ M ₂	10.53	19.30	28.60	36.27	45.80	51.80	65.23	71.00
G ₉ M ₁	22.40	28.70	38.83	47.54	56.93	65.16	76.03	80.89
G ₉ M ₂	17.93	26.70	36.00	43.67	53.20	59.20	72.63	78.40
G ₁₀ M ₁	20.39	26.66	36.74	45.41	54.76	62.94	73.78	78.62
G ₁₀ M ₂	16.03	24.80	34.10	41.77	51.30	57.30	70.73	76.50

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	13.95	20.26	30.37	39.09	48.47	56.70	67.58	72.45
G ₁₁ M ₂	9.55	18.32	27.62	35.29	44.82	50.82	64.25	70.02
G ₁₂ M ₁	15.99	22.26	32.33	40.99	50.33	58.49	69.33	74.16
G ₁₂ M ₂	11.66	20.43	29.73	37.39	46.93	52.93	66.36	72.13
S.Em $\pm$	0.253	0.338	0.435	0.551	0.670	0.766	0.915	0.972
CD (<0.05P)	NS	NS	NS	NS	NS	NS	NS	NS
M ₁ P ₁	23.33	28.32	40.33	48.26	57.20	70.28	76.34	80.23
M ₁ P ₂	18.57	26.38	34.60	43.51	52.42	65.72	71.56	77.87
M ₁ P ₃	21.10	27.09	34.87	46.16	56.25	56.75	75.12	79.32
M ₂ P ₁	15.53	25.31	35.70	38.76	48.33	59.66	73.22	76.44
M ₂ P ₂	14.54	24.83	30.43	41.01	49.60	58.99	68.78	75.87
M ₂ P ₃	19.96	26.16	33.48	45.07	55.48	55.08	74.39	78.99
S.Em $\pm$	0.126	0.169	0.218	0.276	0.335	0.383	0.458	0.486
CD (<0.05P)	0.353	0.473	0.608	0.770	0.936	1.071	1.279	1.358
G ₁ P ₁	35.40	42.80	54.00	52.61	61.83	81.00	89.60	94.40
G ₁ P ₂	32.55	41.62	41.86	58.30	67.06	77.28	86.24	92.96
G ₁ P ₃	36.19	42.24	36.92	61.08	71.25	71.29	89.99	94.36
G ₂ P ₁	27.19	34.56	45.68	46.43	55.67	72.48	81.04	85.81
G ₂ P ₂	24.50	33.55	35.70	50.20	58.95	69.15	78.10	84.80
G ₂ P ₃	28.55	34.66	32.60	53.69	63.96	64.01	82.89	87.30
G ₃ P ₁	19.67	26.96	38.01	44.63	53.80	64.66	81.48	77.87
G ₃ P ₂	17.02	26.07	34.12	42.72	51.47	69.41	70.62	77.32
G ₃ P ₃	21.02	27.12	36.92	46.12	56.37	56.42	75.27	79.67
G ₄ P ₁	15.57	22.88	34.14	40.46	49.40	60.87	75.70	73.96
G ₄ P ₂	12.70	21.75	29.80	38.40	47.15	63.25	66.30	73.00
G ₄ P ₃	16.70	22.80	32.60	41.80	52.05	52.10	70.95	75.35
G ₅ P ₁	21.44	28.85	40.07	46.78	56.10	67.12	75.73	80.54
G ₅ P ₂	18.50	27.55	35.60	44.20	52.95	63.15	72.10	78.80
G ₅ P ₃	22.50	28.60	38.40	47.60	57.85	57.90	76.75	81.15
G ₆ P ₁	17.60	25.00	36.20	42.90	52.20	63.20	71.80	76.60
G ₆ P ₂	14.70	23.75	31.80	40.40	49.15	59.35	68.30	75.00
G ₆ P ₃	18.70	24.80	34.60	43.80	54.05	54.10	72.95	77.35
G ₇ P ₁	16.50	23.90	35.10	41.80	51.10	62.10	70.70	75.50
G ₇ P ₂	13.50	22.47	30.45	38.98	47.66	57.78	66.65	73.29
G ₇ P ₃	17.63	23.74	33.55	42.77	53.04	53.09	71.97	76.38
G ₈ P ₁	13.33	20.74	31.96	38.67	47.99	59.01	67.62	72.42
G ₈ P ₂	10.40	19.45	27.50	36.10	44.85	55.05	64.00	70.70
G ₈ P ₃	14.40	20.50	30.30	39.50	49.75	49.80	68.65	73.05
G ₉ P ₁	20.91	28.35	39.65	46.41	55.79	66.90	75.55	80.38
G ₉ P ₂	17.80	26.85	34.90	43.50	52.25	62.45	71.40	78.10
G ₉ P ₃	21.80	27.90	37.70	46.90	57.15	57.20	76.05	80.45
G ₁₀ P ₁	18.80	26.20	37.40	44.10	53.40	64.40	73.00	77.80
G ₁₀ P ₂	15.93	24.99	33.06	41.67	50.44	60.65	69.62	76.33
G ₁₀ P ₃	19.90	26.00	35.80	45.00	55.25	55.30	74.15	78.55
G ₁₁ P ₁	12.32	19.72	30.92	37.62	46.92	57.92	66.52	71.32
G ₁₁ P ₂	9.52	18.63	26.75	35.42	44.25	54.54	63.56	70.31
G ₁₁ P ₃	13.42	19.52	29.32	38.52	48.77	48.82	67.67	72.07
G ₁₂ P ₁	14.43	21.83	33.03	39.73	49.03	60.03	68.63	73.43

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₂	11.53	20.58	28.63	37.23	45.98	56.18	65.13	71.83
G ₁₂ P ₃	15.53	21.63	31.43	40.63	50.88	50.93	69.78	74.18
S.Em $\pm$	0.310	0.414	0.533	0.675	0.820	0.939	1.121	1.190
CD (<0.05P)	NS	NS	NS	NS	NS	NS	NS	NS
G ₁ M ₁ P ₁	39.30	44.30	56.30	64.30	73.30	86.30	92.30	96.30
G ₁ M ₁ P ₂	34.50	42.30	50.50	59.40	68.30	79.30	87.40	93.70
G ₁ M ₁ P ₃	36.48	42.38	37.62	61.16	71.10	71.59	89.68	93.81
G ₁ M ₂ P ₁	31.50	41.30	51.70	40.93	50.37	75.70	86.90	92.50
G ₁ M ₂ P ₂	30.60	40.94	33.22	57.19	65.82	75.25	85.08	92.21
G ₁ M ₂ P ₃	35.90	42.10	36.22	61.00	71.40	71.00	90.30	94.90
G ₂ M ₁ P ₁	30.88	35.82	47.66	55.55	64.43	77.26	83.18	87.12
G ₂ M ₁ P ₂	26.50	34.30	42.50	51.40	60.30	71.30	79.40	85.70
G ₂ M ₁ P ₃	29.10	35.10	33.30	54.20	64.30	64.80	83.20	87.40
G ₂ M ₂ P ₁	23.50	33.30	43.70	37.30	46.90	67.70	78.90	84.50
G ₂ M ₂ P ₂	22.50	32.80	28.90	49.00	57.60	67.00	76.80	83.90
G ₂ M ₂ P ₃	28.00	34.21	31.90	53.18	63.61	63.21	82.58	87.19
G ₃ M ₁ P ₁	23.58	28.53	40.41	48.33	57.24	70.11	76.05	80.01
G ₃ M ₁ P ₂	19.02	26.82	35.02	43.92	52.82	79.30	71.92	78.22
G ₃ M ₁ P ₃	21.62	27.62	37.62	46.72	56.82	57.32	75.72	79.92
G ₃ M ₂ P ₁	15.75	25.39	35.62	40.92	50.37	59.22	86.90	75.74
G ₃ M ₂ P ₂	15.02	25.32	33.22	41.52	50.12	59.52	69.32	76.42
G ₃ M ₂ P ₃	20.42	26.62	36.22	45.52	55.92	55.52	74.82	79.42
G ₄ M ₁ P ₁	19.44	24.26	36.38	43.61	51.90	65.84	72.50	75.23
G ₄ M ₁ P ₂	14.70	22.50	30.70	39.60	48.50	71.30	67.60	73.90
G ₄ M ₁ P ₃	17.30	23.30	33.30	42.40	52.50	53.00	71.40	75.60
G ₄ M ₂ P ₁	11.70	21.50	31.90	37.30	46.90	55.90	78.90	72.70
G ₄ M ₂ P ₂	10.70	21.00	28.90	37.20	45.80	55.20	65.00	72.10
G ₄ M ₂ P ₃	16.10	22.30	31.90	41.20	51.60	51.20	70.50	75.10
G ₅ M ₁ P ₁	25.38	30.40	42.44	50.47	59.50	72.54	78.56	82.57
G ₅ M ₁ P ₂	20.50	28.30	36.50	45.40	54.30	65.30	73.40	79.70
G ₅ M ₁ P ₃	23.10	29.10	39.10	48.20	58.30	58.80	77.20	81.40
G ₅ M ₂ P ₁	17.50	27.30	37.70	43.10	52.70	61.70	72.90	78.50
G ₅ M ₂ P ₂	16.50	26.80	34.70	43.00	51.60	61.00	70.80	77.90
G ₅ M ₂ P ₃	21.90	28.10	37.70	47.00	57.40	57.00	76.30	80.90
G ₆ M ₁ P ₁	21.50	26.50	38.50	46.50	55.50	68.50	74.50	78.50
G ₆ M ₁ P ₂	16.70	24.50	32.70	41.60	50.50	61.50	69.60	75.90
G ₆ M ₁ P ₃	19.30	25.30	35.30	44.40	54.50	55.00	73.40	77.60
G ₆ M ₂ P ₁	13.70	23.50	33.90	39.30	48.90	57.90	69.10	74.70
G ₆ M ₂ P ₂	12.70	23.00	30.90	39.20	47.80	57.20	67.00	74.10
G ₆ M ₂ P ₃	18.10	24.30	33.90	43.20	53.60	53.20	72.50	77.10
G ₇ M ₁ P ₁	20.40	25.40	37.40	45.40	54.40	67.40	73.40	77.40
G ₇ M ₁ P ₂	15.60	23.40	31.60	40.50	49.40	60.40	68.50	74.80
G ₇ M ₁ P ₃	18.20	24.20	34.20	43.30	53.40	53.90	72.30	76.50
G ₇ M ₂ P ₁	12.60	22.40	32.80	38.20	47.80	56.80	68.00	73.60
G ₇ M ₂ P ₂	11.41	21.54	29.30	37.47	45.92	55.17	64.80	71.78
G ₇ M ₂ P ₃	17.06	23.28	32.91	42.24	52.68	52.27	71.64	76.25
G ₈ M ₁ P ₁	17.26	22.27	34.31	42.34	51.37	64.41	70.43	74.45
G ₈ M ₁ P ₂	12.40	20.20	28.40	37.30	46.20	57.20	65.30	71.60
G ₈ M ₁ P ₃	15.00	21.00	31.00	40.10	50.20	50.70	69.10	73.30

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₂ P ₁	9.40	19.20	29.60	35.00	44.60	53.60	64.80	70.40
G ₈ M ₂ P ₂	8.40	18.70	26.60	34.90	43.50	52.90	62.70	69.80
G ₈ M ₂ P ₃	13.80	20.00	29.60	38.90	49.30	48.90	68.20	72.80
G ₉ M ₁ P ₁	25.01	30.09	42.29	50.43	59.58	72.79	78.89	82.96
G ₉ M ₁ P ₂	19.80	27.60	35.80	44.70	53.60	64.60	72.70	79.00
G ₉ M ₁ P ₃	22.40	28.40	38.40	47.50	57.60	58.10	76.50	80.70
G ₉ M ₂ P ₁	16.80	26.60	37.00	42.40	52.00	61.00	72.20	77.80
G ₉ M ₂ P ₂	15.80	26.10	34.00	42.30	50.90	60.30	70.10	77.20
G ₉ M ₂ P ₃	21.20	27.40	37.00	46.30	56.70	56.30	75.60	80.20
G ₁₀ M ₁ P ₁	22.70	27.70	39.70	47.70	56.70	69.70	75.70	79.70
G ₁₀ M ₁ P ₂	17.96	25.79	34.01	42.94	51.87	62.91	71.04	77.36
G ₁₀ M ₁ P ₃	20.50	26.50	36.50	45.60	55.70	56.20	74.60	78.80
G ₁₀ M ₂ P ₁	14.90	24.70	35.10	40.50	50.10	59.10	70.30	75.90
G ₁₀ M ₂ P ₂	13.90	24.20	32.10	40.40	49.00	58.40	68.20	75.30
G ₁₀ M ₂ P ₃	19.30	25.50	35.10	44.40	54.80	54.40	73.70	78.30
G ₁₁ M ₁ P ₁	16.22	21.22	33.22	41.22	50.22	63.22	69.22	73.22
G ₁₁ M ₁ P ₂	11.61	19.54	27.88	36.93	45.97	57.16	65.39	71.80
G ₁₁ M ₁ P ₃	14.02	20.02	30.02	39.12	49.22	49.72	68.12	72.32
G ₁₁ M ₂ P ₁	8.42	18.22	28.62	34.02	43.62	52.62	63.82	69.42
G ₁₁ M ₂ P ₂	7.42	17.72	25.62	33.92	42.52	51.92	61.72	68.82
G ₁₁ M ₂ P ₃	12.82	19.02	28.62	37.92	48.32	47.92	67.22	71.82
G ₁₂ M ₁ P ₁	18.33	23.33	35.33	43.33	52.33	65.33	71.33	75.33
G ₁₂ M ₁ P ₂	13.53	21.33	29.53	38.43	47.33	58.33	66.43	72.73
G ₁₂ M ₁ P ₃	16.13	22.13	32.13	41.23	51.33	51.83	70.23	74.43
G ₁₂ M ₂ P ₁	10.53	20.33	30.73	36.13	45.73	54.73	65.93	71.53
G ₁₂ M ₂ P ₂	9.53	19.83	27.73	36.03	44.63	54.03	63.83	70.93
G ₁₂ M ₂ P ₃	14.93	21.13	30.73	40.03	50.43	50.03	69.33	73.93
S.Em ±	0.438	0.586	0.753	0.955	1.160	1.327	1.585	1.683
CD (<0.05P)	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.0	5.9	3.7	6.8	7.8	4.8	3.7	5.79

Initial Electrical conductivity (mS cm ⁻¹ g ⁻¹) of seed leachate														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<i><0.05P</i>)	CV (%)
30.24	18.24	15.28	11.35	17.19	14.34	13.28	10.51	17.58	15.78	9.34	11.23	0.39	1.14	4.4

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

followed by G_5 ($38.09 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($39.19 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($60.03 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($53.03 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($46.19 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. During fifteenth month of storage, lower electrical conductivity was recorded in G_6 ($46.65 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($47.53 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($48.63 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($69.66 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($61.45 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($55.63 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. Eighteenth month of storage, lower electrical conductivity was recorded in G_6 ($53.68 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($54.34 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($55.97 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($76.91 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($68.53 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_4 ($62.43 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. At 21st month of storage, the lower electrical conductivity was recorded in G_6 ($65.92 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($69.76 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($67.84 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($90.44 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($83.20 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($74.86 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. At end of the storage month, the lower electrical conductivity was recorded in G_6 ($76.23 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_5 ($77.06 \text{ mS cm}^{-1} \text{ g}^{-1}$), G_7 ($78.30 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in G_1 ($102.28 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by G_2 ($94.35 \text{ mS cm}^{-1} \text{ g}^{-1}$) and G_3 ($87.37 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively.

Fruit and seed materials: Electrical conductivity differed significantly among the materials during the storage period. Whole fruits (M_2) recorded superior over M_1 . At three months storage, the lower electrical conductivity ($16.67 \text{ mS cm}^{-1} \text{ g}^{-1}$) was recorded in M_1 and higher electrical conductivity ($21.00 \text{ mS cm}^{-1} \text{ g}^{-1}$) was recorded in M_2 . At six months storage, the M_1 ($25.43 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2 ($27.47 \text{ mS cm}^{-1} \text{ g}^{-1}$) at nine months M_1 ($34.47 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2 ($37.49 \text{ mS cm}^{-1} \text{ g}^{-1}$). The 12, 15, 18 21 and 24 four months storage, the M_2 was recorded significantly over M_1 . The lower electrical conductivity ($42.43 \text{ mS cm}^{-1} \text{ g}^{-1}$, $51.60 \text{ mS cm}^{-1} \text{ g}^{-1}$, $57.38 \text{ mS cm}^{-1} \text{ g}^{-1}$, $71.23 \text{ mS cm}^{-1} \text{ g}^{-1}$ and $82.23 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively and higher electrical conductivity ($46.15 \text{ mS cm}^{-1} \text{ g}^{-1}$, $55.64 \text{ mS cm}^{-1} \text{ g}^{-1}$, $63.93 \text{ mS cm}^{-1} \text{ g}^{-1}$, $75.17 \text{ mS cm}^{-1} \text{ g}^{-1}$ and $85.79 \text{ mS cm}^{-1} \text{ g}^{-1}$ in M_2 , respectively).

Packaging: The effect of packaging on electrical conductivity was significantly differed throughout storage period. The lower electrical conductivity was recorded in P_3 ($16.55 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by P_2 ($19.43 \text{ mS cm}^{-1} \text{ g}^{-1}$) and (P_1) recorded $20.53 \text{ mS cm}^{-1} \text{ g}^{-1}$

g^{-1} during 3rd month storage. At six months storage, the lower EC recorded in P_3 (25.60 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (26.66 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (27.09 $\text{mS cm}^{-1} \text{g}^{-1}$) and during nine months, lower EC recorded in P_1 (27.09 $\text{mS cm}^{-1} \text{g}^{-1}$), P_3 (33.27 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_2 (36.42 $\text{mS cm}^{-1} \text{g}^{-1}$). The 12 month of storage, lower EC was recorded in P_3 (41.91 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (44.68 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (46.28 $\text{mS cm}^{-1} \text{g}^{-1}$) respectively. At 15th month of storage, the lower EC was recorded in P_3 (50.44 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (53.90 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (56.53 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively. At 18th month of storage, the lower EC was recorded in P_3 (55.45 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (61.11 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (65.41 $\text{mS cm}^{-1} \text{g}^{-1}$) respectively. At 21st month of storage, the lower EC was recorded in P_3 (69.94 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (73.59 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (76.07 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively. At end of month of storage period (21st), the lower EC was recorded in P_3 (81.48 $\text{mS cm}^{-1} \text{g}^{-1}$), P_2 (83.42 $\text{mS cm}^{-1} \text{g}^{-1}$) and P_1 (87.13 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively.

Fruit and seed materials $\times$ Packaging: Materials $\times$ packaging interaction for electrical conductivity was significant throughout storage period. The lower electrical conductivity was recorded in M_1P_3 (14.54 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_1P_2 (15.52 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_2 (23.33 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_1 (21.10 $\text{mS cm}^{-1} \text{g}^{-1}$) during three months of storage. At six months storage, M_1P_3 (24.83 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_1P_1 (25.31 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 (28.88 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_2 (27.15 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively. At 9th month storage, lower EC recorded in M_1P_3 (31.94 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_2P_3 (34.59 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 (40.81 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_2 (37.07 $\text{mS cm}^{-1} \text{g}^{-1}$). At 12th month storage, lower EC recorded in M_1P_3 (40.03 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_1P_2 (41.09 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_2 (48.26 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_1 (46.39 $\text{mS cm}^{-1} \text{g}^{-1}$). At 15th month storage, lower EC recorded in M_1P_3 (48.65 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_1P_2 (50.68 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 (57.58 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_2 (56.12 $\text{mS cm}^{-1} \text{g}^{-1}$). At 18th month storage, lower EC recorded in M_1P_3 (53.91 $\text{mS cm}^{-1} \text{g}^{-1}$) followed by M_2P_3 (57.00 $\text{mS cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 (71.16 $\text{mS cm}^{-1} \text{g}^{-1}$) and M_2P_2 (63.64 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively. At 21st month of storage, lower EC recorded in M_1P_3 (68.45 $\text{mS cm}^{-1} \text{g}^{-1}$), respectively.

$\text{cm}^{-1} \text{ g}^{-1}$) followed by M_1P_2 ($70.85 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 ($77.74 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2P_2 ($76.34 \text{ mS cm}^{-1} \text{ g}^{-1}$). At end of the storage period, lower EC recorded in M_1P_3 ($80.21 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1P_2 ($81.28 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2P_1 ($89.07 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2P_2 ($85.55 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively.

Fruit and seed materials $\times$ Genotypes: Materials $\times$ Genotypes interaction for electrical conductivity was significant throughout storage period except 3 months and 6 months. At 9th month storage, lower EC recorded in M_1G_6 ($27.62 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($28.60 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($54.02 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_1G_1 ($48.24 \text{ mS cm}^{-1} \text{ g}^{-1}$). At 12th month storage, lower EC recorded in M_1G_6 ($35.69 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($36.67 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($64.30 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2G_2 ($57.07 \text{ mS cm}^{-1} \text{ g}^{-1}$). At 15th month storage, lower EC recorded M_1G_6 ($44.82 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($45.80 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($73.61 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_1G_1 ($65.70 \text{ mS cm}^{-1} \text{ g}^{-1}$). At 18th month storage, lower EC recorded in M_1G_6 ($50.66 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($51.24 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($82.39 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2G_2 ($71.71 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively. At 21st month of storage, lower EC recorded in M_1G_6 ($64.25 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($65.23 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($94.74 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_2G_2 ($86.97 \text{ mS cm}^{-1} \text{ g}^{-1}$). At end of the storage period, lower EC recorded in M_1G_6 ($70.02 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by M_1G_5 ($76.00 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in M_2G_1 ($106.82 \text{ mS cm}^{-1} \text{ g}^{-1}$) and M_1G_1 ($97.73 \text{ mS cm}^{-1} \text{ g}^{-1}$), respectively.

Packaging $\times$ Genotypes: Packaging $\times$ Genotypes interaction for electrical conductivity was significant throughout storage period except 3 months. At 6th month storage, lower EC recorded in P_3G_6 ($18.63 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by P_3G_5 ($19.45 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in P_1G_1 ($46.15 \text{ mS cm}^{-1} \text{ g}^{-1}$) and P_2G_1 ($42.61 \text{ mS cm}^{-1} \text{ g}^{-1}$). At 9th month storage, lower EC recorded in P_3G_6 ($26.75 \text{ mS cm}^{-1} \text{ g}^{-1}$) followed by P_3G_5 ($27.50 \text{ mS cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in P_1G_1 ($55.52 \text{ mS cm}^{-1} \text{ g}^{-1}$) and P_2G_1 ($51.96 \text{ mS cm}^{-1} \text{ g}^{-1}$). At 12th month storage, lower

EC recorded in P₃G₆ (35.42 mS cm⁻¹ g⁻¹) followed by P₃G₅ (36.10 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in P₁G₁ (64.75 mS cm⁻¹ g⁻¹) and P₂G₁ (60.70 mS cm⁻¹ g⁻¹). At 15th month storage, lower EC recorded P₃G₆ (44.25 mS cm⁻¹ g⁻¹) followed by P₃G₅ (44.85 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in P₁G₁ (74.70 mS cm⁻¹ g⁻¹) and P₂G₁ (69.49 mS cm⁻¹ g⁻¹). At 18th month storage, lower EC recorded in P₃G₆ (48.82 mS cm⁻¹ g⁻¹) followed by P₃G₅ (49.80 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in P₁G₁ (84.81 mS cm⁻¹ g⁻¹) and P₂G₁ (78.45 mS cm⁻¹ g⁻¹), respectively. At 21st month of storage, lower EC recorded in P₃G₆ (63.56 mS cm⁻¹ g⁻¹) followed by P₃G₅ (64.00 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in P₁G₁ (98.15 mS cm⁻¹ g⁻¹) and P₁G₂ (90.45 mS cm⁻¹ g⁻¹). At end of the storage period, lower EC recorded in P₃G₆ (75.31 mS cm⁻¹ g⁻¹) followed by P₃G₅ (75.70 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in P₁G₁ (110.30 mS cm⁻¹ g⁻¹) and P₁G₂ (104.33 mS cm⁻¹ g⁻¹), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of Genotypes × Materials × Packaging electrical conductivity was non-significantly during 3rd and 9th months storage period and was significantly differed rest of the storage period. At the end of 6th month storage, lower EC was recorded in G₆ × M₁ × P₃ (17.72 mS cm⁻¹ g⁻¹) followed by G₆ × M₁ × P₁ (18.22 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (51.00 mS cm⁻¹ g⁻¹) and G₁ × M₂ × P₂ (43.11 mS cm⁻¹ g⁻¹), respectively. At the end of 12th month storage, lower EC was recorded in G₆ × M₁ × P₃ (33.92 mS cm⁻¹ g⁻¹) followed by G₆ × M₁ × P₂ (34.02 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (68.33 mS cm⁻¹ g⁻¹) and G₁ × M₂ × P₂ (64.30 mS cm⁻¹ g⁻¹), respectively. At the end of 15th month storage, lower EC was recorded in G₆ × M₁ × P₃ (42.52 mS cm⁻¹ g⁻¹) followed by G₅ × M₁ × P₃ (43.50 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (78.00 mS cm⁻¹ g⁻¹) and G₃ × M₂ × P₁ (73.33 mS cm⁻¹ g⁻¹), respectively. At the end of 18th month storage, lower EC was recorded in G₆ × M₁ × P₃ (47.92 mS cm⁻¹ g⁻¹) followed by G₅ × M₁ × P₃ (48.90 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (93.92 mS cm⁻¹ g⁻¹) and G₁ × M₂ × P₂ (81.66 mS cm⁻¹ g⁻¹), respectively. At the end of 21st month storage, lower EC was recorded in G₆ × M₁ × P₃ (61.72 mS cm⁻¹ g⁻¹) followed by G₅ × M₁ × P₃

(62.70 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (106.00 mS cm⁻¹ g⁻¹) and G₂ × M₂ × P₁ (98.33 mS cm⁻¹ g⁻¹), respectively. At the end of 24th month storage, lower EC was recorded in G₆ × M₁ × P₃ (73.82 mS cm⁻¹ g⁻¹) followed by G₆ × M₁ × P₂ (74.42 mS cm⁻¹ g⁻¹) and higher electrical conductivity was recorded in G₁ × M₂ × P₁ (118.00 mS cm⁻¹ g⁻¹) and G₂ × M₁ × P₁ (105.67 mS cm⁻¹ g⁻¹), respectively.

4.3.7 Total soluble seed protein (µg g⁻¹): The results on total soluble seed protein as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table.4.27).

Genotypes: There was significant difference between the genotypes for total soluble seed protein (µg g⁻¹) throughout storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (17.17 µg g⁻¹) and G₆ (16.17 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (5.89 µg g⁻¹) and G₂ (6.33 µg g⁻¹) during three months of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (16.11 µg g⁻¹) and G₆ (15.89 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (5.50 µg g⁻¹) and G₂ (6.06 µg g⁻¹) during 6th month of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (16.06 µg g⁻¹) and G₆ (14.22 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (5.00 µg g⁻¹) and G₂ (5.50 µg g⁻¹) during 9th month of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (14.72 µg g⁻¹) and G₆ (14.22 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (4.44 µg g⁻¹) and G₂ (4.94 µg g⁻¹) during 12th month of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (14.78 µg g⁻¹) and G₆ (13.89 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (3.83 µg g⁻¹) and G₂ (4.61 µg g⁻¹) during 15th month of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (14.39 µg g⁻¹) and G₈ (13.22 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (3.78 µg g⁻¹) and G₂ (4.17 µg g⁻¹) during 18th month of storage period. The higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (14.35 µg g⁻¹) and G₆ (13.66 µg g⁻¹) and lower total soluble seed protein (µg g⁻¹) was recorded in G₁ (3.55 µg g⁻¹) and G₂ (4.04 µg g⁻¹) during 21st month of storage period. At end of the storage period, the higher total soluble seed protein (µg g⁻¹) was recorded in G₇ (13.17 µg g⁻¹) and G₆ (12.28 µg g⁻¹) and lower

Table 4.27. Total soluble seed protein (mg g⁻¹) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	5.89	5.50	5.00	4.44	3.83	3.78	3.55	3.17
G ₂	6.33	6.06	5.50	4.94	4.61	4.17	4.04	3.67
G ₃	13.11	12.78	12.28	11.67	11.06	10.83	10.83	10.03
G ₄	11.44	11.22	10.50	10.00	9.72	9.33	9.16	8.94
G ₅	11.17	10.72	10.11	9.61	9.28	8.89	8.77	8.36
G ₆	16.17	15.89	14.72	14.22	13.89	13.22	13.66	12.28
G ₇	17.17	16.11	16.06	14.72	14.78	14.39	14.35	13.17
G ₈	15.39	14.83	14.50	13.94	12.67	13.22	13.04	12.20
G ₉	10.28	10.00	9.33	8.94	8.50	8.17	7.99	7.59
G ₁₀	15.11	14.78	14.22	13.83	13.44	12.94	12.88	12.03
G ₁₁	13.94	13.72	13.11	12.44	12.00	11.72	11.63	11.23
G ₁₂	13.94	13.56	12.94	12.39	12.00	11.61	11.56	10.87
S.Em ±	0.130	0.150	0.150	0.170	0.170	0.150	0.110	0.180
CD (<0.05P)	0.360	0.420	0.420	0.480	0.460	0.420	0.320	0.500
M ₁	12.71	12.46	11.78	11.09	10.72	10.37	10.35	9.76
M ₂	12.28	11.73	11.27	10.77	10.24	10.01	9.90	9.17
S.Em ±	0.050	0.060	0.060	0.070	0.070	0.060	0.050	0.070
CD (<0.05P)	0.150	0.170	0.170	0.200	0.190	0.170	0.130	0.200
P ₁	11.78	11.18	10.50	9.19	8.75	8.14	8.14	7.41
P ₂	12.67	12.33	11.81	11.68	11.01	10.93	10.84	10.11
P ₃	13.04	12.78	12.26	11.92	11.68	11.50	11.38	10.87
S.Em ±	0.070	0.080	0.080	0.090	0.080	0.070	0.060	0.090
CD (<0.05P)	0.180	0.210	0.210	0.240	0.230	0.210	0.160	0.250
G ₁ M ₁	6.11	5.67	5.33	4.56	3.89	3.89	3.70	3.26
G ₁ M ₂	5.67	5.33	4.67	4.33	3.78	3.67	3.39	3.09
G ₂ M ₁	6.44	6.44	5.56	5.22	4.56	4.22	4.15	3.72
G ₂ M ₂	6.22	5.67	5.44	4.67	4.67	4.11	3.92	3.61
G ₃ M ₁	13.33	12.89	12.33	11.78	11.33	11.22	10.95	10.50
G ₃ M ₂	12.89	12.67	12.22	11.56	10.78	10.44	10.72	9.57
G ₄ M ₁	11.67	11.44	10.78	10.00	9.78	9.44	9.30	8.82
G ₄ M ₂	11.22	11.00	10.22	10.00	9.67	9.22	9.03	9.07
G ₅ M ₁	11.33	11.11	10.22	9.67	9.44	9.00	8.92	8.47
G ₅ M ₂	11.00	10.33	10.00	9.56	9.11	8.78	8.61	8.26
G ₆ M ₁	16.33	16.22	15.67	14.44	14.44	14.00	14.03	12.71
G ₆ M ₂	16.00	15.56	13.78	14.00	13.33	12.44	13.30	11.84
G ₇ M ₁	17.44	17.11	16.44	15.67	15.56	14.33	15.17	14.28
G ₇ M ₂	16.89	15.11	15.67	13.78	14.00	14.44	13.53	12.07
G ₈ M ₁	15.67	15.33	14.78	14.00	13.44	13.44	13.20	12.76
G ₈ M ₂	15.11	14.33	14.22	13.89	11.89	13.00	12.88	11.64
G ₉ M ₁	10.56	10.33	9.44	9.00	8.67	8.33	8.16	7.69
G ₉ M ₂	10.00	9.67	9.22	8.89	8.33	8.00	7.82	7.50
G ₁₀ M ₁	15.33	15.11	14.33	13.89	13.56	13.00	13.04	12.31
G ₁₀ M ₂	14.89	14.44	14.11	13.78	13.33	12.89	12.72	11.74

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	14.22	14.00	13.33	12.44	12.00	11.78	11.82	11.34
G ₁₁ M ₂	13.67	13.44	12.89	12.44	12.00	11.67	11.44	11.12
G ₁₂ M ₁	14.11	13.89	13.11	12.44	12.00	11.78	11.72	11.26
G ₁₂ M ₂	13.78	13.22	12.78	12.33	12.00	11.44	11.41	10.49
S.Em $\pm$	0.180	0.210	0.210	0.240	0.230	0.210	0.160	0.250
CD (<0.05P)	NS	0.590	0.590	0.680	0.660	0.590	0.450	0.700
M ₁ P ₁	11.78	11.53	10.28	8.64	8.00	7.56	7.75	7.16
M ₁ P ₂	13.19	12.94	12.36	12.14	11.78	11.36	11.34	10.58
M ₁ P ₃	13.17	12.92	12.69	12.50	12.39	12.19	11.94	11.54
M ₂ P ₁	11.78	10.83	10.72	9.75	9.50	8.72	8.54	7.65
M ₂ P ₂	12.14	11.72	11.25	11.22	10.25	10.50	10.34	9.64
M ₂ P ₃	12.92	12.64	11.83	11.33	10.97	10.81	10.81	10.20
S.Em $\pm$	0.090	0.110	0.110	0.120	0.120	0.110	0.080	0.130
CD (<0.05P)	0.260	0.300	0.300	0.340	0.330	0.290	0.220	0.350
G ₁ P ₁	5.00	5.00	4.00	2.50	2.00	2.00	1.70	1.42
G ₁ P ₂	6.17	5.50	5.50	5.33	4.50	4.50	4.20	3.68
G ₁ P ₃	6.50	6.00	5.50	5.50	5.00	4.83	4.74	4.42
G ₂ P ₁	5.50	5.17	4.50	3.50	3.00	2.33	2.13	1.87
G ₂ P ₂	6.50	6.33	5.67	5.50	5.33	4.67	4.72	4.18
G ₂ P ₃	7.00	6.67	6.33	5.83	5.50	5.50	5.26	4.95
G ₃ P ₁	12.50	12.17	11.17	10.33	9.17	8.50	9.03	7.45
G ₃ P ₂	13.17	13.00	12.83	12.33	12.00	11.83	11.53	11.00
G ₃ P ₃	13.67	13.17	12.83	12.33	12.00	12.17	11.94	11.65
G ₄ P ₁	10.50	10.50	9.50	8.33	8.00	7.67	7.30	7.52
G ₄ P ₂	11.83	11.33	10.83	10.67	10.50	9.83	9.82	9.27
G ₄ P ₃	12.00	11.83	11.17	11.00	10.67	10.50	10.38	10.05
G ₅ P ₁	10.50	10.00	9.17	8.00	7.50	7.17	6.94	6.58
G ₅ P ₂	11.33	11.00	10.33	10.33	10.00	9.33	9.41	8.88
G ₅ P ₃	11.67	11.17	10.83	10.50	10.33	10.17	9.95	9.62
G ₆ P ₁	15.50	15.00	13.83	11.67	12.00	9.83	11.41	9.00
G ₆ P ₂	16.33	16.17	14.17	15.33	14.33	14.67	14.52	13.98
G ₆ P ₃	16.67	16.50	16.17	15.67	15.33	15.17	15.06	13.85
G ₇ P ₁	16.33	13.50	14.33	12.33	12.83	11.17	11.29	11.22
G ₇ P ₂	17.33	16.67	16.67	15.33	15.00	15.67	15.53	13.35
G ₇ P ₃	17.83	18.17	17.17	16.50	16.50	16.33	16.23	14.95
G ₈ P ₁	14.50	14.00	13.83	12.33	11.50	11.50	11.22	10.00
G ₈ P ₂	15.67	15.00	14.83	14.67	11.67	13.83	13.68	12.68
G ₈ P ₃	16.00	15.50	14.83	14.83	14.83	14.33	14.22	13.92
G ₉ P ₁	9.83	9.33	8.33	7.50	6.83	6.50	6.19	5.87
G ₉ P ₂	10.17	10.17	9.67	9.50	9.17	8.67	8.62	8.08
G ₉ P ₃	10.83	10.50	10.00	9.83	9.50	9.33	9.16	8.83
G ₁₀ P ₁	14.67	14.00	13.33	12.17	11.67	11.33	11.04	9.35
G ₁₀ P ₂	15.17	15.00	14.50	14.50	14.17	13.50	13.54	13.00
G ₁₀ P ₃	15.50	15.33	14.83	14.83	14.50	14.00	14.06	13.73
G ₁₁ P ₁	13.33	12.67	12.00	10.83	10.33	9.83	9.76	9.47
G ₁₁ P ₂	14.17	14.17	13.50	13.50	12.67	12.50	12.35	11.80
G ₁₁ P ₃	14.33	14.33	13.83	13.00	13.00	12.83	12.78	12.43

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₁	13.17	12.83	12.00	10.83	10.17	9.83	9.73	9.17
G ₁₂ P ₂	14.17	13.67	13.17	13.17	12.83	12.17	12.21	11.40
G ₁₂ P ₃	14.50	14.17	13.67	13.17	13.00	12.83	12.75	12.05
S.Em ±	0.230	0.260	0.260	0.300	0.290	0.260	0.200	0.310
CD (<0.05P)	NS	0.730	0.720	0.830	0.800	0.720	0.550	0.860
G ₁ M ₁ P ₁	5.00	5.00	4.00	2.00	1.00	1.00	1.11	0.93
G ₁ M ₁ P ₂	6.67	6.00	6.00	5.67	5.00	5.00	4.68	3.93
G ₁ M ₁ P ₃	6.67	6.00	6.00	6.00	5.67	5.67	5.32	4.90
G ₁ M ₂ P ₁	5.00	5.00	4.00	3.00	3.00	3.00	2.28	1.90
G ₁ M ₂ P ₂	5.67	5.00	5.00	5.00	4.00	4.00	3.72	3.43
G ₁ M ₂ P ₃	6.33	6.00	5.00	5.00	4.33	4.00	4.16	3.93
G ₂ M ₁ P ₁	5.33	5.33	4.00	3.00	2.00	1.67	1.42	1.30
G ₂ M ₁ P ₂	7.00	7.00	6.00	6.00	5.67	5.00	5.20	4.43
G ₂ M ₁ P ₃	7.00	7.00	6.67	6.67	6.00	6.00	5.84	5.43
G ₂ M ₂ P ₁	5.67	5.00	5.00	4.00	4.00	3.00	2.84	2.43
G ₂ M ₂ P ₂	6.00	5.67	5.33	5.00	5.00	4.33	4.24	3.93
G ₂ M ₂ P ₃	7.00	6.33	6.00	5.00	5.00	5.00	4.68	4.47
G ₃ M ₁ P ₁	12.67	12.33	10.67	9.67	8.67	8.67	8.43	8.23
G ₃ M ₁ P ₂	13.67	13.33	13.33	12.67	12.33	12.33	11.99	11.23
G ₃ M ₁ P ₃	13.67	13.00	13.00	13.00	13.00	12.67	12.42	12.03
G ₃ M ₂ P ₁	12.33	12.00	11.67	11.00	9.67	8.33	9.63	6.67
G ₃ M ₂ P ₂	12.67	12.67	12.33	12.00	11.67	11.33	11.07	10.77
G ₃ M ₂ P ₃	13.67	13.33	12.67	11.67	11.00	11.67	11.47	11.27
G ₄ M ₁ P ₁	10.33	10.33	9.33	7.67	7.00	6.67	6.65	6.43
G ₄ M ₁ P ₂	12.33	12.00	11.33	11.00	11.00	10.33	10.30	9.50
G ₄ M ₁ P ₃	12.33	12.00	11.67	11.33	11.33	11.33	10.94	10.53
G ₄ M ₂ P ₁	10.67	10.67	9.67	9.00	9.00	8.67	7.94	8.60
G ₄ M ₂ P ₂	11.33	10.67	10.33	10.33	10.00	9.33	9.34	9.03
G ₄ M ₂ P ₃	11.67	11.67	10.67	10.67	10.00	9.67	9.81	9.57
G ₅ M ₁ P ₁	10.67	10.33	8.67	7.33	6.67	6.33	6.35	6.17
G ₅ M ₁ P ₂	11.67	11.67	10.67	10.67	10.67	9.67	9.89	9.13
G ₅ M ₁ P ₃	11.67	11.33	11.33	11.00	11.00	11.00	10.53	10.10
G ₅ M ₂ P ₁	10.33	9.67	9.67	8.67	8.33	8.00	7.53	7.00
G ₅ M ₂ P ₂	11.00	10.33	10.00	10.00	9.33	9.00	8.93	8.63
G ₅ M ₂ P ₃	11.67	11.00	10.33	10.00	9.67	9.33	9.37	9.13
G ₆ M ₁ P ₁	15.33	15.33	14.33	11.33	11.67	11.33	11.44	8.67
G ₆ M ₁ P ₂	17.00	16.67	16.00	15.67	15.67	15.00	15.00	14.23
G ₆ M ₁ P ₃	16.67	16.67	16.67	16.33	16.00	15.67	15.64	15.23
G ₆ M ₂ P ₁	15.67	14.67	13.33	12.00	12.33	8.33	11.38	9.33
G ₆ M ₂ P ₂	15.67	15.67	12.33	15.00	13.00	14.33	14.04	13.73
G ₆ M ₂ P ₃	16.67	16.33	15.67	15.00	14.67	14.67	14.48	12.47
G ₇ M ₁ P ₁	16.33	15.33	14.33	12.33	13.00	9.67	12.58	11.10
G ₇ M ₁ P ₂	18.00	17.33	17.33	17.00	16.33	16.33	16.14	15.37
G ₇ M ₁ P ₃	18.00	18.67	17.67	17.67	17.33	17.00	16.78	16.37
G ₇ M ₂ P ₁	16.33	11.67	14.33	12.33	12.67	12.67	10.00	11.33
G ₇ M ₂ P ₂	16.67	16.00	16.00	13.67	13.67	15.00	14.93	11.33
G ₇ M ₂ P ₃	17.67	17.67	16.67	15.33	15.67	15.67	15.67	13.53
G ₈ M ₁ P ₁	14.67	14.67	13.67	11.67	10.67	10.67	10.64	10.43

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₂	16.00	15.67	15.33	15.00	14.33	14.33	14.16	13.40
G ₈ M ₁ P ₃	16.33	15.67	15.33	15.33	15.33	15.33	14.80	14.43
G ₈ M ₂ P ₁	14.33	13.33	14.00	13.00	12.33	12.33	11.80	9.57
G ₈ M ₂ P ₂	15.33	14.33	14.33	14.33	9.00	13.33	13.20	11.97
G ₈ M ₂ P ₃	15.67	15.33	14.33	14.33	14.33	13.33	13.64	13.40
G ₉ M ₁ P ₁	10.00	9.67	8.00	7.00	6.00	6.00	5.63	5.40
G ₉ M ₁ P ₂	10.67	10.67	10.00	9.67	9.67	9.00	9.10	8.33
G ₉ M ₁ P ₃	11.00	10.67	10.33	10.33	10.33	10.00	9.74	9.33
G ₉ M ₂ P ₁	9.67	9.00	8.67	8.00	7.67	7.00	6.74	6.33
G ₉ M ₂ P ₂	9.67	9.67	9.33	9.33	8.67	8.33	8.14	7.83
G ₉ M ₂ P ₃	10.67	10.33	9.67	9.33	8.67	8.67	8.58	8.33
G ₁₀ M ₁ P ₁	14.67	14.33	13.00	11.67	10.67	10.67	10.44	9.43
G ₁₀ M ₁ P ₂	15.67	15.67	14.67	14.67	14.67	13.67	14.05	13.27
G ₁₀ M ₁ P ₃	15.67	15.33	15.33	15.33	15.33	14.67	14.64	14.23
G ₁₀ M ₂ P ₁	14.67	13.67	13.67	12.67	12.67	12.00	11.64	9.27
G ₁₀ M ₂ P ₂	14.67	14.33	14.33	14.33	13.67	13.33	13.04	12.73
G ₁₀ M ₂ P ₃	15.33	15.33	14.33	14.33	13.67	13.33	13.48	13.23
G ₁₁ M ₁ P ₁	13.33	12.67	11.67	10.00	9.33	9.00	9.16	8.93
G ₁₁ M ₁ P ₂	15.00	15.00	14.00	14.00	13.00	13.00	12.93	12.17
G ₁₁ M ₁ P ₃	14.33	14.33	14.33	13.33	13.67	13.33	13.36	12.93
G ₁₁ M ₂ P ₁	13.33	12.67	12.33	11.67	11.33	10.67	10.36	10.00
G ₁₁ M ₂ P ₂	13.33	13.33	13.00	13.00	12.33	12.00	11.76	11.43
G ₁₁ M ₂ P ₃	14.33	14.33	13.33	12.67	12.33	12.33	12.20	11.93
G ₁₂ M ₁ P ₁	13.00	13.00	11.67	10.00	9.33	9.00	9.13	8.93
G ₁₂ M ₁ P ₂	14.67	14.33	13.67	13.67	13.00	12.67	12.69	11.90
G ₁₂ M ₁ P ₃	14.67	14.33	14.00	13.67	13.67	13.67	13.33	12.93
G ₁₂ M ₂ P ₁	13.33	12.67	12.33	11.67	11.00	10.67	10.33	9.40
G ₁₂ M ₂ P ₂	13.67	13.00	12.67	12.67	12.67	11.67	11.73	10.90
G ₁₂ M ₂ P ₃	14.33	14.00	13.33	12.67	12.33	12.00	12.17	11.17
S.Em ±	0.320	0.370	0.370	0.420	0.410	0.360	0.280	0.440
CD (<0.05P)	NS	NS	NS	NS	1.14	1.02	0.78	1.22
CV (%)	4.4	5.3	5.5	6.7	6.7	6.2	4.8	8.0

Initial Total soluble seed protein ($\mu\text{g g}^{-1}$)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
6.33	7.21	13.88	12.33	12.88	18.33	19.27	17.42	11.11	17.11	14.2	15.21	0.32	0.94	4.0

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G_1 ($3.17 \mu\text{g g}^{-1}$) and G_2 ($3.67 \mu\text{g g}^{-1}$), respectively.

Fruit and seed materials: Total soluble seed protein ($\mu\text{g g}^{-1}$) differed significantly among the materials throughout storage period. Whole fruits (M_1) recorded the highest total soluble seed protein ($\mu\text{g g}^{-1}$) throughout the storage period. At three months storage, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in M_1 ($12.71 \mu\text{g g}^{-1}$) and M_2 ($12.28 \mu\text{g g}^{-1}$). At six months storage, the M_1 ($12.46 \mu\text{g g}^{-1}$) and M_2 ($11.73 \mu\text{g g}^{-1}$). At nine months, M_1 ($11.78 \mu\text{g g}^{-1}$) and M_2 ($11.27 \mu\text{g g}^{-1}$). The 12, 15, 18 and 24 months storage, the M_1 was recorded significantly over M_2 . The higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) ($11.09 \mu\text{g g}^{-1}$, $10.72 \mu\text{g g}^{-1}$, $10.37 \mu\text{g g}^{-1}$, $10.35 \mu\text{g g}^{-1}$ and $9.76 \mu\text{g g}^{-1}$, respectively) and ($10.77 \mu\text{g g}^{-1}$, $10.24 \mu\text{g g}^{-1}$, $10.01 \mu\text{g g}^{-1}$, $9.90 \mu\text{g g}^{-1}$ and $9.17 \mu\text{g g}^{-1}$ in M_2 , respectively).

Packaging: The effect of packaging on total soluble seed protein ($\mu\text{g g}^{-1}$) was significant differed throughout storage period. The higher total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_3 ($13.04 \mu\text{g g}^{-1}$) followed by P_2 ($12.67 \mu\text{g g}^{-1}$) and (P_1) recorded $11.78 \mu\text{g g}^{-1}$ during 3rd month storage. At six months storage, the higher total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_3 ($12.78 \mu\text{g g}^{-1}$) followed by P_2 ($12.33 \mu\text{g g}^{-1}$) and (P_1) recorded $11.18 \mu\text{g g}^{-1}$ during 6th month storage. At 9th month storage, the higher total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_3 ($12.26 \mu\text{g g}^{-1}$) followed by P_2 ($11.81 \mu\text{g g}^{-1}$) and (P_1) recorded $10.50 \mu\text{g g}^{-1}$ during 3rd month storage. At 12th month storage, the higher total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_3 ($11.92 \mu\text{g g}^{-1}$) followed by P_2 ($11.92 \mu\text{g g}^{-1}$) and (P_1) recorded $9.91 \mu\text{g g}^{-1}$ during 3rd month storage. At 15th month storage, the higher total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_3 ($11.68 \mu\text{g g}^{-1}$) followed by P_2 ($11.01 \mu\text{g g}^{-1}$) and (P_1) recorded $8.75 \mu\text{g g}^{-1}$ during 3rd month storage. At 18th, 21st and 24th month's storage, the P_1 was recorded significantly over P_2 and P_3 . The higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) (11.50 , $11.38 \mu\text{g g}^{-1}$ and 10.87 in P_3 , respectively) and ($10.93 \mu\text{g g}^{-1}$, $10.84 \mu\text{g g}^{-1}$ and 10.11 in P_2 respectively) and lower seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in P_1 (8.14 , 8.14 and $7.41 \mu\text{g g}^{-1}$, respectively).

Genotypes × Fruit and seed materials: Genotypes × materials interaction for total soluble seed protein ($\mu\text{g g}^{-1}$) was significant throughout storage period. Except 3rd month. The higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₆M₁ (16.2 $\mu\text{g g}^{-1}$) and G₆M₁ (16.2 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (5.3 $\mu\text{g g}^{-1}$) followed by G₁M₁ (5.7 $\mu\text{g g}^{-1}$) during 6th month of storage. The higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₇M₁ (16.4 $\mu\text{g g}^{-1}$) and G₆M₁ (15.2 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (4.7 $\mu\text{g g}^{-1}$) followed by G₁M₁ (5.3) during 9th month of storage. At 12th month storage, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₇M₁ (15.7 $\mu\text{g g}^{-1}$) and G₆M₁ (14.46 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (4.3 $\mu\text{g g}^{-1}$) followed by G₁M₁ (4.6 $\mu\text{g g}^{-1}$), respectively. At 15th month storage, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₇M₁ (15.6 $\mu\text{g g}^{-1}$) and G₆M₁ (14.4 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (3.8 $\mu\text{g g}^{-1}$) followed by G₁M₁ (3.9 $\mu\text{g g}^{-1}$), respectively. At 18th month storage, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₇M₂ (14.4 $\mu\text{g g}^{-1}$) and G₁M₇ (14.3 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (3.7 $\mu\text{g g}^{-1}$) followed by G₁M₁ (3.9 $\mu\text{g g}^{-1}$), respectively. At 21st month storage, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₇M₁ (15.2 $\mu\text{g g}^{-1}$) and G₆M₁ (14.00 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (3.4 $\mu\text{g g}^{-1}$) followed by G₁M₁ (3.7 $\mu\text{g g}^{-1}$), respectively. At end of the storage month, the higher seed total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₆M₁ (14.3 $\mu\text{g g}^{-1}$) and G₇M₁ (14.30 $\mu\text{g g}^{-1}$) and lower total soluble seed protein ($\mu\text{g g}^{-1}$) was recorded in G₁M₂ (3.1 $\mu\text{g g}^{-1}$) followed by G₁M₁ (3.3 $\mu\text{g g}^{-1}$), respectively.

Materials × Packaging: Materials × Packaging interaction for total soluble seed protein ($\mu\text{g g}^{-1}$) was significant throughout storage period.

4.3.8 Field emergence (%)

The results on field emergence as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.28).

Table 4.28. Field emergence (%) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	35 (20.18)	27 (15.77)	22 (12.62)	17 (09.72)	14 (07.98)	9 (1.55)	5 (1.22)	2 (0.80)
G ₂	38 (22.47)	32 (18.51)	28 (16.25)	20 (11.31)	17 (09.86)	11 (1.72)	7 (1.27)	4 (1.03)
G ₃	74 (47.78)	70 (44.36)	65 (40.49)	57 (34.92)	49 (29.97)	42 (3.64)	36 (3.30)	28 (2.75)
G ₄	76 (49.40)	72 (45.98)	67 (41.95)	58 (36.19)	51 (31.09)	44 (3.72)	37 (3.39)	30 (2.84)
G ₅	82 (55.23)	78 (51.33)	73 (46.96)	65 (40.80)	57 (35.41)	50 (4.01)	43 (3.71)	35 (3.10)
G ₆	75 (48.20)	70 (44.84)	65 (40.95)	57 (35.23)	50 (30.16)	42 (3.66)	36 (3.32)	28 (2.78)
G ₇	77 (50.62)	73 (46.96)	68 (42.94)	60 (37.20)	52 (32.10)	45 (3.79)	39 (3.48)	31 (2.90)
G ₈	81 (54.62)	77 (50.77)	72 (46.52)	64 (40.41)	57 (35.11)	49 (3.98)	43 (3.69)	34 (3.09)
G ₉	72 (46.47)	68 (43.19)	63 (39.35)	55 (33.76)	48 (28.76)	40 (3.56)	34 (3.21)	27 (2.68)
G ₁₀	77 (49.99)	72 (46.55)	67 (42.41)	59 (36.62)	52 (31.56)	45 (3.77)	38 (3.45)	30 (2.87)
G ₁₁	77 (50.57)	73 (47.00)	68 (42.88)	60 (37.07)	52 (32.08)	45 (3.79)	39 (3.48)	30 (2.89)
G ₁₂	78 (51.58)	74 (47.94)	69 (43.79)	61 (37.93)	53 (32.71)	46 (3.85)	40 (3.53)	31 (2.95)
S.Em ±	0.563	0.512	0.451	0.425	0.328	0.016	0.015	0.013
CD (<0.05P)	1.573	1.431	1.261	1.187	0.916	0.044	0.041	0.037
M ₁	70 (45.68)	66 (42.41)	61 (38.74)	52 (32.62)	45 (27.39)	38 (3.31)	33 (3.02)	27 (2.49)
M ₂	70 (45.51)	65 (41.45)	60 (37.44)	53 (32.57)	47 (28.74)	40 (3.53)	33 (3.16)	25 (2.62)
S.Em ±	0.23	0.209	0.184	0.173	0.134	0.006	0.006	0.005
CD (<0.05P)	0.64	0.582	0.514	0.483	0.373	0.018	0.017	0.015
P ₁	69 (44.45)	60 (37.91)	52 (31.67)	39 (23.49)	29 (16.90)	22 (2.46)	16 (2.06)	4 (1.01)
P ₂	70 (45.22)	66 (42.09)	62 (39.08)	56 (34.68)	50 (30.59)	43 (3.69)	36 (3.32)	31 (3.03)
P ₃	72 (47.11)	70 (45.80)	68 (43.53)	63 (39.62)	59 (36.71)	52 (4.10)	47 (3.89)	42 (3.63)
S.Em ±	0.281	0.256	0.226	0.212	0.164	0.008	0.007	0.007
CD (<0.05P)	0.786	0.715	0.631	0.593	0.458	0.022	0.021	0.018
G ₁ M ₁	35 (20.49)	30 (17.42)	26 (15.12)	19 (11.25)	16 (9.25)	11 (1.7)	7 (1.39)	4 (0.98)
G ₁ M ₂	34 (19.88)	24 (14.13)	18 (10.13)	14 (8.190)	12 (6.72)	6 (1.4)	4 (1.05)	1 (0.63)
G ₂ M ₁	38 (22.54)	35 (20.24)	30 (17.50)	23 (13.64)	19 (10.75)	13 (1.85)	10 (1.59)	6 (1.27)
G ₂ M ₂	38 (22.4)	29 (16.79)	26 (15)	16 (8.98)	16 (8.97)	9 (1.59)	4 (0.95)	2 (0.79)
G ₃ M ₁	75 (48.35)	71 (45.09)	66 (41.39)	56 (34.98)	48 (29.38)	41 (3.5)	36 (3.18)	30 (2.73)
G ₃ M ₂	73 (47.21)	69 (43.63)	64 (39.6)	57 (34.86)	51 (30.56)	43 (3.78)	36 (3.42)	26 (2.78)
G ₄ M ₁	77 (50.05)	73 (46.80)	68 (42.94)	58 (36.51)	50 (30.73)	43 (3.59)	37 (3.28)	32 (2.80)
G ₄ M ₂	75 (48.74)	71 (45.16)	65 (40.96)	58 (35.88)	52 (31.46)	45 (3.85)	37 (3.50)	27 (2.89)
G ₅ M ₁	82 (55.62)	78 (51.87)	73 (47.65)	64 (40.82)	55 (34.73)	48 (3.88)	43 (3.62)	35 (2.93)
G ₅ M ₂	82 (54.84)	77 (50.80)	72 (46.26)	65 (40.78)	59 (36.09)	52 (4.13)	44 (3.80)	34 (3.28)
G ₆ M ₁	75 (48.45)	71 (45.27)	66 (41.48)	56 (34.91)	48 (29.24)	41 (3.49)	35 (3.18)	30 (2.71)
G ₆ M ₂	74 (47.96)	70 (44.42)	65 (40.42)	58 (35.55)	51 (31.08)	44 (3.82)	37 (3.47)	27 (2.86)
G ₇ M ₁	77 (50.82)	73 (47.30)	68 (43.40)	59 (36.92)	50 (31.15)	43 (3.64)	38 (3.35)	32 (2.78)
G ₇ M ₂	77 (50.41)	73 (46.62)	67 (42.49)	61 (37.48)	54 (33.05)	47 (3.94)	39 (3.60)	30 (3.03)
G ₈ M ₁	81 (54.63)	77 (50.95)	73 (46.87)	63 (39.95)	55 (34.05)	47 (3.84)	42 (3.58)	34 (2.88)
G ₈ M ₂	81 (54.61)	77 (50.59)	72 (46.16)	65 (40.86)	59 (36.17)	52 (4.13)	44 (3.80)	34 (3.29)
G ₉ M ₁	72 (46.47)	68 (43.29)	63 (39.59)	54 (33.19)	45 (27.48)	38 (3.37)	33 (3.04)	28 (2.62)
G ₉ M ₂	72 (46.48)	68 (43.10)	63 (39.10)	56 (34.32)	50 (30.04)	43 (3.75)	35 (3.39)	25 (2.74)
G ₁₀ M ₁	76 (49.56)	72 (46.38)	67 (42.51)	58 (36.01)	49 (30.22)	42 (3.6)	37 (3.30)	31 (2.73)
G ₁₀ M ₂	77 (50.41)	73 (46.71)	67 (42.31)	60 (37.23)	54 (32.9)	47 (3.94)	39 (3.60)	29 (3.01)

Treatments	Storage period (month)								
	3	6	9	12	15	18	21	24	
G ₁₁ M ₁	77 (50.22)	73 (46.83)	68 (42.94)	58 (36.34)	50 (30.66)	43 (3.62)	37 (3.34)	31 (2.74)	
G ₁₁ M ₂	78 (50.91)	73 (47.17)	68 (42.83)	61 (37.8)	55 (33.51)	47 (3.96)	40 (3.62)	30 (3.05)	
G ₁₂ M ₁	77 (50.9)	74 (47.55)	68 (43.52)	59 (36.92)	50 (31.08)	44 (3.67)	38 (3.38)	31 (2.76)	
G ₁₂ M ₂	79 (52.25)	75 (48.33)	69 (44.07)	63 (38.94)	56 (34.35)	49 (4.02)	41 (3.68)	31 (3.14)	
S.Em ±	0.796	0.724	0.638	0.6	0.463	0.022	0.021	0.019	
CD (<0.05P)	2.225	2.023	1.784	1.678	1.296	0.062	0.058	0.052	
M ₁ P ₁	69 (44.84)	61 (38.40)	52 (31.42)	33 (19.62)	19 (11.01)	11 (1.82)	7 (1.45)	0 (0.41)	
M ₁ P ₂	69 (44.90)	66 (42.47)	63 (40.10)	58 (36.16)	53 (32.10)	47 (3.85)	40 (3.56)	35 (3.27)	
M ₁ P ₃	72 (47.29)	71 (46.38)	69 (44.71)	66 (42.08)	62 (39.07)	56 (4.26)	51 (4.05)	46 (3.8)	
M ₂ P ₁	68 (44.06)	60 (37.43)	52 (31.91)	45 (27.36)	38 (22.78)	32 (3.10)	24 (2.67)	8 (1.61)	
M ₂ P ₂	70 (45.53)	65 (41.71)	61 (38.07)	54 (33.21)	48 (29.09)	40 (3.53)	32 (3.08)	27 (2.8)	
M ₂ P ₃	72 (46.93)	70 (45.22)	66 (42.36)	59 (37.15)	56 (34.35)	49 (3.95)	44 (3.72)	39 (3.46)	
S.Em ±	0.398	0.362	0.319	0.3	0.232	0.011	0.01	0.009	
CD (<0.05P)	1.112	1.012	0.892	0.839	0.648	0.031	0.029	0.026	
G ₁ P ₁	33 (19.07)	19 (10.86)	12 (6.9)	8 (4.49)	3 (1.62)	1 (0.66)	0 (0.41)	0 (0.41)	
G ₁ P ₂	35 (20.38)	28 (16.28)	25 (14.39)	20 (11.44)	16 (8.92)	8 (1.63)	5 (1.27)	1 (0.55)	
G ₁ P ₃	36 (21.10)	35 (20.18)	29 (16.58)	23 (13.22)	23 (13.4)	17 (2.36)	12 (1.99)	6 (1.45)	
G ₂ P ₁	36 (21.31)	23 (13.42)	17 (9.70)	7 (4.11)	5 (2.96)	1 (0.55)	0 (0.41)	0 (0.41)	
G ₂ P ₂	38 (22.54)	33 (19.48)	31 (17.96)	25 (14.28)	19 (10.86)	12 (1.99)	5 (1.10)	2 (0.83)	
G ₂ P ₃	40 (23.58)	39 (22.64)	36 (21.1)	27 (15.53)	27 (15.77)	21 (2.62)	16 (2.30)	10 (1.86)	
G ₃ P ₁	72 (46.08)	64 (40.05)	56 (33.72)	42 (25.03)	30 (17.69)	22 (2.61)	15 (2.11)	3 (0.95)	
G ₃ P ₂	76 (49.09)	72 (46.12)	68 (42.92)	62 (38.28)	56 (34.12)	49 (4.03)	42 (3.70)	36 (3.44)	
G ₃ P ₃	75 (48.18)	73 (46.91)	71 (44.85)	66 (41.45)	62 (38.1)	55 (4.28)	50 (4.08)	45 (3.86)	
G ₄ P ₁	73 (47.07)	66 (41.20)	57 (34.53)	44 (25.89)	32 (18.5)	24 (2.72)	17 (2.24)	4 (1.04)	
G ₄ P ₂	77 (50.73)	74 (47.67)	70 (44.39)	64 (39.65)	58 (35.17)	51 (4.1)	43 (3.78)	38 (3.55)	
G ₄ P ₃	77 (50.40)	76 (49.07)	73 (46.93)	68 (43.03)	64 (39.6)	57 (4.35)	52 (4.16)	47 (3.95)	
G ₅ P ₁	81 (53.70)	73 (46.94)	64 (39.81)	51 (30.45)	38 (22.72)	31 (3.12)	23 (2.71)	7 (1.32)	
G ₅ P ₂	82 (55.31)	79 (51.93)	75 (48.36)	69 (43.43)	63 (38.73)	56 (4.29)	48 (3.99)	43 (3.76)	
G ₅ P ₃	84 (56.67)	82 (55.14)	80 (52.71)	75 (48.53)	70 (44.77)	64 (4.6)	59 (4.42)	54 (4.22)	
G ₆ P ₁	73 (46.78)	66 (40.93)	57 (34.53)	43 (25.57)	31 (18.1)	23 (2.67)	16 (2.18)	4 (1.02)	
G ₆ P ₂	74 (48.04)	71 (45.12)	67 (41.97)	61 (37.62)	55 (33.28)	48 (3.98)	40 (3.66)	35 (3.41)	
G ₆ P ₃	76 (49.79)	75 (48.48)	72 (46.36)	68 (42.51)	63 (39.1)	57 (4.33)	52 (4.13)	46 (3.92)	
G ₇ P ₁	76 (49.64)	69 (43.25)	60 (36.52)	46 (27.6)	34 (19.93)	26 (2.85)	19 (2.43)	5 (1.15)	
G ₇ P ₂	76 (49.77)	73 (46.76)	69 (43.52)	63 (38.96)	57 (34.89)	50 (4.07)	43 (3.75)	37 (3.51)	
G ₇ P ₃	79 (52.43)	78 (50.88)	75 (48.79)	71 (45.04)	66 (41.49)	60 (4.45)	55 (4.26)	50 (4.05)	
G ₈ P ₁	80 (53.51)	73 (46.78)	64 (39.93)	51 (30.46)	39 (22.82)	30 (3.1)	23 (2.72)	8 (1.33)	
G ₈ P ₂	81 (53.83)	77 (50.54)	73 (47.05)	67 (42.21)	61 (37.72)	54 (4.24)	47 (3.93)	42 (3.71)	
G ₈ P ₃	83 (56.52)	82 (54.99)	79 (52.57)	75 (48.54)	70 (44.78)	64 (4.6)	59 (4.42)	54 (4.22)	
G ₉ P ₁	72 (45.94)	65 (40.17)	55 (33.6)	42 (24.7)	30 (17.29)	22 (2.57)	15 (2.05)	3 (0.93)	
G ₉ P ₂	71 (45.42)	68 (42.48)	64 (39.44)	58 (35.23)	52 (31.12)	45 (3.85)	37 (3.51)	32 (3.25)	
G ₉ P ₃	74 (48.06)	73 (46.92)	71 (45)	66 (41.35)	61 (37.88)	55 (4.27)	50 (4.07)	45 (3.86)	
G ₁₀ P ₁	76 (49.22)	68 (43.13)	59 (36.29)	46 (27.27)	34 (19.73)	26 (2.85)	19 (2.42)	5 (1.13)	
G ₁₀ P ₂	75 (48.66)	72 (45.82)	68 (42.6)	62 (37.96)	56 (33.72)	49 (4.03)	41 (3.7)	36 (3.44)	
G ₁₀ P ₃	79 (52.08)	77 (50.7)	75 (48.34)	70 (44.63)	66 (41.23)	59 (4.43)	54 (4.24)	49 (4.03)	
G ₁₁ P ₁	77 (49.96)	69 (43.66)	60 (36.76)	46 (27.61)	35 (20.34)	26 (2.87)	19 (2.46)	5 (1.16)	
G ₁₁ P ₂	76 (49.21)	72 (46.21)	68 (42.98)	62 (38.44)	56 (34.17)	49 (4.04)	42 (3.72)	36 (3.46)	
G ₁₁ P ₃	79 (52.53)	78 (51.14)	75 (48.92)	71 (45.16)	67 (41.74)	60 (4.45)	55 (4.26)	50 (4.07)	

Treatments	Storage period (month)								
	3	6	9	12	15	18	21	24	
G ₁₂ P ₁	78 (51.14)	70 (44.58)	61 (37.72)	48 (28.69)	36 (21.07)	28 (2.97)	21 (2.55)	6 (1.23)	
G ₁₂ P ₂	76 (49.59)	73 (46.68)	69 (43.4)	63 (38.7)	57 (34.41)	50 (4.06)	42 (3.74)	37 (3.49)	
G ₁₂ P ₃	81 (53.99)	79 (52.55)	77 (50.26)	72 (46.41)	68 (42.66)	61 (4.51)	56 (4.31)	51 (4.12)	
S.Em ±	0.975	0.887	0.782	0.735	0.568	0.027	0.026	0.023	
CD (<0.05P)	2.724	2.478	2.185	2.056	1.587	0.076	0.071	0.063	
G ₁ M ₁ P ₁	33 (19.47)	22 (12.71)	15 (8.82)	9 (5.35)	3 (1.72)	0 (0.41)	0 (0.41)	0 (0.41)	
G ₁ M ₁ P ₂	35 (20.69)	32 (18.86)	29 (17.06)	21 (12.12)	19 (10.76)	12 (2.05)	6 (1.46)	1 (0.7)	
G ₁ M ₁ P ₃	36 (21.30)	35 (20.69)	33 (19.47)	28 (16.26)	26 (15.27)	21 (2.64)	16 (2.3)	10 (1.83)	
G ₁ M ₂ P ₁	32 (18.66)	16 (9.01)	9 (4.97)	6 (3.63)	3 (1.53)	2 (0.91)	0 (0.41)	0 (0.41)	
G ₁ M ₂ P ₂	34 (20.08)	24 (13.69)	20 (11.73)	19 (10.76)	12 (7.08)	4 (1.22)	3 (1.07)	0 (0.41)	
G ₁ M ₂ P ₃	36 (20.89)	34 (19.67)	24 (13.7)	18 (10.17)	20 (11.54)	13 (2.08)	8 (1.67)	3 (1.07)	
G ₂ M ₁ P ₁	36 (21.31)	29 (16.86)	20 (11.73)	9 (4.98)	4 (2.29)	0 (0.41)	0 (0.41)	0 (0.41)	
G ₂ M ₁ P ₂	38 (22.54)	35 (20.69)	32 (18.86)	27 (15.86)	21 (12.32)	15 (2.28)	9 (1.8)	4 (1.26)	
G ₂ M ₁ P ₃	40 (23.78)	39 (23.16)	37 (21.92)	34 (20.08)	30 (17.66)	25 (2.88)	20 (2.57)	14 (2.16)	
G ₂ M ₂ P ₁	36 (21.3)	17 (9.98)	13 (7.66)	6 (3.25)	6 (3.63)	1 (0.70)	0 (0.41)	0 (0.41)	
G ₂ M ₂ P ₂	38 (22.54)	31 (18.26)	29 (17.06)	22 (12.71)	16 (9.40)	8 (1.70)	0 (0.41)	0 (0.41)	
G ₂ M ₂ P ₃	40 (23.37)	38 (22.13)	35 (20.28)	19 (10.99)	24 (13.89)	17 (2.37)	12 (2.03)	7 (1.57)	
G ₃ M ₁ P ₁	72 (46.36)	64 (40.06)	55 (33.15)	35 (20.28)	19 (10.76)	10 (1.83)	5 (1.3)	0 (0.41)	
G ₃ M ₁ P ₂	77 (50.68)	74 (48.04)	71 (45.53)	66 (41.57)	61 (37.35)	55 (4.26)	48 (4.01)	43 (3.8)	
G ₃ M ₁ P ₃	74 (48.02)	73 (47.17)	71 (45.51)	68 (43.1)	64 (40.04)	59 (4.41)	54 (4.22)	48 (3.98)	
G ₃ M ₂ P ₁	72 (45.79)	64 (40.04)	56 (34.29)	50 (29.78)	42 (24.62)	35 (3.40)	25 (2.91)	6 (1.5)	
G ₃ M ₂ P ₂	74 (47.49)	70 (44.19)	65 (40.31)	57 (35)	51 (30.89)	43 (3.79)	35 (3.4)	29 (3.09)	
G ₃ M ₂ P ₃	75 (48.34)	73 (46.64)	70 (44.19)	64 (39.81)	59 (36.17)	52 (4.14)	47 (3.94)	42 (3.74)	
G ₄ M ₁ P ₁	73 (46.94)	65 (40.82)	55 (33.6)	36 (20.9)	20 (11.54)	11 (1.97)	6 (1.46)	0 (0.41)	
G ₄ M ₁ P ₂	80 (52.84)	77 (50.07)	74 (47.46)	69 (43.38)	62 (38.56)	56 (4.32)	50 (4.09)	46 (3.9)	
G ₄ M ₁ P ₃	77 (50.39)	76 (49.5)	74 (47.76)	71 (45.26)	67 (42.08)	61 (4.48)	56 (4.3)	50 (4.09)	
G ₄ M ₂ P ₁	73 (47.20)	66 (41.57)	58 (35.46)	51 (30.89)	43 (25.47)	36 (3.46)	27 (3.02)	8 (1.67)	
G ₄ M ₂ P ₂	75 (48.62)	71 (45.26)	66 (41.32)	59 (35.93)	53 (31.78)	45 (3.88)	36 (3.46)	31 (3.2)	
G ₄ M ₂ P ₃	77 (50.41)	75 (48.64)	72 (46.1)	65 (40.81)	60 (37.12)	54 (4.22)	49 (4.02)	44 (3.81)	
G ₅ M ₁ P ₁	81 (54.19)	73 (46.94)	63 (39.06)	43 (25.68)	27 (15.66)	18 (2.46)	13 (2.08)	0 (0.41)	
G ₅ M ₁ P ₂	83 (55.84)	80 (52.87)	77 (50.1)	72 (45.81)	66 (41.07)	60 (4.45)	54 (4.22)	49 (4.02)	
G ₅ M ₁ P ₃	84 (56.83)	83 (55.79)	81 (53.8)	78 (50.98)	74 (47.46)	68 (4.73)	63 (4.56)	57 (4.36)	
G ₅ M ₂ P ₁	80 (53.21)	73 (46.94)	65 (40.56)	58 (35.22)	50 (29.78)	43 (3.78)	34 (3.35)	15 (2.23)	
G ₅ M ₂ P ₂	82 (54.78)	78 (50.98)	73 (46.62)	66 (41.05)	59 (36.39)	52 (4.14)	43 (3.77)	37 (3.51)	
G ₅ M ₂ P ₃	83 (56.52)	81 (54.49)	78 (51.62)	72 (46.08)	67 (42.08)	60 (4.47)	55 (4.28)	50 (4.09)	
G ₆ M ₁ P ₁	73 (47.19)	66 (41.05)	56 (33.83)	35 (20.69)	19 (11.15)	10 (1.89)	5 (1.38)	0 (0.41)	
G ₆ M ₁ P ₂	74 (48.05)	71 (45.54)	68 (43.13)	63 (39.32)	57 (35)	51 (4.13)	45 (3.88)	40 (3.66)	
G ₆ M ₁ P ₃	77 (50.1)	76 (49.22)	74 (47.49)	70 (44.72)	66 (41.57)	60 (4.47)	55 (4.28)	50 (4.06)	
G ₆ M ₂ P ₁	72 (46.36)	65 (40.81)	58 (35.22)	51 (30.45)	42 (25.05)	36 (3.45)	27 (2.99)	8 (1.64)	
G ₆ M ₂ P ₂	74 (48.03)	70 (44.71)	65 (40.8)	59 (35.92)	52 (31.55)	44 (3.84)	35 (3.43)	30 (3.15)	
G ₆ M ₂ P ₃	76 (49.47)	74 (47.74)	71 (45.24)	65 (40.29)	60 (36.63)	53 (4.18)	48 (3.98)	43 (3.78)	
G ₇ M ₁ P ₁	77 (50.07)	69 (43.38)	58 (35.69)	39 (22.75)	22 (12.9)	13 (2.13)	8 (1.70)	0 (0.41)	
G ₇ M ₁ P ₂	76 (49.79)	73 (47.19)	70 (44.71)	65 (40.81)	60 (36.64)	53 (4.21)	47 (3.96)	42 (3.75)	
G ₇ M ₁ P ₃	79 (52.6)	78 (51.33)	76 (49.8)	73 (47.2)	69 (43.92)	63 (4.58)	58 (4.4)	53 (4.18)	
G ₇ M ₂ P ₁	76 (49.21)	68 (43.12)	61 (37.35)	54 (32.46)	45 (26.96)	38 (3.57)	30 (3.15)	10 (1.89)	
G ₇ M ₂ P ₂	76 (49.76)	72 (46.33)	67 (42.32)	60 (37.11)	55 (33.13)	47 (3.94)	38 (3.54)	32 (3.27)	
G ₇ M ₂ P ₃	79 (52.26)	77 (50.42)	74 (47.78)	68 (42.88)	63 (39.06)	56 (4.31)	51 (4.11)	46 (3.92)	
G ₈ M ₁ P ₁	81 (54.18)	73 (46.93)	63 (39.31)	43 (25.47)	27 (15.86)	18 (2.44)	13 (2.08)	0 (0.41)	

Treatments	Storage period (month)								
	3	6	9	12	15	18	21	24	
G ₈ M ₁ P ₂	80 (52.84)	77 (50.07)	74 (47.46)	69 (43.38)	63 (38.81)	57 (4.34)	51 (4.1)	46 (3.9)	
G ₈ M ₁ P ₃	84 (56.88)	83 (55.84)	81 (53.84)	78 (51.01)	74 (47.49)	68 (4.73)	63 (4.56)	57 (4.35)	
G ₈ M ₂ P ₁	80 (52.84)	73 (46.62)	65 (40.54)	58 (35.45)	50 (29.78)	43 (3.77)	34 (3.37)	15 (2.26)	
G ₈ M ₂ P ₂	82 (54.82)	78 (51.01)	73 (46.64)	66 (41.05)	60 (36.64)	52 (4.14)	42 (3.75)	37 (3.53)	
G ₈ M ₂ P ₃	83 (56.16)	81 (54.14)	78 (51.3)	72 (46.08)	67 (42.08)	60 (4.47)	55 (4.28)	50 (4.09)	
G ₉ M ₁ P ₁	73 (46.88)	65 (40.54)	55 (33.13)	35 (20.28)	18 (10.37)	9 (1.77)	4 (1.22)	0 (0.41)	
G ₉ M ₁ P ₂	70 (44.19)	67 (41.84)	64 (39.57)	59 (35.93)	53 (31.78)	47 (3.94)	41 (3.68)	36 (3.45)	
G ₉ M ₁ P ₃	75 (48.34)	74 (47.49)	72 (46.08)	69 (43.38)	65 (40.3)	59 (4.41)	54 (4.22)	48 (4.01)	
G ₉ M ₂ P ₁	71 (45)	64 (39.81)	56 (34.06)	49 (29.13)	41 (24.2)	34 (3.37)	25 (2.89)	6 (1.46)	
G ₉ M ₂ P ₂	73 (46.65)	68 (43.13)	63 (39.32)	57 (34.53)	51 (30.45)	43 (3.77)	34 (3.35)	28 (3.06)	
G ₉ M ₂ P ₃	74 (47.78)	72 (46.36)	69 (43.92)	63 (39.32)	58 (35.46)	51 (4.13)	46 (3.92)	41 (3.71)	
G ₁₀ M ₁ P ₁	76 (49.52)	68 (43.13)	58 (35.7)	38 (22.54)	22 (12.71)	13 (2.13)	8 (1.7)	0 (0.41)	
G ₁₀ M ₁ P ₂	73 (46.93)	70 (44.72)	67 (42.35)	62 (38.58)	56 (34.3)	51 (4.1)	44 (3.82)	39 (3.6)	
G ₁₀ M ₁ P ₃	79 (52.23)	78 (51.3)	76 (49.5)	73 (46.91)	69 (43.65)	63 (4.57)	58 (4.37)	53 (4.18)	
G ₁₀ M ₂ P ₁	75 (48.91)	68 (43.13)	60 (36.87)	53 (32.01)	45 (26.74)	38 (3.57)	29 (3.13)	10 (1.86)	
G ₁₀ M ₂ P ₂	77 (50.39)	73 (46.91)	68 (42.86)	61 (37.35)	55 (33.14)	47 (3.96)	38 (3.57)	32 (3.28)	
G ₁₀ M ₂ P ₃	79 (51.93)	77 (50.10)	73 (47.19)	67 (42.34)	63 (38.81)	56 (4.30)	51 (4.10)	45 (3.88)	
G ₁₁ M ₁ P ₁	77 (50.39)	69 (43.65)	59 (36.16)	39 (22.75)	23 (13.30)	14 (2.16)	9 (1.77)	0 (0.41)	
G ₁₁ M ₁ P ₂	74 (47.44)	71 (44.96)	68 (42.58)	63 (38.80)	57 (34.51)	51 (4.10)	45 (3.85)	39 (3.60)	
G ₁₁ M ₁ P ₃	80 (52.84)	79 (51.90)	77 (50.07)	74 (47.46)	70 (44.17)	64 (4.59)	58 (4.40)	53 (4.21)	
G ₁₁ M ₂ P ₁	76 (49.52)	69 (43.67)	61 (37.36)	54 (32.46)	46 (27.39)	39 (3.59)	30 (3.15)	11 (1.91)	
G ₁₁ M ₂ P ₂	78 (50.98)	74 (47.46)	69 (43.38)	62 (38.08)	56 (33.82)	48 (3.98)	39 (3.59)	33 (3.32)	
G ₁₁ M ₂ P ₃	79 (52.23)	77 (50.39)	74 (47.76)	68 (42.86)	63 (39.31)	56 (4.31)	51 (4.13)	46 (3.92)	
G ₁₂ M ₁ P ₁	78 (51.59)	70 (44.71)	60 (36.87)	40 (23.78)	24 (13.89)	15 (2.28)	10 (1.86)	0 (0.41)	
G ₁₂ M ₁ P ₂	73 (46.94)	70 (44.72)	67 (42.35)	62 (38.33)	56 (34.06)	50 (4.09)	44 (3.82)	39 (3.60)	
G ₁₂ M ₁ P ₃	81 (54.19)	80 (53.21)	78 (51.33)	75 (48.65)	71 (45.28)	65 (4.65)	60 (4.46)	55 (4.26)	
G ₁₂ M ₂ P ₁	77 (50.70)	70 (44.45)	62 (38.57)	55 (33.6)	47 (28.25)	40 (3.66)	31 (3.23)	12 (2.05)	
G ₁₂ M ₂ P ₂	79 (52.25)	75 (48.64)	70 (44.45)	63 (39.06)	57 (34.76)	49 (4.03)	40 (3.65)	34 (3.38)	
G ₁₂ M ₂ P ₃	81 (53.8)	79 (51.9)	76 (49.19)	70 (44.17)	64 (40.04)	57 (4.36)	52 (4.17)	48 (3.98)	
S.Em ±	1.378	1.254	1.105	1.04	0.803	0.038	0.036	0.032	
CD (<0.05P)	3.853	3.505	3.09	2.907	2.244	0.107	0.101	0.09	
CV (%)	5.2	5.2	5	5.5	5	1.9	2	2.2	

Initial field emergence (%)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
38	42	75	77	86	76	78	83	74	79	78	83	1.68	4.90	4.0

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

Genotypes: There was significant difference between the genotypes for field emergence throughout storage period. Irrespective of the genotypes, there was a decline in field emergence percentage during storage. The higher field emergence was recorded in G₅ (86 %) followed by G₅ (82 %), G₈ (81 %) and lower field emergence was recorded in G₁ (35 %) followed by G₂ (38 %) at 3rd month storage. At six months storage, the higher Field emergence was recorded in G₅ (78 %) followed by G₈ (77 %), G₁₂ (74 %) and lower Field emergence was recorded in G₁ (27 %) followed by G₂ (32 %) and G₉ (68 %), respectively and during nine months G₅ (73 %), G₈ (72 %), G₁₂ (69 %) and lower field emergence was recorded in G₁ (22 %) followed by G₂ (28 %) and G₉ (63 %), respectively. The 12th month storage, The G₅ (65 %) followed by G₈ (64 %), G₁₂ (61 %) and lower field emergence was recorded in G₁ (17 %) followed by G₂ (20 %) and G₉ (55 %) respectively. During 15th storage, The higher field emergence was recorded in G₅ (57 %) followed by G₈ (57 %), G₁₂ (53 %) and lower field emergence was recorded in G₁ (14 %) followed by G₂ (17 %) and G₉ (48 %) respectively and during 18th month storage, The higher field emergence was recorded in G₅ (50 %) followed by G₈ (49 %) and lower field emergence was recorded in G₁ (9 %) and G₂ (11 %), respectively. During 21st storage, the higher field emergence was recorded in G₅ (43 %) followed by G₈ (43 %), G₁₂ (40 %) and lower field emergence was recorded in G₁ (5 %) followed by G₂ (7 %) and G₉ (34 %), respectively. At end of the storage month, the higher field emergence was recorded in G₅ (35 %) followed by G₈ (34 %), G₁₂ (31 %), and lower field emergence was recorded in G₁ (2 %) and G₂ (4 %), respectively.

