"EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)''

by

Mr. Rathod Dhanraj Balu
(Reg. No. 018/072)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY
(SEED SCIENCE AND TECHNOLOGY)

DEPARTMENT OF AGRICULTURAL BOTANY

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. - AHMEDNAGAR
MAHARASHTRA, INDIA.
2021

"EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)''

by

Mr. Rathod Dhanraj Balu
(Reg. No. 018/072)

A Thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA.

in partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY

(SEED SCIENCE AND TECHNOLOGY)

APPROVED BY

Dr. H.J. Rajput
(Chairman and Research Guide)

Dr. V.R. Shelar
(Committee Member)

Dr. S.K. Ransing
(Committee Member)

Prof. R.S. Bhoge
(Committee Member)

Dr. C.A. Nimbalkar
(Committee Member)

DEPARTMENT OF AGRICULTURAL BOTANY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. - AHMEDNAGAR
MAHARASHTRA, INDIA.
2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
Diploma

Place : MPKV, Rahuri

Date : / /2021 **(D.B. Rathod)**

Dr. H.J. Rajput
Assistant Professor,
Division of Agriculture Botany,
College of Agriculture, Pune
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (M.S)

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY (SEED SCIENCE & TECHNOLOGY),** embodies the results of a piece of *bona fide* research work carried out by **MR. RATHOD DHANRAJ BALU,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

Place : MPKV, Rahuri (H.J. Rajput)
Date : Research Guide

Dr. A.S. Jadhav
Head,
Department of Agricultural Botany,
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722, Dist. Ahmednagar,
Maharashtra State, INDIA

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY (SEED SCIENCE & TECHNOLOGY),** embodies the results of a piece of *bona fide* research work carried out by **MR. RATHOD DHANRAJ BALU** under the guidance and supervision of **Dr. H.J. RAJPUT,** Assistant Professor, Division of Agricultural Botany, College of Agriculture, Pune, M.P.K.V., Rahuri and that no part of this thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri (A.S. Jadhav)

Date :

Dr. P.N. Rasal
Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413 722, Dist. Ahmednagar,
Maharashtra State, INDIA

CERTIFICATE

This is to certify that the thesis entitled, "**EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL BOTANY (SEED SCIENCE & TECHNOLOGY),** embodies the results of a piece of *bona fide* research work carried out by **MR. RATHOD DHANRAJ BALU** under the guidance and supervision of **Dr. H.J. RAJPUT,** Assistant Professor, Division of Agricultural Botany, College of Agriculture, Pune, M.P.K.V., Rahuri and that no part of this thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri (P.N. Rasal)

Date : / /2021

ACKNOWLEDGEMENTS

Formal and dead words can not carry the fragrance of emotions with them still they are the only available means of expressing emotions in such a formal acknowledgement. I consider myself to be fortunate for getting a golden opportunity to work under the dynamic and able guidance of my research guide Dr. H. J. Rajput Assistant Professor of Agril. Botany, College of Agriculture Pune, MPKV, Rahuri My vocabulary fails to express my deep and sincere feeling of gratitude. I take this opportunity to express my deep and sincere feeling gratitude to him for suggesting research topic, valuable guidance, counsel, sympathy, generous encouragement and constructive criticism till the successful completion of this venture. His lively with observation was constant source of inspiration and refreshing stimulation. I feel proud to be his one of the students.

I am very thankful to Dr. Prashantkumar Patil, Hon. Vice - Chancellor Mahatma Phule Krishi Vidyapeeth, Rahuri, for providing necessary facilities during the entire course of study.

It is my proud privilege to express my sincere and whole hearted thanks to Dr. A.L. Pharande, Dean Faculty of Agriculture, Dr. S.R. Gadakh, Director of Research and Dr. P.N. Rasal, Associate Dean, Post Gratuate Institute, M.P.K.V., Rahuri for providing necessary facilities for Successful completion of research work.

I avail this opportunity to express my sincere thanks to my committee members Dr. V.R. Shelar, Seed Research Officer, Seed Testing Research Unit, M.P.K.V. Rahuri who has provided constant encouragement, constructive criticism and sympathetic attitude throughout the course of investigation, Dr. S. K. Ransing, Asst. Seed Research Officer, Seed Testing Research Unit,M.P.K.V. Rahuri, Prof. R. S. Bhoge Asst. Seed Research Officer, Seed Testing Research Unit, M.P.K.V. Rahuri. Dr. C. A. Nimbalkar Associate Professor, Department of Statistics, M.P.K.V. Rahuri, for their valuable suggestions and inputs throughout the course of this study.

It is my proud privilege to record my sincere gratitude to Dr. A.S. Jadhav , Head, Department of Botany, Dr. V.L. Amolic, Dr. M.T. Bhingarde and other staff members of Botany Department, M.P.K.V., Rahuri for their valuable help and encouragement throughout the course of study.

I cannot forget my friends who went through hard times together, cheered me on and celebrated each accomplishment. So I pleasantly recall my friends Gopal Rathod, Abhijit Deshmukh, Pushpraj Ingle, Ajinkya Kulkurni, Dayanand Waghmode, Manish Desai, Manoj Gade Amit Sannake, Pradeep Rathod, Sachin Jadhav, Sunil Rathod, Santosh Kokani, Utkarsh Karpe, Jayashree Raykar, Sayali Shinde, Rekha Gondke.

I find no words to express my sincere thanks to my seniors Sagar Sir, Bhukeshwar sir, Ganesh sir, Nilesh sir, Akash Sir, Swapnil Sir, Pranod sir, Sushant sir, Shekhar sir. No words are enough to express my deepest sense of love and affection to my batchmates Sarang Sondwale, Gopal Raut, Albate Tulshiram, Sagar Danane, Viswas Telangre, Mohini Jadhav, Rutuja Manugade, Utkarsha Kadam.

I also sincere thankful to Chairman and Staff members of Adarsh High School Dhulkarwadi for making availability of computer facility during lockdown.

This instrument of acknowledgement would remain out of tune if I do not mention about my beloved Parents Sau. Kalubai Balu Rathod and Late. Balu Pemu Rathod and My Brother Mr. Amit Rathod, Amol Rathod and sister miss. Pooja Rathod and sister in law Mrs. Sonali Amit Rathod who stood like a powerhouse and great source of inspiration for illuminations, the pathway of my every success, good will and constant inspiration during the entire period my student life. I am highly obliged to the scientists, past and present, whose contribution was great source of information which helped me to undertake the present investigation. I also take this opportunity to thank all the Professors, Associate Professors, Assistant Professors, SRA's and JRA's from Post Graduate Institute, M.P.K.V., Rahuri who have directly or indirectly helped me in completing the thesis. And last, I bow my head before Lord Ganesha for giving me wisdom and strength required to complete my post graduate programme successfully. At the outset i am reminded of the saying "A person who is not grateful to his fellow cannot be grateful to God". I therefore take this opportunity to express my heartful thanks and gratitude to all those people who have helped immensely in the successful completion of my research work. Finally, I thank to all my well-wisher.

Place : M.P.K.V., Rahuri (D.B. Rathod)

Date : / / 2021

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREIVATIONS

IPM	:	Integrated Pest Management
^{0}C	:	Degree Celsius
DAS	:	Days after sowing
W/W	:	Wight by weight
V/W	:	Volume by weight
%	:	Per cent
E.g.	:	Exampligratia
et al.	:	Et ali (andothers)
etc	:	Etcetera
Fig.	:	Figure(s)
g	:	Gram
EC	:	Emulsifiable concentrate
i.e.	:	That is
Temp.	:	Temperature
RH	:	Relative Humidity
S.E.	:	Standard error
kg	:	Kilogram (s)
dSm^{-1}	:	Decisiemens per metre
max	:	Maximum
min	:	Minimum
mg	:	Milligram
ml	:	Millilitre
MSCS	:	Minimum seed certification standard
No.	:	Number
DAR	:	Day after release
N.S	:	Non Significant
ppm	:	Parts per million

ABSTRACT

"EFFECT OF ORGANIC AND INORGANIC SEED TREATMENTS ON SEED HEALTH AND QUALITY OF FRENCH BEAN (*Phaseolus vulgaris* L.)''

by

Mr. Rathod Dhanraj Balu

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL BOTANY
(SEED SCIENCE AND TECHNOLOGY)

Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri-413722

2021

Research Guide	**:**	**Dr. H.J. Rajput**
Department	**:**	**Agricultural Botany**
Discipline	**:**	**Seed Science and Technology**

A laboratory experiment was conducted to investigate the "Effect of organic and inorganic seed treatments on seed health and quality of FRENCH BEAN (*Phaseolus vulgaris* L.)" during May 2019 to February 2021 at Seed Technology Reserch Unit, M.P.K.V., Rahuri. The seeds of French bean was subjected to different treatments *viz.,* T_0 : Control (untreated), T_1 : Neem leaf powder @ 5 g/kg of seed, T_2 : neem oil @ 5 ml/kg of seed, T_3 : Castor oil @ 5 ml/kg of seed, T_4 : Karanj oil @ 5 ml/kg of seed, T_5 : vekhand powder @ 10 g/kg of seed, T_6 : Termuric powder @ 5 g/kg of seed, T_7 : Citronella oil @ 5 ml/kg of seed, T_8 : Ash @ 5 g/kg of seeds, T_9 : Deltamethrin @ 0.04 ml/kg of seed. Monthly observations was taken for the seed quality and three monthly observations was taken for seed health.

The results revealed, that Frenchbeanseeds which were treated with Deltamethrin @ 0.04 ml/kg of seed, significantly recorded lower moisture content (7.30 %), higher germination (76.67 %), higher first count (76), higher speed of germination (19.42), root length (11.59 cm), shoot length (7.65 cm), vigour index-I

(1475), vigour index-II (1606), seedling dry weight (20.95 mg), lower electrical conductivity (1.86 dSm^{-1}), test weight (33.60 g) and lower mycoflora (29.67 %) at the end of ten months of storage period.

For seed health, seed treated with deltamethrin @ 0.04 ml/kg of seed significantly recorded the lowest pulse beetle infestation(1.33 %), lower number of egg laying (11), lowest number of adult emergence (1.67), lowest seed weight loss (4.67 %), highest mortality (87.8 %), higher dead insect (15.00) and lower live insect (5.00) at the end of storage period. Among the botanicals seed treated with neem oil @ 5 ml/kg of seed showed higher seed quality and health parameters.

From present investigation the seed treated with organic and inorganic components protected the seed quality and health while control seed deteriorated at the end of storage period.

1. INTRODUCTION

Pulses occupy a very important position in Indian diet. They are important source of protein and calories. On an average, pulses contain 22 to 24 per cent protein as against 8 to 10 per cent in cereals. A good amount of lysine is present in the pulses. They also maintain soil fertility and adopt themselves to the large variation in climatic conditions, they are useful in different cropping systems and also provide nutritive fodder to the farm animals. Among the pulses grown in India, French bean is considered as an important pulse crop.

French bean *(Phaseolus vulgaris* L.*)* belongs to the family Leguminoceae and it is native of South America. It is domesticated in Mexico, Peru and Colombia about 8000 years ago (Schoonhoven and Voysest, 1991). It is widely cultivated in tropics, sub tropics and temperate regions. In India and most of the tropical Asia it is a major vegetable crop where indigenous pulses are also preferred (Kay, 1979, Duke, 1981 and Adams, 1985). French bean is consumed as immature tender fruits, green grains as vegetables and dry grain (Rajmash). The nutritive value of 100 g of green pod contains 1.7 g protein, 0.1 g fat, 4.5 g carbohydrate, 1.8 g fibre and is also rich in minerals and vitamins. It has some medicinal properties in control of diabetes, cardiac problems and natural cure for bladder burn. It has both carminative and reparative properties against constipation and diarrhoea respectively (Duke, 1981).

Globally French bean is cultivated on an area of 29.92 million hectares with an annual production of 23.23 million tons, while in India, it is grown on an area of 10.80 million hectares with annual production of 4.87 million tons and 447 kg per ha productivity (Anon., 2013). As the seed replacement ratio in French bean is 25 per cent, about 4062.5 qt. of seeds required to meet out this demand annually. It is popularly grown in Punjab, Harayana, Jammu and Kashmir, Himachal Pradesh, Western Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu states of our country. Presently the area under French bean is increasing year by year due to its great demand in urban areas for vegetable. As French bean is major crop in *Rabi* season, the seeds are to be produced during *Rabi* and used for sowing during next season or year.

Botanicals have been used from a very long time by many farmers in the world from decades to control stored insect pest (Araya and Emana, 2009). Many scientists revealed that use of botanicals as pre storage seed treatment is effective in management of storage pest and thus helps in improving quality of seed. Botanicals *viz.,* neem leaf powder, neem oil, karanj oil, castor oil, vekhand powder, citronella oil, turmeric powder, ash etc were used.

Neem leaves are known to have insecticidal property, to control any storage pests. Neem contains several active constituents called limonoids among which, azardirachitin, salanin, nimbin, meliantroil which are major components any of these limonoides possessing insecticidal, ovicidal, antifedancy, growth regulatory, sterilising adults and repellency against many insect and storage pest (Akou-Edi, 1984; Makanjoula, 1989; Schmutterer, 1990). Neem leaves when added with the grains during storage, repel storage pest effectively. Neem oil is directly used for the integrated pest management (IPM), alternative to chemical pesticides, due to its biodegradability, relatively low toxicity and botanical nature, it is antifeedant. It contains "Azardirachitin" which is effective against white fly, aphids, mealy bugs and beetles during storage. It is effective against different pests like pulse beetles.

Karanj oil has similar insecticidal properties as neem oil and acts against a number of pests and insects. As it has insecticidal properties, it is great for agriculture use serving as a natural pest repellent. Karanjin is the main active ingredient of karanj oil. It acts as an acaricide and insecticide. Ash is natural product which is easily available. It is most effective for safe storage of seeds with minimum loss as it affects egg development of pest. It damages cuticle of insects during long storage. The vekhand powder (*Acorus calamus* L.) shows potential for storage pest control. Its active ingredient, β-asarone, has toxic and sterilizing effects and effective against pulses beetle of pulses during storage.

Turmeric powder has well-known insecticidal and repellent effects on insect pests. Research efforts so far and data from the International literature have shown a satisfactory potential of turmeric as a natural pesticides. It is cheap and more environmentally friendly alternative to chemical pesticides for control of storage pests. Citronella oil is a naturally occurring insect and animal repellant. It is used mainly for mosquito repellant but it also repels many storage pest and increase the shelf life of seeds.

The United States Environmental Protection Agency considers oil of citronella as a bio-pesticides with a non-toxic mode of action. Deltamethrin products are among the most popular and widely used insecticides in the world. It is effectively used in management of storage pest in pulses.

Storage of seed till next sowing season is an essential part of seed industry. In general, pulses are more susceptible to storage pests and French bean is no exception. Amongst the stored grain pests of pulses the pulse beetle (*Callosobruchus chinensis*) is economic effective pest (Ahmed *et al., 2003)* and causes considerable damage to the seed and deteriorate the quality of seed in the storage. Apart from this, fungi associated with stored seeds are also responsible for deterioration of seed quality. In order to prevent the qualitative and quantitative losses due to storage pests and disease, several methods such as storage in safe conditions and containers with safe moisture levels and seed treatment with suitable chemicals or plant products *etc*, are being adopted.

In storage, viability and vigour of the seeds is regulated by many physico-chemical factors like moisture content of the seed, atmospheric relative humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure, storage insects and packaging materials. Hence, storage of seed till next planting time assumes prime importance for successful seed production programme.

It will be of immense use to the farming community and seed industry that how the higher seed yield and quality seeds can be produced by using botanicals under ambient condition with minimum qualitative and quantitative losses. Hence, the present investigation is based on following objectives :

1. To study the effect of organic and inorganic seed treatments on seed health and quality of French bean seed during storage.

2. REVIEW OF LITERATURE

2.1 Effect of different organic seed treatments on seed health and quality

2.1.1 Neem leaf powder

Shrivale and Borikar (1998) evaluated the neem leaf powder (1 %) against *Callosobruchus chinensis* in chickpea and observed that the adult mortality at 48 hours after release was 1.25 per cent with weight loss of 10.78 per cent after 20 days.

Arati Patil (2000) reported chickpea seeds treated with neem leaf powder recorded higher germination (65.91 %), seedling dry weight (149.00 mg) and vigour index (1282) compared to control (64.17 %, 144.00mg and 1208, respectively) at the end of 10 months of storage period.

Maraddi (2002) observed cowpea seeds treated with neem leaf powder @ 5 g kg^{-1} of seeds recorded higher germination (71.50 %) and vigour index (1072) compared to control (34.25 % and 864) respectively, at the end of 10 months of storage period.

Anantharedy Roopa (2004) observed that, French bean seed treated with neem leaf powder @ 5 g/kg of seed found to be effective in maintaining seed quality up to 9 months of storage period.

Gupta (2010) reported that, soybean seeds treated with neem extract showed 93.7 per cent inhibition of the seed mycoflora thereby enhancing the seed germination as compared to Ricinus plant extract (87.58) and *T. viridae* (62.5 %), which showed that the culture filtrate of the antagonistic fungus.

Khatun *et al*. (2012) reported lentil seeds treated with neem leaf powder recorded germination percentage of 86 and root shoot length of 16.58 cm as compared to 72 per cent of 15.32 cm respectively, in untreated control.

Chandrakala *et al*. (2013) revealed that leaf powder was effective against pulse beetle of green gram (*Callosobruchus chinensis* L.*)* and he observed that neem leaf powder play a vital role in controlling the infection of pulse beetle (*Callosobruchus chinensis* L.) in stored seeds.

Mandali and Reddy (2014) evaluated efficacy of neem leaf powder, neem oil against pulse beetle (*C. chinensis*) in stored red gram. Observations were made on

oviposition, insect damage, germination and seedling vigor index and were recorded at three months interval. They recorded less insect damage with neem leaf powder and neem oil and deltamethrin.

Khinchi *et* al. (2017) studied the efficacy of different plant part powders and revealed that neem leaf powder at 60 g/kg grains was found to be most effective in inhibiting the oviposition (55.40 %), reduction in eggs hatching (40.88 %) and reduction in adult emergence (67.71 %).

