EVALUATION OF VEGETABLE SOYBEAN (*Glycine max* (L.) Merrill) GENOTYPES FOR HORTICULTURAL TRAITS IN EASTERN DRY ZONE OF KARNATAKA

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In

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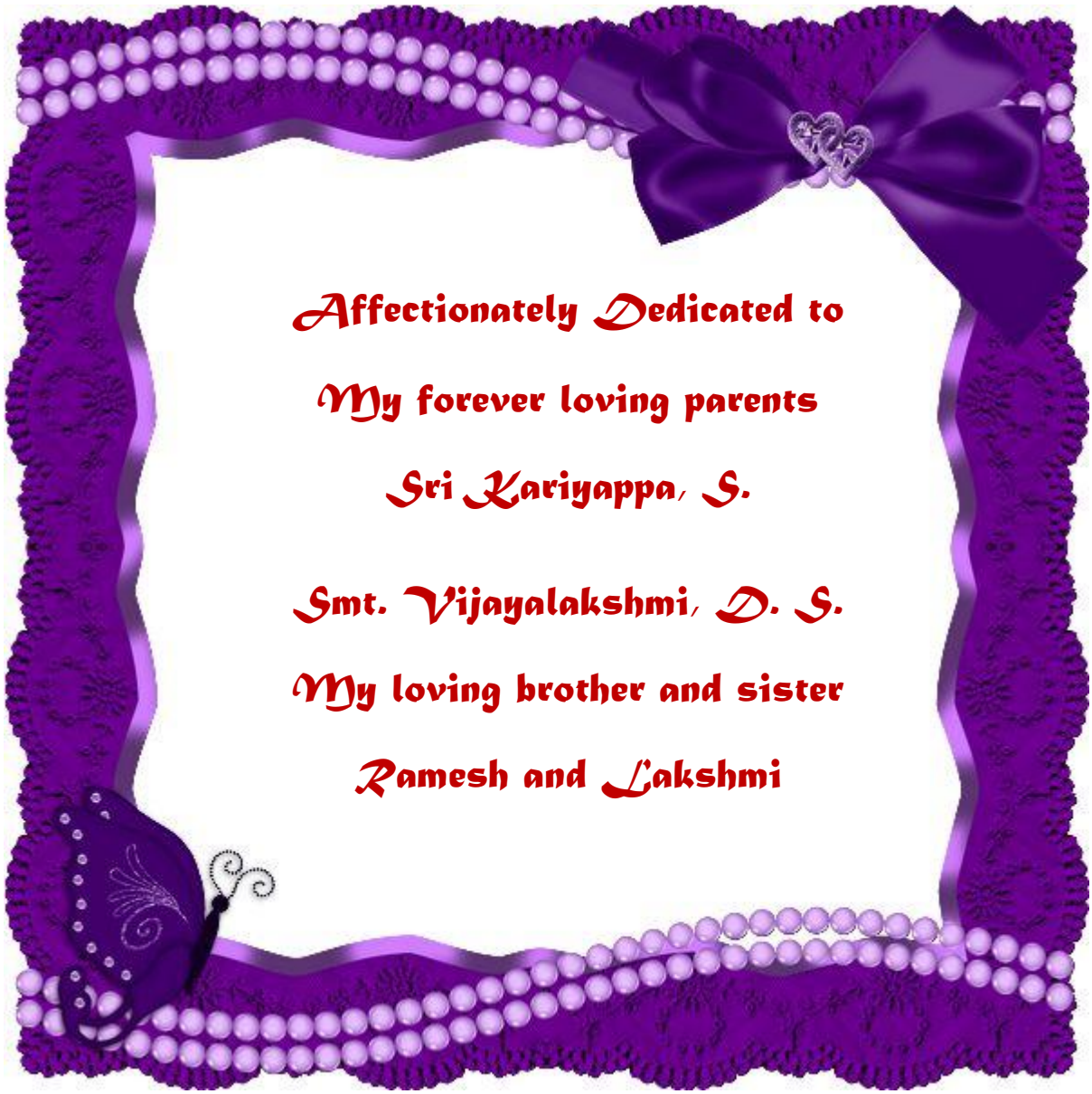
Affectionately Dedicated to
My forever loving parents
Sri Kariyappa, S.
Smt. Vijayalakshmi, D. S.
My loving brother and sister
Ramesh and Lakshmi

DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE, BENGALURU
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BAGALKOT

C E R T I F I C A T E

This is to certify that the thesis entitled **"EVALUATION OF VEGETABLE SOYBEAN (*Glycine max* (L.) Merrill) GENOTYPES FOR HORTICULTURAL TRAITS IN EASTERN DRY ZONE OF KARNATAKA**" submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Horticulture)** in **VEGETABLE SCIENCE** to the University of Horticultural Sciences, Bagalkot, is a *bonafide* record of research work carried out by **Ms. SUSHMA, K., I. D. No. UHS15PGM688,** during the period of her study in this University, under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bengaluru
November, 2017

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Bengaluru
November, 2017 ***(SUSHMA, K.)***

EVALUATION OF VEGETABLE SOYBEAN (*Glycine max* (L.) Merrill) GENOTYPES FOR HORTICULTURAL TRAITS IN EASTERN DRY ZONE OF KARNATAKA

SUSHMA, K.

ABSTRACT

The field experiment entitled "Evaluation of vegetable soybean (*Glycine max* (L.) Merrill) genotypes for horticultural traits in eastern dry zone of Karnataka" was conducted during *kharif*, 2016-17 at College of Horticulture, UHS Campus, GKVK post, Bengaluru. The experiment was carried out in Randomised Complete Block Design with three replications. The 17 genotypes *viz.*, COHBSBM-26, COHBSBM-8, IC 501197, COHBSBM-66, COHBSBM-49, COHBSBM-54, IC 25763, AGS 433, W-80, EC 24207, AGS 432, EC 95286, Karune (check), IC 501164, GC 99013-5, GC 110318 and EC 103153 were used. The research was conducted to identify the elite genotypes for growth, yield, quality and acceptability of genotypes as vegetable types. All the genotypes varied significantly with respect to growth, yield and quality attributes. Among the genotypes evaluated, genotype AGS 433 followed by AGS 432 and COHBSBM-54 were found superior with respect to growth and yield attributing traits after 60 days of sowing. Similarly, protein and total sugars per cent were found maximum in genotypes EC 95286 and COHBSBM-8 respectively. While, genotype Karune has recorded higher overall acceptability value followed by the genotypes AGS 433 and GC 110318 during sensory evaluation and hence suitable for the vegetable type. Correlation studies revealed that, traits like pod length, pod width, number of pods per cluster and number of clusters per plant had high positive significant correlation with pod yield per plant. In path-analysis, number of pods per cluster and number of leaves per plant were the most influenced traits on pod yield per plant after 60 days of sowing.

Sushma, K.
(Student)

M. Anjanappa
(Major Advisor)

ಕರ್ನಾಟಕದ ಪೂರ್ವ ಶುಷ್ಕ ವಲಯದಲ್ಲಿ ತೋಟಗಾರಿಕಾ ಗುಣಲಕ್ಷಣಗಳಿಗೆ ತರಕಾರಿ ಸೋಯಾಬೀನ್ (ಗ್ಲೈಸಿನ್ ಮ್ಯಾಕ್ಸ್ (ಎಲ್.) ಮೆರಿಲ್) ತಳಿಗಳ ಮೌಲ್ಯಮಾಪನ

ಸುಷ್ಮ, ಕೆ.

ಪ್ರಬಂಧದ ಸಾರಾಂಶ

ತರಕಾರಿ ಸೋಯಾಬೀನ್ ತಳಿಗಳ ಮೌಲ್ಯಮಾಪನವನ್ನು ಕರ್ನಾಟಕದ ಪೂರ್ವ ಶುಷ್ಕ ವಲಯದಲ್ಲಿ ಅರಿತುಕೊಳ್ಳಲು ತರಕಾರಿ ವಿಭಾಗ, ತೋಟಗಾರಿಕೆ ಮಹಾವಿದ್ಯಾಲಯ, ಬೆಂಗಳೂರಿನಲ್ಲಿ 2016-17ನೇ ಸಾಲಿನಲ್ಲಿ ಕ್ಷೇತ್ರ ಪ್ರಯೋಗವನ್ನು ಕೈಗೊಳ್ಳಲಾಯಿತು. ಈ ಪ್ರಯೋಗದಲ್ಲಿ ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-8, ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-26, ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-66, ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-49, ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-54, ಐ.ಸಿ 501197, ಐ.ಸಿ 25763, ಐ.ಸಿ 501164, ಎ.ಜಿ.ಎಸ್ 432, ಎ.ಜಿ.ಎಸ್ 433, ಇ.ಸಿ 24207, ಇ.ಸಿ 103153, ಜಿ.ಸಿ 99013-5, ಜಿ.ಸಿ 113018, ಡಬ್ಲ್ಯು-80 ಮತ್ತು ಕರುಣೆ(ಚೆಕ್) ಗಳಾದ ಒಟ್ಟು 17 ತರಕಾರಿ ಸೋಯಾಬೀನ್ ತಳಿಗಳನ್ನು ಬಳಸಿ ಮೂರು ಪ್ರತಿಕೃತಿಯಲ್ಲಿ ಯಾದ್ರಚ್ಛಿಕ ಬ್ಲಾಕ್ ವಿನ್ಯಾಸ (ಆರ್.ಸಿ.ಬಿ.ಡಿ) ಸಂಖ್ಯಾಶಾಸ್ತ್ರ ಉಪಯೋಗಿಸಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಲಾಯಿತು. ಈ ಸಂಶೋಧನೆಯ ಬಹುಮುಖ್ಯ ಉದ್ದೇಶವು ಉತ್ತಮ ಇಳುವರಿ, ಒಳ್ಳೆಯ ಗುಣಲಕ್ಷಣಗಳು ಮತ್ತು ತರಕಾರಿಯಾಗಿ ಸ್ವೀಕೃತ ಅರ್ಹತೆಯನ್ನು ಹೊಂದಿರುವಂತಹ ತಳಿಗಳನ್ನು ಗುರುತಿಸುವುದಾಗಿರುತ್ತದೆ. ಈ ಎಲ್ಲಾ ತಳಿಗಳಲ್ಲಿ ಬೆಳವಣಿಗೆ, ಇಳುವರಿ, ಗುಣಮಟ್ಟ ಮತ್ತು ಸ್ವೀಕೃತ ಅರ್ಹತೆಗೆ ಸಂಬಂಧಿಸಿದ ಗುಣಗಳಲ್ಲಿ ವೈವಿಧ್ಯಮಯ ವ್ಯತ್ಯಾಸವಿರುವುದು ಕಂಡುಬಂದಿರುತ್ತದೆ. ತರಕಾರಿ ಸೋಯಾಬೀನ್ ತಳಿಗಳ ಮೌಲ್ಯಮಾಪನದಲ್ಲಿ ಬಿತ್ತನೆಯಾದ 60 ದಿನಗಳ ನಂತರ ಎ.ಜಿ.ಎಸ್ 433 ಮತ್ತು ತದನಂತರದ ಎ.ಜಿ.ಎಸ್ 432 ಮತ್ತು ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-54 ತಳಿಗಳು ಉತ್ತಮ ಬೆಳವಣಿಗೆ ಮತ್ತು ಇಳುವರಿಯನ್ನು ನೀಡಿರುವುದು ಕಂಡುಬಂದಿರುತ್ತದೆ. ಇನ್ನು ಗುಣಮಟ್ಟದ ಲಕ್ಷಣಗಳಾದ ಪ್ರೋಟೀನ್ ಮತ್ತು ಒಟ್ಟು ಸಕ್ಕರೆಯ ಅಂಶಗಳಿಗೆ ಇ.ಸಿ 95286 ಮತ್ತು ಸಿ.ಒ.ಹೆಚ್.ಬಿ.ಎಸ್.ಬಿ.ಎಂ-8 ತಳಿಗಳು ಅನುಕ್ರಮವಾಗಿ ಉತ್ತಮವೆಂದು ತಿಳಿದು ಬಂದಿರುತ್ತದೆ. ಹಾಗೆಯೇ ಎಲ್ಲಾ ತಳಿಗಳಿಗಿಂತ ಕರುಣೆ ಮತ್ತು ತದನಂತರದ ಎ.ಜಿ.ಎಸ್ 433 ಮತ್ತು ಜಿ.ಸಿ 110318 ತಳಿಗಳು ತರಕಾರಿ ಸೋಯಾಬೀನ್ ಆಗಿ ಬಳಸಲು ಹೆಚ್ಚು ಸ್ವೀಕೃತ ಅರ್ಹತೆಯನ್ನು ಹೊಂದಿವೆ ಎಂಬುದು ಸಂವೇದನ ಮೌಲ್ಯಮಾಪನದಿಂದ ತಿಳಿದು ಬಂದಿರುತ್ತದೆ. ಪರಸ್ಪರ ಅಧ್ಯಯನದಿಂದ ತಿಳಿದು ಬರುವುದೇನೆಂದರೆ, ಬಿತ್ತನೆಯಾದ 60 ದಿನಗಳ ನಂತರ ಕಾಯಿಯ ಉದ್ದ, ಕಾಯಿಯ ಅಗಲ, ಪ್ರತಿ ಗೊಂಚಲಿಗೆ ಕಾಯಿಯ ಸಂಖ್ಯೆ ಮತ್ತು ಪ್ರತಿ ಗಿಡಕ್ಕೆ ಗೊಂಚಲಿನ ಸಂಖ್ಯೆಯು ಇಳುವರಿಯ ಜೊತೆಗೆ ಅತ್ಯಂತ ಗಮನಾರ್ಹ ಮತ್ತು ಗುಣಾತ್ಮಕ ಸಹಯೋಗವನ್ನು ಹೊಂದಿರುತ್ತದೆ. ಮಾರ್ಗ ಗುಣಾಂಕದ ಮೂಲಕ ತಿಳಿದು ಬರುವುದೇನೆಂದರೆ, ಪ್ರತಿ ಗೊಂಚಲಿನ ಕಾಯಿಯ ಸಂಖ್ಯೆ ಮತ್ತು ಗಿಡದ ಎಲೆಗಳ ಸಂಖ್ಯೆಯು ಇಳುವರಿಯ ಮೇಲೆ ನೇರ ಸಕಾರಾತ್ಮಕ ಪರಿಣಾಮ ಬೀರಿರುವುದು ಕಂಡುಬಂದಿರುತ್ತದೆ.