Fruit and seed materials: Field emergence per cent differed significantly among the materials during the storage period. Whole fruits (Mf₁) recorded the highest Field emergence per cent throughout the storage period. At three months storage, the higher field emergence (%) was recorded in M₁ (70 %) and M₂ (70), at six months storage, the M₂ (66 %) and M₂ (65 %), at nine months M₁ (61 %) and M₂ (60 %). At 12 months , M₂ (53 %) and M₁ (52 %). AT 15 months, M₂ (47 %) and M₁ (45 %). At 18 months storage, M₂ (40 %) and M₁ (38 %) and during 21, M₁ (33 %) and M₁ (33 %) and during 24 months storage, the M₁ (27 %) was recorded significantly over M₂ (25 %).

Packaging: The effect of packaging on field emergence per cent was significant differed throughout storage period. The higher field emergence was recorded in P₃ (72 %) followed by P₂ (70 %) and (P₁) recorded 69 % during 3rd month storage. At six months storage, the P₃ (70 %), P₂ (66 %) and P₁ (60 %) and during nine months P₃ (68 %), P₂ (62 %) and P₁ (52 %). The 12, 15, 18 21 and 24 four months storage, the P₃ was recorded significantly over P₂ and P₁. The higher field emergence (63 %, 59 %, 52 %, 47 % and 42 % in P₃, respectively) and (56 %, 50 %, 43 %, 36 % and 31 % in P₂, respectively and lower field emergence % was recorded in P₁ 39 %, 29 %, 22 %, 16 % and 4 %, respectively).

Genotypes × Fruit and seed materials: Genotypes × Materials interaction for field emergence was non-significant during three months and rest of the storage period was significant of storage period. The higher field emergence was recorded in G₅M₁ (82 %) followed by G₅M₂ (82 %), and lower field emergence was recorded in G₁M₂ (34 %) and G₁M₁ (35 %) during six months of storage. At six months storage, the higher field emergence was recorded in G₅M₁ (78 %) and G₈M₁ (77 %) and lower Field emergence was recorded in G₁M₂ (24 %) and G₂M₂ (29 %), respectively. The higher field emergence was recorded in G₅M₁ (73 %) and G₈M₁ (73 %) and lower Field emergence was recorded in G₁M₂ (18 %) and G₂M₂ (26 %), respectively and during 12th month of storage, The higher field emergence was recorded in G₈M₂ (65 %) and G₅M₂ (65 %) and lower Field emergence was recorded in G₁M₂ (14 %) and G₂M₂ (16 %), respectively. At 15th month storage period, the higher field emergence was recorded in G₈M₁ (59 %) and G₁₂M₂ (56 %) and lower Field emergence was recorded in G₁M₂ (12) and G₂M₂ (16 %), respectively. At 18th month storage period, the higher field emergence was recorded in G₅M₂ (52 %) and G₁₂M₂ (49 %) and lower Field emergence was recorded in G₁M₂ (6 %) and G₂M₂ (9 %), respectively. At 21st month storage period, the higher field emergence was recorded in G₅M₂ (44 %) and G₅M₁ (43 %) and lower field emergence was recorded in G₁M₂ (4 %) and G₁M₁ (7 %), respectively. At the end of 24th month of storage period, the higher field emergence was recorded in G₅M₁ (35 %) and G₈M₁ (34 %), and lower Field emergence was recorded in G₁M₂ (1.00 %) and G₂M₂ (2 %), respectively.

Fruit and seed materials × Packaging: The fruit and seed materials × Packaging interaction for field emergence was significant throughout storage period except six months storage. The higher field emergence age was recorded in M₁P₃ (72 %) and M₂P₂ (70 %) and lower Field emergence was recorded in M₂P₁ (68 %) and M₁P₁ (69 %) during three months of storage. At six months storage, the higher field emergence was recorded in M₁P₃ (71 %) and M₂P₃ (70 %) and lower Field emergence was recorded in M₂P₁ (60 %) and (61 %), respectively during six months storage. The higher field emergence was recorded in M₁P₃ (69 %) and M₂P₃ (66 %) and lower Field emergence was recorded in M₁P₁ (52 %) and M₂P₂ (61 %) during 9th month of storage. At 12th month storage period, the higher field emergence was recorded in M₁P₃ (63 %) and M₂P₃ (59 %) and lower Field emergence was recorded in M₁P₁ (33 %) M₂P₁ (45 %), respectively. At 15th month storage period, the higher field emergence was recorded in M₁P₃ (62 %) and M₂P₃ (56 %) and lower Field emergence was recorded in M₁P₁ (19 %) and M₂P₁ (38 %), respectively. At 18st month storage period, the higher field emergence was recorded in M₁P₃ (56 %) and M₂P₃ (49 %) and lower Field emergence was recorded in M₁P₁ (11 %) and M₂P₁ (32 %). At 21st month storage period, the higher field emergence was recorded in M₁P₃ (51 %) and M₂P₃ (44 %) and lower Field emergence was recorded in M₁P₁ (7 %) and M₂P₁ (24 %). At the end of 24th month of storage period, the higher field emergence was recorded in M₁P₃ (46 %) and M₂P₃ (39 %) and lower field emergence was recorded in M₁P₁ (0.00 %) followed by M₂P₁ (8 %), respectively.

Genotypes × Packaging : Genotypes × Packaging interaction for Field emergence was non significantly during 3rd, 6th and 9th of storage period and rest of the storage period showed significantly during storage period. The higher field emergence was recorded in G₅P₃ (75 %) and G₁₂P₃ (72%) and lower field emergence was recorded in G₂P₁ (7 %) and G₁P₂ (20 %) during 12th month of storage. At 15th month storage period, the higher field emergence was recorded in G₅P₃ (70 %) and G₁₂P₃ (68 %) and lower Field emergence was recorded in G₂P₁ (5 %) and G₁P₂ (16 %), respectively. At 18th month storage period, the higher field emergence was recorded in G₅P₃ (64 %) and G₁₂P₃ (61 %) and lower Field emergence was recorded in G₁P₁ (1%) and G₁P₂ (8 %), respectively. At 21st month storage period, the higher field emergence was recorded in

G₅P₃ (59 %) and G₁₂P₃ (56 %) and lower Field emergence was recorded in G₂P₁ (1.00 %) and G₁P₂ (5.00 %), respectively. At the end of 24th month of storage period, the higher field emergence was recorded in G₅P₃ (54 %) and G₁₂P₃ (51 %) and lower field emergence was recorded in G₂P₁ (0 %) and G₁P₂ (1 %), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of genotypes × materials × packaging was non-significantly during 3rd, 6th, 9th and 12th months and significantly differed during 15th, 18th, 21st and 24th months of storage period. During 15th month storage, the maximum field emergence was recorded in G₅ × M₁ × P₃ (74 %) and G₁₂ × M₁ × P₃ (71 %) and lower Field emergence was recorded in G₁ × M₁ × P₁ (3 %) and G₂ × M₁ × P₁ (4 %), respectively. At 18th month storage, the maximum field emergence was recorded in G₅ × M₁ × P₃ (68 %) and G₁₂ × M₁ × P₃ (65 %) and lower Field emergence was recorded in G₁ × M₁ × P₁ (0 %) and G₂ × M₂ × P₁ (1 %), respectively. During 21st month storage, the maximum field emergence was recorded in G₅ × M₁ × P₃ (63 %) and G₁₂ × M₁ × P₃ (60 %) and lower Field emergence was recorded in G₁ × M₁ × P₁ (0 %) and G₁ × M₂ × P₂ (3 %), respectively. At end of the storage period, the maximum field emergence was recorded in G₅ × M₁ × P₃ (57 %) and G₁₂ × M₁ × P₃ (55 %) and lower Field emergence was recorded in G₁ × M₁ × P₁ (0 %) and G₁ × M₁ × P₂ (1 %), respectively.

4.3.9 α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$):

The results on α -Amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.29).

Genotypes: There was significant difference between the genotypes for α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) throughout storage period. The higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆ (35.08 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ (33.22 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -Amylase activity was recorded in G₁ (10.94 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₂ (19.36 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during three months of storage period. The higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆ (32.13 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ (30.40 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁ (8.15) and G₂ (16.56 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 6th month of storage period. The higher α -amylase

Table 4.29. α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	10.94	8.15	6.66	4.51	1.91	2.83	2.45	4.01
G ₂	19.36	16.56	14.24	11.95	7.17	6.57	5.27	4.59
G ₃	21.03	18.21	16.72	13.89	8.73	8.22	7.26	6.72
G ₄	21.55	18.75	17.25	14.42	9.26	8.9	7.69	7.1
G ₅	32.3	29.48	27.98	24.57	19.98	17.64	16.14	15.77
G ₆	35.08	32.13	30.18	27.22	22.32	20.43	18.93	18.57
G ₇	33.22	30.4	28.91	25.64	20.56	18.59	17.1	16.73
G ₈	29.17	26.35	24.85	21.57	16.84	14.51	13.01	12.64
G ₉	21.66	18.83	17.32	14.47	9.3	8.03	7.77	7.74
G ₁₀	32.15	29.34	27.83	24.17	19	17.5	16	15.63
G ₁₁	22.51	19.69	18.19	15.35	10.17	8.62	9.05	7.8
G ₁₂	32.82	30.01	28.51	25.28	20.51	18.17	16.67	16.31
S.Em $\pm$	0.24	0.22	0.22	0.22	0.15	0.17	0.19	0.17
CD (<0.05P)	0.67	0.61	0.61	0.62	0.42	0.47	0.52	0.48
M ₁	26.9	24.17	23.17	19.96	15.72	13.98	13.25	12.74
M ₂	25.07	22.15	19.94	17.22	11.91	11.02	9.64	9.53
S.Em $\pm$	0.1	0.09	0.09	0.09	0.06	0.07	0.08	0.07
CD (<0.05P)	0.27	0.25	0.25	0.25	0.17	0.19	0.21	0.2
P ₁	25.68	19.45	17.64	13.24	8.24	6.83	6.93	6.68
P ₂	25.01	24.01	22.51	20.51	16.09	14.3	12.49	12.19
P ₃	27.25	26	24.5	22	17.1	16.38	14.91	14.54
S.Em $\pm$	0.12	0.11	0.11	0.11	0.08	0.08	0.09	0.09
CD (<0.05P)	0.34	0.31	0.3	0.31	0.21	0.23	0.26	0.24
G ₁ M ₁	11.86	9.15	8.16	6.19	2.9	2.08	2.7	2.52
G ₁ M ₂	10.01	7.15	5.16	2.83	0.92	3.58	2.21	5.5
G ₂ M ₁	20.16	17.45	16.45	13.24	9.01	8.01	6.87	6.42
G ₂ M ₂	18.57	15.67	12.03	10.67	5.34	5.13	3.67	2.76
G ₃ M ₁	21.87	19.14	18.15	14.82	10.52	10.37	9.25	8.57
G ₃ M ₂	20.19	17.28	15.28	12.95	6.94	6.08	5.27	4.88
G ₄ M ₁	22.4	19.7	18.7	15.4	11.08	10.92	9.52	8.99
G ₄ M ₂	20.69	17.79	15.79	13.45	7.44	6.89	5.86	5.21
G ₅ M ₁	33.24	30.49	29.49	26.15	21.82	19.48	18.15	17.74
G ₅ M ₂	31.37	28.47	26.47	22.98	18.13	15.8	14.13	13.8
G ₆ M ₁	36	33.27	32.27	28.93	24.6	22.27	20.93	20.53
G ₆ M ₂	34.17	30.99	28.1	25.51	20.04	18.6	16.93	16.6
G ₇ M ₁	34.2	31.47	30.47	27.13	22.8	20.47	19.13	18.73
G ₇ M ₂	32.23	29.34	27.35	24.15	18.33	16.72	15.06	14.73
G ₈ M ₁	30.1	27.36	26.36	23.02	18.68	16.35	15.01	14.61
G ₈ M ₂	28.24	25.34	23.34	20.11	15	12.67	11	10.67
G ₉ M ₁	22.64	19.87	18.86	15.5	11.14	8.79	9.6	9.25
G ₉ M ₂	20.69	17.78	15.78	13.45	7.45	7.27	5.95	6.24
G ₁₀ M ₁	33.09	30.35	29.35	26.02	21.68	19.34	18.01	17.61
G ₁₀ M ₂	31.22	28.32	26.32	22.32	16.32	15.65	13.98	13.65
G ₁₁ M ₁	23.49	20.75	19.75	16.4	12.04	9.7	11.14	9.63
G ₁₁ M ₂	21.53	18.63	16.63	14.29	8.29	7.55	6.95	5.97

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ M ₁	33.74	31	30	26.67	22.34	20.01	18.67	18.27
G ₁₂ M ₂	31.91	29.01	27.01	23.89	18.67	16.34	14.67	14.34
S.Em $\pm$	0.34	0.31	0.31	0.32	0.21	0.24	0.26	0.24
CD (<0.05P)	NS	NS	NS	0.88	0.6	0.66	0.73	0.68
M ₁ P ₁	26.67	19.47	18.47	12.84	9.12	6.91	7.31	6.92
M ₁ P ₂	26.55	26.55	25.55	22.55	18.04	16.04	14.44	14.31
M ₁ P ₃	27.48	26.48	25.48	24.48	19.99	18.99	17.99	17
M ₂ P ₁	24.7	19.44	16.81	13.65	7.37	6.75	6.56	6.44
M ₂ P ₂	23.47	21.48	19.48	18.48	14.15	12.56	10.53	10.07
M ₂ P ₃	27.03	25.53	23.53	19.52	14.21	13.76	11.84	12.08
S.Em $\pm$	0.17	0.16	0.15	0.16	0.11	0.12	0.13	0.12
CD (<0.05P)	0.48	0.43	0.43	0.44	0.3	0.33	0.37	0.34
G ₁ P ₁	10.56	4.44	2.97	1.03	0.62	1.28	1.11	0.98
G ₁ P ₂	10	9	7.5	5.5	1.97	2.42	2.7	5.72
G ₁ P ₃	12.25	11	9.5	7	3.15	4.78	3.55	5.33
G ₂ P ₁	18.83	12.68	8.73	6.36	1.51	1.92	1.46	1.37
G ₂ P ₂	18.5	17.5	16	14	9.5	7.5	5.5	4.9
G ₂ P ₃	20.75	19.5	18	15.5	10.5	10.3	8.85	7.5
G ₃ P ₁	20.8	14.6	13.1	9.1	3.1	4.72	5.18	4.67
G ₃ P ₂	20.13	19.13	17.62	15.62	11.12	9.11	7.11	6.51
G ₃ P ₃	22.16	20.92	19.43	16.94	11.98	10.84	9.49	9
G ₄ P ₁	21.15	15	13.51	9.55	3.57	5.5	5.37	4.68
G ₄ P ₂	20.6	19.6	18.1	16.1	11.6	9.6	7.6	7
G ₄ P ₃	22.89	21.64	20.13	17.63	12.62	11.61	10.11	9.61
G ₅ P ₁	32.06	25.84	24.34	18.6	14.33	10.32	9.32	9.32
G ₅ P ₂	31.3	30.3	28.8	26.8	22.3	20.3	18.3	17.7
G ₅ P ₃	33.55	32.3	30.8	28.3	23.3	22.3	20.8	20.3
G ₆ P ₁	34.8	28.18	25.34	20.97	15.76	13.1	12.1	12.1
G ₆ P ₂	34.1	33.1	31.6	29.6	25.1	23.1	21.1	20.5
G ₆ P ₃	36.35	35.1	33.6	31.1	26.1	25.1	23.6	23.1
G ₇ P ₁	33	26.8	25.3	19.99	14.23	11.3	10.3	10.3
G ₇ P ₂	32.04	31.06	29.58	27.59	23.12	21.14	19.16	18.57
G ₇ P ₃	34.61	33.36	31.85	29.35	24.34	23.34	21.83	21.33
G ₈ P ₁	28.92	22.71	21.21	15.86	11.19	7.18	6.18	6.18
G ₈ P ₂	28.17	27.17	25.67	23.67	19.17	17.17	15.17	14.57
G ₈ P ₃	30.42	29.17	27.67	25.17	20.17	19.17	17.67	17.17
G ₉ P ₁	21.51	15.24	13.74	9.69	3.65	2.84	5.58	6.58
G ₉ P ₂	20.62	19.62	18.12	16.12	11.62	9.62	7.62	7.02
G ₉ P ₃	22.87	21.62	20.12	17.62	12.62	11.62	10.12	9.62
G ₁₀ P ₁	31.85	25.65	24.15	17.66	11.66	10.15	9.15	9.15
G ₁₀ P ₂	31.21	30.21	28.7	26.7	22.19	20.19	18.18	17.59
G ₁₀ P ₃	33.4	32.15	30.65	28.15	23.15	22.15	20.65	20.15
G ₁₁ P ₁	22.16	15.96	14.46	10.46	4.46	2.85	7.63	5
G ₁₁ P ₂	21.65	20.65	19.14	17.12	12.58	10.56	8.55	7.95
G ₁₁ P ₃	23.71	22.46	20.96	18.46	13.46	12.46	10.96	10.46
G ₁₂ P ₁	32.54	26.34	24.84	19.67	14.84	10.84	9.84	9.84
G ₁₂ P ₂	31.84	30.84	29.34	27.34	22.84	20.84	18.84	18.24
G ₁₂ P ₃	34.09	32.84	31.34	28.84	23.84	22.84	21.34	20.84
S.Em $\pm$	0.42	0.38	0.38	0.39	0.26	0.29	0.32	0.3

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
CD (<0.05P)	NS	NS	1.05	1.08	0.73	0.81	0.9	0.83
G ₁ M ₁ P ₁	11.59	4.46	3.47	1.57	0.7	1.23	1.16	1.07
G ₁ M ₁ P ₂	11.5	11.5	10.5	7.5	3	1	3.93	4.5
G ₁ M ₁ P ₃	12.5	11.5	10.5	9.5	5	4	3	2
G ₁ M ₂ P ₁	9.54	4.43	2.46	0.5	0.54	1.33	1.06	0.89
G ₁ M ₂ P ₂	8.5	6.5	4.5	3.5	0.94	3.83	1.47	6.93
G ₁ M ₂ P ₃	12	10.5	8.5	4.5	1.3	5.57	4.1	8.67
G ₂ M ₁ P ₁	19.47	12.36	11.36	5.71	2.02	2.03	1.6	1.47
G ₂ M ₁ P ₂	20	20	19	16	11.5	9.5	7.5	7.3
G ₂ M ₁ P ₃	21	20	19	18	13.5	12.5	11.5	10.5
G ₂ M ₂ P ₁	18.2	13	6.1	7	1	1.8	1.31	1.27
G ₂ M ₂ P ₂	17	15	13	12	7.5	5.5	3.5	2.5
G ₂ M ₂ P ₃	20.5	19	17	13	7.5	8.1	6.19	4.5
G ₃ M ₁ P ₁	21.8	14.6	13.6	7.6	3.6	6.13	5.77	4.9
G ₃ M ₁ P ₂	21.6	21.6	20.6	17.6	13.1	11.1	9.1	8.9
G ₃ M ₁ P ₃	22.22	21.24	20.25	19.27	14.85	13.87	12.88	11.9
G ₃ M ₂ P ₁	19.8	14.6	12.6	10.6	2.6	3.3	4.6	4.43
G ₃ M ₂ P ₂	18.66	16.65	14.65	13.64	9.13	7.12	5.12	4.11
G ₃ M ₂ P ₃	22.1	20.6	18.6	14.6	9.1	7.82	6.1	6.1
G ₄ M ₁ P ₁	22	14.9	13.91	7.99	4.05	6.57	5.37	4.97
G ₄ M ₁ P ₂	22.1	22.1	21.1	18.1	13.6	11.6	9.6	9.4
G ₄ M ₁ P ₃	23.1	22.1	21.1	20.1	15.6	14.6	13.6	12.6
G ₄ M ₂ P ₁	20.3	15.1	13.1	11.1	3.1	4.43	5.37	4.4
G ₄ M ₂ P ₂	19.1	17.1	15.1	14.1	9.6	7.6	5.6	4.6
G ₄ M ₂ P ₃	22.68	21.17	19.16	15.15	9.63	8.63	6.62	6.62
G ₅ M ₁ P ₁	33.11	25.89	24.88	18.86	14.85	10.84	9.83	9.83
G ₅ M ₁ P ₂	32.8	32.8	31.8	28.8	24.3	22.3	20.3	20.1
G ₅ M ₁ P ₃	33.8	32.8	31.8	30.8	26.3	25.3	24.3	23.3
G ₅ M ₂ P ₁	31	25.8	23.8	18.33	13.8	9.8	8.8	8.8
G ₅ M ₂ P ₂	29.8	27.8	25.8	24.8	20.3	18.3	16.3	15.3
G ₅ M ₂ P ₃	33.3	31.8	29.8	25.8	20.3	19.3	17.3	17.3
G ₆ M ₁ P ₁	35.8	28.6	27.6	21.6	17.6	13.6	12.6	12.6
G ₆ M ₁ P ₂	35.6	35.6	34.6	31.6	27.1	25.1	23.1	22.9
G ₆ M ₁ P ₃	36.6	35.6	34.6	33.6	29.1	28.1	27.1	26.1
G ₆ M ₂ P ₁	33.8	27.77	23.09	20.33	13.92	12.6	11.6	11.6
G ₆ M ₂ P ₂	32.6	30.6	28.6	27.6	23.1	21.1	19.1	18.1
G ₆ M ₂ P ₃	36.1	34.6	32.6	28.6	23.1	22.1	20.1	20.1
G ₇ M ₁ P ₁	34	26.8	25.8	19.8	15.8	11.8	10.8	10.8
G ₇ M ₁ P ₂	33.8	33.8	32.8	29.8	25.3	23.3	21.3	21.1
G ₇ M ₁ P ₃	34.8	33.8	32.8	31.8	27.3	26.3	25.3	24.3
G ₇ M ₂ P ₁	32	26.8	24.8	20.19	12.67	10.8	9.8	9.8
G ₇ M ₂ P ₂	30.29	28.32	26.35	25.37	20.95	18.98	17.01	16.03
G ₇ M ₂ P ₃	34.42	32.91	30.9	26.89	21.37	20.37	18.36	18.36
G ₈ M ₁ P ₁	29.97	22.75	21.74	15.72	11.71	7.7	6.69	6.69
G ₈ M ₁ P ₂	29.67	29.67	28.67	25.67	21.17	19.17	17.17	16.97
G ₈ M ₁ P ₃	30.67	29.67	28.67	27.67	23.17	22.17	21.17	20.17
G ₈ M ₂ P ₁	27.87	22.67	20.67	16	10.67	6.67	5.67	5.67
G ₈ M ₂ P ₂	26.67	24.67	22.67	21.67	17.17	15.17	13.17	12.17
G ₈ M ₂ P ₃	30.17	28.67	26.67	22.67	17.17	16.17	14.17	14.17
G ₉ M ₁ P ₁	22.69	15.37	14.35	8.25	4.19	0.12	5.57	5.7

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₉ M ₁ P ₂	22.12	22.12	21.12	18.12	13.62	11.62	9.62	9.42
G ₉ M ₁ P ₃	23.12	22.12	21.12	20.12	15.62	14.62	13.62	12.62
G ₉ M ₂ P ₁	20.32	15.12	13.12	11.12	3.12	5.57	5.6	7.47
G ₉ M ₂ P ₂	19.12	17.12	15.12	14.12	9.62	7.62	5.62	4.62
G ₉ M ₂ P ₃	22.62	21.12	19.12	15.12	9.62	8.62	6.62	6.62
G ₁₀ M ₁ P ₁	32.85	25.65	24.65	18.65	14.65	10.65	9.65	9.65
G ₁₀ M ₁ P ₂	32.76	32.76	31.76	28.75	24.23	22.22	20.21	20.02
G ₁₀ M ₁ P ₃	33.65	32.65	31.65	30.65	26.15	25.15	24.15	23.15
G ₁₀ M ₂ P ₁	30.85	25.65	23.65	16.67	8.67	9.65	8.65	8.65
G ₁₀ M ₂ P ₂	29.65	27.65	25.65	24.65	20.15	18.15	16.15	15.15
G ₁₀ M ₂ P ₃	33.15	31.65	29.65	25.65	20.15	19.15	17.15	17.15
G ₁₁ M ₁ P ₁	23.16	15.96	14.96	8.96	4.96	0.96	8.33	5
G ₁₁ M ₁ P ₂	23.34	23.34	22.33	19.28	14.7	12.67	10.63	10.43
G ₁₁ M ₁ P ₃	23.96	22.96	21.96	20.96	16.46	15.46	14.46	13.46
G ₁₁ M ₂ P ₁	21.16	15.96	13.96	11.96	3.96	4.73	6.93	5
G ₁₁ M ₂ P ₂	19.96	17.96	15.96	14.96	10.46	8.46	6.46	5.46
G ₁₁ M ₂ P ₃	23.46	21.96	19.96	15.96	10.46	9.46	7.46	7.46
G ₁₂ M ₁ P ₁	33.54	26.34	25.34	19.34	15.34	11.34	10.34	10.34
G ₁₂ M ₁ P ₂	33.34	33.34	32.34	29.34	24.84	22.84	20.84	20.64
G ₁₂ M ₁ P ₃	34.34	33.34	32.34	31.34	26.84	25.84	24.84	23.84
G ₁₂ M ₂ P ₁	31.54	26.34	24.34	20	14.34	10.34	9.34	9.34
G ₁₂ M ₂ P ₂	30.34	28.34	26.34	25.34	20.84	18.84	16.84	15.84
G ₁₂ M ₂ P ₃	33.84	32.34	30.34	26.34	20.84	19.84	17.84	17.84
S.Em ±	0.59	0.54	0.53	0.55	0.37	0.41	0.45	0.42
CD (<0.05P)	NS	NS	NS	1.53	1.04	1.15	1.27	1.18
CV (%)	3.92	4.02	4.27	5.09	4.65	5.68	6.89	6.57

Initial α-amylase activity (µg g ⁻¹ ml ⁻¹ min ⁻¹)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
13.44	21.11	24.61	25.15	35.13	38.11	35.66	33.18	24.16	34.15	25.16	36.36	0.67	1.96	4.0

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($30.18 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($28.91 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1 ($6.66 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($14.24 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 9th month of storage period. The higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($27.22 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($25.64 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1 ($4.51 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($11.95 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 12th month of storage period. The higher α -Amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($22.32 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($20.56 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1 ($1.91 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($7.17 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 15th month of storage period. The higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($20.43 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($18.56 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -Amylase activity was recorded in G_1 ($2.83 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($6.57 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 18th month of storage period. The higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($18.93 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($17.10 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1 ($2.45 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($5.27 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 21st month of storage period. At end of the storage period, the higher α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6 ($18.57 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7 ($16.73 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1 ($4.01 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2 ($4.59 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively.

Fruit and seed materials: α -amylase activity differed significantly among the materials throughout storage period. Whole fruits (M_1) recorded the highest α -amylase activity throughout the storage period.

At three months storage, the higher seed α -amylase activity was recorded in M_1 ($26.90 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and M_2 ($25.07 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At six months storage, the M_1 ($24.17 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and M_2 ($22.15 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At nine months, M_1 ($23.17 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and M_2 ($19.94 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). The 12, 15, 18, 21 and 24 month storage, the M_1 was recorded significantly over M_2 . The higher seed α -Amylase ($19.96 \mu\text{g l}^{-1} \text{min}^{-1}$, $15.72 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$, $13.96 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$, $13.25 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ and $12.74 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$, respectively) and (17.22 , 11.91 , 11.02 , 9.64 and $9.53 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ in M_2 , respectively).

Packaging: The effect of packaging on α -amylase activity was significant differed throughout storage period. The higher α -Amylase activity was recorded in P₃ (27.25 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₁ (25.68 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and P₂ recorded 25.01 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 3rd month storage. At six months storage, the higher α -amylase activity was recorded in P₃ (26.00 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (24.01 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 19.45 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 6th month storage. At 9th month storage, the higher α -amylase activity was recorded in P₃ (24.50 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (22.51 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 17.64 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 9th month storage. At 12th month storage, the higher α -amylase activity was recorded in P₃ (22.00 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (20.51 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 13.24 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 12th month storage. At 15th month storage, the higher α -amylase activity was recorded in P₃ (17.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (16.09 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 8.24 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 15th month storage. At 18th month storage, the higher α -amylase activity was recorded in P₃ (16.38 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (14.30 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 6.83 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 18th month storage. At 21st month storage, the higher α -amylase activity was recorded in P₃ (14.91 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (12.49 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 6.93 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 21st month storage. At 24th month storage, the higher α -Amylase activity was recorded in P₃ (14.54 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by P₂ (12.19 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and (P₁) recorded 6.68 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$ during 24th month storage.

Genotypes × Fruit and seed materials: The interaction of genotypes materials showed non-significant difference in 3rd and 6th month of storage period and rest of the storage period showed significant difference. At 9th month of storage, the higher seed α -Amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆M₁ (32.27 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇M₁ (30.47 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁M₂ (5.16 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G₁M₁ (8.16 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At 12th month of storage, the higher seed α -Amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆M₁ (28.93 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇M₁ (27.13 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and α -amylase activity was recorded in G₁M₂ (2.83 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G₁M₁ (6.19 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At 15th month of storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆M₁

(24.60 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7M_1 (22.80 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1M_2 (0.92 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G_1M_1 (2.90 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At 18th month of storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6M_1 (22.27 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7M_1 (20.47 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1M_1 (2.08 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G_1M_2 (3.58 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At 21th month of storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6M_1 (20.93 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7M_1 (19.13 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1M_2 (2.21 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G_1M_1 (2.70 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$). At 24th month of storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6M_1 (20.53 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7M_1 (18.73 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G_1M_1 (2.52 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by G_2M_2 (2.76 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$).

Fruit and seed materials $\times$ Packaging: The fruit and seed materials $\times$ Packaging interaction for α -Amylase activity was significant throughout storage period.

The higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 (27.48 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_2P_3 (27.03 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -Amylase activity was recorded in M_2P_2 (23.47 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and M_2P_1 (24.70 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during three months of storage.

At 6th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_2 (26.55 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_3 (26.48 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 (19.44 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 (19.47 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 9th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_2 (25.55 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_3 (25.48 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 (16.81 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 (18.47 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 12th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 (24.48 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_2 (22.55 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_1P_1 (12.84 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_2P_1 (13.65 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 15th month storage, the higher seed α -amylase activity

($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 ($19.99 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_2 ($18.04 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 ($7.37 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 ($9.12 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 18th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 ($18.99 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_2 ($16.04 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 ($6.75 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 ($6.91 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 21st month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 ($17.99 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_2 ($14.44 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 ($6.56 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 ($7.31 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 24th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in M_1P_3 ($17.00 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_2 ($14.31 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in M_2P_1 ($6.44 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) followed by M_1P_1 ($6.92 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively.

Genotypes × Packaging: Genotypes × Packaging interaction for α -Amylase activity was significant throughout storage period except 3rd and 6th month of storage. At 9th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6P_3 ($33.60 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7P_3 ($31.85 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G_1P_1 ($2.97 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2P_1 ($7.50 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 9th month of storage. At 12th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6P_3 ($31.10 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_6P_2 ($29.60 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G_1P_1 ($1.03 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2P_1 ($5.50 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 12th month of storage. At 15th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6P_3 ($26.10 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_6P_2 ($25.10 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G_1P_1 ($0.62 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_2P_1 ($1.52 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 15th month of storage. At 18th month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6P_3 ($25.10 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_7P_3 ($23.34 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G_1P_1 ($1.28 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G_1P_2 ($1.92 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 18th month of storage. At 21st month storage, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G_6P_3 ($23.60 \mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and

G₇P₃ (21.83 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G₁P₁ (1.11 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁P₂ (1.46 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 21st month of storage. At end of the storage month, the higher seed α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) was recorded in G₆P₃ (23.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇P₃ (21.33 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), and lower α -amylase activity was recorded in G₁P₁ (0.98 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁P₂ (1.37 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) during 24th month of storage.

Genotypes $\times$ Fruit and seed materials $\times$ Packaging: Interaction of genotypes $\times$ materials $\times$ packaging was non-significant during 3rd, 6th and 9th month storage period and there was significant difference rest of the storage period. At 12th month storage, the maximum seed α -amylase activity was recorded in G₆ $\times$ M₁ $\times$ P₃ (33.60 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ $\times$ M₁ $\times$ P₃ (31.80 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁ $\times$ M₂ $\times$ P₁ (0.50 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₂ $\times$ M₁ $\times$ P₁ (1.57 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 15th month storage, the maximum seed α -amylase activity was recorded in G₆ $\times$ M₁ $\times$ P₃ (29.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ $\times$ M₁ $\times$ P₃ (27.30 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁ $\times$ M₂ $\times$ P₁ (0.54 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁ $\times$ M₁ $\times$ P₁ (0.70 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 18th month storage, the maximum seed α -amylase activity was recorded in G₆ $\times$ M₁ $\times$ P₃ (28.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ $\times$ M₁ $\times$ P₃ (26.30 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₉ $\times$ M₁ $\times$ P₁ (0.120 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁₁ $\times$ M₁ $\times$ P₁ (0.96 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 21st month storage, the maximum seed α -amylase activity was recorded in G₆ $\times$ M₁ $\times$ P₃ (27.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₇ $\times$ M₁ $\times$ P₃ (25.30 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁ $\times$ M₂ $\times$ P₁ (1.06 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁ $\times$ M₂ $\times$ P₁ (1.16 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively. At 24th month storage, the maximum seed α -amylase activity was recorded in G₆ $\times$ M₁ $\times$ P₃ (26.10 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₈ $\times$ M₁ $\times$ P₃ (24.30 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in G₁ $\times$ M₂ $\times$ P₁ (0.89 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) and G₁ $\times$ M₁ $\times$ P₁ (1.07 $\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$), respectively.

4.3.10 Capsaicin ($\mu\text{g g}^{-1}$)

The results on capsaicin ($\mu\text{g g}^{-1}$) as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.30)

Table 4.30. Capsaicin content ($\mu\text{g g}^{-1}$) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	442	416	388	363	333	348	298	222
G ₂	296	282	262	238	208	196	172	117
G ₃	201	187	167	142	112	99	86	44
G ₄	276	262	242	218	187	175	153	96
G ₅	30	26	20	13	12	4	11	1
G ₆	68	54	36	26	20	6	14	1
G ₇	127	113	94	69	51	30	34	10
G ₈	181	167	148	123	92	80	71	32
G ₉	190	176	156	131	100	88	77	36
G ₁₀	41	28	29	17	13	4	11	1
G ₁₁	132	115	96	70	55	35	37	11
G ₁₂	109	95	76	53	39	22	25	6
S.Em $\pm$	1.7	1.7	1.5	1.3	1.2	1.1	1.2	1.3
CD (<0.05P)	4.7	4.7	4.3	3.7	3.4	3.1	3.4	3.7
M ₁	177	164	149	132	116	113	98	64
M ₂	171	156	137	112	88	68	66	32
S.Em $\pm$	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5
CD (<0.05P)	1.9	1.9	1.8	1.5	1.4	1.3	1.4	1.5
P ₁	165	142	116	85	57	79	34	6
P ₂	177	165	152	135	118	96	98	58
P ₃	181	173	160	146	131	97	115	80
S.Em $\pm$	0.8	0.9	0.8	0.7	0.6	0.6	0.6	0.7
CD (<0.05P)	2.3	2.4	2.1	1.9	1.7	1.6	1.7	1.9
G ₁ M ₁	451	420	386	367	345	380	319	257
G ₁ M ₂	432	412	389	359	320	315	278	186
G ₂ M ₁	298	285	270	252	230	228	201	150
G ₂ M ₂	295	278	255	224	186	163	143	85
G ₃ M ₁	202	191	176	156	134	131	108	68
G ₃ M ₂	199	183	159	128	90	67	65	21
G ₄ M ₁	277	266	251	232	209	207	183	122
G ₄ M ₂	274	257	234	204	165	143	122	71
G ₅ M ₁	32	30	19	12	10	3	10	1
G ₅ M ₂	28	22	20	15	14	4	12	1
G ₆ M ₁	70	59	44	36	26	7	16	1
G ₆ M ₂	66	49	29	16	14	4	11	1
G ₇ M ₁	129	118	103	83	65	58	51	19
G ₇ M ₂	124	108	85	54	37	2	17	1
G ₈ M ₁	183	172	157	137	115	112	89	55
G ₈ M ₂	179	162	139	108	70	47	53	9
G ₉ M ₁	192	181	165	146	123	120	97	61
G ₉ M ₂	187	170	147	116	78	55	56	12
G ₁₀ M ₁	43	32	30	18	13	4	11	1
G ₁₀ M ₂	39	23	28	15	14	4	11	1
G ₁₁ M ₁	135	116	101	82	69	64	56	21

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₂	130	113	90	59	40	6	18	1
G ₁₂ M ₁	111	100	85	65	53	40	41	11
G ₁₂ M ₂	107	90	67	42	24	4	10	1
S.Em $\pm$	2.2	2.4	2.2	1.9	1.7	1.6	1.7	1.9
CD (<0.05P)	NS	6.7	6.1	5.3	4.8	4.4	4.8	5.2
M ₁ P ₁	168	141	114	89	66	98	43	12
M ₁ P ₂	182	176	164	150	136	120	117	76
M ₁ P ₃	182	176	168	158	146	120	135	104
M ₂ P ₁	162	143	118	82	47	59	26	1
M ₂ P ₂	172	155	140	119	100	72	79	41
M ₂ P ₃	180	170	152	134	115	73	94	56
S.Em $\pm$	1.2	1.2	1.1	1.0	0.9	0.8	0.9	0.9
CD (<0.05P)	3.3	3.4	3.0	2.6	2.4	2.2	2.4	2.6
G ₁ P ₁	419	362	306	266	215	330	159	36
G ₁ P ₂	451	439	423	405	383	357	357	297
G ₁ P ₃	455	447	434	418	400	357	379	332
G ₂ P ₁	287	263	234	195	144	178	84	27
G ₂ P ₂	299	287	271	253	231	205	205	145
G ₂ P ₃	303	295	282	266	248	205	227	180
G ₃ P ₁	193	172	143	102	50	82	21	1
G ₃ P ₂	203	191	175	157	135	108	109	49
G ₃ P ₃	205	197	184	168	151	108	130	83
G ₄ P ₁	266	245	216	175	124	157	67	6
G ₄ P ₂	278	266	250	232	210	184	184	124
G ₄ P ₃	282	274	261	245	227	184	206	159
G ₅ P ₁	22	27	20	15	14	4	9	1
G ₅ P ₂	32	23	23	11	15	3	11	1
G ₅ P ₃	36	28	16	14	7	4	14	1
G ₆ P ₁	60	39	13	15	15	4	11	1
G ₆ P ₂	70	58	42	27	19	6	12	1
G ₆ P ₃	74	66	53	37	27	7	18	1
G ₇ P ₁	119	98	69	28	13	21	10	1
G ₇ P ₂	128	116	100	82	61	35	35	5
G ₇ P ₃	133	125	112	96	78	35	57	24
G ₈ P ₁	173	152	123	82	30	62	12	1
G ₈ P ₂	183	171	155	137	115	89	89	32
G ₈ P ₃	187	179	166	150	132	89	111	64
G ₉ P ₁	183	161	132	90	38	70	14	1
G ₉ P ₂	191	179	163	145	123	97	97	37
G ₉ P ₃	195	187	174	158	140	97	119	72
G ₁₀ P ₁	33	13	26	15	13	3	8	1
G ₁₀ P ₂	43	31	34	15	14	3	13	1
G ₁₀ P ₃	47	39	26	19	13	5	13	1
G ₁₁ P ₁	124	92	63	22	15	24	9	1
G ₁₁ P ₂	135	123	107	89	67	40	41	5
G ₁₁ P ₃	138	130	117	101	83	40	62	27
G ₁₂ P ₁	101	80	51	17	13	12	10	1

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₂	111	99	83	65	43	26	28	1
G ₁₂ P ₃	115	107	94	78	60	27	39	15
S.Em ±	2.9	2.9	2.7	2.3	2.1	1.9	2.1	2.3
CD (<0.05P)	NS	8.2	7.4	6.5	5.9	5.4	5.8	6.4
G ₁ M ₁ P ₁	442	358	279	246	208	361	166	71
G ₁ M ₁ P ₂	456	450	438	424	406	390	384	331
G ₁ M ₁ P ₃	456	450	442	432	420	390	406	370
G ₁ M ₂ P ₁	395	365	333	286	221	298	151	1
G ₁ M ₂ P ₂	446	428	408	386	360	324	330	263
G ₁ M ₂ P ₃	454	444	426	404	380	324	352	294
G ₂ M ₁ P ₁	286	258	234	204	167	209	118	54
G ₂ M ₁ P ₂	304	298	286	272	254	238	232	179
G ₂ M ₁ P ₃	304	298	290	280	268	238	254	218
G ₂ M ₂ P ₁	288	267	235	187	121	146	50	1
G ₂ M ₂ P ₂	294	276	256	234	208	172	178	111
G ₂ M ₂ P ₃	302	292	274	252	228	172	200	142
G ₃ M ₁ P ₁	194	172	146	112	74	113	32	1
G ₃ M ₁ P ₂	208	202	190	176	158	140	136	83
G ₃ M ₁ P ₃	205	199	191	181	169	140	155	120
G ₃ M ₂ P ₁	192	171	139	91	25	50	9	1
G ₃ M ₂ P ₂	199	181	161	138	112	76	82	15
G ₃ M ₂ P ₃	206	196	178	156	132	76	104	46
G ₄ M ₁ P ₁	266	244	218	185	147	188	106	11
G ₄ M ₁ P ₂	283	277	265	251	233	217	211	158
G ₄ M ₁ P ₃	283	277	269	259	247	217	233	197
G ₄ M ₂ P ₁	267	246	214	166	100	125	29	1
G ₄ M ₂ P ₂	273	255	235	213	187	152	157	90
G ₄ M ₂ P ₃	282	272	254	232	208	152	180	121
G ₅ M ₁ P ₁	23	28	14	15	13	3	9	1
G ₅ M ₁ P ₂	37	31	19	8	15	3	9	1
G ₅ M ₁ P ₃	37	31	23	13	1	4	13	1
G ₅ M ₂ P ₁	21	26	25	15	15	4	9	1
G ₅ M ₂ P ₂	27	16	27	15	14	3	13	1
G ₅ M ₂ P ₃	35	25	9	15	14	5	14	1
G ₆ M ₁ P ₁	61	39	13	15	15	4	12	1
G ₆ M ₁ P ₂	75	69	57	43	25	9	11	1
G ₆ M ₁ P ₃	75	69	61	51	39	9	25	1
G ₆ M ₂ P ₁	59	38	14	15	15	3	10	1
G ₆ M ₂ P ₂	65	47	27	11	14	4	13	1
G ₆ M ₂ P ₃	73	63	45	23	14	4	11	1
G ₇ M ₁ P ₁	120	98	72	38	13	39	7	1
G ₇ M ₁ P ₂	134	128	116	102	84	68	62	9
G ₇ M ₁ P ₃	134	128	120	110	98	68	84	48
G ₇ M ₂ P ₁	118	97	65	17	14	2	12	1
G ₇ M ₂ P ₂	122	104	85	63	37	2	8	1
G ₇ M ₂ P ₃	132	122	104	82	58	2	30	1
G ₈ M ₁ P ₁	174	153	126	92	54	93	12	1
G ₈ M ₁ P ₂	188	182	170	156	138	122	116	63

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₃	188	182	174	164	152	122	138	102
G ₈ M ₂ P ₁	172	151	119	71	5	30	12	1
G ₈ M ₂ P ₂	178	160	140	118	92	56	62	1
G ₈ M ₂ P ₃	186	176	158	136	112	56	84	26
G ₉ M ₁ P ₁	185	163	136	102	63	101	20	1
G ₉ M ₁ P ₂	196	190	178	164	146	130	124	71
G ₉ M ₁ P ₃	196	190	182	172	160	130	146	110
G ₉ M ₂ P ₁	180	159	127	79	13	38	7	1
G ₉ M ₂ P ₂	186	168	148	126	100	64	70	2
G ₉ M ₂ P ₃	194	184	166	144	120	64	92	34
G ₁₀ M ₁ P ₁	34	12	25	15	14	3	10	1
G ₁₀ M ₁ P ₂	48	42	30	16	14	3	10	1
G ₁₀ M ₁ P ₃	48	42	34	24	12	5	14	1
G ₁₀ M ₂ P ₁	32	14	27	15	13	3	6	1
G ₁₀ M ₂ P ₂	38	20	37	15	14	4	16	1
G ₁₀ M ₂ P ₃	46	36	18	15	15	5	12	0
G ₁₁ M ₁ P ₁	125	81	55	21	15	45	10	1
G ₁₁ M ₁ P ₂	141	135	123	109	90	73	68	10
G ₁₁ M ₁ P ₃	139	133	125	115	103	73	89	53
G ₁₁ M ₂ P ₁	123	102	70	22	15	4	7	1
G ₁₁ M ₂ P ₂	129	111	91	69	43	7	13	1
G ₁₁ M ₂ P ₃	137	127	109	87	63	7	35	1
G ₁₂ M ₁ P ₁	102	80	54	20	14	21	12	1
G ₁₂ M ₁ P ₂	116	110	98	84	66	50	44	1
G ₁₂ M ₁ P ₃	116	110	102	92	80	50	66	30
G ₁₂ M ₂ P ₁	100	79	47	15	13	4	7	0
G ₁₂ M ₂ P ₂	106	88	68	46	20	3	12	1
G ₁₂ M ₂ P ₃	114	104	86	64	40	5	12	1
S.Em ±	4.1	4.2	3.8	3.3	3.0	2.7	2.9	3.2
CD (<0.05P)	NS	NS	10.5	9.2	8.3	7.6	8.2	9.1
CV (%)	4.1	4.5	4.6	4.7	5.1	5.2	6.2	11.7

Initial Capsaicin content (µg g ⁻¹)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
468	321	218	382	42	76	138	204	201	48	142	118	5.99	17.49	5.3

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

Genotypes: There was significant difference between the genotypes for capsaicin ($\mu\text{g g}^{-1}$) throughout storage period. Irrespective of the genotypes, there was a decline in capsaicin ($\mu\text{g g}^{-1}$) during storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (442 $\mu\text{g g}^{-1}$) followed by G₂ (296 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (33 $\mu\text{g g}^{-1}$) followed by G₁₀ (41 $\mu\text{g g}^{-1}$). At six months storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (416 $\mu\text{g g}^{-1}$) followed by G₂ (282), and lower seed capsaicin was recorded in G₅ (26 $\mu\text{g g}^{-1}$) followed by G₁₀ (28 $\mu\text{g g}^{-1}$), respectively. At 9th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (388 $\mu\text{g g}^{-1}$) followed by G₂ (262 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (20 $\mu\text{g g}^{-1}$) followed by G₁₀ (29 $\mu\text{g g}^{-1}$), respectively. At 12th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (363 $\mu\text{g g}^{-1}$) followed by G₂ (238 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (13 $\mu\text{g g}^{-1}$) followed by G₁₀ (17 $\mu\text{g g}^{-1}$), respectively. At 15th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (333 $\mu\text{g g}^{-1}$) followed by G₂ (208 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (12 $\mu\text{g g}^{-1}$) followed by G₁₀ (13 $\mu\text{g g}^{-1}$), respectively. At 18th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (348 $\mu\text{g g}^{-1}$) followed by G₂ (196 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (4 $\mu\text{g g}^{-1}$) followed by G₁₀ (4 $\mu\text{g g}^{-1}$), respectively. At 21th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (298 $\mu\text{g g}^{-1}$) followed by G₂ (172 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (11 $\mu\text{g g}^{-1}$) followed by G₁₀ (11 $\mu\text{g g}^{-1}$), respectively. At 24th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G₁ (222 $\mu\text{g g}^{-1}$) followed by G₂ (117 $\mu\text{g g}^{-1}$), and lower seed capsaicin was recorded in G₅ (1 $\mu\text{g g}^{-1}$) followed by G₁₀ (1 $\mu\text{g g}^{-1}$), respectively.

Fruit and seed materials: Capsaicin ($\mu\text{g g}^{-1}$) differed significantly among the materials during the storage period. Whole fruits (M₁) recorded the highest capsaicin ($\mu\text{g g}^{-1}$) throughout the storage period. At three months storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M₁ (178 $\mu\text{g g}^{-1}$) and M₂ (171 $\mu\text{g g}^{-1}$), at six months storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M₁ (164 $\mu\text{g g}^{-1}$) and M₂ (156 $\mu\text{g g}^{-1}$), at nine months M₁ (149 $\mu\text{g g}^{-1}$) and M₂ (137 $\mu\text{g g}^{-1}$). The 12, 15, 18 21 and 24 four months storage, the M₁ was recorded significantly over M₂. The higher seed capsaicin (132 $\mu\text{g g}^{-1}$)

g^{-1} , 116 $\mu g g^{-1}$, 113 $\mu g g^{-1}$, 98 $\mu g g^{-1}$ and 64 $\mu g g^{-1}$, respectively) and (112 $\mu g g^{-1}$, 88 $\mu g g^{-1}$, 68 $\mu g g^{-1}$, 66 $\mu g g^{-1}$ and 32 $\mu g g^{-1}$ in M_2 , respectively).

Packaging: The effect of packaging on capsaicin ($\mu g g^{-1}$) was significant differed throughout storage period. The higher seed capsaicin was recorded in P_3 followed by P_2 and P_1 . The 3, 6, 9, 12, 15, 18, 21 and 24th months storage, the P_3 was recorded significantly over P_2 and P_1 . The higher seed capsaicin (181 $\mu g g^{-1}$, 173 $\mu g g^{-1}$, 160 $\mu g g^{-1}$, 146 $\mu g g^{-1}$, 131 $\mu g g^{-1}$, 97 $\mu g g^{-1}$, 115 $\mu g g^{-1}$ and 80 $\mu g g^{-1}$ in P_3 , respectively) and (117 $\mu g g^{-1}$, 165 $\mu g g^{-1}$, 152 $\mu g g^{-1}$, 135 $\mu g g^{-1}$, 118 $\mu g g^{-1}$, 96 $\mu g g^{-1}$, 98 $\mu g g^{-1}$ and 58 $\mu g g^{-1}$ in P_2 , respectively) and lower seed capsaicin $\mu g g^{-1}$ was recorded in P_1 (166 $\mu g g^{-1}$, 142 $\mu g g^{-1}$, 116 $\mu g g^{-1}$, 85 $\mu g g^{-1}$, 57 $\mu g g^{-1}$, 79 $\mu g g^{-1}$, 34 $\mu g g^{-1}$ and 6 $\mu g g^{-1}$, respectively).

Genotypes $\times$ Fruit and seed materials: Genotypes $\times$ materials interaction for capsaicin was non-significant during three and sixth month and rest of the storage period was significantly differed. At nine month storage, the higher seed capsaicin ($\mu g g^{-1}$) was recorded in G_1M_2 (389 $\mu g g^{-1}$) followed by G_1M_1 (386 $\mu g g^{-1}$) and lower capsaicin was recorded in G_5M_2 (19 $\mu g g^{-1}$) followed by G_5M_1 (20 $\mu g g^{-1}$), respectively. At 12th month storage, the higher seed capsaicin ($\mu g g^{-1}$) was recorded in G_1M_1 (367 $\mu g g^{-1}$) followed by G_1M_2 (359 $\mu g g^{-1}$) and lower capsaicin was recorded in G_5M_1 (12 $\mu g g^{-1}$) followed by $G_{10}M_2$ (15 $\mu g g^{-1}$), respectively. At 15th month storage, the higher seed capsaicin ($\mu g g^{-1}$) was recorded in G_1M_1 (345 $\mu g g^{-1}$) followed by G_1M_2 (320 $\mu g g^{-1}$) and lower capsaicin was recorded in G_5M_1 (10 $\mu g g^{-1}$) followed by $G_{10}M_1$ (13 $\mu g g^{-1}$), respectively. At 18th month storage, the higher seed capsaicin ($\mu g g^{-1}$) was recorded in G_1M_1 (380 $\mu g g^{-1}$) followed by G_1M_2 (315 $\mu g g^{-1}$) and lower capsaicin was recorded in G_7M_2 (2 $\mu g g^{-1}$) followed by G_5M_1 (3 $\mu g g^{-1}$), respectively. At 21st month storage, the higher seed capsaicin ($\mu g g^{-1}$) was recorded in G_1M_1 (319 $\mu g g^{-1}$) followed by G_2M_1 (278 $\mu g g^{-1}$) and lower capsaicin was recorded in $G_{12}M_2$ (10 $\mu g g^{-1}$) followed by G_5M_1 (10 $\mu g g^{-1}$), respectively. At 24th month storage, the higher seed capsaicin was recorded in G_1M_1 (257 $\mu g g^{-1}$) followed by G_1M_2 (186 $\mu g g^{-1}$) and lower capsaicin was recorded in $G_{10}M_2$ (1 $\mu g g^{-1}$) followed by G_6M_1 (1.00 $\mu g g^{-1}$), respectively.

Fruit and seed materials × Packaging: The fruit and seed materials × Packaging interaction for capsaicin was significant throughout storage period. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_2 ($182 \mu\text{g g}^{-1}$) followed by M_1P_3 ($182 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 ($162 \mu\text{g g}^{-1}$) and M_1P_1 ($169 \mu\text{g g}^{-1}$) during three months of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_2 ($176 \mu\text{g g}^{-1}$) followed by M_1P_3 ($176 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_1P_1 ($141 \mu\text{g g}^{-1}$) and M_2P_1 ($143 \mu\text{g g}^{-1}$) during 6th month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_3 ($168 \mu\text{g g}^{-1}$) followed by M_1P_2 ($164 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_1P_1 ($114 \mu\text{g g}^{-1}$) and M_2P_1 ($118 \mu\text{g g}^{-1}$) during 9th month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_3 ($158 \mu\text{g g}^{-1}$) followed by M_1P_2 ($150 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 ($82 \mu\text{g g}^{-1}$) and M_1P_1 ($89 \mu\text{g g}^{-1}$) during 12th month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_3 ($146 \mu\text{g g}^{-1}$) followed by M_1P_2 ($136 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 ($47 \mu\text{g g}^{-1}$) and M_1P_1 ($66 \mu\text{g g}^{-1}$) during 15th month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_3 ($120 \mu\text{g g}^{-1}$) followed by M_1P_2 ($120 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 ($59 \mu\text{g g}^{-1}$) and M_2P_2 ($72 \mu\text{g g}^{-1}$) during 18th month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in $M_{21}P_3$ ($135 \mu\text{g g}^{-1}$) followed by M_1P_2 ($117 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 (26) and M_1P_1 ($43 \mu\text{g g}^{-1}$) during 21st month of storage. The higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in M_1P_3 ($104 \mu\text{g g}^{-1}$) followed by M_1P_2 ($76 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in M_2P_1 ($1 \mu\text{g g}^{-1}$) and M_1P_1 ($12 \mu\text{g g}^{-1}$) during 24th month of storage.

Genotypes × Packaging: Genotypes × Packaging interaction for capsaicin was significant throughout storage period except third month of storage. At 6th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 ($447 \mu\text{g g}^{-1}$) followed by G_1P_2 ($439 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_{10}P_1$ ($13 \mu\text{g g}^{-1}$) followed by G_5P_2 ($23 \mu\text{g g}^{-1}$), respectively. At nine months storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 ($434 \mu\text{g g}^{-1}$) followed by G_1P_2 ($423 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in G_6P_1 ($13 \mu\text{g g}^{-1}$) followed by G_5P_3 ($16 \mu\text{g g}^{-1}$), respectively. At 12th month storage, the higher seed Capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 ($418 \mu\text{g g}^{-1}$) followed by G_1P_2 ($405 \mu\text{g g}^{-1}$) and lower capsaicin was recorded in G_5P_2 ($11 \mu\text{g g}^{-1}$) followed by G_5P_3

(14 $\mu\text{g g}^{-1}$), respectively. At 15th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 (400 $\mu\text{g g}^{-1}$) followed by G_2P_1 (383 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in G_5P_3 (7 $\mu\text{g g}^{-1}$) followed by G_7P_1 (13 $\mu\text{g g}^{-1}$), respectively. At 18th month storage, the higher seed Capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_2 (357 $\mu\text{g g}^{-1}$) followed by G_3P_1 (357 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in G_5P_2 (3 $\mu\text{g g}^{-1}$) followed by $G_{10}P_1$ (3 $\mu\text{g g}^{-1}$), respectively. At 21st month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 (379 $\mu\text{g g}^{-1}$) followed by G_1P_2 (357 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_{10}P_1$ (8 $\mu\text{g g}^{-1}$) followed by $G_{11}P_1$ (9 $\mu\text{g g}^{-1}$), respectively. At 24th month storage, the higher seed capsaicin ($\mu\text{g g}^{-1}$) was recorded in G_1P_3 (332 $\mu\text{g g}^{-1}$) followed by G_1P_2 (297 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in G_6P_2 (1 $\mu\text{g g}^{-1}$) followed by $G_{10}P_3$ (1.0 $\mu\text{g g}^{-1}$), respectively.

Genotypes $\times$ Fruit and seed materials $\times$ Packaging: Interaction of genotypes $\times$ materials $\times$ packaging was significantly differed throughout the storage period except third and sixth month of storage. During 9th month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (442 $\mu\text{g g}^{-1}$) and $G_1M_1P_2$ (438 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_5M_2P_3$ (9 $\mu\text{g g}^{-1}$) and $G_6M_1P_1$ (13 $\mu\text{g g}^{-1}$), respectively. During 12th month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (432 $\mu\text{g g}^{-1}$) and $G_1M_1P_2$ (424 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_5M_2P_2$ (8 $\mu\text{g g}^{-1}$) and $G_6M_2P_2$ (11 $\mu\text{g g}^{-1}$), respectively. During 15th month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (420 $\mu\text{g g}^{-1}$) and $G_1M_1P_2$ (406 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_5M_1P_3$ (1.0 $\mu\text{g g}^{-1}$) and $G_8M_2P_1$ (5 $\mu\text{g g}^{-1}$), respectively. During 18th month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (390 $\mu\text{g g}^{-1}$) and $G_7M_1P_2$ (390 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_7M_2P_2$ (2 $\mu\text{g g}^{-1}$) and $G_7M_2P_3$ (2 $\mu\text{g g}^{-1}$), respectively. During 21st month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (406 $\mu\text{g g}^{-1}$) and $G_1M_1P_2$ (384 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_{10}M_2P_1$ (6 $\mu\text{g g}^{-1}$) and $G_9M_1P_1$ (7.0 $\mu\text{g g}^{-1}$), respectively. During 24th month storage, the maximum seed capsaicin was recorded in $G_1M_1P_3$ (370 $\mu\text{g g}^{-1}$) and $G_1M_1P_2$ (331 $\mu\text{g g}^{-1}$) and lower capsaicin was recorded in $G_{10}M_2P_3$ (0.0 $\mu\text{g g}^{-1}$) and $G_{12}M_2P_1$ (0.0 $\mu\text{g g}^{-1}$), respectively.

4.3.11 Oleoresin (%): The results on Oleoresin (%) as influenced by genotypes, packaging, materials and their interaction effects are presented in (Table 4.31).

Genotypes: There was significant difference between the genotypes for oleoresin percentage throughout storage period. Irrespective of the genotypes, there was a decline in oleoresin percentage during storage. During the initial maximum oleoresin was recorded in genotype G₇ (20.29 %) followed by G₁₀ (18.22 %). The higher seed oleoresin (%) was recorded in G₇ (20.29 %) followed by G₁₀ (18.22 %), and lower seed oleoresin was recorded in G₁ (3.7 %) followed by G₁₁ (4.99 %). At six months storage, The higher seed oleoresin (%) was recorded in G₇ (20.34 %) followed by G₁₀ (18.26 %), and lower seed oleoresin was recorded in G₂ (3.47 %) followed by G₁₁ (5.03 %), respectively and during nine months the higher seed oleoresin (%) was recorded in G₇ (19.77 %) followed by G₁₀ (17.34 %), and lower seed oleoresin was recorded in G₁ (2.37 %) followed by G₂ (3.22 %). The 12th month storage, the higher seed oleoresin (%) was recorded in G₇ (19.99 %) followed by G₁₀ (17.54 %), and lower seed oleoresin was recorded in G₁ (1.29 %) followed by G₂ (2.60 %). During 15th storage, the higher seed oleoresin (%) was recorded in G₇ (19.11 %) followed by G₁₀ (17.04 %), and lower seed oleoresin was recorded in G₁ (2.34 %) followed by G₂ (2.62 %), respectively and during 18th month storage, the higher seed oleoresin was recorded in G₇ (18.77 %) followed by G₁₀ (16.71 %) and lower seed oleoresin was recorded in G₂ (2.26 %) followed by G₁₁ (3.55 %), respectively. During 21st storage, the higher seed oleoresin was recorded in G₇ (18.14 %) followed by G₁₀ (16.4 %) and lower seed oleoresin was recorded in G₂ (2.33 %) followed by G₁ (3.21 %), respectively. At end of the storage month. The higher seed oleoresin was recorded in G₇ (18.37 %) followed by G₁₀ (16.31 %), and lower seed oleoresin was recorded in G₁ (1.89 %) followed by G₁₁ (3.24 %), respectively.