Kaur *et al.* (2018) evaluated effect of neem leaf powder and sweet flag powder on pea seed and resulted 98.89 per cent mortality of the pulse beetle, *Callosobruchus chinensis* at the highest dose (5 g/100 g seeds) neem product that accounted for 18.89, 42.22 and 63.33 per cent mortality. Egg laying by females after one week of treatment was also the least in sweet flag followed by neem treatment (6.33,10.67 eggs/5 females, respectively, at the lowest dose of 1g) as against 97.0 eggs/5 females in untreated control. The progeny development and survival was minimum (3.72, 6.89 adults/ 5females) on pea seeds treated with sweet flag, neem at the tested doses compared to 103.17 adults in untreated control.

2.2 Neem oil

Pandey *et al.* (1976) reported that, the chickpea seeds treated with neem oil as a protectant against pulse beetle *Callosobruchus chinensis* revealed that three and five parts of neem oil 100 g^{-1} of seed (w/w) gave protection up to 135 days while it was 90 days when used at one part. The average per cent damage after 135 days of treatment at one, three and five parts was 50.71, 1.13 and 0.25 per cent, respectively as against 95.92 per cent in the untreated control. The corresponding values after 90 days were 8.42, 1.00, 0.21 and 47.67 per cent.

Sujatha and Punnaiah (1985) reported that, stored seed of green gram could be effectively protected from pulse beetle, *Callosobruchus chinensis* when the seeds were treated with 0.25 per cent neem oil.

Ali *et al.* (1983) found that, gram seed treated with neem oil @ 0.05 ml 100 g^{-1} of seed was found less effective in comparison to 1.00 ml 100 g^{-1} of seed. Neem oil inflicted 100 per cent egg mortality and 100 per cent grub mortality at one ml 100 g^{-1} seed.

Das and Karim (1986) observed seed treatment with neem oil @ 4 ml kg^{-1} of seeds showed no infestation for five months of storage, whereas untreated seeds recorded 73.30 to 91.00 per cent infestation of pulse beetle *Callosobruchus chinensis* in chickpea and lentil seeds.

Choudhary and Pathak (1989) reported that, the neem oil at 0.25, 0.50 and 1.00 ml per 100 g chickpea seeds was found to be good in controlling *Callosobruchus chinensis.* Except for single egg at 0.25ml dosage, neither egg nor adult emergence and seed damage was recorded at any level of dosage tried.

Kumari *et al.* (1990) reported that, pea seeds treated with neem, mustard, groundnut, mahua and til oil @ 1.00 per cent recorded significantly reduced insect damage. Neem oil recorded 22.33 per cent damage over 60.17 per cent in control.

Shreemaiah and Bammegowda (1992) reported that, neem oil treatment @ 5 ml kg^{-1} gave 100 per cent protection to the seeds of five varieties of cowpea against bruchid infestation, maintained higher germination (98.00 to 94.00 %) at the end of eight months of storage period compared to control, the germination reduced from 96.00 to 71 per cent.

Satya (1994) revealed that, the seed treated with neem and karanj oils @ 5 ml kg^{-1} of cowpea seeds were the most effective against oviposition, development period and resulted in minimum growth of insects and showed 30 per cent of protection.

Rajapakse and Senanayake (1997) evaluated the neem oil at 0.4, 0.6 and 0.8 per cent (w/w). They observed mean oviposition of *Callosobruchus chinensis* in pigeon pea was 6.73, 6.18 and 5.57, respectively as against 10.48 in untreated control.

Kumbhar (1999) reported that, chickpea seeds treated with neem oil @ 5 ml kg^{-1} recorded significantly higher germination (70.80 %), rate of germination (4.03) and vigour index (1512), while these were 68.00 per cent and 1398 in untreated control respectively, at the end of 10 months of storage period.

Patil (2000) observed that, chickpea seeds treated with neem oil and castor oil @ 5ml kg^{-1} recorded significantly higher germination (68016 and 68.40 %, respectively), vigour index (1336 and 1364, respectively) and seedling dry weight (163 and 169 mg) while these were 60.17 per cent, 1208 and 144 mg, respectively in control at the end of 10 months of storage period.

Tripathy *et al.* (2001) observed the efficiency of botanical oils, plant powder and extracts against *Callosobruchus chinensis* in black gram.

Maraddi (2002) indicated that, among different seed protectants castor oil and neem oil @ 5 ml kg^{-1} of seeds were found best seed protectants for maintaining germination (72.55 and 70.75), seedling vigour index (2185 and 2115), electrical conductivity (1.608 and 1.613 dsm^{-1}) and lower infestation (6.25 and 7.00 %) compared to control (34.25 %, 864, 1.974 dsm^{-1} and 98.75 %, respectively) during 10 months of storage period of cowpea C-152 seeds in cloth bag.

Bhardwaj and Verma (2012) evaluated neem oil, karanj oil for protection of pea seed from pulse beetle, (*Callosobruchus chinensis* L.) and complete mortality was recorded in neem oil and karanj oil coated seeds at 5 per cent concentration and maximum mortality was observed in seeds coated with neem oil (72.22 %), followed by karanj (65.56 %). The minimum number of eggs (4.78 eggs/5 females) recorded in neem oil coated seeds was statistically at par with karanj (6.67eggs/5 females). Minimum adult emergence (0.56 beetles) was recorded in neem oil coated seeds was statistically at par with karanj (0.89 beetles).

Upadhyay *et al*. (2014) found that, seeds of soybean treated with neem oil @ 5 ml kg^{-1} recorded seed infection of 24.67 per cent, with per cent germination of 78.67 and vigour index of 2078.97 while these were 30.92%, 71.00% and 1236.28 in untreated control.

Kumar*et al*. (2016) evaluated different plant based essential oils for their deterrent effect on oviposition, adult emergence and seed damage caused by *C. chinensis* in green gram. Among different oils, neem oil @ 2.5 ml/kg seeds was found to be most effective against *C. chinensis.* During the course of the study, it was also found that none of the treatments had apparently reduced seed germination even after four months of storage. hence, these botanicals can be used as safer alternatives to chemical insecticides for long term storage of green gram seeds.

Khinchi *et al.* (2017) studied the efficacy of certain vegetable oils against pulse beetle (*Callosobruchus chinensis*) on chickpea (*Cicer arietinum*L.) under laboratory conditions of 28 ± 1^0C temperature. Neem oil at 12 ml/kg grains was found to be most effective in inhibiting the oviposition (67.60 %), reduction in eggs hatching

(69.64 %) and reduction in adult emergence (94.27 %). The tested vegetable oils did not affect the germination of treated chickpea grains.

Kumar *et al*. (2018) evaluated effect of grain protectants on biology of pulse beetle in black gram. Seed treated with higher dose of neem oil (5 ml/kg seed) found in maximum mortality per cent (100.0 %), minimum number of egg laying (1.66 eggs/adult), and lowest adult emergence of pulse beetle (1.0 %) in black gram and concluded that neem oil seed treatment is best in managing pulse beetle infestation to lower levels.

Gupta *et al.* (2018) studied the effect of different packaging materials and pre-storage treatments on storability of chickpea (*Cicer arietinum* L.) seeds. They treated seed with camphor oil @ 10 ml/kg seed, castor oil @ 5 ml/kg seed, neem oil @ 10 ml/kg seed, eucalyptus oil @10 ml/kg seed and packed in polythene bag and maintained for 6 months with 8 per cent seed moisture content under ambient conditions. The results clearly revealed that seed stored in polythene bag and treated with neem oil was found with high germination per cent (84.83 %) and lowest electrical conductivity (1.54 dSm^{-1}). Other parameters like root length (14.83 cm), shoot length (11.19cm), seedling length (26.00 cm), fresh weight (3.40 g), dry weight (1.27 g), vigour index-I (1969) and vigour index- II (94.24) were found best seed treated with neem oil followed by castor oil.

2.3 Castor oil

Sangappa (1977) reported that, castor oil @ 0.75 and 1.00 per cent, neem oil @ 0.50, 0.75 and 1.00 per cent were effective in preventing the adult emergence of *Callosobruchus chinensis*in red gram seeds.

Mummigatti and Raghunathan (1977) observed castor, mustard and gingelly oil inhibited the multiplication of *Callasobruchus chinensis* in green gram at 0.3 per cent, while coconut and groundnut oils at 0.5 per cent level, without affecting their viability.

Ramesh Babu *et al*. (1989) reported mungbean seeds treatment with castor oil and karanj oil @ 10 ml kg^{-1} of seed were effective in controlling bruchid infestation and also maintains the good viability up to 18 months of storage.

Khaire *et al*. (1992) studied the efficacy of castor oil applied @ 1.00, 7.50 and 1.00 ml kg^{-1} of pigeon pea seed (0.50, 0.75 and 1.00% v/w concentrations) as grain

protectant against pulse beetle, they noticed no emergence of adults up to 60 days with castor oil @ 0.75 and 1.00 per cent level with minimum grain level up to 100 days after treatments.

Tammangouda (2002) found that, the green gram seeds treated with castor oil @ 10 ml kg^{-1} had significantly high germination (74.72 %), vigour index (1517) and lower infestation (18.75 %) at the end of 10 months of storage period compared to untreated seeds.

Bhargava and Meena (2002) tested six vegetable oils viz., castor (*Ricinus communis*), mustard, groundnut, sesamum, coconut and sunflower against *C. chinensis* in cowpea and found that castor oil @ 1.0 ml/100 g seed was the most effective in inhibiting the oviposition (26.6 eggs/ female) as against 79.4 eggs/ female in untreated seeds. At 1.0 ml/100 g seeds, castor oil caused maximum reduction in egg viability (61.7 %) followed by mustard oil (56.7 %). The longevity of male and female adult decreased with the increase in doses of oil. The treatment of castor oil @1.0 ml/100 g seeds caused maximum reduction in adult emergence in F_1 generation (85.0 %) followed by mustard oil (83.7 %), groundnut oil (73.3 %). No adverse effect of tested oils was observed on the germination of cowpea seed up to 150 days of treatments.

Harish *et al.* (2013) reported that, pigeon pea seeds treated with castor oil maintained the highest test weight (10.22 g) among the botanicals followed by sweet flag rhizome powder (10.09 g).

Choudhary *et al.* (2014) evaluated efficacy of plant oils, botanical leaf powders as well as synthetic insecticides as grain protectants against *Callosobruchus chinensis* L. in soybean under storage condition. Soybean seed treated with neem oil, castor oil @1 per cent (v/w) recorded significantly higher adult mortality (≥ 55 %) of *C. chinensis* during storage period of 6 months with higher shelf-life (about 2.5 months), higher gross persistency (4492.43 to 3445.88), lower population growth (3.11 to 6.15 adult emergence) and lower per cent loss in germination (15.96 to 20.94 %).

Gowda *et al.* (2018) studied the effect of organic seed treatment on seed storability of chickpea. Seeds were treated with both organic neem leaf powder (50 and 100 g/kg), Neem oil (5 ml/kg), Castor oil (5 ml/kg), Sweet flag rhizome powder (20 g/kg). Among the different seed treatments, the seed treatment with castor oil (5 ml/kg of

seed) has maintained minimum prescribed seed germination (85.67 %) up to eighteen months along with the highest seedling vigour index I and II (1870 and 4118) and lowest insect damage (6 %) as compared to control (82.67, 1587, 3326 and 52 %). So he concluded that castor oil @ 5 ml per kg of seeds has found effective in maintaining the seed quality with minimum seed infestation for more than twenty months of storage.

Rathod *et al.* (2019) studied the efficacy of botanicals against pulse beetle in stored green gram. Castor oil (5 ml/kg) were used against adult pulse beetle (*Callosobruchus chinensis)* in stored green gram seed. Higher rate of per cent seed germination was recorded in all the botanically treated seeds over untreated control.

2.4 Karanj oil

Sudheer *et al.* (1994) studied the effect of pre storage seed treatment of mung bean with Karanj oil at 2.5, 5.0 and 10.0 ml per kg seed as surface protectants against pulse beetle (*C. chinensis)* wherein Karanj oil (10 ml/kg seed) was found effective in ceasing the embryonic development of *C. chinensis* and protected the seed over 12 months after treatment.

Babu *et al.* (1989) investigated the effect of pre-storage treatment of mung bean with neem, karanj, mustard, groundnut, caster oils at 2.5, 5.0 and 10.0 ml/kg seed, against bruchid *C. chinensis*. The treatment with karanj and castor oil (10 ml/kg effectively reduced oviposition by the bruchid, while maintaining a high level of germination for over 18 months of storage under ambient conditions.

Gupta *et al*. (1991) studied the efficacy of seed treatment of karanj, neem, mustard, castor and groundnut oils in green gram and chickpea against pulse beetle, *C. chinensis*, and their effect on seed germination. Oil treatment with 10 ml/ kg gave complete protection from bruchid damage, at least up to one year of storage in both pulses. There was no adverse effect on germination.

Vir (1994) observed that Karanj oil at 5ml per kg of seed was found to be most effective as ovipotion deterrent, increased the development period resulting in minimum growth indices of insect. It offered 80 per cent protection to cowpea seeds which is comparable to the treatment of malathion dust and can be easily exploited for safe storage of pulses.

Sahoo and Chandrakar (2013) evaluated the effect of some edible and non-edible oils and recorded minimum number 10.70 (eggs) of fecundity on 0.25 ml/100g neem oil treated seeds and lowest weight loss (8.06 and 23.73), lowest seed damage (9.25 and 30.39 %) on karanj oils treated with 0.25ml/ 100g seeds.

Mishra *et al*.(2013) studied the per cent of grain damage and weight loss with edible and non-edible oils treated green gram in storage condition. The grain damage and weight loss were studied in different concentrations of oils i.e. 1.00 ml, 1.25 ml and 1.50 ml per 100 g. of green gram seed of neem, karanj, castor. It was found that Neem and Karanj oil @ 1.5 ml/ 100 gram seed effectively manage the grain damage and weight loss of green gram seed in storage condition.

Bhardwaj and Verma (2013) concluded that karanj oil and neem oil at 1% concentration are equally effective against pulse beetle and observe that seed germination of stored pea was improved due to the protection from damage by *C. chinensis* provided by these oils.

Singh *et al*. (2017) studied the bio-efficacy of seed protectants (Neem leaf powder @ (5 g/kg), Karanj oil @ (5 ml/kg), Castor oil @ (5 ml/kg), and deltamethrin 2.8 EC @ (0.04 ml/ kg). Among tested seed protectants besides chemicals karanj oil @ 5 ml/kg seed and botanicals were found effective in respect to less insect infestation per cent and per cent weight loss upto 6 month of storage periods.

2.5 Vekhand powder

Khan and Borle (1985) revealed that, the per cent damage by *Callosobruchus chinensis* in bengal gram was 1.78, 1.42 and 0.06 against 14.58 per cent in untreated control when used vekhand powder at 0.1, 0.3 and 0.5 per cent concentration.

Khan (1986) noticed that, long residual activity of *Acorus calamus* in grain against *Callosobruchus chinensis.* Progeny did not develop up to 30 days after treatment (DAT) and the infestation was almost nil. However, when insects were released at 45 to 120 DAT, the percentage infestation increased from 0.26 to 0.93 per cent as against 19.59 per cent in the untreated control.

Uma Reddy and Shobha Reddy (1987) stated that, green gram seeds treated with sweet flag rhizome powder @16.20 per cent offered with best protection and

maintained viability, whereas untreated seeds recorded highest moisture and insect infestation. Seed damage in sweet flag rhizome powder treated seeds varied from zero to three per cent as compared to 28-98 per cent in untreated control and there was 25.90 to 89.80 per cent weight loss in control.

Abdul Aleem (1988) reported sweet flag at 2-5 per cent offered excellent protection to pigeon pea seeds and recorded zero per cent infestation of bruchid for storage period of 240 days.

Gidaganti (1990) observed that cowpea seeds treated with sweet flag at 5 g per kg maintained higher 100 seed weight, germination, field emergence, seedling length, dry weight and vigour index with moisture content throughout the storage period of 210 days under ambient conditions.

Kittur (1990) noticed that, mean number of eggs laid, adult emerged and per cent weight loss were 3.33, 2.00, 1.33 at 0.50 per cent, zero per cent @ 0.75 per cent and zero per cent @1.00 per cent of sweet flag rhizome powder as against 263.17, 240.17 and 10.78 per cent, respectively in the untreated control in red gram seeds.

Rao *et al.* (1993) evaluated the efficacy of sweet flag (*Acorus calamus*), ginger, Jamun (*Syzygium cumini*), neem and mango leaf powders, neem cake and sesamum, sunflower, groundnut and palm oils and ordinary ash against *C. chinensis* on pigeon pea. *A. calamus* was the most effective followed by neem kernel powder, while neem cake and ash were the least effective.

Shivanna *et al.* (1994) observed sweet flag to be good in controlling *Callosobruchus chinensis* activities in red gram. The mortality of beetles at 24,48 and 72 hours were 50, 50 and 70 per cent, 63.33, 76.67 and 86.33 per cent and 76.67, 80.00 and 100.00 per cent at 0.5, 1.5 and 2.5 g per 50 g seeds, respectively as against no mortality in untreated control. Further, mean number of eggs laid at 0.5, 1.5 and 2.5 g per 50 g seeds were 8.00, 6.67, 0.00 respectively mean number of adult emergence was zero per cent and weight loss was 0.00, 0.00, 0.00 per cent, respectively where in 276.33 eggs, 260 adults and 17.89 per cent weight loss was observed in untreated control.

Singh *et al*. (1995) reported that, the sweet flag rhizome powder gave protection for at least 135 days against the *Callosobruchus chinensis* in chickpea seeds

Patil (2000) observed that, chickpea seeds treated with sweet flag rhizome powder recorded higher germination (66.74 %), seedling dry weight (157.00 mg), vigour index (1312) and 100 seed weight (15.54 g) and lower electrical conductivity (1.47 dSm^{-1}) while, those were 64.17 per cent, 144.00 mg, 120.00 g, 13.50 g and 1.86 dSm^{-1}, respectively in control at the end of 10 months of storage.

Deshpande *et al*. (2004) observed that, black gram seeds treated with sweet flag rhizome powder showing significantly higher germination, seedling vigour index (93.00 % and 2009) respectively, whereas control recorded (89.66% and 1701) respectively.