ಸುಷ್ಮ, ಕೆ. **ಎಂ. ಅಂಜನಪ್ಪ**

(ವಿದ್ಯಾರ್ಥಿಯ ಸಹಿ) **(ಪ್ರಧಾನ ಸಲಹೆಗಾರರು)**

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LIST OF ABBREVATIONS USED

Symbols	Abbreviations
%	Per cent
@	At
º C	Degree centigrade
Min	Minute
Cm	Centimeter
cv.	Cultivar
N	Normality
G	Gram
Kg	Kilogram
Q	Quintal
L	Liter
hr.	Hour
viz.,	As follows
i.e.	That is
et al.	Et allii (and other)
Fig.	Figure
No.	Number
DAS	Days After Sowing
Ha	Hectare
C.D.	Critical difference
S.Em±	Standard Error of Mean
S.D	Standard deviation
NS	Non-Significant

I. INTRODUCTION

The vegetable soybean (*Glycine max* (L.) Merrill) is a self-pollinating annual with a diploid chromosome number 2n=40, belonging to the family Fabaceae. It is a 'miracle legume' of the 21st century as it contains high amount of quality protein (42 per cent) and oil (20 per cent). The earliest reference to vegetable soybean may be found in Chinese writings dating to the second century BC and even today the folk wisdom of medicinal benefits remains in China. The middle and lower yellow river valley in China has been reported to be the place of origin (Chang, 1980). Since the first century AD, this ancient domesticate became widely introduced and landraces are developed in China, Korea, India and other parts of Asia (Zeven and De Wet, 1982). Besides routine grain use of soybean, owing to its high protein content and short duration nature, this crop is potentially suitable for vegetable purpose.

It is called as vegetable soybean, green soybean or edible soybean in North America, edamame in Japanese and maodou in China. This vegetable is cultivated as same as the field-dried soybeans, but they are harvested at an immature green stage (R6) that occurs just as the seeds have filled out the pod. These vegetable soybeans also have larger seeds than other field soybeans, a sweeter, nutty (less beany) taste and are more easily digested. The sweet and savoy taste vegetable soybean is attributed to their sucrose, glutamic acid and alanine content. They are good source of protein, dietary fibre, vitamin- C (Ascorbic acid), vitamin- E (Tocopherol), calcium and phytoes-trogens. This vegetable is quickly gaining popularity in the US along with the other soy foods and soy products. Their demand is growing worldwide, most likely due to their tastiness and the known health benefits of iso-flavones. These include decreasing low density lipoprotein (LDL) cholesterol levels reducing the risk of cardiovascular diseases, cancer and osteoporosis (Duppong and Valenti, 2005).

Vegetable soybean is recognized as a 'tidbit' rather than a basic food. Although there are few available data on consumer preferences, vegetable soybean is widely accepted because of its characteristic volatile flavor, sweetness, various flavour amino acids and nucleotides. Major quality requirements of vegetable soybean in terms of palatability are appearance, taste, flavor and texture (properties of structure). The pods should be bright-green and a good shape with spotless surface to fetch a good price at the wholesale and retail market. The primary requirement is good pod appearance. The surface condition indicates the amounts of chemical components in the seed (e.g. yellowing reflects freshness decline and degradation of sugars, free amino acids and ascorbic acid) (Iwata *et al.,* 1982).

Soybean has the highest protein content of all other food crops and second only to groundnut in terms of oil content among food legumes, due to which it is highly preferred in human diet for mitigating malnutrition. The US, Argentina, Brazil, China and India are the world's largest soybean producers and represent more than 90 per cent of global production. World soybean production during 2013 was recorded to be 251.50 MT from an area of 91.40 M ha with a productivity of 2233 kg ha^{-1}. India stands fifth rank in soybean production after America, Brazil, Argentina and China in the world. In India it is grown in an area of 12.20 M ha and production of 11.99 MT with a productivity of 983 kg ha^{-1} (Anon., 2014).

Pulses, the food legumes, have been grown by farmers since pre-historic time and this has contributed to alleviation of malnutrition by providing nutritionally balanced food to the undernourished as well as the other population of India and other parts of the world (Swaminathan and Bhavani, 2013). India has been growing more than 12 different pulse crops, which are highly rich in their nutrient status. Soybean is one of the important nutrient rich pulse and oil seed crop.

Vegetable soybean is rich in protein, vitamin A, C and E, unsaturated fats, phosphorus, thiamine and riboflavin. Because of its characteristic-pleasing aroma and sweet taste it is widely accepted in Japan and China (Masuda, 1991). Dry vegetable soybean seed is larger (usually over 30 g 100^{-1} seeds), has higher soluble content and a lower number of chemical components associated with negative flavours than grain soybean (Konovsky *et al.,* 1994). Soybean seed has anti-nutritional substances, such as

protease inhibitors. One-third of activity of trypsin inhibitor (TI) is less in vegetable form; vegetable soybean is nutritious than grain soybean.

Vegetable soybean is harvested between R6 and R7 growth stages (approximately 80 per cent maturity) at which pods are full formed and still green. These being comparatively richer and better source of human nutrition, dietary fibre and health promoting phyto-chemicals than the other traditional vegetables, can serve as good source of vegetables or snacks foods for Indians specially the vegetarian representing 65-70 per cent of the total population. As far as India is considered, soybean is mainly cultivated as an oilseed crop. Considering the nutritional importance of vegetable soybean, efforts are being made to breed vegetable soybean (Basavaraja *et al*., 2005).

The performance of different vegetable soybean genotypes varies under different agro climatic conditions due to their specific climatic requirement. Therefore, an appraisal of genotypes for their variability with respect to growth, yield and quality under different conditions is essential to improve the production. Evaluation of different genotypes and identification of high yielding genotypes for a particular agro-climatic region for different season would be very useful to the growers.

There is a great potential for the commercial production of soybean as vegetable type in the country. Even though number of accessions and genotypes of vegetable soybean has been collected, but very little information regarding their performance in India. Considering the importance of this crop, there is a prime need to evaluate some of the available genotypes to find out the suitable genotype for the eastern dry zone of Karnataka.

Keeping these points in view the present study was under taken with the following objectives:

1. To study the performance of vegetable soybean genotypes for growth and yield parameters.
2. To study the performance of vegetable soybean genotypes for quality parameters.
3. To assess the acceptability of the vegetable soybean genotypes.

II. REVIEW OF LITERATURE

A critical comprehensive review of literature is inevitable for any scientific investigation. A proper understanding of the problem requires thorough review of the existing information of the problem. Keeping in view, the objectives of the problem, the review of literature is presented under the following sub-headings.

2.1 Performance studies

2.2 Correlation and path analysis

Genotype plays an important role in determining the crop yield. The potential yield of genotypes with its genetic limit is set by environment where it is grown. Genotypes differ in their yield potential depending on many complex physiological processes taking place in different parts of the plant, which are controlled by both genetic makeup of plant and environment.

The relevant literature on performance with respect to growth, yield and quality characters of vegetable soybean and related crops is presented below.

2.1 Performance studies

2.1.1 Growth characters

2.1.1.1 Plant height

2.1.1.1.1 Vegetable soybean

Vegetable soybean accessions developed by AVRDC, Taiwan were evaluated by Marutani and Schlub (2003) reported that, the accession AGS 332 (27.10 cm) recorded maximum plant height and minimum plant height was recorded by the accession AGS 190 (19.40 cm) at harvest.

A study comprised 10 vegetable soybean genotypes *viz.,* EC 175324, EC 175329, EC 175330, EC 175332, Seminol, Cockerstaurt, GP 15, GP 1055, KB 19 and released cultivar Himso 1563. Among the genotypes, mean performance for plant height ranges from 26.70 cm to 67.73 cm. Maximum plant height was recorded by the genotype EC 175324, while minimum plant height of 26.70 cm was recorded by the genotype Himso 1563 (Basavaraja *et al.*, 2005).

Carson *et al.* (2011) studied the five edamame cultivars for yield potential and yield components during 2008 and 2009. Results revealed that, in 2008 BS2015 had an average plant height of 24.40 inches and was significantly taller than all other cultivars, which were similar in height. In 2009, SR had an average plant height of 26.40 inches and was significantly taller than BS292, MG and BS2001. BS2015 had an average plant height of 23.30 inches, which was similar to all other cultivars.

Sarutayophat (2012) conducted a field experiment on 22 vegetable soybean genotypes to determine the association of yield and its component characters. The results of per se performance revealed that, the genotype AGS 334 has recorded the maximum plant height of 53.70 cm, while the genotype GC88005-3-3-1 (13.80 cm) has recorded the minimum plant height.

An experiment conducted by Poornima *et al.* (2014) on the physiological basis of yield variation in vegetable soybean and organoleptic test for acceptance. From the results it is revealed that, the plant height ranged from 23.00 to 49.00 cm. The vegetable soybean genotypes had significantly lower plant height than grain soybean JS-335 (49.00 cm) except AGS 459 (43.00 cm) and AGS 460 (42.00 cm), which found to be on par with JS-335.

An investigation was carried out by Ramya and Mummigatti (2015) at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during *kharif* 2014 with ten vegetable type and two grain type soybean genotypes for evaluating variation in plant growth. The plant height differed significantly among the genotypes, Swarna (53.17 cm and 92.60 cm) and AGS-406 (31.20 cm and 47.70 cm) showed maximum and minimum plant height at R1 and R6 stage respectively.

2.1.1.1.2 Soybean

Malik *et al.* (2006) evaluated 17 soybean varieties for yield components. The results revealed that the genotype 95034-B has recorded higher plant height (80.40 cm), while the genotype 95078 recorded minimum plant height (37.20 cm).

Ali *et al.* (2013) tested the growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60 and PSC-60 through field study. The maximum plant height was observed in PSC-60 (27.43 cm), whereas minimum plant height was observed in the variety Williams-82 (20.00 cm).

An experiment was conducted by Malek *et al.* (2014) during 2011 to study genetic variability, character association and genetic diversity among 27 soybean mutants and four mother genotypes. The mean performance results revealed that, the mutant BAU-S/64 had recorded maximum plant height (90.00 cm) and minimum plant height was recorded in mutants SBM-01 and SBM-18 (53.00 cm each).

Aniekwe (2015) evaluated soybean for their growth and yield responses in a derived Savanna part of south eastern Nigeria. The results revealed that, the genotype TGx1740-2F has recorded the maximum plant height of 69.30 cm and minimum plant height was recorded by the genotype TGx1909-3F (29.20 cm).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. The results showed a significant difference for plant height among the genotypes. Maximum plant height was recorded by the genotype TGX-1904 (60.00 cm), whereas the minimum plant height was recorded by the genotype TGX-1951 (39.33 cm).

Njoroge *et al.* (2015) evaluated 15 genotypes of soybean for yield and protein content in Kenya. The results revealed that, genotypes DPSB 8 and SBH7/1/1 had recorded highest plant height (95.80 cm and 87.9 cm respectively) whereas, the minimum plant height was recorded by the genotype 931/5/34 (55.30 cm).

2.1.1.1.3 Other leguminous vegetable crops

Jadhao (1993) evaluated the performance of three French bean genotypes *viz.,* VL-63, HUR-87 and HUR-15 and results revealed that, the maximum plant height was recorded in genotype VL- 63(30.00 cm), while the minimum plant height was recorded in HUR-15 (26.00 cm).