Fruit and seed materials: Oleoresin percentage differed significantly among the materials during the storage period. Whole fruits (M₂) recorded the highest oleoresin percentage throughout the storage period except 9th month of storage. At three months storage, the higher seed oleoresin (%) was recorded in M₂ (11.23 %) and M₁ (10.97 %), at six months storage, the higher seed oleoresin (%) was recorded in M₂ (11.26 %) and M₁ (11.03 %), at nine months M₁ (9.84 %) and M₂ (9.66 %). The 12, 15, 18 21 and 24th

Table 4.31. Oleoresin content (%) as influenced by genotypes, fruit and seed, packaging and their interaction on seed storage

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁	14.08	14.13	2.37	1.29	2.34	5.24	3.21	1.89
G ₂	3.44	3.47	3.22	2.6	2.62	2.26	2.33	3.42
G ₃	10.31	10.36	9.81	9.63	9.13	8.8	8.51	8.4
G ₄	14.84	14.89	13.94	14.15	13.65	13.32	13.04	12.92
G ₅	12.26	12.31	12.06	11.36	11.07	10.74	10.47	10.34
G ₆	5.24	5.29	5.04	4.55	4.3	11.08	12.29	12.17
G ₇	20.29	20.34	19.77	19.19	19.11	18.77	18.14	18.37
G ₈	14.11	14.16	13.61	13.44	12.94	12.6	12.32	12.2
G ₉	9.17	9.22	8.98	8.49	7.98	7.65	7.37	7.25
G ₁₀	18.22	18.26	17.34	17.54	17.04	16.71	16.43	16.31
G ₁₁	4.98	5.03	4.78	4.28	3.78	3.55	3.32	3.24
G ₁₂	6.25	6.3	6.05	5.55	5.05	4.72	4.43	4.32
S.Em ±	0.11	0.11	0.15	0.1	0.1	0.1	0.1	0.09
CD (<0.05P)	0.3	0.3	0.43	0.29	0.27	0.27	0.29	0.26
M ₁	11.23	11.26	9.66	9.63	9.56	10.11	10.04	9.83
M ₂	10.97	11.03	9.84	9.04	8.61	9.13	8.64	8.61
S.Em ±	0.04	0.04	0.06	0.04	0.04	0.04	0.04	0.04
CD (<0.05P)	0.12	0.12	0.17	0.12	0.11	0.11	0.12	0.11
P ₁	10.46	10.46	8.9	8.29	7.67	7.93	7.68	7.62
P ₂	11.27	11.36	10.11	9.7	9.66	10.26	9.91	9.81
P ₃	11.57	11.62	10.23	10.03	9.92	10.67	10.37	10.27
S.Em ±	0.05	0.05	0.08	0.05	0.05	0.05	0.05	0.05
CD (<0.05P)	0.15	0.15	0.21	0.14	0.13	0.13	0.15	0.13
G ₁ M ₁	14	14	2.6	1.4	2.4	6	2.8	2
G ₁ M ₂	14.2	14.2	2.2	1.2	2.3	4.5	3.6	1.8
G ₂ M ₁	3.3	3.3	3.1	2.1	2.8	1.8	1.6	3.8
G ₂ M ₂	3.6	3.6	3.4	3.1	2.5	2.7	3	3
G ₃ M ₁	10.1	10.2	10	9.2	8.5	8	7.7	7.6
G ₃ M ₂	10.5	10.5	9.7	10	9.8	9.6	9.3	9.2
G ₄ M ₁	14.7	14.7	14.5	13.7	13	12.5	12.2	12.1
G ₄ M ₂	15	15	13.4	14.6	14.3	14.1	13.9	13.7
G ₅ M ₁	12.1	12.2	11.9	11.2	10.5	10	9.7	9.6
G ₅ M ₂	12.4	12.4	12.2	11.5	11.7	11.5	11.3	11.1
G ₆ M ₁	5.1	5.2	4.9	4.2	3.9	11.8	11.5	11.4
G ₆ M ₂	5.4	5.4	5.2	4.9	4.7	10.4	13.1	12.9
G ₇ M ₁	20.2	20.3	20	19.3	18.5	18	17.7	17.6
G ₇ M ₂	20.4	20.4	19.5	19.1	19.7	19.5	18.6	19.1
G ₈ M ₁	14	14.1	13.8	13.1	12.3	11.8	11.5	11.4
G ₈ M ₂	14.2	14.3	13.4	13.8	13.5	13.4	13.1	13
G ₉ M ₁	9.1	9.1	8.9	8.1	7.4	6.9	6.6	6.5
G ₉ M ₂	9.3	9.3	9.1	8.9	8.6	8.4	8.2	8
G ₁₀ M ₁	18.1	18.2	17.9	17.2	16.4	15.9	15.6	15.5
G ₁₀ M ₂	18.3	18.4	16.8	17.9	17.6	17.5	17.2	17.1

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₁ M ₁	4.9	4.9	4.7	3.9	3.2	2.9	2.7	2.7
G ₁₁ M ₂	5.1	5.1	4.9	4.7	4.4	4.2	4	3.8
G ₁₂ M ₁	6.1	6.2	5.9	5.2	4.4	3.9	3.6	3.5
G ₁₂ M ₂	6.4	6.4	6.2	5.9	5.7	5.5	5.2	5.1
S.Em $\pm$	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
CD (<0.05P)	NS	NS	0.6	0.4	0.4	0.4	0.4	0.4
M ₁ P ₁	9.97	9.96	8.86	7.44	6.39	6.01	5.88	6.29
M ₁ P ₂	11.49	11.58	10.35	9.61	9.48	10.72	9.58	9.48
M ₁ P ₃	11.46	11.56	10.31	10.09	9.96	10.66	10.36	10.16
M ₂ P ₁	10.96	10.96	8.95	9.14	8.95	9.85	9.48	8.95
M ₂ P ₂	11.04	11.14	9.88	9.8	9.85	9.8	10.25	10.15
M ₂ P ₃	11.7	11.7	10.1	10	9.9	10.7	10.4	10.4
S.Em $\pm$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CD (<0.05P)	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
G ₁ P ₁	13.3	13.3	2.2	0.2	1.1	2.1	1.1	0.9
G ₁ P ₂	14.3	14.4	2.1	1.4	2.8	8.9	4	2.2
G ₁ P ₃	14.6	14.7	2.8	2.3	3.1	4.8	4.5	2.6
G ₂ P ₁	2.8	2.8	2.6	1.8	1.8	1.2	2.1	1.9
G ₂ P ₂	3.6	3.7	3.5	2.8	2.9	2.6	2.3	4
G ₂ P ₃	3.9	4	3.7	3.2	3.1	3	2.7	4.4
G ₃ P ₁	9.7	9.7	8.6	8.7	7.6	7.1	6.9	6.7
G ₃ P ₂	10.5	10.6	10.4	10	9.8	9.5	9.2	9.1
G ₃ P ₃	10.7	10.8	10.5	10.2	10	9.8	9.5	9.4
G ₄ P ₁	14.1	14.1	11.8	13.1	12.1	11.5	11.3	11.2
G ₄ P ₂	15	15.1	14.9	14.5	14.3	14	13.7	13.6
G ₄ P ₃	15.4	15.4	15.1	14.8	14.6	14.4	14.1	14
G ₅ P ₁	11.6	11.6	11.4	10	9.5	9	8.8	8.6
G ₅ P ₂	12.4	12.5	12.3	11.9	11.7	11.4	11.1	11
G ₅ P ₃	12.7	12.8	12.5	12.2	12	11.8	11.5	11.4
G ₆ P ₁	4.6	4.6	4.4	3.6	3.2	10.7	10.5	10.4
G ₆ P ₂	5.4	5.5	5.3	4.9	4.7	8.9	13	12.9
G ₆ P ₃	5.7	5.8	5.5	5.2	5	13.7	13.4	13.3
G ₇ P ₁	19.7	19.7	18.5	17.5	17.6	17.1	15.8	16.7
G ₇ P ₂	20.3	20.4	20.2	19.8	19.6	19.3	19	18.9
G ₇ P ₃	20.8	20.9	20.6	20.3	20.1	19.9	19.6	19.5
G ₈ P ₁	13.5	13.5	12.4	12.5	11.4	10.8	10.7	10.5
G ₈ P ₂	14.3	14.4	14.1	13.8	13.6	13.3	12.9	12.8
G ₈ P ₃	14.6	14.6	14.3	14	13.8	13.7	13.4	13.3
G ₉ P ₁	8.6	8.6	8.4	7.6	6.5	5.9	5.7	5.6
G ₉ P ₂	9.3	9.4	9.2	8.8	8.6	8.3	8	7.9
G ₉ P ₃	9.6	9.7	9.4	9.1	8.9	8.7	8.4	8.3
G ₁₀ P ₁	17.6	17.6	16.9	16.6	15.5	14.9	14.7	14.6
G ₁₀ P ₂	18.4	18.5	18.3	17.9	17.7	17.4	17.1	17
G ₁₀ P ₃	18.7	18.7	16.9	18.1	17.9	17.8	17.5	17.4
G ₁₁ P ₁	4.3	4.3	4.1	3.3	2.2	2	1.9	1.9
G ₁₁ P ₂	5.2	5.3	5	4.7	4.5	4.2	3.8	3.7
G ₁₁ P ₃	5.4	5.5	5.2	4.9	4.7	4.5	4.2	4.1

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₁₂ P ₁	5.6	5.6	5.4	4.6	3.5	3	2.7	2.6
G ₁₂ P ₂	6.4	6.5	6.3	5.9	5.7	5.4	5.1	5
G ₁₂ P ₃	6.7	6.8	6.5	6.2	6	5.8	5.5	5.4
S.Em $\pm$	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
CD (<0.05P)	NS	NS	0.7	0.5	0.5	0.5	0.5	0.5
G ₁ M ₁ P ₁	12.9	12.9	1.8	0.2	1.5	0.1	0.2	1.7
G ₁ M ₁ P ₂	14.5	14.6	3	1.5	2.5	13	3.7	1.8
G ₁ M ₁ P ₃	14.5	14.6	2.9	2.5	3.1	4.8	4.5	2.5
G ₁ M ₂ P ₁	13.8	13.8	2.6	0.2	0.8	4	2	0.1
G ₁ M ₂ P ₂	14.1	14.2	1.2	1.3	3	4.7	4.4	2.5
G ₁ M ₂ P ₃	14.7	14.7	2.7	2.1	3.1	4.8	4.5	2.7
G ₂ M ₁ P ₁	2.3	2.2	2	0.7	2.4	0.2	0.3	3.5
G ₂ M ₁ P ₂	3.8	3.9	3.6	2.3	2.7	2.3	1.9	3.6
G ₂ M ₁ P ₃	3.8	3.9	3.6	3.4	3.2	3	2.7	4.3
G ₂ M ₂ P ₁	3.3	3.3	3.1	2.9	1.2	2.2	3.8	0.3
G ₂ M ₂ P ₂	3.4	3.5	3.3	3.2	3.1	2.9	2.6	4.3
G ₂ M ₂ P ₃	4	4	3.7	3.1	3.1	3	2.7	4.5
G ₃ M ₁ P ₁	9.2	9.2	9	7.6	5.9	5	4.8	4.8
G ₃ M ₁ P ₂	10.7	10.8	10.5	9.9	9.6	9.2	8.8	8.7
G ₃ M ₁ P ₃	10.5	10.6	10.3	10.1	9.9	9.7	9.4	9.2
G ₃ M ₂ P ₁	10.2	10.2	8.2	9.8	9.3	9.1	8.9	8.6
G ₃ M ₂ P ₂	10.3	10.4	10.2	10.1	10	9.8	9.5	9.4
G ₃ M ₂ P ₃	10.9	10.9	10.6	10.2	10	9.9	9.6	9.6
G ₄ M ₁ P ₁	13.5	13.5	13.3	12	10.3	9.4	9.2	9.2
G ₄ M ₁ P ₂	15.2	15.3	15	14.4	14.1	13.7	13.3	13.2
G ₄ M ₁ P ₃	15.2	15.3	15	14.8	14.6	14.4	14.1	13.9
G ₄ M ₂ P ₁	14.7	14.7	10.3	14.3	13.8	13.6	13.4	13.1
G ₄ M ₂ P ₂	14.8	14.9	14.7	14.6	14.5	14.3	14	13.9
G ₄ M ₂ P ₃	15.5	15.5	15.2	14.8	14.6	14.5	14.1	14.2
G ₅ M ₁ P ₁	11.2	11.2	11	9.6	7.8	6.9	6.8	6.7
G ₅ M ₁ P ₂	12.6	12.7	12.4	11.8	11.5	11.1	10.7	10.6
G ₅ M ₁ P ₃	12.6	12.7	12.4	12.2	12	11.8	11.5	11.3
G ₅ M ₂ P ₁	12.1	12.1	11.9	10.4	11.2	11	10.8	10.5
G ₅ M ₂ P ₂	12.2	12.3	12.1	12	11.9	11.7	11.4	11.3
G ₅ M ₂ P ₃	12.8	12.8	12.5	12.1	11.9	11.8	11.5	11.5
G ₆ M ₁ P ₁	4.1	4.1	3.9	2.5	2.3	8.7	8.5	8.5
G ₆ M ₁ P ₂	5.6	5.7	5.4	4.8	4.5	13	12.6	12.5
G ₆ M ₁ P ₃	5.6	5.7	5.4	5.2	5	13.7	13.4	13.2
G ₆ M ₂ P ₁	5.1	5.1	4.9	4.7	4.2	12.7	12.5	12.2
G ₆ M ₂ P ₂	5.2	5.3	5.1	5	4.9	4.7	13.3	13.2
G ₆ M ₂ P ₃	5.8	5.8	5.5	5.1	4.9	13.7	13.4	13.4
G ₇ M ₁ P ₁	19.2	19.2	19	17.6	15.9	15	14.8	14.8
G ₇ M ₁ P ₂	20.7	20.8	20.5	19.9	19.6	19.2	18.8	18.7
G ₇ M ₁ P ₃	20.7	20.8	20.5	20.3	20.1	19.9	19.6	19.4
G ₇ M ₂ P ₁	20.2	20.2	18.1	17.3	19.3	19.1	16.8	18.6
G ₇ M ₂ P ₂	20	20.1	19.9	19.8	19.7	19.5	19.2	19.1
G ₇ M ₂ P ₃	21	21	20.7	20.3	20.1	20	19.7	19.7
G ₈ M ₁ P ₁	13	13	12.8	11.4	9.7	8.8	8.6	8.6

Treatments	Storage period (month)							
	3	6	9	12	15	18	21	24
G ₈ M ₁ P ₂	14.5	14.6	14.3	13.7	13.4	13	12.6	12.5
G ₈ M ₁ P ₃	14.5	14.6	14.3	14.1	13.9	13.7	13.4	13.2
G ₈ M ₂ P ₁	14	14	11.9	13.6	13.1	12.9	12.7	12.4
G ₈ M ₂ P ₂	14.1	14.2	14	13.9	13.8	13.6	13.3	13.2
G ₈ M ₂ P ₃	14.7	14.7	14.4	14	13.8	13.7	13.4	13.4
G ₉ M ₁ P ₁	8.2	8.2	8	6.5	4.8	3.9	3.7	3.7
G ₉ M ₁ P ₂	9.5	9.6	9.3	8.7	8.4	8	7.6	7.5
G ₉ M ₁ P ₃	9.5	9.6	9.3	9.1	8.9	8.7	8.4	8.2
G ₉ M ₂ P ₁	9	9	8.8	8.6	8.1	7.9	7.7	7.4
G ₉ M ₂ P ₂	9.1	9.2	9	8.9	8.8	8.6	8.3	8.2
G ₉ M ₂ P ₃	9.7	9.7	9.4	9	8.8	8.7	8.4	8.4
G ₁₀ M ₁ P ₁	17.1	17.1	16.9	15.5	13.8	12.9	12.7	12.7
G ₁₀ M ₁ P ₂	18.6	18.7	18.4	17.8	17.5	17.1	16.7	16.6
G ₁₀ M ₁ P ₃	18.6	18.7	18.4	18.2	18	17.8	17.5	17.3
G ₁₀ M ₂ P ₁	18.1	18.1	17	17.7	17.2	17	16.8	16.5
G ₁₀ M ₂ P ₂	18.2	18.3	18.1	18	17.9	17.7	17.4	17.3
G ₁₀ M ₂ P ₃	18.8	18.8	15.3	18.1	17.9	17.8	17.5	17.5
G ₁₁ M ₁ P ₁	3.8	3.8	3.6	2.2	0.5	0.3	0.3	0.6
G ₁₁ M ₁ P ₂	5.4	5.5	5.2	4.6	4.3	3.9	3.5	3.4
G ₁₁ M ₁ P ₃	5.3	5.4	5.1	4.9	4.7	4.5	4.2	4
G ₁₁ M ₂ P ₁	4.8	4.8	4.6	4.4	3.9	3.7	3.5	3.2
G ₁₁ M ₂ P ₂	4.9	5	4.8	4.7	4.6	4.4	4.1	4
G ₁₁ M ₂ P ₃	5.5	5.5	5.2	4.8	4.6	4.5	4.2	4.2
G ₁₂ M ₁ P ₁	5.1	5.1	4.9	3.5	1.8	0.9	0.7	0.7
G ₁₂ M ₁ P ₂	6.6	6.7	6.4	5.8	5.5	5.1	4.7	4.6
G ₁₂ M ₁ P ₃	6.6	6.7	6.4	6.2	6	5.8	5.5	5.3
G ₁₂ M ₂ P ₁	6.1	6.1	5.9	5.7	5.2	5	4.8	4.5
G ₁₂ M ₂ P ₂	6.2	6.3	6.1	6	5.9	5.7	5.4	5.3
G ₁₂ M ₂ P ₃	6.8	6.8	6.5	6.1	5.9	5.8	5.5	5.5
S.Em ±	0.263	0.264	0.376	0.251	0.235	0.234	0.255	0.229
CD (<0.05P)	NS	NS	1.051	0.701	0.657	0.654	0.712	0.639
CV (%)	4.098	4.098	6.679	4.648	4.48	4.215	4.732	4.289

Initial Oleoresin content (%)														
G ₁	G ₂	G ₃	G ₄	G ₅	G ₆	G ₇	G ₈	G ₉	G ₁₀	G ₁₁	G ₁₂	S.Em±	CD (<0.05P)	CV (%)
14.15	5.31	12.11	15.88	14.12	7.54	22.16	16.1	11.33	20.14	6.33	8.88	0.32	0.94	4.3

Treatment details

Materials (M)

M₁ : Fruits

M₂ : Seeds

Packaging (P)

P₁ : Brown paper cover

P₂ : 700 gauge poly pouches

P₃ : Aluminium foil pouches

Genotypes (G)

G₁ : Assam Bhut Jolokia

G₂ : Majjige Menasu-1

G₃ : Chikkaballapur local

G₄ : Panth C-1

G₅ : Rona

G₆ : Shivani

G₇ : Byadagi Dabba

G₈ : LCA206

G₉ : G4

G₁₀ : Paprika

G₁₁ : Aparna

G₁₂ : Byadagi Orange Selection

months storage, the M_2 was recorded significantly over M_1 . The higher seed oleoresin (9.63, 9.56, 10.11, 10.04 and 9.83 %, respectively) and (9.04, 8.61, 9.13, 8.61 and 8.64 % in M_2 , respectively).

Packaging: The effect of packaging on oleoresin percentage was significant differed throughout storage period. The higher seed oleoresin was recorded in P_3 followed by P_2 and P_1 . The 3, 6, 9, 12, 15, 18 21 and 24th months storage, the P_3 was recorded significantly over P_2 and P_1 . The higher seed oleoresin (11.57, 11.62, 10.23, 10.03, 9.92, 10.67, 10.37 and 10.27 % in P_3 , respectively) and (11.27, 11.36, 10.11, 9.7, 9.66, 10.26, 9.91 and 9.81 % in P_2 respectively and lower seed oleoresin(%) was recorded in P_1 10.46, 10.46, 8.90, 8.29, 7.67, 7.93, 7.68 and 7.62 %, respectively).

Genotypes × Fruit and seed materials: Genotypes × materials interaction for oleoresin was non-significant during three and sixth month and rest of the storage period was significantly differed. At nine months storage, the higher seed oleoresin (%) was recorded in G_7M_1 (20 %) followed by G_7M_2 (19.53 %) and lower oleoresin was recorded in G_1M_2 (2.18 %) followed by G_1M_1 (2.56 %), respectively. At 12th month storage, the higher seed oleoresin (%) was recorded in G_7M_1 (19.27 %) followed by G_7M_2 (19.12 %) and lower oleoresin was recorded in G_1M_2 (1.19 %) followed by G_1M_1 (1.40 %), respectively. At 15th month storage, the higher seed oleoresin (%) was recorded in G_7M_2 (19.68 %) followed by G_7M_1 (18.53 %) and lower oleoresin was recorded in G_1M_2 (2.30 %) followed by G_1M_1 (2.38 %), respectively. At 18th month storage, the higher seed oleoresin (%) was recorded in G_7M_2 (19.51 %) followed by G_7M_1 (18.03 %) and lower oleoresin was recorded in G_2M_1 (1.83 %) followed by G_2M_2 (2.70 %), respectively. At 21st month storage, the higher seed oleoresin (%) was recorded in G_7M_2 (18.56 %) followed by G_7M_1 (17.73 %) and lower oleoresin was recorded in G_2M_1 (1.63 %) followed by $G_{11}M_1$ (2.68 %), respectively. At 24th month storage, the higher seed oleoresin was recorded in G_7M_2 (19.11 %) followed by G_7M_1 (17.63 %) and lower oleoresin was recorded in G_1M_2 (1.78 %) followed by G_1M_1 (2.00 %), respectively.

Fruit and seed materials × Packaging: The fruit and seed materials × Packaging interaction for oleoresin was significant throughout storage period. The higher seed

oleoresin percentage was recorded in M₂P₃ (11.68 %) followed by M₁P₂ (11.49 %) and lower oleoresin was recorded in M₁P₁ (9.97 %) and M₂P₁ (10.96 %) during three months of storage. The higher seed oleoresin percentage was recorded in M₂P₃ (11.68 %) followed by M₁P₂ (11.58 %) and lower oleoresin was recorded in M₁P₁ (9.96 %) and M₂P₁ (10.96 %) during 6th month of storage. The higher seed oleoresin percentage was recorded in M₁P₂ (10.35 %) followed by M₁P₃ (10.31 %) and lower oleoresin was recorded in M₁P₁ (8.86 %) and M₂P₁ (8.95 %) during 9th month of storage. The higher seed oleoresin percentage was recorded in M₁P₃ (10.09 %) followed by M₂P₃ (9.97 %) and lower oleoresin was recorded in M₁P₁ (7.44 %) and M₂P₁ (9.14 %) during 12th month of storage. The higher seed oleoresin percentage was recorded in M₁P₃ (9.96 %) followed by M₂P₃ (9.88 %) and lower oleoresin was recorded in M₁P₁ (6.39 %) and M₂P₁ (8.95 %) during 15th month of storage. The higher seed oleoresin percentage was recorded in M₁P₂ (10.72 %) followed by M₂P₃ (10.68 %) and lower oleoresin was recorded in M₁P₁ (6.01 %) and M₂P₂ (9.8 %) during 18th month of storage. The higher seed oleoresin percentage was recorded in M₂P₃ (10.38 %) followed by M₁P₃ (10.36 %) and lower oleoresin was recorded in M₁P₁ (5.88 %) and M₂P (9.48 %) during 21st month of storage. The higher seed oleoresin percentage was recorded in M₂P₃ (10.38 %) followed by M₁P₃ (10.16 %) and lower oleoresin was recorded in M₁P₁ (6.29 %) and M₂P₁ (8.95 %) during 24th month of storage.

Genotypes × Packaging: Genotypes × Packaging interaction for oleoresin was significant throughout storage period except third and six months storage of storage. At nine months storage, the higher seed oleoresin percentage was recorded in G₇P₃ (20.58 %) followed by G₇P₂ (20.18 %) and lower oleoresin was recorded in G₁P₂ (2.12 %) followed by G₁P₁ (2.20 %), respectively. At 12th month storage, the higher seed oleoresin percentage was recorded in G₇P₃ (20.28 %) followed by G₇P₂ (19.83 %) and lower oleoresin was recorded in G₁P₁ (0.18 %) followed by G₁P₂ (1.40 %), respectively. At 15th month storage, the higher seed oleoresin percentage was recorded in G₇P₃ (20.08 %) followed by G₇P₂ (19.63 %) and lower oleoresin was recorded in G₁P₁ (1.13 %) followed by G₂P₁ (1.82 %), respectively. At 18th month storage, the higher seed oleoresin percentage was recorded in G₇P₃ (19.94 %) followed by G₇P₂ (19.34 %) and lower

oleoresin was recorded in G₂P₁ (1.19 %) followed by G₁₁P₁ (1.99 %), respectively. At 21st month storage, the higher seed oleoresin percentage was recorded in G₇P₃ (19.63 %) followed by G₇P₂ (18.98 %) and lower oleoresin was recorded in G₁P₁ (1.11 %) followed by G₁₁P₁ (1.93 %), respectively. At 24th month storage, the higher seed oleoresin percentage was recorded in G₇P₃ (19.53 %) followed by G₇P₂ (18.89 %) and lower oleoresin was recorded in G₁P₁ (0.91 %) followed by G₁₁P₁ (1.89 %), respectively.

Genotypes × Fruit and seed materials × Packaging: Interaction of genotypes × materials × packaging was significantly differed throughout the storage period except third and sixth month of storage. During ninth month storage, the maximum seed oleoresin was recorded in G₇M₂P₃ (20.67 %) and G₇M₁P₃ (20.50 %) and lower oleoresin was recorded in G₁M₂P₂ (1.20 %) and G₁M₁P₁ (1.77 %), respectively. During 12th month storage, the maximum seed oleoresin was recorded in G₇M₁P₃ (20.30 %) and G₇M₂P₃ (20.27 %) and lower oleoresin was recorded in G₁M₂P₁ (0.16 %) and G₁M₁P₁ (0.21 %), respectively. During 15th month storage, the maximum seed oleoresin was recorded in G₇M₁P₃ (20.10 %) and G₇M₂P₃ (20.07 %) and lower oleoresin was recorded in G₁₁M₁P₁ (0.52 %) and G₁M₂P₁ (0.80 %), respectively. During 18th month storage, the maximum seed oleoresin was recorded in G₇M₂P₃ (19.97 %) and G₇M₁P₃ (19.90 %) and lower oleoresin was recorded in G₁M₁P₁ (0.12 %) and G₂M₁P₁ (0.18 %), respectively. During 21st month storage, the maximum seed oleoresin was recorded in G₇M₂P₃ (19.67 %) and G₇M₁P₃ (19.60 %) and lower oleoresin was recorded in G₁M₁P₁ (0.22 %) and G₂M₁P₁ (0.30 %), respectively. During 24th month storage, the maximum seed oleoresin was recorded in G₇M₂P₃ (19.66 %) and G₇M₁P₃ (19.40 %) and lower oleoresin was recorded in G₁M₂P₁ (0.12 %) and G₂M₂P₁ (0.30 %), respectively.

4.4 Experiment IV: To assess the efficacy of seed treatments to control seed borne anthracnose

Results on seed treatment to control fruit rot causing anthracnose as influenced by varieties, seed treatment, concentration and their interaction effects on germination, abnormal, FUG, root length, shoot length, mean seedling length (MSL) and mean seedling dry weight (MSDW), seedling vigour index based on MSL and MSDW, field

emergence, PGIS, PGIS and seed infection (%) status in hot pepper are presented as follows.

4.4.1 Seed germination (%)

The data on seed germination as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table 4.32).

Varieties: There was significant difference between the varieties for germination (%) and maximum germination was recorded in V₁ (67.79 %) and lowest was recorded in V₂ (63.09 %).

Concentration: Significant differences were recorded between the concentrations for germination (%). The higher germination (%) was recorded in C₂ (66.83 %) followed by C₃ (65.83 %), C₁ (65.06 %) and lower seed germination was recorded in C₄ (64.00 %).

Seed treatment chemicals: There was significant difference between the treatments for germination (%). The higher germination (%) was noticed in T₂ (94.70 %) followed by T₇ (87.68 %), T₈ (86.90 %), T₁ (77.00 %) and lower germination was recorded in T₄ (26.09 %) followed by T₃ (27.47 %), T₅ (51.61 %), respectively.

Varieties × Concentration: The interaction effect of Varieties and Concentration for seed germination differed significantly. The maximum seed germination was recorded in V₁C₃ (69.58 %) followed by V₂C₂ (65.21 %), V₁C₁ (67.69 %), respectively. The lower seed germination (%) was recorded in V₂C₃ (62.20 %) followed by V₂C₄ (62.55 %) and V₂C₁ (62.42 %), respectively.

Varieties × Treatment chemicals: The interaction effect of Varieties and chemical treatments for seed germination differed significantly. The higher germination (%) was noticed in V₁T₂ (96.44 %) followed by V₂T₂ (96.96 %), V₁T₇ (88.69 %) and V₂T₈ (85.17 %) and lower seed germination per cent age was recorded in V₂T₄ (24.62 %) followed by V₂T₃ (25.63 %) and V₁T₄ (27.56 %), respectively.

Table 4.32. Effect of varieties, concentration, seed treatments and their interaction on seed quality

Treatments	Germination (%)	Abnormal (%)	FUG (%)	Root Length (cm)	Shoot Length (cm)	Mean Seedling Length (cm)
V ₁	67.79 (46.5)	4.28	1.50	8.09	4.87	12.96
V ₂	63.09 (42.0)	4.97	1.73	7.68	4.43	12.11
S.Em ±	0.35	0.21	0.11	0.06	0.04	0.07
CD (<0.05P)	1.30	0.77	0.41	NS	NS	NS
C ₁	65.06 (43.2)	3.64	1.03	7.85	4.67	12.52
C ₂	66.83 (44.6)	4.44	1.53	7.97	4.71	12.68
C ₃	65.89 (44.2)	4.89	1.83	7.81	4.56	12.37
C ₄	64.00 (44.9)	5.53	2.07	7.91	4.65	12.56
S.Em ±	0.50	0.29	0.16	0.08	0.05	0.10
CD (<0.05P)	1.84	1.08	NS	0.29	0.19	0.35
T ₁	77.00 (51.0)	4.78	2.28	7.98	5.30	13.28
T ₂	94.70 (72.5)	2.13	1.03	8.51	5.38	13.89
T ₃	27.47 (16.0)	6.84	5.09	8.21	2.83	11.05
T ₄	26.09 (15.1)	8.56	1.28	6.62	4.03	10.65
T ₅	51.61 (32.7)	0.69	0.00	7.93	2.82	10.75
T ₆	68.29 (43.6)	5.22	0.00	7.56	5.28	12.84
T ₇	87.68 (62.1)	3.16	2.13	8.41	5.55	13.96
T ₈	86.90 (60.8)	5.63	1.66	7.62	5.21	12.83
T ₉	69.24 (44.0)	4.63	1.06	8.14	5.42	13.56
S.Em ±	0.75	0.44	0.23	0.12	0.08	0.14
CD (<0.05P)	2.76	1.62	0.86	0.43	0.28	0.53
V ₁ C ₁	67.69 (45.6)	3.39	0.94	8.09	4.87	12.96
V ₁ C ₂	68.44 (46.2)	4.31	1.42	8.17	4.93	13.10
V ₁ C ₃	69.58 (47.1)	4.28	1.69	7.92	4.80	12.72
V ₁ C ₄	65.44 (46.9)	5.14	1.94	8.17	4.87	13.04
V ₂ C ₁	62.42 (40.7)	3.89	1.11	7.61	4.48	12.09
V ₂ C ₂	65.21 (42.9)	4.58	1.64	7.77	4.49	12.26
V ₂ C ₃	62.20 (41.4)	5.50	1.97	7.70	4.32	12.02
V ₂ C ₄	62.55 (42.8)	5.92	2.19	7.65	4.43	12.08
S.Em ±	0.71	0.42	0.22	0.11	0.07	0.14
CD (<0.05P)	2.60	NS	NS	NS	NS	NS
V ₁ T ₁	80.63 (54.3)	4.56	2.13	8.17	5.51	13.68
V ₁ T ₂	96.44 (76.1)	1.69	0.88	8.74	5.61	14.35
V ₁ T ₃	29.31 (17.1)	6.44	4.88	8.18	3.03	11.21
V ₁ T ₄	27.56 (16.0)	7.13	1.06	6.83	4.21	11.04
V ₁ T ₅	58.00 (37.3)	1.38	0.00	8.18	3.01	11.19
V ₁ T ₆	69.25 (44.7)	4.63	0.00	7.84	5.54	13.38
V ₁ T ₇	88.69 (63.6)	3.44	2.00	8.64	5.78	14.41
V ₁ T ₈	88.63 (63.1)	4.75	1.56	7.85	5.43	13.28
V ₁ T ₉	71.63 (46.0)	4.50	1.00	8.38	5.70	14.08

Treatments	Germination (%)	Abnormal (%)	FUG (%)	Root Length (cm)	Shoot Length (cm)	Mean Seedling Length (cm)
V ₂ T ₁	73.37 (47.7)	5.00	2.44	7.78	5.09	12.87
V ₂ T ₂	92.96 (68.9)	2.56	1.19	8.29	5.15	13.44
V ₂ T ₃	25.63 (14.9)	7.25	5.31	8.25	2.64	10.89
V ₂ T ₄	24.62 (14.3)	10.00	1.50	6.42	3.84	10.26
V ₂ T ₅	45.23 (28.2)	0.00	0.00	7.67	2.64	10.31
V ₂ T ₆	67.34 (42.6)	5.81	0.00	7.28	5.02	12.30
V ₂ T ₇	86.68 (60.6)	2.88	2.25	8.18	5.33	13.51
V ₂ T ₈	85.17 (58.5)	6.50	1.75	7.39	5.00	12.39
V ₂ T ₉	66.86 (42.0)	4.75	1.13	7.89	5.15	13.04
S.Em ±	1.06	0.62	0.33	0.17	0.11	0.20
CD (<0.05P)	3.90	NS	NS	NS	NS	NS
C ₁ T ₁	74.41 (48.8)	2.63	2.13	8.02	5.05	13.07
C ₁ T ₂	93.48 (70.1)	2.13	0.00	7.91	5.06	12.97
C ₁ T ₃	28.57 (16.6)	5.00	3.13	8.72	4.03	12.75
C ₁ T ₄	24.94 (14.4)	7.50	0.75	6.68	4.36	11.03
C ₁ T ₅	70.17 (44.6)	0.00	0.00	7.85	3.19	11.04
C ₁ T ₆	57.14 (34.9)	5.13	0.00	7.76	4.72	12.48
C ₁ T ₇	82.20 (55.4)	2.50	1.88	7.90	5.21	13.11
C ₁ T ₈	86.71 (60.6)	4.88	1.38	8.30	5.13	13.43
C ₁ T ₉	67.91 (43.1)	3.00	0.00	7.53	5.32	12.85
C ₂ T ₁	71.17 (45.4)	4.75	2.38	7.98	5.13	13.12
C ₂ T ₂	93.98 (70.6)	2.63	1.50	9.18	5.40	14.58
C ₂ T ₃	30.57 (17.8)	5.63	4.50	8.87	3.56	12.43
C ₂ T ₄	24.06 (13.9)	8.13	1.25	6.46	4.18	10.64
C ₂ T ₅	73.68 (47.5)	0.00	0.00	7.78	2.88	10.66
C ₂ T ₆	68.17 (43.0)	5.38	0.00	7.53	5.46	12.99
C ₂ T ₇	84.71 (58.4)	2.63	2.13	8.50	5.11	13.61
C ₂ T ₈	87.46 (61.6)	6.00	1.63	7.33	5.23	12.56
C ₂ T ₉	67.67 (42.7)	4.88	0.38	8.11	5.44	13.55
C ₃ T ₁	75.18 (48.9)	4.88	2.25	8.10	5.49	13.60
C ₃ T ₂	94.23 (70.9)	2.75	1.25	8.42	5.40	13.81
C ₃ T ₃	27.56 (16.0)	8.25	5.88	7.72	1.94	9.66
C ₃ T ₄	25.69 (14.9)	5.50	1.38	6.70	3.93	10.63
C ₃ T ₅	53.58 (33.7)	2.75	0.00	7.80	2.67	10.47
C ₃ T ₆	71.18 (45.4)	4.25	0.00	6.68	5.42	12.10
C ₃ T ₇	90.73 (65.2)	4.63	2.13	8.76	5.49	14.25
C ₃ T ₈	86.21 (59.6)	5.50	1.75	7.52	5.21	12.73
C ₃ T ₉	68.67 (43.4)	5.50	1.88	8.60	5.48	14.08
C ₄ T ₁	87.21 (60.9)	6.88	2.38	7.80	5.52	13.32
C ₄ T ₂	97.11 (78.5)	1.00	1.38	8.55	5.67	14.22
C ₄ T ₃	23.18 (13.4)	8.50	6.88	7.55	1.80	9.35
C ₄ T ₄	29.70 (17.3)	13.13	1.75	6.65	3.63	10.28
C ₄ T ₅	9.02 (5.2)	0.00	0.00	8.28	2.54	10.82
C ₄ T ₆	76.69 (51.2)	6.13	0.00	8.28	5.51	13.79
C ₄ T ₇	93.10 (69.4)	2.88	2.38	8.47	6.41	14.88

Treatments	Germination (%)	Abnormal (%)	FUG (%)	Root Length (cm)	Shoot Length (cm)	Mean Seedling Length (cm)
C ₄ T ₈	87.21 (61.2)	6.13	1.88	7.33	5.29	12.62
C ₄ T ₉	72.73 (46.8)	5.13	2.00	8.31	5.46	13.76
S.Em ±	1.50	0.88	0.47	0.23	0.15	0.29
CD (<0.05P)	5.52	3.25	NS	0.86	0.56	1.06
V ₁ C ₁ T ₁	83.50 (56.8)	2.50	2.00	8.40	5.23	13.63
V ₁ C ₁ T ₂	95.50 (73.7)	2.00	0.00	8.18	5.25	13.43
V ₁ C ₁ T ₃	30.00 (17.5)	4.50	3.00	8.93	4.18	13.10
V ₁ C ₁ T ₄	25.75 (14.9)	7.25	0.50	6.80	4.53	11.33
V ₁ C ₁ T ₅	72.00 (46.1)	0.00	0.00	8.03	3.35	11.38
V ₁ C ₁ T ₆	59.00 (36.2)	5.00	0.00	8.08	4.95	13.03
V ₁ C ₁ T ₇	83.00 (56.3)	2.25	1.75	8.13	5.40	13.53
V ₁ C ₁ T ₈	88.00 (62.4)	4.25	1.25	8.55	5.33	13.88
V ₁ C ₁ T ₉	72.50 (46.8)	2.75	0.00	7.78	5.60	13.38
V ₁ C ₂ T ₁	65.33 (40.8)	2.75	2.25	7.64	4.87	12.51
V ₁ C ₂ T ₂	91.46 (66.5)	2.25	0.00	7.64	4.87	12.51
V ₁ C ₂ T ₃	27.14 (15.7)	5.50	3.25	8.51	3.89	12.40
V ₁ C ₂ T ₄	24.12 (14.0)	7.75	1.00	6.55	4.19	10.74
V ₁ C ₂ T ₅	68.34 (43.1)	0.00	0.00	7.67	3.03	10.69
V ₁ C ₂ T ₆	55.28 (33.6)	5.25	0.00	7.44	4.49	11.93
V ₁ C ₂ T ₇	81.41 (54.5)	2.75	2.00	7.68	5.01	12.69
V ₁ C ₂ T ₈	85.43 (58.8)	5.50	1.50	8.05	4.93	12.98
V ₁ C ₂ T ₉	63.32 (39.3)	3.25	0.00	7.29	5.04	12.32
V ₁ C ₃ T ₁	73.00 (47.0)	4.75	2.25	8.00	5.33	13.33
V ₁ C ₃ T ₂	95.50 (73.2)	2.50	1.50	9.40	5.63	15.03
V ₁ C ₃ T ₃	32.00 (18.7)	5.25	4.25	9.05	3.85	12.90
V ₁ C ₃ T ₄	26.00 (15.1)	8.50	1.00	6.65	4.40	11.05
V ₁ C ₃ T ₅	75.00 (48.6)	0.00	0.00	8.02	3.00	11.02
V ₁ C ₃ T ₆	70.00 (44.4)	5.25	0.00	7.83	5.70	13.53
V ₁ C ₃ T ₇	86.00 (60.3)	2.50	2.00	8.75	5.35	14.10
V ₁ C ₃ T ₈	89.50 (64.5)	5.25	1.50	7.53	5.43	12.95
V ₁ C ₃ T ₉	69.00 (43.9)	4.75	0.25	8.33	5.70	14.03
V ₁ C ₄ T ₁	69.35 (43.9)	4.75	2.50	7.97	4.94	12.91
V ₁ C ₄ T ₂	92.46 (67.9)	2.75	1.50	8.95	5.18	14.13
V ₁ C ₄ T ₃	29.15 (16.9)	6.00	4.75	8.69	3.27	11.96
V ₁ C ₄ T ₄	22.11 (12.8)	7.75	1.50	6.26	3.97	10.23
V ₁ C ₄ T ₅	72.36 (46.4)	0.00	0.00	7.54	2.76	10.30
V ₁ C ₄ T ₆	66.33 (41.6)	5.50	0.00	7.24	5.22	12.45
V ₁ C ₄ T ₇	83.42 (56.6)	2.75	2.25	8.25	4.87	13.13
V ₁ C ₄ T ₈	85.43 (58.8)	6.75	1.75	7.14	5.04	12.17
V ₁ C ₄ T ₉	66.33 (41.6)	5.00	0.50	7.90	5.18	13.08
V ₂ C ₁ T ₁	77.00 (50.6)	4.25	2.00	8.23	5.75	13.98
V ₂ C ₁ T ₂	96.00 (74.1)	2.00	1.00	8.68	5.68	14.35
V ₂ C ₁ T ₃	32.00 (18.7)	8.00	5.50	6.90	2.13	9.03
V ₂ C ₁ T ₄	27.25 (15.8)	0.00	1.25	6.90	4.13	11.03
V ₂ C ₁ T ₅	75.00 (48.6)	5.50	0.00	8.11	2.93	11.04

Treatments	Germination (%)	Abnormal (%)	FUG (%)	Root Length (cm)	Shoot Length (cm)	Mean Seedling Length (cm)
V ₂ C ₁ T ₆	70.00 (44.4)	2.75	0.00	6.98	5.70	12.68
V ₂ C ₁ T ₇	91.00 (65.5)	6.25	2.00	8.88	5.75	14.63
V ₂ C ₁ T ₈	88.00 (61.6)	4.25	1.75	7.75	5.43	13.18
V ₂ C ₁ T ₉	70.00 (44.4)	5.50	1.75	8.85	5.75	14.60
V ₂ C ₂ T ₁	73.37 (47.2)	5.50	2.50	7.98	5.24	13.22
V ₂ C ₂ T ₂	92.46 (67.8)	3.50	1.50	8.16	5.12	13.28
V ₂ C ₂ T ₃	23.12 (13.4)	8.50	6.25	8.54	1.76	10.30
V ₂ C ₂ T ₄	24.12 (14.0)	11.00	1.50	6.50	3.74	10.24
V ₂ C ₂ T ₅	32.16 (18.8)	0.00	0.00	7.49	2.42	9.91
V ₂ C ₂ T ₆	72.36 (46.4)	5.75	0.00	6.38	5.15	11.53
V ₂ C ₂ T ₇	90.45 (64.9)	3.00	2.25	8.65	5.23	13.88
V ₂ C ₂ T ₈	84.42 (57.7)	6.75	1.75	7.29	5.00	12.29
V ₂ C ₂ T ₉	67.34 (42.3)	5.50	2.00	8.34	5.22	13.56
V ₂ C ₃ T ₁	89.00 (63.0)	6.75	2.25	8.05	5.75	13.80
V ₂ C ₃ T ₂	98.75 (83.6)	0.25	1.00	8.70	5.90	14.60
V ₂ C ₃ T ₃	23.25 (13.4)	8.00	6.75	7.85	1.95	9.80
V ₂ C ₃ T ₄	31.25 (18.2)	12.75	1.50	6.95	3.80	10.75
V ₂ C ₃ T ₅	10.00 (5.7)	0.00	0.00	8.56	2.75	11.31
V ₂ C ₃ T ₆	78.00 (53.5)	5.50	0.00	8.50	5.80	14.30
V ₂ C ₃ T ₇	94.75 (72.4)	2.75	2.25	8.80	6.60	15.40
V ₂ C ₃ T ₈	89.00 (63.7)	5.25	1.75	7.58	5.53	13.10
V ₂ C ₃ T ₉	75.00 (48.9)	5.00	2.00	8.58	5.75	14.33
V ₂ C ₄ T ₁	85.43 (58.8)	7.00	2.50	7.55	5.29	12.83
V ₂ C ₄ T ₂	95.48 (73.5)	1.75	1.75	8.39	5.45	13.84
V ₂ C ₄ T ₃	23.12 (13.4)	9.00	7.00	7.25	1.65	8.89
V ₂ C ₄ T ₄	28.14 (16.3)	13.50	2.00	6.35	3.47	9.82
V ₂ C ₄ T ₅	8.04 (4.6)	0.00	0.00	8.00	2.33	10.33
V ₂ C ₄ T ₆	75.38 (48.9)	6.75	0.00	8.06	5.23	13.29
V ₂ C ₄ T ₇	91.46 (66.4)	3.00	2.50	8.14	6.22	14.36
V ₂ C ₄ T ₈	85.43 (58.7)	7.00	2.00	7.09	5.05	12.13
V ₂ C ₄ T ₉	70.47 (44.8)	5.25	2.00	8.04	5.16	13.20
S.Em ±	2.12	1.25	0.66	0.33	0.22	0.41
CD (<0.05P)	7.81	4.59	2.43	1.22	0.79	1.50
CV (%)	9.6	4.04	NS	NS	NS	6.52

Note: T₅= 10, 20, 25 and 30 minutes @ 55 °C.

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G₄

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintal

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (@ 55°C)

T₆ : *Trichoderma viride*

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

Concentration × Treatment chemicals: The interaction effect between concentration and chemical treatments differed significantly. The highest germination was recorded between C₄T₂ (97.11 %) followed by C₃T₂ (94.23 %), C₂T₂ (93.98 %) and was on par with C₄T₇ (93.10 %), respectively. Whereas, the lower seed germination was noticed in C₄T₅ (9.02 %) followed by C₄T₃ (23.18 %), C₂T₄ (24.06 %) and C₃T₄ (25.69 %), respectively.

Varieties × Concentration × Treatment chemicals: The third order interaction between varieties, concentration and chemical treatment differed significantly. The highest germination (%) was Observed in V₂C₃T₂ (98.75 %) followed by V₂C₁T₂ (96.00 %), V₁C₁T₂ (95.50 %), V₂C₄T₂ (95.48 %) and V₂C₃T₇ (94.75 %), respectively. The lowest germination (5 %) was recorded in V₂C₄T₅ (8.04) followed by V₂C₃T₅ (10.00 %), V₁C₄T₄ (22.11 %), V₂C₂T₄ (23.121 %), respectively.

4.4.2 Abnormal seedling (%)

The data on abnormal seedlings as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.32).

Varieties: There was significant difference between the varieties for abnormal seedlings (%). The lower abnormal seedlings percentage was recorded in V₁ (4.28 %) and maximum abnormal seedlings (%) was recorded in V₂ (4.97 %).

Concentration: There was significant difference between the concentrations for abnormal seedlings (%). Lower abnormal seedlings (%) was recorded in C₁ (3.64 %) followed by C₂ (4.44 %), C₁ (65.06 %). Whereas, maximum abnormal seedlings was recorded in C₄ (5.53 %) and C₃ (4.89 %), respectively.

Seed treatment chemicals: There was significant difference between the chemical treatments for abnormal seedlings (%). Lower abnormal seedlings (%) was recorded in T₅ (0.69 %) followed by T₂ (2.13 %), T₇ (3.16 %) and T₁ (5.22 %). The maximum seed abnormal was recorded in T₄ (8.56 %), T₃ (6.84 %), T₈ (5.64 %) and T₆ (5.22 %), respectively.

Varieties × Concentration: There was no significant difference between the varieties and concentration for abnormal seedlings per cent age.

Varieties × Treatment chemicals: There was no significant difference between the varieties and chemical treatments for abnormal seedlings per cent age.

Concentration × Treatment chemicals: Interaction effect of concentration and chemical treatments recorded significant differences. Lower abnormal seedlings per cent age was recorded in C₂T₅ (0) followed by C₁T₅ (0), C₄T₁ (1.00). The maximum seed abnormal was recorded in C₄T₄ (13.13), C₄T₃ (8.50), C₃T₃ (8.25) and C₂T₄ (8.13), respectively.

Varieties × Concentration × Treatment chemicals: There was no significant difference between the interaction of varieties, concentration and chemical treatments were recorded on abnormal seedlings (%).

4.4.3 Fresh ungerminated seeds (FUG %)

The data on fresh ungerminated seedlings as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.32).

Varieties: There was significant difference between the varieties for fresh ungerminated seeds (FUG). The lower fresh ungerminated seeds (FUG) was recorded in V₁ (1.50 %) and lower fresh ungerminated seeds (FUG) was recorded in V₂ (1.73 %).

Concentration: There was no significant difference between the concentrations for fresh ungerminated seeds (FUG).

Seed treatment chemicals: There was significant difference between the chemical treatments for fresh ungerminated seeds (FUG). Lower fresh ungerminated seeds (FUG) was recorded in T₅ and T₆, (0.00 %) followed by T₂ (1.03 %) and T₉ (01.6 %), respectively.

Varieties × Concentration: There was no significant difference between the varieties and concentration for fresh ungerminated seeds (FUG).

Varieties × Treatment chemicals: There was no significant difference between the varieties and chemical treatment for fresh ungerminated seeds (FUG).

Concentration × Treatment chemicals: Interaction effect of concentration and chemical treatments has no significant difference fresh ungerminated seeds (FUG).

Varieties × Concentration × Treatment chemicals: The interaction effect of varieties, concentration and chemical treatments recorded has no significant difference on fresh ungerminated seeds (FUG).

4.4.4 Root Length (cm)

The data on root length (cm) as influenced by varieties, seed treatment, concentration and their interaction are presented in Table 4.32.

Varieties: The average root length (cm) ranged from 7.68 to 8.09 cm between varieties. However, non significant differences were noticed between varieties for root length (cm).

Concentration: There was significant difference between the concentrations for root length (cm). The maximum root length was recorded in C₂ (7.97 cm) followed by C₄ (47.91 cm), C₁ (7.85 cm) and lower root length was recorded in C₄ (5.53 cm) and C₃ (7.81 cm), respectively.

Seed treatment chemicals: Significant difference was observed between the chemical treatments for root length (cm). Maximum root length was recorded in T₂ (8.50 cm) followed by T₇ (8.41 cm), T₉ (8.14 cm) and lower root length in T₄ (6.62 cm), T₆ (7.56 cm) and T₅ (7.93 cm), respectively.

Varieties × Concentration: The average root length (cm) from 7.61 to 8.17 cm. There was no significant difference between the varieties and concentration recorded for root length.

Varieties × Treatment chemicals: The average root length (cm) from 6.42 to 8.74 cm. There was no significant difference between the varieties and chemical treatments for root length (cm).

Concentration × Treatment chemicals: There was significant difference observed in the interaction of concentration and chemical treatments for root length. Higher root length was recorded in C₂T₁ (9.18 cm) followed by C₂T₃ (8.87 cm), C₃T₃ (8.60 cm), C₄T₂ (8.55 cm) and lower root length was recorded in C₂T₄ (6.46 cm) followed by C₁T₄ (6.66 cm), C₃T₆ (6.68 cm) and C₂T₈ (7.33 cm), respectively.

Varieties × Concentration × Treatment chemicals: The average root length (cm) from 6.26 to 9.4 cm. In the interaction of varieties, concentration and chemical treatments no significant difference was recorded on root length (cm).

4.4.5 Shoot length (cm)

The data on shoot length (cm) as influenced by varieties, seed treatment, concentration and their interaction are presented (Table. 4.32).

Varieties: The average shoot length (cm) was recorded from 4.43 to 4.87 cm. There was no significant difference between the varieties shoot length (cm).

Concentration: There was significant difference between the concentrations for shoot length (cm). The maximum shoot length was observed in C₂ (4.71) followed by C₁ (4.67 cm), C₄ (4.65 cm) and lowest was recorded in C₃ (4.56 cm).

Seed treatment chemicals: There was significant difference recorded in chemical treatments for shoot length (cm). The Maximum shoot length (cm) was recorded in T₇ (5.55 cm) followed by T₉ (5.42 cm), T₂ (5.38 cm) and lower shoot length in T₅ (2.82 cm), T₃ (2.83 cm) and T₄ (4.03 cm), respectively.

Varieties × Concentration: The average shoot length (cm) from 4.32 to 4.87 cm and there was no significant difference between the varieties and concentration for shoot length (cm).

Varieties × Treatment chemicals: The average shoot length (cm) from 2.64 to 5.78 cm. There was no significant difference between the varieties and chemical treatments for shoot length (cm).

Concentration × Treatment chemicals: Significant difference was noticed in the interaction of concentration and chemical treatments on shoot length (cm). The higher shoot length was recorded in C₄T₇ (6.41 cm) followed by C₃T₁ (5.49 cm), C₂T₆ (5.46 cm), C₁T₉ (5.32 cm). Lower shoot length was recorded in C₄T₃ (1.80 cm) followed by C₁T₅ (2.54 cm), C₃T₅ (2.67 cm) and C₂T₅ (2.88 cm), respectively.

Varieties × Concentration × Treatment chemicals: The average shoot length (cm) from 1.65 to 6.60 cm. No significant difference was observed on shoot length (cm) in the interaction of varieties, concentration and chemical treatments.

4.4.6 Mean seedling length (cm)

The data on mean seedling length (cm) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.32).

Varieties: The average mean seedling length (cm) was recorded from 12.11 to 12.96 cm. There was no significant difference is recorded between the varieties shoot length (cm).

Concentration: There was significant difference between the concentrations for mean seedling length (cm). The maximum mean seedling length was recorded in C₂ (12.68 cm) followed by C₄ (12.56 cm), C₁ (12.84 cm) and lowest was recorded in C₃ (12.37 cm).

Seed treatment chemicals: Significant difference was observed between the chemical treatments for mean seedling length (cm). The Maximum mean seedling length was recorded in T₇ (13.96 cm) followed by T₂ (13.89 cm), T₆ (12.84 cm) and minimum mean seedling length in T₄ (10.65 cm), T₅ (10.75 cm) and T₃ (11.05 cm), respectively.

Varieties × Concentration: No significant difference was recorded between the varieties and concentration for mean seedling length (cm). The average mean seedling length (cm) from 12.02 to 13.10 cm.

Varieties × Treatment chemicals: The mean seedling length (cm) averaged from 10.26 to 14.35 cm. There was no significant difference was noticed between the varieties and chemical treatments for mean seedling length (cm).

Concentration × Treatment chemicals: In the interaction of concentration and chemical treatments significant difference was observed for mean seedling length (cm). Maximum mean seedling length (cm) was recorded in C₄T₇ (14.88 cm) followed by C₂T₂ (14.58 cm), C₃T₇ (14.25 cm), C₃T₁ (14.08 cm) and lower mean seedling length (cm) was recorded in C₄T₃ (9.35 cm) followed by C₁T₃ (9.66 cm), C₂T₄ (10.64 cm) and C₂T₅ (10.66 cm), respectively.

Varieties × Concentration × Treatment chemicals: Significant difference was recorded in interaction of varieties, concentration and chemical treatments for mean seedling length (cm). The maximum mean seedling length was observed in V₂C₃T₂₇ (15.40 cm) followed by V₁C₃T₂ (15.03 cm), V₂C₁T₇ (14.63 cm), V₂C₁T₉ (14.60 cm) and V₂C₁T₂ (14.35 cm), respectively and lower mean seedling length was recorded in V₂C₄T₃ (8.89 cm) followed by V₂C₁T₃ (9.03 cm), V₂C₃T₃ (9.80 cm), respectively.

4.4.7 Seedling dry weight (mg)

The data on seedling dry weight (mg) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.33)

Varieties: There was significant difference between the varieties for seedling dry weight (mg). The maximum seedling dry weight was recorded in V₁ (11.26 mg) and lowest was recorded in V₂ (8.05 mg).

Concentration: There was significant difference between the concentrations for seedling dry weight (mg). The higher seedling dry weight was recorded in C₁ (9.78 mg) followed by C₂ (9.76 mg), C₄ (9.66 mg) and lowest was recorded in C₃ (9.42 mg).

Table 4.33. Influence of varieties, seed treatments, concentration and their interaction on seed quality

Treatments	SDW (mg)	Vigour Index-I	Vigour Index-II	Seed infection (%)	PGEI (%)	PGIS (%)	Field emergence (%)
V ₁	11.26	907	805	54	33.48	13.24	50.03 (3.87)
V ₂	8.05	793	547	48	30.69	12.26	45.43 (3.65)
S.Em ±	0.07	7	8	0.1	0.39	0.47	0.298 0.01
CD (<0.05P)	0.25	NS	NS	0.6	1.42	1.71	1.096 0.05
C ₁	9.78	827	671	62	35.26	9.54	46.30 (3.77)
C ₂	9.76	866	687	55	31.69	11.71	49.26 (3.89)
C ₃	9.42	851	665	48	32.17	13.58	48.55 (3.81)
C ₄	9.66	857	680	40	29.21	16.17	46.81 (3.57)
S.Em ±	0.10	10	11	0.2	0.55	0.66	0.422 0.02
CD (<0.05P)	0.36	NS	40	0.8	2.01	NS	1.550 0.07
T ₁	9.20	1024	720	43	30.13	12.03	57.55 (4.36)
T ₂	11.94	1318	1135	23	17.81	12.75	75.62 (5.00)
T ₃	7.20	307	200	32	10.66	6.94	10.09 (1.82)
T ₄	7.08	278	188	78	42.41	13.69	9.79 (1.82)
T ₅	9.58	558	531	67	43.28	15.66	36.31 (3.06)
T ₆	10.11	878	695	81	45.75	18.81	52.00 (4.13)
T ₇	11.39	1229	1002	40	23.16	10.16	67.29 (4.72)
T ₈	10.72	1117	937	56	34.56	13.25	66.41 (4.69)
T ₉	9.67	942	675	43	41.00	11.47	54.52 (4.24)
S.Em ±	0.15	15	16	0.3	0.82	0.99	0.633 0.03
CD (<0.05P)	0.53	NS	60	1.2	3.01	3.63	2.325 0.10
V ₁ C ₁	11.28	889	799	67	36.81	10.00	47.44 (3.84)
V ₁ C ₂	11.25	915	800	59	33.17	11.72	50.85 (3.97)
V ₁ C ₃	10.85	919	800	51	33.47	13.89	52.32 (4.00)
V ₁ C ₄	11.67	906	822	40	30.47	17.33	49.52 (3.67)
V ₂ C ₁	8.28	764	543	58	33.72	9.08	45.16 (3.71)
V ₂ C ₂	8.28	817	575	51	30.22	11.69	47.67 (3.81)
V ₂ C ₃	7.99	783	531	44	30.86	13.28	44.79 (3.63)
V ₂ C ₄	7.65	808	539	40	27.94	15.00	44.11 (3.47)
S.Em ±	0.14	14	15	0.3	0.77	0.93	0.597 0.03
CD (<0.05P)	0.50	51	NS	1.2	NS	NS	2.192 0.09
V ₁ T ₁	10.94	1103	887	50	31.25	12.25	61.55 (4.51)
V ₁ T ₂	13.63	1384	1315	27	18.94	14.50	77.40 (5.06)
V ₁ T ₃	8.78	331	256	34	11.69	6.00	10.90 (1.88)
V ₁ T ₄	8.34	304	232	83	44.06	14.50	11.59 (1.98)
V ₁ T ₅	10.78	647	626	67	45.25	16.50	42.41 (3.36)
V ₁ T ₆	12.13	925	846	84	47.38	20.75	57.92 (4.36)
V ₁ T ₇	12.91	1283	1148	43	24.44	10.44	67.85 (4.73)
V ₁ T ₈	12.84	1177	1142	55	36.25	13.00	66.37 (4.68)
V ₁ T ₉	11.00	1010	794	44	42.06	11.19	54.29 (4.24)

Treatments	SDW (mg)	Vigour Index-I	Vigour Index-II	Seed infection (%)	PGEI (%)	PGIS (%)	Field emergence (%)
V ₂ T ₁	7.47	945	553	35	29.00	11.81	53.54 (4.21)
V ₂ T ₂	10.25	1251	956	19	16.69	11.00	73.84 (4.95)
V ₂ T ₃	5.63	282	145	30	9.63	7.88	9.29 (1.76)
V ₂ T ₄	5.81	252	143	73	40.75	12.88	7.99 (1.66)
V ₂ T ₅	8.38	470	436	66	41.31	14.81	30.21 (2.76)
V ₂ T ₆	8.09	830	544	77	44.13	16.88	46.09 (3.91)
V ₂ T ₇	9.88	1175	857	36	21.88	9.88	66.73 (4.70)
V ₂ T ₈	8.59	1056	733	57	32.88	13.50	66.46 (4.69)
V ₂ T ₉	8.34	873	556	42	39.94	11.75	54.75 (4.24)
S.Em ±	0.21	21	23	0.5	1.16	1.40	0.895 0.04
CD (<0.05P)	0.75	77	84	1.8	NS	NS	3.289 0.14
C ₁ T ₁	9.06	977	696	50	35.00	9.25	55.25 (4.27)
C ₁ T ₂	10.94	1214	1029	32	29.63	9.50	75.25 (4.99)
C ₁ T ₃	7.88	365	228	54	26.13	1.25	12.61 (2.05)
C ₁ T ₄	7.19	276	180	88	43.38	11.13	8.81 (1.74)
C ₁ T ₅	10.44	776	734	76	25.00	12.75	51.38 (4.13)
C ₁ T ₆	10.00	711	577	88	47.38	15.00	42.38 (3.75)
C ₁ T ₇	11.50	1080	947	48	30.38	7.88	60.86 (4.49)
C ₁ T ₈	11.38	1167	991	66	36.00	11.13	61.36 (4.50)
C ₁ T ₉	9.63	874	659	60	44.50	8.00	48.83 (4.02)
C ₂ T ₁	8.75	935	626	44	30.38	12.50	52.88 (4.19)
C ₂ T ₂	12.06	1371	1137	24	24.13	11.00	74.14 (4.94)
C ₂ T ₃	7.69	380	234	52	11.13	4.38	14.25 (2.20)
C ₂ T ₄	7.25	258	178	80	46.50	12.25	7.96 (1.65)
C ₂ T ₅	11.19	787	826	68	22.13	14.75	56.19 (4.32)
C ₂ T ₆	10.25	887	702	80	47.50	18.25	50.76 (4.10)
C ₂ T ₇	10.75	1155	915	46	24.75	9.50	68.88 (4.71)
C ₂ T ₈	10.38	1102	915	54	36.25	12.13	51.24 (4.78)
C ₂ T ₉	9.56	919	652	46	42.50	10.63	58.01 (4.12)
C ₃ T ₁	9.00	1023	681	40	29.38	13.00	77.76 (4.39)
C ₃ T ₂	12.25	1303	1157	20	9.88	12.13	7.67 (5.07)
C ₃ T ₃	6.56	264	185	12	3.13	7.50	10.18 (1.61)
C ₃ T ₄	6.56	275	170	74	43.38	14.13	37.60 (1.86)
C ₃ T ₅	9.06	574	492	64	61.88	16.75	54.70 (3.37)
C ₃ T ₆	10.00	860	710	84	46.38	20.13	69.43 (4.26)
C ₃ T ₇	11.50	1293	1044	36	19.25	12.25	68.05 (4.79)
C ₃ T ₈	10.19	1098	883	56	35.75	14.00	53.57 (4.75)
C ₃ T ₉	9.63	968	664	42	40.50	12.38	64.05 (4.22)
C ₄ T ₁	10.00	1163	876	36	25.75	13.38	75.33 (4.60)
C ₄ T ₂	12.50	1383	1217	16	7.63	18.38	5.84 (4.99)
C ₄ T ₃	6.69	217	154	10	2.25	14.63	12.21 (1.43)
C ₄ T ₄	7.31	304	222	70	36.38	17.25	0.06 (2.03)
C ₄ T ₅	7.63	97	73	58	64.13	18.38	60.18 (0.43)
C ₄ T ₆	10.19	1052	790	70	41.75	21.88	71.84 (4.43)
C ₄ T ₇	11.81	1388	1104	28	18.25	11.00	67.36 (4.88)
C ₄ T ₈	10.94	1100	961	48	30.25	15.75	64.44 (4.72)

Treatments	SDW (mg)	Vigour Index-I	Vigour Index-II	Seed infection (%)	PGEI (%)	PGIS (%)	Field emergence (%)	
C ₄ T ₉	9.88	1005	726	24	36.50	14.88	1.265	(4.61)
S.Em ±	0.29	30	32	0.7	1.64	1.98	4.651	0.05
CD (<0.05P)	1.07	109	119	2.5	6.02	NS	68.88	0.20
V ₁ C ₁ T ₁	11.38	1136	952	56	36.50	9.00	62.85	(4.56)
V ₁ C ₁ T ₂	13.25	1283	1267	36	31.50	11.25	78.83	(5.11)
V ₁ C ₁ T ₃	9.75	394	293	60	27.25	0.00	13.98	(2.18)
V ₁ C ₁ T ₄	8.00	293	207	92	45.25	12.50	10.00	(1.86)
V ₁ C ₁ T ₅	11.13	820	802	80	26.75	12.75	51.88	(4.15)
V ₁ C ₁ T ₆	12.00	762	712	92	49.25	17.25	46.83	(3.94)
V ₁ C ₁ T ₇	12.75	1126	1060	52	31.75	7.25	55.88	(4.31)
V ₁ C ₁ T ₈	13.25	1223	1170	68	37.50	11.00	53.88	(4.23)
V ₁ C ₁ T ₉	10.00	967	731	64	45.50	9.00	52.88	(4.19)
V ₁ C ₂ T ₁	6.75	818	441	44	33.50	9.50	47.65	(3.98)
V ₁ C ₂ T ₂	8.63	1146	791	28	27.75	7.75	71.68	(4.87)
V ₁ C ₂ T ₃	6.00	337	163	48	25.00	2.50	11.25	(1.92)
V ₁ C ₂ T ₄	6.38	259	154	84	41.50	9.75	7.63	(1.63)
V ₁ C ₂ T ₅	9.75	731	666	72	23.25	12.75	50.88	(4.11)
V ₁ C ₂ T ₆	8.00	660	442	84	45.50	12.75	37.93	(3.55)
V ₁ C ₂ T ₇	10.25	1034	834	44	29.00	8.50	65.85	(4.67)
V ₁ C ₂ T ₈	9.50	1110	812	64	34.50	11.25	68.85	(4.78)
V ₁ C ₂ T ₉	9.25	781	586	56	43.50	7.00	44.78	(3.86)
V ₁ C ₃ T ₁	10.50	975	766	52	31.25	12.75	53.88	(4.23)
V ₁ C ₃ T ₂	13.50	1435	1291	28	25.75	11.50	74.25	(4.93)
V ₁ C ₃ T ₃	9.75	412	305	60	12.75	2.75	15.98	(2.33)
V ₁ C ₃ T ₄	9.00	290	234	84	48.25	12.75	10.20	(1.87)
V ₁ C ₃ T ₅	11.88	827	892	68	23.75	15.25	57.88	(4.38)
V ₁ C ₃ T ₆	11.50	948	807	84	48.75	19.25	53.88	(4.23)
V ₁ C ₃ T ₇	12.25	1215	1059	52	26.00	9.00	68.85	(4.78)
V ₁ C ₃ T ₈	12.50	1163	1124	52	38.75	11.75	71.85	(4.88)
V ₁ C ₃ T ₉	10.38	971	724	48	43.25	10.50	50.88	(4.11)
V ₁ C ₄ T ₁	7.00	896	486	36	29.50	12.25	51.88	(4.15)
V ₁ C ₄ T ₂	10.63	1307	984	20	22.50	10.50	74.03	(4.95)
V ₁ C ₄ T ₃	5.63	349	164	44	9.50	6.00	12.53	(2.07)
V ₁ C ₄ T ₄	5.50	226	122	76	44.75	11.75	5.73	(1.43)
V ₁ C ₄ T ₅	10.50	746	760	68	20.50	14.25	54.50	(4.25)
V ₁ C ₄ T ₆	9.00	827	597	76	46.25	17.25	47.65	(3.98)
V ₁ C ₄ T ₇	9.25	1096	771	40	23.50	10.00	65.23	(4.65)
V ₁ C ₄ T ₈	8.25	1041	706	56	33.75	12.50	65.90	(4.67)
V ₁ C ₄ T ₉	8.75	868	581	44	41.75	10.75	51.60	(4.14)
V ₂ C ₁ T ₁	10.13	1075	784	48	30.25	13.50	57.25	(4.36)
V ₂ C ₁ T ₂	13.75	1377	1320	24	10.75	13.00	80.70	(5.17)
V ₂ C ₁ T ₃	7.75	290	245	8	4.25	5.50	8.65	(1.69)
V ₂ C ₁ T ₄	7.50	303	206	80	45.25	15.25	7.63	(2.08)
V ₂ C ₁ T ₅	9.38	828	703	64	63.75	18.00	50.88	(4.45)
V ₂ C ₁ T ₆	12.13	887	850	88	48.25	22.25	37.93	(4.29)
V ₂ C ₁ T ₇	13.00	1331	1182	40	20.25	13.00	65.85	(4.84)

Treatments	SDW (mg)	Vigour Index-I	Vigour Index-II	Seed infection (%)	PGEI (%)	PGIS (%)	Field emergence (%)
V ₂ C ₁ T ₈	12.50	1159	1100	56	37.00	14.00	68.85 (4.81)
V ₂ C ₁ T ₉	11.50	1022	807	48	41.50	10.50	44.78 (4.29)
V ₂ C ₂ T ₁	7.88	971	579	32	28.50	12.50	12.73 (4.41)
V ₂ C ₂ T ₂	10.75	1228	995	16	9.00	11.25	59.75 (4.98)
V ₂ C ₂ T ₃	5.38	238	124	16	2.00	9.50	55.53 (1.53)
V ₂ C ₂ T ₄	5.63	247	135	68	41.50	13.00	70.85 (1.63)
V ₂ C ₂ T ₅	8.75	319	282	64	60.00	15.50	69.88 (2.29)
V ₂ C ₂ T ₆	7.88	834	569	80	44.50	18.00	55.53 (4.23)
V ₂ C ₂ T ₇	10.00	1256	906	32	18.25	11.50	58.78 (4.73)
V ₂ C ₂ T ₈	7.88	1037	665	56	34.50	14.00	74.83 (4.68)
V ₂ C ₂ T ₉	7.75	913	522	36	39.50	14.25	6.69 (4.14)
V ₂ C ₃ T ₁	11.75	1227	1047	44	27.00	13.75	7.63 (4.89)
V ₂ C ₃ T ₂	14.00	1443	1383	20	7.75	22.25	15.45 (5.01)
V ₂ C ₃ T ₃	7.88	229	181	8	2.50	15.75	53.88 (1.33)
V ₂ C ₃ T ₄	8.88	332	281	76	37.50	17.50	68.00 (2.11)
V ₂ C ₃ T ₅	10.75	111	109	56	66.75	20.00	66.22 (0.45)
V ₂ C ₃ T ₆	12.88	1103	1014	72	43.25	24.25	51.61 (4.99)
V ₂ C ₃ T ₇	13.63	1462	1292	28	19.75	12.50	72.23 (5.01)
V ₂ C ₃ T ₈	13.13	1163	1174	44	31.75	15.25	75.83 (4.81)
V ₂ C ₃ T ₉	12.13	1080	915	16	38.00	14.75	5.00 (4.38)
V ₂ C ₄ T ₁	8.25	1098	705	28	24.50	13.00	13.45 (4.31)
V ₂ C ₄ T ₂	11.00	1323	1052	12	7.50	14.50	0.13 (4.98)
V ₂ C ₄ T ₃	5.50	206	127	12	2.00	13.50	75.46 (1.53)
V ₂ C ₄ T ₄	5.75	277	162	64	35.25	17.00	75.83 (1.94)
V ₂ C ₄ T ₅	4.50	83	36	60	61.50	16.75	69.88 (0.41)
V ₂ C ₄ T ₆	7.50	1001	566	68	40.25	19.50	57.88 (3.86)
V ₂ C ₄ T ₇	10.00	1315	915	28	16.75	9.50	55.88 (4.74)
V ₂ C ₄ T ₈	8.75	1036	747	52	28.75	16.25	74.83 (4.64)
V ₂ C ₄ T ₉	7.63	930	537	32	35.00	15.00	6.69 (4.83)
S.Em ±	0.41	42	46	0.9	2.32	2.80	10.98 0.08
CD (<0.05P)	1.51	154	169	3.6	NS	NS	0.00 0.28
CV (%)	8.50	NS	14	3.8	8.51	10.28	44.90 4.1

Note: T₅= 10, 20, 25 and 30 minutes @ 55 °C.

Treatment details:

Varieties

V₁ : Byadagi Dabba
V₂ : G₄

Concentrations (%)

C₁ : 0.2
C₂ : 0.3
C₃ : 0.4
C₄ : 0.5

Treatments

T₁ : Kavach
T₂ : Quintal
T₃ : Propiclonazole
T₄ : Hexaconazole
T₅ : Hot water (@ 55⁰C)
T₆ : *Trichoderma viride*
T₇ : Bavistin
T₈ : Thiram
T₉ : Captan

Seed treatment chemicals: There was significant difference between the chemical treatments for seedling dry weight (mg) was noticed. The maximum seedling dry weight was recorded in T₂ (11.94 mg) followed by T₇ (11.39 mg), T₈ (10.72 mg) and lower seedling dry weight in T₃ (7.20 mg), T₄ (7.08 mg), respectively.

Varieties × Concentration: Significant difference between the varieties and concentration was observed for seedling weight (mg). The maximum seedling dry weight was recorded in V₁C₁ (12.91 mg) followed by V₁C₁ (11.28 mg), V₁C₂ (11.25 mg) and lower seedling dry weight in V₂C₄ (7.65 mg) and V₂C₂ (8.28 mg), respectively.

Varieties × Treatment chemicals: There was significant difference between the varieties and chemical treatments for seedling dry weight (mg). The maximum seedling dry weight was recorded in V₁T₂ (13.63 mg) followed by V₁T₇ (12.97 mg), V₁T₈ (12.8 mg) and V₁T₆ (12.13 mg). The lower seedling dry weight (mg) was noticed in V₂T₃ (5.63 mg) followed by V₂T₄ (5.81 mg) and V₂T₁ (7.47 mg).

Concentration × Treatment chemicals: Interaction of concentration and chemical treatments was significantly different for seedling dry weight (mg). The maximum seedling dry weight was recorded in C₄T₂ (12.50 mg) followed by C₂T₂ (12.25 mg), C₄T₈ (10.94 mg) and lower seedling dry weight was observed in C₄T₃ (6.69 mg) followed by C₁T₄ (7.19 mg), C₄T₄ (7.31 mg) and C₄T₅ (7.63 mg), respectively.

Varieties × Concentration × Treatment chemicals: Interaction effect of varieties, concentration and chemical treatments was significantly different for seedling dry weight (mg). The maximum seedling dry weight was observed in V₂C₃T₇ (13.63 mg) followed by V₂C₁T₇ (13.00 mg), V₁C₁T₈ (13.25 mg), respectively and lower seedling dry weight was recorded in V₂C₄T₅ (4.50 mg) followed by V₂C₂T₃ (4.38 mg), respectively.

4.4.8 Seedling vigour index-I (SVI-I)

The data on seedling vigour index-I (SVI-I) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table 4.33).

Varieties: Significant difference was observed between the varieties seedling vigour index-I (SVI-I). The maximum seedling vigour index-I (SVI-I) was recorded in V₁ (907) and V₂ (793).

Concentration: There was significant difference between the concentration for seedling vigour index-I (SVI-I). The higher seedling vigour index-I (SVI-I) was observed in C₂ (866) followed by C₄ (857), C₃ (851) and whereas lowest was recorded in C₁ (827), respectively.

Seed treatment chemicals: Mean seedling vigour index-I (SVI-I) ranged from 278 to 1318. No significant difference was recorded between the chemical treatments for seedling vigour index-I (SVI-I).

Varieties × Concentration: In the interaction of varieties and concentration significant difference was recorded for seedling vigour index-I (SVI-I). The maximum seedling vigour index-I (SVI-I) was recorded in V₁C₃ (919) followed by V₁C₂ (915), V₁C₄ (906) and minimum seedling vigour index-I (SVI-I) in V₂C₁ (764) and V₂C₃ (783), respectively.

Varieties × Treatment chemicals: There was significant difference noticed between the interaction of varieties and chemical treatments for seedling vigour index-I (SVI-I). The maximum seedling vigour index-I (SVI-I) was recorded in V₁T₂ (1384) followed by V₁T₇ (1283), V₁T₈ (1056) and V₂T₄ (252). The lower seedling vigour index-I (SVI-I) was noticed in V₂T₄ (252) followed by V₂T₃ (282) and V₂T₄ (304).

Concentration × Treatment chemicals: Significant difference was recorded in interaction effect of concentration and chemical treatments for seedling vigour index-I (SVI-I). The maximum seedling vigour index-I (SVI-I) was recorded in C₄T₇ (1388) followed by C₄T₂ (1383) and C₁T₈ (1167) and minimum seedling vigour index-I (SVI-I) was recorded in C₄T₅ (97) followed by C₄T₃ (217), C₃T₄ (275) and C₄T₄ (304), respectively.

Varieties × Concentration × Treatment chemicals: The seedling vigour index-I (SVI-I) was ranged from 83 to 547. In the interaction effect of varieties, concentration and chemical treatments no significant difference was noticed on seedling vigour index-I (SVI-I).

4.4.9 Seedling vigour index-II (SVI-II)

The data on seedling vigour index-II (SVI-II) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.33).

Varieties: Significant difference was observed between the varieties seedling vigour index-II (SVI-II). The maximum seedling vigour index-II (SVI-II) was recorded in V₁ (805) and V₂ (547).

Concentration: There was significant difference between the concentrations for seedling vigour index-II (SVI-II). The higher seedling vigour index-II (SVI-II) was observed in C₂ (687) followed by C₄ (680), C₁ (671) and C₃ (665), respectively.

Seed treatment chemicals: Between the chemical treatments significant difference was recorded for seedling vigour index-II (SVI-II). Higher seedling vigour index-II (SVI-II) was noticed in T₂ (1135) followed by T₇ (1007) and T₈ (937) and lower SVI-II was T₃ (200) and T₅ (531).

Varieties × Concentration: Average seedling vigour index-II (SVI-II) from 531 to 822. There was no significant difference noticed between the varieties and concentration for seedling vigour index-II (SVI-II).

Varieties × Treatment chemicals: Significant difference between the varieties and chemical treatments was recorded for seedling vigour index-II (SVI-II). The maximum recorded in V₂T₇ (1175), V₁T₇ (1148) and the minimum seedling vigour index-II (SVI-II) was noticed in V₂T₄ (252) followed by V₂T₃ (145).

Concentration × Treatment chemicals: Interaction effect of concentration and chemical treatments was significant recorded for seedling vigour index-II (SVI-II). The

maximum seedling vigour index-II (SVI-II) was recorded in C₄T₂ (1217) C₂T₂ (1137), and C₃T₈ (991) and lower seedling vigour index-II (SVI-II) was recorded in C₄T₅ (73) followed by C₄T₃ (154), C₃T₄ (170) and C₂T₄ (178), respectively.

Varieties × Concentration × Treatment chemicals: Interaction effect of varieties, concentration and chemical treatments was recorded and are significantly different for seedling vigour index-II (SVI-II). The maximum seedling vigour index-II (SVI-II) was noticed V₂C₃T₅ (1383), V₂C₁T₂ (1320) and lower seedling vigour index-II was recorded in V₂C₄T₅ (36) followed by V₂C₃T₅ (109) and V₁C₄T₄ (122).

4.4.10 Seed infection (%)

The data on seed Infection (%) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.33).

Varieties: There was significant difference between the varieties for seed infection (%). The lowest seed infection was recorded in V₂ (48.00 %) and V₁ (54.00 %).

Concentration: Significant difference was observed between the concentrations for seed infection (%). Lower seed infection was recorded in C₄ (40.00 %) followed by C₃ (48.00 %) and Higher seed infection was recorded in C₁ (62.00 %).

Seed treatment chemicals: There was significant difference between the chemical treatments for seed infection (%). The lower seed infection was noticed in T₂ (23.00 %) followed by T₃ (32.00 %), T₇ (40.00 %) and higher seed infection was recorded in T₆ (81.00 %) followed by T₄ (78.00 %) and T₅ (67.00 %), respectively.

Varieties × Concentration: The interaction effect of varieties and concentration for seed infection (%) was noticed significantly different. The lowest seed infection was observed in V₂C₄ (40.00 %) followed by V₂C₃ (44.00 %). The higher seed infection (%) recorded in V₁C₁ (67.00 %) followed by V₁C₂ (59.00 %) and V₂C₂ (67.00 %), respectively.

Varieties × Treatment chemicals: Varieties and chemical treatments interaction were significantly different for seed infection (%). The lower seed infection was noticed in V₂T₂ (19.00 %) followed by V₂T₂ (27.00 %), V₁T₃ (34.00 %) and V₂T₁ (35.00 %). Higher seed infection was recorded in V₁T₆ (84.00 %) followed by V₁T₄ (83.00 %), V₂T₆ (77.00 %) and V₂T₄ (73.00 %), respectively.

Concentration × Treatment chemicals: Interaction effect of concentration and chemicals recorded were significantly different for seed infection (%). Lower seed infection in C₄T₃ (10.00 %) followed by C₃T₃ (12.00 %), C₄T₂ (16.00 %) and higher seed infection) was recorded in C₁T₄ (88.00 %) followed by C₃T₄ (74.00 %) and C₄T₄ (70.00 %), respectively.

Varieties × Concentration × Treatment chemicals: Interaction effect of varieties, concentration and chemical treatments recorded were significantly different for seed infection (%). The lower seed infection was observed in V₂C₁T₃ (8.00 %) followed by V₂C₄T₃ (12.00 %), V₂C₃T₉ (16.00 %), V₂C₁T₅ (24.00 %) and higher seed infection was recorded in V₁C₁T₆ (92.00 %) followed by V₂C₁T₆ (88.00 %), V₁C₃T₄ (84.00 %) and V₂C₁T₄ (80.00 %), respectively.

4.4.11 PGEI (%): The data on PGEI (%) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table. 4.33)

Varieties: There was significant difference between the varieties for PGEI (%). The lowest seed infection was recorded in V₁ (33.48 %) followed by V₂ (30.69).