Shukla *et al.*(2008) investigated the bioefficacy of sweet flag (*Acorus calamus*) against the pulse beetle *(Callosobruchus chinensis)*,which infests stored chick pea seeds and reported that rhizome powder (5mg/g seed) was more efficacious, causing 100 % mortality, 100 % ovicidal activity and thus completely inhibited adult emergence. Hence, sweet flag rhizome powder of *A. calamus* may be recommended as admixtures in the integrated management of beetle infestation of pulse seeds during storage.

Mahesh Babu and Ravi Hunje (2008) reported that, among botanicals soybean seeds treated with sweet flag rhizome powder @ 10 g kg^{-1} of seed showed higher germination percentage (81.44 %), root length (16.78 cm), shoot length (15.65 cm), seedling dry weight (94.34 mg), seedling vigour index (2641) and electrical conductivity of (1.198 dSm^{-1}) compared to control (73.22 %, 14.73 cm, 14.10 cm, 87.20 mg, 2146, 1.353 dSm^{-1}), respectively.

Deshpande *et al.* (2010) studied the effect of plant products against pulse beetle infestation in stored soybean seed and he observed that there was complete bruchid mortality with zero per cent brunched population build up and no seed weight loss in seeds treated with sweet flag rhizome powder (5 g/kg) and the treatments were effective in maintaining satisfactory germination (70 %) as per minimum seed certification standards up to six months besides higher seedling vigour.

Devi and Kalita (2011) studied the efficacy of plant materials against *Callosobruchus chinensis* in green gram. Based on the parameters of grain damage and percentage of weight loss, they found that sweet flag rhizome powder was the most effective treatment in pulse beetle control during storage.

Adhe *et al.* (2018) investigated efficacy of botanicals against pulse beetle in stored pigeon pea and result revealed that *Acorus calamus* rhizome powder @ 10gm/kg seed and turmeric rhizome powder @ 10 g/kg seed, proved best in giving highest per cent mortality up to six months storage period. The per cent mortality was significantly maximum (70 %) in treatments *Acorus calamus,* rhizome powder @ 10 g/kg seed, turmeric rhizome powder @ 10 g/kg seed (30 %), in first month while, in six month highest mortality was recorded in treatment *Acorus calamus,* rhizome powder @10g/kg seed (30.00 %) followed by turmeric rhizome powder @10 g/kg seed (10 %).

2.6 Termuric powder

Ali *et al.* (2006) evaluated the bio-efficacy of ash and turmeric powder mixture against pulse beetle*, Callosobruchus cliinensis* L. on stored gram seeds at 100:5, 100:2 and 100: I ratio) considering oviposition rate, adult emergence, intensity of seed damage and seed weight loss caused due to pulse beetle. The mixture was found effective in checking oviposition, adult progeny development and severity of seed damage. Seeds treated with 100:5 ratio was less preferred for oviposition, adult emergence and seed weight loss and might be useful in protecting pulse seeds against *C. chinensis* in storage.

Mahesh Babu and Ravi Hunje (2008) reported that, among botanicals soybean seeds treated with termuric powder @ 10g kg^{-1} showed germination percentage of 74.22 per cent, root length 15.71 cm, shoot length 14.78 cm, seedling dry weight 89.93 mg, seedling vigour index 2280 and electrical conductivity of 1.269 dSm^{-1} compared to control 73.22 per cent, 14.73 cm 14.10 cm, 87.20 mg, 2146, 1.353 dSm^{-1}, respectively at the end of seven months of storage.

Sharma and Devi (2012) revealed the effectiveness of termuric powder against pulse beetle observed that turmeric powder @ 3.5 g/kg seed was effective when compared with control after 160 days of storage and treatments resulted in significantly lesser number of eggs/500 seeds as compared to untreated control after 1, 50, 110 and 160 days of storage.

Pal *et al*. (2013) found soybean seeds treated with 0.5 per cent of termuric powder extracts recorded seed germination of 90 per cent while 84 per cent in untreated control.

Zafar *et al.*(2017)investigated the efficacy of different botanicals (neem, turmeric etc.), each at six different concentrations (0.5, 1.0, 1.5, 2.0, 2.5 and 3 %) for the management of *C. chinensis*. Neem and Turmeric were found to be more effective in all concentrations against pulse beetle as they showed more toxicity against the tested pest. They concluded from the present findings that neem and turmeric powders should be incorporated into grain protection practices.

2.7 Citronella oil

Kumar *et al*. (2016) evaluated the efficacy of some plant oils against pulse beetle, *Callosobruchus chinensis* L. infesting green gram under storage conditions and reported maximum standard germination in green gram seeds was found in treatment of citronella oil @ 2.5 ml/kg seeds.

Yadav *et al.* (2018) evaluated different seed protectant against pulse beetle infestation in pigeon pea in storage condition and seed were treated with citronella oil @ 5 ml/kg seed and sweet flag (*Acorus Calamus*) 10 ml/kg seed and assessed for their effectiveness in which the minimum per cent damage and weight loss were observed.

2.8 Ash

Chiranjeevi (1991) found cow dung ash as most effective in reducing the percentage seed damage and increasing protection against bruchid infestation of green gram seeds compared to other ashes.

Shaheen and Khaliq (2005) tested insecticidal potency of different grain protectant *viz.,* Fly ash, cow-dung ash etc against pulse beetle attacking stored chickpea. The results revealed that fly ash and cow-dung ash proved to be the best in managing pulse beetle infestation.

Swain and Baral (2005) evaluated the effect of different ashes, i.e. wood ash, rice straw ash, bamboo ash, cow dung ash, rice husk ash and fly ash for controlling pulse beetle (*C. chinensis*). Pulse seeds were thoroughly mixed with ash at 0.5 g/ 100 g seeds. The results revealed that the different ashes significantly hindered the normal growth of the insect population.

Hampanna *et al.* (2006) evaluated the animal origin inert materials as seed mixing and storing materials to know the population build up, seed damage and weight loss of pulse beetle and also germination of the seeds (after 90 days and 180 days) of

release respectively, and malathion as standard check. The results of the studies revealed that malathion treatment was effective and superior in reducing the population buildup of both insects and prevented the infestation. Cow dung ash (2.0 %) and dry cow dung powder (20.0 %) were effective in reducing the population buildup of pulse beetle. Minimum seed damage of 32.40 per cent by *C. chinensis* was recorded in cow dung ash and dry dung powder, respectively. Whereas, population build up was least in cow dung ash (2.31 adults/ 100 g) and 52.14 adults/ 100 g for *C. chinensis* in dry dung powder. There was no effect on germination in cow dung ash and dry dung powder despite damage caused by the insects.

Tesema *et al*. (2015) studied the efficacy of cow dung ash against bruchid on chickpea and levels of infestation, weight loss, germination capacity and germination of the seeds up to six months and were found to be effective in reducing the damage inflicted by bruchid compared to the control. However, looking in to the side effects of synthetic pesticides, we suggest that the locally available cow dung ash, which is cheap, ecologically friendly and non-hazardous to human health can play an important role in protection of chickpea during storage against invasion by bruchid.

Kebebush *et al.* (2015) studied the efficacy of cow dung ash, neem leaf powder, basil leaf powder and malathion dust against bruchid on two chickpea varieties for levels of infestation, weight loss and germination of the seeds were evaluated monthly up to six months. In the bruchid infested treatment (control), hundred seeds weight, seed germination decreased over time, while levels of infestation and weight loss increased. All the tested locally available treatments (cow dung ash, leaf powder of neem and leaf powder of basil) were found to be effective in reducing the damage inflicted by bruchid compared to the control. Malathion dust was observed to be the most effective of all treatments in this study.

II. Effect of inorganic seed treatment on seed health and quality.

2.9 Deltamethrin

Saroj and Yadav (1989) reported full protection of green gram seed was observed with 1ppm deltamethrin dust against *Callosobruchus chinensis* and even with 40 ppm of malathion @ 10 per cent against pulse beetles. Seed germination was not affected by these chemical treatments.

Bajpai *et al.* (2000) reported urdbean seed treated with deltamethrin @ 5ml per kg of seeds recorded higher germination (78.70 %) and seedling length (14.50 cm) as compared to control (69.70 % and 14.00 cm) respectively, at the end of eight month of storage period.

Malarkodi and Srimathi (2001) observed that the seeds of maize cv. CO-1 can be preserved safely for a period of nine months when treated with deltamethrin 2.8 EC (0.04 ml/kg) and stored under ambient condition.

Parmar and Patel (2016) evaluated the synthetic insecticides as seed protectants against *Callosobruchus chinensis* L. and result revealed that among the different insecticides, deltamethrin 2.8 EC at 4 ppm were found to be more effective against *C. chinensis* damaging mung bean under storage condition. These insecticides recorded significantly lower number of adult emergence (<1.63), higher shelf-life values (173.15 days) and higher gross persistency (7564.58 to 6631.25). In addition, none of the insecticidal treatments affected mung bean seed germination.

Rathod *et al*. (2018) evaluated never insecticides *viz.,* deltamethrin, emamectin benzoate, spinosad, indoxacarb, novaluron for their efficacy against pulse beetle, *Callosobruchus chinensis* on stored pigeon pea seed. The observation on germination and insect infestation were recorded at interval of one month up to six month of storage period. Among different insecticides, deltamethrin 2.8 EC @ 0.04 ml/kg and spinosad 45 SC @ 4.4 mg/kg of seed were found equally effective for control of pulse beetle in stored pigeon pea seed and maintained the pigeon pea seed germination above minimum seed certification standard (87.66 %) upto 6 months of storage.

Jaiswal *et al.*(2019) studied the bioefficacy of commercial formulations of neem oil, deltamethrin as a preventive measure against pulse beetle, *Callosobruchus chinensis* (L.) on fresh chickpea seeds under laboratory conditions and observed the lowest mean seed damage with the seeds treated of deltamethrin followed by neem oil. A similar trend was found even after 60, 90 and 120 days of storage.

3. MATERIALS AND METHODS

A comprehensive laboratory study on "Effect of organic and inorganic seed treatments on seed health and quality of French bean (*Phaseolus vulgaris)*" was under taken at Seed Technology Research Unit, Mahatma Phule Krishi Vidyapeeth, Rahuri. Dist. Ahmednagar (MS) during May 2019 to Feb 2020. The information on materials and methods adopted for the conduct of various experiments during the course of investigation is described in this chapter.

3.1 Source of Seed

Freshly harvested seeds of French bean (*Phaseolus vulgaris)* variety Varun was obtained from Botany Farm, College of Agriculture, Pune.

3.2 Pulse beetle Culture:

The initial culture of pulse beetle, *Callosobruchus chinensis* L. was obtained from the Entomology Laboratory, Seed Technology Research Unit, MPKV, Rahuri. The identification key of *Callosbruchus* spp. given by Raina (1970) was used. Initial culture and healthy seed of French bean was kept in to 32×22.5 cm size cylindrical jar and 10 pairs of adult beetles was isolated and released into jar. The top of the jar was covered with muslin cloth secured firmly by rubber band. After emergence of new adults, the beetles was introduced into French bean seed kept in a series of cylindrical jars for building up a homogenous population.

3.3 Treatment Details

1. Crop : French bean *(Phaseolus vulgaris*).
2. Variety : Varun.
3. Design : Completely Randomized Design.
4. Containers : HDPE (High Density Polyethelene) bag.
5. Replication : 3
6. Seed treatments (T)

	Treatments	**Concentrations**
T_0	Control	-
T_1	Neem oil	5 ml/kg of seed
T_2	Neem leaf powder	5 g/kg of seed
T_3	Castor oil	5 ml/kg of seed
T_4	Karanj oil	5 ml/kg of seed

T_5	Vekhand powder	10 g/kg of seed
T_6	Termuric powder	5 g/kg of seed
T_7	Citronella oil	5 ml/kg of seed
T_8	Ash	5 g/kg of seed
T_9	Deltamethrin (2.8 EC)	0.04 ml/kg of seed

3.4 Storage Studies

After treating the seeds as per given treatment initial observations was recorded as detailed below.

3.4.1 Initial Observations

The initial observations *viz.,* germination (%), first count, speed of germination, root length (cm), shoot length (cm), vigour index I and II, seedling dry weight (mg/10 seedlings), electrical conductivity (dSm^{-1}), test weight (g), moisture content (%) and seed mycoflora (%) was carried out before keeping seeds for storage experiment.

3.4.2 Storage Conditions

The treated seeds was stored in recommended storage container i.e. HDPE bag under ambient conditions at Seed Technology Research Unit, MPKV, Rahuri.

3.4.3 Laboratory Observations

Following observations was recorded at monthly interval during storage period.

I. Seed Quality Parameters

1. Moisture content (%)

Three replicates of 10 grams of seed was taken from each treatment for determining the moisture content using hot air oven method. The seed was placed in a weighed metal cup and after covering the lid, moisture cups was placed in hot air oven maintained at 103 + 2^0C temperature for 16+1hr and the contents was allowed to dry. Then the contents was weighed in an electronic balance along with metal cup and lid. The moisture content was worked out using the following formula and expressed in percentage (Anon., 1999).

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

Where,

M_1 : Weight of the metal cup alone (g).

M_2 : Weight of the metal cup + sample before drying (g).

M_3 : Weight of the metal cup + sample after drying (g).

2. Germination (%)

Hundred seeds in four replications was drawn at random from each treatment and then germination test was conducted using between paper methods as per the ISTA procedure (Anon., 1996).

The rolled paper was placed in a seed germinator maintained at $25^0 \pm 2^0$C temperature and 95 ± 1 % relative humidity. The numbers of seeds germinated was counted on 8th day (final count) of germination from all the replications. The average of four replications expressed as germination percentage.

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds put for germination}} \times 100$$

3. First count

The test is done along with the regular germination test. The number of normal seedlings germinated on the first count day (4th day), as specified in the germination test for each species, are counted. The number of normal seedlings gives an idea of the level of seed vigour in the sample.

4. Speed of germination

One hundred seeds each in three replications are planted in recommended substratum for germination. The substratum is kept in a germinator maintained at recommended temperature for the crop. Number of seedlings emerging daily was counted from day of planting the seeds in the medium till the time germination is complete.

Speed of germination was calculated by the following formula.

Speed of germination= n1/d1 + n2/d2 + n3/d3 + ----------

Where,

n = Number of germinated seeds

d = Number of days

5. Root length (cm)

On the day of final count (8^{th} day), ten normal seedlings was selected randomly from different treatments of all the replications. The root length was measured from the tip of primary root to the base of hypocotyls. The mean root length was computed and expressed in centimeters.

6. Shoot length (cm)

On the day of final count (8^{th} day) ten normal seedlings used for measurement of root length was also used for shoot length measurement. The shoot length was measured from the base of the primary leaf to the base of hypocotyls and mean shoot length was computed and expressed in centimeters.

7. Seedling Vigour index I

Ten normal seedlings was selected randomly immediately after germination test. Total root shoot length of ten seedlings and average was worked out for calculating the seedling vigour index I. The vigour index was computed by formula suggested by Abdul-Baki and Anderson (1973) as given below.

Vigour Index I = Average seedling length (root + shoot) (cm) × Germination (%)

8. Vigour index II

The seedlings selected for calculating seedling vigour index I was oven dried at 85 ± 1^0C for 24 hours and oven dried weight of seedlings was used for calculating seedling vigour index II. The vigour index II was computed by using formula suggested byAbdul-Baki and Anderson (1973) as below.

Vigour index II= Average dry seedlings wt. (mg) x Germination (%)

9. Seedling dry weight (mg)

Ten normal seedlings selected (wherever the germination percentage is below 10 per cent, all the seedlings was used) which was used for root and shoot length measurement was dried in an oven maintained at 85° ± 1°C for 24 hours. After drying the weight of dry seedlings was calculated and means weight was calculated and expressed in miligrams/10 seedlings (Anon., 1996).

10. Electrical conductivity (dSm^{-1})

Three replications of 50 seeds was randomly counted from different treatment combinations. Then the seeds was soaked in 75 ml distilled water and kept in

an incubator maintained at 25° ± 1°C for 24 hours. The solution and seeds was gently stir for 10 to 15sec prior to evaluation. Then the electrical conductivity of the seed was measured in the Digital Electrical Conductivity meter and expressed in deci Simons per meter (dSm^{-1}) (Presley, 1958).

11. Test weight (g)

Hundred seeds in each treatment were counted manually and their weight was recorded as per ISTA rules (Anon, 1999). The average hundred seed weight was recorded in grams.

12. Seed mycoflora (%)

The seed health was determined by blotter test to detect the presence of seed borne fungi of French bean seed (Anon., 1999). Three layers of blotter (size fitting to the size of petri dish) paper soaked in sterilized distilled water in petri dish. Ten seeds was placed in each petri dish in three replications and the petri dish was kept in incubator at 20±2 ^{0}C for 7 days beneath near ultraviolet light with a cycle of 12 hrs. light and 12 hrs. darkness. The seeds was examined on 8th day under stereoscopic binocular microscope. The fungi was identified on the basis of sporulation and their fruiting structures

The per cent seed mycoflora and percentage frequency of various fungal species was calculated. The incidence of fungi on seed performed under these methods was calculated as follows:

$$\% \text{ incidence} = \frac{\text{Number of infected seeds}}{\text{Number of seeds placed in plate}} \times 100$$

13. Bio-efficacy Test

Treated seeds was kept in bottle container and 10 pair pulse beetle was released in the bottle, various observations was performed at every three month to check the bio-efficacy of organic and inorganic seed treatment against pulse beetle *Callosobruchus chinensis* of French bean seed.

i. Pulse beetle infestation (%)

The number of grains infested by *C. chinensis* was counted and per cent infestation was worked out on the basis of seed with characteristics holes made by

beetles. The seed infestation was calculated by using following formula.

$$\text{Seed infestation (\%)} = \frac{\text{Total number of seeds} - \text{Number of damaged seeds}}{\text{Total number of seeds}} \times 100$$

ii. Per cent Seed weight loss (%)

After removing the beetles from each jar the weight of grains was taken separately on an electric balance from each replicate after 90 days of release. The mean per cent loss in weight was calculated by the following formula:

$$\text{Mean weight loss (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

iii. Number of eggs /100 seeds

From treated seed jar 100 seeds was taken for observation and presence of eggs of pulse beetle on seed was observed and recorded.

iv. Number of adult emergence

Total number of adult insects emerged was recorded on the basis of number of seeds with exist holes was counted on each alternate day from the date of emergence of adult up to 20 days.

v. Per cent Mortality (%)

Number of survived and dead insects was collected, counted and recorded daily from 3rd, 5th and 7th day of beetle release. Moribund insect was taken as dead. After 7th days per cent mortality of *Callosobruchus chinensis* was calculated with the help of following formula.

$$\text{Per cent Mortality} = \frac{\text{Number of dead insect}}{\text{Total number of insect released}} \times 100$$

vi. Dead insect

Treated seeds was observed on 3rd, 5th and 7th day of beetle release and presence of dead insect counted at every three months interval.

vii. Live insect

Treated seeds was observed on 3rd, 5th and 7th day of beetle release for presence of live pulse beetle population in the bottle for every three months and pulse beetle population was be counted.