Ramakrishna (1999) evaluated two genotypes of French bean *viz.,* Arka Komal (26.60 cm) and Burpee's Stringless (22.20 cm) for plant height. The results showed no significant difference in plant height.

Screening of six varieties of French bean by Roy and Parthasarathy (1999) reported that, the variety Manipuri recorded significantly higher plant height (82.26 cm) as compared to the other varieties except Meghalaya pole whereas lower plant height (34.23 cm) was recorded in Canadian Wonder.

Anjanappa *et al.* (2000) reported that, the variety Arka Komal has recorded the highest plant height (52.70cm) followed by Burfi Stringless (48.36cm) and the lowest plant height was recorded in local variety (43.99cm) during kharif season. Similarly Selection-11 recorded maximum plant height (56.88cm)

followed by Arka Komal (54.45cm) and lowest plant height (45.89cm) was recorded in local variety during rabi season.

Evaluation of three French bean varieties namely, HUR-87, VL-63 and PDR-14 for plant height. The results showed that, the variety HUR-87 (26.45 cm) has recorded higher plant height compared to VL-63 (21.70 cm) and it was on par with PDR-14 (Dhanjal *et al.,* 2001).

Saiyad (2003) reported the significant difference for the plant height in French bean ranged from 41.20 cm (Contender) to 101.90 cm (IIHR-1137, pole type) and the mean value was 51.46 cm.

Smitha (2005) has studied ninety four genotypes of French bean and reported that the plant height ranged from 31.50 cm in DWD-FB-32 to 56.73 cm in DWD-FB-27 with a mean of 43.75 cm.

A field experiment was carried out to investigate the performance of French bean (*Phaseolus vulgaris* L.) varieties during *rabi* season from 2005-06 at Parbhani. Among the four varieties studied, the variety HPR 35 has recorded significantly higher plant height over other varieties (Maske *et al*., 2009).

Pandey *et al*. (2011) studied the variability among 18 exotic and indigenous French bean (*Phaseolus vulgaris* L.) genotypes during the summer season of 2010. The plant height differed significantly among the genotypes where, the variety Mandir was the tallest (102.07 cm) and LB-27 was dwarfest (26.80 cm) among the 18 genotypes.

Eight cowpea (*Vigna unguiculata*) species were evaluated for yield and its associated traits. The result on plant height shows that there was significant difference among the species with IT90K-277-2 having the highest plant height of $104.91^{a} \pm 11.46$ at 6th week than the other plant species (Ekpo *et al.,* 2012).

Ichi *et al*. (2013) conducted two field trials to evaluate growth and yield response of selected cowpea varieties at BUK and Kadawa during 2009 and 2010 dry season. Among the genotypes evaluated, Achishuru produced significantly taller plants whereas, the variety IT97K-205-8 produced stunted plants at both locations.

According to Khan *et al.* (2013), the maximum plant height of 126.70 cm was observed in genotype Shareen followed by DMR-20 (121.30 cm). Genotype 2001-55 had showed minimum plant height of 65.67 cm in peas.

Sharma *et al*. (2013) noticed that, the maximum plant height in French bean cultivar was recorded by Swarna Priya (42.09 cm) followed by Arka Komal (36.17 cm) and minimum plant height was found with cultivar Contender (35.85 cm).

An experiment was conducted to assess the genetic variability in 22 diverse genotypes of bush cowpea during 2011-2012 at Vellayani, Kerala by Vavilapalli *et al.* (2013). Among the genotypes, VU 24 has recorded maximum plant height (58.90 cm) and minimum was recorded by VU 22 (182.97 cm) with a mean value of 123.34 cm.

Jitender *et al.* (2014) studied the comparative performance in 25 genotypes of cluster bean during kharif 2010 at Hissar. The maximum plant height was recorded in RGC-986(167.83 cm) followed by HG-9-1(158.33 cm) and minimum in *C. Serrata* (51.33 cm).

Phom *et al.* (2014) studied the comparative performance in 7 genotypes of pea over two years (2012 and 2014) during *Rabi* season under foot hill condition of Nagaland. All the genotypes showed significant variation with regard to plant height. The genotype PEVAR-1 produced tallest plants (30.05 and 33.28 cm) at both the stages of growth i.e. 30 and 45 days after sowing respectively which was

followed by genotype PEVAR-4. The minimum plant height (14.65 and 16.10 cm) was recorded in genotype VRD-6(C) during both the seasons.

In a performance study of 34 genotypes of French bean in two consecutive years 2010-11 and 2011-12 under NEH Region showed that, the genotype RCMFB1 (282.00 cm) has recorded maximum plant height whereas, the genotype RCMFB19(102.64 cm) recorded the minimum plant height (Verma *et al.,* 2014).

Ravinaik *et al.* (2015) assessed nine dolichos bean genotypes performance at Main Agriculture Research Station, Raichur. The genotypes differed significantly with each other for plant height. At all the stages of growth, PD-31 showed maximum plant height (108.87, 185.33 and 196.27 cm, respectively).

Santhi *et al.* (2015) evaluated ten accessions of traditional French beans - types for yield and quality at Nanjanad Farm, HRS, Ooty. Among the bush bean types, accession number FBB-7 (Aruvath avarai) has recorded the maximum plant height (67.21 cm).

2.1.1.2 Number of leaves per plant

2.1.1.2.1 Soybean

Ali *et al.* (2013) tested the growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60 and PSC-60 through field study. More number of leaves per plant was observed in the variety PSC-60 (25.00), whereas the minimum number of leaves per plant was observed in the variety Williams-82 (11.47).

2.1.1.2.2 Other leguminous vegetable crops

Abdel *et al.* (2005) studied the comparative performance in four genotypes of French bean over two seasons (2003 and 2004). Among the genotypes, the variety Coby recorded maximum number of leaves per plant (11.40 and 13.84) as against the lowest (6.84 and 8.95) in Juela during both the seasons.

Among the five cultivars of Fenugreek evaluated by Bhattacharya *et al.* (2006). The J. Fenu 115 exhibited superiority over other cultivars with respect to number of leaves (117.84). Whereas, the local cultivar (99.13) has exhibited minimum number of leaves.

Among the French bean varieties studied, Sharma *et al.* (2013) observed that the number of leaves per plant was maximum in Swarna Priya (66.84) followed by Arka Komal (57.76) and lowest number of leaves per plant was recorded in the variety Contender (53.69).

Phom *et al.* (2014) evaluated seven genotypes of pea and reported that maximum number of leaves per plant was observed in the genotype PEVAR-1 (37.00 and 39.07) at 30 and 45 days after sowing respectively and the minimum number of leaves per plant (22.87 and 27.00) was reported in the genotype VRD-6(C).

2.1.1.3 Number of branches per plant

2.1.1.3.1 Vegetable soybean

A Study comprised 10 vegetable soybean genotypes *viz.,* EC 175324, EC 175329, EC 175330, EC 175332, Seminol, Cockerstaurt, GP 15, GP 1055, KB 19 and released cultivar Himso 1563. Mean performance of vegetable soybean genotypes for number of branches ranges from 2.17 to 3.00 among the genotypes. More number of branches were recorded by the genotypes EC 176332, Seminol,

Cockerstaurt and GP 1055 (3.00 each), while the genotype EC 175330 (2.17) had recoded the minimum number of branches (Basavaraja *et al.,* 2005).

In vegetable soybean, Ramya and Mummigatti (2015) reported that, number of branches per plant differed significantly among the genotypes. The maximum number of branches per plant was observed in the genotype AGS-447 (5.00 and 11.30) and the minimum number of branches per plant was recorded in the genotype AGS-610 (6.70 and 8.50) at R1 and R6 stages respectively.

Sarutayophat (2012) has conducted study the on 22 genotypes of vegetable soybean to determine the association of yield and its components. Among the genotypes, more number of branches per plant was recorded in the genotype Chiang Mail (4.42) and less number of branches per plant was recorded in the genotype GC89020-2-3-3 (2.13).

2.1.1.3.2 Soybean

Malik *et al.* (2006) evaluated 17 soybean varieties for yield components. The results revealed that, the genotypes 95035-A and AGS-194 has recorded the more number of branches per plant (8.00 each) while, the genotype 95078 has recorded more number of branches per plant (2.00).

Machikowa and Laosuwan (2011) evaluated 14 lines or varieties of soybean and reported that, the mean performance for the branches per plant was maximum in M-3215 (2.80), while the minimum number of branches per plant was recorded in the genotype NS 1 (1.80).

An experiment was conducted by Malek *et al.* (2014) during 2011 to study genetic variability, character association and genetic diversity among 27 soybean mutants and four mother genotypes. The results revealed that, the mutant SBM-11 has recorded more number of branches per plant (6.26) and the minimum number of branches per plant was recorded in the mutant SBM-21 (2.30).

Aniekwe (2015) evaluated soybean genotypes for their growth and yield characters in a derived Savanna part of South-eastern Nigeria. The results revealed that, the genotype TGx1740-2F has recorded the more number of branches per plant 5.80 and less number of branches per plant was recorded by the genotype TGx1909-3F (29.10).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. The results revealed that, there was a significant difference for number of branches per plant among the genotypes. More number of branches per plant was found in the genotype TGX-1835 (9.67) and less number of branches was found in the genotype TGX-1935 (8.00).

2.1.1.3.3 Other leguminous vegetable crops

Jadhao (1993) evaluated three varieties of French bean for number of primary branches per plant. Among the three varieties, the variety HUR-15 (3.6) has recorded the maximum number of primary branches per plant followed by VL-63 (3.4) and HUR-87 (3.1).

Omkarappa (1994) reported that, the cowpea genotypes differed significantly for number of branches where, TVU-393 had the highest number of branches per plant (5.17) followed by P-14 (4.32), TVU-1460 6 (4.25) and P-1355 (3.90). The genotype with least number of branches per plant was recorded in the genotype TVU- 113 (1.55) followed by TVX-1193-7PO and P- 583 (1.80).

Khyad (1996) reported that, the maximum number of primary branches was recorded in the cv. Arka Komal (3.93) and minimum number of primary branches was recorded in the cv. Burpee's Stringless (3.62) in French bean.

According to Baboo *et al*. (1998) in French bean, the maximum number of primary branches was recorded in the variety PDR-14 (7.10) and minimum number of primary number of branches was recorded in the variety Contender (5.20).

Ramakrishna (1999) studied two genotypes of French bean for number of primary branches per plant. The variety, Arka Komal (3.93) recorded significantly higher number of primary branches per plant as compared to Burpee's Stringless (3.62).

According to Roy and Parthasarathy (1999) among the six cultivars of French bean cv. Stringless Cluster has recorded the highest number of primary branches (5.44) followed by Tender Crop (4.84) and lowest number of primary branches was recorded in cv. Meghalaya pole (3.52).

Dhanjal *et al.* (2001) evaluated three French bean varieties namely HUR-87, VL-63 and PDR-14 for number of primary branches per plant. Among them variety VL-63 recorded significantly higher number of primary branches 7.74 per plant followed by PDR-14 (6.62) HUR-87 (6.14).

Sahu *et al.* (2005) reported that, among the ten cultivars of winged bean, higher number of branches per plant (7.3) was recorded in EC142665 and minimum in Mysore local (5.4).

Smitha (2005) reported that, among the 94 genotypes of French bean number of primary branches per plant was ranged from 2.30 in IIHR-909 and 5.20 in DWD-FB-78.

Bhuvneshwari (2008) has recorded the more number of primary branches in DA-15 (6.90) and in the DA-68 (2.88) genotype of dolichos bean.

Maske *et al.* (2009) reported that, the variety HPR 35 has recorded significantly higher number of branches over rest of the varieties of French bean.

Adat *et al.* (2011) reported that, the maximum numbers of branches was found in Varun (2.33) followed by Malav-51 (2.30) and Jyothi-51 (2.27) and the minimum number of branches per plant was found in Nylon-55 (1.22).

Pandey *et al*. (2011) noticed that, the number of branches per plant in 18 exotic and indigenous French bean genotypes differed significantly. Among the genotypes, the highest number of branches was produced by S-9 (7.93) and the lowest number of branches was recorded by the genotype Mandir (5.20).

Rai *et al*. (2012) evaluated 31 genotypes of cluster bean to estimate variability for vegetable pod yield and related attributes at Dharwad during *Kharif* 2009. Among the genotypes, line 14 has recorded highest number of branches (9.00) whereas, Pusa Navbahar has recorded least number of branches (0.00).

Soori and Nejad (2012) reported that among six fenugreek genotypes, genotype Esfahan had more number of branches (7.61) while the least number of branches was recorded in genotype Mazandaran (2.58).

In French bean, Alemu *et al.* (2013) observed that, the number of primary branches was in the range of 3.30 in genotype S-61 and 4.90 in Contender.

A study was conducted by Khan *et al.* (2013) to evaluate the performance of 13 pea's genotypes for higher yield during autumn 2009-10. Among the genotypes the genotype DMR-4 was recorded maximum number of branches per plant (5.66) followed by Climax (4.00). The lowest number of branches was observed in the genotypes 10679 and PS- 810240 (2.33 each).