Concentration: There was significant difference between the concentrations for PGEI (%) recorded. The higher PGEI (%) was in C₁ (35.26 %) followed by C₂ (31.69 %). The Lower PGEI (%) was recorded in C₃ (31.69 and C₄ 29.21 %).

Seed treatment chemicals: There was significant difference noticed between the chemical treatments for PGEI (%). The higher PGEI was noticed in T₆ (45.75 %) followed by T₄ (42.41 %) and lower PGEI was recorded in T₃ (10.66 %) followed by T₂ (17.81 %), respectively.

Varieties × Concentration: The average of PGEI (%) from 9.08 to 13.80 %. The interaction effect of varieties and concentration for PGEI recorded has no significant difference.

Varieties × Treatment chemicals: The average of PGEI (%) from 9.63 to 44.13 %. No significant difference was noticed in the interaction of varieties and chemical treatments for PGEI (%).

Concentration × Treatment chemicals: Interaction effect of concentration and chemical treatments was recorded and are significantly different for PGEI (%). The higher PGEI in C₄T₅ (64.13 %) followed by C₂T₆ (47.50 %), C₁T₆ (47.38 %) and lower PGEI was recorded in C₄T₃ (2.25 %) followed by C₄T₂ (7.63 %) and C₃T₂ (9.88 %), respectively.

Varieties × Concentration × Treatment chemicals: Interaction effect of varieties, concentration and chemical treatments recorded was non-significant. The average of PGEI (%) from 2 to 60(%).

4.4.12 PGIS (%): The data on PGIS (%) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table 4.33).

Varieties: There was significant difference between the varieties for PGIS (%) The PGIS (%) was recorded in V₁ (13.24 %) and lowest was recorded in V₂ (12.26 %).

Concentration: The average of PGIS (%) ranges from 9.54 to 16.17 %. There was no significant difference between the concentrations for PGIS (%).

Seed treatment chemicals: There was significant difference between the chemical treatments for PGIS (%). The Higher PGIS was noticed in T₆ (18.81 %) followed by T₅ (15.66 %) and lower PGIS was recorded in T₃ (6.94 %) followed by T₇ (10.16 %) and T₉ (11.47 %), respectively.

Varieties × Concentration: The average of PGIS (%) ranges from 9.08 to 13.80 %. The interaction effect of varieties and concentration for PGIS (%) recorded has no significant difference.

Varieties × Treatment chemicals: The average of PGIS (%) ranges from 7.88 to 20.25 %. No significant difference was noticed in the interaction effect of varieties and chemical treatments for PGEI (%).

Concentration × Treatment chemicals: The average of PGIS (%) ranges from 1.50 to 21.88 %, respectively. The interaction effect of concentration and chemical treatments for PGIS (%) recorded has no significant difference.

Varieties × Concentration × Treatment chemicals: The average of PGIS (%) ranges from 0.00 to 24.00 %, respectively. Interaction effect of varieties, concentration and chemical treatments has no significant difference for PGEI (%).

4.4.13 Field emergence (%)

The data on field emergence (%) as influenced by varieties, seed treatment, concentration and their interaction are presented in (Table 4.33).

Varieties: There was significant difference between the varieties for field emergence (%). The maximum Field emergence was recorded in V₁ (68.50 %) and V₂ (59.50 %).

Concentration: There was significant difference between the concentrations for field emergence (%). The maximum Field emergence was recorded in C₄ (91.00 %) followed by C₃ (73.00 %), C₂ (55.00 %) and C₁ (37.00 %), respectively.

Seed treatment chemicals: The average of Field emergence (%) ranges from 60.00 to 68.00 %. There was no significant difference between the chemical treatments for field emergence (%).

Varieties × Concentration: The average of Field emergence (%) ranges from 32.5 to 86.00 %, respectively. No significant difference was observed in interaction effect of varieties and concentration for field emergence (%).

Varieties × Treatment chemicals: In varieties and chemical treatments interaction no significant difference was recorded for field emergence (%). The average of field emergence (%) from 55.50 to 72.50 %.

Concentration × Treatment chemicals: The average of Field emergence (%) ranges from 33.00 to 95.00 % respectively. The interaction effect of concentration and chemical treatments recorded has no significant difference for field emergence (%).

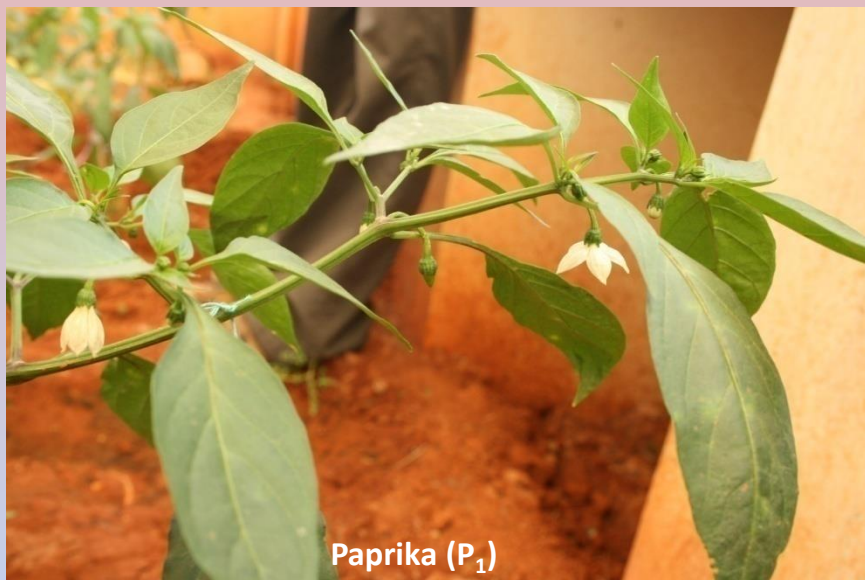
Varieties × Concentration × Treatment chemicals: The average of field emergence (%) ranges from 28.50 to 99.50 %, respectively. The interaction effect of varieties, concentration and chemical treatments has no significant difference recorded for field emergence (%).

4.5 Experiment V: Validation of trait specific DNA markers linked to pungency

Among the DNA markers employed in the present study none of the scar markers and caps markers we amplified in the genotypes/population. Validation of pungency specify markers in hot peer genotypes under investigation revealed that, among the genic SSR markers used to evaluate the pungency trait revealed that, The marker 3F/3R amplified co dominantly with parent and F₂ genotypes (Plate. 4.3) . Whereas, Single dominant band at 100 Kb was amplified with marker 7F/15R in all the genotypes wherein it was absent with the genotypes AR-75, Bayadagi Kaddi, Dyavanur Delux, G4, Gouribidanur Local, HMT-1 for pungency (Plate 4.4).

4.5.1 Joint scaling test for seedling vigour index

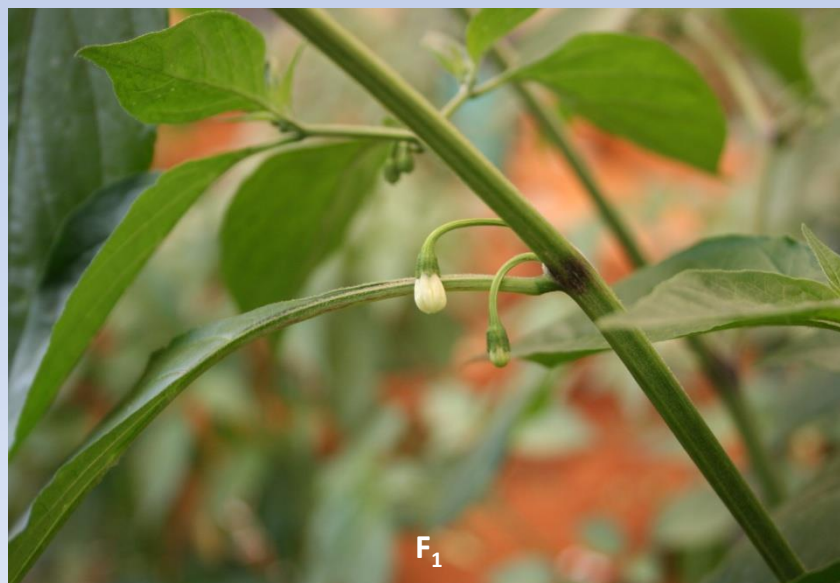
The present study reports the first inter specific hybrid between *C. annuum* and *C. Chinense* by employing low pungent Paprikia (P₁) and world hottest cultivar Assam Bhuth Jolokia (P₂) (Plate 4.1a and 4.1b).



Paprika (P₁)



Assam Bhut Jolokia (P₂)



F₁

Plate 4.1. Variation in number of flowers per axial in P₁, P₂ and F₁



Plate 4.2. Difference in capsaicin content of P_1 , P_2 and F_1

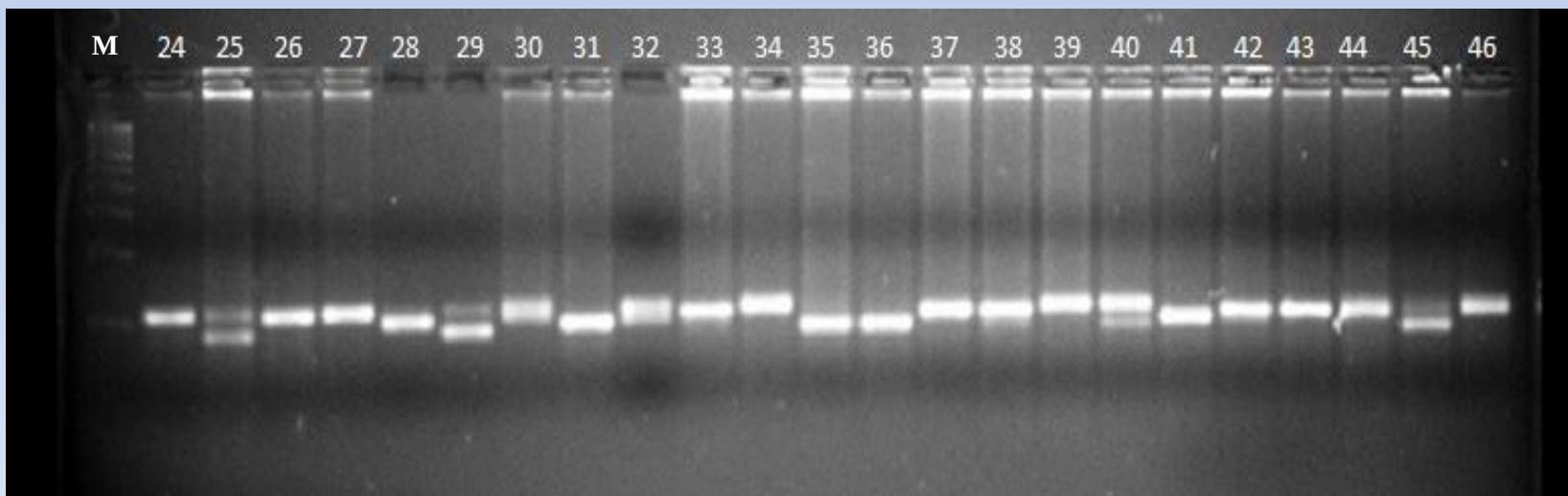
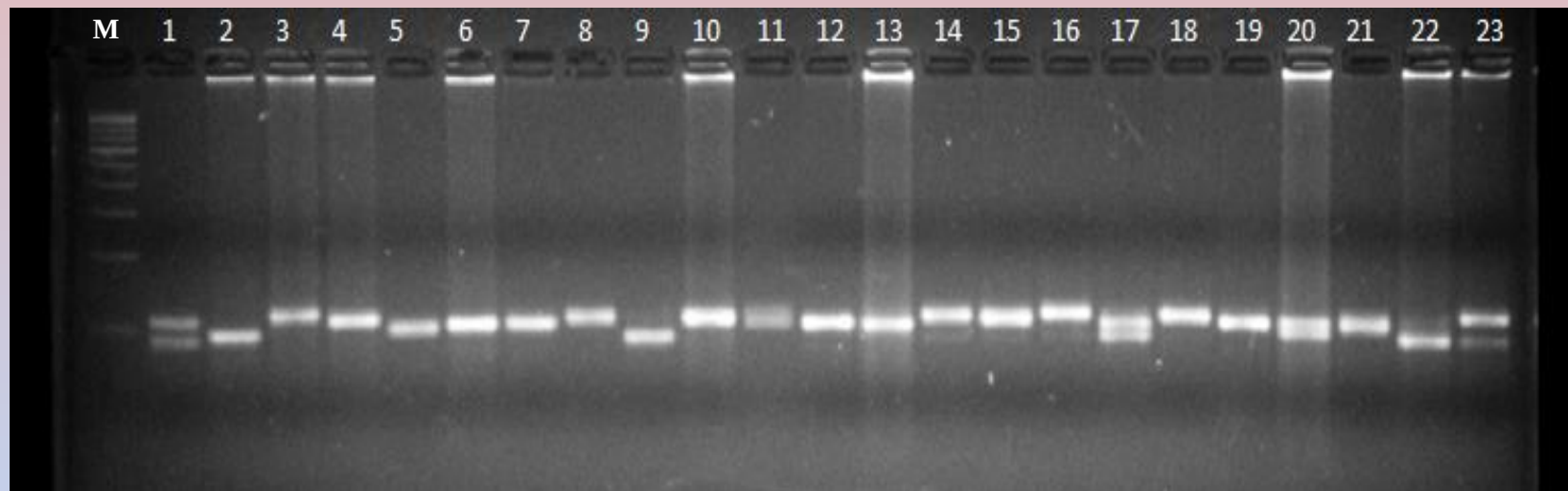
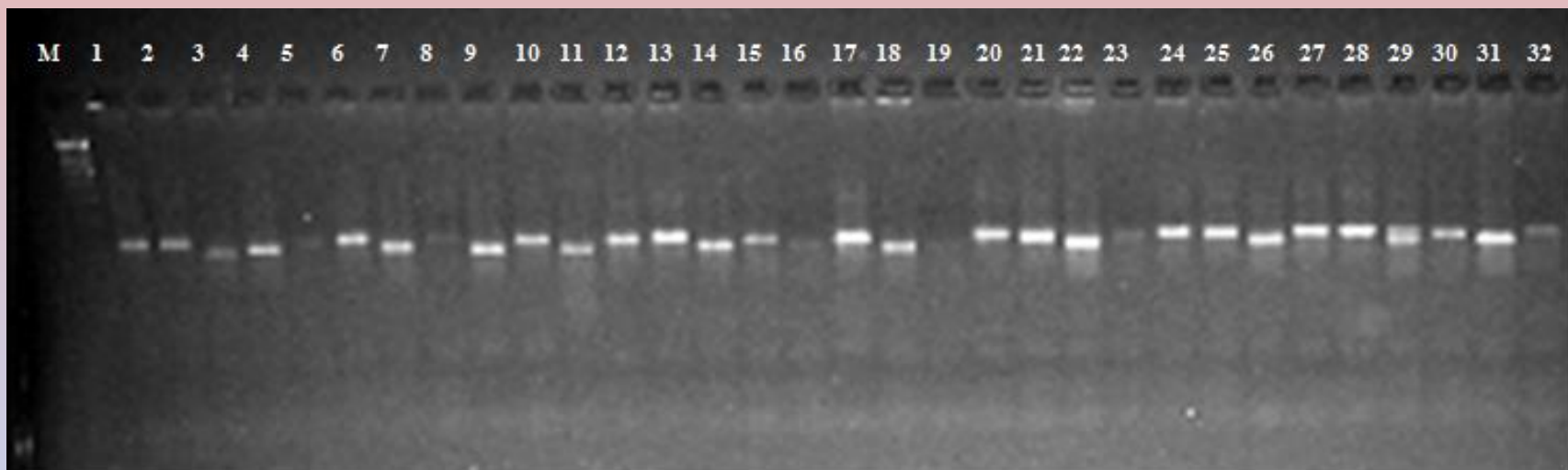
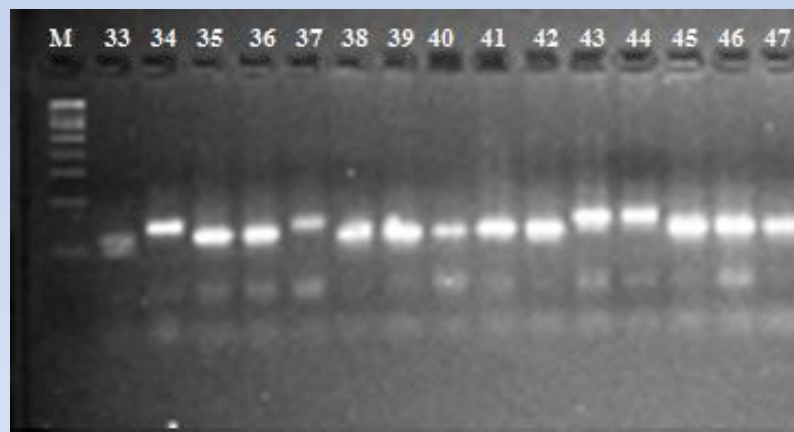


Plate 4.3. Validation of trait specific DNA markers linked to pungency in hot pepper F_2 individuals by Primer 3F/3R



M. Marker **1.** Arka Abhir, **2.** Arka Lohith, **3.** Arka Suphal, **4.** Aparna, **5.** AR-75, **6.** Assam Bhut Jolokia, **7.** Bayadagi Dabba, **8.** Bayadagi Kaddi, **9.** Bayadagi orange selection, **10.** CA-6, **11.** Chikkaballapur Local, **12.** CO-1, **13.** CO-2, **14.** CO-3, **15.** Coorg local, **16.** Dyavanur Delux, **17.** G4, **18.** Gouribidanur Local, **19.** HMT-1, **20.** JCA283, **21.** Kashi Anmol, **22.** KDC-1, **23.** Lavanga, **24.** LCA206, **25.** LCA235, **26.** LCA245, **27.** LCA 334, **28.** LCA353, **29.** LCA960, **30.** Minchalli Betta, **31.** Panth C-1, **32.** Paparika,



M. Marker, **33.** PBC-, **42.** **34.** PBC-613, **35.** Phule Jothi, **36.** Pusa Sadabahar, **37.** Rona, **38.** Samrudhi, **39.** Sankeshwara, **40.** Sahyadri wonder hot, **41.** Shivani, **42.** Soogi Menasu, **43.** Majjige Menasu-1, **44.** Majjige Menasu-2, **45.** Tiwari, **46.** TMR-23, **47.** Utkal Awa

Plate 4.4. Validation of trait specific DNA markers linked to pungency in hot pepper genotypes by Primer 7F/15R

Table 4.34. Descriptive statistics of different parameters for P₁, P₂ and F₁

Parameter	Min	Max	Mean	Std. error	Variance	Stand.de.	Median
Total fruit weight (g)							
P ₁	1.23	2.08	1.754	0.087	0.076	0.275	1.73
P ₂	0.79	1.20	1.006	0.046	0.021	0.144	0.97
F ₁	0.67	1.62	0.983	0.098	0.095	0.308	0.92
True weight of fruit (g)							
P ₁	1.23	2.08	1.754	0.087	0.076	0.275	1.73
P ₂	0.75	1.16	0.966	0.046	0.021	0.145	0.93
F ₁	0.61	1.35	0.864	0.069	0.048	0.218	0.84
Fruit length (cm)							
P ₁	10.90	13.40	12.03	0.288	0.829	0.910	11.90
P ₂	3.50	5.30	4.71	0.166	0.277	0.526	4.65
F ₁	7.00	9.10	8.07	0.216	0.467	0.683	8.00
Fruit width (cm)							
P ₁	1.10	1.80	1.49	0.072	0.052	0.228	1.60
P ₂	1.80	2.80	2.30	0.103	0.107	0.327	2.25
F ₁	1.60	2.10	1.82	0.051	0.026	0.162	1.80
Pedicle length (cm)							
P ₁	5.40	7.20	6.04	0.173	0.298	0.546	6.45
P ₂	1.90	3.30	2.71	0.121	0.145	0.381	2.70
F ₁	3.40	4.00	3.71	0.069	0.048	0.218	3.80
Pedicle weight (g)							
P ₁	0.086	0.205	0.164	0.012	0.001	0.038	0.174
P ₂	0.031	0.064	0.040	0.003	0.000	0.009	0.038
F ₁	0.049	0.098	0.071	0.005	0.000	0.015	0.072
Total seeds (#)							
P ₁	32.00	123.00	85.80	7.87	618.84	24.88	88.50
P ₂	12.00	82.00	41.50	7.42	550.72	23.47	38.50
F ₁	31.00	73.00	50.00	4.42	195.33	13.98	50.00
Filled seeds (#)							
P ₁	32.00	120.00	82.40	7.78	606.04	24.62	82.50
P ₂	0.060	0.105	0.078	0.005	0.000	0.017	0.073
F ₁	17.00	64.00	35.80	4.38	191.96	13.85	36.00
Unfilled seeds (#)							
P ₁	0.00	11.00	3.40	1.18	13.82	3.72	2.00
P ₂	12.00	80.00	41.10	7.24	524.32	22.90	38.50
F ₁	2.00	27.00	14.20	2.94	86.62	9.31	12.50
Pericarp weight (g)							
P ₁	0.867	1.286	1.073	0.043	0.019	0.137	1.070
P ₂	0.511	0.804	0.638	0.028	0.008	0.088	0.664
F ₁	0.479	0.769	0.612	0.033	0.011	0.103	0.621
Placenta weight (g)							
P ₁	0.046	0.087	0.071	0.005	0.000	0.014	0.072
P ₂	0.00	2.00	0.40	0.27	0.71	0.84	0.00
F ₁	0.040	0.103	0.056	0.006	0.000	0.018	0.053
Seed weight / fruit (g)							
P ₁	0.177	0.623	0.447	0.041	0.016	0.128	0.461
P ₂	0.086	0.387	0.229	0.033	0.011	0.103	0.221
F ₁	0.079	0.475	0.196	0.036	0.013	0.114	0.184
Germination (%)							
P ₁	98	100	99	0.577	1.333	1.155	99
P ₂	30	45	36	3.189	40.667	6.377	35
F ₁	99	100	100	0.289	0.333	0.577	100
Dormancy (%)							
P ₁	0	0	0	0	0	0	0
P ₂	55	70	64	3.189	40.667	6.377	65.50
F ₁	0	0	0	0	0	0	0
Seedling length (cm)							
P ₁	3.7	5.1	4.28	0.058	0.102	0.320	4.2
P ₂	0.5	2.2	1.41	0.085	0.218	0.4673	1.4
F ₁	4.3	6.3	4.95	0.083	0.2115	0.4598	4.9

Note: P₁= Paprika; P₂= Naga Bhut Jolokia; F₁ (Paprika x Naga Bhut Jolokia)

Table 4.35 Correlation of different parameters for P₁, P₂ and F₁

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1															
2	0.997	1														
3	0.876	0.836	1													
4	-0.792	-0.742	-0.988	1												
5	0.948	0.920	0.984	-0.945	1											
6	0.964	0.940	0.973	-0.926	0.999*	1										
7	0.978	0.959	0.957	-0.901	0.993	0.998*	1									
8	0.813	0.765	0.993	-0.999*	0.956	0.938	0.916	1								
9	-0.703	-0.645	-0.959	0.991	-0.892	-0.866	-0.835	-0.986	1							
10	0.995	1.000*	0.827	-0.731	0.914	0.935	0.954	0.754	-0.632	1						
11	0.426	0.353	0.809	-0.889	0.691	0.651	0.603	0.873	-0.943	0.338	1					
12	-0.477	-0.407	-0.841	0.914	-0.732	-0.693	-0.648	-0.900	0.961	-0.392	-0.998*	1				
13	0.295	0.219	0.718	-0.817	0.583	0.538	0.486	0.796	-0.887	0.203	0.990	-0.980	1			
14	0.478	0.407	0.842	-0.914	0.732	0.694	0.649	0.900	-0.961	0.392	0.998*	-1.000**	0.980	1		
15	-0.261	-0.185	-0.694	0.796	-0.554	-0.508	-0.455	-0.775	0.870	-0.169	-0.985	.973	-0.999*	-0.973	1	
16	-0.672	-0.612	-0.946	0.984	-0.873	-0.845	-0.811	-0.978	0.999*	-0.599	-0.956	.971	-0.906	-0.972	0.890	1

*correlation is significant at 0.05 level **correlation is significant at 0.01 level

Sl. No.	Parameter	Sl. No.	Parameter	Sl. No.	Parameter	Sl. No.	Parameter
1	Total fruit weight (g)	5	Pedicle length (cm)	9	Unfilled seeds #	13	Seedling length (cm)
2	True weight of fruit (g)	6	Pedicle weight (g)	10	Seed weight / fruit (g)	14	Seedling vigour index-i
3	Fruit length (cm)	7	Total seeds #	11	Germination (%)	15	Oleoresin (%)
4	Fruit width (cm)	8	Filled seeds #	12	Dormancy (%)	16	Capsaicin (µg/g)

Table 4.36. Seedling length (cm) at 14 day after sowing for P₁ ‘Paprika’, P₂ (Assam Bhut Jolokia), and their F₁, F₂, BCP₁ (F₁ x P₁), and BCP₂ (F₁ x P₂)

Family	Min.	Max.	Mean	Std. error	Variance	Stand. dev	Skewness	Kurtosis	Geom. mean	N
P₁	3.7	5.1	4.287	0.058	0.103	0.320	0.703	0.576	4.275	30
P₂	0.5	2.2	1.413	0.085	0.218	0.467	-0.162	-0.787	1.327	30
F₁	4.3	6.3	4.957	0.084	0.212	0.460	1.108	1.672	4.937	30
F₂	0.4	6.1	3.516	0.047	1.062	1.031	-0.464	0.295	3.313	487
BCP₁	0.3	5.5	2.428	0.044	0.765	0.875	0.156	0.057	2.242	393
BCP₂	0.5	5.5	2.977	0.047	0.826	0.909	-0.241	-0.285	2.807	381

Table 4.37. Joint scaling test and estimates with three-parameter model using six families mean for days to seedling emergence

Days to seedling emergence								
Family	Mean	Var						
P₁	1	0.2479	m	0.58115	A	-0.4888	T(A)	-12.22
P₂	0.2667	0.2184	d	0.36665	B	0.2445	T(B)	6.1125
F₁	1	0.2115	h	0.46775	C	-0.0555	T(C)	-0.51754
F₂	0.8028	1.0624	i	0.0522				
BCP₁	0.8761	0.7634	j	1.5077				
BCP₂	0.7556	0.8265	l	-0.0489				

Table 4.38. Joint scaling test and estimates with three-parameter model using six families mean for days to seedling length

Seedling length (cm)								
Family	Mean	Var						
P₁	4.22	0.2479	m	6.07085	A	-3.2233	T(A)	-20.7202
P₂	1.4133	0.2184	d	1.40335	B	-0.4166	T(B)	-2.67801
F₁	4.9567	0.2115	h	-9.10685	C	-1.4843	T(C)	-5.27423
F₂	3.5156	1.0624	i	-3.2542				
BCP₁	2.4274	0.7634	j	4.5347				
BCP₂	2.9767	0.8265	l	7.9927				

Germination (%) ranged from 98-100, 30-45 and 99-100 for P_1 , P_2 and F_1 , respectively. Whereas, number of dormant seeds ranged from 55-70 in P_2 , while, P_1 and F_1 seeds recorded nil (Table 4.34 and 4.35).

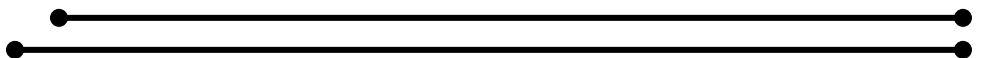
Seedling length (cm) ranged from 3.7-5.1, 0.5-2.2 and 4.3-6.3 with P_1 , P_2 and F_1 , respectively. The distribution of individuals in F_2 indicated quantitative nature of seedling length and seedling emergence.

Germination (%) ranged from 98-100, 30-45 and 99-100 for P_1 , P_2 and F_1 , respectively. Whereas, number of dormant seeds ranged from 55-70 in P_2 , while, P_1 and F_1 seeds recorded nil. The seedling length (cm) ranged from 3.7-5.1, 0.5-2.2 and 4.3-6.3 with P_1 , P_2 and F_1 , respectively.

The distribution of individuals in F_2 , B_1 and B_2 indicated quantitative nature of seedling length and seedling emergence.

Higher seedling length and the higher seedling emergence were predominantly under the control of genes with dominance effect and the dominance effect were unidirectional as evidenced by higher magnitudes of dominance gene effects and opposite signs of dominance and dominance $\times$ dominance epistatic gene effects (Table 4.36, 4.37 and 4.38 Fig. 3, 4, 5 and Fig. 4.3).

DISCUSSION



V DISCUSSION

The two chemical groups of greatest interest in hot pepper are the capsaicinoids and the carotenoids. Capsaicin is a unique alkaloid of the plant kingdom restricted to the genus *Capsicum*. Capsaicin is the pungency factor, a bioactive molecule of food and of medicinal importance. Fruit capsaicin content has an international commercial prime rate. The present study was carried out to study the variability for capsaicin and oleoresin of hot pepper genotypes to assess their role on seed quality, anthracnose fruit rot incidence and severity and also the effect of capsaicin and oleoresin on seed quality attributes during storage. To assess efficacy of seed treatment chemical to control seed borne anthracnose and validation of trait specific DNA markers linked to pungency. The results obtained in the present study are discussed under the following headings.

5.1 Genetic variability and seed quality parameters

5.1.1 Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV)

Number of seed fruit⁻¹, 1000 seed weight, electrical conductivity, total dehydrogenase activity, fresh ungerminated seeds, Seedling length, Vigour Index I, vigour index II, seed infection, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content, capsaicin, oleoresin, ASTA colour value manifested higher level of PCV and GCV while germination per cent and seedling dry weight manifested moderate level of PCV and GCV with close correspondence between them indicated lesser influence of environment on these traits thus selection for these traits to study seed quality attributes at in hot peppers cultivars will be effective.

Present results are in accordance with the earlier reports of high PCV and GCV for no. of seed fruit⁻¹ (Mini *et al.*, 2004; Yudhviri *et al.*, 2009), oleoresin (Pitchumuthu and Pappiah, 1995), fresh unfermented seeds (Claudinei *et al.*, 2006), fruit rot disease incidence on ripe fruits (Jayashree *et al.*, 2007 and Gadal *et al.*, 2003), total soluble seed protein content and capsaicin (Yudhviri *et al.*, 2009; Hedau *et al.*, 2008), oleoresin and ASTA colour value (Mini *et al.*, 2004; Naresh *et al.*, 2013; Shiva *et al.*, 2014).

5.1.2 Heritability and genetic advance

Electrical conductivity, total dehydrogenase activity, seedling dry weight, seed infection, fruit rot disease incidence on ripe fruits, total soluble seed protein content, capsaicin, ASTA colour value, number of seed/fruit, 1000 seed weight, germination percent, fresh ungerminated seeds, seedling length, vigour index I, vigour index II, α -amylase activity and oleoresin manifested higher heritability and GAM indicated the role of additive gene effects and hence selection would be rewarding for improvement of such traits.

Whereas, the present study reported the presence of moderate PCV and GCV for germination, seedlings dry weight, α -amylase activity, seed infection, seedling length, seedling vigour index I and II in the studied hot pepper genotypes.

Similarly, many researchers observed such presence of high GCV, PCV and high heritability coupled with genetic advance in (%) grand mean viz., Sarkar *et al.* (2009) for number of seeds fruit⁻¹; Manju and Srilathakumari (2002) for seed yield per fruit; Mini and Khader (2004) for 100 seed weight; Verma *et al.* (2004) for days to 50 (%) germination; Yudhvir Singh and Madhu Sharma (2008) for oleoresin and capsaicin content in hot peppers;

These major seed quality traits showed high values for GCV, PCV and heritability coupled with high GAM suggesting predominance of additive gene action and low influence of environmental factors in the trait expression in the present study.

5.2 Association of characters

The results pertaining to correlations and path coefficients are considered here simultaneously to have reliable information about the association of characters and to know the characters one has to look for in selecting for the dependent characters

The independent characters showing

- (i) Correlation

- (ii) High magnitude of direct effect
- (iii) High magnitude of indirect effects and
- (iv) Serving as channel for the high indirect effects of other independent characters were considered to be the ones that were influencing the dependent character. The direction in which an independent character was influencing a dependent character also was taken in to consideration in deciding the actual plant type, one has to keep in mind, while selecting for the concerned dependent character. Whether in is correlation or direct effect or indirect effect, it has to be at genotypic level to consider it as reliable. If it is at both phenotypic and genotypic levels, it is much reliable, but if it is only at phenotypic level, it is not reliable. This point it considered in deciding the desirable plant type.

5.2.1 Association of Germination per cent with other characters

Number of seed fruit⁻¹, 1000 seed weight , total dehydrogenase activity, seedling length , seedling vigour index-I, seedling vigour index-I, seed infection, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content, oleoresin, ASTA colour value and seedling dry weight manifested significant positive correlation with germination per cent suggested the effectiveness of selection based on these characters in improving the germination per cent while electrical conductivity, fresh ungerminated seeds and capsaicin showed significant negative correlation with germination per cent indicated limited success of selection for these traits in improving germination per cent.

5.2.2 Association of vigour index-I with other characters

Number of seed fruit⁻¹, 1000 seed weight, total dehydrogenase activity, germination per cent, seedling length, seedling dry weight, vigour index II, seed infection, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content, oleoresin and ASTA colour value showed significant positive correlation with seedling vigour index-I suggested the effectiveness of selection based on these characters in improving the seedling vigour index-I. While, electrical conductivity, fresh

ungerminated seeds and capsaicin showed significant negative correlation with vigour index I indicated limited success of selection for these traits in improving vigour index I.

5.2.3 Association of vigour index-II with other characters

The characters such as number of seed fruit⁻¹, 1000 seed weight, total dehydrogenase activity, germination, seedling length, seedling dry weight, seedling vigour index-I, seed infection, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content, oleoresin and ASTA colour value showed significant positive correlation with seedling vigour index-II suggested the effectiveness of selection based on these characters in improving the seedling vigour index-II while electrical conductivity, fresh ungerminated seeds and capsaicin showed significant negative correlation with seedling vigour index-II indicated limited success of selection for these traits in improving seedling vigour index-II.

5.2.4 Association of seed infection with other characters

The characters such as number of seed fruit⁻¹, 1000 seed weight, total dehydrogenase activity, germination, seedling length, seedling vigour index-I, seedling dry weight, seedling vigour index-II, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content, oleoresin and ASTA colour value showed significant positive correlation with seed infection suggested the effectiveness of selection based on these characters in improving the seed infection. While, electrical conductivity, fresh ungerminated seeds and capsaicin showed significant negative correlation with seed infection indicated limited success of selection for these traits in improving seed infection.

5.2.5 Association of fruit rot disease incidence on ripe fruits with other characters

The characters such as number of seed fruit⁻¹, 1000 seed weight, total dehydrogenase activity, germination, seedling length, seedling vigour index I, seedling dry weight, seedling vigour index-II, seed infection, α -amylase activity, total soluble seed protein content, oleoresin and ASTA colour value showed significant positive correlation with fruit rot disease incidence on ripe fruits suggested the effectiveness of selection

based on these characters in improving the fruit rot disease incidence on ripe fruits while electrical conductivity, fresh ungerminated seeds and capsaicin showed significant negative correlation with fruit rot disease incidence on ripe fruits indicated limited success of selection for these traits in improving fruit rot disease incidence on ripe fruits.

5.3 Path coefficient analysis

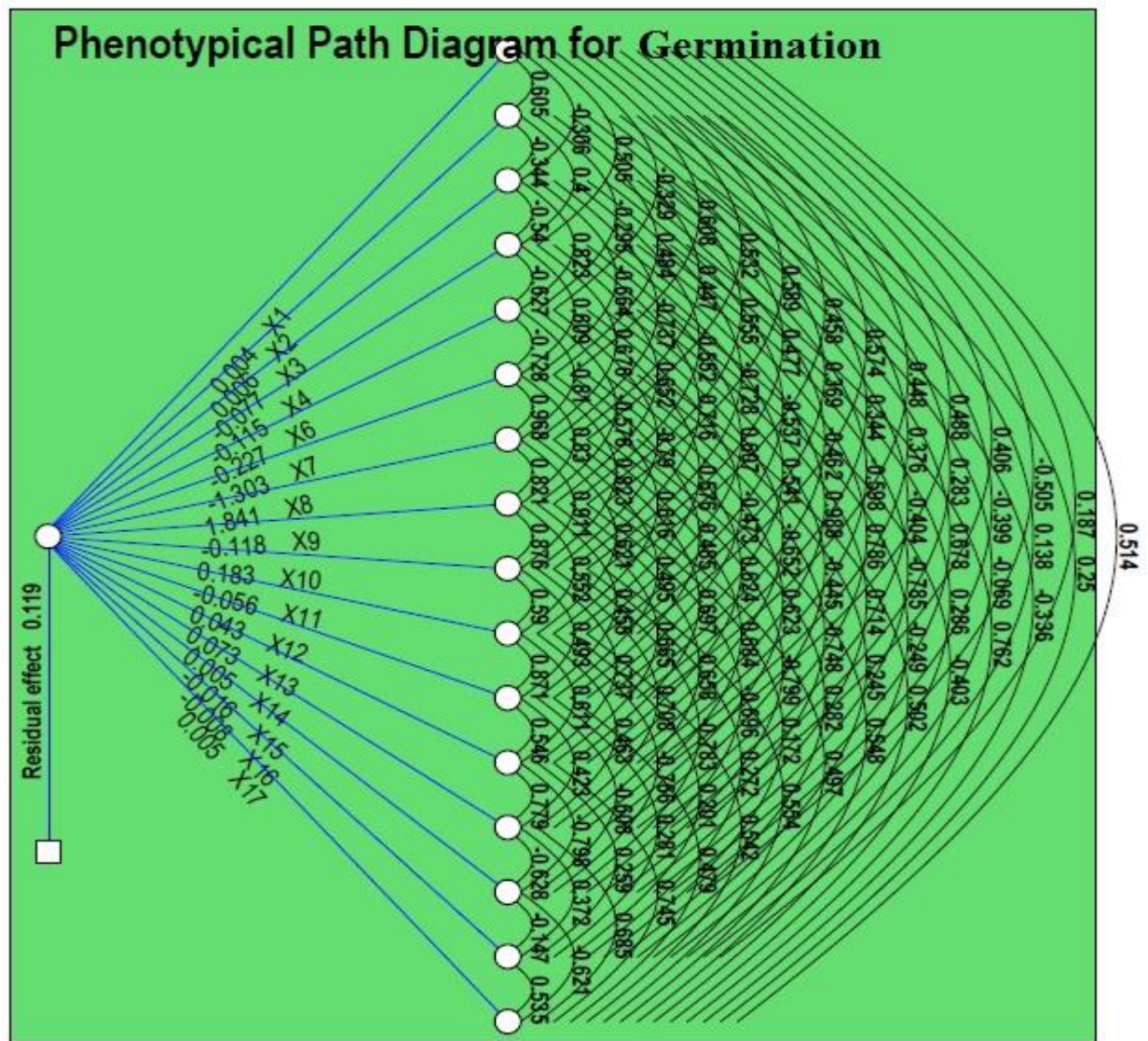
Path coefficient analysis was carried out at both genotypic and phenotypic levels taking germination per cent, seedling vigour index-I, seedling vigour index-II, seed infection per cent and fruit rot disease incidence on ripe fruits as dependent characters. The discussion pertaining to the path coefficient analyses are presented below

5.3.1 Direct effect of different characters on seed germination per cent at phenotypic level

At the phenotypic level, seedling vigour index-I recorded the highest positive direct effect on germination per cent, followed by seedling vigour index-II which was of considerable magnitude. number of seed fruit⁻¹, 1000 seed weight, fruit rot disease incidence on ripe fruits, α -amylase activity, total soluble seed protein content and ASTA colour value recorded positive direct effects on germination per cent but their magnitude were low. However, seedling length recorded the highest negative direct effect on germination per cent followed by fresh ungerminated seeds, seedling dry weight, and total dehydrogenase activity. Electrical conductivity, seed infection, capsaicin and oleoresin recorded negative direct effect on germination per cent but their magnitude were low (*Fig. 5.1*).

5.3.2 Direct effects of different characters on vigour index-I at phenotypic level

At the phenotypic level, seedling length recorded the highest positive direct effect on seedling vigour index-I, followed by germination per cent which was of considerable magnitude. Electrical conductivity, total dehydrogenase activity, fresh ungerminated seeds, seedling vigour index-II, seed infection, total soluble seed protein content and oleoresin recorded positive direct effects on seedling vigour index-I but their magnitude were low. however, number of seed fruit⁻¹, 1000 seed weight, seedling dry weight, fruit



rot disease incidence on ripe fruits, α -amylase activity, capsaicin and ASTA colour value recorded the negative direct effect on vigour index I but their magnitude were low (*Fig. 5.2*).

5.3.3 Direct effect of different characters on vigour index II at phenotypic level

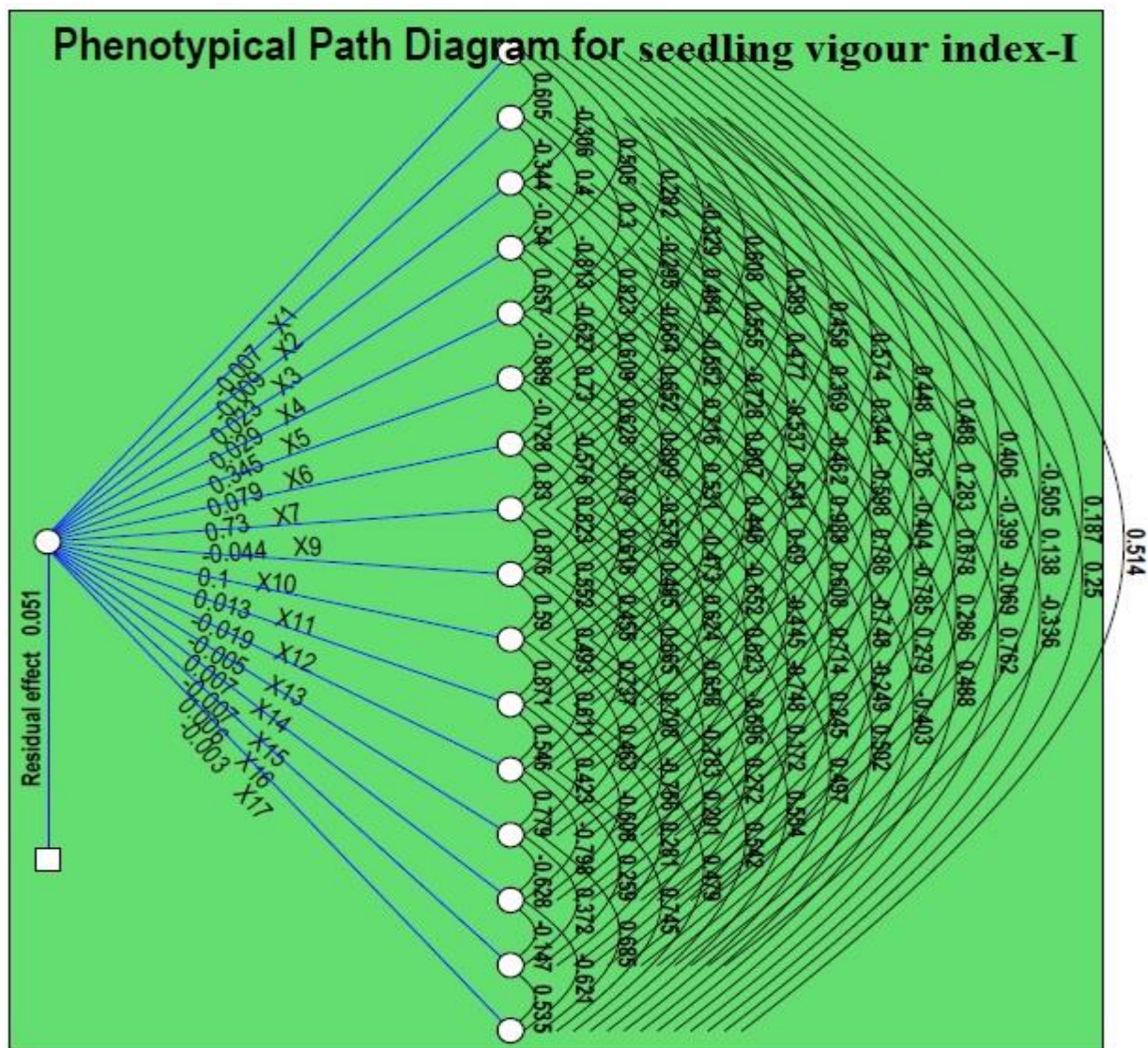
At the phenotypic level, seedling vigour index-I recorded the highest positive direct effect on seedling vigour index-II, followed by seedling dry weight and germination per cent which was of considerable magnitude. 1000 seed weight, electrical conductivity, seed infection, total soluble seed protein content, capsaicin and ASTA colour value recorded positive direct effects on seedling vigour index-II but their magnitude were low. However, number of seed fruit⁻¹, total dehydrogenase activity, fresh ungerminated seeds, seedling length, fruit rot disease incidence on ripe fruits, α -amylase activity and oleoresin recorded the negative direct effect on seedling vigour index-II nevertheless their magnitude were low (*Fig. 5.3*).

5.3.4 Direct effect of different characters on seed infection at phenotypic level

At the phenotypic level, fruit rot disease incidence on ripe fruits recorded the highest positive direct effect on seed infection, followed by vigour index I which was of considerable magnitude. Number of seed fruit⁻¹, total dehydrogenase activity, vigour index ii and ASTA colour value recorded positive direct effects on seed infection but their magnitude were low. Whereas, germination per cent recorded the highest positive direct effect on seed infection followed by seedling length, capsaicin which was of considerable magnitude. 1000 seed weight, electrical conductivity, fresh ungerminated seeds, seedling dry weight, α -amylase activity, total soluble seed protein content and oleoresin recorded the negative direct effect on seed infection but their magnitude were low (*Fig. 5.4*).

5.3.4 Direct effect of different characters on fruit rot disease incidence on ripe fruits at phenotypic level

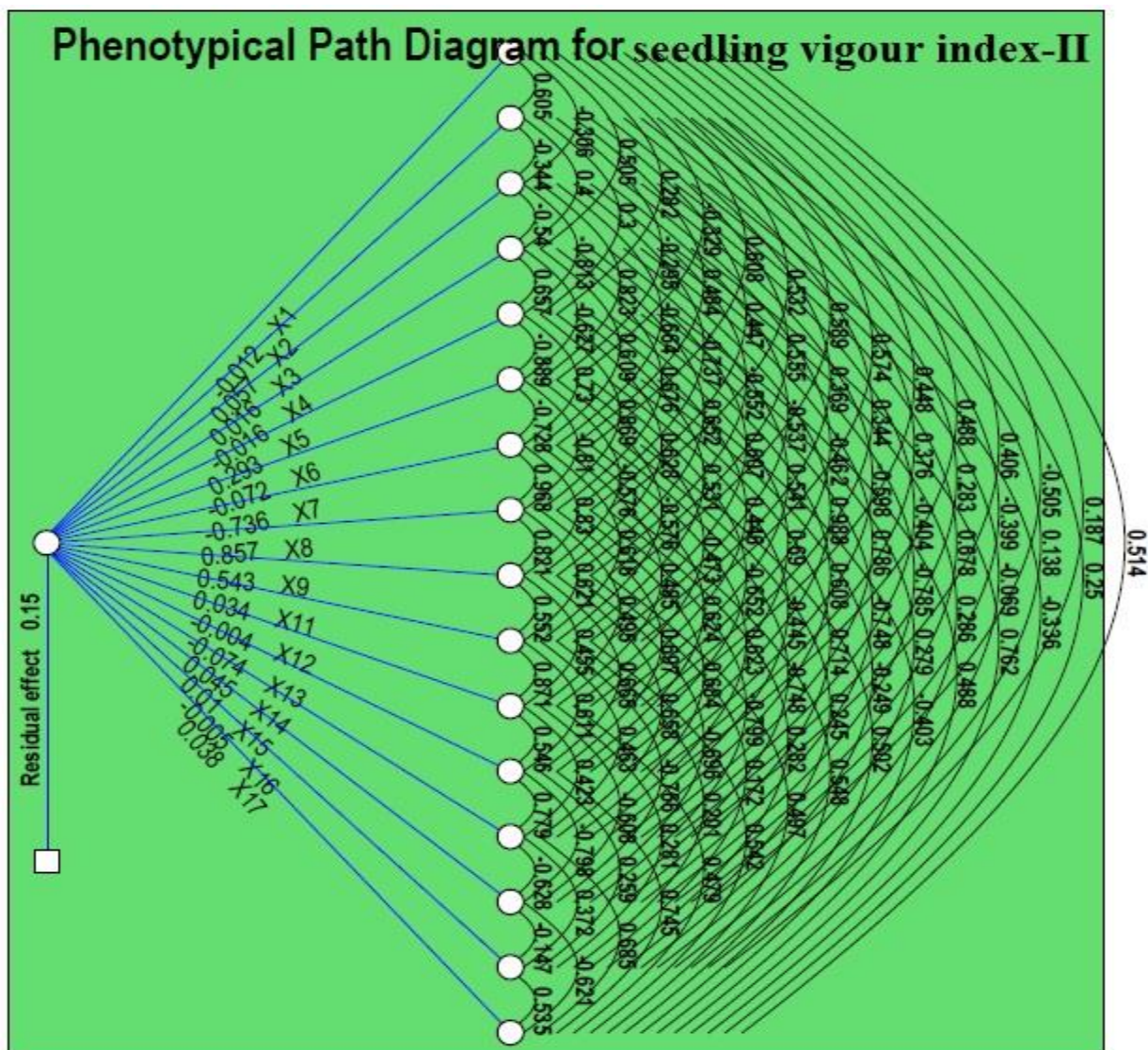
At the phenotypic level, seed infection recorded the highest positive direct effect on fruit rot disease incidence on ripe fruits, followed by seedling length and germination



Where,

X ₁ : No. of seed fruit ⁻¹	X ₁₁ : Seed infection (%)
X ₂ : Test weight (g)	X ₁₂ : Fruit rot disease incidence on ripe fruits (%)
X ₃ : Electrical conductivity ($\mu\text{S cm}^{-1} \text{ g}^{-1}$)	X ₁₃ : α -amylase activity ($\mu\text{g ml}^{-1} \text{ min}^{-1}$)
X ₄ : Total dehydrogenase activity ($\text{A}^\circ 480\text{nm}$)	X ₁₄ : Total soluble seed protein content (mg g^{-1})
X ₅ : Germination (%)	X ₁₅ : Capsaicin ($\mu\text{g g}^{-1}$)
X ₆ : Fresh ungerminated seeds (%)	X ₁₆ : Oleoresin (%)
X ₇ : Seedling length (cm)	X ₁₇ : ASTA color value
X ₈ : Seedling vigour index-I	
X ₉ : Seedling dry weight (mg)	
X ₁₀ : Seedling vigour index-II	

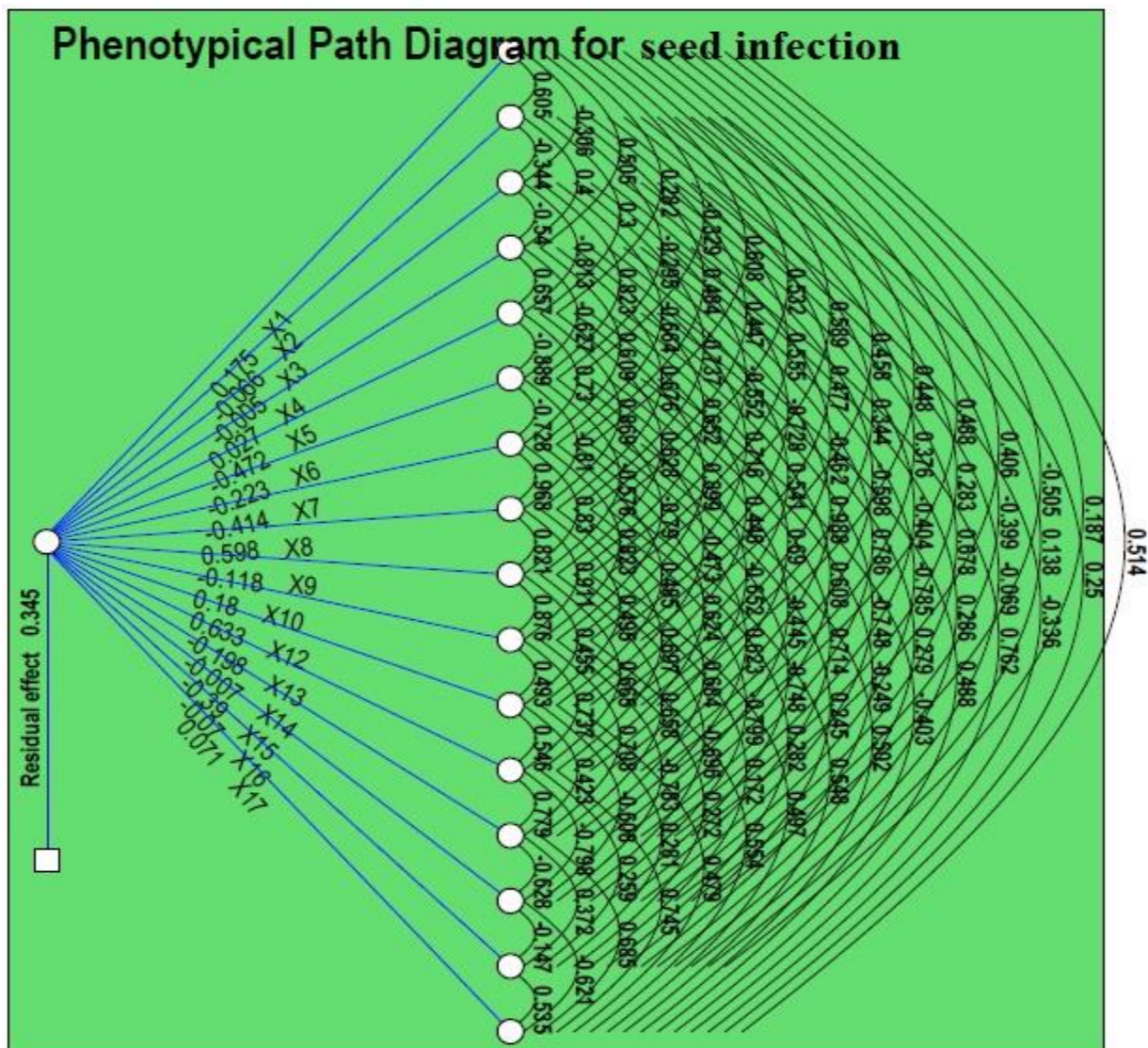
Fig. 5.2. Estimation of phenotypic path coefficients between seed quality attributes and seedling vigour index-I



Where,

X ₁ : No. of seed fruit ⁻¹	X ₁₁ : Seed infection (%)
X ₂ : Test weight (g)	X ₁₂ : Fruit rot disease incidence on ripe fruits (%)
X ₃ : Electrical conductivity ($\mu\text{S cm}^{-1} \text{g}^{-1}$)	X ₁₃ : α -amylase activity ($\mu\text{g ml}^{-1} \text{min}^{-1}$)
X ₄ : Total dehydrogenase activity ($A^{480\text{nm}}$)	X ₁₄ : Total soluble seed protein content (mg g^{-1})
X ₅ : Germination (%)	X ₁₅ : Capsaicin ($\mu\text{g g}^{-1}$)
X ₆ : Fresh ungerminated seeds (%)	X ₁₆ : Oleoresin (%)
X ₇ : Seedling length (cm)	X ₁₇ : ASTA color value
X ₈ : Seedling vigour index-I	
X ₉ : Seedling dry weight (mg)	
X ₁₀ : Seedling vigour index-II	

Fig. 5.3. Estimation of phenotypic path coefficients between seed quality attributes and seedling vigour index-II



Where,

X ₁ : No. of seed fruit ⁻¹	X ₁₁ : Seed infection (%)
X ₂ : Test weight (g)	X ₁₂ : Fruit rot disease incidence on ripe fruits (%)
X ₃ : Electrical conductivity ($\mu\text{S cm}^{-1} \text{ g}^{-1}$)	X ₁₃ : α -amylase activity ($\mu\text{g ml}^{-1} \text{ min}^{-1}$)
X ₄ : Total dehydrogenase activity ($A^{0} 480\text{nm}$)	X ₁₄ : Total soluble seed protein content (mg g^{-1})
X ₅ : Germination (%)	X ₁₅ : Capsaicin ($\mu\text{g g}^{-1}$)
X ₆ : Fresh ungerminated seeds (%)	X ₁₆ : Oleoresin (%)
X ₇ : Seedling length (cm)	X ₁₇ : ASTA color value
X ₈ : Seedling vigour index-I	
X ₉ : Seedling dry weight (mg)	
X ₁₀ : Seedling vigour index-II	

Fig. 5.4. Estimation of phenotypic path coefficients between seed quality attributes and seed infection

per cent which was of considerable magnitude. 1000 seed weight, fresh ungerminated seeds, seedling dry weight, α -amylase activity, total soluble seed protein content, capsaicin and oleoresin recorded positive direct effects on fruit rot disease incidence on ripe fruits. However, seedling vigour index-I recorded the highest negative direct effect on fruit rot disease incidence on ripe fruits, number of seed fruit⁻¹, electrical conductivity, total dehydrogenase activity, seedling vigour index-II and ASTA colour value recorded the negative direct effect on fruit rot disease incidence on ripe fruits (*Fig. 5.5*).

5.4 Anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin

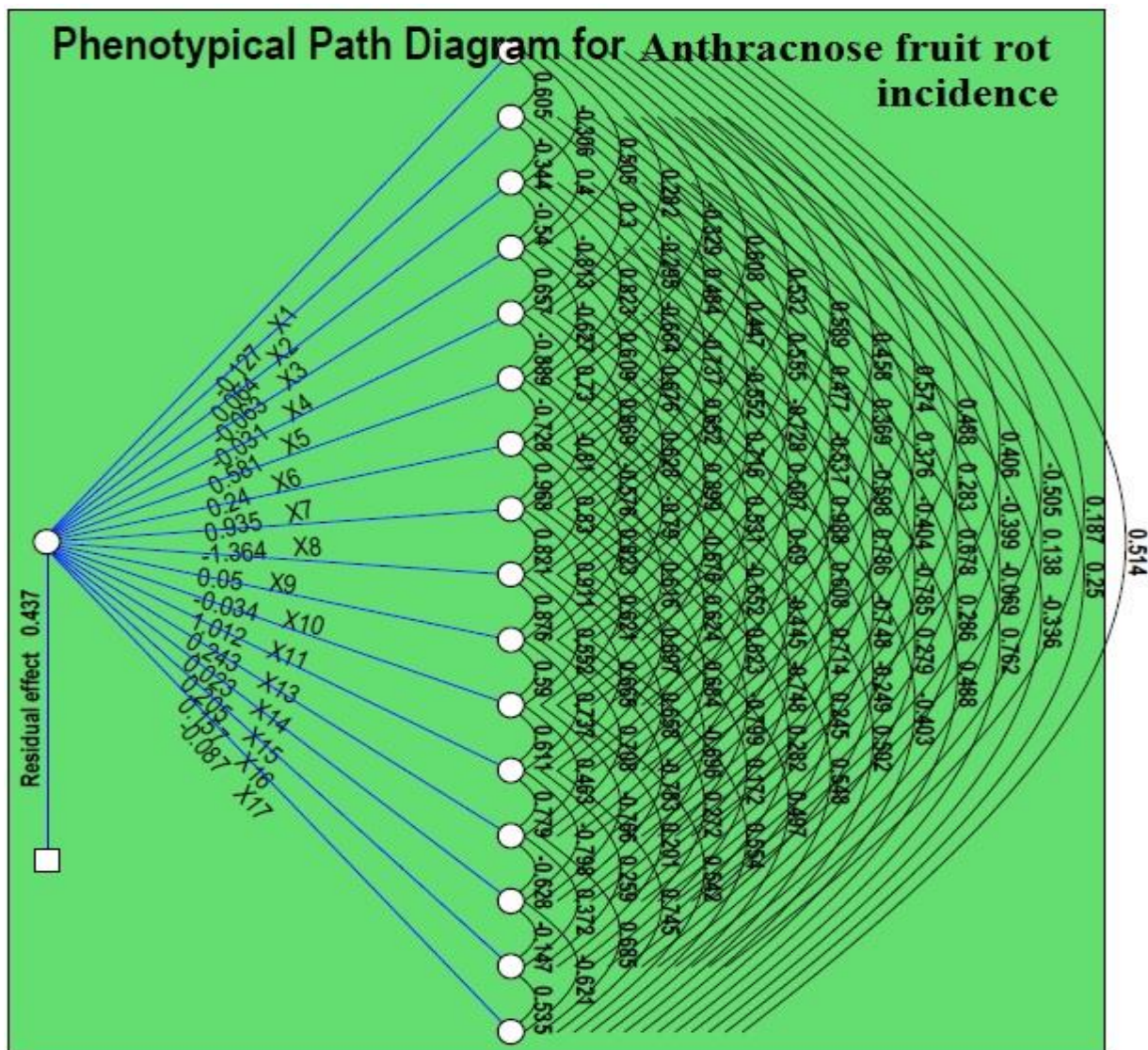
The results pertaining to effect of capsaicin and oleoresin on anthracnose fruit rot are discussed as follows

The fruit quality attributes such as capsaicin and oleoresin contents was estimated in healthy, naturally infected fruits and artificially inoculated fruits among 12 genotypes to assess the extent of capsaicin and oleoresin on anthracnose infection.

In general, the seed quality parameters, capsaicin and oleoresin contents of hot pepper fruits were reduced in infected fruits as compared to healthy fruits in all the genotypes studied (*Plate 5.1*).

Under natural field conditions significant differences were recorded for number of infected fruits per plant, fruit rot disease incidence, fruit rot severity (%) fruit width (mm), fruit length (cm) (*Fig. 5.6*), number of infected fruits per plant, fruit rot disease incidence (%) and fresh ungerminated seeds (%) with capsaicin and oleoresin content

Number of infected seeds per fruit in naturally infected (NIF) and artificially inoculated fruits (AIF) of anthracnose showed significant differences (*Fig. 5.7*). Seed infection was absent in naturally infected fruits (NIF) of genotype Majjige Menasu-1 with higher capsaicin in Pericarp (832028 SHU) and low oleoresin (4.29%). While the same genotype seeds evaluated after artificial inoculation of fruits (AIF) recorded lowest of 4 (%) seed infection. Whereas, genotype Byadagi Dabba recorded highest number of



Where,

X ₁ : No. of seed fruit ⁻¹	X ₁₁ : Seed infection (%)
X ₂ : Test weight (g)	X ₁₂ : Fruit rot disease incidence on ripe fruits (%)
X ₃ : Electrical conductivity ($\mu\text{S cm}^{-1} \text{ g}^{-1}$)	X ₁₃ : α -amylase activity ($\mu\text{g ml}^{-1} \text{ min}^{-1}$)
X ₄ : Total dehydrogenase activity ($A^{0} 480\text{nm}$)	X ₁₄ : Total soluble seed protein content (mg g^{-1})
X ₅ : Germination (%)	X ₁₅ : Capsaicin ($\mu\text{g g}^{-1}$)
X ₆ : Fresh ungerminated seeds (%)	X ₁₆ : Oleoresin (%)
X ₇ : Seedling length (cm)	X ₁₇ : ASTA color value
X ₈ : Seedling vigour index-I	
X ₉ : Seedling dry weight (mg)	
X ₁₀ : Seedling vigour index-II	

Fig. 5.5. Estimation of phenotypic path coefficients between seed quality attributes and anthracnose fruit rot disease incidence

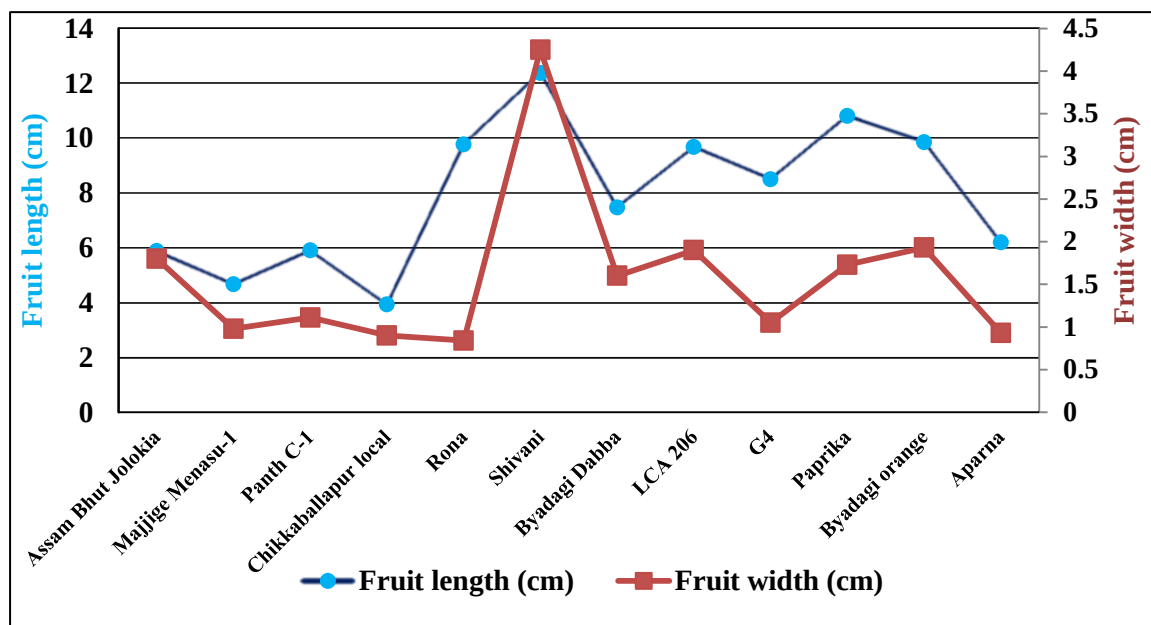


Fig. 5.6. Fruit length and width (cm) in relation to capsaicin and oleoresin content

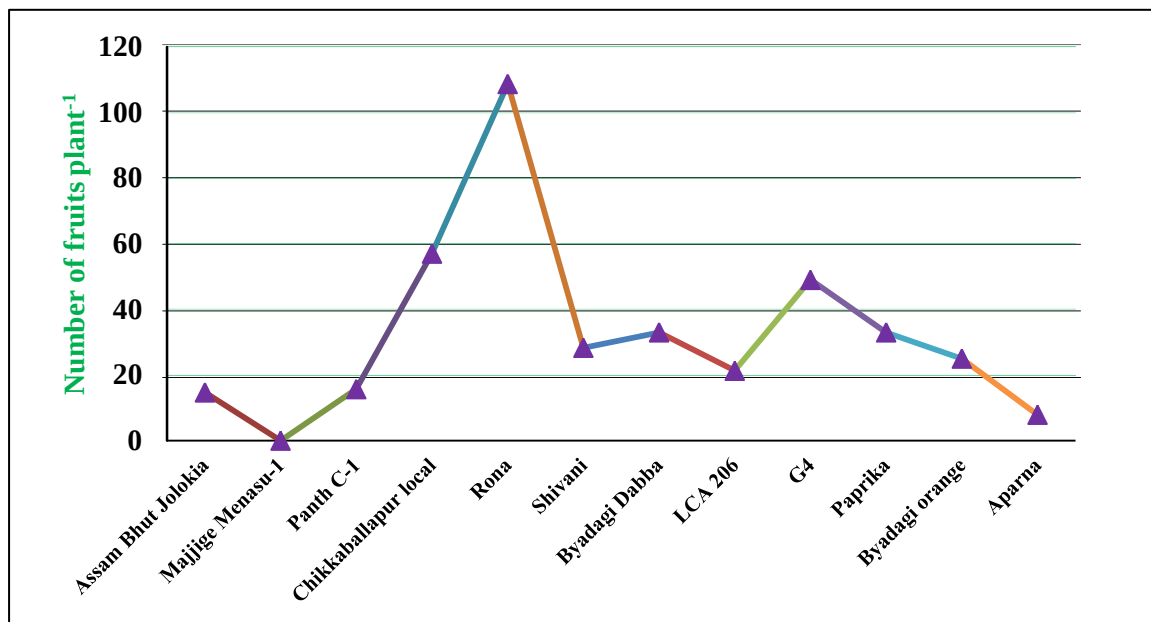


Fig. 5.7. Number of infected fruits per plant in relation to capsaicin and oleoresin content

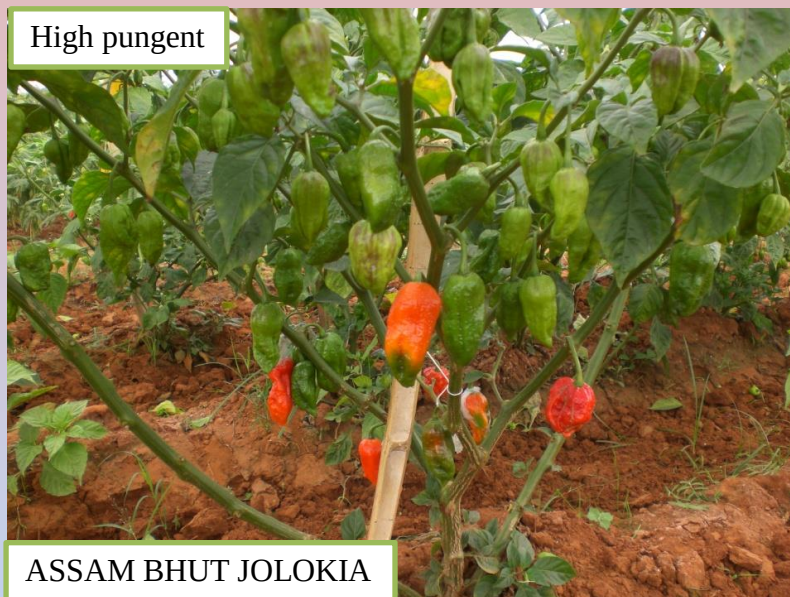


Plate 5.1. Genotypes identified with high capsaicin and low oleoresin contains with low disease incidence of anthracnose in field

infected seeds per fruit both under NIF and AIF (104.18 and 107.7, respectively) (*Fig. 5.8*). This genotype considerably recorded lower capsaicin in pericarp and higher oleoresin (7798 SHU and 21.4 %, respectively).

The highest fruit rot disease incidence was recorded in Rona (95 %) followed by Paprika and Shivani (93 % each). Whereas, no symptom of fruit rot disease incidence was recorded on genotype Majjige Menasu-1. The highest fruit rot disease severity was recorded in Shivani (87.47%) followed by Aparna (87.09%) (*Fig. 5.12*). However, no symptom of fruit rot severity was recorded on genotype Majjige Menasu-1 which recorded lower oleoresin and higher capsaicin (*Fig. 5.9*). While, highest number of seeds per fruit was recorded in Shivani (188.1) followed by Byadagi Dabba (137). Whereas, lowest was recorded in Rona (61.7) (*Fig. 5.10*). similar results were also reported by Tenaya *et al.*, 2001, Mesta *et al.*, (2007a) Vinaya *et al.*, 2009 Ranbir Singh and Chowdury, 2010, Patil *et al.*, 2003, Anamika *et al.*, 2012, In general, increased content of capsaicin recorded lower disease incidence. Whereas, increased oleoresin content increased the fruit rot and other related parameters.

Significant differences were recorded for true lesion diameter, germination, seedling length, seedling vigour index-I and II among naturally infected and artificially inoculated fruits for genotypes under investigation (*Fig. 5.11*).