3.4.5 Statistical analysis

Statistical analysis of the data generated from the above studies was carried out as per the procedure given by Panse and Sukhatme (1967) and Sundaraj *et al.* (1972) adopting “Fishers ‘analysis of variance techniques” and Critical difference (CD) value was computed at five per cent level of probability.

4. RESULT AND DISCUSSION

The present investigation entitled "Effect of organic and inorganic seed treatments on seed health and quality of French bean (*Phaseolus vulgaris).*" was carried out at Seed Technology Research Unit, M.P.K.V., Rahuri during May 2019 to Feb 2020. The seed was harvested in the month of March and cleaned and processed in month of April. The research trial started from May month and after initial observation, the next observation was recorded in 60 days. Thereafter, the monthly observations on seed quality and health parameters was recorded and results of this experiment and discussion are given below.

4.1 Moisture Content (%)

4.1 Effect of seed treatment on moisture content (%) of French bean

The results on seed moisture content as influenced by seed treatments is presented in Table 1.

The moisture contents of seeds due to treatment with botanicals and chemicals varied significantly at all days of storage, except at initial days of storage i.e. immediately after receipt of seed sample.

At initial period, lower moisture content (8.23 %) was recorded in deltamethrin (T_9) treated seeds, while higher moisture content (8.26 %) was recorded in neem oil (T_2), castor oil (T_4) and turmeric powder (T_9). At 90 days of storage, highest moisture content (8.48 %) was recorded in untreated control (T_0), whereas lowest moisture content (8.35 %) was recorded in seeds treated with deltamethrin (T_9). At the end of 300 days of storage period, lowest moisture content (7.30 %) was recorded in deltamethrin (T_9) followed by neem oil (T_2), castor oil (T_4), karanj oil (T_3) and highest moisture content (7.69 %) was recorded in untreated control (T_0).

During storage period, relative humidity of ambient condition fluctuates and accordingly seed moisture content also fluctuates with atmospheric relative humidity. At initial period of storage, moisture content in the seeds increased up to 90 days of storage and thereafter decreased progressively up to the end of storage period. Similar trends in moisture fluctuation and effect of seed treatment on moisture content was reported by Anantareddy (2004).

Table 1. Effect of seed treatment on moisture content (%) of French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	8.25 (16.69)	8.42 (16.87)	8.48 (16.93)	8.46 (16.91)	8.39 (16.84)	8.28 (16.72)	8.13 (16.57)	7.95 (16.38)	7.84 (16.26)	7.69 (16.10)
T_1	8.24 (16.68)	8.34 (16.79)	8.40 (16.85)	8.32 (16.76)	8.23 (16.67)	8.08 (16.51)	7.90 (16.32)	7.67 (16.08)	7.56 (15.96)	7.41 (15.80)
T_2	8.26 (16.70)	8.35 (16.80)	8.42 (16.87)	8.26 (16.70)	8.17 (16.61)	8.02 (16.45)	7.84 (16.26)	7.60 (16.00)	7.48 (15.87)	7.34 (15.72)
T_3	8.25 (16.69)	8.34 (16.79)	8.43 (16.88)	8.28 (16.72)	8.19 (16.63)	8.04 (16.47)	7.86 (16.28)	7.63 (16.03)	7.52 (15.92)	7.37 (15.75)
T_4	8.26 (16.70)	8.38 (16.83)	8.41 (16.86)	8.30 (16.74)	8.21 (16.65)	8.06 (16.49)	7.88 (16.30)	7.65 (16.06)	7.54 (15.94)	7.39 (15.77)
T_5	8.25 (16.69)	8.35 (16.80)	8.38 (16.83)	8.36 (16.81)	8.27 (16.71)	8.12 (16.56)	7.94 (16.37)	7.71 (16.12)	7.60 (16.00)	7.45 (15.84)
T_6	8.26 (16.70)	8.34(16. 79)	8.37 (16.82)	8.32 (16.76)	8.23 (16.67)	8.08 (16.51)	7.92 (16.35)	7.70 (16.11)	7.58 (15.98)	7.44 (15.83)
T_7	8.24 (16.68)	8.37(16. 82)	8.40 (16.85)	8.31 (16.75)	8.22 (16.66)	8.07 (16.50)	7.89 (16.31)	7.66 (16.07)	7.55 (15.95)	7.40 (15.78)
T_8	8.26 (16.70)	8.36(16. 81)	8.37 (16.82)	8.33 (16.78)	8.24 (16.68)	8.09 (16.52)	7.98 (16.41)	7.75 (16.16)	7.63 (16.03)	7.49 (15.88)
T_9	8.23 (16.70)	8.33(16. 76)	8.35 (16.80)	8.26 (16.70)	8.16 (16.60)	7.97 (16.40)	7.79 (16.21)	7.56 (15.96)	7.45 (15.84)	7.30 (15.68)
SE±	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.04	0.04
CD at 5%	(NS) (0.06)	0.05	0.07	0.10	0.10	0.05	0.07	0.09	0.11	0.13

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

At initial period of storage, higher moisture content was recorded in the seeds treated with neem oil, karanj oil, turmeric powder and ash, while lower moisture content was recorded in deltamethrin treated seeds. At initial storage period seed treatment was found non significance as seed treatment does not effect at early stage of storage but at the end of storage period lower moisture content was recorded in seed treatment with deltamethrin followed by neem oil and higher seed moisture content was recorded in control seeds showing the effect of seed treatment. It was clear from the recording that, seed treated with chemicals and botanical oils protect the seed from fluctuation in the seed moisture content.

4.2 Germination (%)

4.2.1 Effect of seed treatment on seed germination (%) on French bean

The results on germination percentage as influenced by seed treatment effect during storage period are presented in Table 2.

The germination due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 60 days of storage. At initial period, highest germination (89.67 %) was recorded in seeds treated with neem oil (T_2) followed by control (T_0), neem leaf powder (T_1), castor oil (T_4), deltamethrin (T_9) and lower germination (88.0 %) in vekhand powder (T_5). At the end of storage period (300 days), highest germination (76.67 %) was recorded in deltamethrin (T_9) and it was on par with neem oil (T_2), castor oil (T_4), while lowest germination (64.33 %) was recorded in untreated control (T_0).

Table 2. Effect of seed treatment on seed germination (%)of French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	89.00 (70.63)	86.67 (68.60)	84.67 (66.96)	83.33 (65.91)	81.67 (64.65)	78.67 (62.49)	76.67 (61.12)	73.67 (59.13)	68.33 (55.76)	64.33 (53.33)
T_1	89.00 (70.64)	87.33 (69.15)	86.67 (68.59)	85.33 (67.48)	83.67 (66.17)	81.67 (64.65)	80.00 (63.44)	78.33 (62.26)	76.00 (60.67)	73.67 (59.13)
T_2	89.67 (71.25)	88.67 (70.33)	88.00 (69.74)	86.67 (68.59)	85.00 (67.22)	83.67 (66.16)	82.00 (64.90)	80.00 (63.44)	78.00 (62.03)	75.33 (60.22)
T_3	88.67 (70.35)	88.33 (70.05)	87.00 (68.88)	85.67 (67.77)	84.00 (66.44)	82.00 (64.90)	80.67 (63.92)	79.00 (62.73)	76.67 (61.12)	73.33 (58.92)
T_4	89.00 (70.68)	87.33 (69.15)	86.67 (68.60)	85.33 (67.48)	83.67 (66.16)	81.33 (64.40)	80.33 (63.68)	78.67 (62.49)	76.33 (60.89)	74.33 (59.56)
T_5	88.00 (69.74)	87.33 (69.15)	86.00 (68.04)	84.67 (66.95)	82.33 (65.15)	80.00 (63.44)	78.00 (62.03)	75.33 (60.22)	73.00 (58.70)	69.33 (56.37)
T_6	88.33 (70.03)	87.00 (68.88)	86.33 (68.31)	85.00 (67.22)	83.33 (65.92)	81.33 (64.41)	79.33 (62.97)	77.33 (61.57)	75.00 (60.00)	71.67 (57.84)
T_7	88.67 (70.33)	87.33 (69.16)	86.67 (68.60)	85.33 (67.49)	83.67 (66.18)	80.67 (63.92)	79.00 (62.73)	76.33 (60.90)	74.00 (59.35)	70.67 (57.21)
T_8	88.00 (69.77)	88.00 (69.73)	87.00 (68.88)	85.67 (67.76)	84.00 (66.42)	81.33 (64.40)	79.33 (62.96)	77.00 (61.35)	74.67 (59.78)	72.00 (58.05)
T_9	89.00 (70.64)	89.00 (70.78)	88.33 (70.04)	87.00 (68.88)	85.33 (67.48)	84.33 (66.70)	82.67 (65.41)	81.00 (64.16)	79.00 (62.73)	76.67 (61.12)
SE±	0.62	0.73	0.53	0.41	0.50	0.40	0.42	0.36	0.33	0.44
CD at 5%	(NS) 1.84	(NS) 2.16	1.58	1.21	1.46	1.19	1.23	1.06	0.98	1.29

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The minimum seed standard for germination percentage due to seed treatment with deltamethrin (T_9) and neem oil (T_2) was maintained up to 300 days of

storage. The MSCS for germination in control was maintained for only 210 days where seeds were stored without any treatment.

Seed treatment with deltamethrin @ 0.04 ml/kg of seed showed significantly higher germination percentage throughout the storage period and it was on par with neem oil @ 5 ml/kg of seed and castor oil @ 5 ml/kg of seed. Seed treated with deltamethrin, neem oil and some botanicals controlled seed deterioration in storage. These chemical and botanicals prevent the pulse beetle infestation and also supresses the growth of mycoflora on French bean seed thus maintaining higher germination percentage. Similar findings was also observed by Gupta *et al* (2018) in chickpea, Mandali and Reddy (2014) in red gram and Rathod *et al.* (2018) in pigeon pea seed.

4.3 First Count

4.3.1 Effect of seed treatment on first count of French bean

The results on first count as influenced by seed treatment effect are presented in Table 3.

Table 3. Effect of seed treatment on first count of French bean

Treatments	Storage Period (days)									
	Initial	60	90	120	150	180	210	240	270	300
T_0	84.00	83.33	82.00	81.33	80.67	79.67	78.00	73.33	69.67	63.67
T_1	84.33	83.67	83.67	83.00	82.33	81.67	80.33	78.67	76.67	74.33
T_2	84.00	84.33	84.33	83.33	82.67	82.33	81.33	80.00	77.67	75.33
T_3	85.00	84.33	83.67	83.00	82.33	81.67	80.33	78.67	76.67	74.33
T_4	84.33	84.33	84.00	83.33	82.67	82.00	80.67	79.00	77.00	74.67
T_5	84.00	83.67	82.00	81.67	81.00	80.00	78.33	75.33	73.00	69.33
T_6	84.00	84.00	84.00	83.33	82.67	82.00	80.67	79.00	76.33	74.00
T_7	84.33	83.67	83.33	82.67	82.00	81.33	80.00	78.33	76.33	74.00
T_8	84.33	83.67	83.67	83.00	82.33	81.33	80.00	78.00	75.33	73.00
T_9	85.33	85.00	84.67	83.67	83.00	82.33	81.33	80.33	78.33	76.00
SE±	0.596	0.435	0.447	0.422	0.422	0.587	0.641	0.683	0.699	0.516
CD at 5%	NS	NS	1.319	1.244	1.244	1.731	1.892	2.015	2.063	1.523

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

First count due to seed treatment differed significantly in all the months of storage period except at initial and 60 days after storage. It declined with the advancement of storage period. Initially, significantly higher first count (85.33) was noticed in the seeds treated with deltamethrin (T_9) followed by castor oil (T_4) and lower first count (84.00) was recorded in control (T_0), neem oil (T_2), vekhand powder (T_5) treated seeds. At the end of storage period (300 days), highest first count (76.00) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), castor oil (T_4) and lowest speed of germination (63.67) was recorded untreated control (T_0).

Seed treatment with deltamethrin @ 0.04 ml/kg of seed showed significantly higher first count throughout the storage period and it was on par with neem oil @ 5 ml/kg of seed and karanj oil @ 5 ml/kg of seed. First count due to seed treatment also differed significantly in all the months of storage period except at initial and 60 days after storage. It declined with the advancement of storage period. From these results it is indicated that higher the first count indicates higher seed vigour.

4.4 Speed of Germination in French bean

4.4.1 Effect of seed treatment on speed of germination of French bean

The results on speed of germination as influenced by seed treatments effect are presented in Table 4.

Speed of germination due to seed treatment differed markedly in all the months of storage period except at initial and 60 days of storage. It declined with the advancement of storage period. Initially, significantly higher speed of germination (21.74) was noticed in the seeds treated with neem oil (T_2) followed by deltamethrin (T_9), control (T_0) and lower speed of germination (21.57) was recorded in turmeric powder (T_6) treated seeds. At the end of storage period (300 days), the highest speed of germination (19.42) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), karanj oil (T_3) and lowest speed of germination (15.68) was recorded untreated control (T_0).

Seed treatment with deltamethrin @ 0.04 ml/kg of seed showed significantly higher speed of germination throughout the storage period and it was on par with neem oil @ 5 ml/kg of seed and castor oil @ 5 ml/kg of seed. Speed of germination due to seed treatment differed markedly in all the months of storage period except at

initial and 60 days after storage. It declined with the advancement of storage period. From the above results it is indicated that higher the speed of germination eventually indicates the higher seed vigour.

Table 4. Effect of seed treatment on speed of germination of French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	21.62	21.54	20.95	20.70	20.45	19.79	19.37	18.62	16.97	15.68
T_1	21.62	21.57	21.40	21.20	20.95	20.78	20.49	20.11	19.55	18.79
T_2	21.74	21.65	21.65	21.39	21.14	21.05	20.79	20.47	19.91	19.28
T_3	21.65	21.61	21.47	21.24	20.99	20.81	20.56	20.18	19.62	18.93
T_4	21.67	21.64	21.48	21.25	21.00	20.77	20.50	20.12	19.56	18.87
T_5	21.59	21.57	21.09	20.87	20.62	20.37	20.08	19.60	18.80	17.90
T_6	21.57	21.55	21.37	21.17	20.92	20.68	20.39	20.02	19.46	18.69
T_7	21.59	21.56	21.25	21.05	20.80	20.54	20.25	19.80	19.07	18.31
T_8	21.60	21.55	21.20	21.00	20.75	20.49	20.14	19.77	19.11	18.34
T_9	21.70	21.62	21.52	21.44	21.19	21.08	20.84	20.53	19.97	19.42
SE±	0.0415	0.026	0.037	0.114	0.111	0.125	0.124	0.100	0.127	0.101
CD at 5%	NS	NS	0.111	0.338	0.330	0.369	0.367	0.297	0.375	0.299

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

4.5 Root Length (cm)

4.5.1 Effect of seed treatment on root length (cm) in French bean

The results on root length as influenced by seed treatments during storage period are presented in Table 5. It was noticed that root length decreased with the advancement of storage period irrespective of seed treatment.

The root length due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 60 days of storage. Initially higher root length (13.63 cm) was recorded in seeds treated with karanj oil (T_3) followed by castor oil (T_4), neem oil (T_2) and lower root length (13.57 cm) was recorded in control (T_0), neem leaf powder(T_1) and turmeric powder(T_6) treated seeds. At the end of 300 days of storage period, highest root length (11.59 cm) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), while lowest root length (9.46 cm) was recorded in untreated control (T_0).

It was observed that the root length of French bean seed decreased, irrespective of seed treatment during storage. The decrease in root length of seedling of French bean seed could be described to the ageing or deterioration of seed, which is progressive process accompanied by accumulation of metabolites, which progressively depress germination and growth of seedling (Floris, 1970), with increasing age ultimately reducing the dry matter and vigour of French bean seed during storage.

Table 5. Effect of seed treatment on root length (cm) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	13.57	13.54	12.97	12.61	12.33	11.80	10.99	10.42	10.01	9.46
T_1	13.57	13.54	13.18	13.01	12.73	12.37	11.81	11.45	11.07	10.62
T_2	13.61	13.57	13.55	13.45	13.17	12.81	12.22	11.90	11.67	11.43
T_3	13.63	13.63	13.45	13.27	12.99	12.56	12.08	11.54	11.16	10.78
T_4	13.62	13.58	13.37	13.19	12.91	12.50	12.02	11.48	11.12	10.73
T_5	13.59	13.57	13.12	12.83	12.55	12.04	11.48	10.83	10.42	10.00
T_6	13.57	13.55	13.18	13.00	12.72	12.36	11.88	11.34	10.93	10.47
T_7	13.60	13.59	13.34	13.17	12.89	12.22	11.76	11.22	10.81	10.36
T_8	13.58	13.56	13.32	12.97	12.69	12.21	11.80	11.26	10.78	10.33
T_9	13.59	13.58	13.58	13.58	13.30	12.94	12.35	12.15	11.87	11.59
SE±	0.044	0.034	0.037	0.112	0.113	0.101	0.092	0.088	0.094	0.087
CD at 5%	NS	NS	0.110	0.330	0.334	0.298	0.272	0.262	0.277	0.257

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The root length of the seeds treated with deltamethrin was significantly higher during all the period except at initial and 60 days of storage. This might be due to the treatment of seeds with deltamethrin and botanicals, which maintains higher 100 seed weight, seed vigour and less deterioration of the seeds.