In French bean, Sharma *et al.* (2013) observed higher number of branches per plant (11.69) in cultivar Swarna Priya followed by Arka Komal (10.45) and minimum number of branches per plant was in Contender (9.69).

According to Vavilapalli *et al.* (2013) the genotype VU 11 has showed maximum number of primary branches per plant (7.44). While the genotype VU 19 and VU 21 has recorded least number of branches (5.22) among the 22 genotypes of bush cowpea.

A study conducted by Kole *et al.* (2014) to know the performance of some Fenugreek genotypes. The genotype IC-143875 had recorded the maximum number of branches per plant while, the Sonali had recorded the minimum number of branches per plant.

Phom *et al.* (2014) conducted an experiment to assess the performance of seven pea cultivars in Nagaland. Maximum number of branches per plant was recorded (7.20 and 7.80) at 30 and 45 days after sowing respectively was observed in genotype PEVAR-1 followed by genotype PEVAR-3. The minimum number of branches (5.20 and 5.93) was recorded in genotype VRD-6(C).

2.1.1.4 Chlorophyll content

2.1.1.4.1 Vegetable soybean

Sharma *et al.* (2013) evaluated four vegetable soybean genotypes for physico-chemical, sensory and cooking quality attributes. The results revealed that, the total chlorophyll content was highest in the genotype SL 688 and SL 744 (2.45 mg g^{-1} each) and lowest chlorophyll content was recorded in (1.94 mg g^{-1}).

Poornima *et al.* (2014) observed that, the SPAD value was significantly higher in AGS 447 (36.80) and AGS 457 (35.00).

Ramya and Mummigatti (2015) showed that, the genotypes AGS-457 (39.76 and 43.83) and AGS-447 (37.58 and 42.82) had higher SPAD value at R1 and R6 reproductive stages respectively, as compared to other genotypes. But lowest SPAD value was recorded in AGS-460 (33.41) at R1 and Swarna (37.49) at R6 stage.

2.1.1.4.2 Soybean

Malik *et al.* (2006) evaluated 17 soybean varieties for yield components. The results revealed that, the genotype 95039-A recorded higher chlorophyll content (59.07) while the genotype 95035-A has recorded minimum chlorophyll content (38.23).

2.1.1.4.3 Other leguminous vegetable crops

According to Basavaraja (2013) out of 30 genotypes of fenugreek**,** the total chlorophyll content was highest in genotype DFC-14 (4.00 mg g^{-1}) followed by DFC- 17 and DFC-22 (3.98 mg g^{-1}) and minimum chlorophyll content was recorded in the genotype DFC 11 (1.31 mg g^{-1}).

Jitender *et al.* (2014) studied the comparative performance of the 25 clusterbean genotypes for the 18 characters at Hissar during *kharif*. The results revealed that, the chlorophyll content ranged from 0.71-0.84 mg g^{-1} and the highest was recorded in the genotype RGC-1017 (0.84 mg g^{-1}) and HG-75 (0.83 mg g^{-1}).

2.1.2 Yield and yield attributing characters

2.1.2.1 Days to first flowering

2.1.2.1.1 Vegetable soybean

According to Ramya and Mummigatti (2015) among the vegetable soybean genotypes AGS-406 took less number of days to first flowering (31-42) and maximum number of days to first flowering was recorded in the genotype Dsb-21 (42.70).

2.1.2.1.2 Soybean

Machikowa and Laosuwan (2011) evaluated 14 lines or varieties of soybean and results showed that genotypes NS1 and CM 2 took minimum number of days to flowering (29 days each) and genotype SJ 5 took maximum number of days to flowering (35 days).

2.1.2.1.3 Other leguminous vegetable crops

The significant variation in French bean genotypes for the days to first flowering was observed by Saiyad (2003) and noticed that, it was ranged from 30.30 days in IIHR-1135 to 37.60 days in CHFB-1 with a mean value of 31.98 days.

Smitha (2005) evaluated French bean genotype and reported that days required for first flowering was maximum in the genotype DWD-FB-80 (38.50) and minimum in the genotype DWD-FB-6 (26.00).

Five vegetable type cowpea varieties were evaluated at Chambas, Tanahu in two consecutive years 2003 and 2004 during rainy season. Results indicated that, the difference among the varieties on days to flowering showed significant difference. Cultivar Prakash took the shortest period of 37 days in the first and second year, whereas IT 86F-2062-5 (White) and IT 86D-798 took the longest period of 44 days Pandey *et al.* (2006).

Rana and Arvind (2008) conducted a field experiment consisting of 16 genotypes of French bean in the temperate mid hills of Himalaya. Among the genotypes, early flowering was recorded in Contender (42.33 days) and IIHR-909 (42.33 days) followed by Arka Komal (43 days).

Futuless *et al.* (2010) observed longer days to flowering (50.12 days) which was recorded in Ife-Brown and other varieties flowered between 38.02 to 50.12 days after sowing.

A varietal trial was conducted on 41 exotic and one local check of French bean to know the duration for first flowering. Among the genotypes G 4069 (35 days) took less number of days for first flowering. While, maximum number of days was recorded in Shalimar Rajmash-1(58 days) under temperate conditions of Kashmir valley (Sofi *et al*., 2011).

According to the results of Pandey *et al.* (2011), the earliest flowering genotype was S-9 (32 days) and the late flowering genotype was Mandir (47 days) in French bean.

The significant difference among the cluster bean genotypes for days to first flowering was recorded by Malaghan (2012). The genotype AVT-II GR-4 took least number of days (23 days) to first flowering while, Bandakeri-I took maximum number of days (39 days), with an average of 27.04 days for appearance of first flower.

Vavilapalli *et al.* (2013) evaluated different cultivars of bush cowpea under Kerala condition to record the duration of flowering. It was shortest in the case of VU 6 (31.29 days) and longest in VU14 (38.40 days).

The study conducted by Kole *et al.* (2014) on variability of 30 Fenugreek genotypes indicated that, the least number of days taken for flowering was in JF-22 (52.33 days). Whereas, the genotype IC-143875 took more number of days (74.50 days).

A varietal trial on pea during rabi season under foot hill condition of Nagaland reported that, number of days taken to first flowering was less in case of PEVAR-2 (21.33 days).While, it was maximum (42.33 days) in genotype VRD-6 (Phom *et al.,* 2014).

2.1.2.2 Days to 50 per cent flowering

2.1.2.2.1 Vegetable soybean

Basavaraja *et al.* (2005) revealed that, among the 10 vegetable soybean genotypes studied, mean performance for days to fifty per cent flowering was minimum in the genotypes GP 15, KB 19 and EC 175332 (35) and maximum days to fifty percent flowering was recorded in the genotype EC 176324 (46).

2.1.2.2.2 Soybean

Malik *et al.* (2006) evaluated 17 soybean varieties for yield components. The results revealed that, the genotype 95049 took more number of days for 50 per cent flowering (55 days) while 95039-B took minimum days for 50 per cent flowering (30 days).

An experiment was conducted by Malek *et al.* (2014) during 2011 to study genetic variability, character association and genetic diversity among 27 soybean mutants and four mother genotypes. The results revealed that, the mutant SBM-11 recorded minimum number of days to 50 per cent flowering (58 days) and maximum number of days to 50 per cent flowering was recorded in mutant BAU-S/64 (80 days).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. From the results it is revealed that, the genotype TGX-1904 (55.17) has taken less number of days to 50 per cent flowering, whereas more number of days to 50 per cent flowering was taken by the genotype TGX-1951 (60.83).

Njoroge *et al.* (2015) evaluated 15 genotypes of soybean for yield and protein content in Kenya. Results revealed that, the genotype DPSB 19 (74.00) took less number of days for 50 per cent flowering and DPSB 8 had took the maximum number of days for 50 per cent flowering.

2.1.2.2.3 Other leguminous vegetable crops

Khyad (1996) noticed earliest flowering in the French bean cultivar of Arka Komal (33.83 days) followed by Burpee's Stringless (34 days).

Dandannavar (2000) recorded the days taken for 50 per cent flowering in winged bean which varied significantly among the genotypes. The genotype PTK-8 took significantly less (91.16 days) number of days to attain 50 per cent flowering compared to all other genotypes.

Nimbalkar *et al.* (2002) evaluated 16 genotypes of French bean revealed that, days to fifty per cent flowering ranged from 28.11 to 35 days.

According to Saiyad (2003) the overall mean days taken to 50 per cent flowering among French bean genotypes were 34.76 days. Range of variation for this character was from 33.10 (Arka Komal) to 38.60 days (CHFB-1).

Dhuhan *et al.* (2005) revealed that, there was significant differences among the genotypes in fenugreek with respect to 50 per cent flowering. Among them HM-211 took maximum days (85.6). While, HM-257 took minimum number of days (75.60).

Sahu *et al.* (2005) evaluated ten winged bean genotypes along with check variety AKWBI. The results revealed that, the genotype Dwarf mutant took least number of days (60) for 50 per cent flowering. Whereas, the genotype EC142665 took maximum number of days (75).

Smitha (2005) evaluated 94 genotype of French bean and recorded the range for days to 50 per cent flowering from 27.50 (DWD-FB-16- 1) to 39.50 (DWD-FB-80) days.

Bhuvneshwari (2008) observed the high variability for days taken to 50 per cent flowering in dolichos bean. Among the genotype variation for this character was ranges from 60 (DA-39) to 95 days (DA-19).

Mohan *et al.* (2009) evaluated dolichos bean genotypes for days to 50 per cent flowering. The variety IIHR 5 (83 days) recorded significantly more number of days to 50 per cent flowering compared to other genotypes. The variety IIHR 177 took least number of days to 50 per cent flowering.

Rai *et al*. (2012) evaluated 31 cluster bean genotypes. They revealed that, the genotype Sarphan took the least number of days (29.50) for 50 per cent flowering. Whereas, RB-1 took maximum number of days (42.50).

Alemu *et al.* (2013) reported that the days to fifty per cent flowering ranged from 38.00 days in PHA-5783/93 to 47.00 days in BC-440 in snap bean.

Among the French bean varieties studied at Bahadari farm, Mandsaur by Sharma *et al.* (2013), the *cv.* Contender has recorded the minimum number of days (31.60) for 50 per cent flowering whereas, the *cv.* Arka Komal took maximum number of days (33) for 50 per cent flowering.

In dolichos bean, Parmar *et al.* (2013) showed that, the minimum number of days to 50 per cent flowering was taken by Pushpa (39.33) and the maximum number of days to 50 per cent flowering was taken by genotype PD 21 (47.30).

Khan *et al.* (2013) reported that, the genotype Climax (60 days) took minimum number of days for 50 per cent flowering followed by Meteor (62.6 days) and FS-21-87. Whereas, maximum number of days for 50 per cent flowering was noted in genotype PS 810240 (82 days) followed by DMR-4 (81 days) in garden peas.

2.1.2.3 Number of clusters per plant

2.1.2.3.1 Other leguminous vegetable crops

Pandey *et al.* (2006) observed that, the difference among the varieties of cowpea on number of clusters per plant was significant. The highest number of clusters (7.80 in 2003 and 8.04 in 2004 with the mean of 7.92) was produced by IT 86F-2062-5. Whereas, the lowest number of clusters (5.43 in 2003 and 5.51 in 2004 with the mean of 5.43) was produced by IT 86F-2062-5.

Arora *et al.* (2011) reported the significant difference among the cluster bean genotypes for number of cluster per plant. The results showed that variation existed for this character with coefficient of variation 17.33 per cent. The number of clusters per plant was varied from 19.00 to 113.40 with a mean of 36.68.

Malaghan (2012) reported the significant difference among the genotypes for number of clusters per plant in cluster bean. Maximum number of clusters per plant was recorded in AVT-I GR-9 (73.00) and minimum in Bandikeri-I (9.00).

In a survey of 31 entries of cluster bean Rai *et al*. (2012) noted that, the number of clusters per plant was maximum in *cv.* Line14 (49.67) and minimum in *cv.* Varsha (12.80).

Girish *et al*. (2013) reported the maximum number of clusters per plant in the genotype HGS-02-1 (12.50) and minimum number of clusters per plant in the genotype AVT-I (6.80) of cluster bean.

2.1.2.4 Number of pods per cluster

2.1.2.4.1 Other leguminous vegetable crops

Anila and Balakrishnan (1990) studied 56 genotypes of guar and reported the considerable amount of variability for pods per cluster with a mean of 5.03 and range of 1.82 to 10.71.

Pandey *et al.* (2006) noticed the non-significant differences among the genotypes in cowpea with respect to number of pods per cluster. Among them, highest numbers of pods (4.77) were recorded in the genotype IT 86D-792.

Arora *et al.* (2011) conducted a study on 30 genotypes of cluster bean and observed that, there was a significant difference among varieties for number of pods per cluster and it was varied from 5.13 to 11.10 with a mean of 7.09.