Seed quality parameters showed significantly considerable reduction in both naturally and artificially inoculated fruits of hot pepper genotypes. In NIF the highest germination (%) was recorded in Byadagi Dabba (95%) (*Fig. 5.10*). While among the artificially inoculated fruits, Chikkaballapur local (76%) recorded highest germination (%). The lowest seed germination Majjige Menasu-1 (37 and 27 %, respectively) was recorded in both NIF and AIF. Whereas, for both NIF and AIF highest was recorded in Byadagi Dabba (18 and 16.35 cm, respectively). Whereas, for both NIF and AIF lowest seedling length was recorded in Assam Bhut Jolokia (7.67 and 6.48cm, respectively) (*Fig. 5.11*). Among naturally infected and artificially inoculated highest seedling vigour index-I was recorded in Byadagi Dabba (1706 and 984 respectively. The lowest seedling vigour index-I among NIF and AIF was recorded in Majjige Menasu-1 (307 and 205,

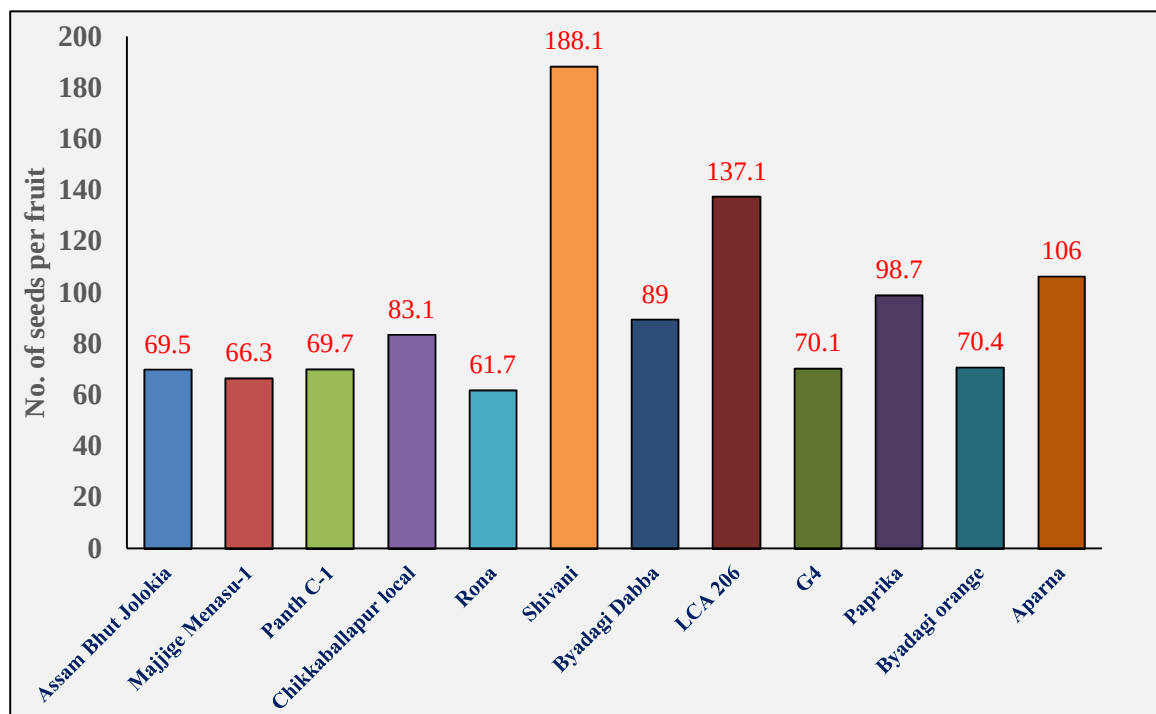
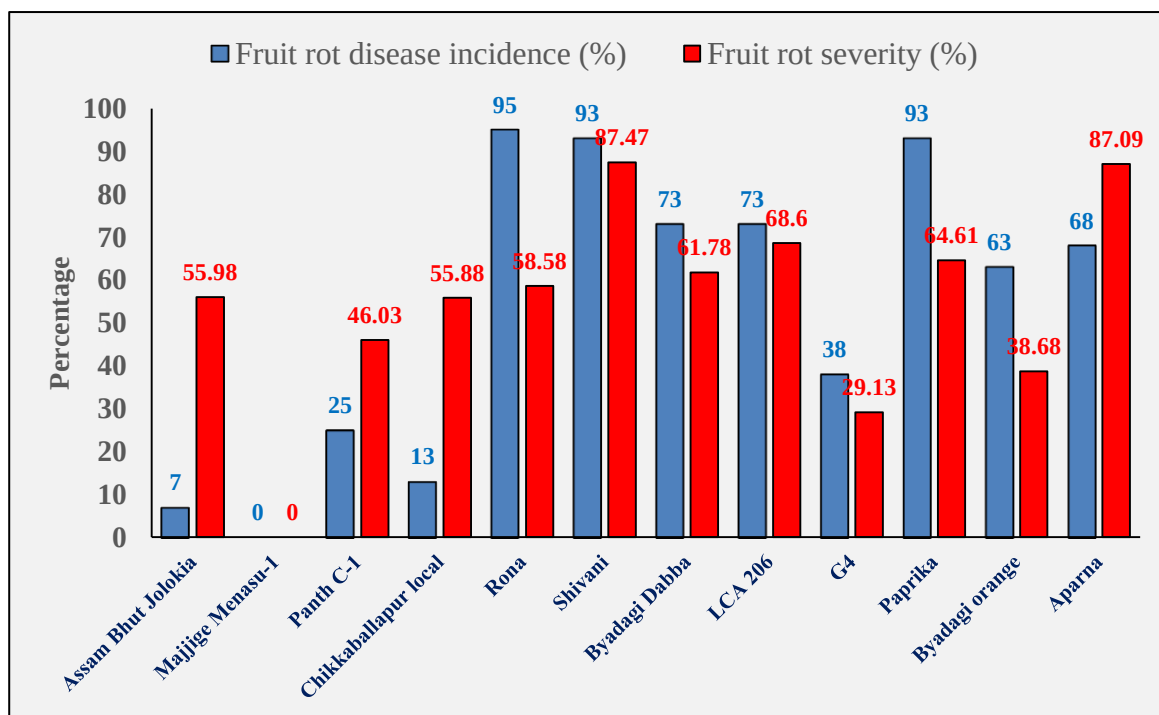


Fig. 5.8. Total number of seeds and number of infected seeds per fruit in relation to capsaicin and oleoresin content

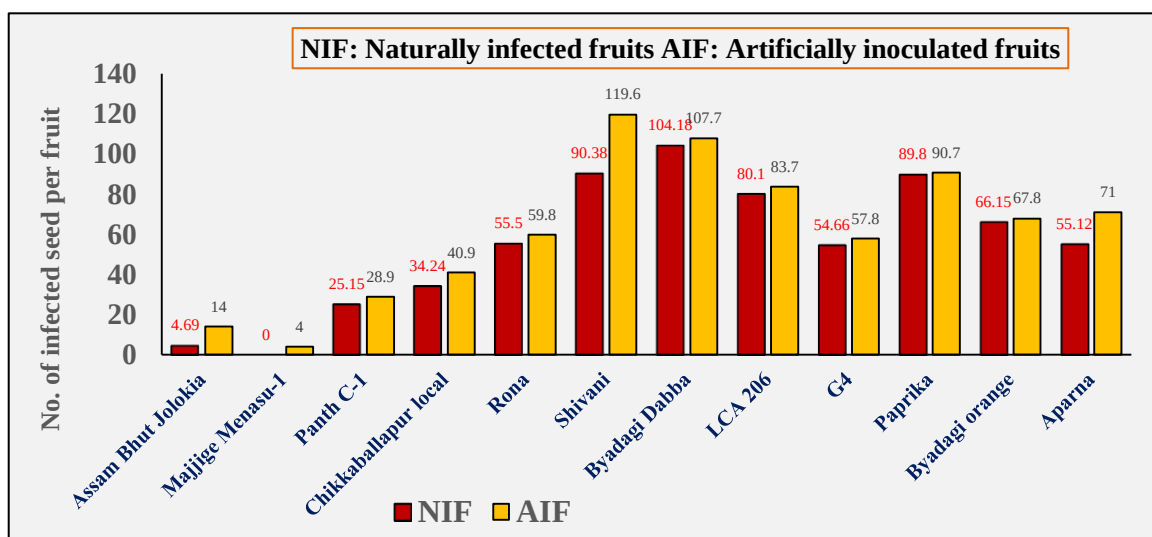
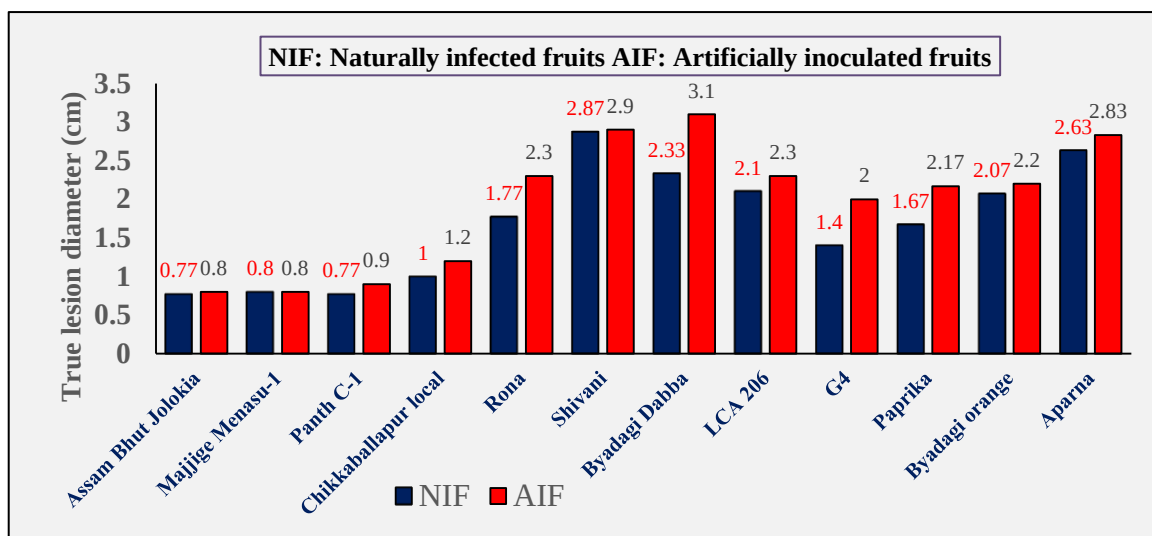
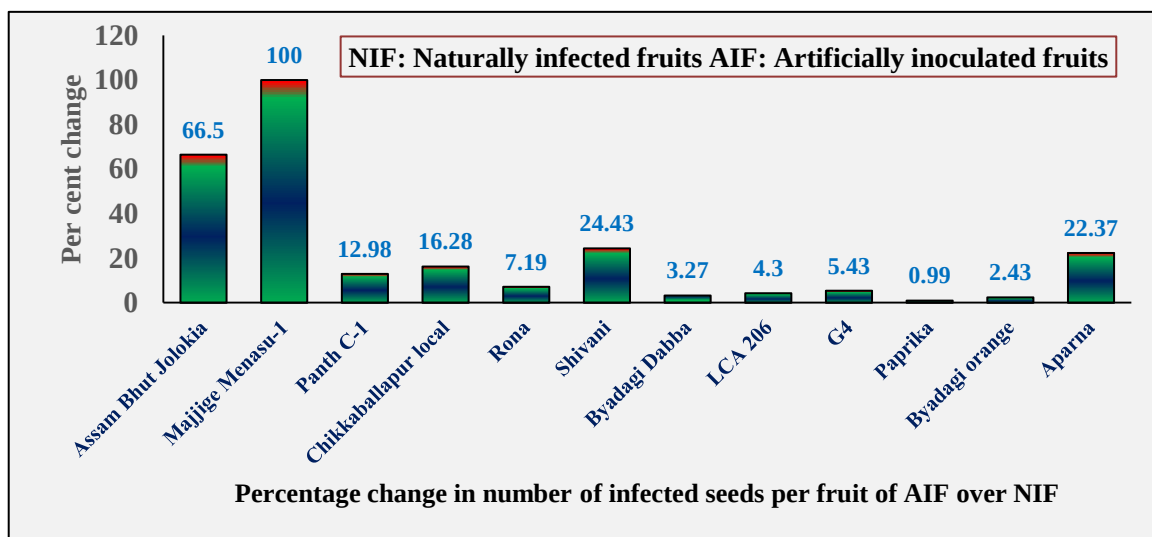


Fig. 5.9. Per cent change of number of infected seeds per fruits, true lesions diameters and number of infected seed per fruit in relation to capsaicin and oleoresin content

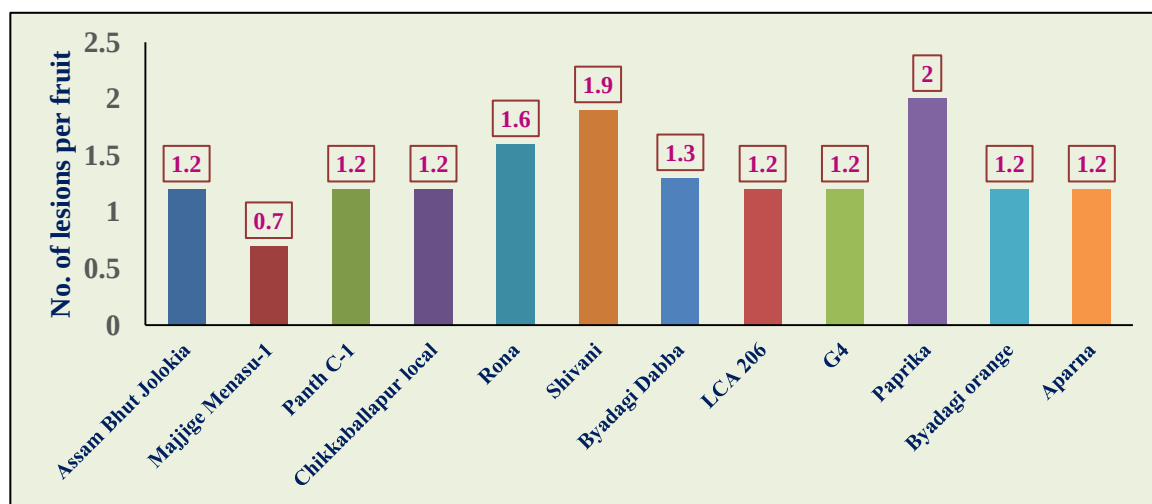
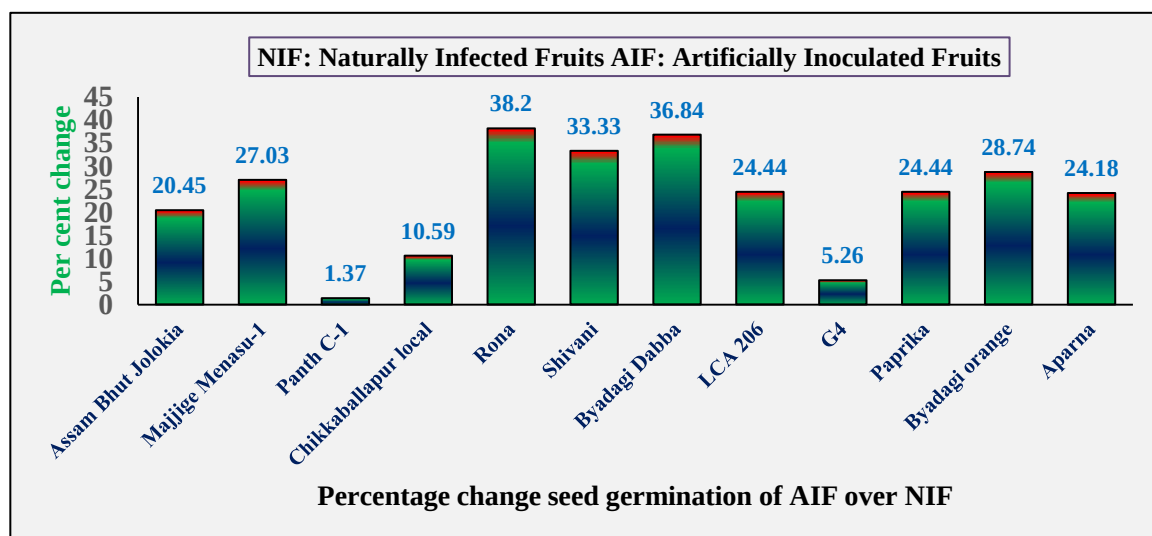
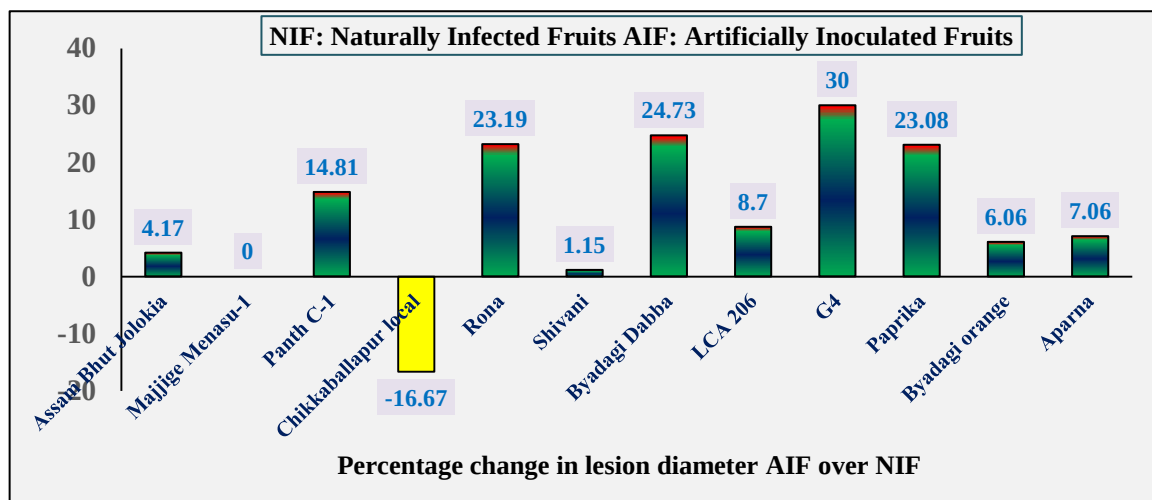


Fig. 5.10. Per cent change of lesion diameter, germination and number of lesions per fruit in relation to capsaicin and oleoresin content

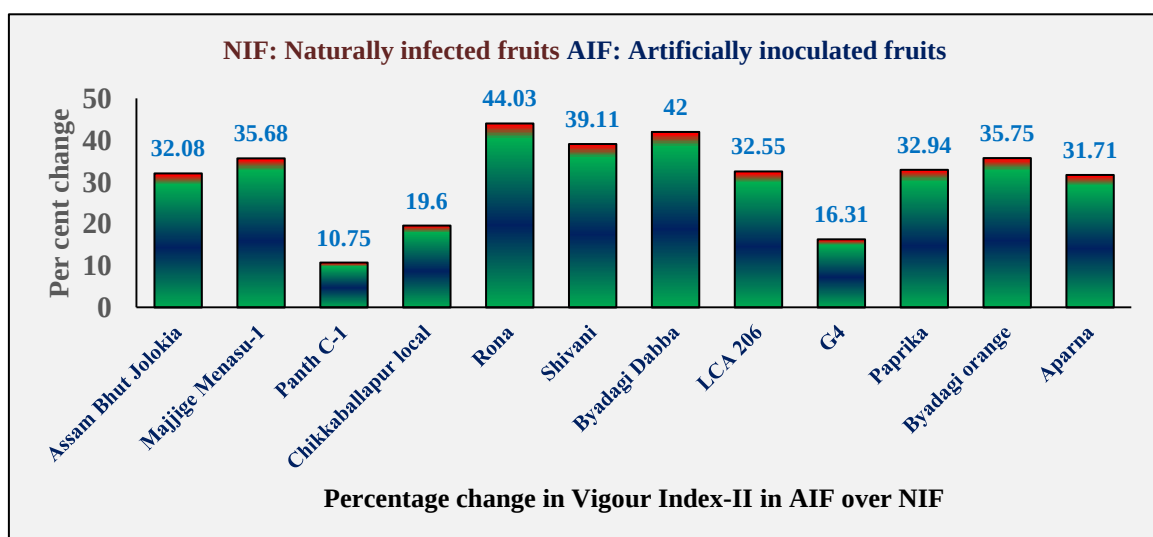
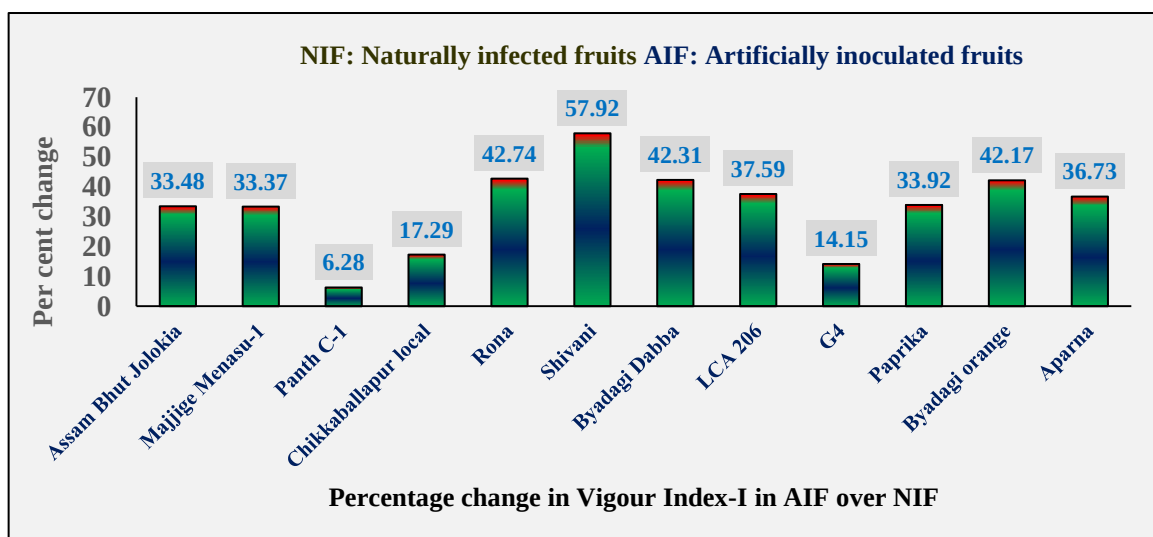
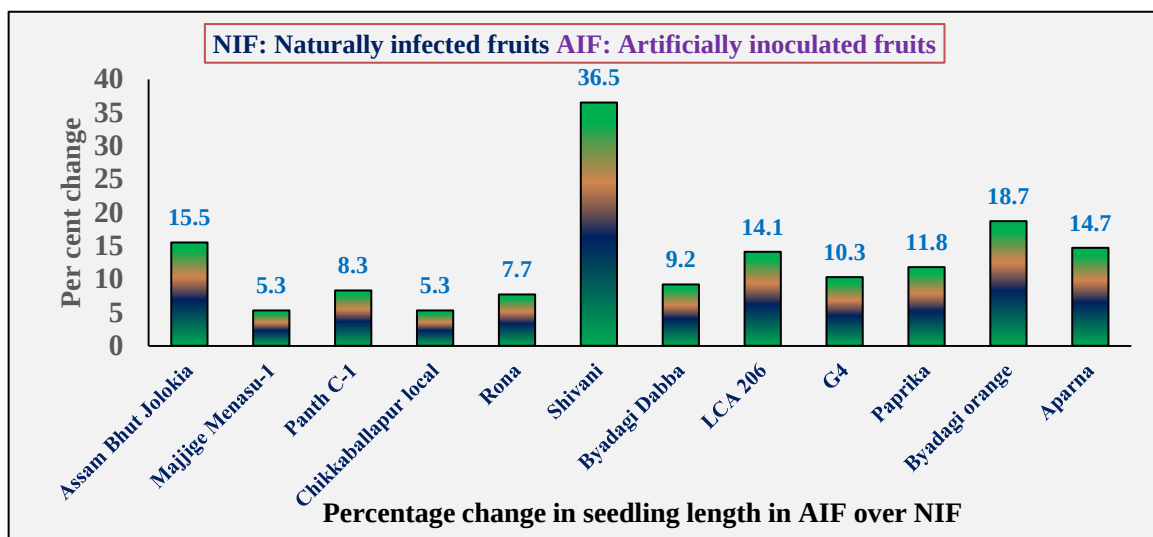


Fig. 5.11. Per cent change in seedling length, vigour index-I and II over naturally and artificially infected fruits in relation to capsaicin and oleoresin content

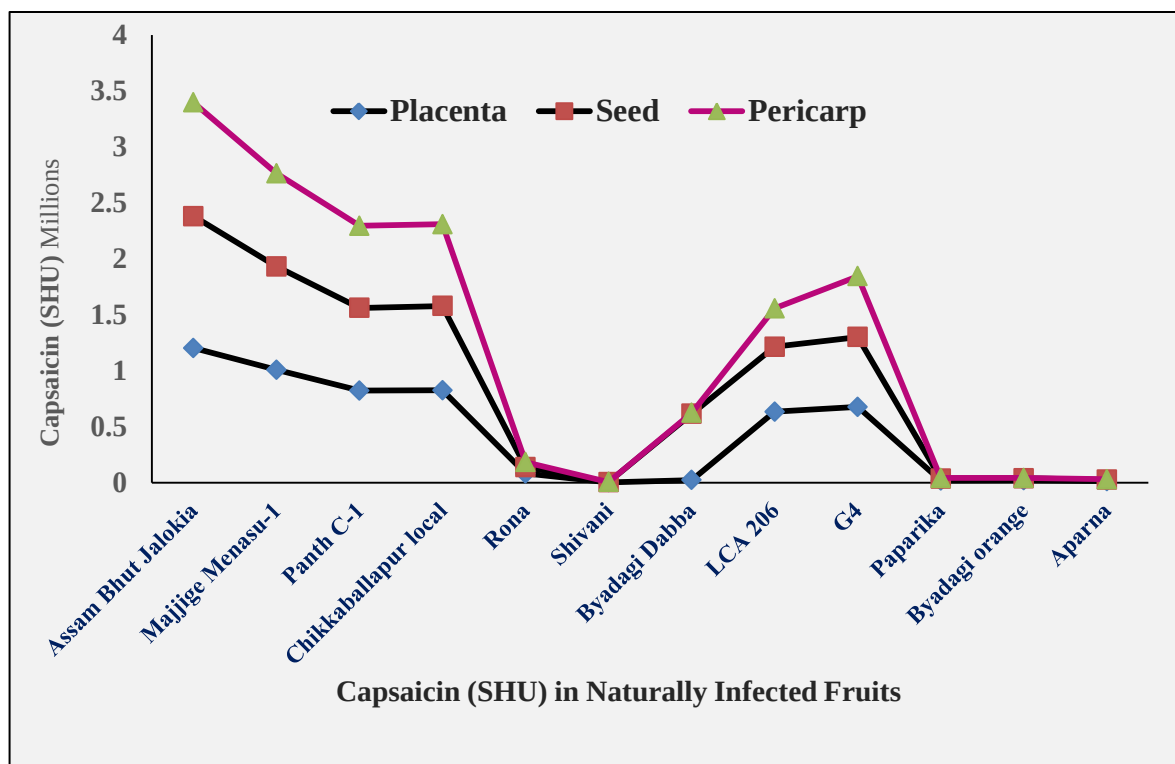


Fig. 5.12 . Fruit rot incidence and severity in relation to capsaicin and oleoresin content

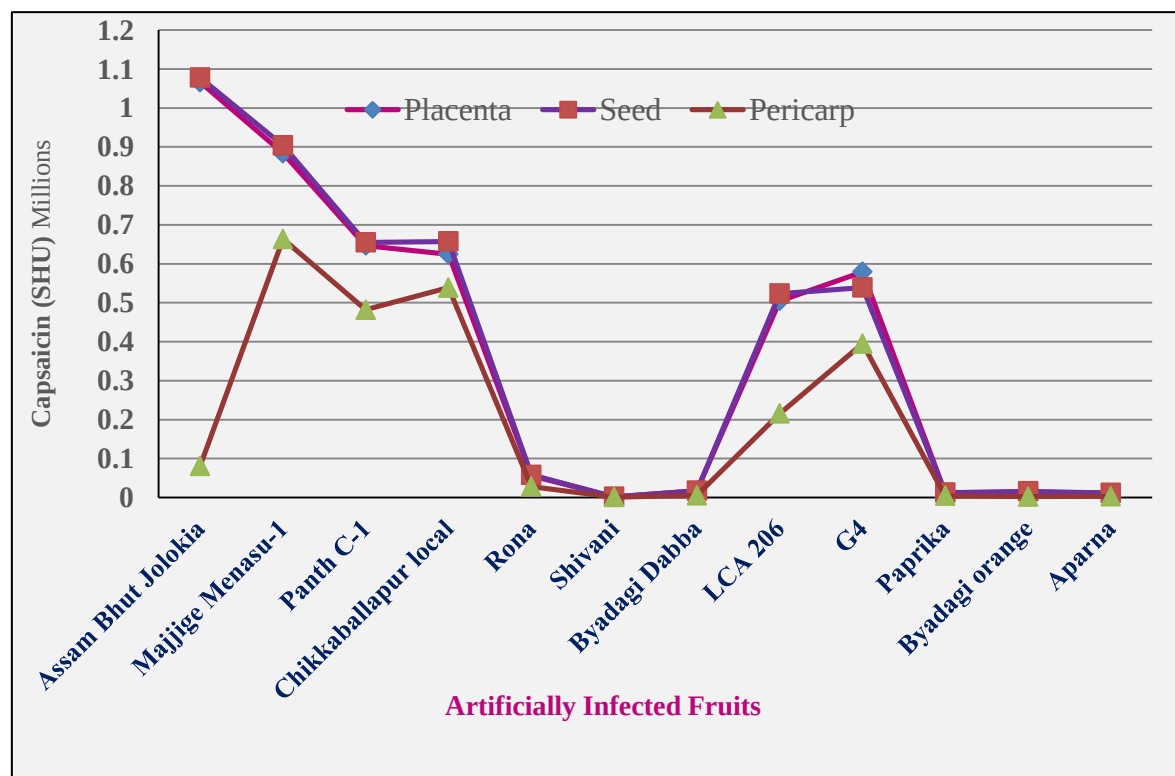


Fig. 5.13. Fruit rot incidence and severity in relation to capsaicin and oleoresin content

respectively). The highest vigour index-II was recorded in Byadagi Dabba (1404) whereas the lower vigour index-II was recorded in Assam Bhut Jolokia (376). In AIF the highest vigour index-II was recorded in Chikkaballapur local (874) whereas, lower was recorded in Assam Bhut Jolokia (256).

Assam Bhut Jolokia, Majjige Menasu-1 and Panth C-1 with capsaicin content (1016960, 832028 and 722364 SHU, respectively) and oleoresin content (14.2, 4.29 and 11.79 %, respectively) recorded lower true lesion diameter of 0.77, 0.80 and 0.77 cm, respectively in NIF (*Fig. 5.13*). Whereas, the highest true lesion diameter was recorded in Shivani (2.87 cm) with Aparna (2.63 cm) followed by LCA 206 (2.33 cm) recording lower capsaicin content (1630 and 5983 SHU, respectively) and higher oleoresin content (12.28 and 17.83 %, respectively) compared to artificial inoculation of fruits. Where in, AIF of genotypes Assam Bhut Jolokia and Majjige Menasu-1 recorded lower true lesion diameter of 0.8 cm each. However, genotypes LCA 206 recorded highest (3.1 cm) followed by Shivani (2.9 cm) (*Fig. 5.14*). These genotypes after AIF recorded significantly lower capsaicin (811130, 663626 and 215627 SHU, respectively). The oleoresin content of AIF genotypes recording lower true lesion diameter was 13.38, 3.76 and 14.13, respectively.

Either decreased reduction in capsaicin content (20.24, 20.24 and 34.20 %, respectively) or increased reduction in oleoresin content (4.57, 12.24 and 9.08 %, respectively) might have contributed for the inoculum of *C. capsici* for the increased rate of establishment in manifesting the anthracnose fruit rot. Similar results were also reported by Hegde and Kulkarni (2001), Jeyalakshmi and Seetharaman (1999), Wilawan *et al.* (2008), Molina Torres *et al.* (1999) and Tewksbury *et al.* (2008).

Healthy fruits, naturally infected (NIF) and artificially inoculated (AIF) fruits with anthracnose showed significant differences for capsaicin content in Scoville Hot unit (SHU) among the hot pepper genotypes under study (*Fig. 5.12, 5.13 and 5.14*). However, the per cent reduction in capsaicin content in Pericarp, placenta and seed was high in naturally infected fruits than artificially inoculated fruits. All the genotypes showed positive reaction for *Colletotrichum* inoculation under *in vitro* conditions.

The capsaicin content varied significantly in placenta, seed and pericarp of NIF and AIF. The genotype Assam Bhut Jolokia (Plate 5.2 and 5.3) recorded highest capsaicin content (1113963, 1078003, and 882100 SHU) in placenta, seed and pericarp respectively. The lowest was recorded in genotype Shivani (1779, 1362, and 1138 SHU) in placenta, seed and pericarp respectively in naturally infected fruits. Whereas, in AIF genotype Assam Bhut Jolokia recorded highest capsaicin content (1078003, 1066025, and 811130 SHU) in placenta, seed and pericarp respectively. The lowest was recorded in genotype Shivani (1665, 1587, and 975 SHU) in placenta, seed and pericarp respectively (*Fig. 5.14*) (Plate 5.4 and 5.5). The present findings are in agreement with Tewksbury and Nabhan (2001) and Jamiolkowska (2014). They also reported such variations in capsaicin content in healthy and infected fruits of hot pepper.

The present study revealed that, oleoresin content of healthy fruits, naturally infected (NIF) and artificially inoculated (AIF) fruits of anthracnose fruits differed significantly among the genotypes. Highest per cent oleoresin was recorded in Byadagi Dabba (21.14, 16.37 and 18.57 %, respectively) (*Fig. 5.15*) followed by Paprika (19.02 14.52 and 16.74 %, respectively) which recorded higher lesion diameter both in NIF and AIF (2.10, 2.30cm and 1.67, 2.17 cm, respectively). While, the lowest oleoresin content was recorded in Majjige Menasu-1 (4.29, 3.25 and 3.76 %) which recorded lower lesion diameter both in NIF and AIF (0.80 cm, respectively). Naveen Kumar. (2009) and Prathibha *et al.* (2013) also reported similar findings indicating increased content of oleoresin is positively correlated with disease reaction and severity in hot pepper.

5.5 Seed quality attributes as influenced by capsaicin and oleoresin during storage

The importance of seed storage to mankind has been recognized since prehistoric times (Priestley, 1986). Most seed storage practices have developed empirically, often as a result of a combination of chance observation and pragmatic decisions on what can be achieved most easily by way of environmental control or modification. In agriculture, for example, the driving force for such empirical knowledge has been the simple practical requirement to store seeds reliably from harvest to the next production season.

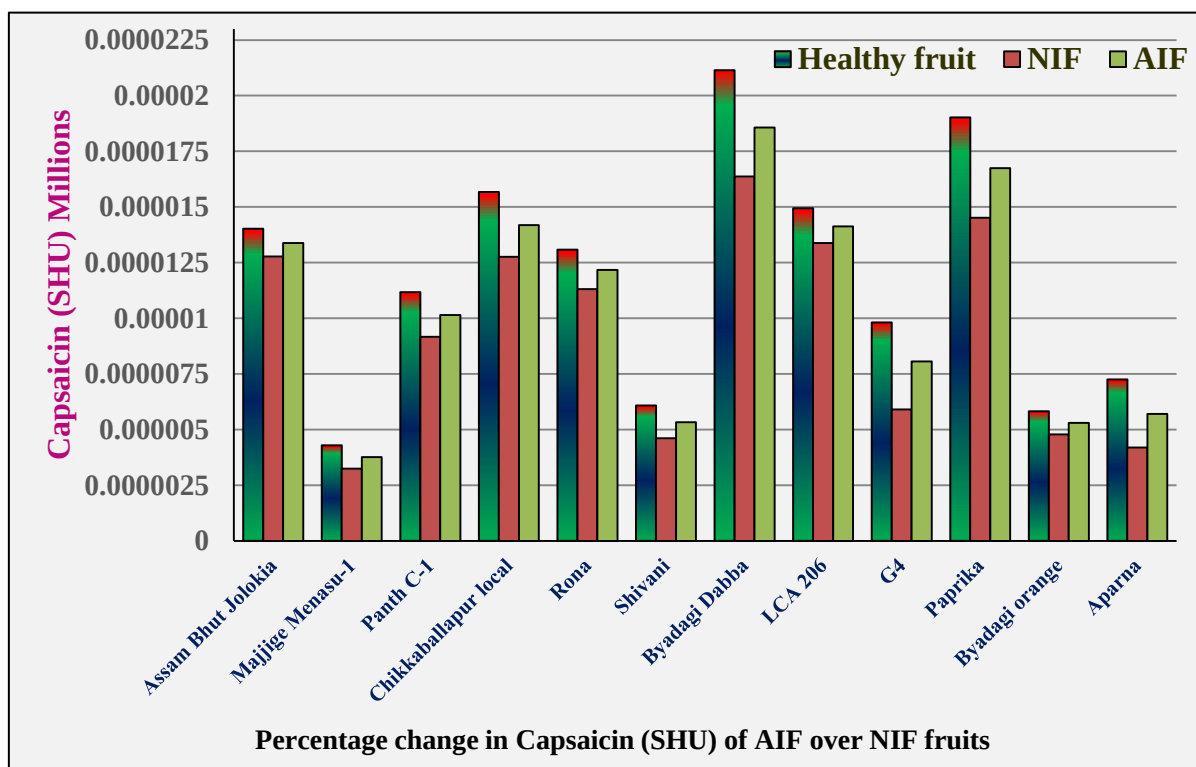


Fig. 5.14. Fruit rot incidence and severity in relation to capsaicin and oleoresin content

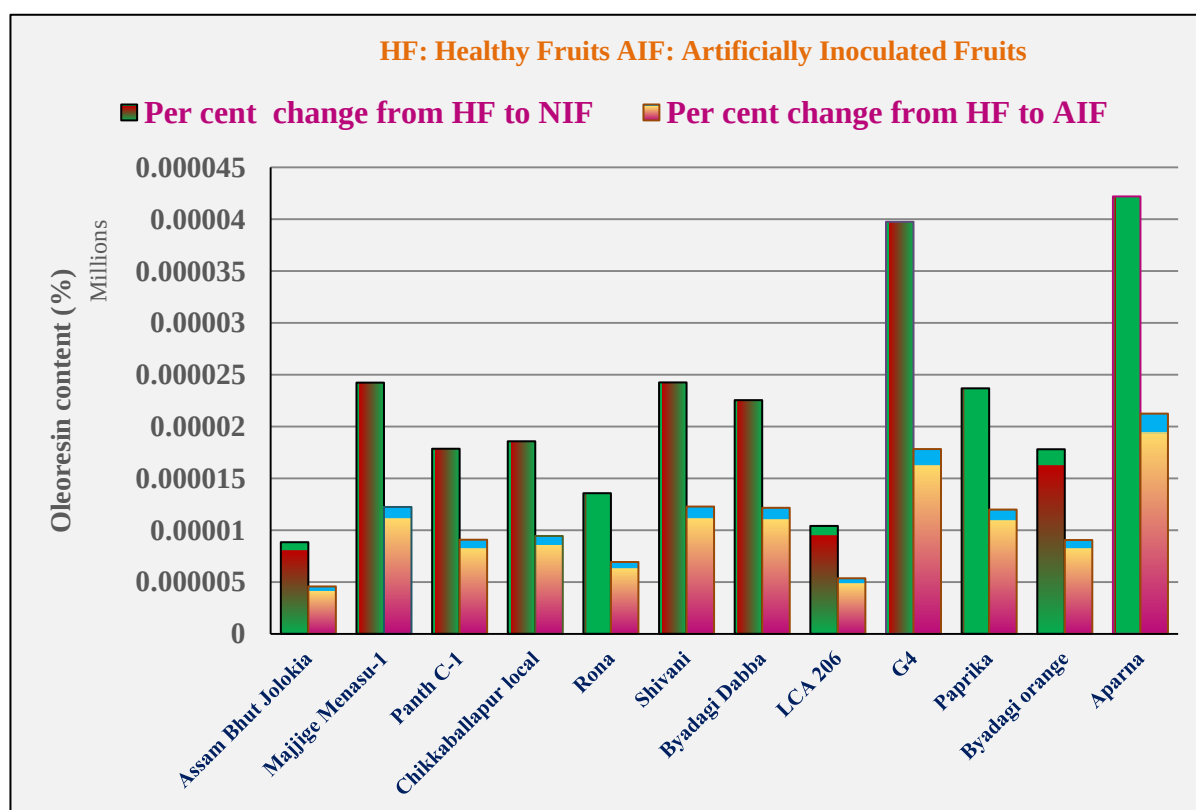


Fig. 5.15. Fruit rot incidence and severity in relation to capsaicin and oleoresin content

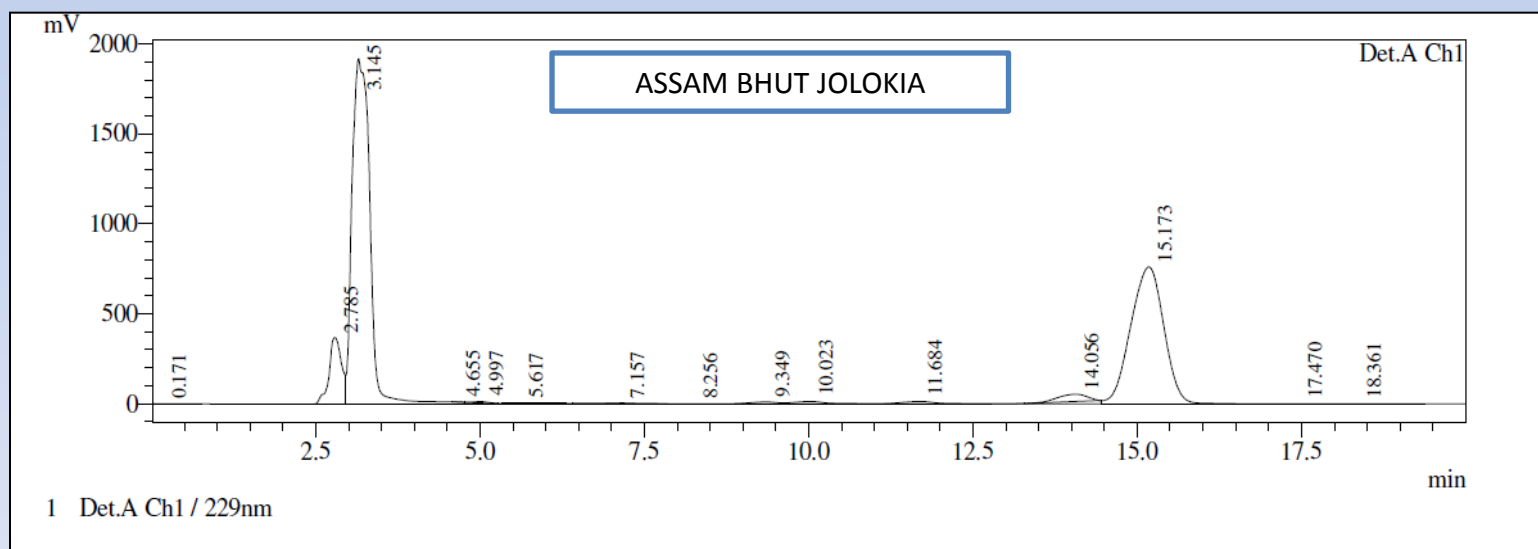
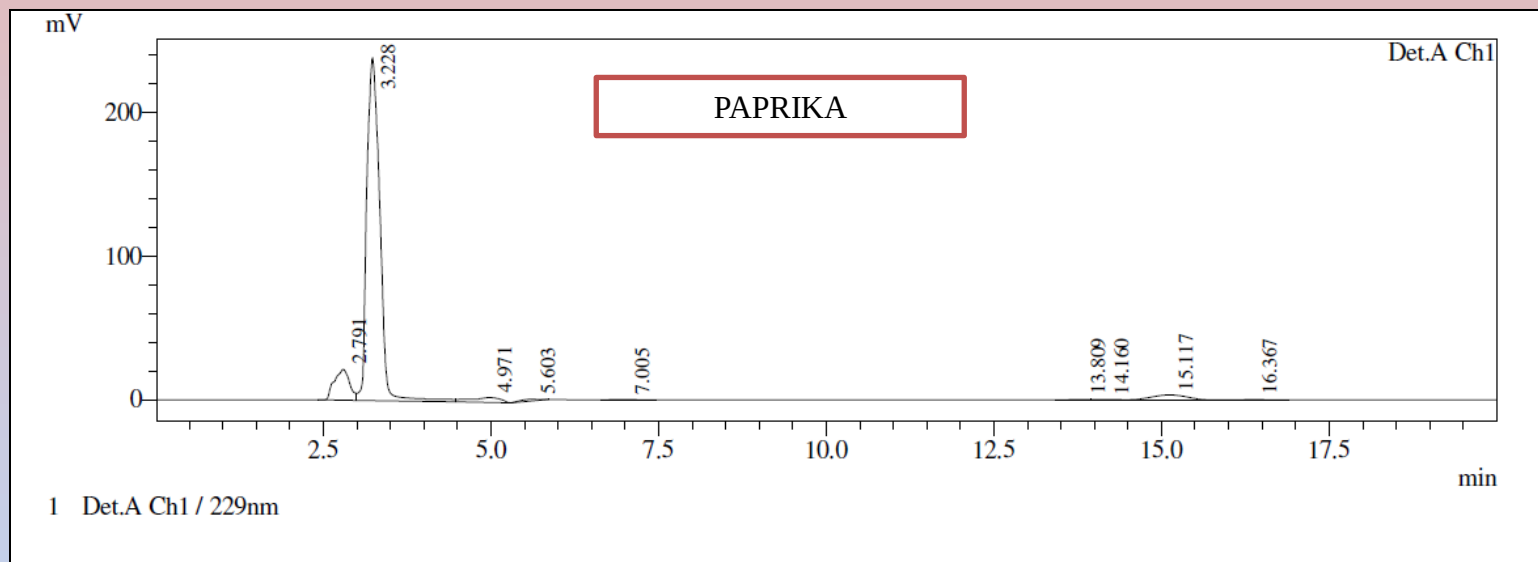


Plate 5.2. Chromatogram of capsaicin determination by HPLC method in Paprika and Assam Bhut Jolokia

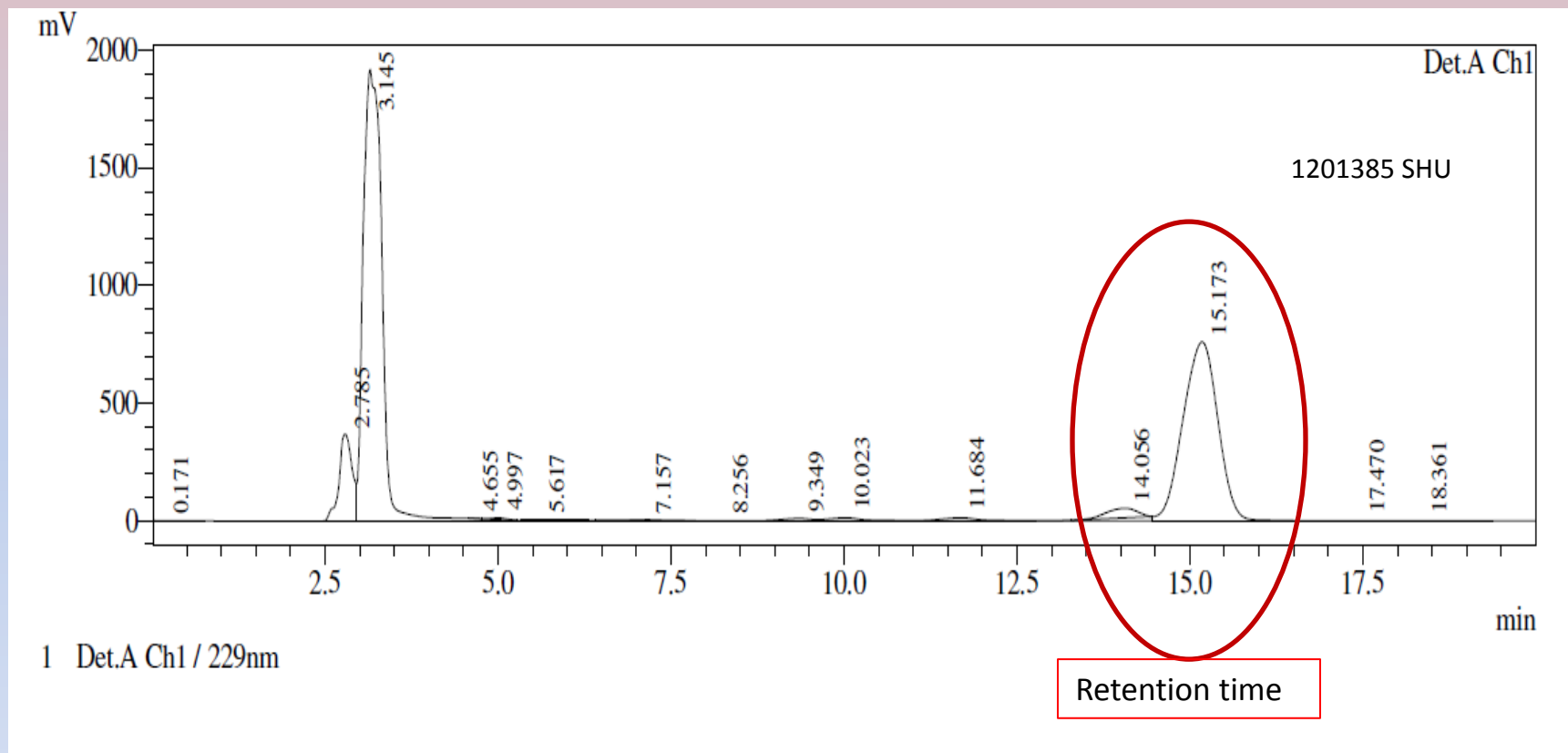
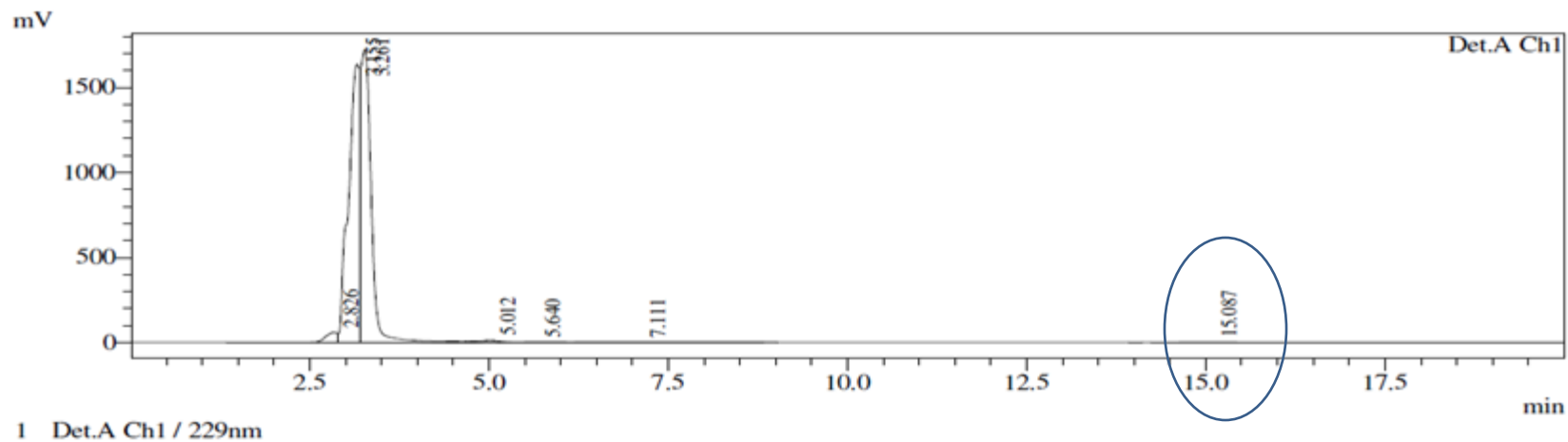


Plate 5.3. HPLC chromatogram with highest pungency (1201385 SHU) of whole fruit dried Assam Bhut Jolokia sample powder

Chromatogram

(A) Byadagi Dabba



Chromatogram

(B) Assam Bhut Jolokia

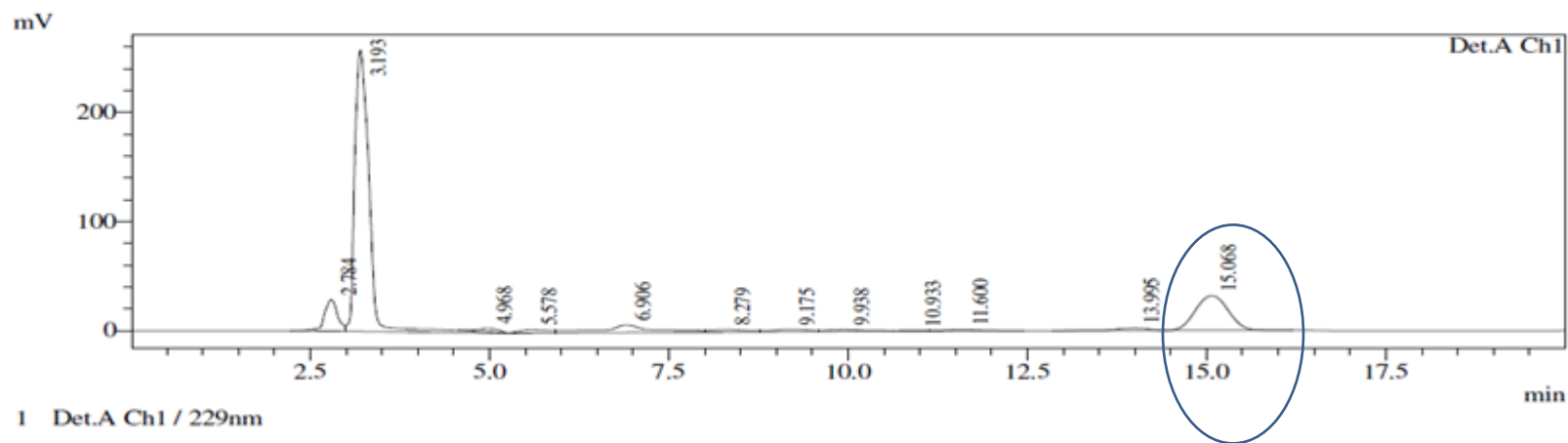
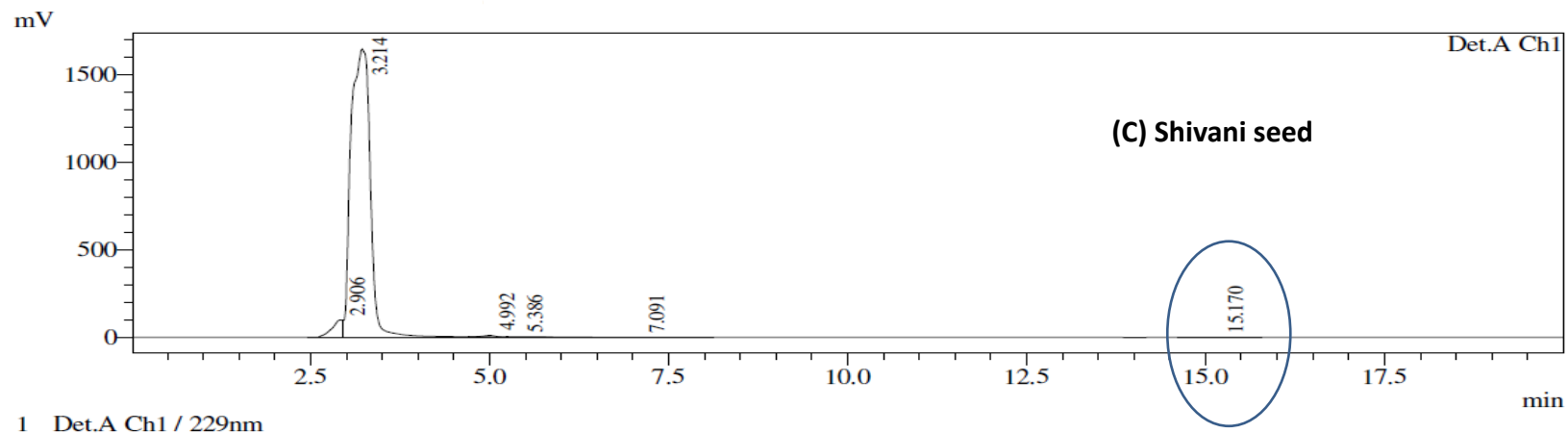


Plate 5.4. HPLC chromatograms of dried seeds of genotypes Byadagi Dabba and Assam Bhut Jolokia

Chromatogram



Chromatogram

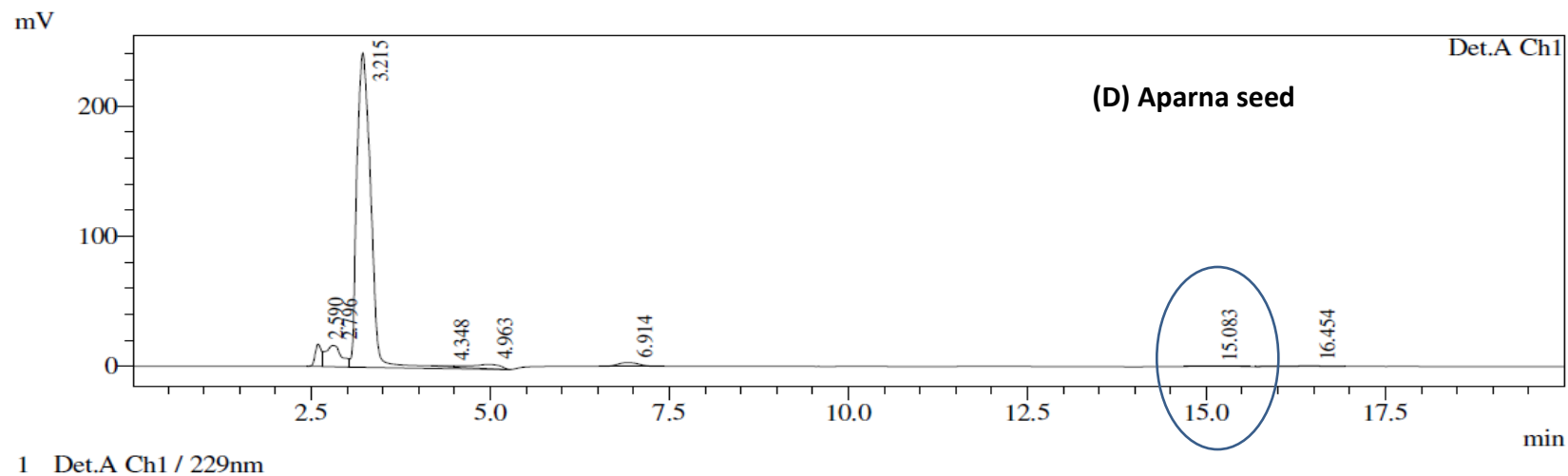


Plate 5.5. HPLC chromatograms of dried seeds of genotypes Shivani and Aparna

Seed deterioration which is an irreversible and inexorable process could not be prevented completely during storage. Physiological quality of the seeds is highest when it completes 'structural' and 'functional' development on the mother plant itself. Thereafter, it deteriorates irreparably and irreversibly at varying rates (Mc Donald, 1999). The rate of deterioration mainly depends on seed composition. Hot peppers are the rich source of vitamin 'A', 'C' and numerous chemicals including steam-volatile oil, fatty oils, capsaicinoids, carotenoids, vitamins, protein, fibre, and mineral elements (Bosland and Votava, 2000; Anon., 2003). Capsaicin is a bioactive molecule of food and of medicinal importance and its analogues called capsaicinoids synthesized in placenta of the fruits are the compounds responsible for the pungency of the fruits and seed. The present study envisages importance of catabolic activity of pungent principles (capsaicinoids) and colouring pigments (carotenoids) in order to understand hot pepper seed storage.

Among genotypes, higher seed moisture was recorded in Byadagi Dabba (7.6 %) and G4 (7.53). The lower seed moisture was recorded in Shivani (7.09 %) followed by Aparna (7.25 %), Rona (7.42 %) respectively at the end of 24 months of storage (*Fig. 5.16 and 5.16a*). This variation in moisture content implies greater sensitivity of genotypes to storability. Which could be attributed to genotypic factor besides physico-chemical properties i.e., seed composition may vary with genotypes. Among, fruit and seed stored, fruits recorded significantly higher moisture (8.40 %) compare to seeds (6.39 %) at the end of storage. This might be attributed to the reduction of water binding sites due to chemical and structural changes in cells of the seed samples. Similar results were observed in onion by Kumar and Sreenarayanam (2000). While, brown paper cover has registered higher seed moisture (7.51 %) whereas aluminium foil pouches registered lower seed moisture (7.24 %) at the end of 24 months of storage. This could be attributed to air tight conditions maintained by aluminium foil pouches which helped in preventing absorption of moisture from the surrounding air. Seeds in vapour pervious container have gained relatively higher moisture than seeds aluminium foil pouches and due to the higher vapour pressure gradient between the seeds and external environment. Aluminium foil pouches acted as moisture proof barrier. Similar results were reported by Doijode (1997) in hot pepper and brinjal and Sharma *et al.* (1998) in hot pepper varieties.

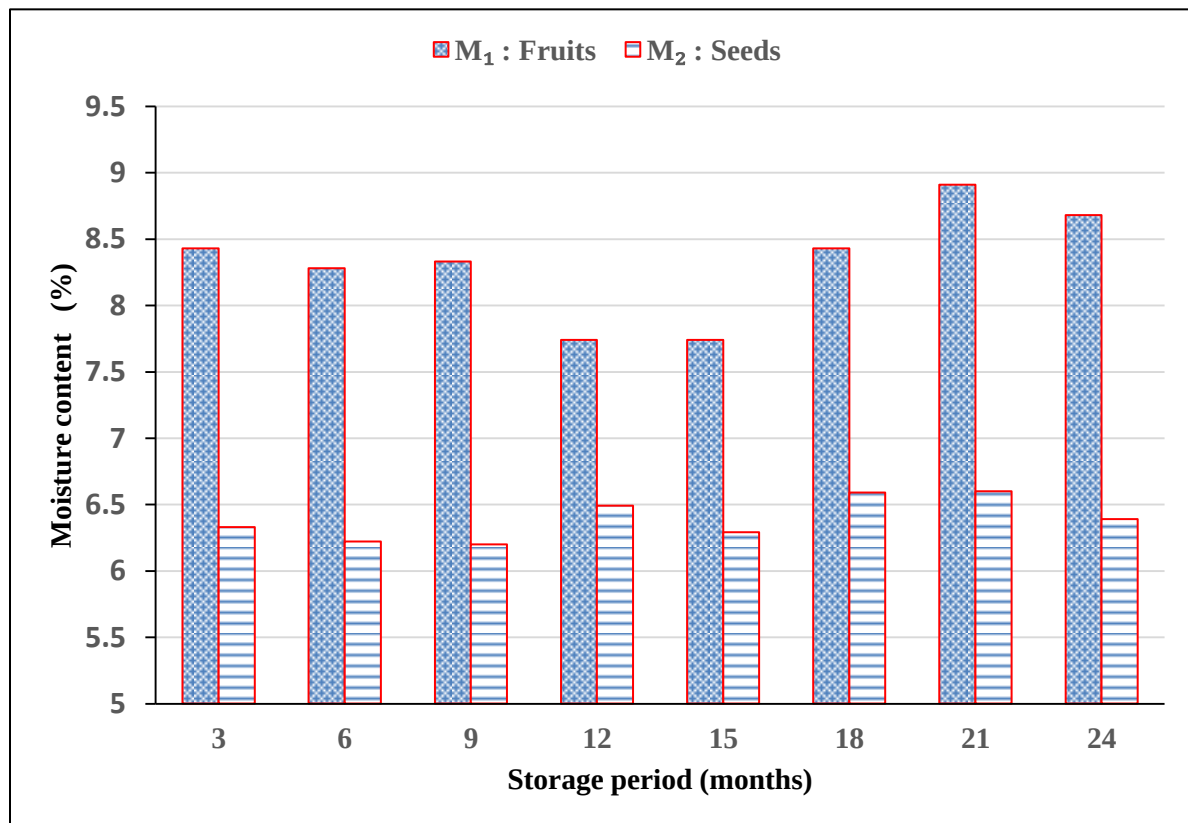
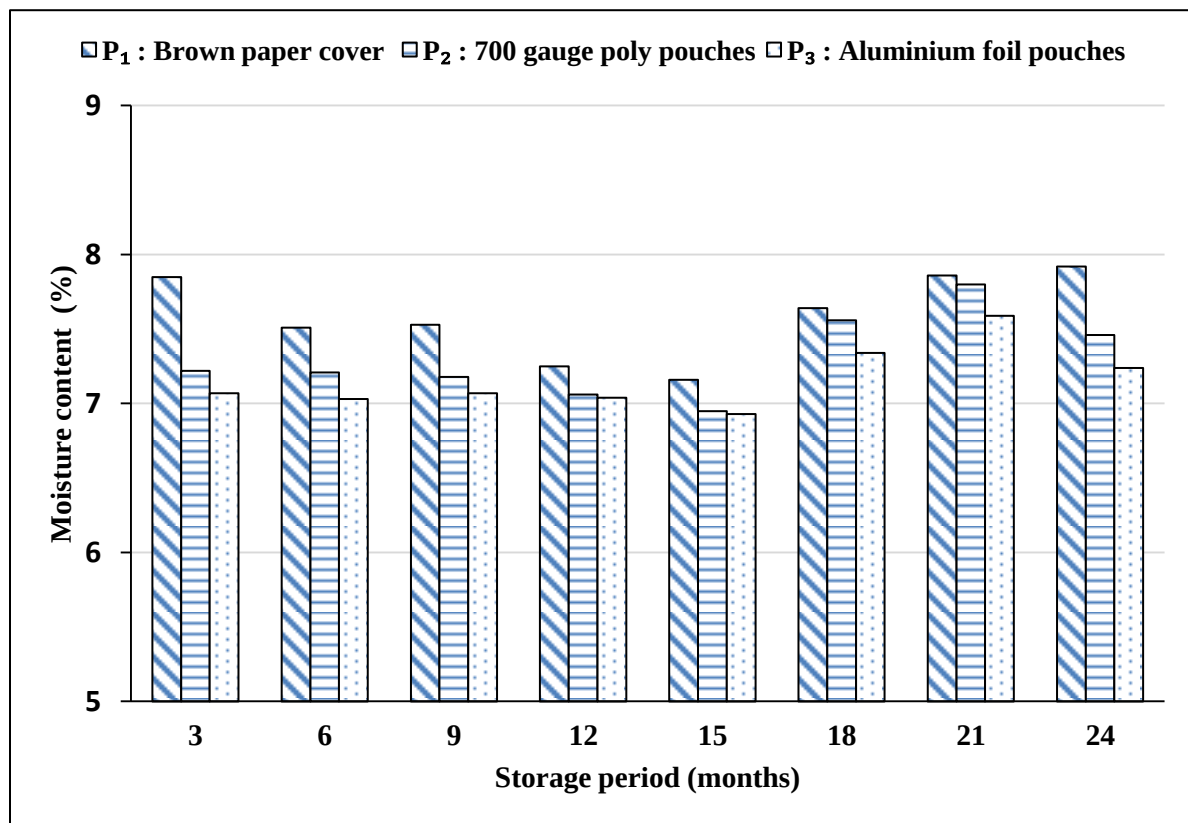


Fig. 5.16 . Moisture content as influenced by packaging material, fruits and seeds on storability

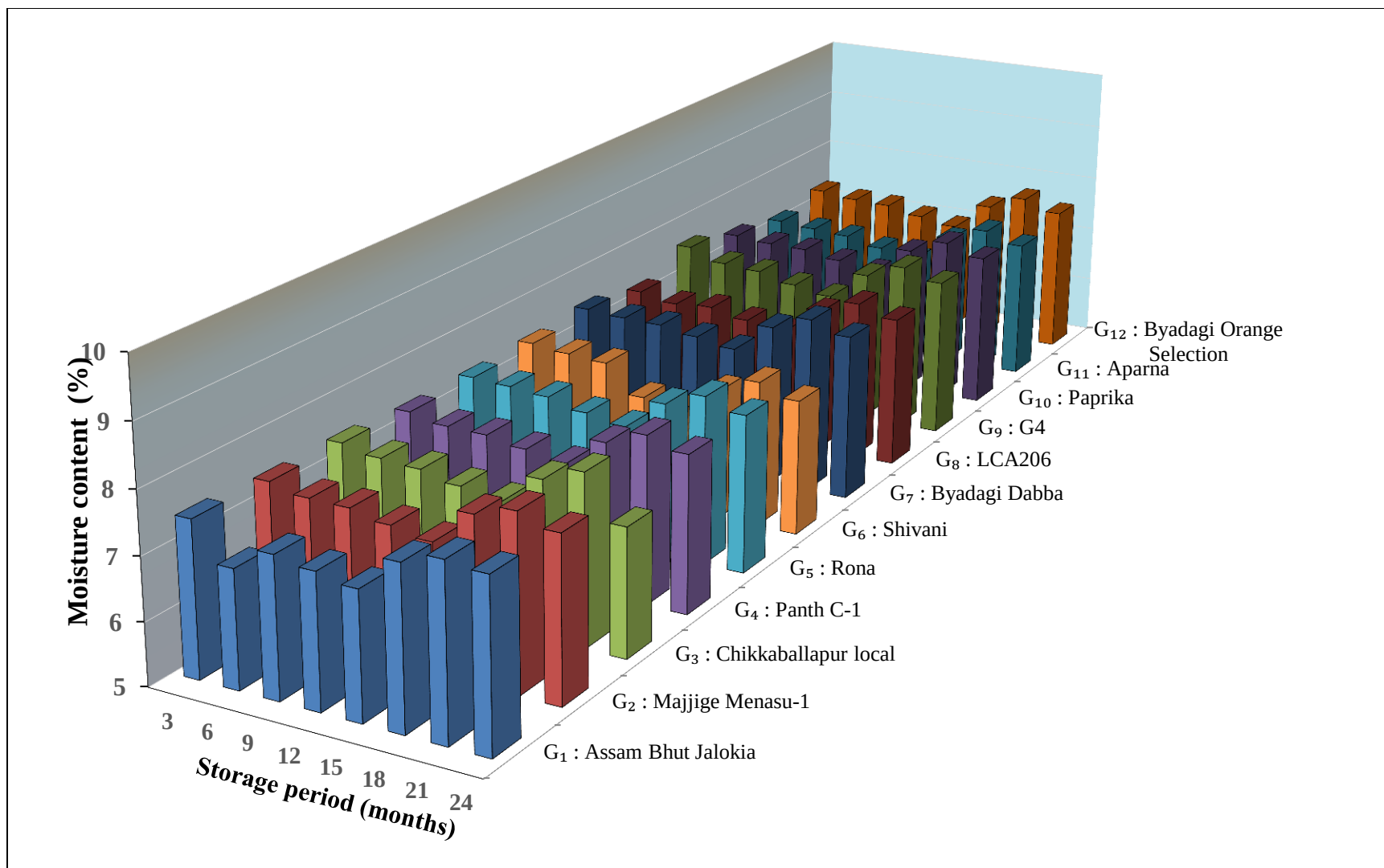


Fig. 5.16a. Moisture content of seed as influenced by genotypes, fruits, seeds and packaging material on storability

Ageing process also disrupts cellular structures and impairs key physiological functions. In present study, among genotypes lower electrical conductivity was recorded in Aparna ($71.23 \mu\text{S cm}^{-1} \text{g}^{-1}$) and higher electrical conductivity was recorded in Chikkaballapur local ($93.90 \mu\text{S cm}^{-1} \text{g}^{-1}$) at the end of the storage period which could be attributed to resistance of genotype to age induced phenomenon in most kind of seeds i.e., inevitable and irreversible. Among fruits and seeds stored, lower electrical conductivity ($77.10 \mu\text{S cm}^{-1} \text{g}^{-1}$) registered in seeds and higher electrical conductivity in fruits ($79.14 \mu\text{S cm}^{-1} \text{g}^{-1}$). At end of month of storage period, the lower EC was recorded in 700 gauge poly pouches ($76.87 \mu\text{S cm}^{-1} \text{g}^{-1}$) and higher EC was recorded in aluminium foil pouches ($79.15 \mu\text{S cm}^{-1} \text{g}^{-1}$). This may be ascribed to less fluctuation of moisture in aluminium foil pouches which might have reduced the deterioration rate by maintaining membrane integrity. The various factors acting on seeds such as fluctuation in relative humidity and temperature in pervious container including fungal invasion might have enhanced the process of degradation of membrane integrity leading to higher quantity of electrolytes to leach out. This is in accordance with the findings of by Sharma *et al.* (1998) and Ravi Hunje *et al.* (2007b) in hot pepper (*Fig. 5.17 and 5.17a*).