4.6 Shoot Length (cm)

4.6.1 Effect of treatment on shoot length (cm) in French bean

The results on shoot length as influenced by seed treatments during storage period are presented in Table 6. It was noticed that shoot length decreased with the advancement of storage period irrespective of seed treatment.

The shoot length due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 30 days of storage. Initially higher shoot length (9.12 cm) was recorded in seeds treated with castor oil (T_4) followed by deltamethrin (T_9), neem oil (T_2) and lower shoot length (9.05 cm) was recorded in control (T_0), Ash (T_8) and turmeric powder (T_6) treated seeds. At the end of 300 days of storage period, highest shoot length (7.65 cm) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), while lowest shoot length (6.58 cm) was recorded in untreated control (T_0).

Table 6. Effect of treatment on shoot length (cm) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	9.05	9.02	8.73	8.49	8.29	8.13	7.91	7.67	7.21	6.58
T_1	9.07	9.04	8.94	8.80	8.58	8.45	8.29	8.10	7.80	7.39
T_2	9.10	9.08	8.98	8.93	8.71	8.57	8.41	8.23	7.96	7.59
T_3	9.12	9.09	8.96	8.82	8.58	8.46	8.28	8.07	7.76	7.35
T_4	9.08	9.05	8.97	8.83	8.61	8.47	8.29	8.08	7.77	7.36
T_5	9.03	9.02	8.83	8.62	8.42	8.27	8.08	7.84	7.46	6.93
T_6	9.05	9.00	8.93	8.79	8.57	8.44	8.25	8.04	7.74	7.33
T_7	9.05	9.02	8.86	8.72	8.50	8.36	8.20	7.99	7.68	7.27
T_8	9.09	9.04	8.95	8.81	8.61	8.45	8.27	8.06	7.70	7.29
T_9	9.10	9.07	9.06	8.98	8.76	8.62	8.44	8.26	8.04	7.65
SE±	0.03	0.03	0.04	0.06	0.05	0.04	0.03	0.03	0.05	0.07
CD at 5%	NS	NS	0.14	0.18	0.15	0.14	0.09	0.10	0.16	0.21

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

It was observed that the shoot length of French bean seed decreased irrespective of seed treatment during storage. The decrease in shoot length of seedling of French bean seed could be described to the ageing or deterioration of seed, which is progressive process accompanied by accumulation of metabolites, which progressively depress germination and growth of seedling (Floris, 1970), with increasing age ultimately reducing the dry matter and vigour of French bean seed during storage.

The shoot length of the seeds treated with deltamethrin was significantly higher during all the period except at initial and 60 days of storage. This might be due to the treatment of seeds with deltamethrin and botanicals, which maintained higher 100 seed weight and seed vigour.

4.7 Vigour Index-I

4.7.1 Effect of seed treatment on vigour index-I in French bean

The results on vigour index-I as influenced by seed treatments during storage period are presented in Table 7. It was noticed that vigour index-I decreased with the advancement of storage period irrespective of seed treatment.

Table 7. Effect of seed treatment on vigour index-I in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	2013	1955	1840	1758	1793	1568	1449	1333	1177	1032
T_1	2015	1972	1917	1861	1783	1700	1608	1531	1434	1327
T_2	2036	2008	1989	1940	1860	1789	1692	1610	1531	1432
T_3	2017	2007	1950	1892	1812	1724	1642	1549	1477	1330
T_4	2020	1976	1936	1879	1801	1706	1632	1539	1442	1345
T_5	1991	1973	1888	1816	1727	1625	1526	1406	1305	1174
T_6	1998	1962	1909	1852	1774	1692	1597	1499	1400	1276
T_7	2009	1974	1924	1868	1790	1660	1577	1466	1368	1246
T_8	1995	1989	1938	1866	1789	1680	1592	1488	1380	1269
T_9	2019	2015	2005	1963	1882	1818	1719	1653	1573	1475
SE±	15.64	18.78	16.03	11.31	23.50	12.13	12.92	9.22	15.22	13.47
CD at 5%	(NS)	(NS)	47.30	33.37	69.32	35.78	38.12	27.20	44.89	39.75

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The vigour index-I due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 30 days of storage. Initially higher vigour index-I (2036.31) was recorded in seeds treated with neem oil (T_2) followed by karanj oil (T_4) and lower vigour index-I (1990.93) in vekhand powder (T_5) treated seeds. At the end of 300 days of storage period, highest vigour index-

I (1475.08) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), while lowest vigour index-I (1031.93) was recorded in untreated control (T_0).

It was observed that vigour index-I of French bean seed decreased irrespective of seed treatment during storage. The decrease in root shoot length of seedling of French bean seed could be described to the ageing or deterioration of seed, which is progressive process accompanied by accumulation of metabolites, which progressively depress germination and growth of seedling (Floris, 1970), with increasing age ultimately reducing the dry matter and vigour of French bean seed during storage.

Vigour index-I decreased with advancement of storage period irrespective of seed treatment. Seed treated with deltamethrin @0.04 ml/kg of seed showed higher vigour index-I followed by neem oil @ 5 ml/kg of seed due to higher germination percentage, root shoot length and seedling dry weight. Similar findings regarding with vigour index I was also reported by Gupta *et al.* (2018) in chickpea and Rathod *et al.* (2018) in pigeon pea.

4.8 Vigour Index-II

4.8.1 Effect of seed treatment on vigour index-II in French bean

The results on vigour index-II as influenced by seed treatments during storage period are presented in Table 8. It was noticed that vigour index-II decreased with the advancement of storage period irrespective of seed treatment.

The vigour index-II due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 30 days of storage. Initially higher vigour index-II (2123.36) was recorded in seeds treated with neem oil (T_2) followed by deltamethrin (T_9) and lower vigour index-II (2050.15) was recorded in ash (T_8) treated seeds. At the end of 300 days of storage period, highest vigour index-II (1606.41) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2) while lower vigour index-II (1193.01) was recorded in untreated control (T_0).

Vigour index-II decreased with advancement of storage period irrespective of seed treatment. Seed treated with deltamethrin @ 0.04 ml/kg of seed showed highest vigour index-II followed by neem oil @ 5 ml/kg of seed due to higher germination percentage, root shoot length and seedling dry weight. Similar findings regarding with

vigour-II was reported by Gupta *et al.* (2018) in chickpea and Rathod *et al.* (2018) in pigeonpea.

Table 8. Effect of seed treatment on vigour index-II in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	2077	1979	1898	1842	1763	1682	1622	1524	1328	1193
T_1	2094	2012	1986	1936	1864	1813	1758	1693	1611	1512
T_2	2123	2055	2036	1990	1926	1876	1820	1752	1673	1572
T_3	2090	2037	1996	1946	1874	1827	1788	1723	1627	1507
T_4	2101	2018	1992	1953	1892	1823	1782	1717	1621	1529
T_5	2050	1991	1942	1891	1805	1733	1666	1582	1490	1362
T_6	2069	1995	1969	1926	1854	1801	1739	1667	1573	1455
T_7	2079	2004	1979	1937	1865	1782	1727	1641	1548	1430
T_8	2050	2006	1973	1880	1809	1735	1686	1632	1539	1435
T_9	2115	2071	2052	2005	1931	1894	1838	1783	1701	1606
SE±	22.33	25.79	20.04	20.03	23.34	18.36	18.04	18.87	18.79	16.82
CD at 5%	NS	NS	59.12	59.10	68.84	54.16	53.22	55.66	55.43	49.61

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

4.9 Seedling Dry Weight (mg)

4.9 Effect of seed treatment on seedling dry weight (mg) in French bean

The results on seedling dry weight as influenced by seed treatments during storage period are presented in Table 9. It was observed that seedling dry weight decreased with the advancement of storage period irrespective of seed treatment.

The seedling dry weight due to seed treatments with botanicals and chemicals differed significantly at all the months of storage period except at initial and 60 days of storage. Initially, higher seedling dry weight (23.77) was recorded in seeds treated with deltamethrin (T_9) followed by neem oil (T_2), castor oil (T_4) and lower seedling dry weight (23.30) was recorded in vekhand powder (T_5) treated seeds. At the end of 300 days of storage period, higher seedling dry weight (20.95) was recorded in

deltamethrin (T_9) treated seeds followed by neem oil (T_2), while lowest seedling dry weight (18.54) was recorded in untreated control (T_0).

The seedlings dry weight of French bean differed significantly during all the period of storage except at initial and 60 days of storage period. This could be attributed to low rate of germination, reducing vigour and root shoot length of seedling (Srimathi *et al.* 2003). Seed treated with deltamethrin @0.04 ml/kg of seed showed higher seedling dry weight and was on par with neem oil @ 5 ml/kg of seed and karanj oil @ 5 ml/kg of seed due to higher test weight, root shoot length and less deterioration of seed.

Table 9. Effect of seed treatment on seedling dry weight (mg) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	23.50	22.83	22.41	22.11	21.58	21.38	21.15	20.69	19.43	18.54
T_1	23.53	23.03	22.91	22.68	22.27	22.20	21.97	21.62	21.20	20.53
T_2	23.68	23.18	23.14	22.97	22.66	22.42	22.19	21.90	21.45	20.87
T_3	23.56	23.06	22.95	22.72	22.31	22.28	22.16	21.81	21.22	20.55
T_4	23.61	23.11	22.99	22.89	22.62	22.41	22.18	21.83	21.24	20.57
T_5	23.30	22.80	22.58	22.33	21.92	21.67	21.36	21.00	20.41	19.65
T_6	23.43	22.93	22.81	22.66	22.25	22.14	21.92	21.56	20.97	20.30
T_7	23.45	22.95	22.83	22.70	22.29	22.09	21.86	21.50	20.92	20.24
T_8	23.35	22.80	22.68	21.94	21.53	21.33	21.26	21.20	20.61	19.94
T_9	23.77	23.27	23.23	23.04	22.63	22.46	22.23	22.01	21.53	20.95
SE±	0.24	0.16	0.16	0.19	0.19	0.17	0.17	0.18	0.18	0.18
CD at 5%	NS	NS	0.46	0.56	0.56	0.50	0.50	0.54	0.53	0.52

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

4.10 Electrical Conductivity (dSm^{-1})

4.10.1 Effect of seed treatment on electrical conductivity (dSm^{-1}) in French bean

The results on electrical conductivity as influenced by seed treatments during storage period are presented in Table 10. It was noticed that electrical conductivity increased with the advancement of storage period irrespective of seed treatment.

The electrical conductivity due to seed treatments with botanicals and chemicals differed significantly, in all the months of storage period except at initial and 60 days of storage. Initially, higher electrical conductivity (1.02) was recorded in seeds treated with ash (T_8), castor oil (T_4) followed by karanj oil (T_3) and lower electrical conductivity (0.98) was recorded in control (T_0) and deltamethrin (T_9) treated seeds. At the end of 270 days of storage period, lowest electrical conductivity (1.86) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2), while highest electrical conductivity (2.27) was recorded in untreated control (T_0).

Table 10. Effect of seed treatment on electrical conductivity (dSm^{-1}) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	0.98	0.99	1.05	1.21	1.31	1.46	1.70	1.86	1.98	2.27
T_1	1.00	1.00	1.04	1.11	1.21	1.34	1.52	1.65	1.77	2.00
T_2	0.99	0.99	1.04	1.11	1.21	1.33	1.50	1.60	1.67	1.91
T_3	1.01	1.02	1.06	1.13	1.23	1.35	1.53	1.69	1.79	1.97
T_4	1.02	1.02	1.07	1.13	1.23	1.36	1.54	1.67	1.77	2.01
T_5	1.00	1.00	1.07	1.18	1.28	1.41	1.60	1.76	1.88	2.17
T_6	1.03	1.04	1.09	1.16	1.26	1.38	1.56	1.72	1.81	2.05
T_7	1.01	1.01	1.06	1.12	1.22	1.35	1.53	1.69	1.81	2.09
T_8	1.02	1.02	1.07	1.13	1.23	1.36	1.54	1.70	1.82	2.10
T_9	0.98	0.98	1.02	1.09	1.19	1.31	1.48	1.55	1.63	1.86
SE±	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.03
CD at 5%	NS	NS	NS	0.06	0.05	0.04	0.07	0.07	0.06	0.10

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The electrical conductivity of seed leachate indicates the membrane integrity and quality of seed and it is negatively related with seed quality. Hampton *et al.* (1995) reported that the electrical conductivity was increased with increment in storage period.

Seeds treated with deltamethrin showed lower electrical conductivity followed by neem oil as these treated seed recorded low pulse beetle infestation and

lower seed mycoflora. These results finding are in conformity with Gupta *et al.* (2018) in chickpea.

4.11 Test Weight (g)

4.11.1 Effect of seed treatment on test weight (g) in French bean.

The results on test weight as influenced by seed treatments during storage period are presented in Table 11. It was noticed that test weight decreased with the advancement of storage period irrespective of seed treatment.

Table 11. Effect of seed treatment on test weight (g) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	34.32	34.37	34.43	34.25	34.13	33.98	33.82	33.61	33.13	31.90
T_1	34.33	34.51	34.63	34.55	34.43	34.32	34.15	33.97	33.82	33.42
T_2	34.44	34.62	34.76	34.68	34.56	34.44	34.28	34.10	33.86	33.51
T_3	34.43	34.61	34.73	34.65	34.53	34.42	34.25	34.04	33.84	33.47
T_4	34.36	34.54	34.65	34.57	34.45	34.34	34.17	33.99	33.74	33.34
T_5	34.30	34.48	34.61	34.49	34.37	34.22	34.06	33.80	33.48	32.80
T_6	34.32	34.50	34.63	34.55	34.43	34.32	34.15	33.97	33.72	33.29
T_7	34.37	34.50	34.63	34.55	34.43	34.32	34.15	33.97	33.72	33.32
T_8	34.36	34.54	34.67	34.59	34.47	34.36	34.16	33.98	33.73	33.30
T_9	34.35	34.62	34.80	34.72	34.60	34.48	34.32	34.14	33.93	33.60
SE±	0.07	0.08	0.05	0.06	0.06	0.05	0.05	0.06	0.06	0.07
CD at 5%	(NS)	(NS)	0.16	0.17	0.16	0.16	0.15	0.17	0.18	0.19

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The test weight due to seed treatments with botanicals and chemicals differed significantly in all the months of storage period except at initial and 60 days of storage. Initially, higher test weight (34.80) was recorded in seeds treated with deltamethrin (T_9) followed by neem oil (T_2), karanj oil (T_3) and lower test weight (34.68) was recorded in control (T_0) and citronella oil (T_7) treated seeds. At the end of 300 days of storage period, highest test weight (33.60) was recorded in deltamethrin (T_9) treated

seeds followed by neem oil (T_2) while lowest test weight (31.90) was recorded in untreated control (T_0).

Among the seed treatments, seeds treated with deltamethrin maintained significantly higher test weight during all the period of storage except at initial and 60 days of storage and it was on par with neem oil @ 5 ml/kg of seed and castor oil @ 5 ml/kg of seed.

4.12 Seed Mycoflora (%)

4.12.1 Effect of seed treatment on seed mycoflora(%) in French bean.

The results on seed mycoflora as influenced by seed treatments during storage period are presented in Table 12. It was noticed that seed mycoflora increased with the advancement of storage period irrespective of seed treatment.

Table 12. Effect of seed treatment on seed mycoflora (%) in French bean

Treatments	Storage Period (days)									
	Initial	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**
T_0	8.33 (16.77)	9.00 (17.44)	14.00 (21.94)	17.67 (24.84)	25.33 (30.21)	27.67 (31.72)	32.67 (34.85)	37.00 (37.46)	42.67 (40.78)	48.00 (43.85)
T_1	9.00 (16.41)	9.33 (17.78)	12.33 (20.51)	13.67 (21.68)	17.67 (24.85)	22.33 (28.20)	28.33 (32.16)	31.67 (34.24)	33.67 (35.46)	37.00 (37.46)
T_2	8.67 (17.12)	8.67 (17.12)	10.00 (18.38)	12.67 (20.85)	14.00 (21.96)	18.00 (25.08)	22.33 (28.19)	25.67 (30.44)	28.00 (31.95)	32.00 (34.43)
T_3	10.00 (18.38)	10.00 (18.38)	12.00 (20.27)	14.33 (22.21)	16.67 (24.09)	21.00 (27.26)	27.33 (31.52)	30.33 (33.41)	32.67 (34.86)	36.33 (37.07)
T_4	9.67 (18.11)	10.33 (18.75)	11.33 (19.97)	14.33 (22.21)	17.00 (24.33)	21.33 (27.51)	27.67 (31.72)	32.00 (34.44)	34.00 (35.66)	38.33 (38.25)
T_5	10.67 (19.06)	10.67 (18.99)	12.00 (20.27)	16.33 (23.84)	20.00 (26.56)	23.00 (28.63)	30.00 (33.21)	34.33 (35.86)	38.00 (38.30)	41.67 (40.20)
T_6	9.00 (17.39)	10.33 (18.63)	10.67 (19.06)	13.67 (21.68)	16.33 (23.31)	22.00 (27.97)	28.67 (32.37)	31.33 (34.04)	33.67 (35.47)	39.00 (38.65)
T_7	8.67 (17.12)	9.33 (17.69)	11.33 (19.66)	13.00 (21.12)	16.00 (23.57)	22.33 (28.19)	26.67 (31.08)	30.00 (33.19)	32.33 (34.65)	36.33 (37.07)
T_8	9.67 (18.11)	9.67 (18.05)	11.67 (19.95)	15.00 (22.78)	17.67 (24.84)	22.67 (28.41)	26.67 (31.08)	30.33 (33.42)	30.67 (33.63)	35.00 (36.26)
T_9	8.67 (17.12)	9.33 (17.69)	9.67 (18.11)	12.00 (20.27)	13.00 (21.13)	16.67 (24.09)	21.67 (27.74)	23.00 (28.63)	25.00 (30.00)	29.67 (33.00)
SE±	0.6	1.07	0.67	0.64	0.51	0.72	0.61	0.71	0.50	0.75
CD at 5%	(NS) 1.80	(NS) 3.17	1.99	1.89	1.52	2.13	1.80	2.09	1.48	2.22

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The seed mycoflora due to seed treatments with botanicals and chemicals differed significantly in all the months of storage period except at initial and 60 days of storage. Initially, higher seed mycoflora (10.67) was recorded in seeds treated withvekhand powder (T_5) followed by karanj oil (T_3) and lower seed mycoflora (8.33) was recorded in control (T_0). At the end of 300 days of storage period, lower seed mycoflora (29.67) was recorded in deltamethrin (T_9) treated seeds followed by neem oil (T_2) while highest seed mycoflora (48.00) was recorded in untreated control (T_0).