A study conducted by Malaghan (2012) reported the significant difference among the genotypes of cluster bean for number of pods per cluster which was varied from 3.12 (Bandikeri-I) to 9.60 (RGC-1025) with a grand mean of 6.75.

Among the 31 cluster bean entries studied by Rai *et al*. (2012), the genotype RB-1 has recorded the maximum number of pods per cluster (14.10) and the lowest number of clusters per plant in Line 21 (5.40).

According to Girish *et al.* (2013) a wide variability for number of pods per cluster was noticed in cluster bean and it was reported to be varied from 10.41 (HGS-75) to 16.90 (AVT-I GR-15) with a grand mean of 13.45.

Parmar *et al.* (2013) reported the significant difference among 31 dolichos bean genotypes for number of pods per cluster. Genotype Pusa Sem-2 had maximum number of pods per cluster (12.93) and the lowest was observed in PD-11 (3.66) with a mean of 7.01.

Kole *et al*. (2014) evaluated 30 genotypes of fenugreek in Eastern India. They reported that, range of variance for number of pods per cluster was 14.83 to 32.87 with a mean value of 23.04. Among the genotypes, the JF -17 had the highest number of pods per cluster. Whereas, UM-128 was recorded the lowest pods per cluster.

Among the 29 geographically diverse French bean genotypes, the DWDFB-1 has recorded the maximum per cent pod set per cluster of 67.1 per cent (Kumar *et al.,* 2014).

2.1.2.5 Pod length

2.1.2.5.1 Vegetable soybean

Basavaraja *et al.* (2005) revealed that, among the 10 vegetable soybean genotypes studied, mean performance for pod length was maximum in the genotype EC 175329 (4.61) minimum pod length was recorded in the genotype EC 175324 (3.32).

Sharma *et al.* (2013) studied four vegetable soybean genotypes for yield and quality attributes. Among the genotypes maximum pod length was recorded by SL 388 (4.08 cm) and minimum pod length was recorded by the SL 744 (3.28 cm).

2.1.2.5.2 Other leguminous vegetable crops

In French bean, Saini and Negi (1998) noticed that, the variety, Jwala (14.1 cm) recorded significantly higher pod length compared to other genotypes and it was on par with Him-1 (12.30 cm) and the lower pod length was recorded in Local (9.60 cm).

Roy and Parthasarathy (1999) showed that, the maximum pod length was noticed in *cv.* Tender Crop (13.64 cm) and minimum in *cv.* Manipuri (10.95 cm) out of six genotypes of French bean.

Ramakrishna (1999) evaluated two genotypes of French bean for its pod length. The results revealed that, the variety Arka Komal (13.24 cm) recorded significantly higher pod length as compared to variety Burpee's Stringless.

According to Singh *et al.* (2000) evaluation of French bean genotypes for pod length showed the range from 9.62 cm to 15.16 cm.

Among the 62 genotypes of French bean the pod length was ranged from 9.00 cm to 15.70 cm (Govanakoppa, 2001).

An investigation conducted by Nimbalkar *et al.* (2002) on 16 genotypes of French bean revealed that, the range for pod length was from 9.67 cm to 12.40 cm.

Six fenugreek cultivars were studied by Raje *et al.* (2003) at Jobner and recorded the highest pod length in UM-305 (10.86 cm) and lowest in UM-117 (9.35 cm).

Saiyad (2003) observed the variability for pod length in French bean. The results revealed that, it was ranged from 9.16 cm (IIHR-1137) to 17.58 cm [(220 × AK) 17-2, 3-6-2)] with an overall mean value of 15.01 cm.

Kumar (2004) observed that, the pod length was ranged from 11.39 cm to 18.45 cm in French bean genotypes.

Sahu *et al.* (2005) conducted an experiment to evaluate the performance of ten winged bean cultivars. The results showed that, the mean pod length was significantly higher in *cv.* EC142665 (17.83cm) and the lowest in *cv.* Dwarf mutant (14.34 cm).

Variety JF-210 was found superior for pod length (7.50 cm) and was significantly superior to check Lam Sel-1. On the contrary, the fenugreek genotypes HM-346 and UM-323 were reported to have less pod length (Sarada *et al.,* 2008).

From the study conducted by Smitha (2005) showed that, there was wide variation occurs for green pod length i.e. from 10.75 cm (DWD-FB-71) to 18.36 cm (DWD-FB-62) with a mean of 14.35 cm.

Out of four French bean cultivars evaluated by Abdel *et al.* (2005) during two consecutive year (2003 and 2004) revealed that, the pod length was maximum in Royl Nel (14.59 and 16.75 cm) and minimum in Coby (10.21 and 11.75 cm).

Bhattacharya *et al.* (2006) studied and reported that, there were significant differences among the genotypes with respect to yield attributes in fenugreek. Among five cultivars, the cultivar RM-10 has recorded the higher length of pods (10.78 cm).

Pandey *et al.* (2006) studied five genotypes of bush cowpea and results revealed that, genotypes varied significantly with respect to pod length. The genotype IT 86F- 2062-5(Green) has recorded the longest pods (25.40 cm and 25.80 cm in 2003 and 2004 respectively with the mean 25.60 cm). Whereas, the genotype Prakash (check) has produced the shortest pods (16.21 cm).

Rana and Arvind (2008) studied the 16 genotypes of French bean (*Phaseolus vulgaris* L.) at temperate mid hills of Himalaya. Among the genotypes, the maximum pod length was noticed in Arka Komal with 16.20 cm.

In dolichos bean, 57 genotypes were evaluated by Mohan *et al.* (2009) for pod width. The results revealed that, the variety IIHR 11 (4.10 cm) recorded significantly higher pod width compared to other genotypes and it was on par with IIHR 1, IIHR 8, IIHR 17 and IIHR160. The lower pod width was recorded in IIHR 169 (1.15 cm).

Sarangi and De (2010) observed that, the pod length was highest (16.35 cm) in the variety Selection-9, which was on par with Contender (15.86 cm) in French bean.

Among 42 genotypes of rajmash, Shalimar Rajmash-1 has recorded maximum pod length of 16.86 cm and minimum pod length was recorded in G 51145(8.85 cm) genotype under Kashmir valley conditions (Sofi *et al*., 2011).

In this study, the pod length was significantly differed among 18 genotypes of French bean. The longest pods (15.71cm) were produced by Mandir and shortest pods (10.73 cm) by Mallika (Pandey *et al*., 2011).

Among the 36 genotypes of French bean studied, the pod length was ranged from 9.53 cm in PHA-5783/93 to 14.02 cm in S-61 (Alemu *et al.,* 2013).

Khan *et al*. (2013) in this study reported that, the genotype 2001-55 had the longest pod (9.333 cm) followed by FS-21-87 (8.83 cm) and the lowest pod length (4.38 cm) was found in genotype DMR-4.

Vavilapalli *et al.* (2013) revealed that, the pod length was maximum (32.53 cm) in VU 20 followed by VU 1 (28.20 cm) and was minimum in VU 24 (12.40 cm).

Kole *et al.* (2014) reported that, among the 30 genotypes of fenugreek RMT-1 had the shortest pod length (5.83 cm) while JF-22 had the longest pod length (7.15 cm).

Kumar *et al.* (2014) noticed significant variations among 29 French bean cultivars. The highest pod length was recorded in cv. Arka Anoop fallowed by RCMFB-SKM-2004-12.

Phom *et al.* (2014) assessed seven cultivars of pea during rabi season under Nagaland condition. Among the cultivars, the longest pod length (6.83 cm) was recorded in genotype PEVAR-1 followed by AP-3 having 5.93 cm while the shortest length (4.26 cm) was recorded in genotype the VRD-6(C).

2.1.2.6 Pod width

2.1.2.6.1 Vegetable soybean

Basavaraja *et al.* (2005) revealed that, among the 10 vegetable soybean genotypes studied, mean performance for pod width was maximum in the genotype Cockerstaurt (1.12) minimum pod width was recorded in the genotype EC 175324 (0.86).

Sharma *et al.* (2013) studied four vegetable soybean genotypes for yield and quality atributes. Among the genotypes maximum pod width was recorded by SL 295 (0.87 cm) and minimum pod width was recorded by the SL 744 (0.79 cm).

2.1.2.6.2 Other leguminous vegetable crops

Roy and Parthasarathy (1999) evaluated six genotypes of French bean for pod width and observed no significant difference among the genotypes for pod width.

Dandannavar (2000) studied the significant difference among the winged bean genotypes with respect to pod breadth. The results revealed that, the genotype PTK- 2 had recorded maximum (2.54 cm) pod breadth which was on par with PTK-5 and PTK-7 (2.48 cm each). The pod width was least (2.34 cm) in PTK-6.

In French bean genotypes, Govanakoppa (2001) recorded the pod width which was in the range of 0.44 cm to 1.0 cm.

Kumar (2004) evaluated 22 genotypes of French bean and recorded the pod width in the range of 0.70 cm to 1.15 cm.

Smitha (2005) evaluated and reported that, the green pod width was ranged from 0.40 cm (DWD-FB-54) to 0.90 cm (DWD-FB-47, DWDFB- 53 and DWD-FB-66) with a mean of 0.64 cm in French bean genotypes.

The range pod width from 0.75 cm (PHA-6048/95) to 1.32 cm (PHA-5783/93) was reported by Alemu *et al.* (2013) by studying 36 genotypes of French bean.

An investigation was conducted by Parmar *et al.* (2013) on 30 genotypes of dolichos bean, showed that, the genotype PD-21 had maximum pod width (30.03 mm) and the lowest width was observed in PD-9 (14.96 mm).

Vavilapalli *et al.* (2013) evaluated 22 genotypes of bush cowpea and reported that, the maximum pod girth was recorded in the *cv.* VU 1(2.93 cm). Whereas, minimum pod girth was observed in the *cv.* VU 24 (1.83 cm).

Kumar *et al.* (2014) evaluated 29 varieties of French bean among which the maximum pod width was recorded in Arka Anoop followed by RCMFB-SKM-2004-12.

2.1.2.7 Number of seeds per pod

2.1.2.7.1 Soybean

Sharma *et al.* (2013) studied four vegetable soybean genotypes for yield and quality attributes. Among the genotypes maximum number of grains per pod was recorded by SL 295 (2.31) and minimum number of grains per pod was recorded by the SL 688 (2.16).

Ali *et al.* (2013) tested the growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60 and PSC-60 through field study. Results revealed that, more number of seeds per pod was observed in the variety PSC-60 (2.87), whereas minimum number of seeds per pod was observed in the variety Williams-82 (2.23).

Obidiebube *et al.* (2013) conducted a field experiment to evaluate the adaptation of ten soybean varieties to this agro-ecological zone. Results revealed that, variety TGx1910-8F recorded the highest number of seeds per pod (17.7), whereas lowest number of seeds per pod was recorded by variety TGx-6F (10.10)

An experiment was conducted by Malek *et al.* (2014) during 2011 to study genetic variability, character association and genetic diversity among 27 soybean mutants and four mother genotypes. The results revealed that SBM-13 mutant recorded maximum number of seeds per pod (2.53) and minimum number of seeds per pod was recorded in BAU-S/64 mutant SBM-25 (1.70).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. From the results it is revealed that, the genotypes TGX-1904 and TGX-1951 (2.83 each) had more number of seeds per pod, whereas less number of seeds per pod was recorded by the genotype TGX-1935 (2.17).

Njoroge *et al.* (2015) evaluated 15 genotypes of soybean for yield and protein content in Kenya. Results revealed that, SBH 10/5/6, SBH 1/12/9, SBH 7/1/1, SBH 4/4/4/, EAI3600 and DPSB 8931/5/34 (2.40 each) genotypes has recorded the maximum number of seeds per pod and Gazelle (1.90).

2.1.2.7.2 Other leguminous vegetable crops

Jadhao (1993) evaluated three genotypes of French bean namely, VL-63 (10.5), HUR-87 (10.20) and HUR-15 (9.40) and noticed no significant difference in number of seeds per pod.

In vegetable cowpea, Narayanankutty *et al.* (2003) noticed wide range for seeds per pod from 11.65 to 18.90.

The three genotypes French bean namely, KPV-1, EC-39439, Pusa Parvati and FB-2 had more number of seeds per pod Singh *et al.* (2007).

An investigation carried out by Bhuvneshwari (2008) in cluster bean revealed that, the number of seeds per pod ranged from 3.20 (DA-43) to 5.37 (DA-36) with a mean of 4.15.

The investigation carried out by Sarangi and De (2010) revealed that, Kentucky wonder recorded higher number of seeds per pod (7.77) and the lower number of seeds per pod was in Pusa Parvati (5.58).

2.1.2.8 Pod yield per plant

2.1.2.8.1 Vegetable soybean

Basavaraja *et al.* (2005) revealed that, among the 10 vegetable soybean genotypes studied, mean performance for pod yield was highest in the genotype GP 15 (11418) and lowest pod yield was recorded in the genotype EC 175324 (6201).