With the advance in the storage period, irrespective of seed source all the seed quality parameters were gradually decreased. It is generally seen that reduction in germinability depends on duration of aging. Germination decreases with increase in ageing period, as seen by Ravi Hunje *et al.* (2007b) in hot pepper due to natural aging. Among seed quality attributes, seed germination greatly influenced by ageing process, but the response intensity and harmful effects of stress depend on the genotypes. At end of the storage month, genotype Rona had shown resistant to ageing process by maintaining higher seed germination (69 %) compare to other genotypes, whereas lower germination was maintained by Assam Bhut Jalokia (11%) (*Fig. 5.18 and 5.18a*). The findings of the study are in concord with, Thaigarajan (1994) who noticed that difference in germination in hot pepper was due to variation in genetic makeup. Among fruits and seeds materials employed for storage, seeds in fruits were able to maintain by higher seed germination (57 %) and lower seed germination (54 %) was registered in seeds. Demonstrating the advantage of storing fruits over seeds in maintaining seed germination

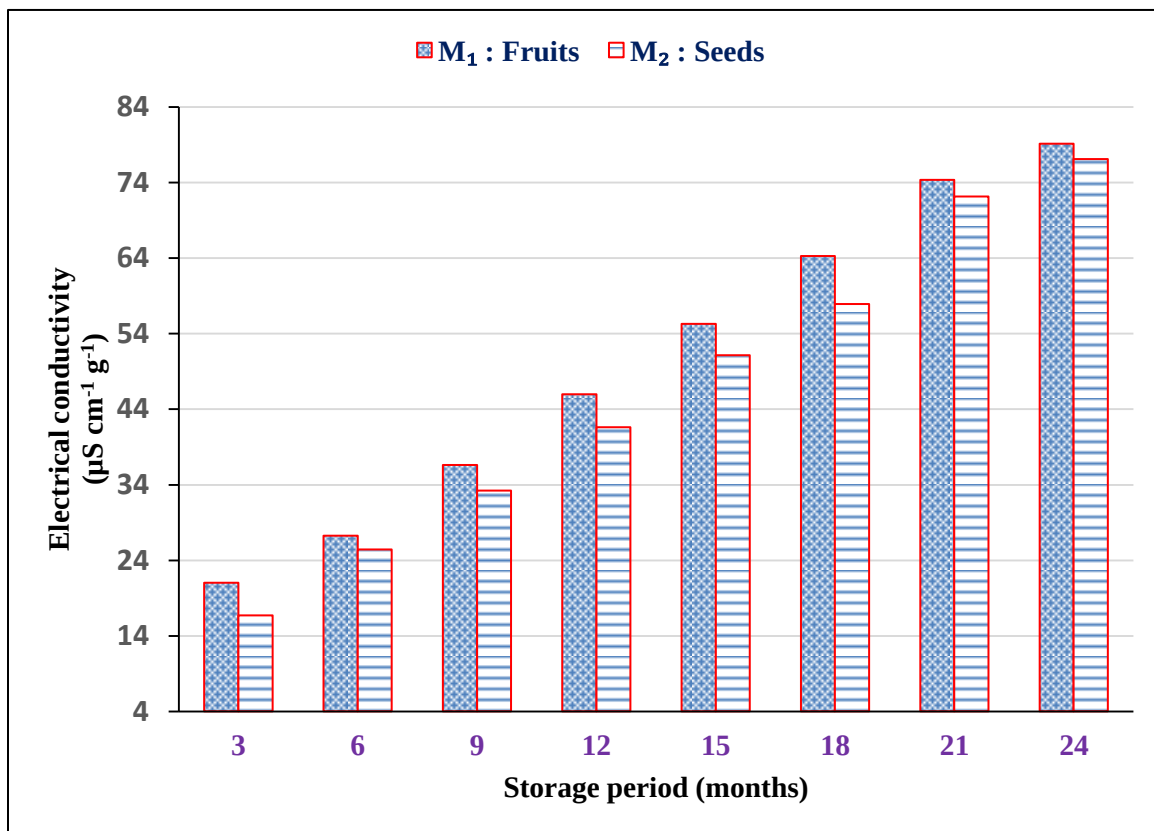
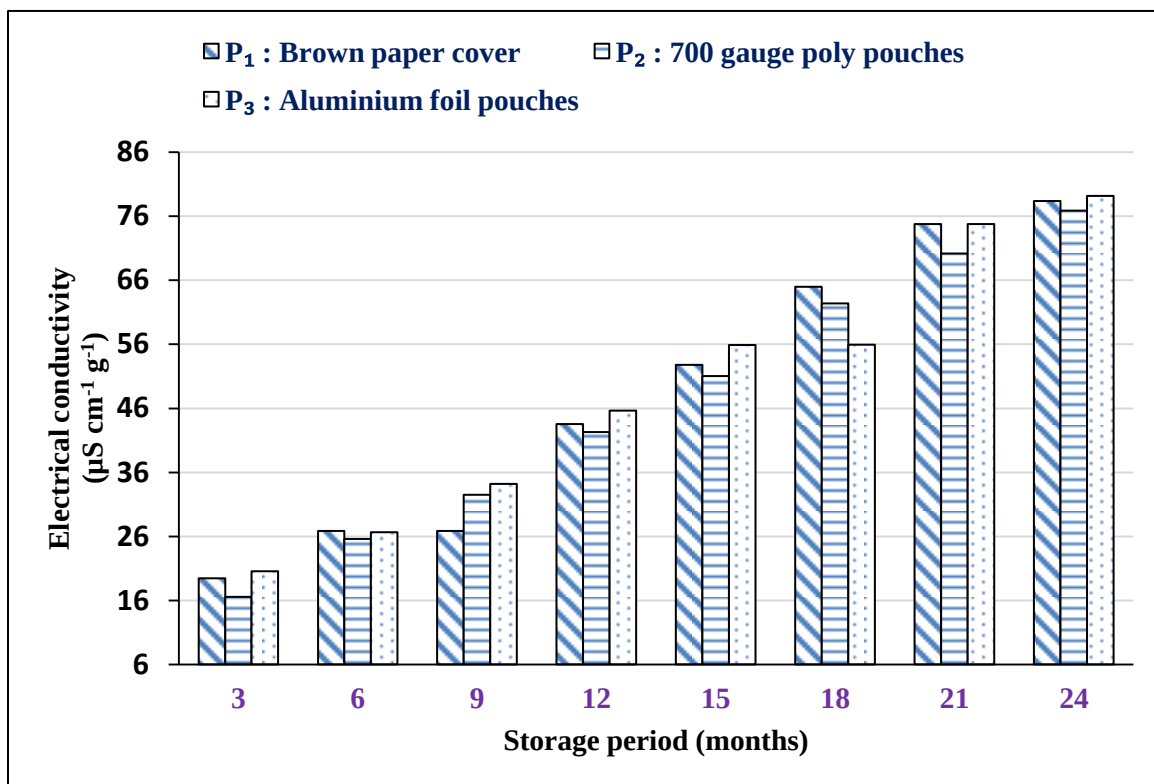


Fig. 5.17. Electrical conductivity of seed leachate as influenced by packaging material, fruits and seeds on storability

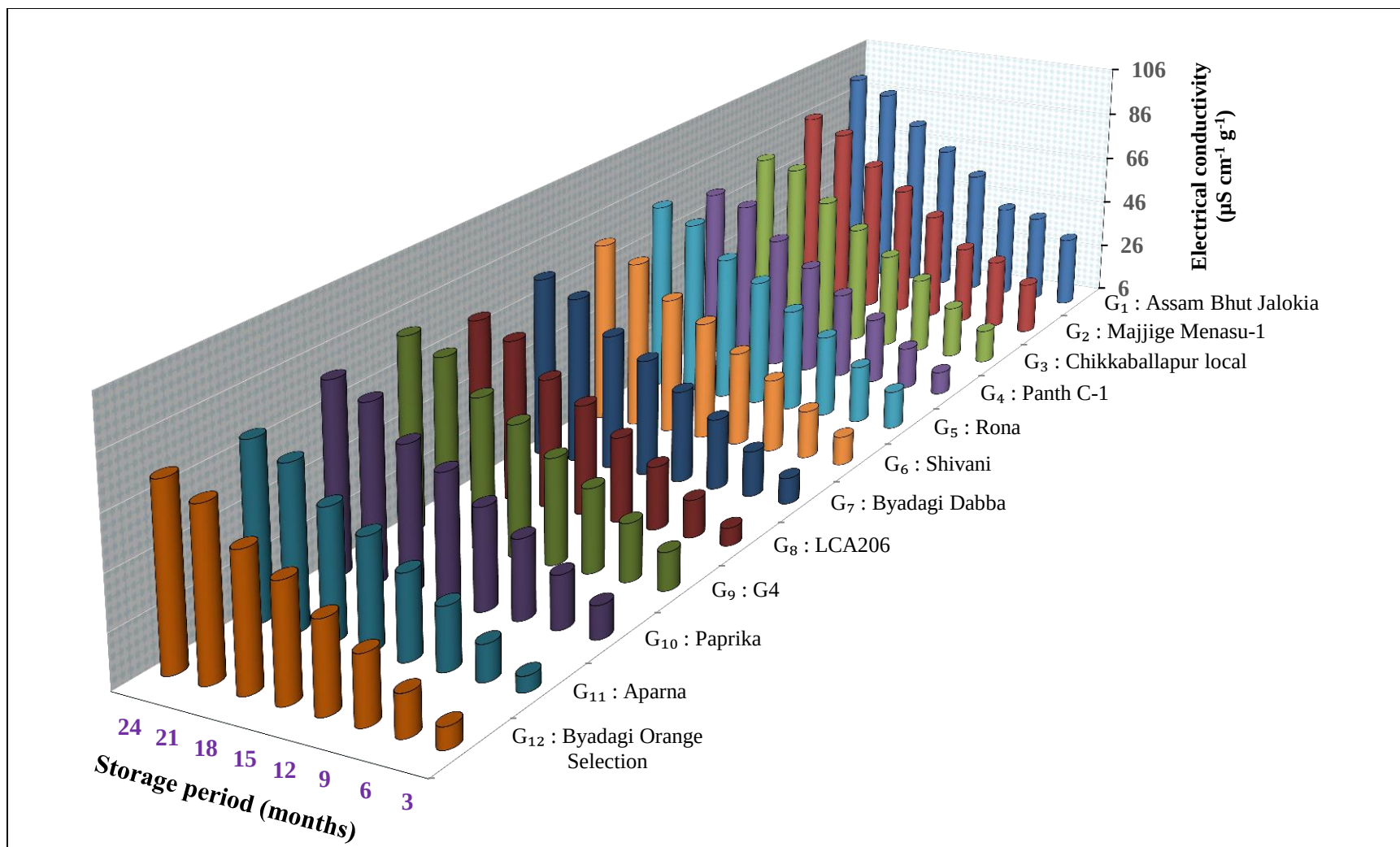


Fig. 5.17a. Electrical conductivity of seed leachate as influenced by genotypes, fruits, seeds and packaging material on storability

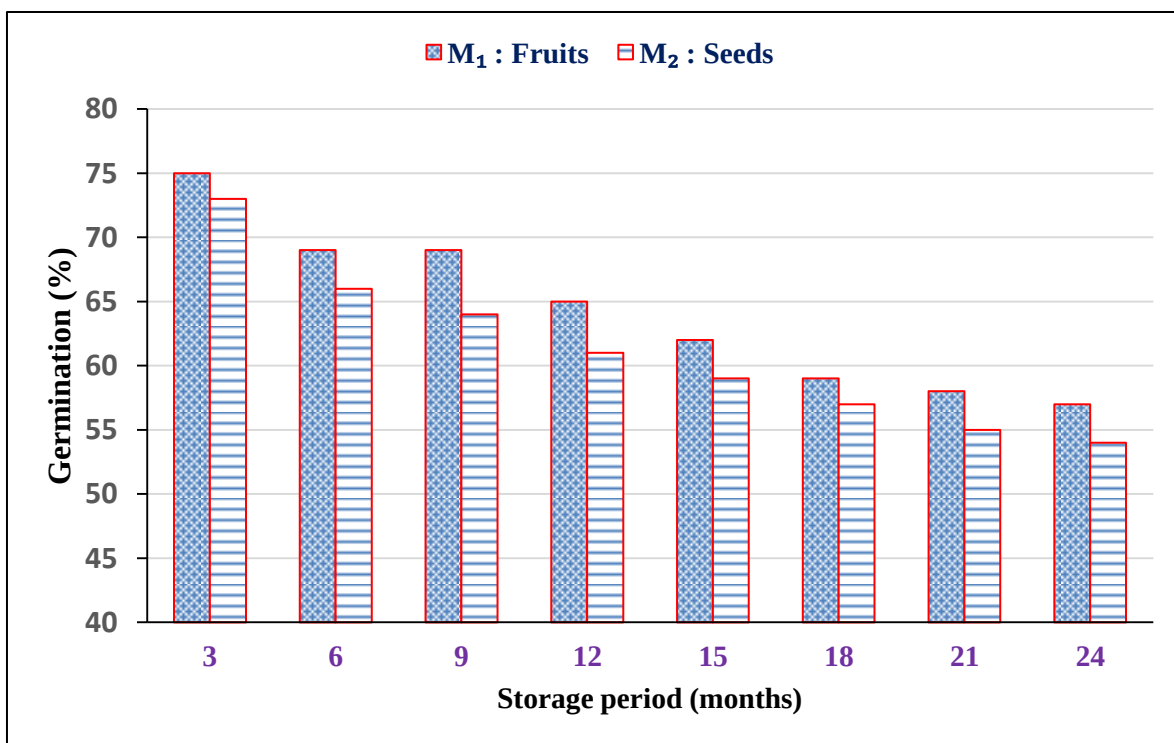
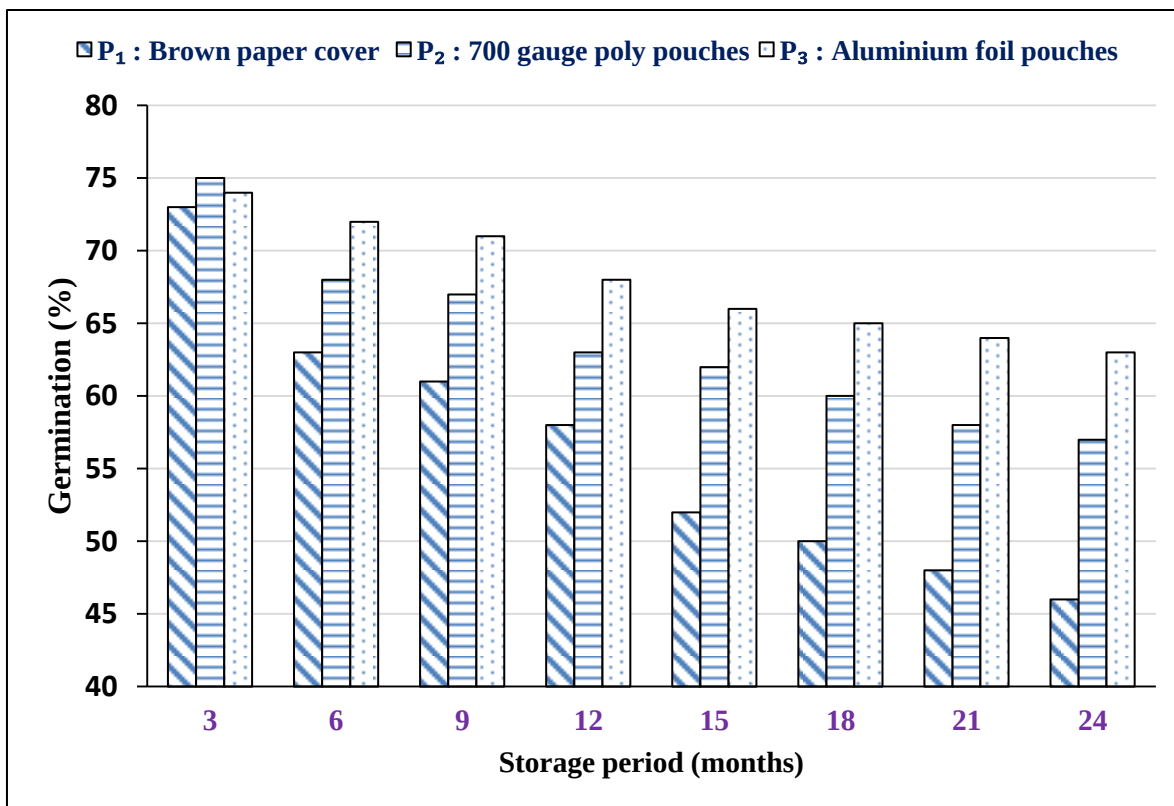


Fig. 5.18. Germination percentage as influenced by packaging material, fruits and seeds on storability

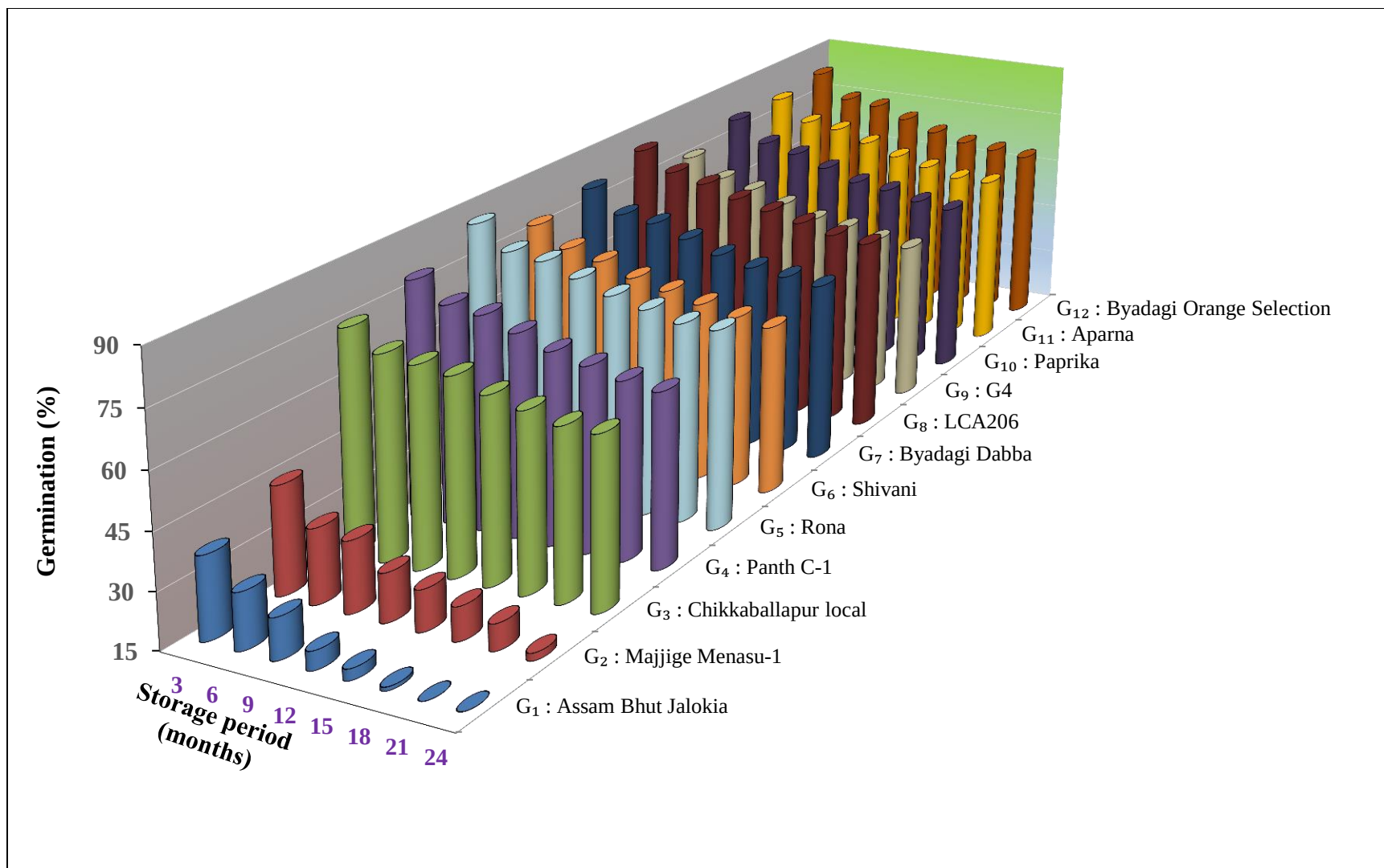


Fig. 5.18a. Germination percentage as influenced by genotypes, fruits, seeds and packaging material on storability

for longer period. The benefit is likely to have been derived from protection provided by the fruits against free radical attack by capsaicin through the carotenoids fungal attack which is very common under natural storage. These results are in conformity with findings of Stewart *et al.* (2005) in pepper who perceived that, fruit were rich in capsaicin and its analogues capsaicinoids synthesized in placenta of the fruits which were the compounds (at minimum concentrations) responsible for maintenance of internal physiology (a complex series of metabolic processes such as water imbibition, respiration, mobilization of food reserves, nucleic acid and protein synthesis, as well as cell differentiation and growth) with least disturbance by ROS by acting as antioxidant (Qumer *et al.*, 2015). Thus germination was maintained for a longer period in fruits than exposed seeds. Among packing materials, higher seed germination (63%) was maintained aluminium foil pouches and lower seed germination per cent was registered in brown paper cover (46 %) which could be attributed to maintenance of lower moisture content during the storage period, since it acted as moisture proof barrier. The lower moisture content might had resulted in lower respiration rate, lower catabolic activity (in terms of energy exhaustion) by inhibiting the hydrolytic enzymes (catalyzes stored materials) by maintaining unfavorable conditions for essential for activation and by maintaining integrity of all cellular structures essential for normal germination. Thus it can able to maintain energy availability until the germination process as reported by Angamuthu (1996) in rice.

Ageing process not only influence seed germination percentage but also seriously affects early seedling growth: seedlings are highly sensitive to stress induced by ageing process and require normal conditions for continued growth. There was a genotypic variation for mean seedling length. Among genotypes, the higher seed mean seedling length was recorded in Byadagi Dabba (13.71 cm) and lower was recorded in Assam Bhut Jolokia (3.69 cm) at end of the storage month (*Fig. 5.19 and 5.19a*). The variation might be attributed to genotypic factor besides physic-chemical properties like seed composition. Reason behind these negative effects may be the disturbance in the physiology due to increased sensitivity of genotype to ageing process, which affects metabolism in terms hydrolysis of stored products which are utilized for cell expansion,

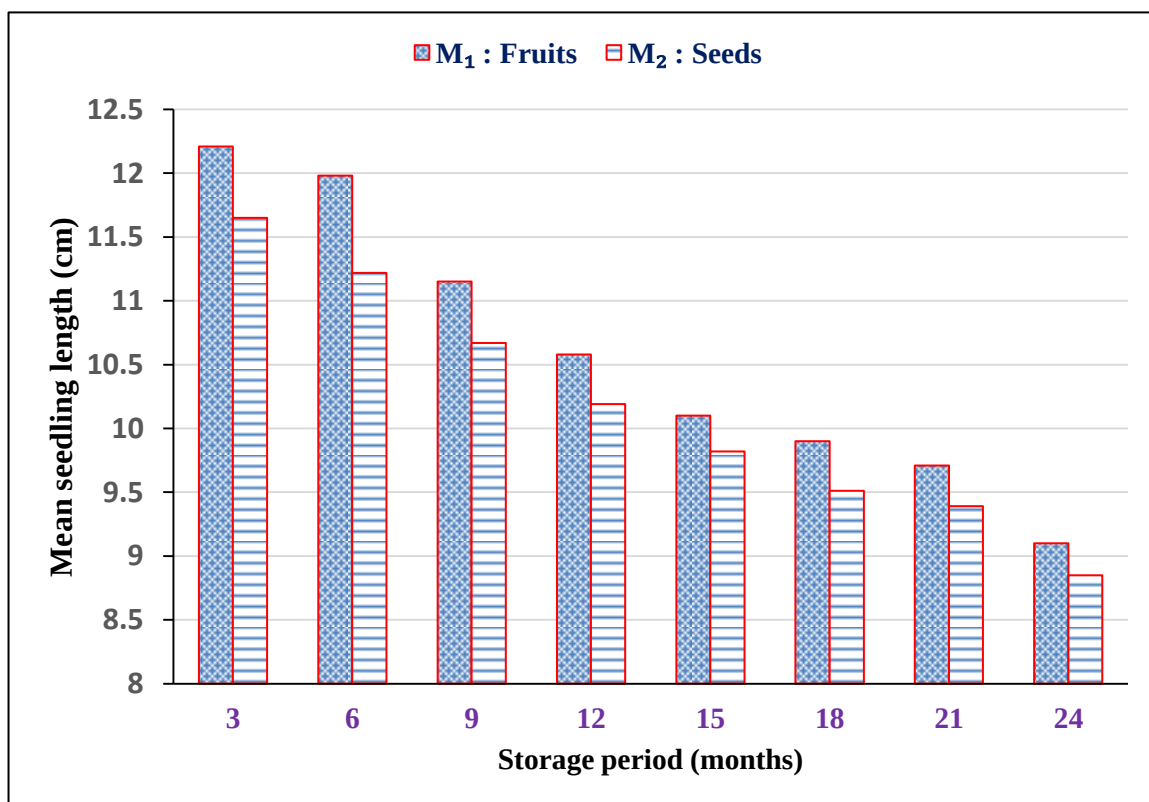
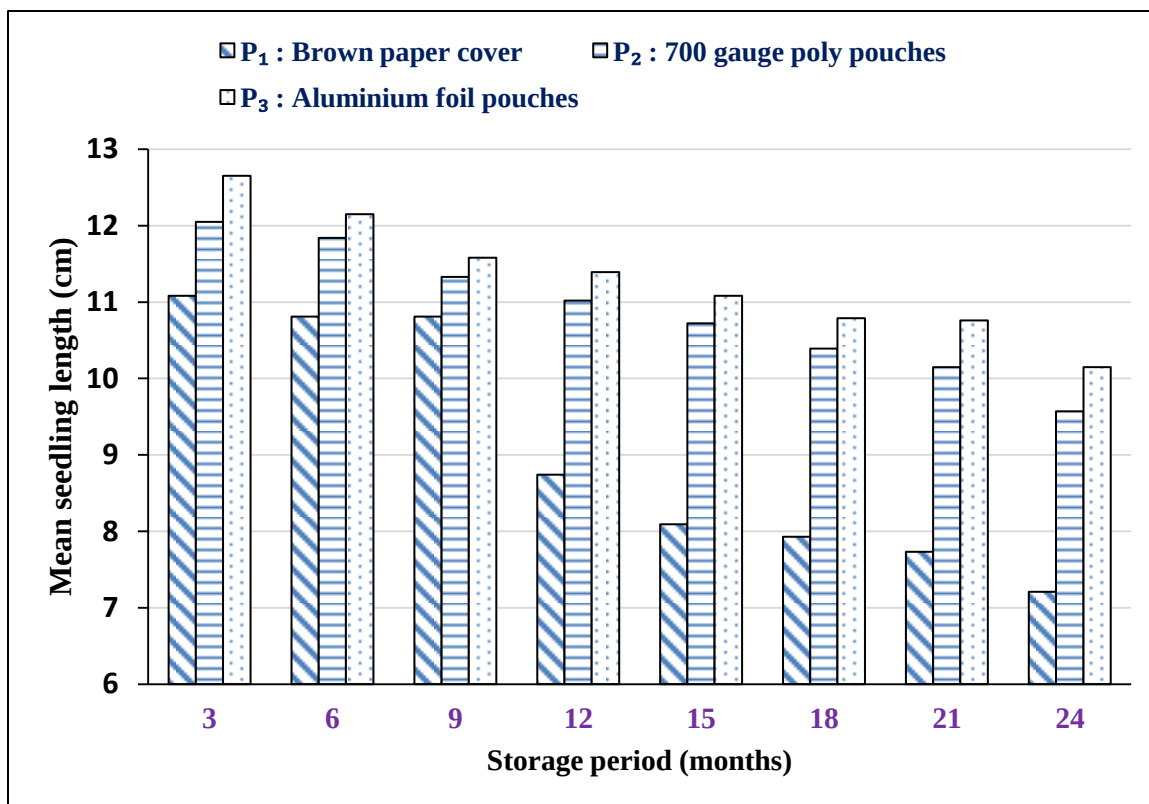


Fig. 5.19. Mean seedling length (cm) as influenced by packaging material, fruits and seeds on storability

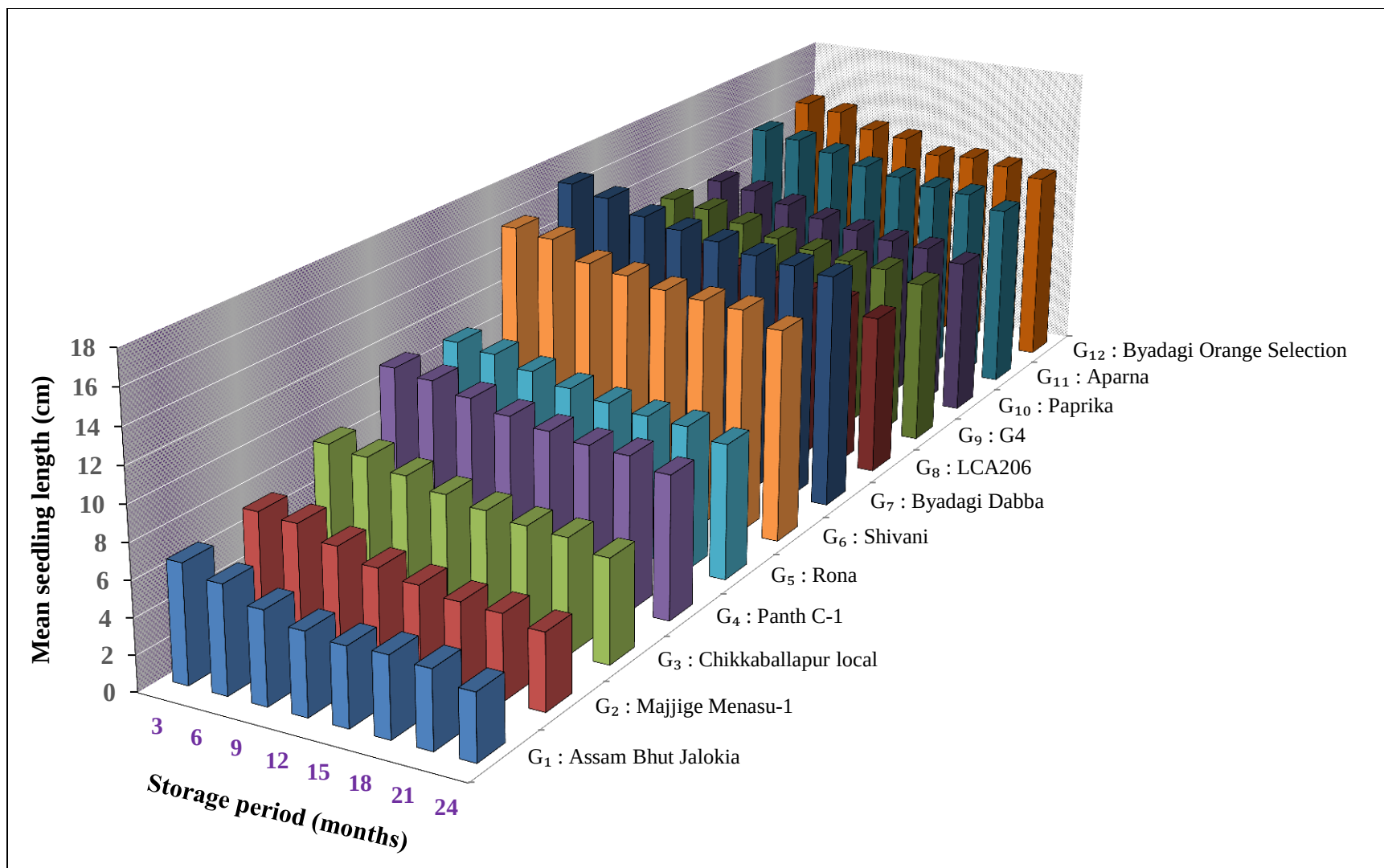


Fig. 5.19a. Mean seedling length (cm) as influenced by genotypes, fruits, seeds and packaging material on storability

seedling tissue synthesis, radicle and plumule elongation (Thaigarajan, 1994 in hot pepper ; Abdul, 2009 in maize; Khayatnezhad *et al.*, 2010) in maize). At the end of storage month, seeds from fruits have maintained higher mean seedling length (9.10 cm) whereas seeds maintained lower mean seedling length (8.85 cm). The results were in agreement with Thaigarajan, (1994) who observed that, defects in cellular activities viz., cell division and cell elongation in hot pepper was mainly due to lack metabolism in terms hydrolysis of stored products essential for development of essential structures. The higher seed mean seedling length (10.15 cm) was registered in P₃ and lower seed mean seedling length was recorded in brown paper cover (7.21 cm). The results were in agreement with Tripathi (2014) in onion. The reason may be pervious container allowed higher moisture entry in to the seed which was congenial for seed metabolites as well as for growth of fungus and activate the some of the deleterious enzymes like lepoxygenase which has the capacity to generate free radicals as the seed moisture increases. These are responsible for chromosomal abnormalities which adversely affect germination of seed and seedling growth.

Seedling vigour index was the one of the key parameter to know response of genotypes to ageing and packaging materials. At end of the storage month, among genotypes higher SVI-I was recorded in Byadagi Dabba (887) and lower SVI-I was recorded in Assam Bhut Jolokia (51) (*Fig. 5.20 and 5.20a*). From the present study it was plausible to presume that the decreased seedling vigour index- I in response to ageing condition. But the response may vary with genotype since it depends on genetic makeup. Loss in seedling vigour is an indicator of loss of quality and vigour of the seed and a common deteriorating effect on seed ageing. This is expected because of a decline in the normal physiological activities during storage along with an increase in various deteriorative biochemical changes. Loss of seedling vigour following seed storage has been reported Ravi Hunje *et al.* (2007b) in hot pepper. Among fruits and seeds employed for storage studies, seeds extracted from stored fruits recorded higher SVI-I (570) whereas extracted and stored seeds registered lower SVI-I 525 at the end of the storage period. The reason might be advantage of storing of fruits as it is was able to maintain seed germination by providing protection against biotic stresses results in maintaining

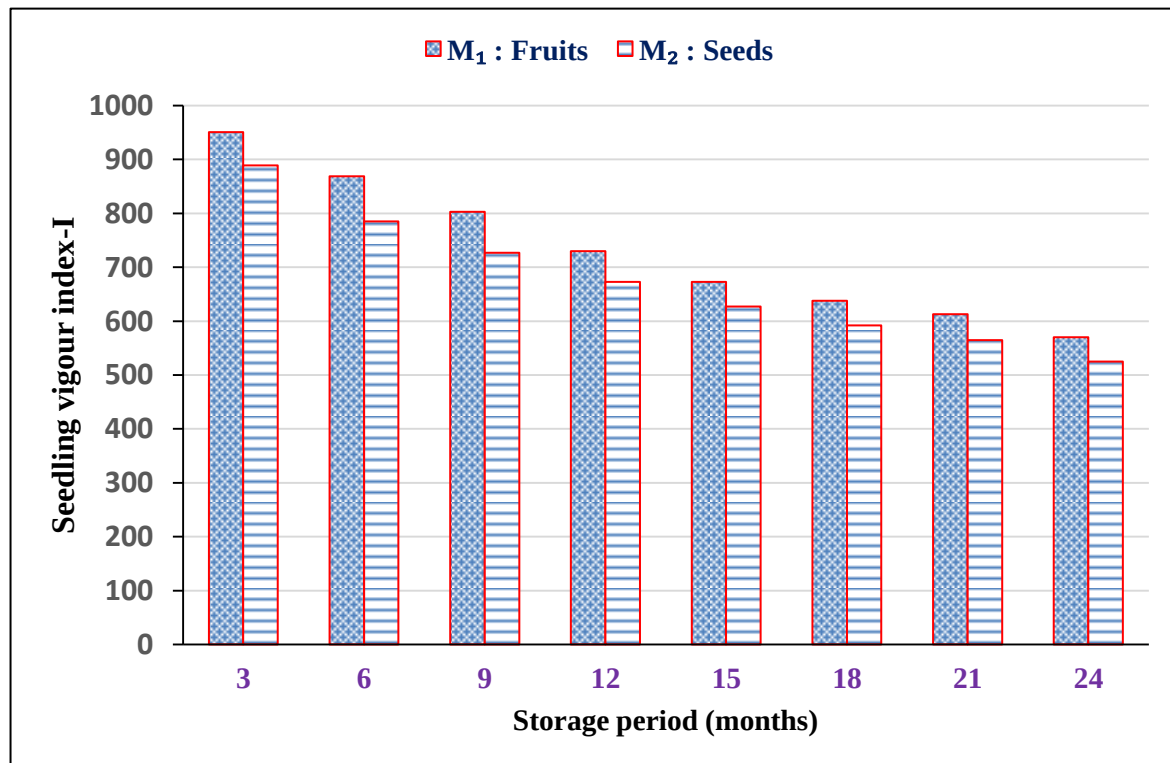
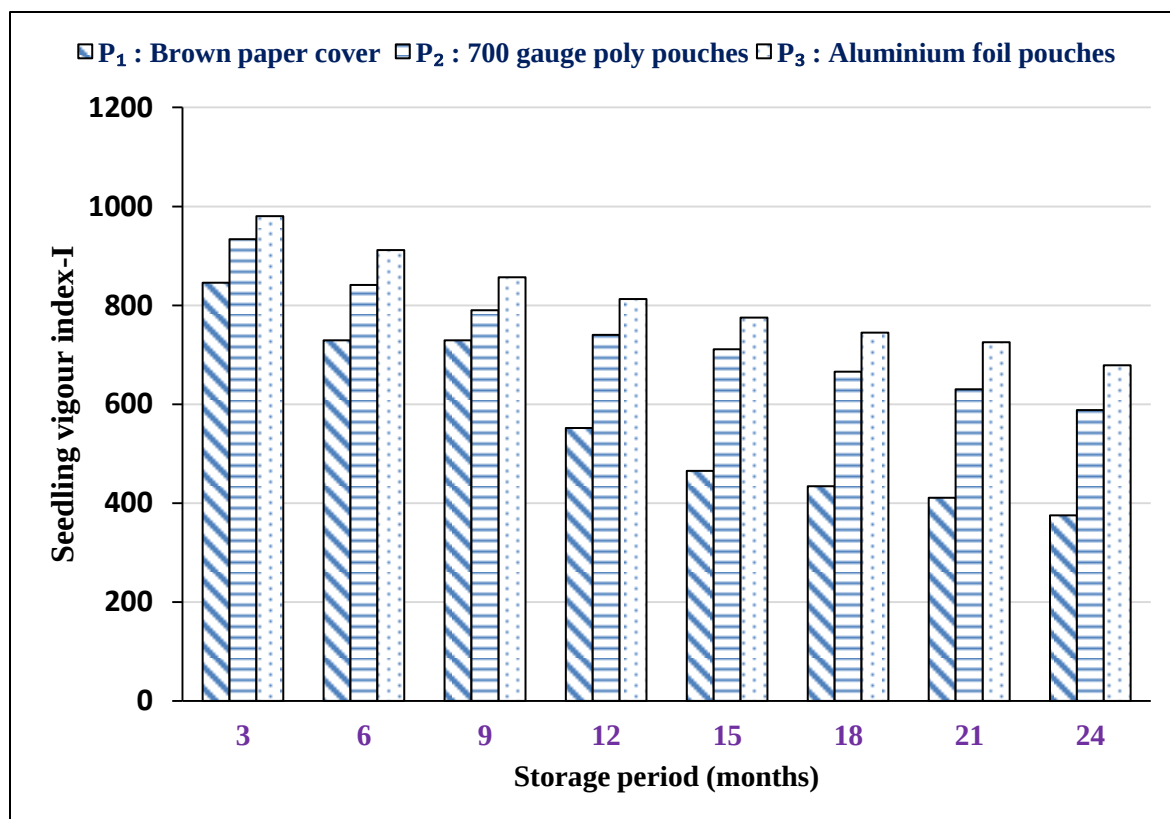


Fig. 5.20. Seedling vigour index-I as influenced by packaging material, fruits and seeds on storability

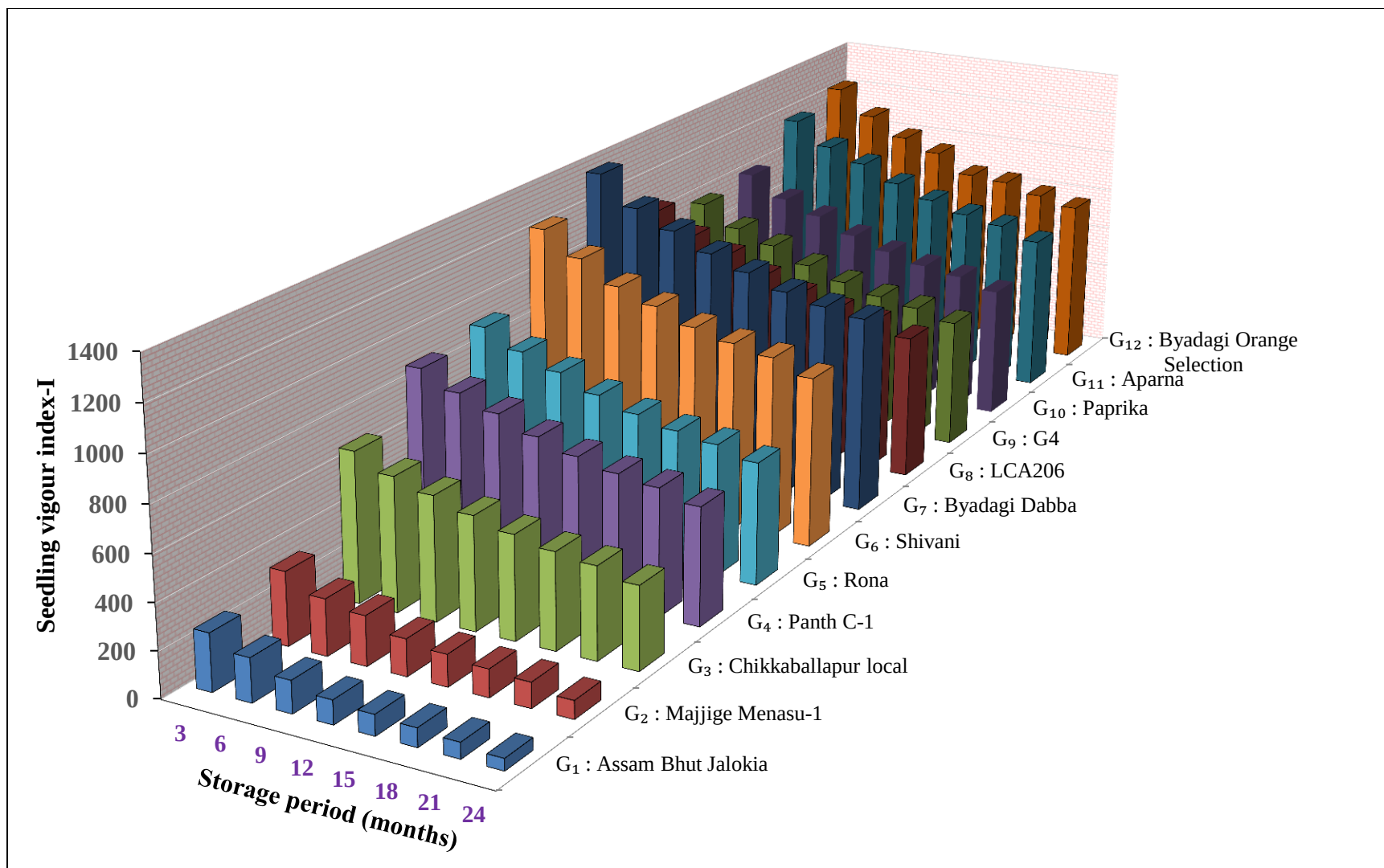


Fig. 5.20a. Seedling vigour index-I as influenced by genotypes, fruits, seeds and packaging material on storability

internal physiological activities which were linked vigour maintenance. Among packaging materials, aluminium foil pouches had maintained higher SVI-I (679) and compare to P₂ (588) and brown paper cover (375). The variation might be due to maintenance of lower moisture content during the storage period. Aluminium foil pouches acts as moisture proof barrier. This lower moisture content resulted in lower respiration rate, lower metabolic activity and maintenance of higher vigour during storage. This is in accordance with the findings of by Ravi Hunje *et al.* (2007b) in hot pepper.

Among genotypes, higher total dehydrogenase activity was recorded in Byadagi Dabba (2.012 A° 480 nm) and lower total dehydrogenase activity was recorded in Assam Bhut Jolokia (0.129 A° 480 nm) at end of the storage period (*Fig. 5.23 and 5.23a*). The variations may be attributed to genotypic resistance to compositional changes induced by deterioration process. The findings of the study were in agreement with Chauhan *et al.* (2011) in wheat. Among materials, fruits have maintained higher total dehydrogenase activity (0.991 A° 480 nm) compare to seeds alone (0.943 A° 480 nm). Among packaging materials, aluminium foil pouches has maintained (1.082 A° 480 nm) higher total dehydrogenase activity whereas brown paper cover has maintained lower (0.783 A° 480 nm) total dehydrogenase activity at the end of the storage period. The reason might be higher content of seeds in pervious container cause a decrease of inner membrane integrity of mitochondria which intern damage the membrane localized enzymes particularly dehydrogenases. The results were in agreement with Aurella Tatipata (2010) in soybean.

Apart from seed germination, seedling length, vigour and electrical conductivity, variation was observed in protein content. Among genotypes, Byadagi Dabba has showed higher protein content (13.17 µg g⁻¹) compare to other varieties and lower protein content was recorded in Assam Bhut Jolokia (3.17 µg g⁻¹). This indicates that the protein content in the seeds is subjected for deterioration depending on the genotype and genetic make which intern indicating its sensitivity of genotype to ageing process. The higher total soluble seed protein (µg g⁻¹) (9.76 µg g⁻¹) was registered in seeds stored in fruits and lower total soluble seed protein (9.17 µg g⁻¹) was registered in seeds extracted and stored

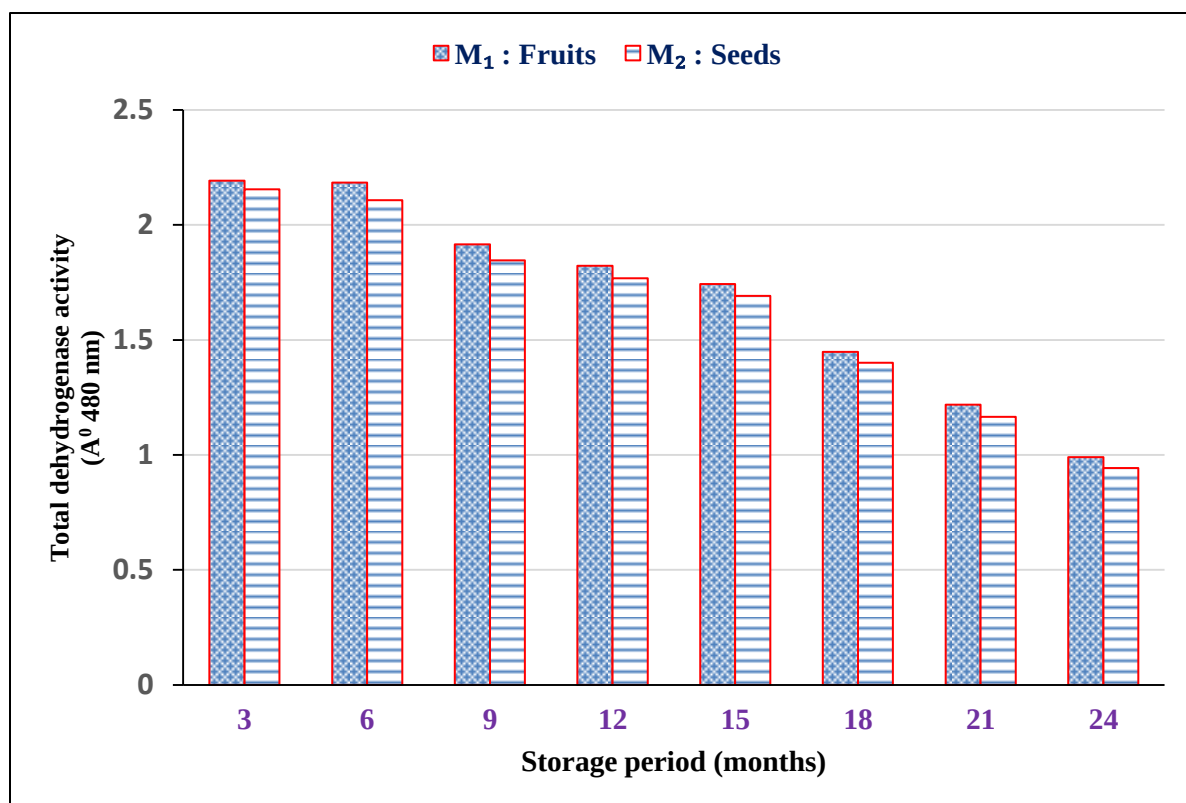
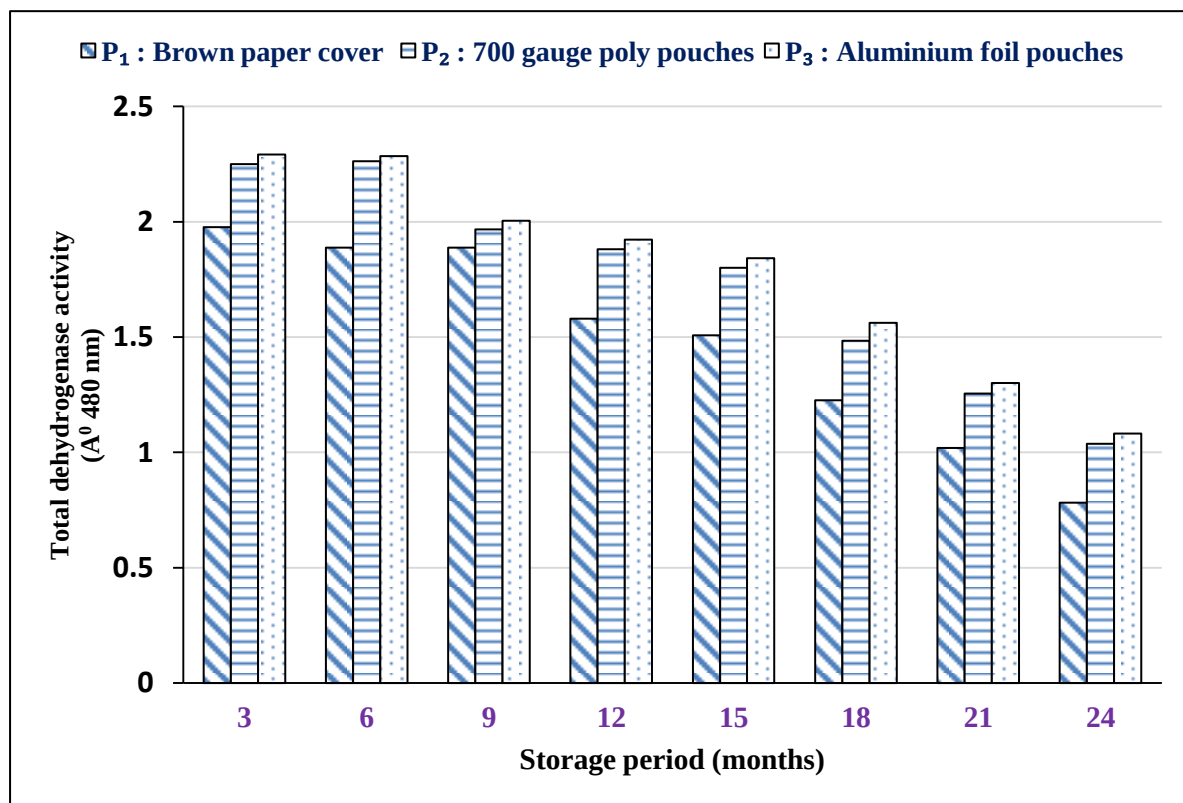


Fig. 5.23. Total dehydrogenase activity (A° 480 nm) as influenced by packaging material, fruits and seeds on storability

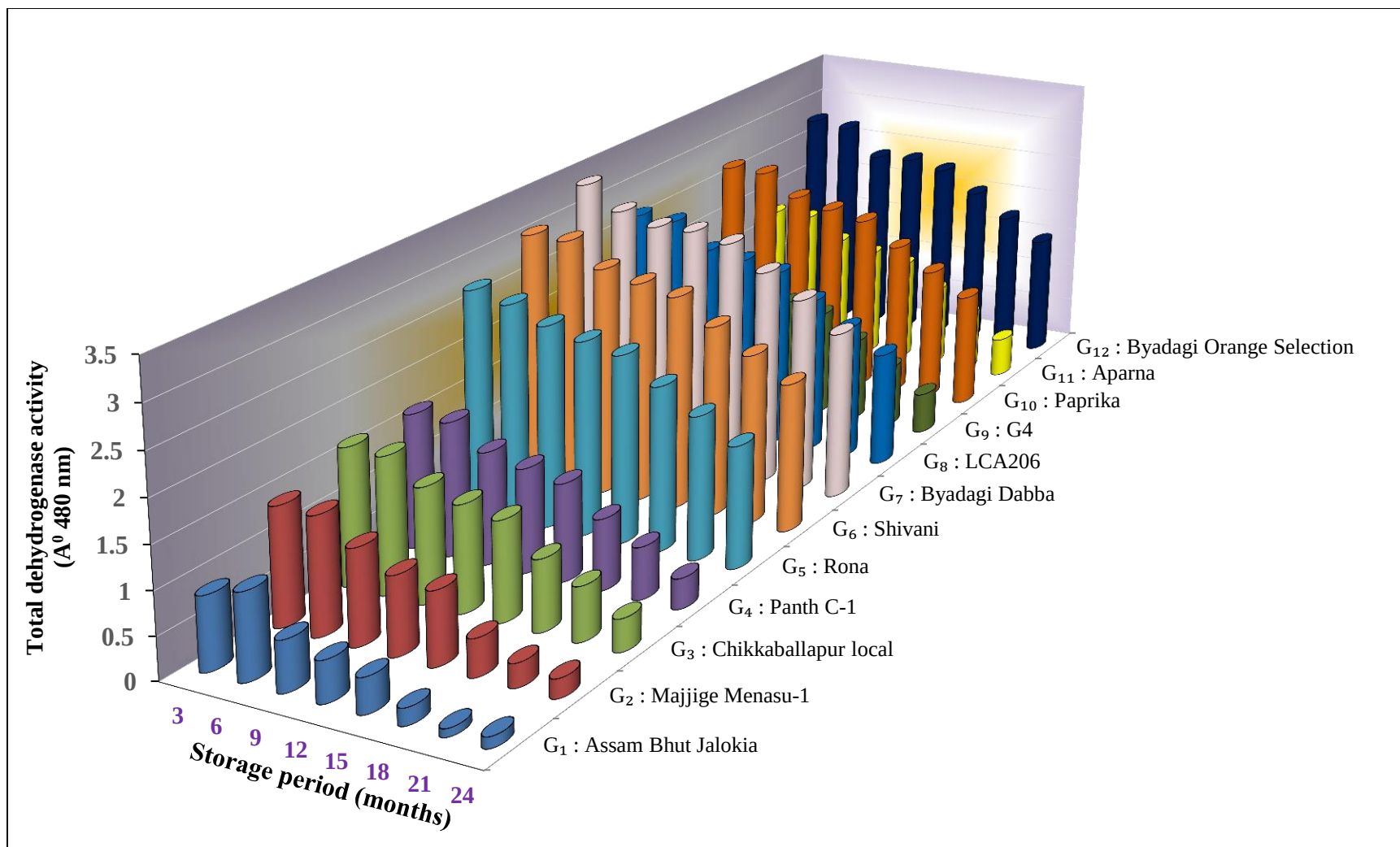


Fig. 5.23a. Total dehydrogenase activity ($A^{\circ} 480 \text{ nm}$) as influenced by genotypes, fruits, seeds and packaging material on storability

at the end of the storage period. Among packaging materials, aluminium foil pouches has maintained higher seed total soluble seed protein ($10.87 \mu\text{g g}^{-1}$) whereas brown paper cover has maintained lower seed total soluble seed protein ($7.41 \mu\text{g g}^{-1}$) (Fig. 5.21 and 5.21a). The results were in agreement with Ben-Yehoshua (1985) in vegetables; Sandhya and Singh (2004) in peas who had observed loss of protein content was higher in pervious bag which could be mainly attributed to property of protein chains forming loose mesh when the moisture content is more. Whereas, with loss in moisture content they become disorganized.

At end of the storage period, among genotypes higher field emergence was recorded in Rona (35%) and lower field emergence was recorded in Assam Bhut Jolokia (2%). The results indicated that existence of genotypic variation between the genotypes. Similar variations in genotypes during storage were reported by Sharma *et al.* (1998) in hot pepper. Such differential variation between genotypes may be due to genetic makeup of the genotypes and their performance during storage. Among fruits and seeds, fruits (27%) recorded higher field emergence compare to seeds (25%). Among packaging materials, higher field emergence was maintained in aluminium foil pouches (42 %) and lower field emergence was maintained in brown paper cover (4 %) (Fig. 5.22 and 5.22a). The findings were in agreement with Sharma *et al.* (1998) who also observed, as seed moisture increases, there was parallel increase in free radicle activity and reduction in DNA, RNA, ribonuclease and enzyme activity and damage. The propensity for genetic damage increases since; free radicals have effect on chromosomal DNA. These mutations can be detected as chromosomal aberrations. These chromosomal aberration delays the onset of mitosis necessary for germination.

Higher α -amylase activity ($\mu\text{g ml}^{-1} \text{min}^{-1}$) was noted in G₆ and lower α -amylase activity was recorded in aluminium foil pouches ($4.01 \mu\text{g ml}^{-1} \text{min}^{-1}$) among genotypes. Among materials, seeds had maintained higher seed α -amylase ($12.74 \mu\text{g ml}^{-1} \text{min}^{-1}$) compare seeds stored in fruits ($9.53 \mu\text{g ml}^{-1} \text{min}^{-1}$). Among packaging materials, higher α -amylase activity was recorded in aluminium foil pouches ($14.54 \mu\text{g ml}^{-1} \text{min}^{-1}$) and lower α -amylase activity was recorded in brown paper cover ($6.68 \mu\text{g ml}^{-1} \text{min}^{-1}$) (Fig. 5.25 and 5.25a). The findings were in agreement with Sharma *et al.* (1998) who also observed, as

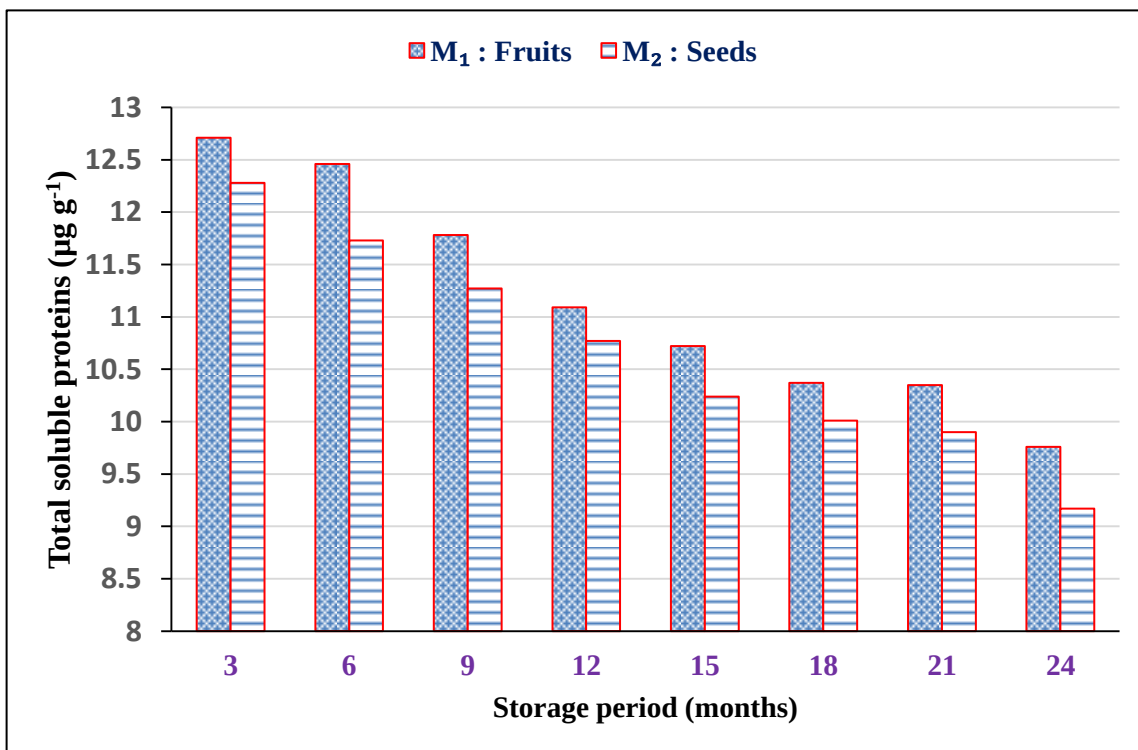
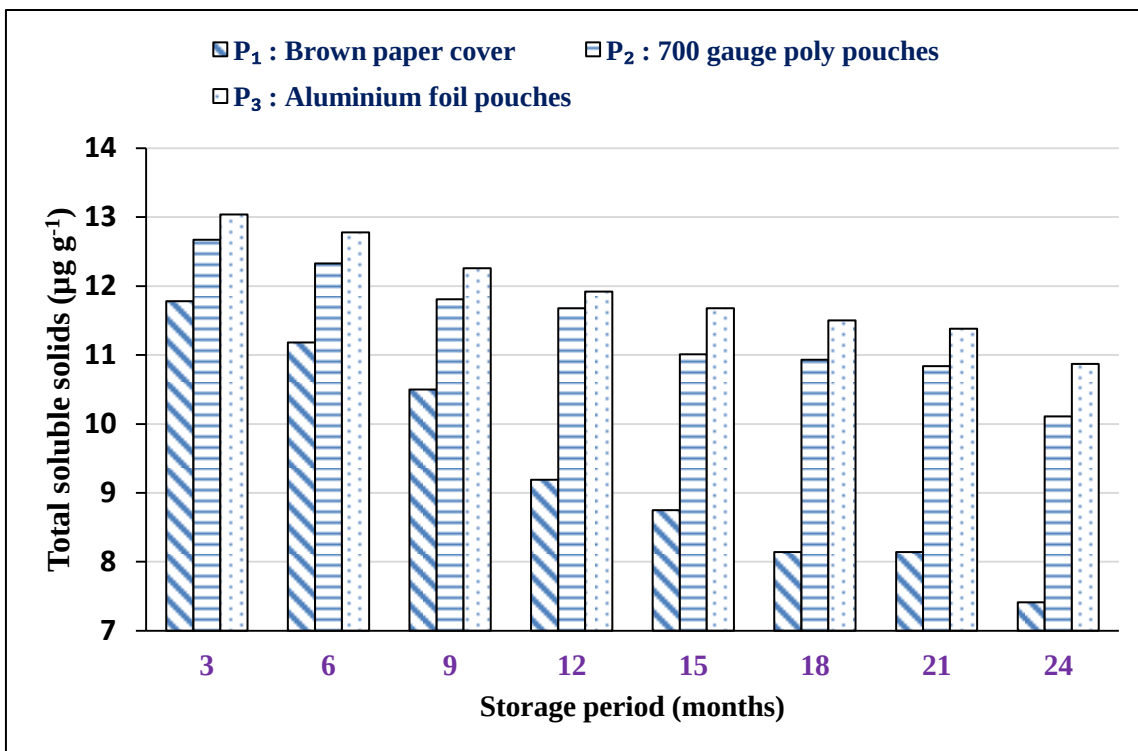


Fig. 5.21. Total soluble seed proteins ($\mu\text{g g}^{-1}$) as influenced by packaging material, fruits and seeds on storability

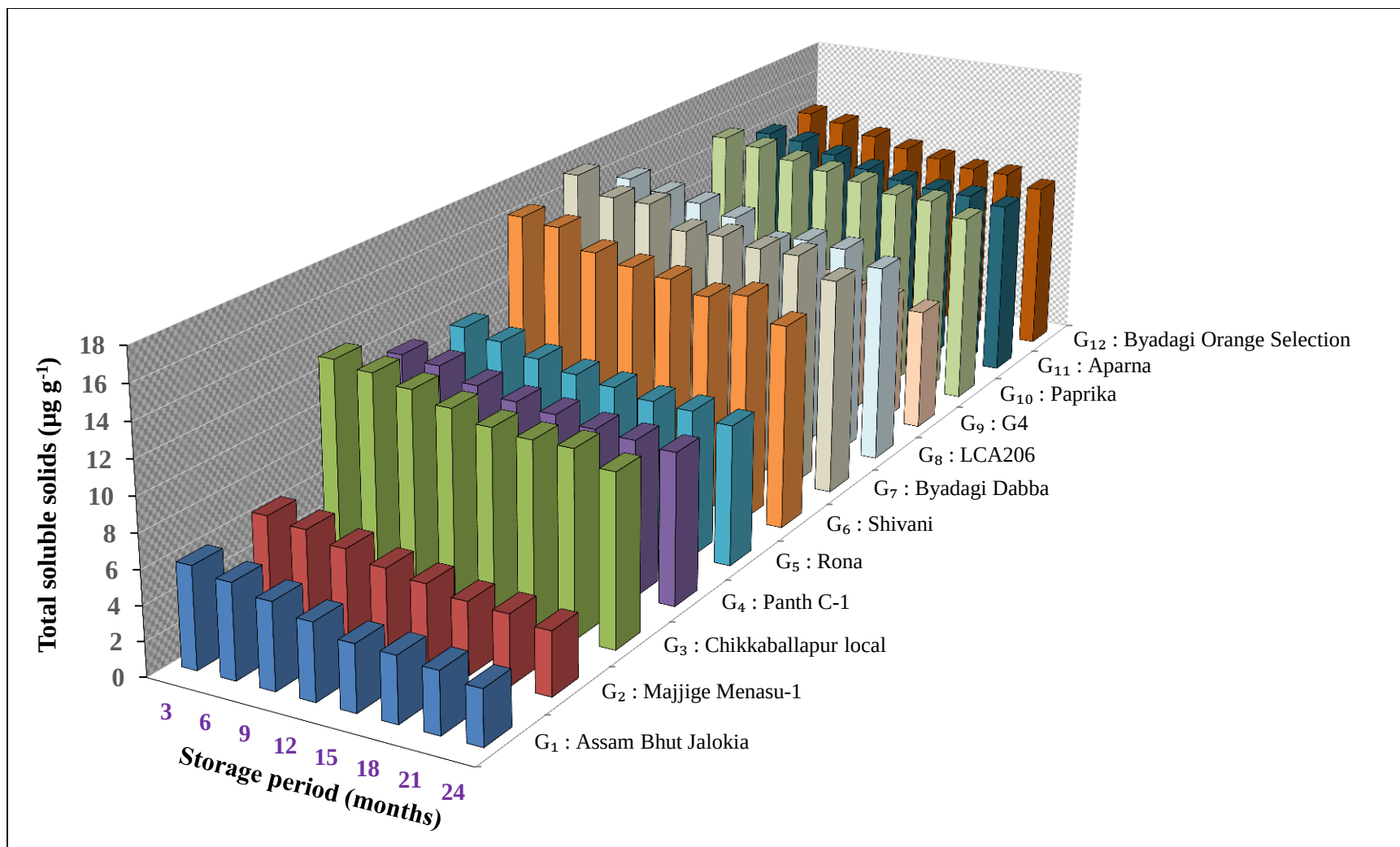


Fig. 5.21a. Total soluble seed protein ($\mu\text{g g}^{-1}$) as influenced by genotypes, fruits, seeds and packaging material on storability

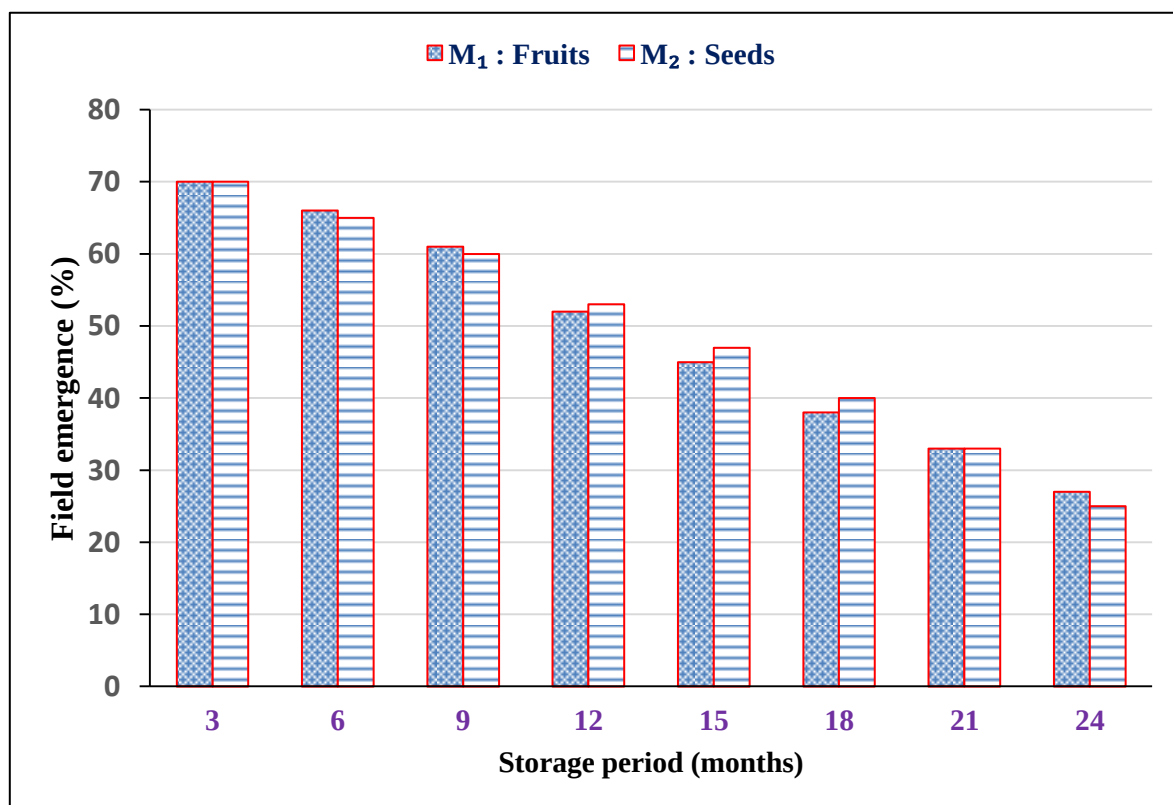
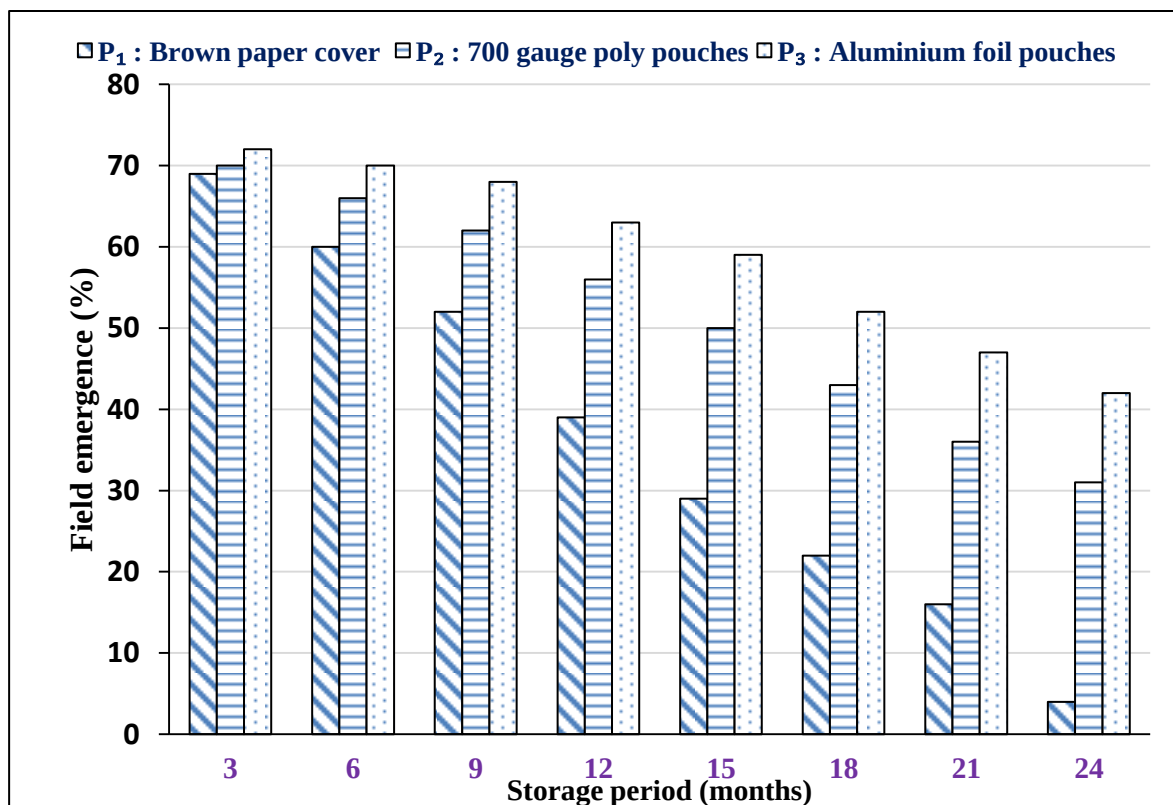


Fig. 5.22 . Field emergence (%) as influenced by packaging material, fruits and seeds on storability

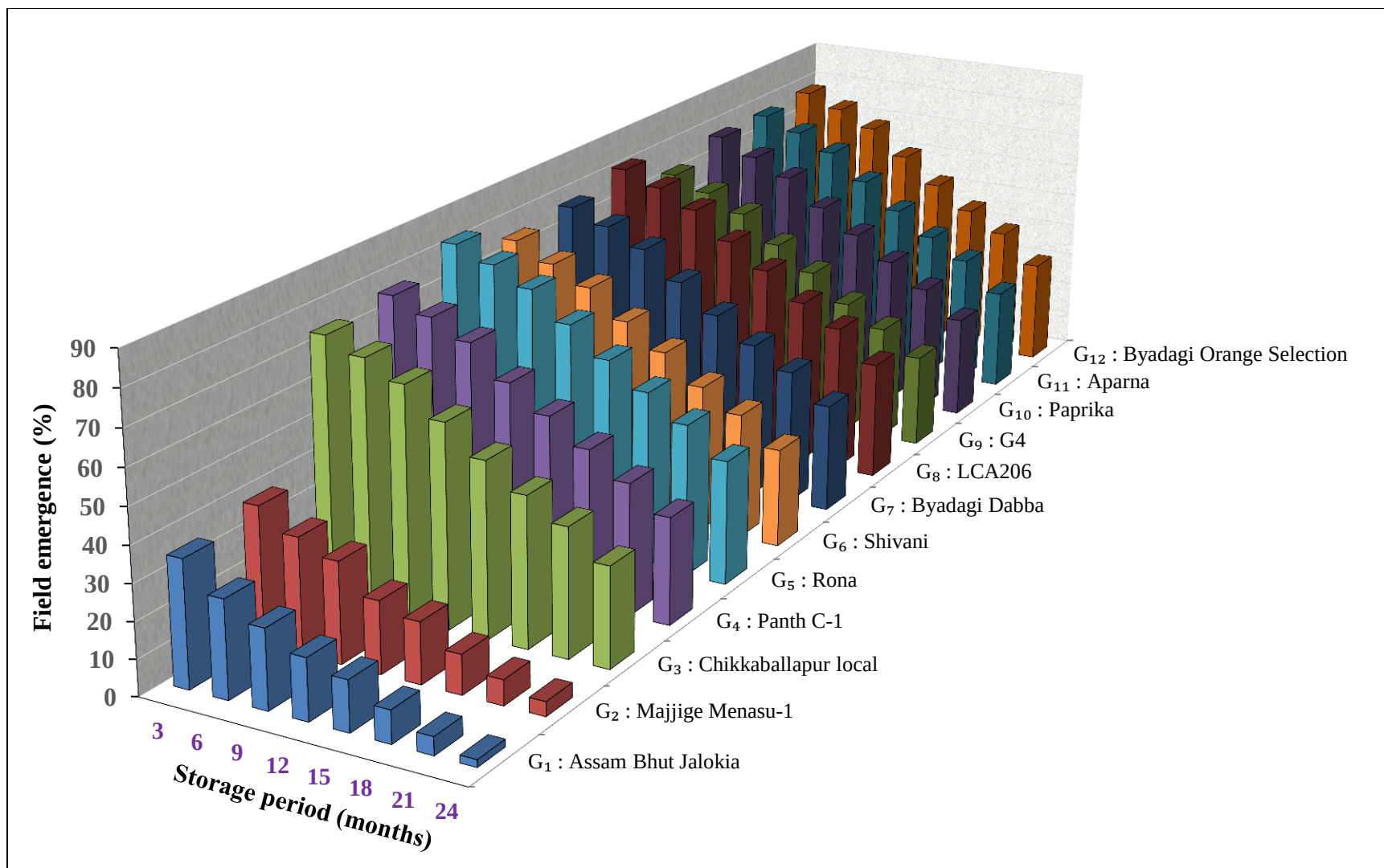


Fig. 5.22a. Field emergence (%) as influenced by genotypes, fruits, seeds and packaging material on storability

seed moisture increases, there was parallel reduction in DNA, RNA, ribonuclease and enzyme activity which are essential for germination process.

Seed capsaicin content ($222 \mu\text{g g}^{-1}$) of the genotype Assam Bhut Jolokia was recorded higher and whereas lower seed capsaicin was recorded in Rona and Paprika ($1 \mu\text{g g}^{-1}$) respectively among the genotypes. The outcomes were in agreement with Russo and Biles (2004) who had reported that differences in biochemical factors (*i.e.*, peroxidase activity) within hot pepper genotypes can influence the stability of capsaicinoids. Among materials, higher seed capsaicin ($64 \mu\text{g g}^{-1}$) was recorded in fruits and lower capsaicin ($64 \mu\text{g g}^{-1}$) was recorded in seeds ($32 \mu\text{g g}^{-1}$). Among packaging materials higher seed capsaicin was recorded in aluminium foil pouches ($58 \mu\text{g g}^{-1}$) whereas lower seed capsaicin was recorded in brown paper cover ($6 \mu\text{g g}^{-1}$) (*Fig. 5.26 and 5.26a*). The results were in agreement with Topuz and Ozdemir (2003) who had stated that stability of capsaicinoids during storage was decreased due to substantial fluctuations of seed moisture. Thus, the concentration of capsaicinoids significantly decreased as storage prolonged under ambient storage conditions.

Among genotypes, higher seed oleoresin was recorded in Byadagi Dabba (18.37 %) and lower seed oleoresin was recorded in Assam Bhut Jolokia (1.89 %). Among fruits and seeds stored, higher seed oleoresin (9.83 %) was registered in fruits and lower oleoresin (8.64 %) was registered in seed. Among packaging materials higher seed oleoresin (10.27 %) was maintained by aluminium foil pouches whereas brown paper cover had maintained lower (7.62 %) seed oleoresin (*Fig. 5.24 and 5.24a*).