Seed treatment with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5ml showed lowest seed mycoflora throughout the period of storage. During study, the different mycoflora observed were *fusarium oxysporum, Aspergillus niger, Aspergillus flavus*. Among the mycoflora observed during the storage of French bean seed *Aspergillus spp.* occupied the major percentage.

4.13 Bioefficacy Test

The bio efficacy test was undertaken to find out the effect of chemical and different botanicals against pulse beetle in French bean seed. The experiment was conducted in the Entomology laboratory at STRU, MPKV, Rahuri.

The seeds of French bean was treated with deltamethrin @ 0.04 ml/kg of seed and various botanicals viz. neem leaf powder @ 5 g/kg of seed, neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed, vekhand powder @ 10 g/kg of seed, turmeric powder @ 5 g/kg of seed, citronella oil @ 5 ml/kg of seed, ash @ 5 g/kg of seed. From treated seed 100 gram seed was taken out from each replication and kept in 200 ml capacity plastic jar and 10 pairs of pulse beetle was released in each set and the observations was recorded on pulse beetle infestation, per cent seed weight loss, number of eggs laid, adult emergence, per cent mortality. The data generated on the foresaid aspects was statistically analyzed and presented below.

4.13.1 Pulse beetle infestation (%)

4.13.1.1 Effect of seed treatment on pulse beetle infestation (%) in French bean

The result in Table 13 indicated significant difference in respect of per cent pulse beetle infestation during storage period. Per cent seed infestation was recorded on 3rd, 6th and 9th month after storage period.

Table 13. Effect of seed treatment on pulse beetle infestation (%) in French bean

Treatments	Storage period (months)		
	3	**6**	**9**
T_0	3.67 (11.02)	10.00 (18.42)	24.67 (29.75)
T_1	0.00 (4.83)	1.67 (7.33)	8.67 (17.12)
T_2	0.00 (4.83)	0.67 (5.44)	4.00 (11.48)
T_3	0.00 (4.83)	1.33 (6.54)	7.67 (16.07)
T_4	0.00 (4.83)	1.33 (6.54)	8.00 (16.41)
T_5	1.33 (6.54)	5.67 (13.73)	16.33 (23.82)
T_6	4.00 (11.54)	5.00 (12.88)	15.33 (23.05)
T_7	2.67 (9.36)	4.00 (11.54)	11.33 (19.67)
T_8	3.67 (11.02)	6.67 (14.95)	15.33 (23.05)
T_9	0.00 (4.83)	0.00 (4.83)	0.67 (5.44)
SE±	0.39	0.60	0.59
CD at 5%	1.16	1.79	1.74

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

All the treatments was significantly superior over untreated control in checking per cent seed infestation. During storage period trend of pulse beetle infestation was increasing with storage period.

At three month of storage period lowest pulse beetle infestation (0.00 %) was recorded in the seed treated with deltamethrin @ 0.04 ml/kg of seed, neem leaf powder @ 5 g/kg of seed, neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed and highest pulse beetle infestation was recorded in the control (3.67 %).

At 6 months of storage lowest pulse beetle infestation (0.00 %) was recorded in the seed treated with deltamethrin @ 0.04 ml/kg of seed, which was found

statistically at par with neem oil @ 5 ml/kg of seed (0.66 %), while highest pulse beetle infestation was recorded in the control (10.00 %).

At the end of 9 month of storage period lowest pulse beetle infestation (0.67 %) was recorded in the seed treated with deltamethrin @ 0.04 ml/kg of seed, which was found statistically at par with neem oil @ 5 ml/kg of seed (4.00 %) and highest pulse beetle infestation was recorded in the control (24.67 %).

The present investigation recorded that absolute protection of seeds was found in seed treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed while control seed has high infestation of pulse beetle about 24.67 per cent at the end of storage period. Similar findings was observed by Rathod *et al.* (2018) in pigeon pea, Rashmi *et al.* (2014) in pigeon pea, Singh *et al.* (2017) in chickpea, Kumar *et al.* (2018) in black gram.

4.13.2 Seed weight loss (%)

4.13.1.2 Effect of seed treatment on seed weight loss in French bean

The data presented in Table 14 indicated the significant difference in all the storage period after treatment in respect of the per cent weight loss in French bean seeds treated with deltamethrin and various botanicals.

All the treatment was significantly superior over untreated control in minimizing per cent weight loss due to pulse beetle damage. At three month of storage period the per cent weight loss was absolutely prevented in the seed treated with deltamethrin @ 0.04 ml/kg of seed (1.67 %), neem leaf powder @ 5 g/kg of seed, neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed. Significantly maximum (3.56 %) seed weight loss was recorded in untreated control.

At sixth month of storage period the per cent weight loss was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (0.00 %), which was found statistically at par with neem oil @ 5 ml/kg of seed (0.34 %), castor oil @ 5 ml/kg of seed (0.81 %), karanj oil @ 5 ml/kg of seed (0.88 %). Significantly maximum (8.55 %) seed weight loss was recorded in untreated control.

At the end of storage period (9 month) the per cent weight loss was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (0.33 %), which was found statistically at par with neem oil @ 5 ml/kg of seed (1.85 %), neem leaf

powder @ 5 g/kg of seed (2.87 %), castor oil @ 5 ml/kg of seed (5.25 %), karanj oil @ 5 ml/kg of seed (5.62 %). Significantly maximum (14.50 %) seed weight loss was recorded in untreated control.

Table 14. Effect of seed treatment on seed weight loss in French bean

Treatments	Storage period (months)		
	3	**6**	**9**
T_0	3.56 (10.87)	8.55 (17.00)	14.50 (22.38)
T_1	0.00 (4.83)	0.92 (5.49)	2.87 (9.75)
T_2	0.00 (4.83)	0.34 (3.35)	1.85 (7.82)
T_3	0.00 (4.83)	0.81 (5.15)	5.25 (13.25)
T_4	0.00 (4.83)	0.88 (5.39)	5.62 (13.71)
T_5	0.83 (5.23)	3.10 (10.14)	8.43 (16.88)
T_6	2.31 (8.74)	4.01 (11.55)	10.34 (18.76)
T_7	1.79 (7.68)	3.36 (10.56)	8.16 (16.60)
T_8	1.27 (6.48)	5.22 (13.21)	10.18 (18.61)
T_9	0.00 (4.83)	0.00 (4.83)	0.33 (3.30)
SE±	0.08	0.10	0.08
CD at 5%	0.25	0.31	0.26

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The present investigation recorded that seed weight loss prevention was found in seed treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, neem leaf powder @ 5 g/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed, while control seed has high per cent seed weight loss about 14.50 per cent at the end of storage period. A similar finding was observed by Singh *et al.* (2017) in chickpea, Kumar *et al.* (2018) in black gram.

4.13.3 Number of eggs /100 seeds

4.12.3.1 Effect of seed treatment on number of eggs /100 seeds in French bean

The data presented in Table 15 indicated the significant difference in all the treatment throughout the storage period in respect of number of eggs laid/100 seeds in French bean seeds treated with deltamethrin and various botanicals.

Table 15. Effect of seed treatment on number of eggs /100 seeds in French bean

Treatments	Storage period (months)		
	3	6	9
T_0	17.67	34.33	53.33
T_1	0.00	7.33	13.67
T_2	0.00	2.33	8.67
T_3	0.33	17.33	30.67
T_4	0.67	17.00	26.00
T_5	3.67	21.33	38.00
T_6	12.00	18.33	34.33
T_7	6.67	14.33	31.00
T_8	7.33	18.67	34.33
T_9	0.00	0.00	2.67
SE±	0.31	0.47	0.71
CD at 5%	0.93	1.39	2.10

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

All the treatments was found significally superior over control and proved effective in bringing about significally lower egg laying of pulse beetle as compared to untreated control. After three months of storage minimum number of eggs (0.00 %) was laid by the beetles in seed treated with deltamethrin @0.04 ml/kg of seed, neem oil @ 5 ml/kg of seed, neem leaf powder @ 5 g/kg of seed. Significantly maximum (17.67) egg laying was recorded in untreated control.

At sixth month of storage period the effect of treatment on number of egg laid was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (0.00), which was found statistically at par with neem oil @ 5 ml/kg of seed (2.33), neem

leaf powder @ 5 g/kg of seed (7.33), karanj oil @ 5 ml/kg of seed (17.00), castor oil @ 5 ml/kg of seed (17.33). Significantly maximum (34.33) egg laid was recorded in untreated control.

At the end of storage period (9 month) the effect of treatment on number of eggs laid was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (2.67), which was found statistically at par with neem oil @ 5 ml/kg of seed (8.67), neem leaf powder @ 5 g/kg of seed (13.67), karanj oil @ 5 ml/kg of seed (26), castor oil @ 5 ml/kg of seed (30.67). Significantly maximum (53.33) number of egg laying was recorded in untreated control.

The present investigation recorded that prevention of egg laying was found in seed treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, neem leaf powder @ 5 g/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed, while control seed has highest egg laying about 55.33 at the end of storage period. Similar findings were observed by Kumar *et al.* (2018) in black gram, Mandali and Reddy (2014) in red gram.

4.13.4 Number of adult emergence

4.13.4.1 Effect of seed treatment onnumber of adult emergence in French bean

The data presented in Table 16 indicates significant difference in all the treatment throughout the storage period in respect of number of adult emergence in French bean seeds treated with deltamethrin and various botanicals.

All the treatments was found significally superior over control and proved effective in bringing about significally lower adult emergence of pulse beetle as compared to untreated control. After three months of storage no any adult emergence was recorded in seed treated with deltamethrin @ 0.04 ml/kg of seed (0.00), neem leaf powder @ 5 g/kg of seed (0.00), neem oil @ 5 ml/kg of seed (0.00), castor oil @ 5 ml/kg of seed (0.00), karanj oil @ 5 ml/kg of seed (0.00). Significantly maximum (7.00) adult emergence was recorded in untreated control.

At sixth month of storage period the effect of treatment on number of adult emergence was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (0.00), which was found statistically at par with neem oil @ 5 ml/kg of seed

(1.00), castor oil @ 5 ml/kg of seed (3.67), karanj oil @ 5 ml/kg of seed (4.33). Significantly maximum (18.33) adult emergence was recorded in untreated control.

Table 16. Effect of seed treatment on number of adult emergence in French bean

Treatments	Storage period (months)		
	3	**6**	**9**
T_0	7.00	18.33	36.33
T_1	0.00	5.00	8.00
T_2	0.00	1.00	3.67
T_3	0.00	3.67	7.33
T_4	0.33	4.33	9.00
T_5	2.33	7.67	13.33
T_6	3.00	8.33	13.33
T_7	1.67	5.67	10.67
T_8	2.67	9.33	12.67
T_9	0.00	0.00	1.00
SE±	0.27	0.38	0.52
CD at 5%	0.82	1.12	1.55

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

At the end of storage period (9 month) the effect of treatment on number of adult emergence was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (1.00), which was found statistically at par with neem oil @ 5 ml/kg of seed (3.67), castor oil @ 5 ml/kg of seed (7.33), karanj oil @ 5 ml/kg of seed (9.00). Significantly maximum (36.33) adult emergence was recorded in untreated control.

The present investigation recorded that prevention of adult emergence was found in seed treated with deltamethrin @0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, karanj oil @ 5 ml/kg of seed while control seed has high adult emergence about 36.33 at the end of storage period. Similar findings was observed by Rashmi *et al.* (2014) in pigeon pea, Kumar *et al.* (2018) in black gram, Mandali and Reddy (2014) in red gram.

4.13.5 Mortality (%)

The test insects was released in 3rd month, 6th month and 9th month in 100g stored French bean seeds, which was treated initially with deltamethrin as standard chemical and various botanicals. Per cent mortality was recorded on 3rd, 7th and 10th day of beetle release in each replication of treatment for every three month. The data on per cent mortality was presented in Table 17 and discussed as follows.

4.13.5.1 Effect of seed treatment on mortality (%) in French bean

Result presented in Table 17 revealed that all the treatments was found statistically superior over untreated control. After three months of storage maximum mortality i.e 100 per cent was recorded in deltamethrin treated seed followed by neem oil @ 5 ml/kg of seed while untreated control had 0.00 per cent mortality.

Table 17. Effect of seed treatment on mortality (%) in French bean

Treatments	Storage Period (days)											
	3				6				9			
	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean
T_0	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)	0.00 (4.83)
T_1	91.64 (73.19)	94.33 (76.24)	100.00 (90)	95.32 (79.81)	73.67 (59.14)	77.00 (61.35)	81.33 (64.41)	77.33 (61.63)	48.00 (43.85)	54.33 (47.49)	56.00 (48.45)	52.78 (46.60)
T_2	96.32 (78.19)	98.33 (82.67)	100.00 (90)	98.22 (83.87)	81.67 (64.66)	85.00 (67.22)	89.00 (70.41)	85.22 (67.51)	53.67 (47.11)	57.67 (49.41)	61.33 (51.56)	57.56 (49.36)
T_3	93.33 (75.05)	95.67 (78.00)	100.00 (90)	96.33 (81.02)	76.33 (60.90)	79.33 (62.97)	84.33 (66.70)	80.00 (63.52)	48.67 (44.24)	54.67 (47.68)	56.33 (48.64)	53.22 (46.85)
T_4	92.00 73.57()	95.33 (77.54)	100.00 (90)	95.78 (80.37)	73.33 (58.91)	76.33 (60.90)	83.33 (65.91)	77.67 (61.91)	46.00 (42.71)	54.33 (47.49)	56.00 (48.45)	52.11 (46.21)
T_5	72.64 (58.46)	80.00 (63.43)	83.00 (65.69)	78.55 (62.53)	63.67 (52.93)	69.67 (56.59)	74.00 (59.35)	69.11 (56.29)	33.67 (35.46)	41.00 (39.81)	42.67 (40.78)	39.11 (38.69)
T_6	63.33 (52.74)	71.33 (57.63)	81.33 (64.41)	72.00 (58.26)	54.33 (47.49)	58.33 (49.80)	62.00 (51.95)	58.22 (49.74)	41.67 (40.20)	44.33 (41.74)	45.67 (42.51)	43.89 (41.49)
T_7	64.67 (53.53)	76.33 (60.90)	84.67 (67.06)	75.22 (60.50)	52.33 (46.34)	57.67 (49.41)	60.67 (51.16)	56.89 (48.97)	43.00 (40.97)	44.67 (41.94)	47.67 (43.66)	45.11 (42.19)
T_8	61.33 (51.55)	69.67 (56.59)	76.33 (60.90)	69.11 (56.35)	50.00 (45.00)	56.33 (48.64)	59.67 (50.58)	55.33 (48.07)	31.33 (34.04)	35.33 (36.46)	41.33 (40.01)	36.00 (36.84)
T_9	100.00 (90)	100.00 (90)	100.00 (90)	100.00 (90.00)	92.00 (73.65)	94.33 (76.24)	95.67 (78.00)	94.00 (75.96)	68.67 (55.96)	76.33 (60.90)	79.33 (62.97)	74.78 (59.94)
SE±	0.36	0.48	0.73		0.66	0.56	0.57		0.56	0.62	0.46	
CD at 5%	1.07	1.42	2.17		1.96	1.66	1.70		1.65	1.83	1.36	

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

At six months of storage maximum per cent mortality was recorded in seed treated with deltamethrin @ 0.04 ml/kg of seed (94.00 %), which is statistically at par with neem oil @ 5 ml/kg of seed (85.22 %), castor oil @ 5 ml/kg of seed (80.00 %), karanj oil @ 5 ml/kg of seed (77.67 %), while untreated control has 0.00 per cent mortality.

At nine months of storage maximum per cent mortality was recorded in seed treated with deltamethrin @ 0.04 ml/kg of seed (74.48 %) which is statistically at par with neem oil @ 5 ml/kg of seed (57.56 %), castor oil @ 5 ml/kg of seed (53.22 %), while untreated control had 0.00 per cent mortality.

In the present investigation it was found that per cent mortality was decreasing with storage period as its efficacy decreases. At 3 months of the order of per cent mortality was recorded higher i.e. about cent per cent mortality was recorded in deltamethrin @ 0.04 ml/kg of seed treatment followed by neem oil @ 5 ml/kg of seed while untreated control had 0.00 per cent mortality. At end of storage period, higher mortality was recorded in deltamethrin @ 0.04 ml/kg of seed which is statistically at par with neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed while untreated control was only 0.00 per cent mortality.

From results it is revealed that seeds of treatment maintained up to end of the storage period with slightly reduction. Similar findings was observed by Kumar *et al.* (2018) in black gram, Mandali and Reddy (2014) in red gram.

4.13.6 Dead insect

4.13.6 Effect of seed treatment on number of dead insect in French bean

The test insects was released in 3rd month, 6th month and 9th month in 100g stored French bean seeds, which was treated initially with deltamethrin as standard chemical and various botanicals. The no. of dead insect was recorded on 3rd, 7th and 10th day of beetle release in each replication of treatment for every three month. The data on number of dead insect was presented in Table 18 and discussed as follows.

The data presented in Table 18 indicates significance difference in all the treatment throughout the storage period in respect of number of dead insect observed in French bean seeds treated with deltamethrin and various botanicals.

All the treatments was found significantly superior over control and proved effective in bringing about higher mortality of the pulse beetle as compared to untreated control.

After three months of storage highest dead insect was recorded in the seed treated with deltamethrin @ 0.04 ml/kg of seed (20.00), followed by neem oil @ 5 ml/kg of seed (19.67), castor oil @ 5 ml/kg of seed (19.33), significantly lowest i.e. 0.00 dead insect was recorded in untreated control.