Sciarappa *et al.* (2007) evaluated 16 vegetable soybean cultivars for pod yield per plant. Results revealed that, cultivar Taiwame has recorded the highest pod yield of 389.60 g per plant and the cultivar Neu Ta Pien (1.50 g) has recorded the lowest pod yield per plant.

Sarutayophat (2012) conducted a field experiment on 22 vegetable soybean genotypes to determine the association of yield and its components. The results revealed that, the genotype AGS 334 has recorded higher pod yield per plant (71.6 g), while the genotype AGS 330 has recorded the lower pod yield per plant (33.83 g).

According to Poornima *et al.* (2014) among ten vegetable soybean genotypes, AGS 447 gives the maximum pod fresh weight of 62.00 g per plant. While the minimum pod fresh weight per plant was recorded in the genotype AGS 461 (31.00 g).

2.1.2.8.2 Other leguminous vegetable crops

Dandannavar (2000) in winged bean reported that, the genotype PTK-8 had recorded significantly higher vegetable pod yield (1.04 kg) followed by PTK-5, PTK-7 and PTK-9 (0.93, 0.87 and 0.86 kg, respectively). The genotype PTK-6 was least (0.53 kg) in vegetable green pod yield production.

Singh *et al.* (2000) reported the range for pod yield per plant from 49.00 g to 143.33 g by evaluating the French bean genotypes.

In French bean Govanakoppa (2001) observed that, the range for pod yield per plant was from 49.85 g to 157.0 g.

Ndegwa *et al.* (2004) reported that, among the eight introduced French bean varieties, Kutuless-J12 significantly out yielded all the other varieties in the first season and out yielded check variety by 48 per cent in the second season.

Smitha (2005) reported that, there was a wide range from 40.20 g (DWD-FB-49) to 186.15 g (DWD-FB-53) with a mean of 92.58 g for this character among these French bean genotypes.

Mohan *et al.* (2009) evaluated 57 varieties of dolichos bean for yield per plant. Among these genotypes, IIHR 150 (576.90 g) recorded significantly higher yield per plant as compared to other genotypes except IIHR 159. The lower yield per plant was observed in IIHR 169.

Sarangi and De (2010) showed that, the variety Contender has recorded higher pod yield (747.92 g) while, lower pod yield was recorded in Kentucky wonder (96.77 g).

In cluster bean, Arora *et al.* (2011) reported the significant difference among genotypes. Highest yield per plant was recorded in PCB-9 (0.807 Kg) followed by BR- 112 (0.798 Kg). The check Pusa Navbahar recorded 0.674 Kg pods per plant.

Malaghan (2012) reported that significant difference among the genotypes of cluster bean for vegetable pod yield per plant. It was ranged from 15.65 g (Bandikeri-I) to 268.90 g (IC 11704) with a mean of 119.63 g.

Rai *et al.* (2012) observed significant difference among the cluster bean genotypes for this character. The vegetable pod yield per plant in the cluster bean genotypes ranged from 57.74g (Varsha) to 222.34g (Line-22).

Girish *et al.* (2013) reported wide variability for vegetable pod yield per plant among the genotypes cluster bean. It was ranged from 34.60 g (HGS-70) to 103.20 g (NS-661) with average mean of 63.70 g.

Evaluation of 36 genotypes of French bean for green pod yield per plant showed that, the variety HAB-430 (143.60 g) produce higher green pod yield per plant whereas BC- 44 (32.20 g) produce lower green pod yield per plant (Alemu *et al.,* 2013).

Chadha *et al*. (2013) conducted the evaluation trial of different garden pea varieties consecutively for two years (2011-12 and 2012-13) at Palampur for identifying suitable varieties. Among 55 genotypes, variety IC267732 (55.72g) recorded maximum yield per plant as against the lowest in variety KMMR-89 (14.6 g) in 2011-12. While, in 2012-13, variety EC538008 (52.13 g) found to be high yielder whereas var. KMMR-89 recorded minimum yield per plant (5.21 g).

A field experiment conducted by Parmar *et al.* (2013) for two consecutive years from 2002 to 2003 in Ludhiana during kharif seasons revealed that, the accession PD-10 had registered the highest yield per plant (2.03 kg) followed by the Pusa Sem 2 (1.79 kg) and least in the PD-21 (0.26 kg).

A study was conducted by Vavilapalli *et al.* (2013) to assess the genetic variability in 22 diverse genotypes of bush cowpea during the period 2011-2012 at Vellayani, Kerala. Among the genotypes, yield per plant was highest in genotype VU 6 (310.41 g) and lowest was in VU 15 genotype (150.86 g).

Among 29 French bean varieties Kumar *et al.* (2014) reported that, variety IVFB-1 gave highest yield ((246.40 g) per plant followed by the variety VRFBB-2 (235.60 g).

Phom *et al.* (2014) assessed seven cultivars of pea under Nagaland condition. It was observed that, the genotype PEVAR-1 produced the highest pod yield per plant (29.67 g) whereas minimum yield per plant (22.00g) was recorded in the genotype VRD- 6(C).

2.1.2.9 Pod yield per plot

2.1.2.9.1 Other leguminous vegetable crops

In winged bean Dandannavar (2000) showed that, the green pod yield was significantly higher (17.16 kg plot^{-1}) in PTK-8 compared to all other genotypes. The green pod yield was least in PTK-6 (9.66 kg plot^{-1}) and this was on par with PTK – 4 (11.24 kg plot^{-1}).

Sarangi and De (2010) reported that**,** the highest mean pod yield of 747.92 g m^{-2} was observed in the variety Contender. Whereas, the variety Kentuky Wonder produced the lowest pod yield of 96.77 g m^{-2} under Mid-hills of Arunachal Pradesh.

Girish *et al.* (2013) reported wide variability for vegetable pod yield per plot among the cluster bean genotypes and it was ranged from 458.00 g (IVT- I GR-17) to 2393.50 g (NS-661) with an average mean of 1063.09 g.

Sharma *et al.* (2014) reported that, the mean performance results for pod yield per plot in dolichos bean revealed that, genotype 10/DOLPVAR-6 (38.50 kg) has recorded the highest protein per cent in pod. Whereas lowest protein per cent of 1.30 per cent each was recorded in the genotype 08/DOLBVAR-1(2.30 kg).

Cowpea genotypes were evaluated and characterized by Reddy *et al.* (2016) for growth, yield and quality parameters. Among the 14 genotypes, KUR-MOHINI (10.33 kg) has recorded the highest pod yield per plot, whereas the genotype 2012/COPBVAR-3 (4.20 kg) has recorded the minimum pod yield per plot.

2.1.2.10 Pod yield per hectare

2.1.2.10.1 Vegetable soybean

Basavaraja *et al.* (2005) evaluated ten vegetable soybean genotypes for yield and component traits. The results revealed that, fresh pod yield varied between 11418 kg ha^{-1} (Cockerstaurt) and 6201 kg ha^{-1} (EC 175324).

2.1.2.10.2 Other leguminous vegetable crops

Evaluation of six genotypes of French bean for its green pod yield under variable climatic conditions by Joshi *et al.* (1993) revealed that, the variety VL-6 out yielded other varieties numerically except VL-5 in summer season. These varieties when grown under rainy season, exhibited remarkable increase in green pod yield over summer season. The variety Contender (108.69 q ha^{-1}) recorded higher green pod yield followed by VL-5 and Arka komal.

Ramakrishna (1999) observed that, among two varieties of French bean Arka Komal (22.09 q ha^{-1}) recorded significantly higher green pod yield per ha than Burpee's Stringless.

An investigation carried out by Dandannavar (2000) reported that, the winged bean genotype PTK-8 was superior by recording significantly highest green pod yield per hectare (10.11 t ha^{-1}), followed by PTK- 5 (8.98 t ha^{-1}), PTK-9 (7.89 t ha^{-1}) and PTK-7 (7.68 t ha^{-1}). The genotype PTK–6 was the poorest (5.51 t ha^{-1}) performer with regard to green pod yield.

Abdel *et al.* (2005) evaluated four French bean genotypes for pod yield and revealed that, the genotype Coby recorded highest yield (4.083 and 4.891 t fed^{-1}) in first and second seasons respectively. While, it was lowest in case of Royl Nel (3.444 and 4.114 t fed^{-1}, respectively).

Pandey *et al.* (2006) revealed that, the difference among the varieties on marketable fresh pod yield was highly significant. IT 86F-2062-5 produced the highest marketable fresh pod yield of 4.97 t ha^{-1} followed by IT 86F-2062-5 produced 3.81 t ha^{-1}. While, Prakash produced the lowest yield (2.44 t ha^{-1}).

Screening of four French bean varieties for pod yield per hectare during rabi season showed that, the variety Arka Anoop (20.00 t ha^{-1}) recorded significantly higher green pod yield per hectare than other varieties (Aghora *et al.,* 2007).

Ndegwa *et al.* (2007) evaluated French bean lines for pod yield per hectare during rainy season. Among 11 lines, JSAMX5 (9.74 t ha^{-1}) recorded significantly higher green pod yield per ha while, lowest pod yield per hectare was observed in SAMJX3 (1.60 t ha^{-1}).

An investigation conducted by Singh *et al*. (2007) reported that Contender, EC-94461, VRF-2, Arka Komal, HUR-15, Pusa Parvati, FB-33A, VRF-1, HUF-0 and HUR-4 were found most promising and higher pod yielding genotypes.

Rana and Arvind (2008) noticed that, among the 16 genoypes of French bean, the green pod yield was maximum in IIHR-909 (130.00 q ha^{-1}) followed by CH-808 (123.33 q ha^{-1}) and MFB-2 (114.07 q ha^{-1})**.**

Chadha *et al*. (2013) observed that *cv.* EC538008 was recorded the highest yield (108.58 q ha^{-1}) and was statistically on par with Kukumseri-6 (101.61 q ha^{-1}), IC 267732 (101.07 q ha^{-1}), DPPM-74 (92.84 q ha^{-1}) and DPP-54 (91.96 q ha^{-1}) and it was statistically on par with two standard checks *viz.,* Palam Priya (85.24 q ha^{-1}) and Punjab-89 (91.12 q ha^{-1}) out of 55 varieties of garden pea screened during Rabi 2011-12 & 2012-13 for higher productivity under organic farming conditions.

According to Khan *et al.* (2013) highly significant variation in pod yield was observed among different genotypes of peas. Genotype 2001-55 had a maximum pod yield (10.43 t ha^{-1}) followed by FS-21-87 (9.25 t ha^{-1}) and Shareen (8.43 t ha^{-1}), whereas minimum yield recorded in genotype 9461091 produced minimum yield (3.74 t ha^{-1}) followed by DMR-4 (4.91 t ha^{-1}).

An investigation carried out by Sharma *et al.* (2013) revealed that, yield and yield parameters of French bean were significantly influenced by varieties. Cultivar Swarna Priya recorded highest pod yield per hectare (104.05 q ha^{-1}) followed by *cvs.* Arka Komal and Contender (94.38 q ha^{-1} and 86.33 q ha^{-1} respectively).

Phom *et al.* (2014) evaluated the performance of pea genotypes for growth and yield traits. As per the result, the genotype PEVAR-1 recorded the highest green pod yield (56.60 q ha^{-1}) followed by genotype PEVAR-4 (55.57 q ha^{-1}) and it was lowest (43.20 q ha^{-1}) in VRD- 6(C).

2.1.2.11 Hundred seed weight

2.1.2.11.1 Vegetable soybean

Vegetable soybean genotypes accessions developed by AVRDC, Taiwan were evaluated by Marutani and Schlub (2003) reported that weight of 100 seeds ranges from 12.30 g to 21.40 g. The accession AGS 190 gives more 100 seed weight (21.40 g) and lowest seed weight was recorded in AGS 336 (12.30 g).

Basavaraja *et al.* 2005 revealed that, among the 10 vegetable soybean genotypes studied, mean performance for hundred seed weight was highest in the genotype KB 19 (35.80) and lowest hundred seed weight was recorded in the genotype EC 175324 (16.70).

Sharma *et al.* (2013) studied four vegetable soybean genotypes for yield and quality attributes. Among the genotypes maximum hundred seed weight was recorded by SL 295 (6.10 g) and minimum hundred seed weight was recorded by the SL 688 (12.60 g).

Ramya and Mummigatti (2015) observed that, highest green seed test weight was recorded in AGS-610 (64.97) and lowest in Dsb-21 (15.17) among the vegetable soybean genotypes.

2.1.2.11.2 Soybean

Ali *et al.* (2013) tested the growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60 and PSC-60 through field study. Results revealed that highest hundred seed

weight was observed in the variety Williams-82 (15.73 g), whereas lowest hundred seed weight was observed in the variety PSC-60 (12.57 g).