5.6 To assess the efficacy of seed treatments to control seed borne anthracnose

The anthracnose is both seed borne and air borne and affects seed germination and vigour to a greater extent (Ahmed, 1982; Perane and Joi, 1988; Mesta, 1996 and Asalmol *et al.*, 2001). Fruit rot up to 32 per cent and dieback up to 29 per cent has been noticed. Seedling decay and seed rot up to 21 per cent were recorded under Central Indian conditions. Thind and Jhooty (1985) reported that losses due to anthracnose of hot pepper varied between 66-84 per cent. The market value and nutritive value is degraded

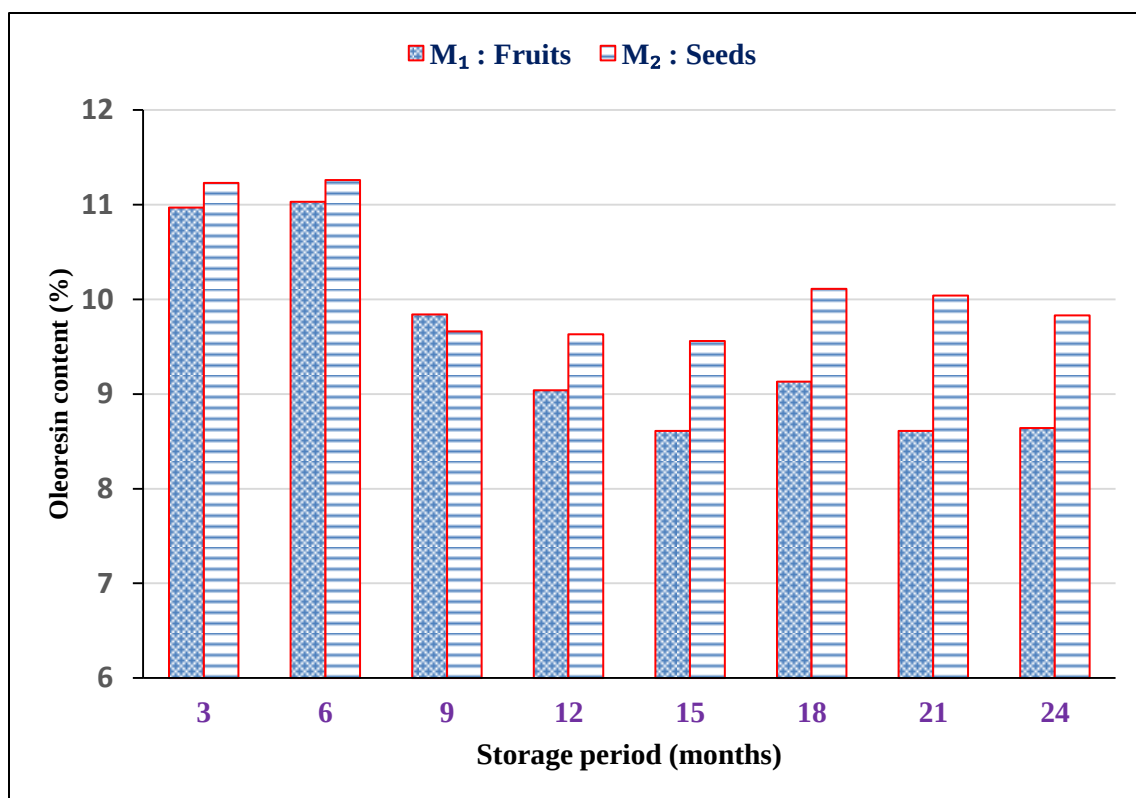
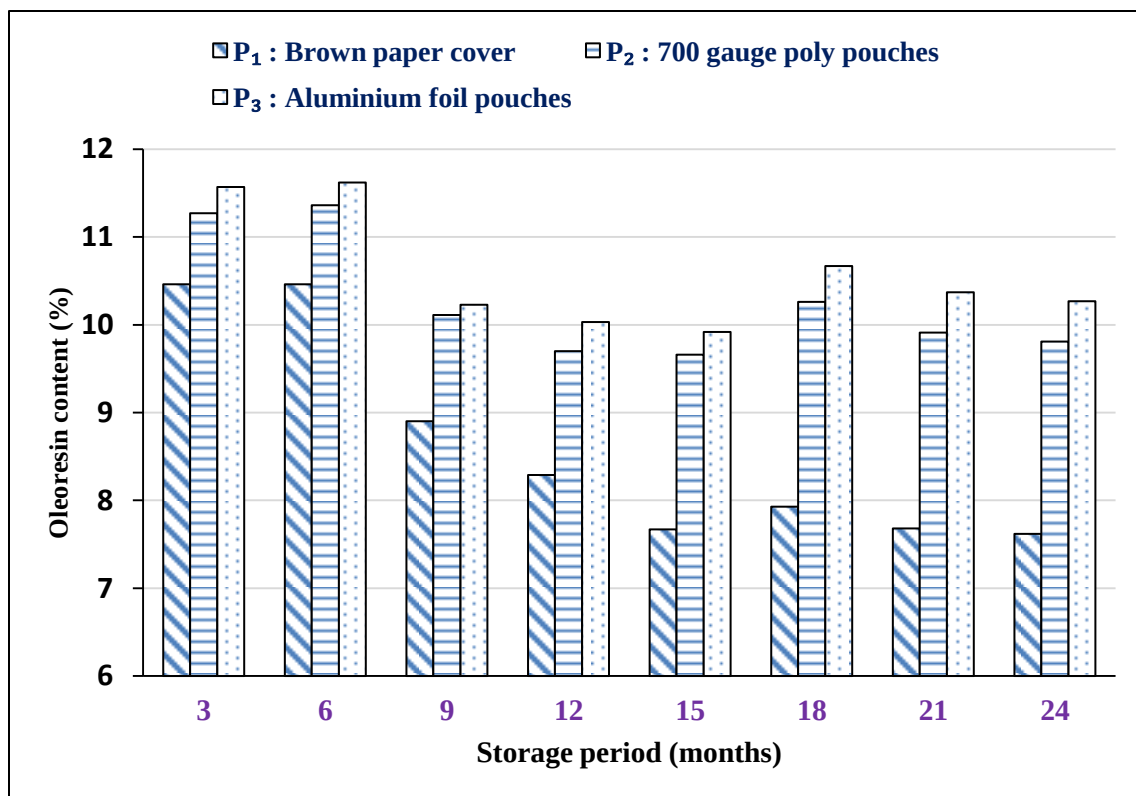


Fig. 5.24. Oleoresin content (%) as influenced by packaging material, fruits and seeds on storability

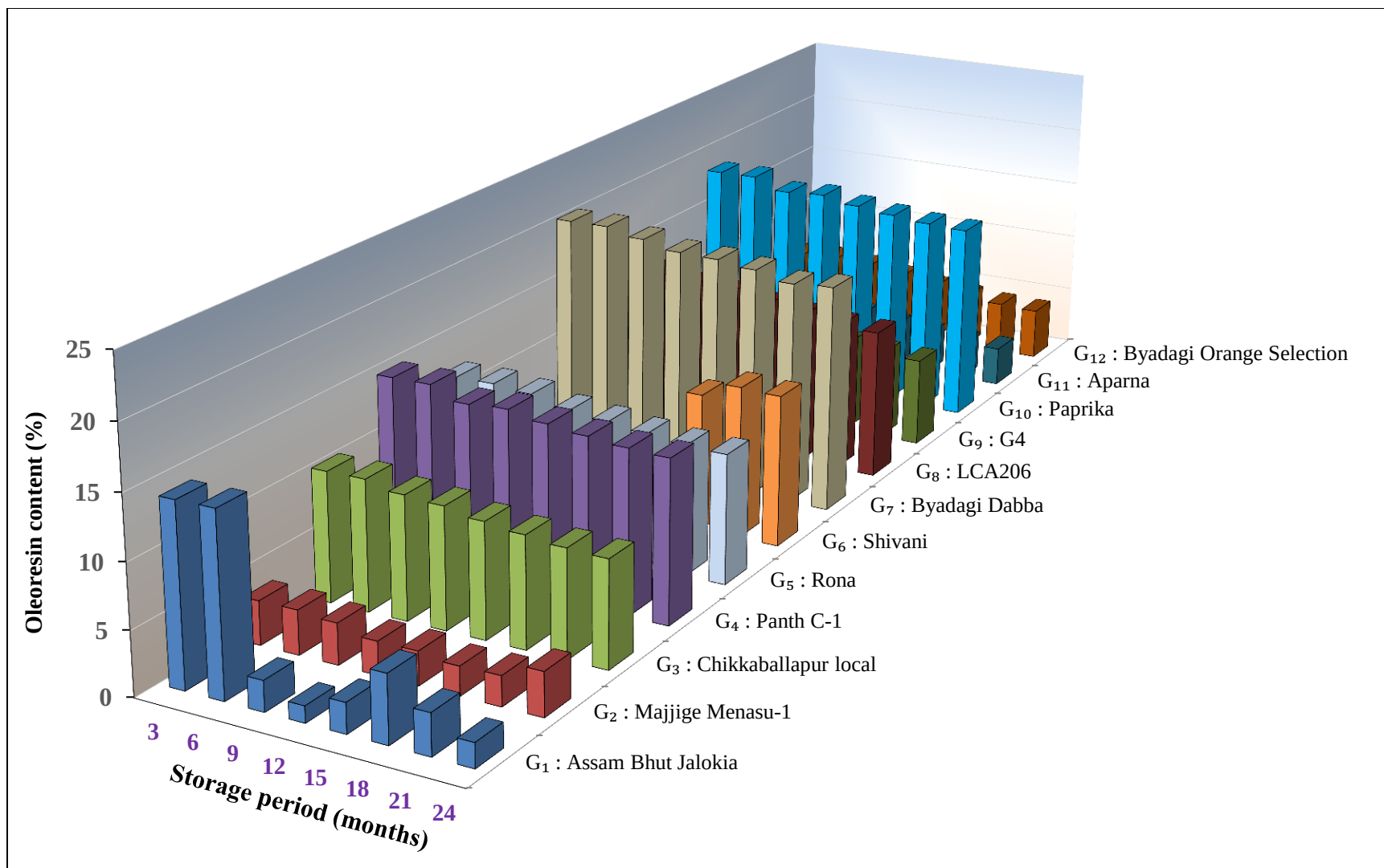


Fig. 5.24a. Oleoresin content (%) as influenced by genotypes, fruits, seeds and packaging material on storability

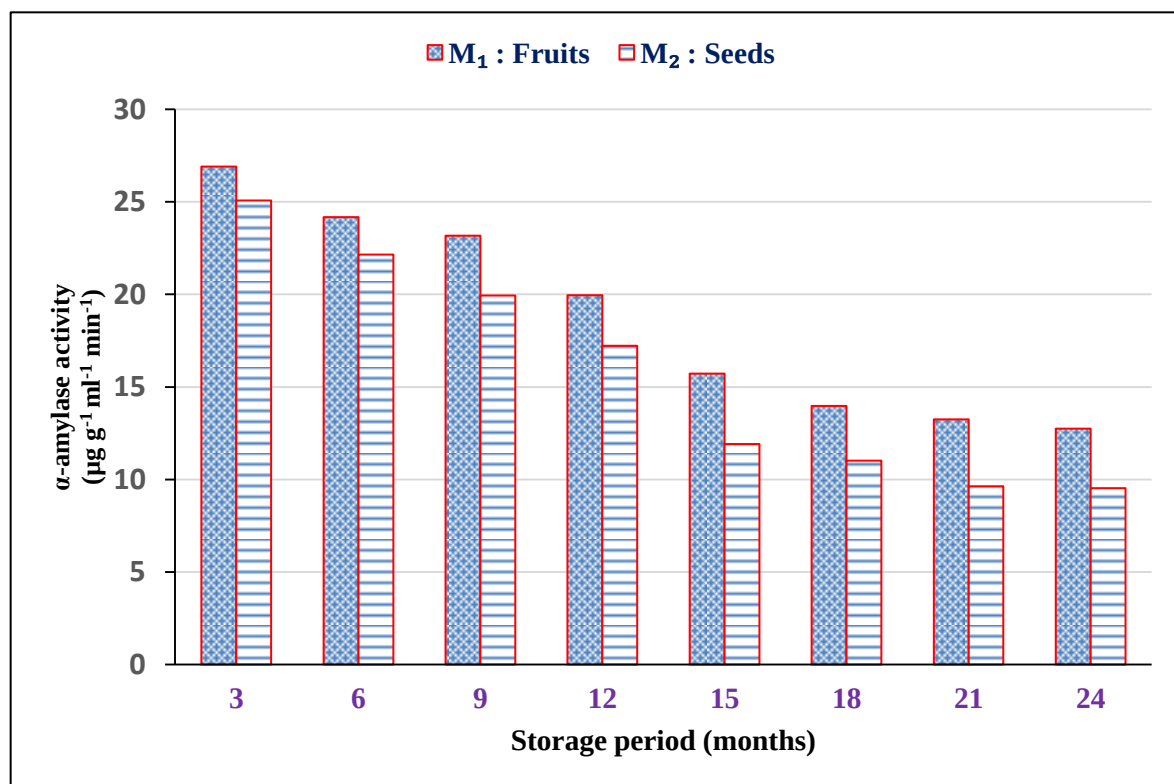
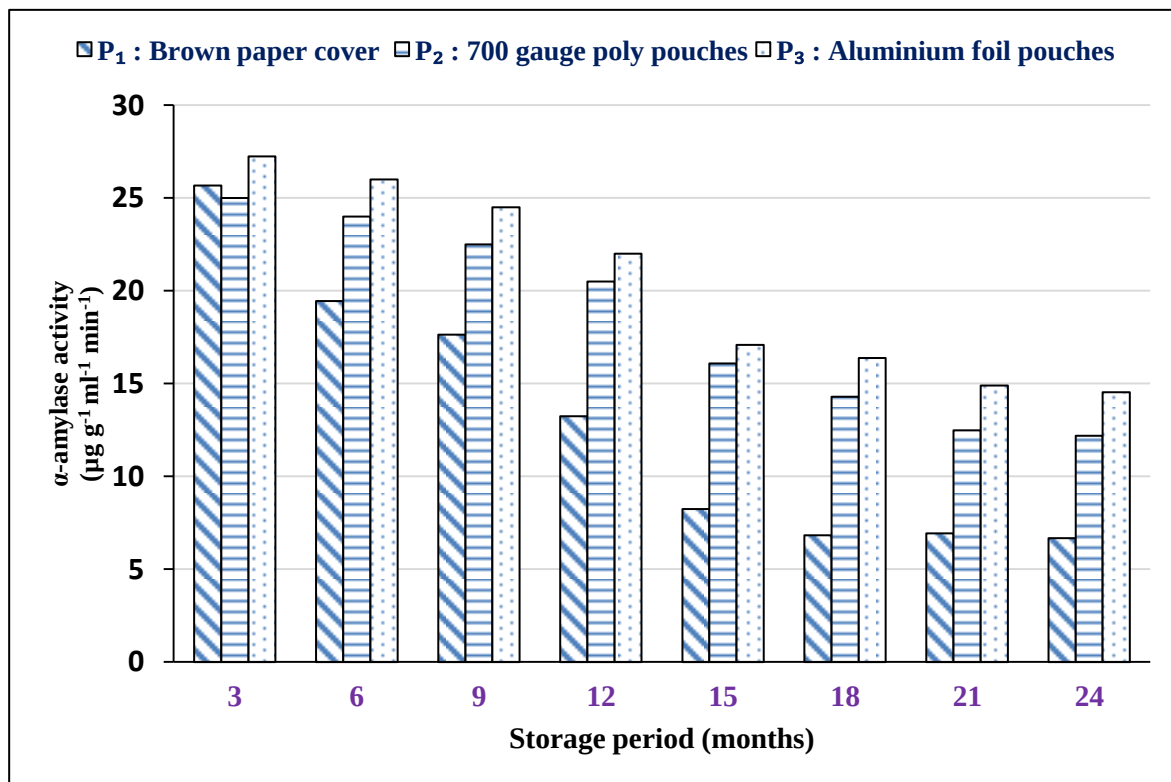


Fig. 5.25. α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) as influenced by packaging material, fruits and seeds on storability

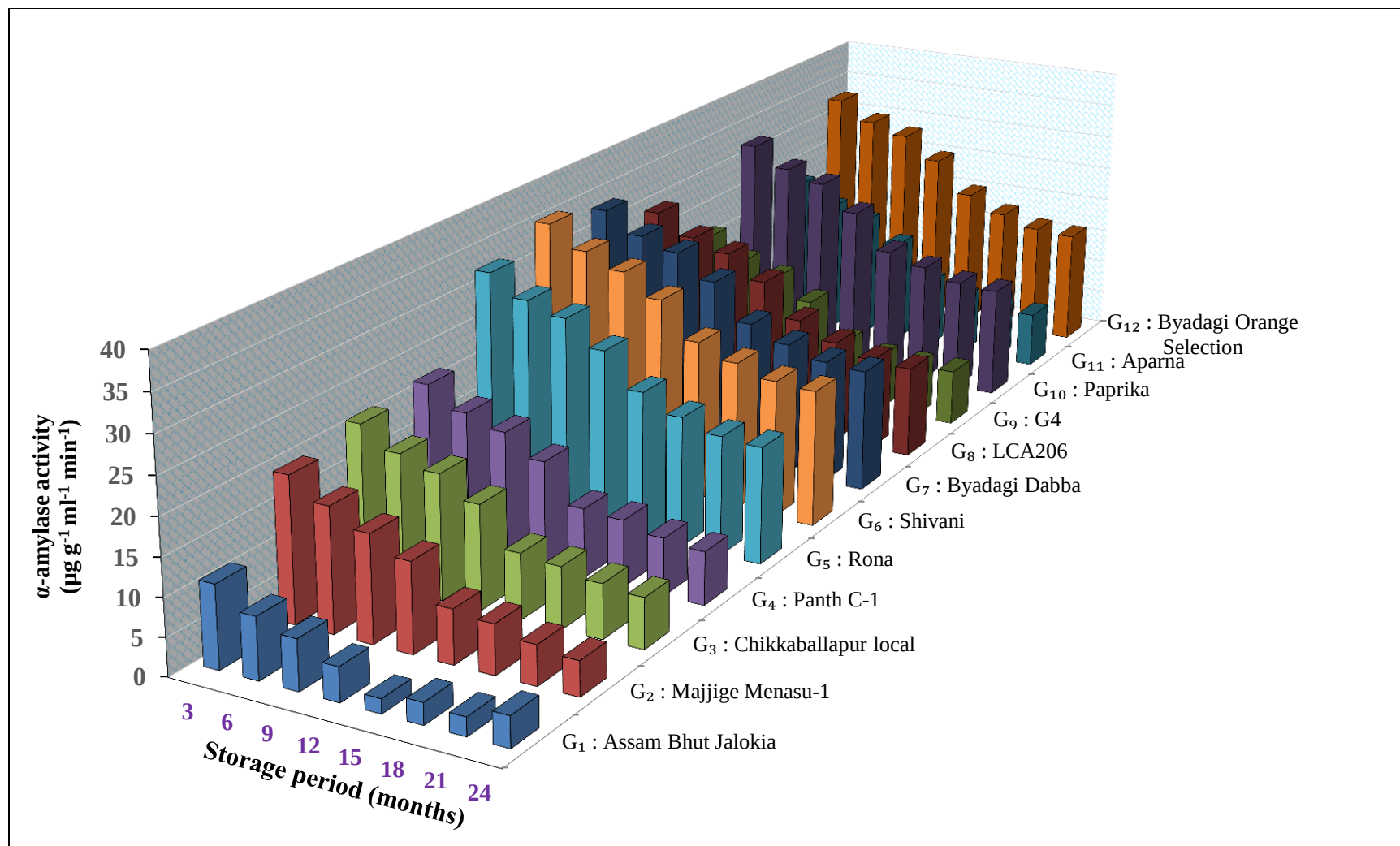


Fig. 5.25a. α -amylase activity ($\mu\text{g g}^{-1} \text{ml}^{-1} \text{min}^{-1}$) as influenced by genotypes, fruits, seeds and packaging material on storability

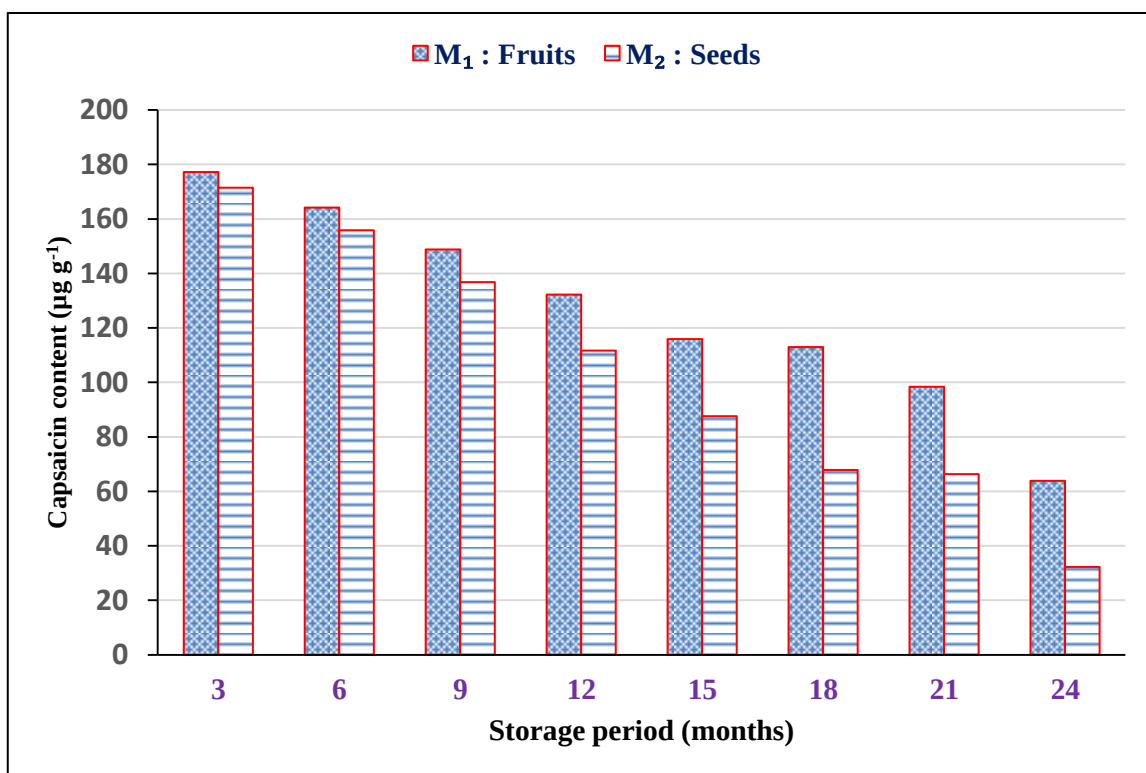
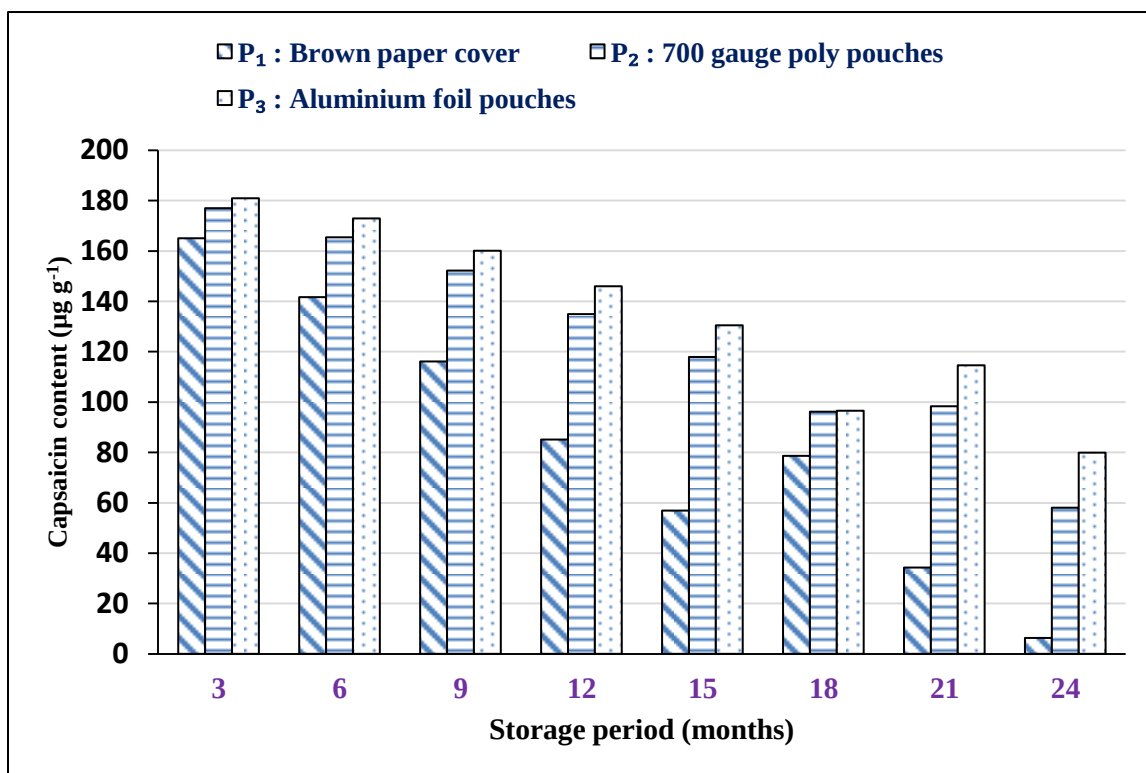


Fig. 5.26. Capsaicin content ($\mu\text{g g}^{-1}$) as influenced by packaging material, fruits and seeds on storability

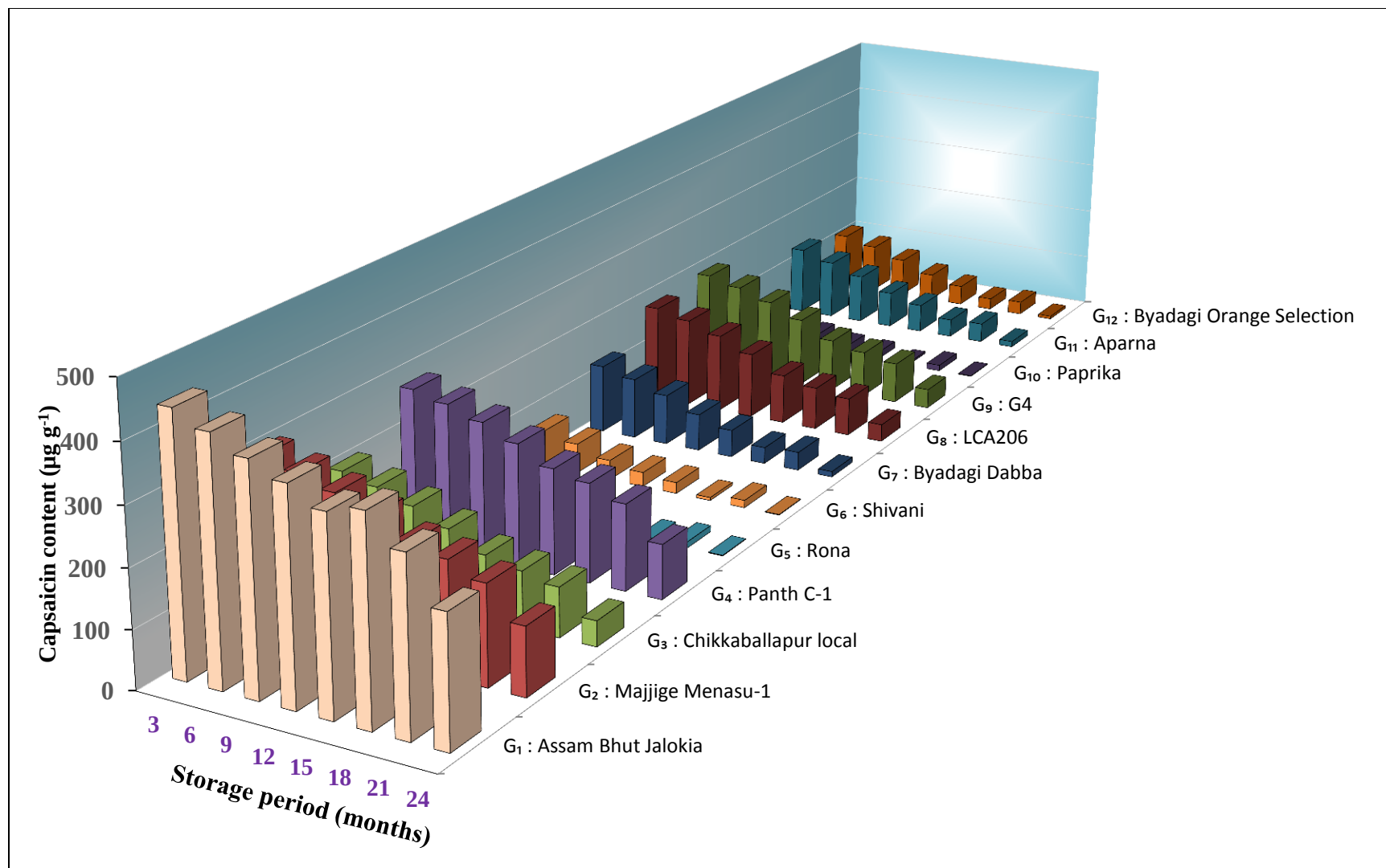


Fig. 5.26a. Capsaicin content ($\mu\text{g g}^{-1}$) as influenced by genotypes, fruits, seeds and packaging material on storability

in infected fruits resulting in poor quality seed. Seed treatment was the feasible control measure available to maintain seed quality against infection by the fungal attack.

Packaging creates a barrier between seeds and the external environment. It protects the seeds from high relative humidity and prevents entry of pathogens (Doijode, 2002).

Between varieties higher germination was maintained by Byadagi Dabba (67.79 %) whereas, G4 maintained lower germination (63.09 %) after seed treatment. Similarly, Anil Kasyap *et al.* (2008) reported that genotypic variations for germination due to genetic variations. Among concentrations, higher germination (%) was recorded in 0.3 per cent (66.83 %) and lower seed germination was recorded in 0.5 per cent (64.00 %). This might be due to appropriate concentration was very much important for maintain quality attributes for longer time *i.e.*, treated chemical concentration is enough to suppress only fungal activity but non toxic to seed. Among seed treatment chemicals, higher germination percentage was noticed in Quintal (94.70 %) and lower germination was recorded in Hexaconazole (26.09) (*Fig. 5.27*). The findings were in agreement with Mesta (1996) and Choudhary *et al.* (2013). That quintal (Carbendazim + Iprodione) seed treatment is known to reduce the seed-borne infection of *Colletotrichum* and subsequently protect seed from deterioration in hot pepper. As Quintal might have possibly interfered with the biosynthesis of DNA during fungal cell division. Thus, it checks the multiplication and establishment of fungi results in maintenance of seed health.

Lower abnormal seedling percentage was recorded in Byadagi Dabba (4.28 %) and increased abnormal seedling percentage was recorded in G4 (4.97) between varieties. Among concentrations, lower abnormal seedling were recorded in 0.2 per cent (3.64 %) and maximum seed abnormal were recorded in 0.5 per cent (5.53 %) (*Fig. 5.27*). This might be due to appropriate concentration was very much important for maintain quality attributes for longer time *i.e.*, treated chemical concentration is enough to suppress only fungal activity but it should not be toxic to seed. Across seed treatment chemicals, lower abnormal seedling percentage was recorded in hot water treatment (0.69 %) and

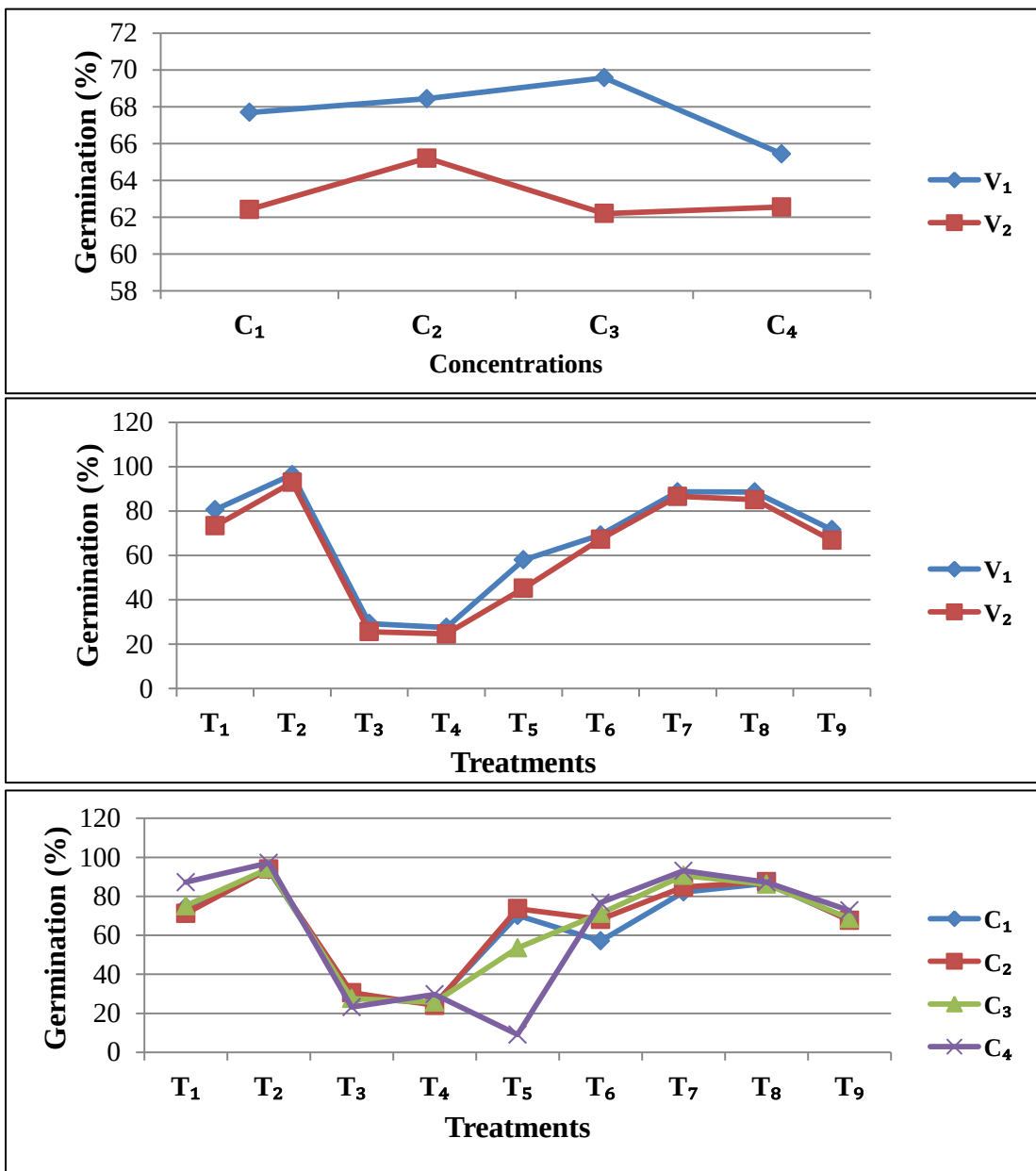


Fig. 5.27. Influence of varieties, seed treatments and concentrations on germination (%)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

maximum seed abnormal was recorded in Hexaconazole (8.56 %). The findings of the study were in agreement with Alam *et al.* (2014). The chemical Quintal suppresses the fungal establishment there by it prevents production of toxic compounds i.e., mycotoxin by fungi. These compounds are known to inhibit nucleic acid and protein synthesis necessary for cell division essential for tissue formation especially root and shoot thus seeds became almost unable to support de novo protein synthesis.

Between varieties, lower fresh ungerminated seeds (FUG) percentage was registered in Byadagi Dabba (1.50 %) and maximum abnormal seedling percentage was recorded in G4 (1.73 %). There was non-significant difference between the concentrations for fresh ungerminated seeds (FUG) percentage. Among seed treatment chemicals, lower fresh ungerminated seeds (FUG) percentage was recorded in hot water treatment and *Trichoderma viride* (0.00) and higher fresh ungerminated seeds were recorded in Propiconazole (5.09 %) respectively. The findings of the study were in agreement with Alam *et al.* (2014). This may be attributed to Quintal inhibiting some of the key enzymes which are essential for germination process.

Varieties had shown non-significant differences for root length, shoot length and mean seedling length. Among concentration maximum root length, shoot length and mean seedling length was found in 0.3 per cent (7.97, 4.71 and 12.68 cm respectively,) and minimum root length was recorded in 0.5 per cent (5.53, 4.56 and 12.56 cm respectively) (*Fig. 5.28*). The variation might be due to mode of action of chemical and dosage. Among seed treatments chemicals, maximum root length (cm) was recorded in Quintal (8.50cm), shoot and mean seedling length in Bavistin (5.55, 13.96cm respectively) and lower root and mean seedling length in Hexaconazole (6.62 and 10.65 cm respectively), lower shoot length in Propiconazole (2.82 cm). The findings of the study were in agreement with Solanke *et al.*, 2001. The reason might be, by maintaining the integrity of cell organelles particularly mitochondria which was very essential for glyoxylate pathway and mobilization of the storage reserves in terms of ATP required for seedling growth.

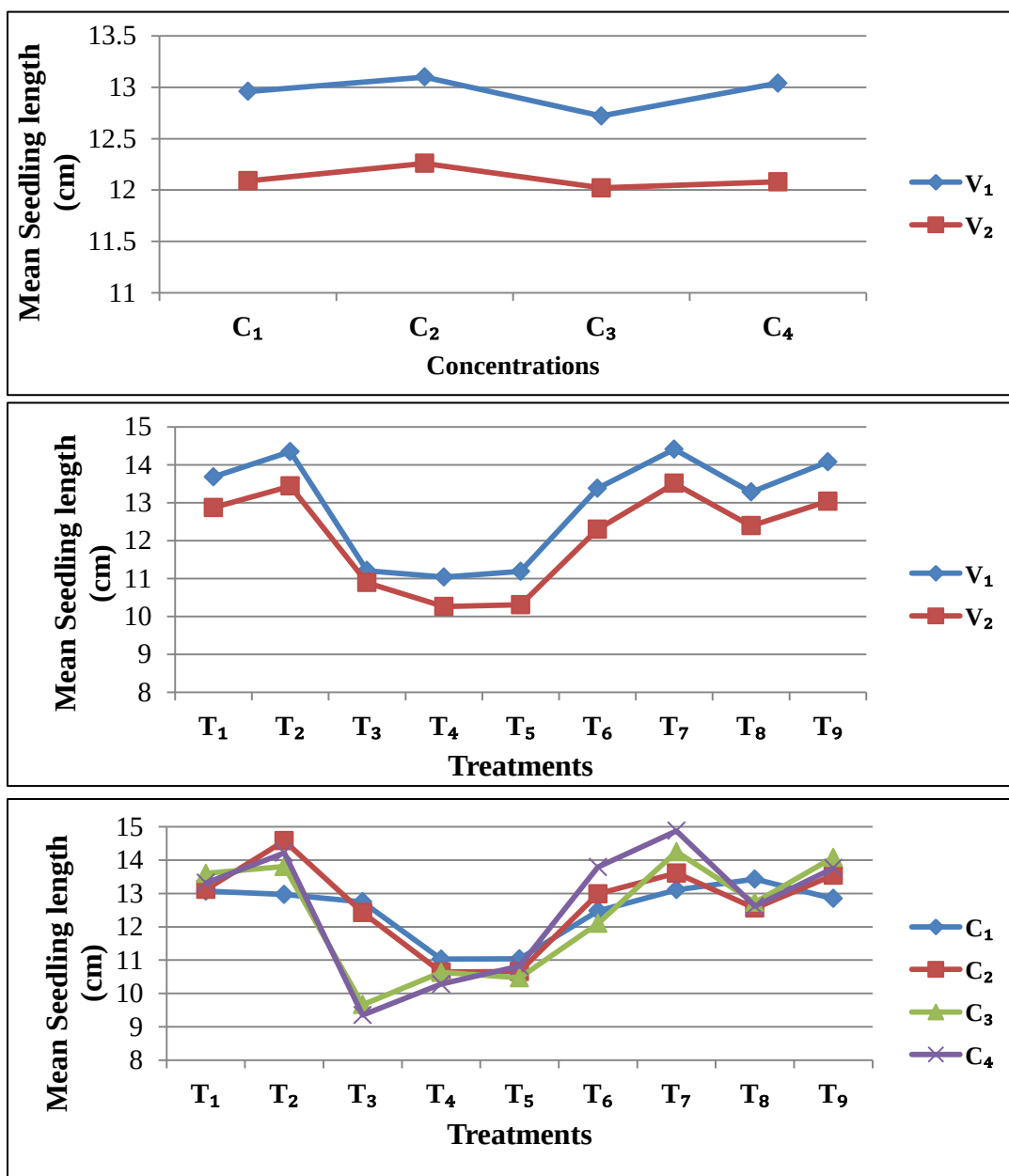


Fig. 5. 28. Influence of varieties, seed treatments and concentrations on mean seedling length

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

Between varieties, higher seedling dry weight was recorded in Byadagi Dabba (11.26 mg) and lower seedling dry weight was recorded in G4 (8.05 mg). Among concentrations, higher seedling dry weight was found in 0.2 per cent (9.78 mg) and lower seedling dry weight 0.4 per cent (9.42 mg). Among seed treatments chemicals, higher seedling dry weight was recorded in Quintal (11.94 mg) and lower seedling dry weight in Propiconazole (7.20 mg) (*Fig. 5.29*). The findings of the study were in agreement with Alam *et al.* (2014). The reason might be fungi can damage seed by production of exo-cellular hydrolytic enzymes like phospholipases, which hydrolysed the phospholipids to free fatty acids, phosphatase hydrolysed the ATP in to ADP results in energy get exhausted results in increased phosphatase acidity and proteases are very much potential in hydrolyzing in amino acids. In view of the fact that there is no source for dry matter accumulation in essential structures even though germination processes occurs and essential structures were produced.

Seedling vigour index-I and II were recorded higher in Byadagi Dabba (907 and 805 respectively) and lower seedling vigour index-I and II were recorded in G4 (793 and 547, respectively) between varieties. Among concentrations, higher seedling vigour index-I and II was registered in 0.3 per cent (866 and 687, respectively) and lower seedling vigour index-I in 0.2 per cent (827), seedling vigour index-II in 0.4 percent (665). Among seed treatment chemicals, higher seedling vigour index-II (SVI-II) was noticed in Quintal (1135) and lower SVI-II was recorded in Propiconazole (200) (*Fig. 5.29 and 5.30*). Quintal might had played significant role in growth inhibition of storage fungi and attributed to higher vigour. Alam *et al.* (2014) noticed similar trend in hot pepper. All interactions show highest mean seedling length which could be attributed to additive effects of interactions.

Among varieties, lowest seed infection was recorded in G4 (48 %) whereas Byadagi Dabba has recorded highest seed infection (54 %). Among concentrations, lower seed infection (%) was recorded in 0.5 per cent (40 and higher seed infection was recorded in 0.2 per cent (62 %). Among seed treatment chemicals, lower seed infection was registered in Quintal (23 %) and higher seed infection was recorded in *Trichoderma*

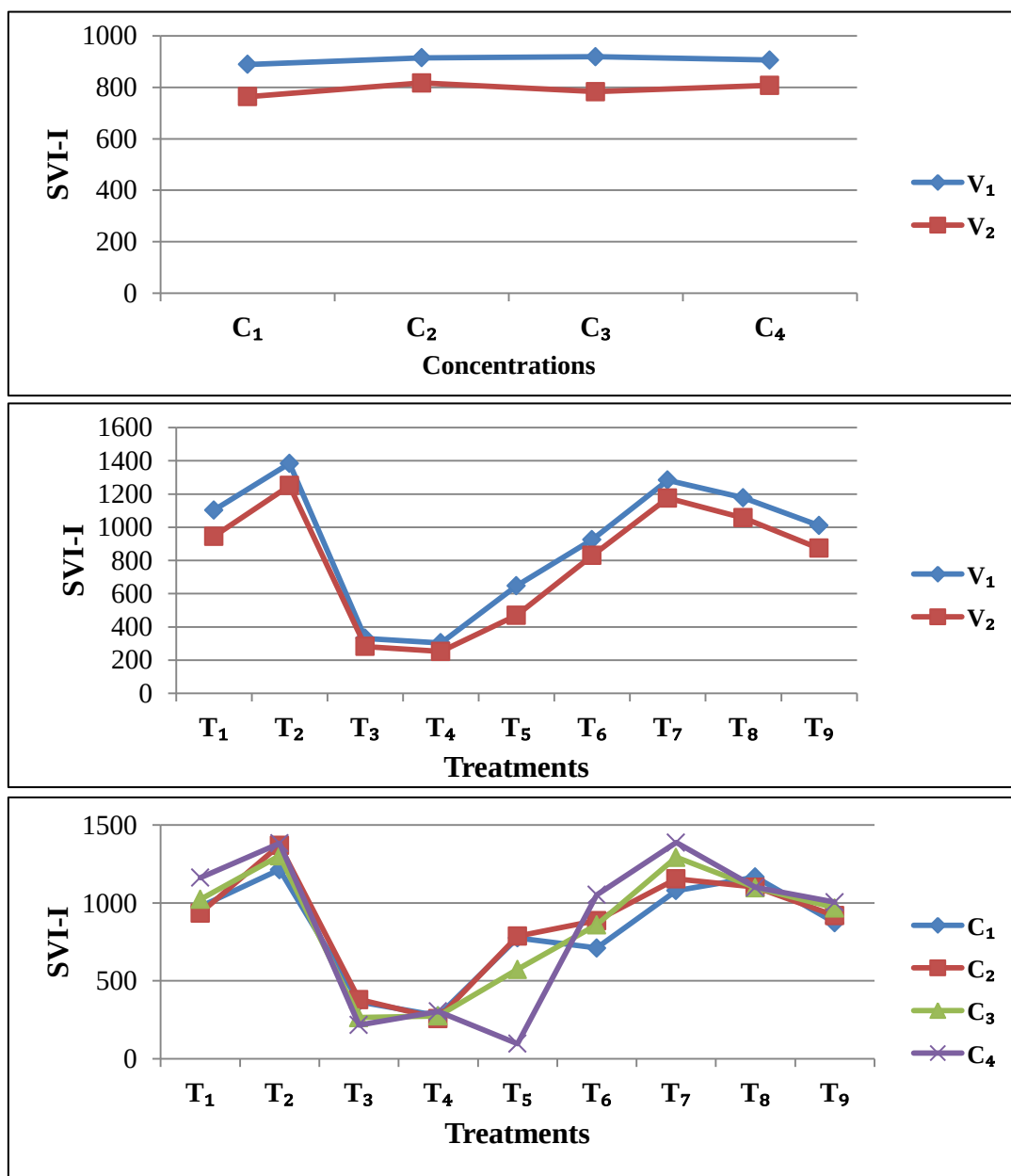


Fig. 5.29. Influence of varieties, seed treatments and concentrations on seedling vigour index-I (SVI-I)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

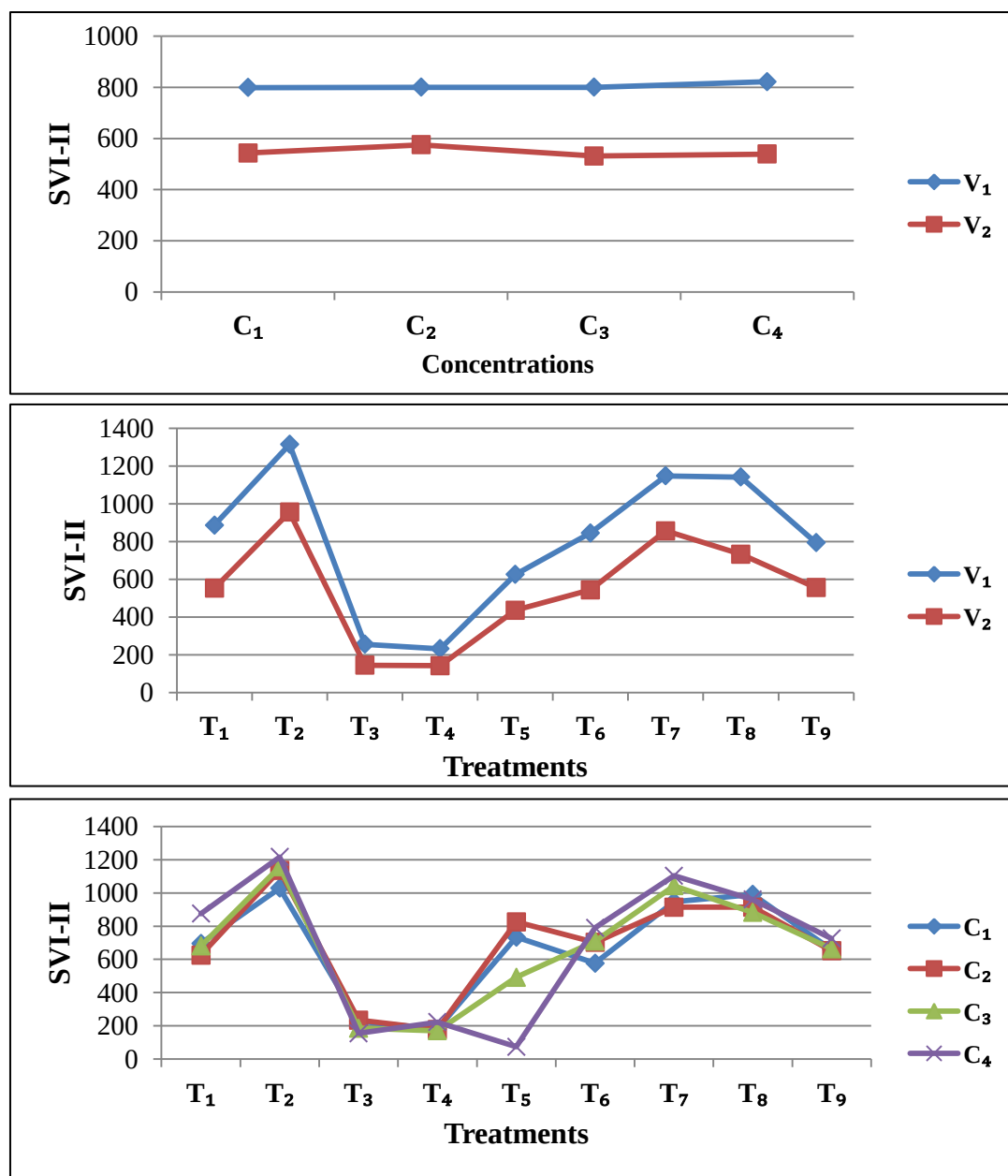


Fig. 5. 30. Influence of varieties, seed treatments and concentrations on seedling vigour index-I I (SVI-I I)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

viride (81 %) (Fig. 5.31). This might be due to the effective control of pathogens by Quintal since it acts as antifungal agent (Hyi *et al.*, 2014).

Between varieties, highest PGEI and PGIS were recorded in Byadagi Dabba (33.48 % and 13.24 % respectively) whereas G4 recorded lowest PGEI (30.69 and 12.26 %). Among concentrations, 0.2 per cent has recorded higher PGEI (35.26) and lower PGEI was recorded in 0.5 per cent (29.21 %). However, PGIS had shown non-significant for concentrations. Among seed treatment chemicals, highest PGEI and PGIS were recorded in *Trichoderma viride* (45.75 and 18.81). Lower PGEI (%) was recorded in Propiconazole (10.66) and lower PGIS (%) was recorded in Propiconazole (6.94) (Fig. 5.32 and 5.33). The findings were in agreement (Mesta, 1996) and Choudhary (2013) reported that Quintal (Carbendazim + Iprodione) seed treatment is known to reduce the seed-borne infection of *Colletotrichum* and subsequently protect seed from deterioration in hot pepper. The reason might be Quintal may interference with the biosynthesis of DNA during fungal cell division. Thus, it checks the multiplication and establishment of fungi results in maintenance of seed health.

Between varieties, highest field emergence was recorded in Byadagi Dabba (68.50 %) and lowest was registered in G4 (59.50 %) these genotypic variations might be attributed to genetic variations. Among concentrations, higher field emergence was recorded in 0.5 per cent (91 %) and lower field emergence was recorded in 0.2 per cent (37 %) (Fig. 5.34). This might be due to appropriate concentration was very much important for maintain quality attributes for longer time *i.e.*, treated chemical concentration is enough to suppress only fungal activity but non toxic to seed Anil Kasyap *et al.* (2008). However, seed treatment chemicals had shown non-significance to field emergence. Since the chemical applied to the seed diluted immediately when seeds are sown in to soil for emergence.

5.5 Validation of trait specific DNA markers linked to pungency.

Validation of pungency specify markers in hot pepper genotypes under investigation revealed that, Among the genic SSR markers used to evaluated the trait, Single dominant band at 100 Kb was amplified with marker 7F/15R in all the genotypes

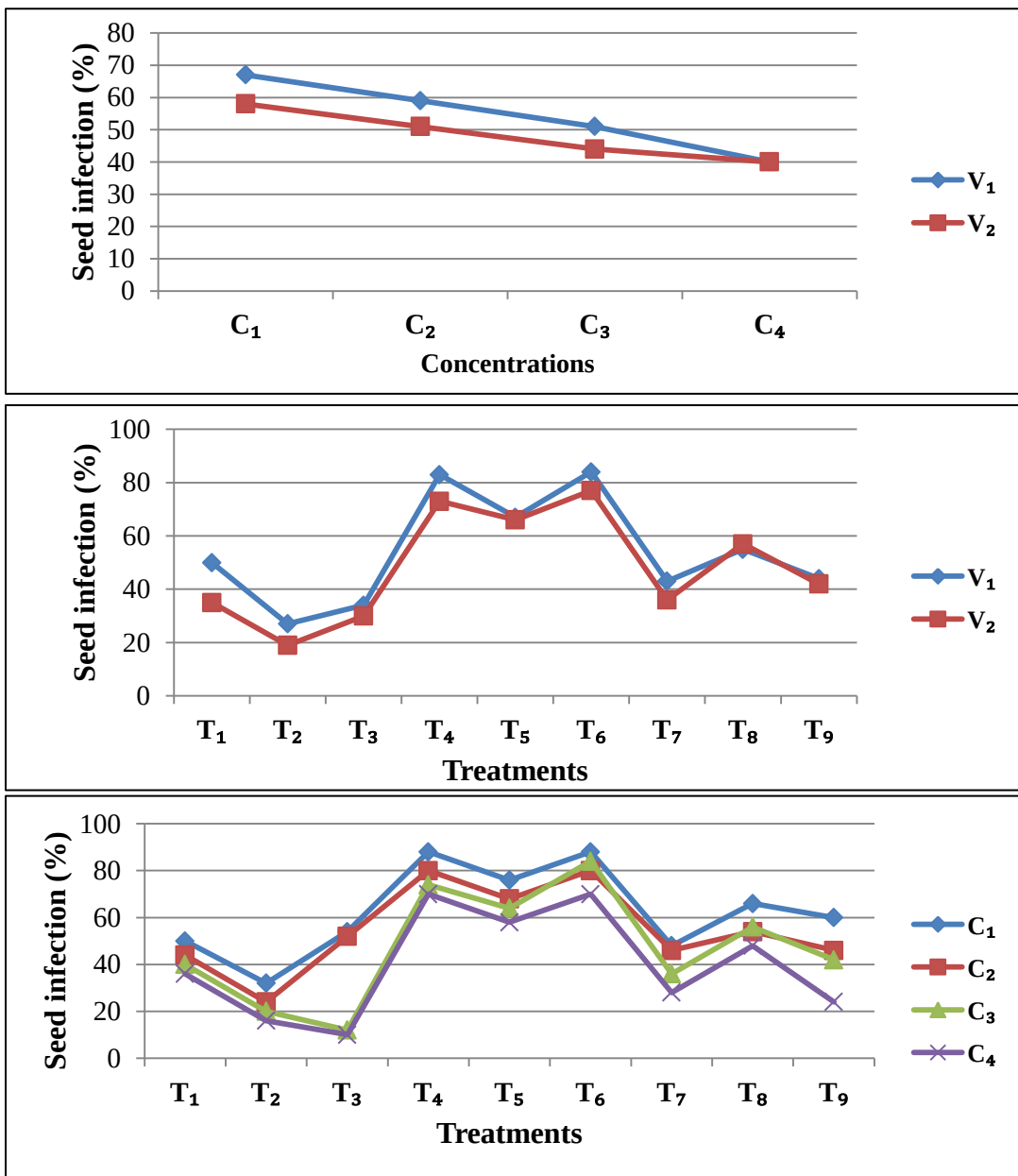


Fig. 5.31. Influence of varieties, seed treatments and concentrations on seed infection (%)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

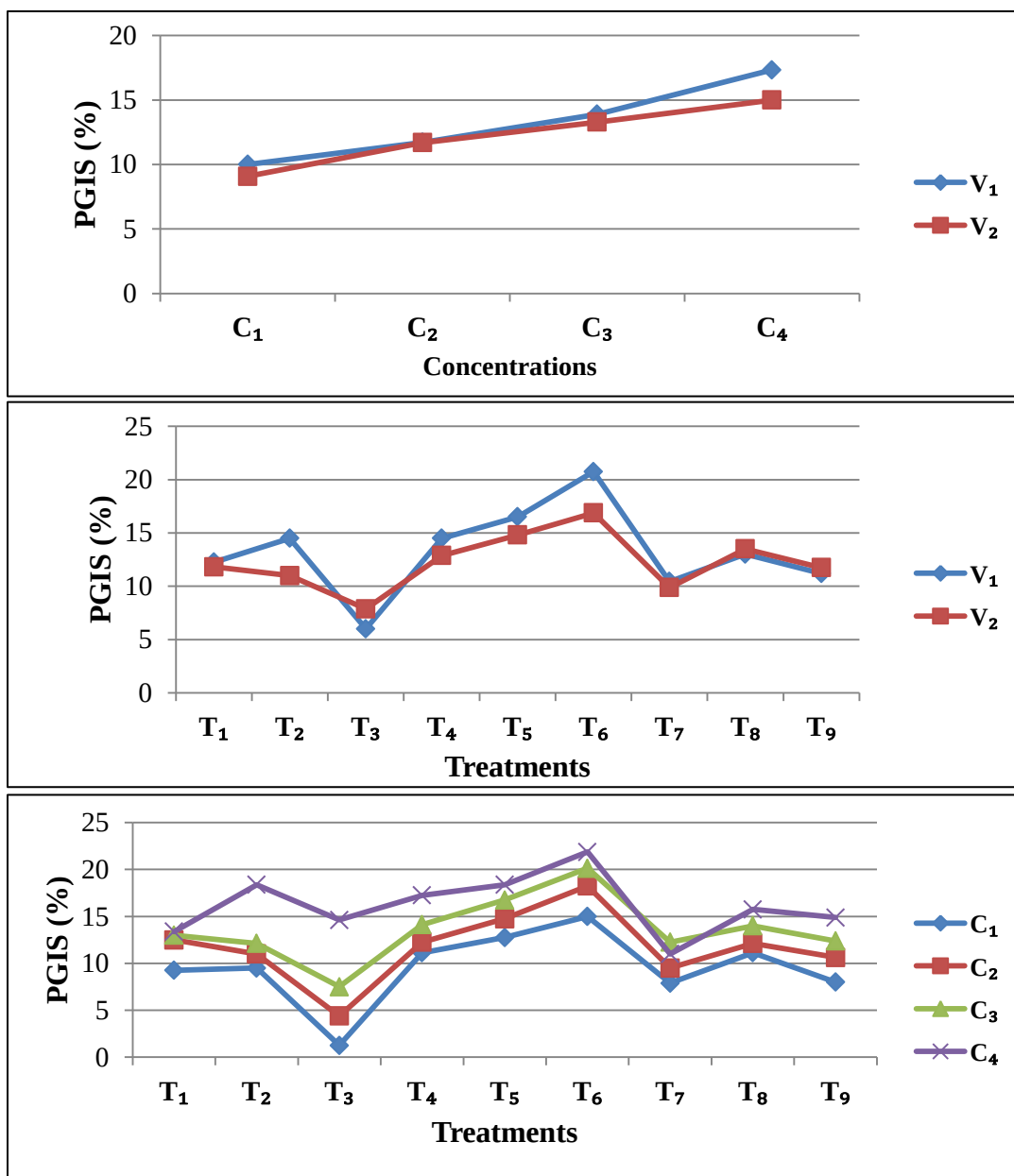


Fig. 5.32. Influence of varieties, seed treatments and concentrations on post germination infected survival (PGIS) (%)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

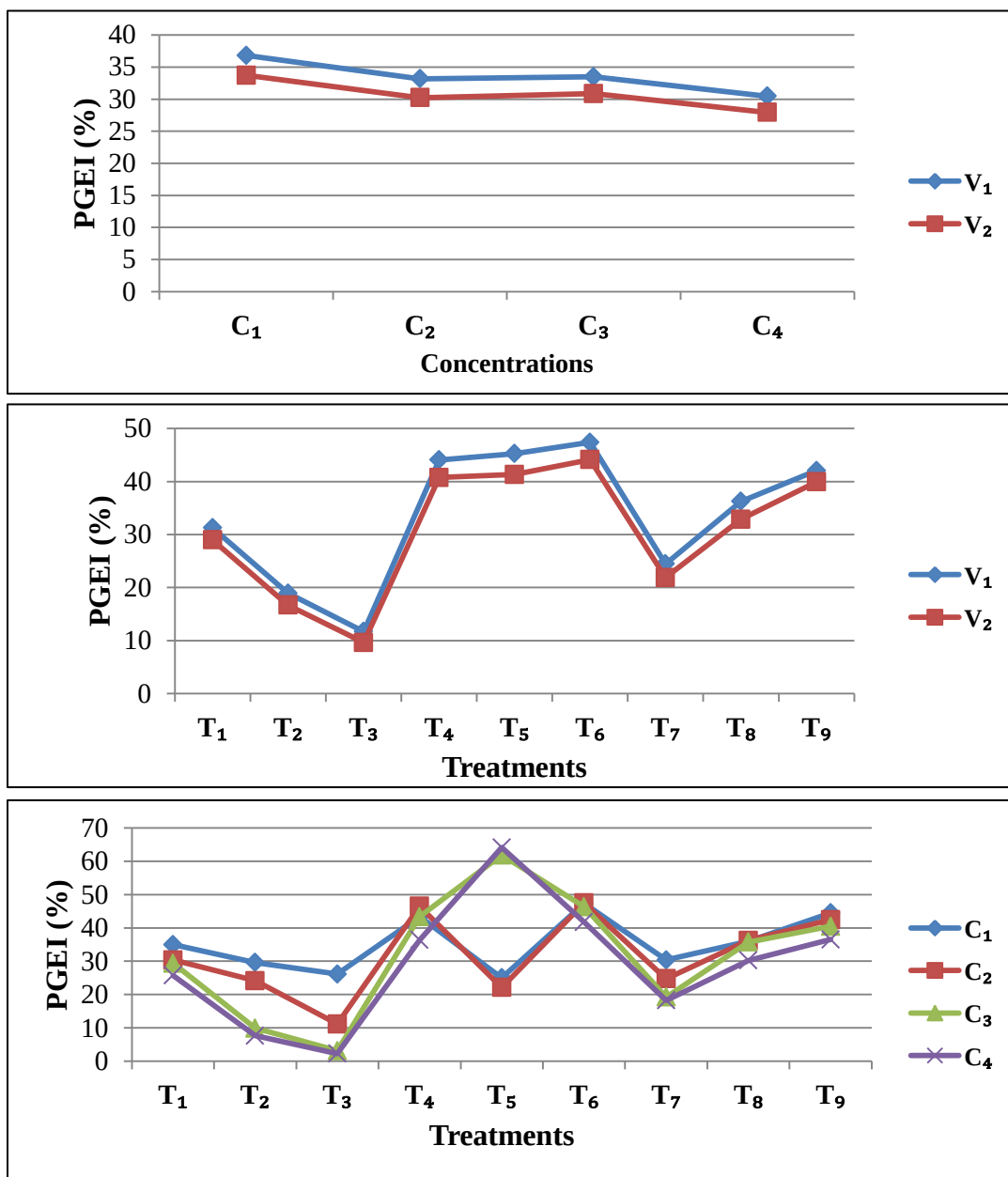


Fig. 5.33. Influence of varieties, seed treatments and concentrations on post germination emergence infected (PGEI) (%)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

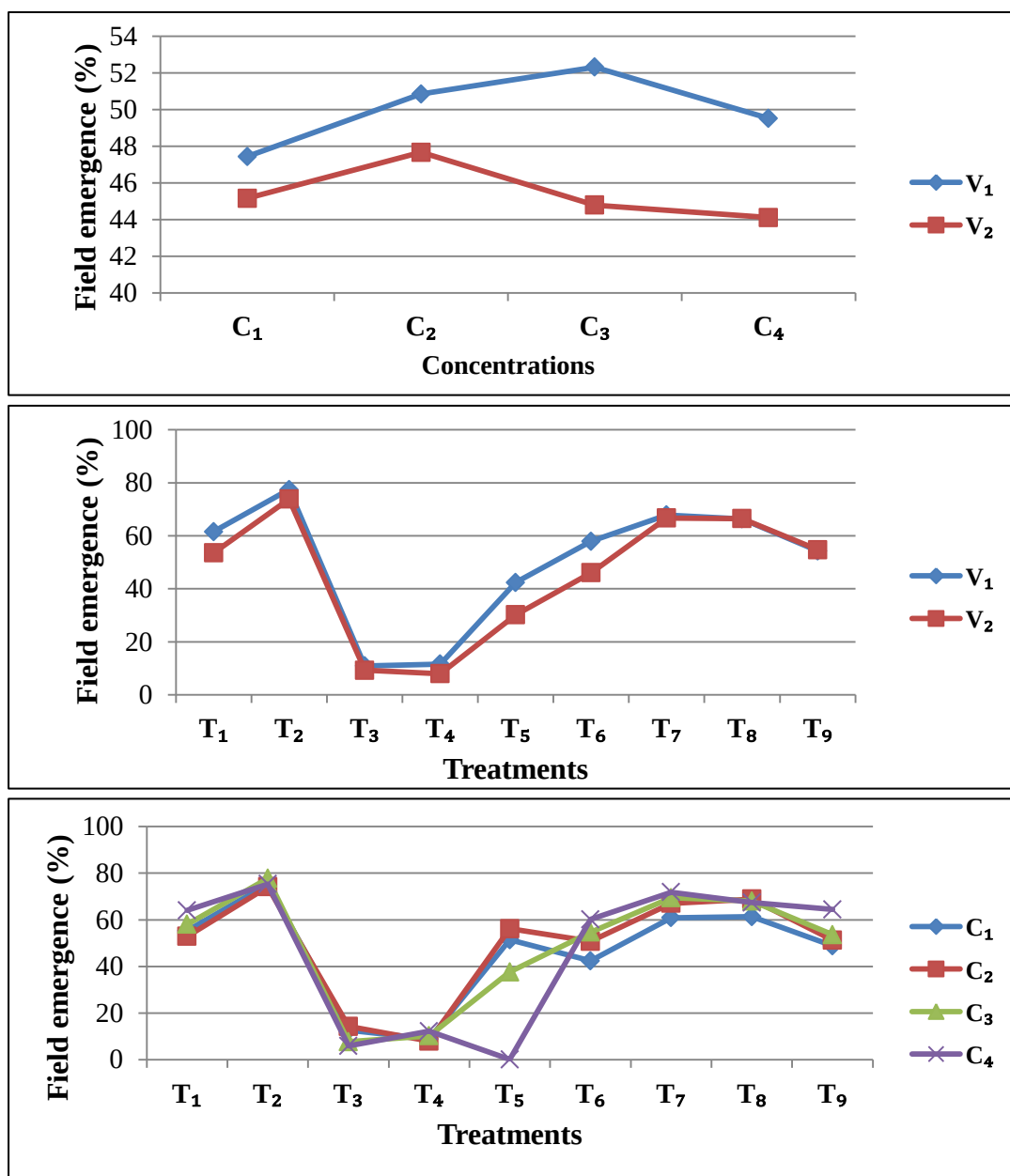


Fig. 5.34. Influence of varieties, seed treatments and concentrations on field emergence (%)

Treatment details:

Varieties

V₁ : Byadagi Dabba

V₂ : G4

Concentrations (%)

C₁ : 0.2

C₂ : 0.3

C₃ : 0.4

C₄ : 0.5

Treatments

T₁ : Kavach

T₂ : Quintol

T₃ : Propiconazole

T₄ : Hexaconazole

T₅ : Hot water (min@ 55°C)

T₆ : Trichoderma viride

T₇ : Bavistin

T₈ : Thiram

T₉ : Captan

wherein it was absent with the genotypes AR-75, Bayadagi Kaddi, Dyavanur Delux, G4, Gouribidanur Local, HMT-1 for pungency. However, the allele specific marker segregation and phenotypic quantification for pungency were not associated with the marker.

Seedling length (cm) ranged from 3.7 to 5.1, 0.5 to 2.2 and 4.3 to 6.3 with P_1 , P_2 and F_1 respectively. The distribution of individuals in F_2 indicated quantitative nature of seedling length and seedling emergence with normal distribution in hotpper (Fig. 5.35 to 5.38).

From the ABC scaling test and three parameter joint scaling test it is evident that, presence of higher seedling length and the higher seedling emergence were predominantly under the control of genes with dominance effect and the dominance effect were unidirectional as indicated by higher magnitudes of dominance gene effects and opposite signs of dominance and dominance X dominance epistatic gene effects. Similar results were also reported by Dhal *et al.*, 2010.

Practical utility

- ✓ The present study reported presence of moderate PCV and GCV for seed quality parameters viz., germination, seedling dry weight, α -amylase activity, seed infection, seedling length, seedling vigour index I and II in hot pepper genotypes.
- ✓ The genotypes Sankeshwara, Rona, Byadagi Dabba, LCA-206, Dyavanur Delux, Paprika and TMR-23 with higher oleoresin and lower capsaicin content recorded superior seed quality parameters. While, Chikkaballapur Local, Gouribidanur Local, Lavanga, Panth C-1, Tiwari with medium oleoresin and Capsicin recorded medium seed quality parameters.
- ✓ The increased content of capsaicin recorded lower disease incidence. Whereas, increased content of oleoresin increased the fruit rot and other related parameters in hot pepper.
- ✓ The increased content of capsaicin is known to affect the seed quality parameters by inhibiting α -amylase activity the first enzyme synthesized during seed

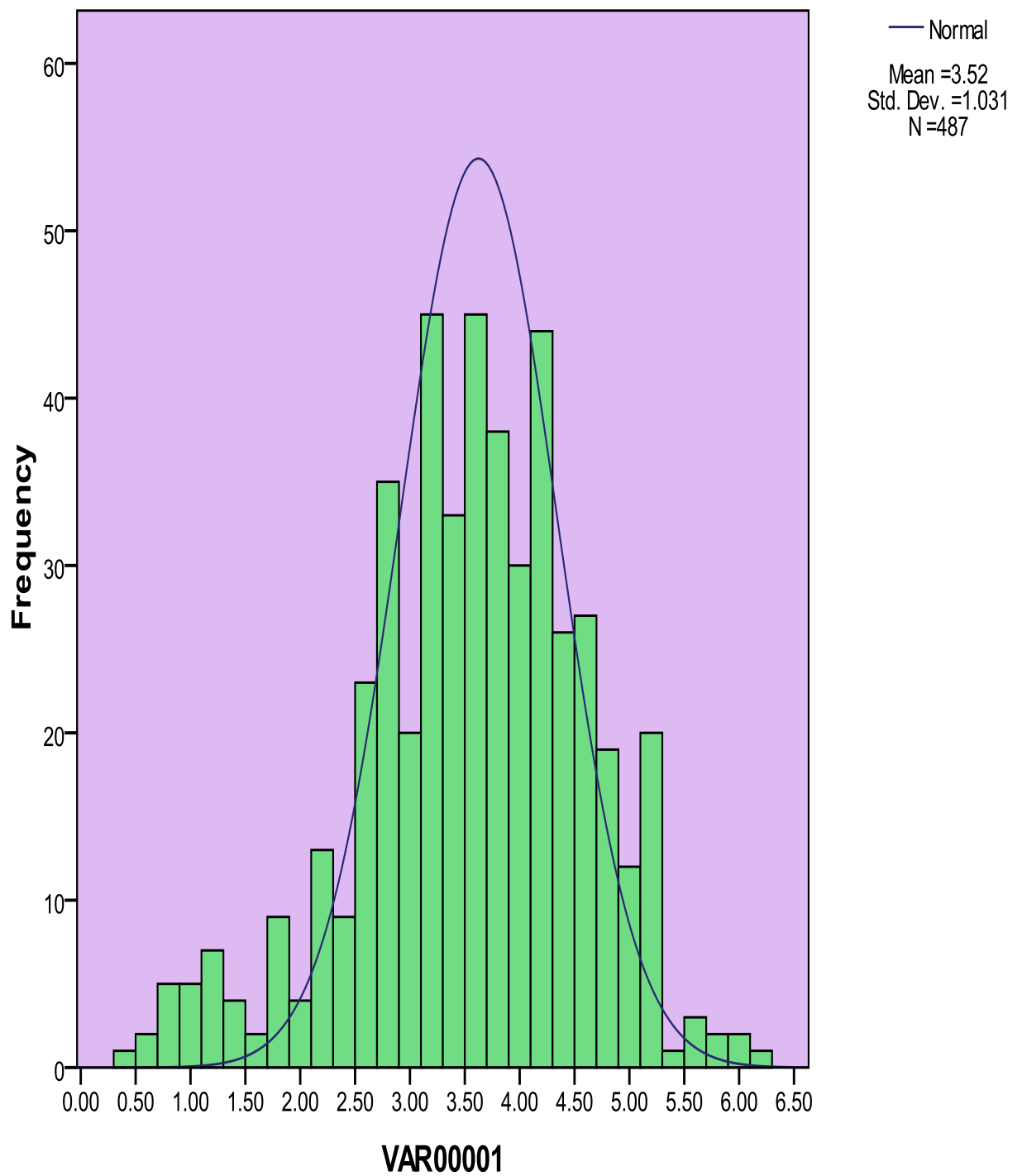


Fig. 5.35. Frequency distribution of F_2 for seedling length at 14th day after sowing (n=487)

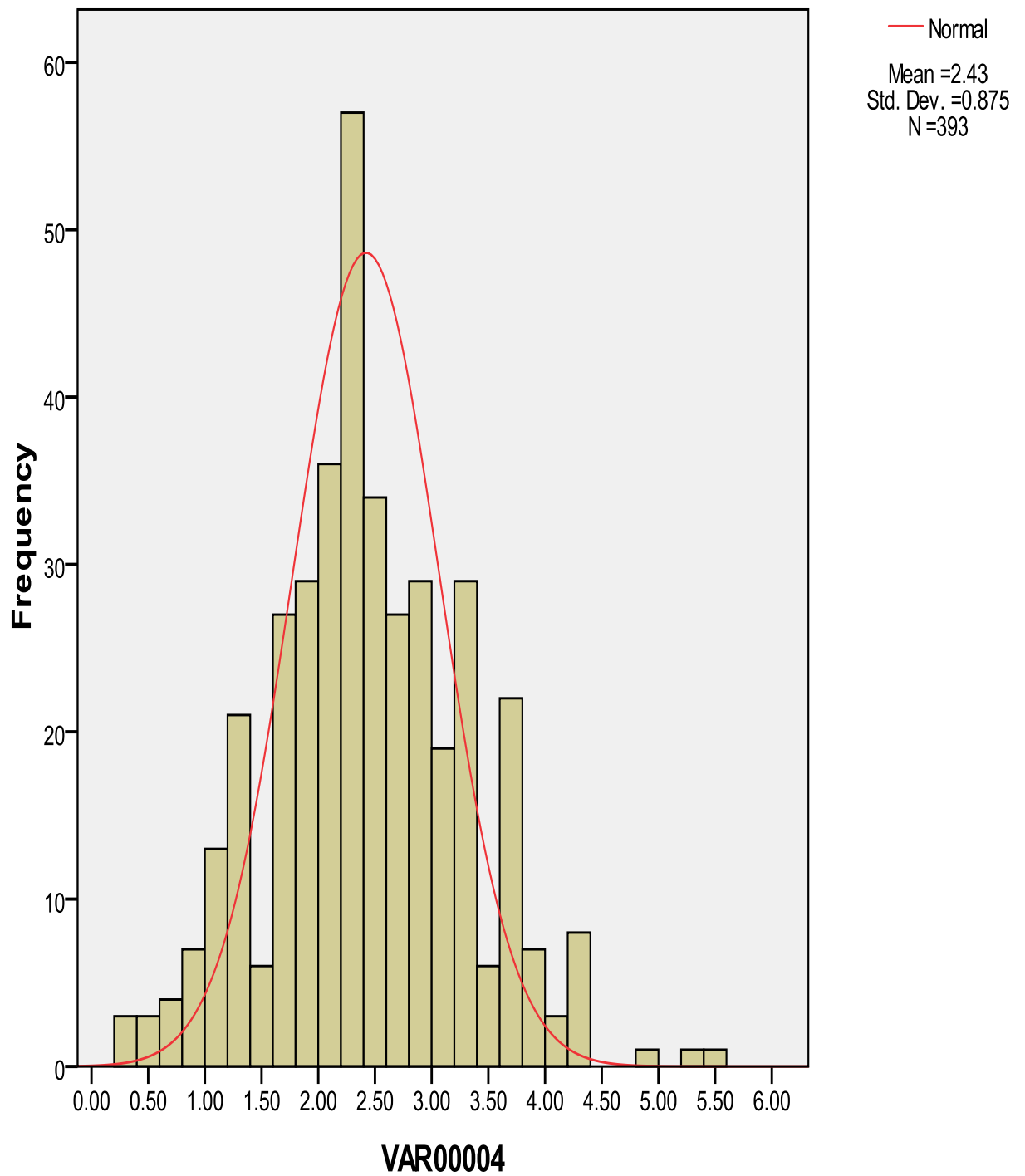


Fig. 5.36. Frequency distribution of B_1 for seedling length at 14th day after sowing (n= 393)

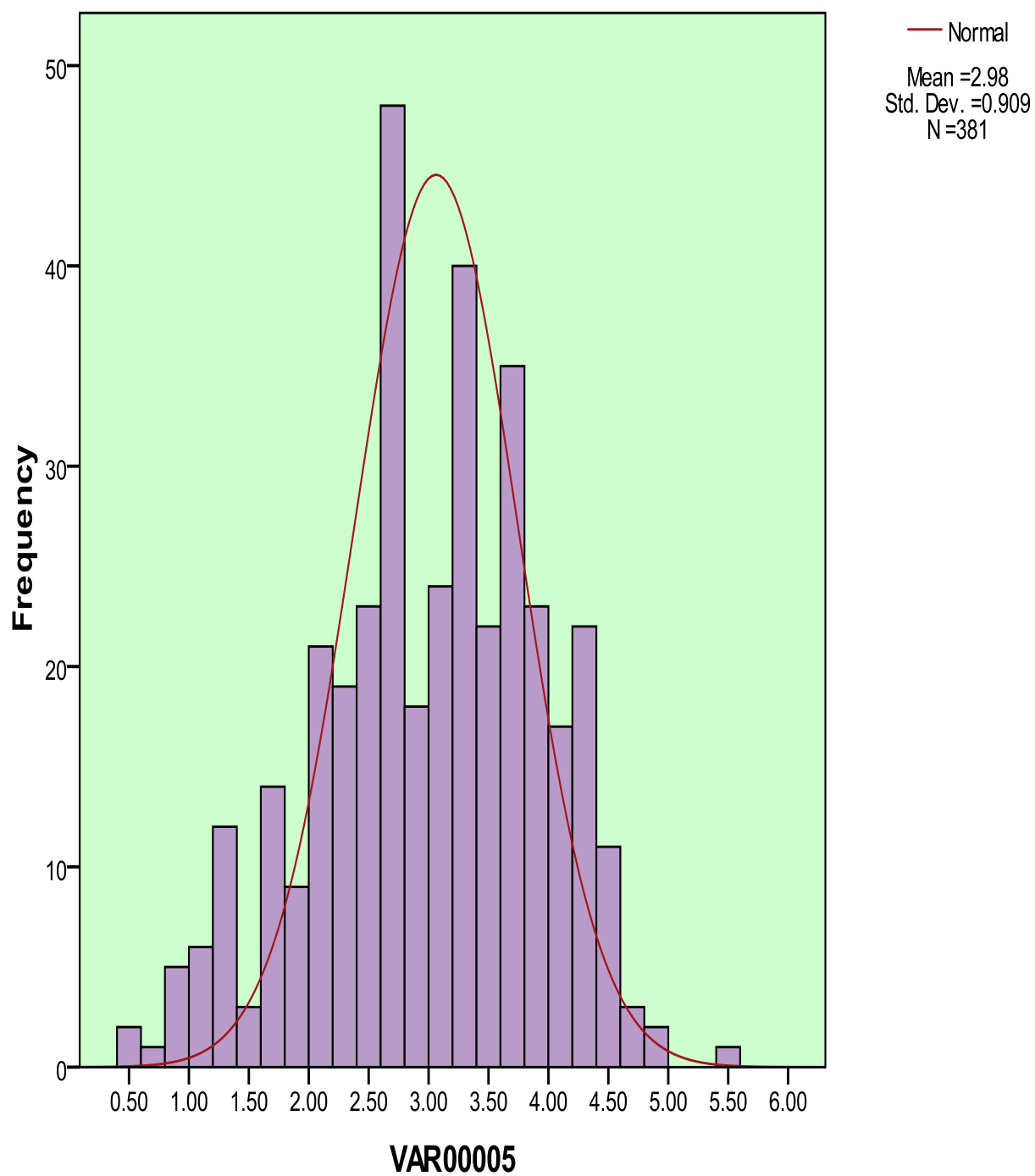


Fig. 5.37. Frequency distribution of B_2 for seedling length at 14th day after sowing (n=381)

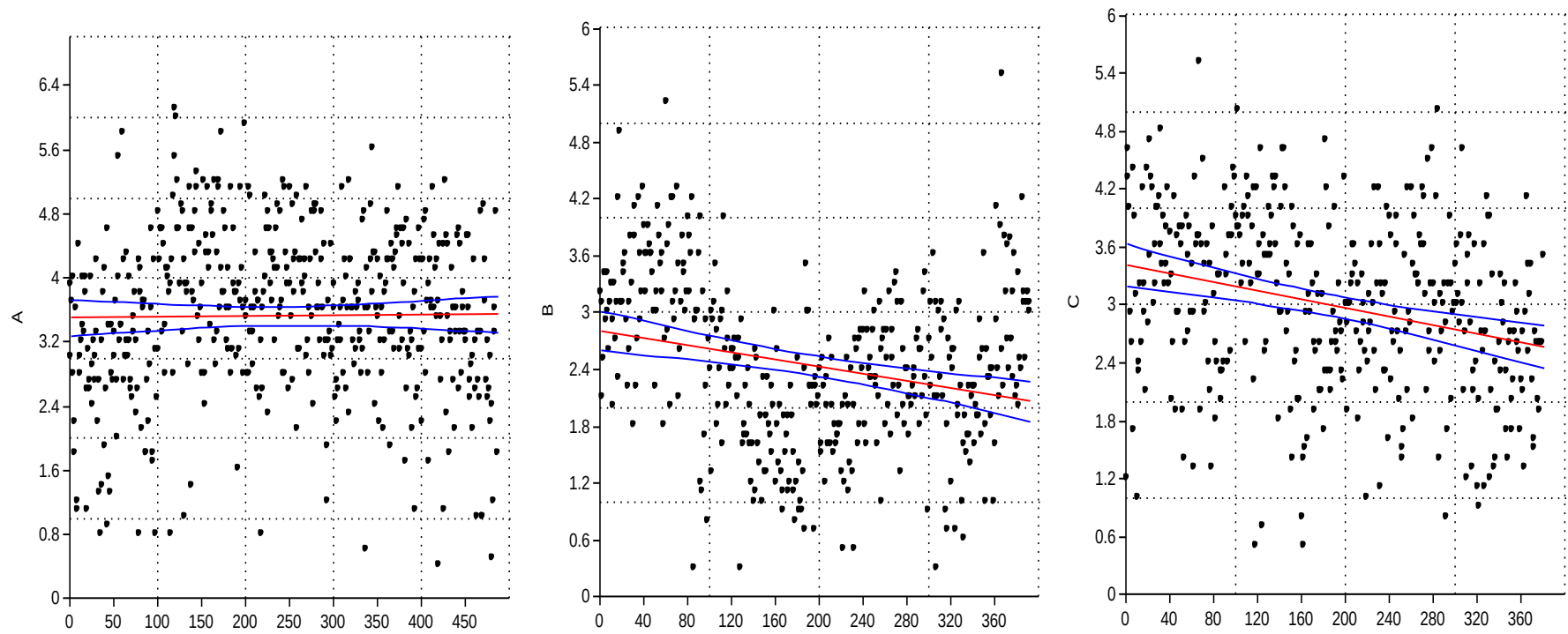


Fig. 5.38. Scatter plot of F₂ (A), B₁ (B) and B₂ (C) populations for seedling length at 14th day with 487, 487 and 487 plants respectively

germination process mediated by GA₃ indicating selection for low and medium capsaicin varieties for higher seed quality parameters.