At sixth month of storage period the effect of treatment of number dead insect was significantly superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (18.78), which was found statistically at par with neem oil @ 5 ml/kg of seed (17.00), castor oil @ 5 ml/kg of seed (16.11) significantly lowest number of dead insect (0.00) was recorded in untreated control.

Table 18. Effect of seed treatment on number of dead insect in French bean

Treatments	Storage Period (days)											
	3				6				9			
	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean
T_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	18.33	19.00	20.00	19.11	14.67	15.33	16.33	15.44	9.67	11.00	11.33	10.67
T_2	19.33	19.67	20.00	19.67	16.33	17.00	17.67	17.00	10.67	11.67	12.33	11.56
T_3	18.67	19.33	20.00	19.33	15.33	16.00	17.00	16.11	9.67	11.00	11.33	10.67
T_4	18.33	19.00	20.00	19.11	14.67	15.33	16.67	15.56	9.33	11.00	11.33	10.55
T_5	14.67	16.00	16.67	15.78	12.67	14.00	14.67	13.78	6.67	8.33	8.67	7.89
T_6	12.67	14.33	16.33	14.44	11.00	11.67	12.33	11.67	8.33	9.00	9.00	8.78
T_7	13.00	15.00	17.00	15.00	10.33	11.67	12.00	11.33	8.67	9.00	9.67	9.11
T_8	12.33	13.67	15.33	13.78	10.00	11.33	12.00	11.11	6.33	7.00	8.33	7.22
T_9	20.00	20.00	20.00	20.00	18.33	19.00	19.00	18.78	13.67	15.33	16.00	15.00
SE±	0.27	0.27	0.25		0.27	0.23	0.29		0.31	0.31	0.27	
CD at 5%	0.82	0.82	0.76		0.82	0.69	0.87		0.93	0.93	0.82	

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

At the end of storage period (9 month) the effect of treatment on number of dead insect was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (15.00), which was found statistically at par with neem oil @ 5 ml/kg of seed

(11.56), neem leaf powder @ 5 g/kg of seed (10.67). Significantly lowest number of dead insect (0.00) was recorded in untreated control.

The present investigation recorded that highest number of dead insect was found in seed treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, while control seed has found no any dead insect upto end of the storage period. So from result it indicates that higher the number of dead insect, higher the efficacy of chemical and botanicals.

4.13.7 Live insect

4.13.7.1 Effect of seed treatment on number of live insect in French bean

The test insects was released in 3rd month, 6th month and 9th month in 100g stored French bean seeds, which was treated initially with deltamethrin as standard chemical and various botanicals. The no. of live insect was recorded on 3rd, 7th and 10th day of beetle release in each replication of treatment for every three month. The data on number of live insect was presented in Table 19 and discussed as follows.

Table 19. Effect of seed treatment on number of live insect in French bean

Treatments	Storage Period (days)											
	3				6				9			
	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean	3 DAR	7 DAR	10 DAR	Mean
T_0	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
T_1	1.67	1.00	0.00	0.89	5.33	3.67	4.67	4.56	10.33	9.00	8.67	9.33
T_2	0.67	0.33	0.00	0.33	3.67	2.33	3.00	3.00	9.33	8.33	7.67	8.44
T_3	1.33	0.67	0.00	0.67	4.67	3.00	4.00	3.89	10.33	9.00	8.67	9.33
T_4	1.67	1.00	0.00	0.89	5.33	3.33	4.67	4.44	10.67	9.00	8.67	9.45
T_5	5.33	4.00	3.33	4.22	7.33	5.33	6.00	6.22	13.33	11.67	11.33	12.11
T_6	7.33	5.67	3.67	5.56	9.00	7.67	8.33	8.33	11.67	11.00	11.00	11.22
T_7	7.00	5.00	3.00	5.00	9.67	8.00	8.33	8.67	11.33	11.00	10.33	10.89
T_8	7.67	6.33	4.67	6.22	10.00	8.00	8.67	8.89	13.67	13.00	11.67	12.78
T_9	0.00	0.00	0.00	0.00	1.67	1.00	1.00	1.22	6.33	4.67	4.00	5.00
SE±	0.27	0.28	0.25		0.27	0.29	0.23		0.31	0.32	0.27	
CD at 5%	0.82	0.83	0.76		0.82	0.87	0.69		0.93	0.93	0.82	

T_0 : Control T_1 : Neem leaf powder T_2 : Neem oil T_3 : Castor oil
T_4 : Karanj oil T_5 : Vekhand powder T_6 : Turmeric powder T_7 : Citronella oil
T_8 : Ash T_9 : Deltamethrin

The data presented in Table 19 indicates significance difference in all the treatment throughut the storage period in respect of number of live insect present in French bean seeds treated with deltamethrin and various botanicals.

All the treatments was found significantly superior over control and proved effective in bringing about higher mortality i.e. lower number of live insect as compared to untreated control.

After three months of storage lowest live insect was recorded in the seed with deltamethrin @ 0.04 ml/kg of seed (0.00) followed by neem oil @ 5 ml/kg of seed (2.33), castor oil @ 5 ml/kg of seed (3.00). Significantly highest live insect (20.00) was recorded in untreated control.

At sixth month of storage period the effect of treatment on number of live insect was significantly superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (1.22) which was found statistically at par with neem oil @ 5 ml/kg of seed (3.00), castor oil @ 5 ml/kg of seed (3.89). However, significant highest number of live insect (20.00) was recorded in untreated control.

At the end of storage period (9 month) the effect of treatment on number of live insect was significant superior in seed treated with deltamethrin @ 0.04 ml/kg of seed (5.00), which was found statistically at par with neem oil @ 5 ml/kg of seed (8.44), castor oil @ 5 ml/kg of seed (9.33), neem leaf powder @ 5 g/kg of seed (9.33). Significantly higher number of live insect (20.00) was recorded in untreated control.

The present investigation recorded that lowest number of live insect was found in seed treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed, castor oil @ 5 ml/kg of seed, while control seed has recorded highest number of live insect upto end of the storage period.

So, from results it indicates that the lower the number of live insect, higher the efficacy of chemicals and botanicals.

5. SUMMARY AND CONCLUSION

The present research entitled “Effect of organic and inorganic seed treatment on seed health and quality of French bean (*Phaseolus vulgaris* L.)” was conducted during May 2019 to February 2020 at Seed Technology Research Unit, M.P.K.V., Rahuri.

The laboratory experiment consisted of ten treatments viz., control (T_0), neem leaf powder (T_1) @ 5 g/kg of seed, neem oil (T_2) @ 5 ml/kg of seed, castor oil (T_3) @ 5 ml/kg of seed, karanj oil (T_4) @ 5 ml/kg of seed, vekhand powder (T_5) @ 10gm/kg of seed, termuric powder (T_6) @ 5 g/kg of seed, citronella (T_7) @ 5 ml/kg of seed, ash (T_8) @ 5 g/kg of seed and deltamethrin (T_9) @ 0.04 ml/kg of seed. The experiment was laid out in Completely Randomized Design (CRD) in three replications and their results are summarized here under.

5.1 Summary

The results obtained in the present investigation are summarized as below.

The French bean seed quality parameters *viz*., moisture content (%), germination (%), first count, speed of germination, root length (cm), shoot length (cm), seedling dry weight (mg), vigour index I and II, electrical conductivity (dSm^{-1}), test weight (g) and seed mycoflora (%) differed significantly due to seed treatments. The Germination percentage, first count, speed of germination, root shoot length, seedling dry weight, vigour index I and II was found to be decreased with advancement of storage period irrespective of seed treatments. The moisture content and test weight increased up to 60 days of storage and then decreased with advancement of storage period irrespective of seed treatments. The electrical conductivity and seed mycoflora was increasing with advancement of storage period.

In French bean the seed health parameters viz., pulse beetle infestation, seed weight loss, egg laying, adult emergence, per cent mortality, dead insects and live insects differed significantly due to seed treatments. The pulse beetle infestation, seed weight loss, egg laying, adult emergence and mean live insects was found to be increased, while per cent mortality was decreased with advancement of storage period.

Among the treatments, seeds treated with deltamethrin @ 0.04 ml/kg of seed followed by neem oil @ 5 ml/kg of seed recorded higher germination percentage, first count, speed of germination, root shoot length, seedling dry weight, vigour index I and II, test weight, lower moisture content, electrical conductivity, seed mycoflora and higher mortality percentage, lower per cent seed weight loss, lower egg laying, low adult emergence, lower pulse beetle infestation as compared to other treatments and control.

5.2 Conclusions

1. The seeds treated with deltamethrin (T_9) followed by neem oil (T_2) maintained better quality throughout storage period (300 days). It maintained germination percentage (76.67 %) above MSCS up to 300 days of storage.
2. Among botanicals, neem oil (T_2) @ 5 ml kg^{-1} seed maintained better quality during storage period (300 days) as compared to other botanicals. It maintained germination percentage (75.33 %) above MSCS up to 300 days of storage period.
3. Among all treatments, deltamethrin (T_9) @0.04 ml/kg of seed found to be superior over rest of treatments, which recorded highest per cent mortality, lower pulse beetle infestation, lowest egg laying, adult emergences, highest dead insects and lowest live insects when seed treated with chemicals.
4. Among all the botanicals treatments, neem oil (T_2) @ 5ml kg^{-1} of seed found to be superior over rest of treatments which recorded highest per cent mortality, lower pulse beetle infestation, egg laying, adult emergences, higher dead insects and lower live insects.

The above conclusions are based on one season experimentation and therefore, needs further detailed investigations to confirm benefits due to botanicals and chemical in French bean for maintaining seed health and quality of French bean.

6. LITERATURE CITED

Abdul Aleem, M.D., 1988, Efficacy of botanical product against pulse beetle *Callosobruchus chinensis* (L.). M.Sc. (Agri.) Thesis, Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad.

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean by multiple criteria. *Crop Scince,* **13** : 630–633.

Adams, M.W., 1985. Common Bean : In Grain Legume Crops. *William Collins and Sons and Company, London*. pp. 433-476.

Adhe, F.R., Rathod, P.K., Rathod, L., Bhalkare, S.K., Murumkar, R.P., Borkar, P.A. and Mate, V.N., 2018, Effects of botanicals on mortality of pulse beetle, *callosobruchus spp*. in stored pigeon pea. *Int. Jr Current Microbiology and Applied Sciences,* **6** : 2554-2560.

Ahmed, K.S., Itino, T. and Ichikawa, T. 2003. Duration of developmental stages of *Callosobruchus Chinensis* (*Coleoptera: Bruchidae*) on Azuki Bean and the effects of neem and sesame oils at different stages of their development. *Pakistan Journal of Biological Sciences,* **6**(10) : 932-335.

Akou-Edi, D. 1984. Effect of neem seed powder and oil on *Tribolium confusum* and *Sitophilus zeamais*. Natural Pesticides from Neem Tree (*Azadirachta indica*) and Other Tropical Plants. *Proc. 2nd Int. Neem Conf. pp*. 445-452.

Ali, M.A., Rahman, M.H. and Ahmed, K.S. 2006. Bio-efficacy of ash and turmeric powder mixture as seed protectants against pulse beetle, *Callosobruchus chinensis* L. on stored gram seeds. *Bangladesh Journal of Seed Science and Technology,* **10**(1 &2) : 7-10.

Ali, S. I., Singh, O. P. and Misiza, U. A., 1983, Effectiveness of plant oils against pulse beetle *Callosobruchus chinensis* L. *Indian Journal of Entomlogy*, **45** : 6-8.

Anantharedy Roopa, M. 2004. Influence of seed treatment, containers and locations on storability of French bean (*Phaseolus vulgaris* L.), Thesis, University of Agricultural Sciences GKVK, Bangalore.

Anonymous, 1996. International Rules for Seed Testing. *Seed Science and Technology.* 27 : 13 -35.

Anonymous, 1999. International Rules for Seed Testing. *Seed Science and Technology*., **27** : 1-333.

Anonymous, 2013. Food and Agriculture Organization of the United Nations FAOSTAT database.

Arati Patil, 2000, Influence of containers and seed treatments on storability of chickpea. M.Sc. (Agri) Thesis, submitted to UAS, Dharwad.

Araya, G. and Emana, G. 2009. Evaluation of botanical plants powders against *Zabrotes sub fasciatus* (Boheman) (*Coleoptera: Bruchidae*) in stored haricot beans under laboratory condition. *African Jr. of Agri. Res.* **4**(10) : 1073-1079.

Babu, T.R., Hussaini, S.H. and Satyanarayana, B. 1989, Effect of pre storage seed treatments on adult mortality, oviposition and development of *Callosobruchus chinensis* L. and the viability of mungbean (*Vigna radiata* (L.) in India. *Tropical Pest Management*, **35** : 397-398.

Bajpai, V.P., Khan, A.A., Vyas, R.P., Tiwari, I.P. and Tripathi, R.A. 2000, Effect of bioinsecticides on viability of urdbean seed (*Vigna mungo*) stored in different containers. *Seed Res*. **30**(2) : 331-332.

Bhardwaj, A. and Verma, S.C. 2012. Evaluation of vegetable oils against pulse beetle, *Callosobruchus chinensis* L. infesting pea seeds. *Pest Management in Horticultural Ecosystems,* **18** : 46-53.

Bhardwaj, A. and Verma, S.C. 2013. Effect of vegetable oils on pulse beetle, C*allosobruchus chinensis* (*Coleoptera*: *Bruchidae*) infestation and germination of pea seeds (*Pisum sativum*). *Pest Management in Horticultural Ecosystems*, **19** : 116-118.

Bhargava, M.C. and Meena, B.L. 2002. Efficacy of some vegetable oils against pulse beetle, *Callosobruchus chinensis* (L.) on cowpea, *Vigna unguiculata* (L.). *Indian Journal of Plant Protection*, **30** : 46-50.

Chandrakala, A., Prabha, A.R., Chitra, D., Muralidharan, S. and Saravanababu, S. 2013. Toxic effect of neem leaf powder against *callosobruchus chinensis* infestation (*Bruchidae* : *Coleoptera*) on the green gram (*Vigna radiata*) seeds. *International Journal of Pure and Applied Zoology,* **1**(1) : 86-91.

Chiranjeevi, C.H. 1991. Efficacy of some indigenous plant materials and ashes on the percentage of damaged grain, percentage of protection and viability of green gram seed infested by pulse beetle. *Bulletin of Grain Technology*, **29** : 84-88.

Choudhary, B.S. and Pathak, S. C. 1989. Efficacy of organics material for the control of (*Callosobruchus chinensis)*. *Indian Journal of Plant Protection.,* **17** : 47-52.

Choudhary, S., Bharpoda, T.M. and Deb, S. 2014 Seed protectants against *Callosobruchus chinensis* (L.) on soybeanunder storage condition. *Pesticide Research Journal.* **26**(1) : 56-62.

Das, G.P. and Karim, M.A. 1986. Effectiveness of neem seed kernel oil as surface protectant against the pulse beetle *Callosobruchus chinensis* L. Wapl. (*Bruchidae* : *Coleoptera*), *Tropical Grain Legume Bulletin*. **33** : 30-33

Deshpande, V.K., Deshpande, H.H. and Topagi, S.C. 2010. Effect of plant products and insecticides on *(Callosobruchus chinensis)* infestation, seed viability and vigour of soybean during storage*, Int. Jr. of Agri. Sci.,* **6**(2) : 630-633.

Deshpande, V.K., Sibi, V.G. and Vyakarnahal, B.S. 2004. Effect of botanical seed treatment against (*Callosobruchus chinensis)* in viability and vigour of black gram seed during storage. *Seed Res.*, **32**(2) : 193-196.

Devi, W.S., and Kalita, J. 2011. Efficacy of plant materials against *Callosobruchus chinensis* in green gram. *Indian J. Entom*, **73**(1) : 56-58.

Duke, J.A. 1981. Handbook of Legumes of World Economic Importance Pleanum Press, New York. pp. 195-200.

Floris, C. 1970. Aeging in Triticum durum seeds: Behaviour of embryos and endosperm from aged seeds as revealed by the embryo transplantation technique. Bot. **21** : 461-468.

Gidaganti, S. S. 1990. Effect of pre harvest spray of insecticides and post harvest seed treatments on seed quality cowpea (*Vigna radiata* L.) during storage. M.Sc. (Agri.) Thesis, UAS, Dharwad.

Gowda, B., Huded, B., Hosmani, A., Mathad, R.C., Raghu, B.N. and Rekha, K. 2018, Effect of organics in enhancing seed storability of chickpea. *International Jounal of Chemical Studies,* **6**(2) : 1890-1893.0

Gupta, J., Abhinav Dayal, Chaurasia, A.K., Vishal Kumar and Nawaz Ali. 2018. Effect of different packaging materials and pre-storage treatments on storability of chickpea (*Cicer arietinum* L.) seeds. *International Jr of Current Microbiology and Applied Sciences.* **7**(8) : 1983-1990.

Gupta, H.C., Bareth, S.S. and Sharma, S.K. 1991. Bioefficacy of edible and non-edible oils against pulse beetle (*Callosobruchus chinensis* L.) on stored pulse and their effect on germination. *Agricultural Biological Research*, **7** : 101-107.

Gupta, M. 2010. Studies on influence of packing materials and seed treatments on storability of soybean (*Glycine max* (L) Merrill). M.Sc. (Agri) thesis submitted to University of Agricultural Science, Bangalore.

Hampanna, Y.L., Naganagoud, A. and Patil, B.V. 2006. Evaluation of animal origin inert materials against rice weevil and pulse beetle in stored sorghum and chickpea. *J. of Farm Sciences.* **19** : 54- 57.

Hampton, J.G., Tekrony, D.M. 1995. Handbook of vigour test methods. Ed. Zurich: ISTA. p. 117.

Harish, K.K., Shakuntala, N.M., Vasudevan, S.N. and Sangeeta, I. 2013. Organic in pigeon pea an eco-friendly approach for sustainable agriculture. *An International Quarterly of Environmental Sciences,* **6** : 237-243.

Jaiswal, D.K., Raju, S.V.S., Singh, D.K. and Singh, V. 2019. Evaluation of some seed protectants against pulse beetle, *Callosobruchus chinensis* (L.) in stored chickpea seeds under laboratory conditions. *Pharma Innovation Journal.* **8**(3) : 188-192.