Poornima *et al.* (2014) screened ten vegetable soybean genotypes for 100 seed weight. It was highest in the genotype AGS 406 (35.90 g) and lowest 100 seed weight was recorded in JS-335 (15.70 g).

Njoroge *et al.* (2015) evaluated 15 genotypes of soybean for yield and protein content in Kenya. Results revealed that, genotypes Gazelle and Nyala (17.50 and 17.60 g) has recorded the highest hundred seed weight. While lowest hundred seed weight was recorded by the SBH 13/8.5/1 (10.50 g).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. From the results it is revealed that, the genotype TGX-1448 (55.17 g) has recorded the highest hundred seed weight, whereas lowest hundred seed weight was recorded by the genotype TGX-1935 (11.57 g).

2.1.2.12 Seed yield per plant

2.1.2.12.1 Vegetable soybean

Among the ten cultivars studied by Basavaraja *et al.* (2005) highest mean value for seed yield was ranged from 4983 in cultivar Himso 1563, while lowest mean value of 2033 was recorded in cultivar EC 175324.

In vegetable soybean, Ramya and Mummigatti (2015) observed that, the highest seed yield was recorded in Swarna (60.27) and lowest was recorded in the genotype AGS 477 (12.66).

2.1.2.12.2 Soybean

Ali *et al.* (2013) tested the growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60 and PSC-60 through field study. Results revealed that, the highest seed yield per hectare was observed in the variety PSC-60 (697.30 kg ha^{-1}), whereas minimum number of seeds per pod was observed in the variety Williams-82 (354.20 kg ha^{-1}).

Malek *et al.* (2014) evaluated 31 genotypes of soybean and reported that, the mean performance for the seed yield per plant was maximium in the SBM-27 (13.60 g) while, the minimum seed yield per plant was recorded in the genotype SBM-18 (8.00 g)

2.1.2.12.3 Other leguminous vegetable crops

Devi *et al.* (2012) investigated 33 genotypes of French bean and reported that, the genotype DPDFB-2(M) has recorded the maximum seed yield per plant of 38.57 g and minimum seed yield of 12.58 g was recorded in the genotype JFB-97-1.

2.1.2.13 Seed yield per hectare

2.1.2.13.1 Soybean

Growth and yield performance of four soybean varieties *viz.,* Rawal, Williams-82, SA-72-60, and PSC-60 was conducted by Ali *et al.* (2013). Soybean variety PSC-60 showed best performance as it gave significantly higher seed yield (697.3 kg ha^{-1}) and variety Williams-82 recorded lowest seed yield per hectare (354.82 kg).

Haruna *et al.* (2015) conducted a field experiment to determine the performance of five soybean genotypes in Northern Guinea Savanna. From the results it is revealed that, the genotype TGX-194 (1133.30 kg) has highest seed yield per hectare, whereas lowest seed yield per hectare was recorded by the genotype TGX-1935 (925.00 kg).

Soybean varieties were evaluated by Aniekwe (2015) for their growth and yield in a derived savanna part of south-eastern Nigeria. The variety TGx1844-18E had recorded higher seed yield per hectare (11.35 t) and variety TGx1485-1D had recorded lower seed yield per hectare (6.22 t).

2.1.2.14 Pubescence

According to Poornima *et al.* (2014) pod pubescence varies distinctly among the genotypes indicating there is lot of diversity. Among ten genotypes, AGS 339, AGS 380, AGS 447, AGS 460, AGS 461 and Swarna produce hairy pods. While others AGS 406, AGS 610 and JS-335 produces non hairy pods and AGS 457 and AGS 459 produce less hairy pods.

2.1.3 Quality parameters

2.1.3.1 Protein

2.1.3.1.1 Vegetable soybean

Carson *et al.* (2011) evaluated five edamame cultivars and reported that, the cultivar BS292 and BS2001 had the least and greatest protein concentrations with 36.10 per cent and 38.30 per cent in 2008, respectively. In 2009, cultivars MG and SR had the least and greatest protein concentrations with 35.70 per cent and 39.50 per cent respectively.

Ten vegetable soybean genotypes were evaluated for nutrient and anti nutrient component by Salmani *et al.* (2012). The results reported that, the protein percentage was highest in AGS 435 (14.96 g), whereas the lowest protein percentage was recorded in the genotype GC- 99010-35-1-2-2 (12.32 g).

Sharma *et al.* (2013) evaluated four genotypes of vegetable type soybean namely SL 688, SL 744, SL 295 and SL 525 for physico-chemical, sensory and cooking quality attributes. The results revealed that, the mean per cent protein was 11.93 per cent and ranged from 10.93 for SL 525 to 13.89 per cent for SL 688.

Poornima *et al.* (2014) screened ten vegetable soybean genotypes for physiological parameters yield and yield parameters and reported that, seed protein percentage was ranged from 17.80 per cent to 44.20 per cent. Highest protein per cent was recorded in the genotype AGS 447 (44.20 per cent) and lowest was recorded in the genotype Swarna (17.80 per cent).

2.1.3.1.2 Soybean

Njoroge *et al.* (2015) evaluated 15 genotypes of soybean for yield and protein content in Kenya. Results revealed that, the genotype DPSB 19 has recorded the highest protein content of 40.30 per cent and lowest protein content was recorded in 931/15/34 (35.20 per cent) genotype.

2.1.3.1.3 Other leguminous vegetable crops

An experiment was conducted with 25 genotypes of dolichos bean for analysis of protein content in pod. Mean performance results revealed that, genotype 08/DOLPVAR-5 (19.50 per cent) has highest protein content in pod. Whereas lowest protein content of 1.30 per cent each was recorded in the genotypes 08/DOLBVAR-3 and 08/DOLPVAR-6 (Sharma *et al.,* 2014).

In French bean Sharma *et al.* (2016) reported that, the mean protein per cent was highest in the genotype Azad Razma (21.00 per cent), while lowest protein was recorded in the genotype VRFBB-80 (7.50 per cent).

2.1.3.2 Total sugars

2.1.3.2.1 Vegetable soybean

Sharma *et al.* (2013) evaluated four genotypes of vegetable type soybean namely SL 688, SL 744, SL 295 and SL 525 for physico-chemical, sensory and cooking quality attributes. The results revealed that, the total sugars were highest in the genotype SL 525 (3.70 per cent) and lowest in the genotype SL 744 (2.50 per cent).

2.1.3.2.2 Other leguminous vegetable crops

In French bean Sharma *et al.* (2016) reported that, the mean total sugars per cent was highest in the genotype VL Bean-3 (8.50 per cent), while lowest protein was recorded in the genotype Swarnapya (3.00 per cent).

2.1.3.3 Starch

Sharma *et al.* (2013) evaluated four genotypes of soybean namely SL 688, SL 744, SL 295 and SL 525 for physico-chemical, sensory and cooking quality attributes. The results revealed that, the starch content was highest in the genotype SL 744 (4.05 per cent) and lowest in the genotype SL 688 and SL 525 (3.78 per cent).

2.1.3.4 Trypsin inhibitory activity

2.1.3.4.1 Vegetable soybean

Ten vegetable soybean genotypes were evaluated for anti-nutrient component by Salmani *et al.* (2012). The trypsin inhibitor content of vegetable soybean genotypes ranged from 23.05 to 28.89 unit mg^{-1} of protein. The highest content was observed in GC- 98017-7-196-1-2 (28.89 units mg^{-1}) and the lowest in AGS-434 (23.05 units mg^{-1}).

2.1.3.5 Texture

Jae-Yeun Song *et al.* (2013) observed the texture of vegetable soybean which was measured by texture analyser and reported that, the force of 575.6±41.80 g required in raw soybean, 468.9±20.50 g in

blanched soybean at 80˚C for 30 min, 391.7±51.50 g in blanched soybean at 90˚C for 20 and 283.8±41.20 g in blanched soybean at 100˚C for 10 minutes.

2.2 Correlation and path analysis

The expression of a character in a plant is the consequence of a chain of inter relationships between characters either directly or throughout other events. In any crop, yield is a complex character being influenced by several other traits. Selection for such traits may not necessarily lead to its improvement unless the unfavourable linkages among such components are favourably adhered through hybridization.

Correlation coefficients provide a measure of association among characters and can serve to identify the characters of high yielding ability, while making selection for base population. The path analysis reveals whether the association between yield and other characters are direct or not. The technique of path co-efficient analysis was developed by Wright (1921) and is still considered as a valuable tool in detecting the real merits of characters contributing yield.

Reports of many authors on correlation and path analysis of green pod yield per plant with yield components and studies on association of different yield components with green pod yield per plant are presented below.

2.2.1 Correlation studies

2.2.1.1 Vegetable soybean

Sarutayophat (2012) observed positive and statistically significant relationships for the plant height with the number of marketable pods per plant (0.821, $p < 0.01$) and with the marketable pod yield per plant (0.520, $p < 0.05$) and for the number of marketable pods per plant with the marketable pod yield per plant (0.822, $p < 0.01$).

Correlation coefficients of fresh pod yield and yield components of vegetable soybean were investigated by Li *et al.* (2013). The results showed that, fresh pod yield was positively correlated with 3-seed pod per plant (0.81**), 2-seed pod per plant (0.76**), 2-seed pod width (0.59**) and 100-fresh seed weight (0.47**) and negatively correlated with plant height (-0.75**) and 2-seed pod length (-0.64**).

2.2.1.2 Soybean

Aditya *et al*. (2011) opined that, at genotypic and phenotypic level, yield per plant showed highly significant positive correlation with number of pods per plant, dry matter weight per plant, harvest index and number of primary branches per plant in soybean.

Mahbub *et al.* (2015) 28 evaluated soybean genotypes for eleven morphological characters. From the results significant positive genotypic and phenotypic correlations were found between days to first flowering, days to 50 per cent flowering, days to maturity, plant height, number of branches per plant and pod length. Number of pods per plant showed significant positive correlations with plant height, branches per plant and seed yield. Seed yield showed the highest significant positive genotypic and phenotypic correlation with pod length followed by number of seeds per pod, branches per plant, plant height and number of seeds per number of pods per plant, hundred seed weight, branches per plant, plant height and number of seeds per plant.

2.2.1.3 Other leguminous vegetable crops

Dahiya *et al*. (2000) reported that, in French bean the values for genotypic correlation coefficient were significantly higher than corresponding phenotypic values.

Govanakoppa (2001) noticed that, the pod yield per plant was positively correlated with plant height (0.191), number of primary branches (0.151) and number of secondary branches (0.111). Plant height had significant and positive correlation with number of pods per plant (0.330). Number of primary branches showed negative correlation with plant height (-0.090), pod breadth (-0.109) and pod width (-0.015). Number of secondary branches is significant and positively correlated with plant height (0.223) and pod length (0.300) and pod width was negatively correlated with plant height, number of primary branches and number of secondary branches at genotypic level in French bean.

Patel and Choudhari (2001) reported that, the genotypic correlation coefficients were higher than their corresponding phenotypic correlation coefficients. Grain yield per plant was found to be positively and significantly associated with all the characters except pod length.

Javid *et al*. (2002) reported that, the biological yield of pea has significant positive correlation with grain yield and grain yield has significant positive correlation with harvest index.

Singh *et al.* (2002) reported that, pods per plant had a significant and positive association with days to 50 per cent flowering, plant height, number of branches per plant and number of clusters per plant. The number of clusters per plant was positively and significantly correlated with plant height and number of branches per plant. Days to 50 per cent flowering had a positive significant association with plant height in cluster bean.

Kutty *et al.* (2003) stated that, the number of pods per plant, number of pickings, average weight of pods and pod length were positively and significantly correlated with yield per plant both at phenotypic and genotypic levels.

Venkatesan *et al.* (2003) stated that, the magnitude of genetic correlation was higher than that of phenotypic correlation in 20 genotypes of cowpea. The number of clusters per plant was positively associated with number of branches per plant, number of pods per cluster and number of pods per plant, but was negatively correlated with number of days to flowering.

Yadav *et al.* (2003) revealed that studying 28 F_1 and 28 F_2, green pod yield per plant had positive and significant association with plant height, pods per cluster, pod length in all the three generations.

Hanchinamani (2003) carried out correlation coefficient analysis in 80 genotypes and revealed that, a significant and positive association of vegetable pod yield per plant with number of branches per plant, number of leaves per plant, plant spread (East-West) and number of clusters per plant.

Positive and highly significant correlations were found between fresh pod yield per plant and pod harvest period, number of pods per plant, pod width and length. There was also significant and positive correlations among fresh pod yield per plant and number of branches per plant (Peksen, 2004).

Nath and Korla (2004) reported that, green pod yield per plant was negatively correlated with plant height (-0.025), pod length (-0.521) and number of pods per plant (-0.934) and days to first flowering was positively correlated with number of green pods per plant (0.087) and negatively correlated with plant height (-0.456) at genotypic level in 28 genotypes of French bean.