- ✓ Role of capsaicin in storage is pronounced and indication production of capsaicin free radical. This is countered by the colouring pigments to enhance seed quality in hot pepper.
- ✓ Seed treatment with quintal @ 0.4 (%) was effective in controlling seed borne anthracnose and enhanced all the seed quality parameters maintain minimum seed certification standards.
- ✓ The marker SSR 7F/15R can be employed to validate the pungency in genotypes Assam Bhut Jolokia, Gouribidanur Local, LCA 206, LCA 245, Minchalli Betta and Soogi Menasu at 125 Kb dominantly besides for genetic purity identification.
- ✓ The six generation variability analysis revealed that, higher seedling length and the higher seedling emergence were predominantly under the control of genes with dominance effect and the dominance effect were unidirectional as evidenced by higher magnitudes of dominance gene effects.

Future line of work

- ✓ Beneficial effects of oleoresin on seed quality needs to be exploited through its extraction and seed treatment.
- ✓ Capsaicin seed treatment to induce dormancy needs to be explored.
- ✓ The catabolism of capsaicin in seeds where in production of capsaicin peroxidase deterring the seeds storage potential can be investigated.
- ✓ Assessment and prediction of capsaicin in storage in order to use it as physico-biochemical marker to assess the seed quality in storage.

SUMMARY



VI SUMMARY

The results obtained in the present study pertaining to variability for capsaicin and oleoresin of hot pepper genotypes and to assess their role on seed quality, anthracnose fruit rot incidence and severity; effect of capsaicin and oleoresin on seed quality attributes during storage; assessment of seed treatment chemicals to control seed borne anthracnose and validation of trait specific DNA markers linked to pungency are summarised under the following headings.

6.1 Variability for capsaicin and oleoresin among selected hot pepper genotypes and to assess their role on seed quality

6.1.1 Genetic variability

- The mean sum of squares due to genotypes for 17 different characters, all the 47 genotypes evaluated differed significantly.
- The results with regards to overall mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and expected genetic advance as per cent mean (GAM) for all 17 characters indicated presence of wide range for all 17 characters studied. The higher range was noticed in seedling vigour index-I followed by seedling vigour index-II.
- GCV ranged from 13.12 per cent (seedling dry weight) to 144.13 per cent (Electrical conductivity). All the characters in the present study manifested higher level of GCV except germination (16.47 %) and seedling dry weight (13.12 %) manifested moderate level of GCV.
- All the characters in the present study manifested higher level of PCV except germination (16.79%) and seedling dry weight (13.12%) manifested moderate level of PCV.
- The heritability (broad sense) ranged 92 per cent (seedling length) to 100 per cent (Electrical conductivity).
- The GAM ranged 27.03 per cent (seedling dry weight) to 296.91 per cent (Electrical conductivity). All the characters manifested higher GAM.

6.1.2 Trait inter relationship by correlation

- Hot pepper characters in the present investigation showed significant positive correlation with germination while electrical conductivity (-0.8125), fresh ungerminated seeds (-0.8890), capsaicin (-0.7482) showed significant negative correlation with germination per cent.
- Various seed quality parameters showed significant positive correlation with vigour index. Whereas, electrical conductivity (-0.7374), fresh ungerminated seeds (-0.8100), capsaicin (-0.7993) showed significant negative correlation with vigour index I
- Electrical conductivity (-0.7284), fresh ungerminated seeds (-0.7905), capsaicin (-0.7832) showed significant negative correlation with seedling vigour index-II except all other seed quality parameters.
- All the characters in the present investigation showed significant positive correlation with seed infection. While, fresh ungerminated seeds (-0.5763) and capsaicin (-0.7655) showed significant negative correlation with seed infection.
- Except fresh ungerminated seeds (-0.4733) and capsaicin (-0.6076) showed significant negative correlation with fruit rot disease incidence on ripe fruits.

6.1.3 Direct and indirect effect of traits in hot pepper

- Path coefficient analysis were carried out both at genotypic and phenotypic levels taking germination per cent, seed vigour index-I, seedling vigour index II, seed infection per cent and fruit rot disease incidence on ripe fruits as dependent characters.

6.1.3.1 Direct effect of different characters at phenotypic level

- At the phenotypic level, seedling length (-1.3034) recorded the highest negative direct effect on germination per cent followed by fresh ungerminated seeds (-0.2268), seedling dry weight (-0.1182), total dehydrogenase activity (-0.1147).

- Electrical conductivity (-0.0773), seed infection (-0.0557), capsaicin (-0.0156) and oleoresin (-0.0083) recorded negative direct effect on germination per cent but their magnitude were low.
- At the phenotypic level, seedling length (0.7297) recorded the highest positive direct effect on vigour index I, followed by germination per cent (0.3452) which were of considerable magnitude.
- Number of seed fruit⁻¹ (-0.0071), 1000 seed weight (-0.0094), seedling dry weight (-0.0441), fruit rot disease incidence on ripe fruits (-0.0189), α -amylase activity (-0.0055), capsaicin (-0.0068) and ASTA color value (-0.0030) recorded the negative direct effect on vigour index I but their magnitude were low.
- At the phenotypic level, 1000 seed weight (0.0575), electrical conductivity (0.0156), seed infection (0.0340), total soluble seed protein content (0.0453), capsaicin (0.0097) and ASTA color value (0.0378) recorded positive direct effects on vigour index II but their magnitude was low.
- Number of seed fruit⁻¹ (-0.0120), total dehydrogenase activity (-0.0156), fresh ungerminated seeds (-0.0715), seedling length (-0.7362), fruit rot disease incidence on ripe fruits (-0.0040), α -amylase activity (-0.0743) and oleoresin (-0.0053) recorded the negative direct effect on seedling vigour index II but their magnitude were low.
- 1000 seed weight (-0.0657), electrical conductivity (-0.0054), fresh ungerminated seeds (-0.2225), seedling dry weight (-0.1184), α -amylase activity (-0.1978), total soluble seed protein content (-0.0071) and oleoresin (-0.0699) recorded the negative direct effect on seed infection but their magnitude were low at the phenotypic level.
- At the phenotypic level, vigour index I (-1.3644) recorded the highest negative direct effect on fruit rot disease incidence on ripe fruits. Number of seed fruit⁻¹ (-0.1266), electrical conductivity (-0.0627), total dehydrogenase activity (-0.0312), seedling vigour index II (-0.0339) and ASTA color value (-0.0872) recorded the negative direct effect on fruit rot disease incidence on ripe fruits.

6.2 Anthracnose fruit rot incidence and severity in relation to capsaicin and oleoresin

- The seed quality parameters, capsaicin and oleoresin contents of hot pepper fruits such as was reduced in infected fruits as compared to healthy fruits in all the genotypes studied.
- The highest fruit rot disease incidence was recorded in Rona (95%) followed by Paprika and Shivani (93% each) having low capsaicin. Whereas, no symptom of fruit rot disease incidence was recorded on genotype Majjige Menasu-1.
- The highest fruit rot disease severity was recorded in Shivani (87.47%) followed by Aparna (87.09%). However, no symptom of fruit rot severity was recorded on genotype Majjige Menasu-1 with high capsaicin.
- Seed infection was absent in naturally infected fruits (NIF) of genotype Majjige Menasu-1 with higher capsaicin in Pericarp (832028 SHU) and low oleoresin (4.29%).
- Assam Bhut Jolokia, Majjige Menasu-1 and Panth C-1 with high capsaicin content (1016960, 832028 and 722364 SHU, respectively) and low oleoresin content (14.02, 4.29 and 11.79 %, respectively) recorded lower true lesion diameter of 0.77, 0.80 and 0.77 cm, respectively in NIF.
- Seed quality parameters showed significantly considerable reduction in both naturally and artificially inoculated fruits of hot pepper genotypes.
- In naturally Infected Fruits (NIF) the highest germination (%) was recorded in Byadagi Dabba (95 %). While among the artificially inoculated fruits, Chikkaballapur local (76 %) recorded highest germination.
- The lowest seed germination Majjige Menasu-1 (37 and 27 %, respectively) was recorded in both NIF and Artificially inoculated fruits (AIF). Whereas, for both NIF and AIF highest was recorded in Byadagi Dabba (18 and 16.35 cm, respectively). Whereas, for both NIF and AIF lowest seedling length was recorded in Assam Bhut Jolokia (7.67 and 6.48 cm, respectively).

- The genotype Assam Bhut Jolokia recorded highest Capsaicin content (1113963, 1078003, and 882100 SHU) in placenta, seed and pericarp respectively in NIF. Whereas, in AIF genotype Assam Bhut Jolokia recorded highest Capsaicin content (1078003, 1066025, and 811130 SHU) in placenta, seed and pericarp respectively.
- The lowest capsaicin content was recorded in genotype Shivani (1779, 1362, and 1138 SHU) in placenta, seed and pericarp respectively in naturally infected fruits and artificially inoculated fruits (1665, 1587, and 975 SHU) in placenta, seed and Pericarp respectively.
- Genotypes with higher oleoresin Byadagi Dabba 21.14, 16.37 and 18.57 per cent followed by Paprika 19.02, 14.52 and 16.74 per cent respectively, recording higher anthracnose lesion diameter both in NIF and AIF (2.10, 2.30 and 1.67, 2.17 cm, respectively). While, the genotype Majjige Menasu-1 with lowest oleoresin content (4.29, 3.25 and 3.76 %) recorded lower lesion (0.80 cm) diameter both in NIF and AIF.

6.3 Seed quality attributes as influenced by capsaicin and oleoresin during storage

- At end of the 24 months storage period, Rona had shown resistant to ageing process by maintaining higher seed germination (69 %). Seeds extracted in stored fruits maintained higher seed germination (57 %) and lower seed germination (54 %) was registered in extracted and stored seeds at the end of 24 moth's storage period. Among packing materials, higher seed germination (63 %) was maintained aluminium foil pouches and lower seed germination per cent was registered in brown paper cover (46 %).
- There was a genotypic variation for mean seedling length, the higher seed mean seedling length was recorded in Byadagi Dabba (13.71 cm) and lower was recorded in Assam Bhut Jolokia (3.69 cm) at end of the storage month. Whole fruits maintained higher mean seedling length (9.10 cm) whereas seeds stored after extraction maintained lower mean seedling length (8.85 cm). The higher seed mean seedling length (10.15 cm) was registered in aluminium foil pouches and lower seed mean

seedling length was recorded in brown paper cover (7.21 cm) at end of the 24 months storage period.

- The higher seed seedling length (10.15 cm) was registered in aluminium foil pouches and lower seed mean seedling length was recorded in brown paper cover (7.21 cm). Among genotypes higher SVI-I was recorded in Byadagi Dabba (887) and lower SVI-I was recorded in Assam Bhut Jolokia (51). Aluminium foil pouches has maintained higher SVI-I (679) and compare to 700 gauge poly pouches (588) and brown paper cover (375) among packaging materials.
- Higher total dehydrogenase activity was recorded in Byadagi Dabba ($2.012 \text{ A}^\circ 480 \text{ nm}$) and lower total dehydrogenase activity was recorded in Assam Bhut Jolokia ($0.129 \text{ A}^\circ 480 \text{ nm}$) at end of the 24 months storage period, whereas, at end of the storage month, among genotypes higher SVI-I was recorded in Byadagi Dabba (887) and lower SVI-I was recorded in Assam Bhut Jolokia (51). Among packaging materials, aluminium foil pouches had maintained higher SVI-I (679) and compare to 700 gauge poly pouches (588) and brown paper cover (375).
- Higher total dehydrogenase activity was recorded in Byadagi Dabba ($2.012 \text{ A}^\circ 480 \text{ nm}$) and lower was recorded in Assam Bhut Jolokia ($0.129 \text{ A}^\circ 480 \text{ nm}$) at end of 24 months storage period. Among materials, seeds in fruits stored maintained higher total dehydrogenase activity ($0.991 \text{ A}^\circ 480 \text{ nm}$) compare to seeds used for storage ($0.943 \text{ A}^\circ 480 \text{ nm}$). Among packaging materials, aluminium foil pouches has maintained ($1.082 \text{ A}^\circ 480 \text{ nm}$) higher total dehydrogenase activity whereas brown paper cover has maintained lower ($0.783 \text{ A}^\circ 480 \text{ nm}$)
- In present study lower electrical conductivity was recorded in Aparna ($71.23 \mu\text{S cm}^{-1} \text{ g}^{-1}$) and higher electrical conductivity was recorded in Chikkaballapur local ($93.90 \mu\text{S cm}^{-1} \text{ g}^{-1}$) at the end of the storage period. Lower electrical conductivity ($77.10 \mu\text{S cm}^{-1} \text{ g}^{-1}$) registered in fruits and higher electrical conductivity in seeds ($79.14 \mu\text{S cm}^{-1} \text{ g}^{-1}$) among materials. At end of month of storage period, the lower EC was recorded in 700 gauge poly pouches ($76.87 \mu\text{S cm}^{-1} \text{ g}^{-1}$) and higher EC was recorded in Aluminium foil pouches ($79.15 \mu\text{S cm}^{-1} \text{ g}^{-1}$).

- Genotypes, Byadagi Dabba has showed higher protein content ($13.17 \mu\text{g g}^{-1}$) compare to other varieties and lower protein content was recorded in Assam Bhut Jolokia ($3.17 \mu\text{g g}^{-1}$). The higher total soluble seed protein ($9.76 \mu\text{g g}^{-1}$) was registered in seeds from fruits and lower ($9.17 \mu\text{g g}^{-1}$) was registered in seeds stored at the end of the storage period. In packaging materials, aluminium foil pouches has maintained higher seed total soluble seed protein ($10.87 \mu\text{g g}^{-1}$) whereas brown paper cover has maintained lower seed total soluble seed protein ($7.41 \mu\text{g g}^{-1}$).
- At end of the storage month, among genotypes higher field emergence was recorded in genotype Rona (35 %) and lower field emergence was recorded in Assam Bhut Jolokia (2 %). Among materials, fruits (27 %) recorded higher field emergence compare to seeds (25 %). Among packaging materials, higher field emergence was recorded with aluminium foil pouches (42 %) and lower field emergence was recorded with brown paper cover (4 %).
- Among the genotypes, higher seed capsaicin was recorded in Assam Bhut Jolokia ($222 \mu\text{g g}^{-1}$) and whereas lower seed capsaicin was recorded in Rona and Paprika ($1 \mu\text{g g}^{-1}$) respectively. Among materials, higher seed capsaicin ($64 \mu\text{g g}^{-1}$) was recorded in fruits and lower capsaicin ($64 \mu\text{g g}^{-1}$) was recorded in seeds ($32 \mu\text{g g}^{-1}$). Among packaging materials higher seed capsaicin was recorded in aluminium foil pouches ($58 \mu\text{g g}^{-1}$) whereas lower seed capsaicin was recorded in brown paper cover ($6 \mu\text{g g}^{-1}$).
- Higher oleoresin was recorded in Byadagi Dabba (18.37 %) and lower seed oleoresin was recorded in Assam Bhut Jolokia (1.89 %). Higher oleoresin (9.83 %) was registered in fruits and lower oleoresin (8.64 %) was registered in seeds among materials. Among packaging materials higher oleoresin (10.27 %) was maintained by aluminium foil pouches whereas brown paper cover had maintained lower (7.62 %) oleoresin.
- Fruits and seeds recorded lower electrical conductivity ($77.10 \mu\text{S cm}^{-1} \text{g}^{-1}$) registered in fruits and higher electrical conductivity in seeds ($79.14 \mu\text{S cm}^{-1} \text{g}^{-1}$).

- At end of month of storage period, the lower EC was recorded in 700 gauge poly pouches ($76.87 \mu\text{S cm}^{-1} \text{ g}^{-1}$) and higher EC was recorded in aluminium foil pouches ($79.15 \mu\text{S cm}^{-1} \text{ g}^{-1}$).
- Among genotypes, Byadagi Dabba has showed higher protein content ($13.17 \mu\text{g g}^{-1}$) compare to other varieties and lower protein content was recorded in Assam Bhut Jolokia ($3.17 \mu\text{g g}^{-1}$).
- The higher total soluble seed protein ($\mu\text{g g}^{-1}$) ($9.76 \mu\text{g g}^{-1}$) was registered in seeds of fruits and lower total soluble seed protein ($9.17 \mu\text{g g}^{-1}$) was registered in stored seeds at the end of the storage period.
- Among packaging materials, aluminium foil pouches has maintained higher seed total soluble seed protein ($10.87 \mu\text{g g}^{-1}$) whereas brown paper cover has maintained lower seed total soluble seed protein ($7.41 \mu\text{g g}^{-1}$).
- At end of the storage month, among genotypes higher field emergence was recorded in Rona (35 %) and lower field emergence was recorded in Assam Bhut Jolokia (2 %).
- Among materials, the seeds from fruits (27 %) recorded higher field emergence compare to seeds (25 %). Among packaging materials, higher field emergence was maintained in aluminium foil pouches (42 %) and lower field emergence was maintained in brown paper cover (4 %).
- Among genotypes, higher α -amylase activity ($\mu\text{g ml}^{-1} \text{ min}^{-1}$) was noted in Shivani ($18.57 \mu\text{g ml}^{-1} \text{ min}^{-1}$) and lower α -amylase activity was recorded in Assam Bhut Jolokia ($4.01 \mu\text{g ml}^{-1} \text{ min}^{-1}$). The seeds in fruits maintained higher seed α -amylase ($12.74 \mu\text{g ml}^{-1} \text{ min}^{-1}$) compared to seeds ($9.53 \mu\text{g ml}^{-1} \text{ min}^{-1}$). Aluminium foil pouches recorded higher α -amylase activity ($14.54 \mu\text{g ml}^{-1} \text{ min}^{-1}$) and lower was recorded with brown paper cover ($6.68 \mu\text{g ml}^{-1} \text{ min}^{-1}$).
- The genotype Assam Bhut Jolokia, recorded higher seed capsaicin ($222 \mu\text{g g}^{-1}$) and whereas lower seed capsaicin ($1 \mu\text{g g}^{-1}$) was recorded in Rona and Paprika, respectively

- Among materials, higher seed capsaicin ($64 \mu\text{g g}^{-1}$) was recorded in seeds in fruits and lower capsaicin ($32 \mu\text{g g}^{-1}$) was recorded in seeds. Among packaging materials higher seed capsaicin was recorded in aluminium foil pouches ($58 \mu\text{g g}^{-1}$) whereas lower seed capsaicin was recorded in brown paper cover ($6 \mu\text{g g}^{-1}$).
- Among genotypes, higher seed oleoresin was recorded in Byadagi Dabba (18.37 %) and lower seed oleoresin was recorded in Assam Bhut Jolokia (1.89 %). Among materials, higher seed oleoresin (9.83 %) was registered in seeds of fruits and lower seed oleoresin (8.64 %) was registered in seed. Among packaging materials higher seed oleoresin (10.27 %) was maintained by aluminium foil pouches whereas brown paper cover had maintained lower (7.62 %) seed oleoresin.

6.4 To assess the efficacy of seed treatments to control seed borne anthracnose

- Higher germination was maintained by Byadagi Dabba (67.79 %) whereas, Panth C-1 maintained lower germination (63.09 %). Among concentrations, higher germination (%) was recorded at 0.3 per cent concentration (66.83 %) and lower seed germination (64.00 %) was recorded with 0.5 per cent concentration. Whereas, higher germination per cent age was noticed in quintal (94.70 %) and lower germination was recorded in hexaconazole (26.09 %) across seed treatment chemicals.
- Among concentration maximum root length, shoot length and mean seedling length was found with 0.3 per cent concentration (7.97, 4.71 and 12.68 cm) and minimum root length was recorded in with 0.5 per cent concentration (5.53, 4.56 and 12.56 cm respectively). Higher root length (cm) was recorded in Quintal (8.50cm), shoot and mean seedling length in Bavistin (5.55, 13.96cm respectively) and lower root and mean seedling length in Hexaconazole (6.62 and 10.65 cm respectively), lower shoot length in hot water treatment (2.82 cm) between seed treatments chemicals
- Seedling dry weight was recorded higher in Byadagi Dabba (11.26 mg) and lower seedling dry weight was recorded in Panth C-1 (8.05 mg) between varieties. Among concentrations, higher seedling dry weight was recorded with 0.2 per cent concentration (9.78 mg) and lower seedling dry weight at 0.4 per cent concentration

- (9.42 mg). With seed treatments chemicals, higher seedling dry weight was recorded in quintal (11.94 mg) and lower seedling dry weight in Propiconazole (7.20 mg).
- Between varieties, higher seedling vigour index-I and II were recorded in Byadagi Dabba (907 and 805 respectively) and lower seedling vigour index-I and II were recorded in Panth C-1 (793 and 547 respectively). Among concentrations, higher seedling vigour index-I and II was registered in 0.3 per cent concentration (866 and 687 respectively) and lower seedling vigour index-I with 0.2 per cent concentration (827), seedling vigour index-II in 0.4 per cent concentration (665). Whereas, in seed treatment chemicals, higher seedling vigour index-II (SVI-II) was noticed in quintal (1135) and lower SVI-II was recorded in Propiconazole (200).
 - Amongst varieties, lowest seed infection was recorded in Panth C-1 (48.00 %) whereas Byadagi Dabba has recorded highest seed infection (54.00 %). Among concentrations, lower seed infection (%) was recorded in with 0.5 per cent concentration (40 %) and higher seed infection was recorded in 0.2 per cent concentration (62.00 %). Among seed treatment chemicals, lower seed infection was registered in quintal (23.00%) and higher seed infection was recorded in *Trichoderma viride* (81.00 %).
 - Higher PGEI and PGIS were recorded in Byadagi Dabba (33.48 and 13.24 % respectively) whereas Panth C-1 recorded lowest PGEI (30.69 and 12.26 %) between varieties. With concentrations, 0.2 per cent has recorded higher PGEI (35.26 %) and lower PGEI was recorded with 0.5 per cent concentration (29.21 %). Amongst seed treatment chemicals, highest PGEI and PGIS were recorded in *Trichoderma viride* (45.75 and 18.81 %). Lower PGEI and lower PGIS (%) was recorded in Propiconazole (10.66 and 6.94 % respectively).
 - Across varieties, highest field emergence was recorded in Byadagi Dabba (68.50%) and lowest was registered in Panth C-1 (59.50 %). Higher field emergence was recorded with 0.5 per cent concentration (91.00 %) and lower field emergence was recorded at 0.2 per cent concentration (37.00 %).

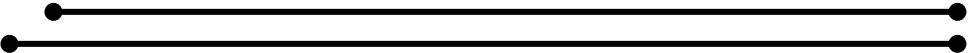
6.5 Validation of trait specific DNA markers linked to pungency.

- Single dominant band at 100 Kb was amplified with marker 7F/15R in all the genotypes wherein it was absent with the genotypes AR-75, Bayadagi Kaddi, Dyavanur delux, Panth C-1, Gouribidanur Local, HMT-1 for pungency.

6.5.1 Joint scaling test for seedling vigour index.

- ✓ The distribution of individuals in F_2 indicated quantitative nature of seedling length and seedling emergence.
- ✓ Higher seedling length and the higher seedling emergence were predominantly under the control of genes with dominance effect and the dominance effect were unidirectional as evidenced by higher magnitudes of dominance gene effects and opposite signs of dominance and dominance X dominance epistatic gene effects.

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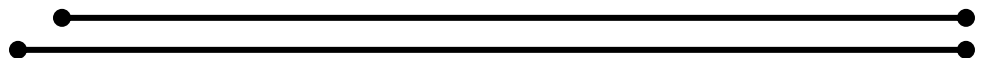
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APPENDICES



APPENDIX-I

**Table. Meteorological data of the experiment during- 2008 at ZARS, UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	28.50	13.60	21.05	89.00	37.00	63.00	9.10	0.00
February	29.40	16.70	23.05	89.00	41.00	65.00	8.40	13.20
March	30.20	17.00	23.60	91.00	39.00	65.00	7.40	1.00
April	32.70	19.30	26.00	88.00	33.00	60.50	8.40	1.60
May	33.30	20.50	26.90	87.00	33.00	60.00	8.80	98.80
June	29.80	18.70	24.25	89.00	47.00	68.00	5.30	32.40
July	28.60	19.30	23.95	94.00	48.00	71.00	4.90	182.80
August	27.90	19.30	23.60	94.00	55.00	74.50	4.10	249.80
September	28.90	19.70	24.30	92.00	50.00	71.00	6.60	126.60
October	27.00	17.80	22.40	92.00	51.00	71.50	5.90	208.00
November	26.80	15.80	21.30	92.00	53.00	72.50	6.60	20.60
December	26.80	15.80	21.30	94.00	49.00	71.50	8.20	1.80
Mean	29.16	17.79	23.48	90.92	44.67	67.79	6.98	78.05

**Table. Meteorological data of the experiment during 2009 at ZARS, UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	28.50	13.60	21.05	89.00	37.00	63.00	9.00	0.00
February	29.40	16.70	23.05	89.00	41.00	65.00	9.90	0.00
March	30.20	17.00	23.60	91.00	39.00	65.00	8.20	10.20
April	32.70	19.30	26.00	88.00	33.00	60.50	7.90	106.00
May	33.30	20.50	26.90	87.00	33.00	60.00	7.20	153.00
June	28.80	18.70	23.75	89.00	47.00	68.00	7.00	58.80
July	28.60	19.30	23.95	94.00	48.00	71.00	4.20	95.80
August	27.90	19.30	23.60	94.00	55.00	74.50	5.80	106.80
September	28.90	19.70	24.30	92.00	50.00	71.00	3.50	231.70
October	27.80	17.80	22.80	92.00	51.00	71.50	7.00	29.60
November	26.80	15.80	21.30	92.00	53.00	72.50	5.20	49.40
December	26.80	14.70	20.75	94.00	49.00	71.50	5.70	11.00
Mean	29.14	17.70	23.42	90.92	44.67	67.79	6.72	71.03

**Table. Meteorological data of the experiment during 2010 at ZARS,UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	27.5	15.1	21.3	92	48	70	8.30	1.00
February	31.1	15.7	23.4	90	38	64	9.80	0.00
March	34.2	18.7	26.45	85	34	59.5	8.30	34.20
April	34.1	20.5	27.3	86	34	60	8.50	112.00
May	32.7	20	26.35	84	39	61.5	8.00	137.40
June	29.7	19.7	24.7	89	46	67.5	5.90	95.40
July	27.8	19.2	23.5	94	53	73.5	3.30	142.20
August	27.1	19.2	23.15	94	58	76	8.20	158.20
September	27.2	19.1	23.15	92	59	75.5	3.80	89.40
October	28.2	19.1	23.65	99	54	76.5	5.00	119.00
November	26.3	17.7	22	95	58	76.5	4.20	128.60
December	25.7	15.2	20.45	92	53	72.5	5.10	9.80
Mean	27.5	15.1	21.3	92	48	70	6.53	85.60

**Table. Meteorological data of the experiment during 2011 at ZARS, UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	27.1	14.7	20.9	89.00	41.00	65.00	9.10	0.00
February	28.5	15.8	22.15	87.00	39.00	63.00	8.10	166.00
March	31.5	18.3	24.9	85.00	33.00	59.00	9.00	0.00
April	31	21.5	26.25	81.00	31.00	56.00	7.30	57.40
May	31	18.5	24.75	85.00	33.00	59.00	7.80	126.00
June	31	20.5	25.75	89.00	38.00	63.50	6.10	30.00
July	27	20.1	23.55	94.00	53.00	73.50	4.20	95.80
August	26.7	20	23.35	94.00	55.00	74.50	3.30	253.20
September	27.4	21.1	24.25	94.00	51.00	72.50	5.90	59.70
October	27.7	21.1	24.4	92.00	51.00	71.50	5.60	122.60
November	26.1	18.2	22.15	89.00	53.00	71.00	6.20	38.00
December	26.2	16.3	21.25	91.00	52.00	71.50	7.30	5.20
Mean	28.78	18.46	23.62	90.24	46.24	68.24	6.66	79.49

**Table. Meteorological data of the experiment during 2012 at ZARS, UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	28.00	14.30	21.15	90.00	45.00	67.50	9.20	0.00
February	30.50	15.50	23.00	86.00	36.00	61.00	9.30	0.00
March	33.70	18.70	26.20	82.00	32.00	57.00	8.90	0.40
April	33.70	18.10	25.90	88.00	49.00	68.50	8.20	8.60
May	33.90	20.10	27.00	86.00	40.00	63.00	7.50	84.40
June	30.90	20.30	25.60	87.00	44.00	65.50	6.30	26.60
July	28.70	19.60	24.15	93.00	52.00	72.50	4.30	97.20
August	28.20	19.30	23.75	93.00	53.00	73.00	4.40	100.10
September	29.20	19.40	24.30	92.00	51.00	71.50	5.60	29.20
October	28.30	18.70	23.50	90.00	53.00	71.50	5.70	71.20
November	27.20	16.20	21.70	88.00	53.00	70.50	7.40	150.00
December	27.40	15.40	21.40	88.00	52.00	70.00	8.00	11.20
Mean	30.15	17.97	24.06	88.58	46.67	67.63	7.07	48.24

**Table. Meteorological data of the experiment during 2013 at ZARS, UAS, GKVK,
Bengaluru**

Month	Temperature (°C)		Mean	Relative Humidity (%)		Mean	Bright sun shine (Hours)	Rainfall (mm)
	Max	Min		Morning	Evening			
January	28.80	14.80	21.80	87.00	43.00	65.00	9.60	0.00
February	30.50	16.40	23.45	87.00	40.00	63.50	8.90	2.20
March	32.70	19.20	25.95	87.00	37.00	62.00	8.00	0.00
April	34.60	21.80	28.20	85.00	35.00	60.00	8.40	56.80
May	33.20	21.10	27.15	87.00	44.00	65.50	6.50	92.80
June	28.10	19.70	23.90	90.00	55.00	72.50	3.60	96.50
July	27.50	19.30	23.40	92.00	55.00	73.50	2.20	59.20
August	27.90	19.00	23.45	93.00	54.00	73.50	4.00	58.80
September	27.40	18.90	23.15	92.00	59.00	75.50	4.50	362.30
October	27.80	19.10	23.45	92.00	52.00	72.00	5.10	81.90
November	27.90	17.00	22.45	92.00	53.00	72.50	5.80	37.00
December	26.60	14.10	20.35	89.00	52.00	70.50	7.80	0.00
Mean	29.42	18.37	23.89	89.42	48.25	68.83	6.20	70.63

APPENDIX-II

Table. List of genotypes collected for the study

Sl. No	Genotypes	Source
1.	ACS-2001-1	IIHR, Bengaluru
2.	AKC-29132	IIHR, Bengaluru
3.	Aparna	HRS, Lamfarm APHU, Guntur
4.	Arakale	Local collection from Mangalore
5.	Arka Abhir	IIHR, Bengaluru
6.	Arka Gourav	IIHR, Bengaluru
7.	Arka Lohit	IIHR, Bengaluru
8.	Arka Mohini	IIHR, Bengaluru
9.	Arka Suphal	IIHR, Bengaluru
10.	AR-75	Dry Farming Unit, Bengaluru
11.	Assam Bhut Jolokia*	Local collection from Assam
12.	B. Daddi Orange	Chilli research station Devi Hosur
13.	BC-25	IVRC, Varanasi
14.	BD Keresur-Local	Local collection
15.	BD Short	Local collection
16.	BD -Annigeri-Dyavanur	Local collection
17.	BD -Bhadrapur	Local collection
18.	BD -Gadag Farmer Selection-1	Local collection
19.	BD-Gadag Farmer Selection-2	Local collection
20.	Bird Eye Chilli	Local collection
21.	BK Raichur	Local collection
22.	Byadagi Orange Selection	Chilli research station, Devi Hosur
23.	California Wonder	Ms. Namadhari Pvt. Ltd.
24.	Capsicum Red	Ms. Namadhari Pvt. Ltd.
25.	CBP*	Local collection
26.	CO-1	TAU, Coimbatore
27.	CO-2	TAU, Coimbatore
28.	CO-3	TAU, Coimbatore
29.	CO-4	TAU, Coimbatore
30.	Coorg Local	Local collection
31.	D. Deluxe	Local collection
32.	Byadagi Dabba	Local collection
33.	Dabbi Local	Local collection
34.	Dyavanur-Delux	Local collection
35.	Frutescence Long	AVRDC, Taiwan
36.	G-4	HRS, Lamfarm APHU, Guntur
37.	Icchangi Local	Local collection
38.	Guribidanur Local	Local collection
39.	Guntur Sannam	Local collection
40.	H-24	Ms. Namadhari Pvt. Ltd.
41.	H-26	Ms. Namadhari Pvt. Ltd.
42.	H54R	Ms. Namadhari Pvt. Ltd.
43.	JCA-283	IIHR, Bengaluru
44.	Japanese Lounge	IVRC, Varanasi

Sl. No	Genotypes	Source
45.	Jogishetti local	Local collection
46.	Jogishetti Dabbi Yellow	Local collection
47.	Jowhar-218	IVRC, Varanasi
48.	Kaddi Chittor	Local collection
49.	Kaddi Devihosur	Local collection
50.	Kaddi Devihosur Pure	Local collection
51.	Kaddi Local	Local collection
52.	Kaddi Shiggao-1	Local collection
53.	Khasi Anmol	IVRC, Varanasi
54.	Lakshmi	Indo Spanish Export Pvt. Ltd.
55.	Lavanga*	Local collection, Assam
56.	LCA-206	HRS, Lamfarm APHU, Guntur
57.	LCA-235	HRS, Lamfarm APHU, Guntur
58.	LCA-245	HRS, Lamfarm APHU, Guntur
59.	LCA-353	HRS, Lamfarm APHU, Guntur
60.	LCA- 334	HRS, Lamfarm APHU, Guntur
61.	LCA-960	HRS, Lamfarm APHU, Guntur
62.	Mandaragi Local	Local collection
63.	Mathania Local	Local collection from Rajasthan
64.	Meitei-Community Chill-Manipur	Local collection from Manipur
65.	Munnar Cherry	Local collection from munnar
66.	Oothgod Local	Local collection from Sagar
67.	Panth C-1**	PAU, Ludiana
68.	Paparika	HRS, Lamfarm APHU, Guntur
69.	PAU-LI5	IVRC, Varanasi
70.	PBC-142**	AVRDC, Taiwan
71.	PBC-61(5)3	AVRDC, Taiwan
72.	Pusa Jwala	IARI, New, Delhi
73.	Phule Jyothi**	MPUAT, Udaipur
74.	Pusa Sadabahar**	IARI, New, Delhi
75.	Raja Mirchi	Local collection from Kashmir
76.	Sahyadri wonder hot	Local collection from Sagar
77.	Sankeshwara	Chilli research station Devi Hosur
78.	Shivani	East West Company, Bengaluru
79.	Sooji menasu	Local collection from Sagar
80.	Majjige Menasu Big*	Local collection
81.	Majjige Menasu Small*	Local collection
82.	Tiwari **	PAU, Ludiana
83.	TMR-23	United Genetics, Bengaluru
84.	Uchi-Morh (Rat Chilli-Manipur)	Local collection from Manipur
85.	Uthkal Awa #	OUAT, Bhubaneswar
86.	Vijipura Local	Local collection
87.	Yellow Capsicum	Ms. Namadhari Pvt. Ltd.
88.	X-235	NSC, Bengaluru

*Genotypes from provided by Dr. K. P Rama Prasanna.

**Genotypes kindly provided by Hot Pepper Improvement Unit, Department Genetics and Plant Breeding, University of Agricultural Sciences, G.K.V.K., Bengaluru.

APPENDIX –III

Table: List of fungicide and insecticide control undertaken as preventive and curative measure in hot pepper field production

Sl. No.	Disease/ pest	Trade name	Chemical name	Dosage	Manufacturer
1	Leaf Spot	SAFF	Carbendizim + 63 % (WP) mancozeb	300-400 gm/acre	United Phosphorus Ltd.
2	Powdery Mildew	Tilt 25 EC	Propiconazol 25 % EC	15 ml/100L	Syngenta Pvt. Ltd.
3	Powdery Mildew	Topaz 10 EC	Propiconazol 25 % EC	25 ml/100L	Syngenta Pvt. Ltd.
4	Powdery Mildew	Karathane	Dinocap 48 % EC	4.5 ml/l	Dow agro science Pvt. Ltd.
5	Powdery Mildew	Baycor	Bitertanol 22 % WP	2g/l	Bayer Pvt. Ltd.
6	Anthravnose	Leo M-45	Mancozeb 75 % Wp	1-2g/l	Insecticide India Ltd.
7	Anthravnose	Contaf 5 EC	Hexaconazol 5 % EC	0.1-0.5ml/l	Tata Pvt. Ltd.
8	Thrips	VICTOR	Imidacloprid 17.8 % SL	0.1ml/l	Insecticide India Ltd.
9	Thrips	Confider	Imidacloprid 17.8 % EC	0.1ml/l	Bayer Pvt. Ltd.
10	Pod borer & Thrips	Lannate	Methomyl 40 % SP	1-2g/l	Dupont Pvt. Ltd.
11	Red spider mites	OMITE	Propopargate 57 % EC	1-2ml/l	Agritec Ltd.
12	Red spider mites	Oberon 240 SC	Spiromerigen 22.9 % w/w SC	1-2ml/l	Bayer Pvt. Ltd.
13	Thrips & mites	Pegasus	Diafentharon 50 % WP	1g/l	Syngenta Pvt. Ltd.
14	Anthravnose	Bayleton	Triadimefon 25 % WP	1-2g/l	Bayer Pvt. Ltd.
15	Anthravnose	Bavistin	Carbendizim 30 % WP	0.5%	BASF

APPENDIX-IV

Table. Characters studied to access the variability and association of capsaicin, oleoresin and anthracnose fruit rot incidence of hot pepper genotypes

Sl. No.	Genotype	Days to flower initiation	Days to maturity	Fruit length (cm)	Fruit width (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Fruit rot disease incidence on ripe fruits	No. of seed/ fruit	1000 seed weight (g)	Electrical conductivity (mS cm ⁻¹ g ⁻¹)	Total dehydrogenase activity	Germination (%)	Abnormal seedlings (%)	Fresh ungerminated seeds (%)	Seedling length (cm)	Seedling dry weight (mg)
1	A. Abhir	33.54	84.73	9.61	2.51	6.01	2.04	11.30*	98.5	6.743	0.94	1.78	80	20	0	14.24	12.08
2	A. Lohith	39.61	90.33	7.81	1.61	4.01	1.45	26.17	94.7	8.029	0.76	1.68	85	15	0	14.11	11.74
3	A. Suphul	30.14	81.40	8.14	1.78	5.11	1.45	35.67	121.7	5.062	1.69	1.63	81	14	5	14.98	12.41
4	Aparna	34.68	84.37	6.65	1.45	4.74	1.21	63.37	70.4	5.202	0.59	1.98	84	16	0	15.34	12.74
5	AR-75	29.84	83.27	9.05	1.96	5.78	1.35	32.10	90.5	5.516	1.23	1.64	80	20	0	13.84	11.74
6	Assam Bhuth Jalokia	58.88	115.27	5.88	2.81	12.58	1.51	6.73	69.5	5.802	13.52	1.10	23	17	60	7.76	8.56
7	Bayadagi Dabba	34.33	90.40	10.75	2.45	11.24	2.41	72.53	137.1	6.449	1.01	3.01	83	17	0	17.88	14.74
8	Bayadagi Kaddi	29.33	81.77	12.21	1.21	3.18	1.44	44.40	70.4	5.326	1.12	2.68	88	12	0	14.81	12.41
9	Bayadagi orange selection	32.52	93.83	9.85	1.93	1.06	1.27	67.70	106.0	6.070	0.80	2.95	85	15	0	15.87	13.55
10	CA-6	28.67	81.47	10.30	0.62	2.96	1.71	26.43	67.0	5.263	0.38	2.70	84	16	0	15.35	11.44
11	Chikkaballapur Local	43.74	93.87	3.05	1.31	2.61	0.68	13.23	83.1	4.259	2.10	1.86	81	19	0	12.13	12.74
12	CO-1	28.41	78.40	11.58	3.35	31.04	5.75	56.47	228.4	9.743	0.33	3.02	84	16	0	17.74	14.74
13	CO-2	28.01	79.07	13.58	2.95	27.24	4.45	75.20	220.7	7.906	0.44	2.95	82	18	0	16.41	13.74
14	CO-3	29.58	81.37	6.75	2.61	19.58	2.58	12.33	119.1	4.652	0.85	2.91	84	16	0	15.71	13.08
15	Coorg local	57.69	109.40	3.54	3.74	10.80	1.22	8.37	73.1	4.953	12.34	1.26	25	20	55	7.56	8.76
16	Dyavanur Delux	33.08	83.00	11.25	1.65	6.91	1.31	62.33	89.1	5.916	0.96	2.91	82	18	0	14.35	12.08
17	G4	32.94	82.80	8.50	1.05	3.18	1.01	37.83	70.1	7.496	1.43	1.89	79	3	18	13.75	11.41
18	Gouribidanur Local	41.21	84.17	3.13	1.33	2.72	1.50	16.43	69.7	4.660	1.76	1.70	82	18	0	14.33	11.29
19	HMT-1	31.41	81.30	6.01	1.85	6.11	1.75	71.43	89.4	6.612	0.97	1.56	78	22	0	15.11	12.74
20	JCA283	33.54	82.20	6.04	1.45	2.75	1.05	82.63	98.4	4.896	1.09	2.10	78	22	0	12.21	10.08
21	Kashi Anmol	26.28	75.60	6.51	1.45	3.05	1.14	90.77	75.1	4.332	0.85	1.60	79	21	0	13.44	11.08
22	KDC-1	37.33	86.73	6.45	1.45	3.01	0.85	58.23	85.1	4.196	0.80	1.80	76	24	0	12.78	10.74
23	Lavanga	31.48	79.50	3.75	1.21	1.94	0.75	11.40	81.5	4.059	2.20	2.10	79	21	0	13.78	11.41
24	LCA206	32.27	81.30	8.07	1.01	5.25	0.71	72.63	89.0	4.822	0.69	2.60	88	12	0	13.40	12.38
25	LCA235	35.16	83.83	7.34	1.15	2.23	0.67	54.83	68.0	5.533	0.89	2.40	75	25	0	11.55	10.50

Sl. No.	Genotype	Days to flower initiation	Days to maturity	Fruit length (cm)	Fruit width (cm)	Fresh fruit weight (g)	Dry fruit weight (g)	Fruit rot disease incidence on ripe fruits	No. of seed/ fruit	1000 seed weight (g)	Electrical conductivity (mS cm ⁻¹ g ⁻¹)	Total dehydrogenase activity	Germination (%)	Abnormal seedlings (%)	Fresh ungerminated seeds (%)	Seedling length (cm)	Seedling dry weight (mg)
26	LCA245	45.00	77.33	6.57	1.19	2.27	0.95	44.63	75.1	5.327	0.66	2.10	77	23	0	10.30	10.52
27	LCA 334	47.33	82.83	6.52	1.13	2.62	1.00	38.67	60.0	4.825	1.18	2.20	81	19	0	12.09	11.60
28	LCA353	66.17	82.10	7.07	1.28	2.67	1.25	42.03	66.7	5.190	0.90	2.50	76	24	0	11.32	10.77
29	LCA960	37.62	77.40	5.62	2.12	8.81	2.84	78.23	84.4	5.317	1.36	2.80	83	17	0	11.16	10.72
30	Minchalli Betta	31.92	80.83	7.42	1.50	9.37	4.15	6.00	70.2	5.763	2.80	2.90	82	18	0	11.43	11.00
31	Panth C-1	34.44	83.10	5.90	1.11	3.41	2.48	24.30	69.7	5.084	2.90	1.80	72	7	21	9.83	11.10
32	Paprika	32.88	84.97	12.41	2.21	14.55	2.81	92.53	98.7	5.366	1.24	2.90	83	17	0	13.44	11.08
33	PBC-142	40.83	76.00	6.41	1.18	3.18	1.20	5.50	83.0	3.954	1.84	1.70	80	20	0	12.64	10.13
34	PBC-613	30.83	80.47	8.21	1.31	4.94	0.98	21.67	88.4	4.529	0.65	1.90	79	21	0	14.24	12.08
35	Phule Jothi	41.58	93.50	7.75	1.51	4.01	1.01	34.40	111.7	4.552	1.61	2.10	79	21	0	12.34	10.41
36	Pusa Sadabahar	39.48	90.27	6.08	1.34	3.04	0.85	16.73	93.1	4.113	1.40	2.40	81	19	0	11.24	9.41
37	Rona	34.63	73.53	9.77	0.84	3.52	2.63	94.53	61.7	5.356	1.50	2.90	88	12	0	11.73	12.58
38	Samrudhi	30.48	84.60	8.58	1.54	4.28	1.28	54.70	55.4	6.702	0.90	2.10	81	19	0	13.91	11.74
39	Sankeshwara	65.04	88.80	22.73	0.91	6.23	4.54	22.77	53.0	5.371	1.04	3.10	96	4	0	13.88	12.66
40	Sahyadri Wonder Hot	57.09	117.60	5.67	2.96	12.89	1.49	19.60	70.2	5.460	1.23	1.15	28	26	46	7.60	8.13
41	Shivani	21.74	74.70	12.38	4.25	44.50	5.28	92.63	188.1	6.832	1.12	3.20	80	20	0	16.50	13.74
42	Soogi Menasu	83.71	97.27	2.30	0.38	1.03	0.66	4.23	17.7	0.297	12.60	0.89	3	1	96	5.87	8.29
43	Majjige Menasu-1	92.00	108.33	4.67	0.98	1.54	1.03	0.00	68.0	5.217	9.20	1.60	30	3	67	8.22	11.21
44	Majjige Menasu-2	84.00	98.47	2.07	0.48	1.29	0.78	0.00	33.7	4.193	3.02	1.40	49	1	50	7.30	10.28
45	Tiwari	54.87	75.00	6.70	1.09	5.30	2.29	24.63	58.3	4.127	1.95	2.10	82	18	0	11.72	10.72
46	TMR-23	29.68	81.73	14.24	4.18	37.88	6.78	89.47	242.5	8.819	0.48	3.12	84	16	0	15.68	13.08
47	Utkal Awa	33.30	75.47	5.32	1.37	5.30	3.41	23.43	82.0	8.373	2.09	2.00	84	16	0	11.45	12.05
Mean		40.60	85.82	7.87	1.72	7.82	1.93	5.97	91.4	5.495	2.16	2.18	75	17	9	12.81	11.52
S.Em±		2.075	2.931	0.472	0.170	1.415	0.284	0.419	5.704	0.367	0.085	0.070	2.826	0.982	0.056	0.829	0.515
CD(<0.05P)		5.826	8.231	1.325	0.477	1.415	0.797	1.177	16.017	1.031	0.239	0.198	7.935	2.592	0.157	2.328	1.447

Table. Characters studied to access the variability and association of capsaicin, oleoresin and anthracnose fruit rot incidence of hot pepper genotypes

Sl. No.	Genotype	Vigour Index I	Vigour Index II	Seed infection (%)	α -amylase activity (mg/ml/min.)	Total seed soluble Protein (μ g/g)	Capsaicin (μ g/g)	Oleoresin (%)	ASTA color value
1	A. Abhir	1144	970	22.5*	22.77	12.10	147	10	55
2	A. Lohith	1198	999	17.5	21.78	9.70	174	11	33
3	A. Suphul	1218	1009	32.0	21.30	9.90	196	14	38
4	Aparna	1283	1066	55.0	24.77	14.65	141	6	13
5	AR-75	1102	936	38.0	21.37	9.80	122	12	38
6	Assam local	312	345	2.0	12.00	6.50	417	15	21
7	Bayadagi Dabba	1489	1229	55.0	35.10	17.49	136	23	161
8	Bayadagi Kaddi	1302	1093	23.5	31.81	15.60	146	19	154
9	Bayadagi orange selection	1349	1152	34.5	34.66	14.90	123	7	33
10	CA-6	1294	965	43.2	32.00	15.80	27	10	38
11	Chikkaballapur Local	979	1031	12.0	23.60	12.30	265	16	33
12	CO-1	1481	1236	54.0	35.20	15.20	38	11	119
13	CO-2	1339	1123	56.0	34.12	13.20	39	11	131
14	CO-3	1324	1103	22.5	34.10	15.50	63	8	125
15	Coorg local	343	397	0.0	13.90	7.60	398	14	22
16	Dyavanur Delux	1177	990	28.0	34.10	16.30	132	22	147
17	G4	1082	896	18.5	23.90	11.10	204	9	65
18	Gouribidanur Local	1175	926	12.0	22.00	13.10	238	15	56
19	HMT-1	1177	995	48.0	20.60	9.60	143	10	32
20	JCA283	956	790	48.0	26.00	8.40	154	11	42
21	Kashi Anmol	1059	877	46.0	21.00	8.90	132	11	41
22	KDC-1	978	811	49.0	23.00	9.70	186	11	26
23	Lavanga	1089	901	5.0	26.00	12.30	296	12	63
24	LCA206	1175	1085	52.0	31.00	16.40	198	15	125
25	LCA235	862	784	38.5	29.00	7.80	189	12	84

Sl. No.	Genotype	Vigour Index I	Vigour Index II	Seed infection (%)	α -amylase activity (mg/ml/min.)	Total seed soluble Protein (μ g/g)	Capsaicin (μ g/g)	Oleoresin (%)	ASTA color value
26	LCA245	790	806	23.0	26.00	8.40	192	15	67
27	LCA 334	984	943	21.5	27.00	9.90	194	11	36
28	LCA353	860	819	24.0	30.00	10.60	193	11	48
29	LCA960	928	891	46.7	33.00	16.20	160	8	65
30	Minchalli Betta	934	898	12.0	34.00	14.00	156	10	54
31	Panth C-1	780	881	8.5	23.00	14.10	221	11	56
32	Paparika	1115	919	64.5	34.00	16.30	57	20	165
33	PBC-142	1011	811	26.0	22.00	9.00	248	9	48
34	PBC-613	1124	955	44.0	24.00	8.10	146	9	88
35	Phule Jothi	979	825	23.5	26.00	8.70	182	9	97
36	Pusa Sadabahar	910	762	32.0	29.00	9.60	132	10	101
37	Rona	1028	1103	77.0	34.00	11.80	42	13	123
38	Samrudhi	1126	951	43.0	26.00	9.20	148	9	32
39	Sankeshwara	1336	1220	23.3	35.67	17.40	54	14	142
40	Sahyadri Wonder Hot	407	436	9.0	16.40	7.90	400	9	16
41	Shivani	1327	1102	76.0	37.00	17.20	74	6	155
42	Soogi Menasu	283	401	0.0	13.90	8.90	341	9	44
43	Majjige Menasu-1	318	434	0.0	21.00	7.10	302	4	3
44	Majjige Menasu-2	355	501	0.0	19.00	6.40	311	3	2
45	Tiwari	965	883	21.0	26.00	8.60	246	13	32
46	TMR-23	1323	1102	82.0	36.20	15.80	38	20	146
47	Utkal Awa	966	1016	14.0	25.00	9.60	268	10	28
Mean		1016	901	31.6	26.66	11.67	179	12	69
S.Em $\pm$		41.501	37.793	0.173	0.833	0.298	4.841	0.400	0.744
CD(<0.05P)		116.532	106.120	0.484	2.340	0.838	13.592	1.123	2.088

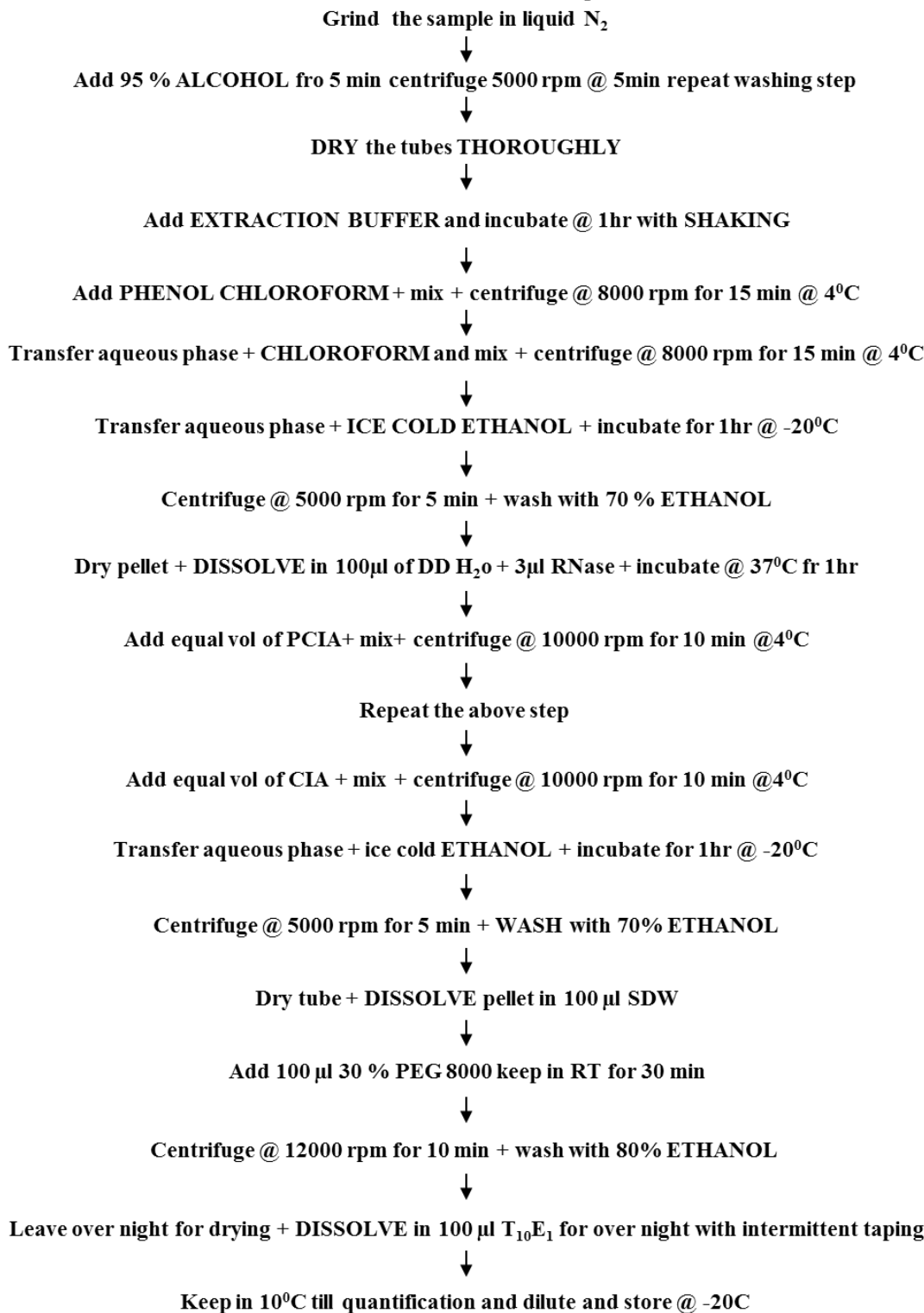
APPENDIX V

Morphological characters of (Paprika) P₁, (Assam Bhut Jalokia) P₂ and F₁.

Parameter	Female parent	Male parent	F ₁
Species	<i>Capsicum annuum</i> L var. <i>longum</i> cv. Paprika	<i>Capsicum</i> <i>chinense</i> Jacq. cv. Assam Bhut Jalokia	
Chromosome No. (2n)	24	24	24
Growth habit	Determinate*	Indeterminate*	Indeterminate*
Plant growth habit	Prostrate	Intermediate (compact)	Intermediate (compact)
Tillering	Sparse	Dense	Dense
Leaf colour	Dark green	Light green	Green
No. of flowers per axel	Single	2-6	Two
Pollen viability	Viable	Viable	Partial
Anthocyanin stripes	Absent	Present	Absent
Fruit set	High	Low	High
Immature Fruit colour	Green	Light Green	Dark green
Colour break stage	Red	Orange	Green to red
Mature fruit colour	Dark red	Red	Dark red
Fruit shape	Elongate	Blocky	Elongate
Fruit cross-sectional corrugation	Slightly corrugated	Corrugated	Slightly corrugated
Number of locules	Two	Three	Two
Fruit surface	Smooth	Wrinkled	Smooth
Average no. of seeds per fruit	100-120	50-60	16
Seed germination	Normal	Dormant	Normal
Capsaicin	Low	Very high (World hottest pepper)	High
Oleoresin	High	High	High
α -amylase activity (seeds)	High	Low	-

APPENDIX-VI

Modified CTAB DNA extraction protocol



(Remia *et al.*, 2004)



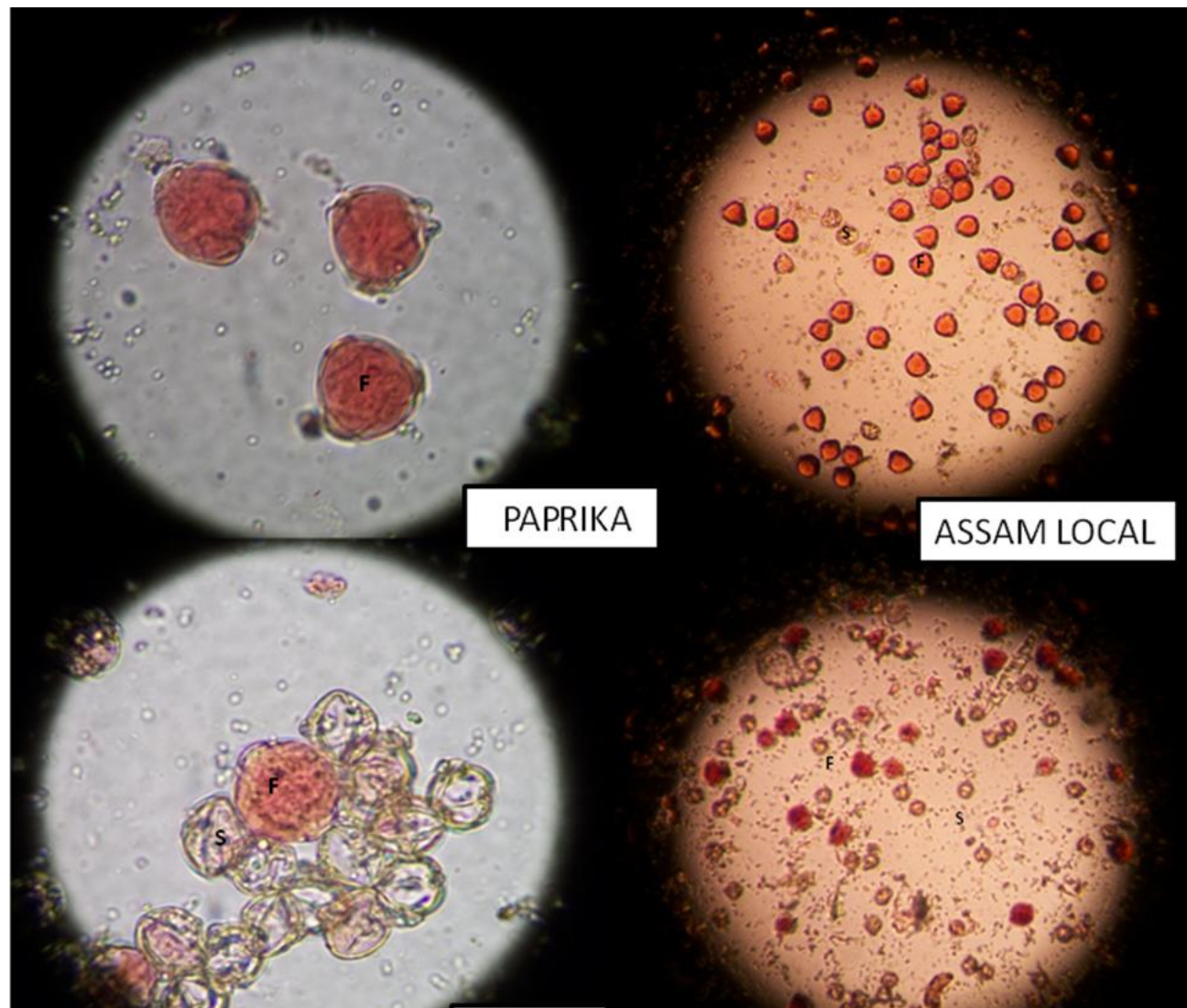
Variations with respect to fruit shape, colour and length in F₂ population



Variations with respect to fruit shape, colour and length in B_1 ($F_1 \times \text{PAP}$) population



Variations with respect to fruit shape, colour and length in B₂ (F₁ × AL) population



Pollen viability studies in Paparika (P_1), Bhuth Jalokia (P_2) and F_1



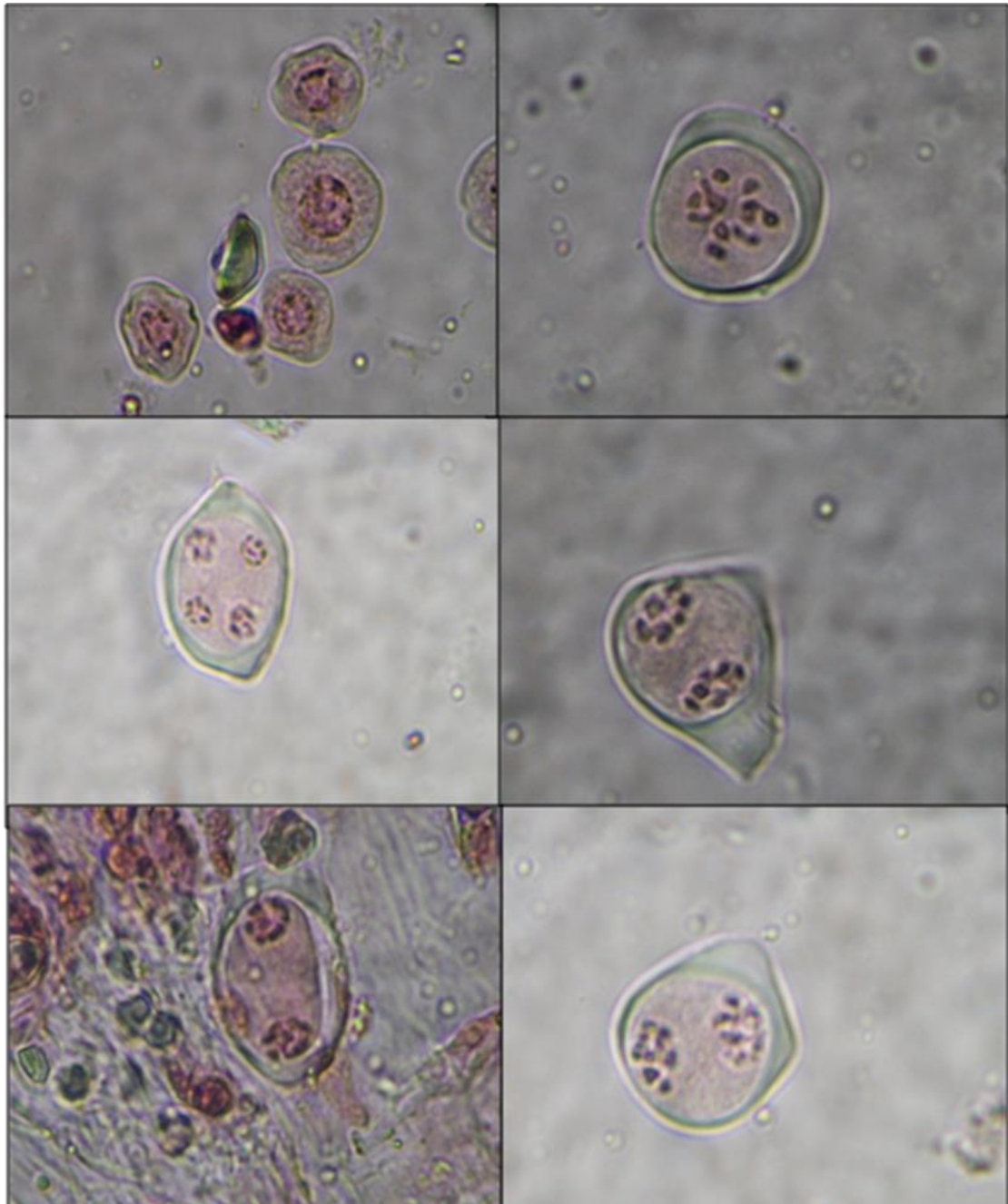
The picture depicts normal chromosomal behaviour in meiosis of F_1 (absence of univalent's). However, the F_1 was partially sterile and recorded poor seed set



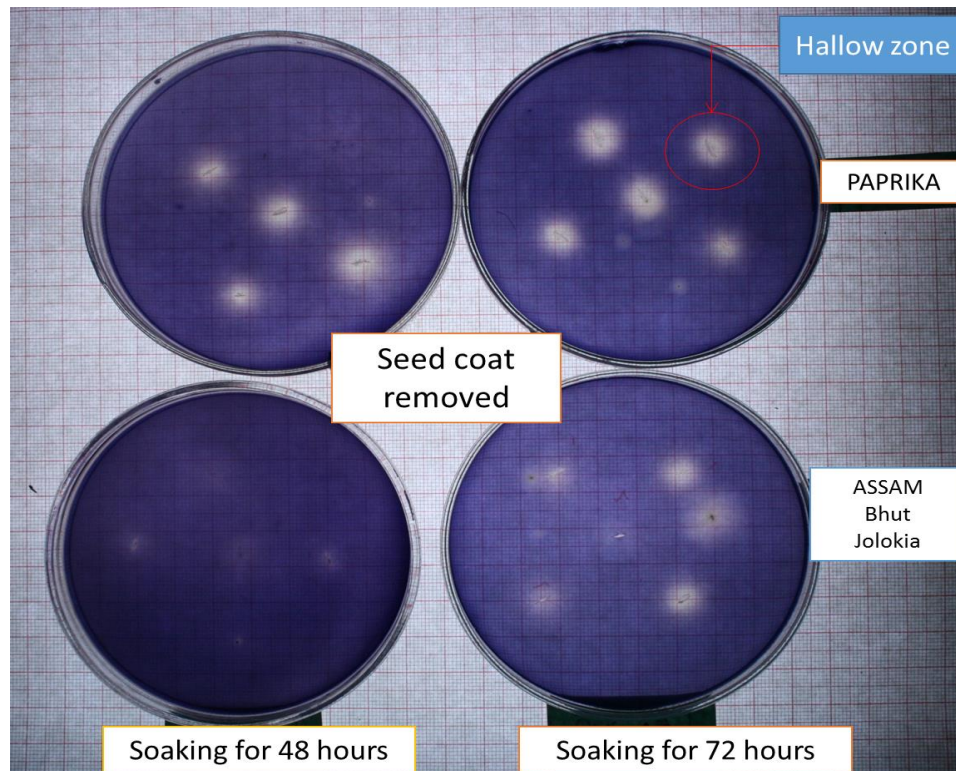
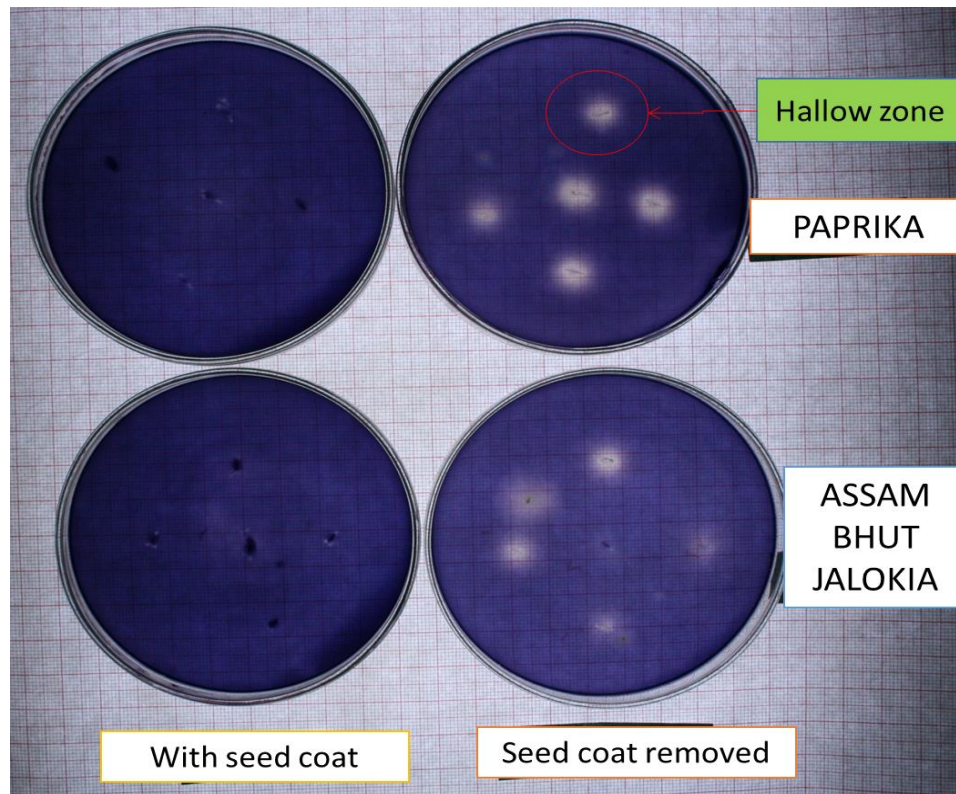
Difference in fruit length and width in f_1 self fertilized and back crossed fruit; B- F_1 fruits after auxin supplementation; C- sparse seed set in F_1 after self fertilization.; D- Variation in fruit size and seed set in F_1 ($PAP \times AL$), BC_1 ($F_1 \times PPA$) and BC_2 ($F_1 \times AL$)



Female (A-Paprika) and male (B-Assam Bhut Jolokia) genotypes and their F₁ (inter specific hybrid-*C. annuum* × *C. Chinense*) in filed



Meiotic phases of F₁ immature flower buds fixed in Carnoy's fixative (6 ethanol: 3 chloroform : acetic acid) and observed for normal meiosis



Variation in α -amylase activity in P_1 (Paprika) and P_2 (Assam Bhut Jolokia) seeds