Kaur, K.D., Verma, S.C. and Sharma, P.L. 2018. Efficacy of plant powders against pulse beetle, *Callosobruchus chinensis*, L. infesting pea seed. *Journal of Entomology and Zoology Studies,* **7**(1) : 737-741.

Kay, D.E. 1979. Crops and product digest number 3 : *Food Legumes Tropical Products Institute, London.* pp. 125-176.

Kebebush, T., Henok, K. and Teferra, F.T. 2015. Evaluation of the efficacy of plant powders, cow dung ash and malathion dust against *Callosobruchus chinensis* L. (*Coleoptera: Bruchidae*) on chickpea in JoleAndegna. *J. Agri. St.*, **3** : 129-144.

Khaire, V.M., Kachare, B.V. and Mote, V.N. 1992. Efficacy of different vegetable oils against pulse beetle in increasing storability of pigeon pea. *J. Stored Product Research.* **28**(3): 153-156.

Khan, I.M. and Borle, M.N. 1985. Efficacy of some safer grain protectants against the pulse beetle *Callosobruchus chinensis* L. infesting stored bengalgram (*Cicer arietinum* L.) *PKV Res. Jr.* **9** : 53-55.

Khan, M.I. 1986. Efficacy of *Acorus calamus* L. rhizome powder against pulse beetle *Callosobruchus chinensis*. *PKV Research Journal.* **10** : 72-74.

Khatun, A., Kabir, G., Bhuiyan, M.A.H. and Khanam, D. 2012. Effect of preserved seeds using different botanicals on seed quality of lentil. *Bangladesh J. Agril. Res.* **36**(3) : 381-387.

Khinchi, S.K., Sharma, M.M., Khinchi, M.K., Bairwa, D.K., Acharya, D., Naga, B.L. and Naga, R.P. 2017. Studies on efficacy of certain vegetable oils against pulse beetle, *Callosobruchus chinensis* (L.) on chickpea, (*Cicer arietinum* L.). *International Journal of Chemical Studies*, **5**(3) : 255-259.

Kittur, N.A. 1990. Evaluation of natural products against the pulse beetle in redgram. M.Sc. (Agri) Thesis, submitted to UAS, Dharwad.

Kumar, L., Chakravarty, S., Agnihotri, M. and Karnatak, A.K. 2016. Efficacy of some plant oils against pulse beetle, *Callosobruchus chinensis* (L.) infesting green gram under storage conditions. *Research on Crops,* **18**(1): 157-163.

Kumar, S., Sathish, B.N., Kumar, S., Singh, V.V. and Pal, K. 2018. Effect of grain protectants on biology of pulse beetle (*Callosobruchus chinensis* L.) in black gram. *Bulletin of Environment, Pharmacology and Life Sciences*, **7**(12) : 141-145.

Kumari, K., Sinha, M.M., Mehta, D.N. and Hameed, S.R. 1990. Effect of some vegetable oils as protectant against pulse beetles (*Callosobruchus chinensis* L.) *Bulletin on Grain Technology.* **28** : 58-66.

Kumbhar, R.I. 1999. Influence of seed treatment and container on seed quality during storage in chickpea. M.Sc. (Agri.) Thesis, submitted to UAS, Dharwad.

Mahesh Babu, H.M. and Ravi Hunje. 2008. Effect of Seed Treatment with Botanicals on Storability of Soybean, *Karnataka J. Agril. Sci.*, **21**(3): 357-360.

Makanjoula, W.A. 1989. Evaluation of extracts of neem (*Azadirachata indica*) for the control of some stored product pests. *Journal of Stored Product Research*, **25**(4) : 231-237.

Malarkodi, K. and Srimathi, P. 2001. Effect of insecticide treatment on maintenance of seed quality in maize cv. Co-1. *Seed Res*earch. **29**(2) : 197-201.

Mandali, R. and Reddy, K.D. 2014. Neem formulations safer seed protectants for long term storage of red gram against *Callosobruchus chinensis*. *Journal on Biopesticide***,** **7**(1): 128-132.

Maraddi, B.M. 2002. Influence of growth retardents on seed yield and quality of seed treatments on storability of cowpea Co-152. M.Sc. (Agri.) Thesis, submitted to UAS, Dharwad.

Mishra, S.N., Jena, B.C., and Guru, B.C. 2013. Study of impact of edible and non-edible oils on grain damage and weight loss of green gram in storage condition infested with pulse beetle *Callosobruchus chinensis*. *International Journal of Science and Research (IJSR) Index Copernicus.* **6** : 14.

Mummigatti, S.G. and Raghunathan, A.N. 1977. Inhibition of the multiplication of *Callosobruchus chinensis* by vegetable oils.*Journal of Food Science and Technology*, **14** : 184-185.

Pal, G.K., Pooja and Popeen Kumar. 2013. Enhancing seed germination of Maize and Soybean by using botanical extracts. *International Journal of Current Discoveries and Innovations,* **2**(1) : 72-75.

Pandey, N.D., Shivarajsingh and Tewari, G.C. 1976. Use of some plant products, oils and extracts as protectants against pulse beetle. *Indian Journal of Entomology,* 38(2) : 110-113.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research, New Delhi pp*. 1-10.

Parmar, V.R. and Patel, B.H. 2016. Evaluation of synthetic insecticides as seed protectants against pulse beetle, *Callosobruchus chinensis* L. on mungbean. *Advances in Life Sciences.* **5**(16) : 2278-3849.

Patil, A.K. 2000. Influence of containers and seed treatment on storability of chickpea. M.Sc. (Agri.) Thesis, submitted UAS, Dharwad.

Presely, J.T. 1958. Relations of protoplast permeability of cotton seed viability and pre disposition of seedling disease. *Plant Dis. Report.,* **42** : 582.

Raina, A.K. 1970. *Callosobruchus spp*. infesting stored pulses in India and comparative study of their biology. *Indian Journal of Entomology*, **32** : 303-310.

Rajapakse, R.H.S. and Senanayake, S.G.J.N. 1997. Effectiveness of seven vegetable oils against *Callosobruchus chinensis* L. in pigeon pea (*Cajanuscajan* L.). *Entomon,* 22(3 & 4) : 179-183.

Rajapakse, R.H.S., Senanayake, S.G.J.N. and Ratnasekara, D. 1998. Effect of five botanicals on oviposition, adult emergence and mortality of *Callosobruchus chinensis* Fab. (*Coleoptera: Bruchidae*) infesting cowpea (*vigna unguiculata* L. Walp.). *Journal of Entomological Research.*, **22**(2) : 117-112.

Ramesh Babu, T., Sudheer Reddy, V. and Hussaini, S. H. 1989. Effect of edible and non edible oils on the development of the pulse beetle (*Callosobruchus chinensis* L.) and on viability and yield of mung bean(*Vigna radiate* L.). *Tropical science,* **29** : 215-220.

Rao, P.K., Aleem, M.A., Chitra, K.C. and Mani, A. 1993. Efficacy of some botanicals and ash against pulse beetle, *Callosobruchus chinensis* (L.).In botanical pesticides in integrated pest management. Rajahmundry, India. *Indian Society of Tobacco Science*, **16** : 282-287.

Rashmi, K., Mukherjee, U., Neeraj Kumar And Nagendra Kumar, 2014, Efficacy of botanicals and insecticides against *Callosobruchus chinensis* L. on pigeon pea seeds. *Pest Management in Horticultural Ecosystems.* **20**(1) : 41-46

Rathod, L., Sasane, A.R., Kawre, P.R., Chaware, G.G. and Rathod, P.K. 2019. Effect of botanicals on pulse beetle and per cent seed germination of stored green gram. *Journal of Pharmacognosy and Phytochemistry,* **8**(3) : 2428-2430.

Rathod, P.K., Kolhe, G.K., Chopade, B.J., Borkar, P.A., Murumkar, R.P., Bhalkare, S.K. and Mate, V.N. 2018. Effect of newer insecticide molecules on seed viability. *Int. J. Current Microbiology and Applied Sciences,* **6** : 2561-2566.

Sahoo, A.K. and Chandrakar, H.K. 2013. Efficacy of edible and non-edible oils against pulse beetle *Callosobruchus chinensis* L. in stored chickpea. *Int Jr of Plant Protection*, **6**(2) : 299-303.

Sangappa, H.K. 1977. Effectiveness of oils as surface protectants against the bruchid (*Callosobruchus chinensis*) infestation on redgram. *Mysur. J. Agril. Sci.* **11** : 391-397.

Saroj Jain and Yadav, T.D. 1989. Efficacy of deltamethrin and malathion on greengram seeds against *Callosobruchus chinensis* (L.) and *C. analis* (fab.). *Bulletin of Grain Technology.* **27**(1) : 39-44.

Satya, V. 1994. Effectiveness of natural oils on protection of cowpea seeds from bean weevil on greengram Cv. Chinamung. M.Sc. (Agri) Thesis, submitted to UAS, Dharwad.

Schmutterer, H. 1990. Properties and potantial of natural pesticides from neem tree*, (Azadirachta indica)*. *Annual Review of Entomology.* **35** : 271-297.

Schoonhoven, A.V. and Voysest, O. 1991. Common Beans : *Research for Crop Imrovement. C.A.B. International, Wallingford, U.K. and CIAT, Cali, Colombia.* pp. 707-735.

Shaheen, F.A. and Khaliq, A. 2005. Management of pulse beetle, *Callosobruchus chinensis* (*Coleoptera : Bruchidae*) in stored chickpea using ashes, red soil powder and turpentine oil. *Pakistan Entomology*, **27**(2) : 45-48.

Sharma, R. and Devi, R. 2012. Effect of mustard oil and turmeric powder on the adult mortality and egg lying of the pulse beetle, *callosobruchus chinensis* (L.) on stored chickpea seeds. *J. Advances in Sci. and Techno.*, **3**(4): 2230-9659.

Shivanna, S., Lingappa, S. and Patil, B.V. 1994. Effectiveness of selected plant materials as protectant against pulse beetle *Callosobruchus chinensis* L. during storage of redgram, *Karnataka J. of Agril. Sci.*, **7**(3) : 285-290.

Shreemaiah, T. and Bommegowda, A. 1992. Studies on the effect of containers and seed treatments on the storability of cowpea. *Seed Technology News*, **22** : 47-48.

Shrivale, T.G. and Borikar, P.S. 1998. Laboratory evaluation of plant products and grain protectants for prevention of damage by *callosobruchus chinensis* (L.) in stored chickpea. *Agri. Sci. Digest*, **18**(4) : 234-236.

Shukla, R., Kumar, A., Prasad, C., Srivastava, B. and Dubey, N.K. 2008. Efficacy of *Acorus calamus* L. leaves and rhizome on mortality and reproduction of *Callosobruchus chinensis* L. *Applied Entomolgy and Zoology.* 44(2) : 241–247.

Singh, R.B., Nishad, R.N. and Singh, R.P. 2017. Relative efficacy of botanicals against pulse beetle (*Callosobruchus chinensis* L.) infestation in chickpea during storage. *Environment, Pharmacology and Life Sciences.* **6**(1) : 333-336.

Singh, V.N., Pandey, N.D. and Singh, Y.P. 1995. Relative to resistence of gram varieties to *Callosobruchus chinensis* on the basis of biochemical parameters. *Indian Journal of Entomology.* 57 : 77-82.

Srimathi, P., Sasthri, G. and Venkatasalam, E.P. 2003, influence of pre- storage treatments on storability of vegetable cowpea (*Vigna sinensis* L. *Savi.*). *Legume Research.* **26**(3) : 19-46.

Sudheer Reddy, V., Ramesh Babu, T., Hussaini, S.H. and Muralimohan Reddy, B. 1994. Effect of edible and non-edible oils on the development of pulses beetle, *Callosobruchus chinensis* L. and on viability of mung bean seeds. *Pest Management and Economic Zoology*, **2**(1) : 15-17.

Sujatha, A. and Punnaiah, K.C. 1985. Effect of coating stored seeds of green gram with vegetable oil on the development of pulse beetle. *Indian Jr. Agril. Sci.,* 55 : 475-477.

Sundaraj, N., Nagaraju, S., Venkataram, M. N. and Jagannath, K. 1972. Design and Analysis of Field Experiments, *Univ. Agric. Sci., Bangalore*.

Swain, T.K. and Baral, K. 2005. Low cost technology for controlling some stored grain pests. *Journal of Plant Protection and Environment*, **2** : 26-29.

Tammangouda, P. 2002. Influence of organics on seed yield, quality and storability studies on greengram Cv. Chinamung. *M.Sc. (Agri) Thesis, submitted to UAS, Dharwad.*

Tesema, K., Kurabachew, H. and Tadesse, T.F. 2015. Evaluation of the efficacy of plant powders, cow dung ash and malathion dust against *Callosobruchus chinensis* (L.) on chickpea in joleandegna: southern Ethiopia. *J. Agril. Studies.* **3** : 2.

Tripathy, M.L., Sahoop Das, B.C. and Mohanty, S. 2001. Efficiency of Botanical oils, plant extracts and plant powder against *Collsobrunchus chinensis* in Black gram. *Legume Research.* **24**(2) : 82-86.

Uma Reddy, M. and Shobha Reddy, G. 1987. Effectiveness of selected plant materials as protectants against insect infestation and nutrient composition during storage of greengram. *Bull. Grain Techn*., **25**(1): 48-57.

Upadhyay, V., Sajeesh, P.K. and Rao, M.S. 2014. Management of seed borne diseases of soybean (*Glycine max* L.) through novel seed dressing fungicides, botanicals and bioagents.*Trends in Biosciences.* **7**(8) : 645-650.

Vir, S. 1994, Varietal preference in cowpea by the pulse beetle *Callosobruchus maculatus, Science Culture,* **48**(10) : 346-347.

Yadav, M.K., Ram Kumar Sahu, R. and Singh, R.B. 2018. Standardization of seed protectants for improving the seed quality of pigeonpea (*Cajanus cajan* L.) seed under the ambient storage. *International J. Chemical Studies.* **6**(4) : 1985-1990.

Zafar, U., Muhammad, M.R. and Shah, M. 2017. Entomotoxicity of plant powders against Pulse beetle (*Callosobruchus chinensis*) on stored mung bean (*Vigna radiata*). *J. Entom. and Zoo. Studies.* **6**(1) : 1637-1641.

7. APPENDIX

Weekly data collected from Central Campus, MPKV, Rahuri on different weather parameters from May 2019 to Feb 2020.

Meteorological data at M. P. K. V., Rahuri from May 2019 to Feb 2020

Month	Met. week	Temp. (^{o}C)		Humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
May-19	18	39.09	20.74	37.29	15.86	0.00
	19	39.29	21.73	44.29	17.57	0.00
	20	40.00	21.81	34.57	14.00	0.00
	21	41.26	25.49	38.29	16.29	0.00
June-19	22	41.20	23.47	39.14	19.00	0.00
	23	39.17	24.87	58.71	35.14	0.00
	24	37.17	24.87	58.71	35.14	7.4
	25	36.06	24.33	69.86	40.00	12.3
June-19	26	31.43	23.81	80.71	60.29	68.6
	27	30.61	23.54	79.00	63.14	110.5
	28	32.00	23.60	76.00	56.57	116.7
	29	33.83	23.24	71.43	51.29	125.8
	30	30.51	23.59	78.43	68.14	180.4
Aug-19	31	27.03	22.86	87.00	77.43	191.5
	32	28.03	23.27	80.57	68.14	218.4
	33	31.00	22.47	75.14	59.57	219.6
	34	32.49	21.29	72.43	47.57	220.8
Sept-19	35	31.97	22.99	75.41	55.71	255.3
	36	29.97	23.33	77.57	70.57	309.7
	37	28.77	22.47	78.57	68.43	325.1
	38	29.83	21.73	83.57	71.00	387.5
	39	30.23	21.94	83.43	66.86	451.5

Contd….

Month	Met. week	Temp. (^{o}C)		Humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
Oct-19	40	31.14	21.11	80.57	58.71	457.7
	41	31.69	21.13	77.00	50.29	463.4
	42	28.26	18.57	81.57	67.71	479.7
	43	25.71	20.80	87.14	79.57	616.3
Nov-19	44	30.43	20.97	84.00	58.57	661.0
	45	31.09	18.41	76.14	46.14	680.3
	46	29.69	16.74	73.00	48.00	200.34
	47	30.04	15.21	74.00	45.29	686.4
Dec-19	48	30.47	15.93	73.86	44.29	80.00
	49	28.77	16.41	71.14	46.86	60.00
	50	29.66	16.34	74.29	42.00	0.00
	51	28.00	15.84	78.57	46.86	25.1
	52	27.09	17.19	78.86	51.14	16.4
Jan-20	1	29.34	17.56	42.29	23.57	0.00
	2	28.93	9.27	57.50	40.00	0.00
	3	29.37	11.29	57.71	33.00	0.00
	4	27.29	10.36	60.57	42.14	0.00
Feb-20	5	27.74	10.39	53.43	29.43	0.00
	6	27.86	9.06	54.00	29.29	0.00
	7	31.83	14.14	55.14	27.71	0.00
	8	34.65	15.91	49.85	24.42	0.00

8. VITAE

MR. RATHOD DHANRAJ BALU

MASTER OF SCIENCE (AGRICULTURE)

IN

AGRICULTURAL BOTANY
(SEED SCIENCE AND TECHNOLOGY)
2021

Title of thesis		**:**	"Effect of organic and inorganic seed treatments on seed health and quality of French bean (*Phaseolus vulgaris* L.)"
Department		**:**	Agricultural Botany
Discipline		**:**	Seed Science and Technology
Biographical information			
Personal Data	**Date of Birth**	**:**	04May1996
	Place of Birth	**:**	Dhulakarwadi
	Father's Name	**:**	Shri. Balu Pemu Rathod
	Mother's Name	**:**	Sou. Kalubai Balu Rathod
Educational Background	**Bachelor Degree**		Passed from College of Agriculture, Karad with 8.39 CGPA
	Class	**:**	First
	Name of University	**:**	MPKV, Rahuri
	Class	**:**	First
Personal Address		**:**	A/P. Dhulakarwadi, Tal. Jath, Dist. Sangli Pin code: 416412
	Email- id	**:**	dhanrajrathod1946@gmail.com
	Contact Number	**:**	9370716409, 8308220116