Singh *et al.* (2004) stated that, plant height exhibited significant correlation with number of branches per plant, clusters per plant and pods per plant. Branches per plant exhibited positive

correlation with clusters per plant and pods per plant. The number of clusters per plant was significantly correlated with pods per plant in cluster bean genotypes.

Simple correlation coefficient and path analysis were calculated for seven characters with 441 exotic French bean germplasm lines by Bhushan *et al.* (2005). Seed yield per plant had showed positive and significant correlation with number of pods per plant and pod length**.** However, number of pods per plant exhibited positive and significant correlations with pod length, days to maturity and plant height.

Singh *et al.* (2005) carried out correlation coefficient analysis in 24 advanced cluster bean genotypes. High estimates of the phenotypic and genotypic coefficients of variation were obtained for pod yield per plant, pods per plant, clusters per plant, days to flowering and branches per plant.

Roy *et al.* (2006) Relationship between yield and its component characters of 27 bush bean (*Phaseolus vulgaris* L.) genotypes were studied during November 2002 to February 2003. Days to 50 per cent flowering, duration of flowering, plant height and pods per plant had high degree of significant positive correlation with yield per plant.

Bhushan *et al*. (2007) reported that, days to 50 per cent flowering showed negative non-significant correlation with number of pods per plant (-0.041) and pod length (-0.038). Significant positive correlation with days to maturity (0.538) and plant height (0.479). Pod length showed positive and significant correlation with plant height (0.179), whereas positive but non-significant with days to maturity (0.010) in French bean.

Dursun (2007) reported the high correlation between pod numbers per plant, fresh pod weight and yield and they were found positive and significant.

Golani *et al.* (2007) green pod yield had showed significant and positive correlation with pod width at genotypic level and significant and negative relationship with days to first picking at both levels in hyacinth bean.

A study involving 20 diverse pea genotypes for four summers Sharma *et al.* (2007) revealed positive association of pod yield per plant with pods per plant, pod length and seeds per pod.

Nawab *et al.* (2008) revealed that, days to emergence showed a positive and significant association with number of pods per plant (0.446) and a negative and significant correlation of days to emergence was observed with pod length (-0.402) and green pod yield per plot (-0.489).

Pod length in common bean showed highly significant and positive correlation with green pod yield per plant. It also showed significant and negative correlation with days to fifty per cent flowering in both the genotypic and phenotypic level. It indicates that as the days to fifty per cent flowering increases there is correspond decrease in pod length (Salehi *et al*., 2008).

Sarada *et al.* (2008) based on their investigations with 12 genotypes of fenugreek conducted over four years reported that in general the phenotypic correlation coefficients were smaller than genotypic correlation coefficients for majority of the characters. Among the yield component characters, plant height with number of pods per plant (0.961 and 0.971) and pod length (0.818 and 0.939); number of pods per plant with pod length (0.743 and 0.932) and pod length with number of seeds per pod (0.815 and 0.979) showed significant positive association both at phenotypic and genotypic level.

Anjani *et al*. (2009) reported that in French bean, green pod yield per plant showed positive and significant association with number of pods per plant and pod length.

Based on their study on field pea, Shivastava *et al.* (2009) suggested that cluster per plant, pods per plant seed per plant and harvest index must be taken in to account during the course of selection for higher yield in dry pea. They further reported characters like pod bearing length, plant height, and seed setting per cent and 100 seed weight as potential characters.

Kumari *et al.* (2010) carried out the correlation studies in cowpea and the results of genotypic correlation revealed that, days to fifty per cent flowering was highly positive significant relationship with days to maturity. Plant height had highly positive significant correlation with number of branches per plant and pods per plant.

Singh *et al.* (2010) evaluated 44 genotypes of cluster bean and reported that days to flowering appeared to have high correlation with days to maturity, primary branches per plant, plant height, pods per clusters and pods per plant and biological yield per plot.

A study on 30 bean cultivars was conducted by Karasu and Oz (2010) and reported positive correlations among number of pods per plant with number of seeds per plant ($r=+0.866^{**}$) number of seeds per pod ($r=+0.306^{**}$) biomass yield ($r=+0.848^{**}$), seed yield per plant ($r=+0.860^{**}$) and plant height ($r=+0.188^{**}$). Number of seeds per plant were given positive and significant associates with number of seeds per pod ($r=+0.658^{**}$), biomass yield ($r=+0.849^{**}$) and seed yield per plant ($r=+0.854^{**}$). While number of seeds per pod had positive and significant correlations with biomass yield and seed yield per plant.

Yadav *et al.* (2010) Pods per plant were positively and significantly associated with number of primary branches. This suggests that, the higher pods per plant are possible in varieties which bear more number of primary branches in pea.

Islam *et al.* (2011) reported that, there was positive correlation between pod yield with individual pod weight (r=0.540), number of pods per plant (r=0.71) and harvesting duration (r=0.198) in hyacinth bean.

Correlation of pod yield per plant in yard long bean was found to be highly significant and positive for pod weight, number of pods per plant, pod length at both genotypic and phenotypic level and pod diameter at genotypic level and negatively significant for days to first flowering and days to marketable harvest at both level (Ullah *et al.,* 2011).

Singh *et al.* (2011) reported that, pod yield/plant showed maximum positive and significant association with number of pods per plant (0.708) at both genotypic and phenotypic levels. The days to first flower showed the positive correlation with days to first picking (0.763) in dolichos bean.

Correlation coefficient studies in common bean revealed that yield was significantly correlated with number of pods per plant (0.732) followed by 100 seed (0.430), leaf area (0.371), seeds per pod (0.355) and plant height (0.329) but was negatively correlated with days to flowering, days to maturity and pod length (Sofi *et al*., 2011).

Angadi *et al.* (2012b) noticed that, pod yield per hectare was significant and positively correlated with pod yield per plant, pod length, plant height, leaf area ,leaf area index ovule number per pod, pod width at both genotypic and phenotypic level. Days to 50 per cent flowering showed significant and negatively associated with the yield. Number of branches exhibited significant association with stem thickness, number of pods per plant. Plant height exhibited significant association with number of pods per plant, pod length, pod width and yield per plant and negative significant association with days to 50 per cent flowering, leaf area index strongly and positively associated with pod length and pod yield per plant both at genotypic and phenotypic level and negative significant correlation with days to 50 per cent flowering and pod width. Pod length had strong positive correlation with pod yield per plant. Pod width exhibited strong positive significant association with yield per plant at both genotypic and phenotypic

levels. Leaf area has significant and positive association with leaf area index, pod length and pod yield per plant while significant negative correlation with days to 50 per cent flowering at both genotypic and phenotypic levels in French bean.

Gangadhara (2012) found the highly significant and positive association of green pod yield with number of branches per plant, number of pods per plant, plant height, pod length and hundred seed weight in French bean.

Girish *et al*. (2012) reported that, cluster bean green pod yield per plant showed positive and significant correlation with dry pod yield per plant, green pod yield per plot, number of clusters per plant, plant height both at 45 and 90 DAS, plant spread North-South direction at 45 DAS, stem girth, number of pods per cluster, cluster length and pod length.

Kulaz and Ciftci (2012) conducted a study to determine the relationship among yield and some yield components of 12 dry bean cultivars during 2004-2005 and 2005-2006. Positively significant relationships were found among seed yield and biological yield per unit and seed yield per plant, number of branches per plant, number of pods per plant.

Pal and Singh (2012) opined that, the green pod yield per plant had positive and highly significant correlation with plant height, days to first flower emergence, days to 50 per cent flower emergence, days to maturity of edible green pod, number of primary branches per plant at phenotypic and genotypic level, respectively while pod width at genotypic level only. Plant height was positively correlated with pod length in garden pea.

Bahadur *et al.* (2013) reported that, the traits like plant height, number of primary branches per plant, number of inflorescence per plant, number of flowers per inflorescence, number of pods per inflorescence, number of pods per plant, number of seeds per pod, pod length, pod width and pod weight showed positive significant correlation with pod yield per plant at both genotypic and phenotypic levels in dolichos bean.

Gangadhara (2013) noticed that, germination had highly positive and significant correlation with pod yield per plot (r= 0.733), pod yield per hectare (r= 0.737), number of pods per cluster (r= 0.580) and it had highly negative correlation with number of cluster per plant (r= -0.724) in cluster bean.

The genotypic and phenotypic correlation of pod yield with yield components revealed that, the pod yield per plant was positively and significantly associated with green pod width, number of flowers per cluster, pod length and individual green pod weight. While, negatively correlated with days to 50 percent flowering and days to maturity in dolichos bean (Magalingam *et al.*, 2013).

Kumar *et al*. (2014) conducted correlation studies on 18 marketable pod yield and yield attributing traits in 44 accessions of French bean and revealed that, marketable pod yield per plant had highly significant and positive association with pod length, pod weight, number of pods per plant and pod width.

Correlation coefficient analysis revealed that, number of pods per plant, pod width, pod weight and pod length had positive correlation with pod yield per plant (Kiran *et al.* 2014). The traits like number of branches and leaf length showed positive relation with yield at the same time days to 50 per cent flowering and days to first picking showed negative effect on yield. Hence, direct selection for these characters may lead to the development of high pod yielding dolichos genotypes.

Field experiment was conducted by Alemu *et al.* (2017) to study the nature and extent of association among 16 traits in snap bean genotypes. Results reported that, there is a positive and significant genotypic correlation between green pod yield with number of pod per plant (rg=0.775), single green pod weight (rg=0.664), pod dry weight (rg=0.333), pod length (rg=0.537) and leaf area per plant

(rg=0.665) while significant negative genotypic correlation was found between green pod yield and days to 50 per cent flowering (rg=-0.437) and days to first picking (rg=-0.557).

2.2.2 Path coefficient analysis

2.2.2.1 Vegetable soybean

Sarutayophat (2012) observed the direct effect of the number of marketable pods per plant and green pod weight on marketable pod yield were positive and significant with path coefficient of 1.310 ($p < 0.01$) and 0.707 ($p < 0.01$), respectively. The number of marketable pods per plant had the highest value of the direct effects (1.310, $p < 0.01$) on marketable pod yield. Plant height and 100 beans weight had non-significantly negative direct effects on marketable pod yield with path coefficient value of -0.102 and -0.077, respectively. The indirect effect of plant height on marketable pod yield through its association with the number of marketable pods per plant was significantly positive (1.075, $p < 0.01$), suggesting a positive relationship between the plant height and number of marketable pods per plant.

Path coefficient analysis of fresh pod yield and yield components of vegetable soybean were investigated by Li *et al.* (2013). The results revealed that, 3-seed pod per plant (0.58) had the greatest direct positive effect on fresh pod yield followed by 2-seed pod per plant (0.56), 2-seed pod width (0.31) and 100 fresh seed weight (0.23), whereas plant height (-0.36) and 2-seed length (-0.35) had negative direct effect on fresh pod yield.

2.2.2.2 Soybean

Mahbub *et al.* (2015) in soybean showed that, seeds per pod had the maximum positive direct effect on yield (1.20) followed by hundred seed weight (0.739), pod length (0.072), days to maturity (0.062) and plant height (0.043). Number of pods per plant showed the highest negative direct effect on yield (-0.040) followed by branches per plant (-0.031), days to first flowering (-0.010), number of seeds per pod (-0.004) and days to 50 per cent flowering (-0.001).

2.2.2.3 Other leguminous vegetable crops

Vardhan and Savithramma (1998) studied the path coefficient analysis for green pod yield per plant in 29 accessions of cowpea and concluded that, green pods per plant, pod length, pod width and number of primary branches were major traits contributing to yield.

Govanakoppa (2001) found that, plant height, number of primary branches and number of secondary branches had negative direct effect on yield. Days to first flowering, pod width and pod breadth had positive direct effect on yield in French bean.

Shinde and Dumbre (2001) reported that, 100 seed weight showed strong positive direct effect on yield while the direct negative effect on yield was observed for pod length and days to first flowering in French bean.

Kumar *et al.* (2002) studied five cowpea cultivars and showed that dry fodder yield had the highest direct positive contribution towards green fodder yield followed by number of days to 50 per cent flowering, number of branches per plant and plant height respectively.

Path analysis indicated that the number of pods per plant followed by average weight of pods and number of pickings had the greatest positive direct effect on yield in cowpea (Kutty *et al.,* 2003).

The path analysis for ten traits were conducted by Venkatesan *et al.* (2003) using 20 genotypes of cowpea and it showed the positive direct effect of number of pods per plant, pod length, number of clusters per plant and number of seeds per pod on yield.

Yadav *et al.* (2003) found that dry matter in pod, pods per plant and plant height was the main components of green pod yield in the early generation of cowpea.

Kumari *et al.* (2010) revealed that, the number of clusters, pods, seeds per pod, and 100 seed weight showed the greatest positive direct effects on seed yield in cowpea.

Nath and Korla (2004) conducted path analysis for some quantitative characters in dwarf French bean in relation to pod yield and revealed that plant height, days to first flowering, pod length and number of pods per plant had positive direct effect on yield.

Raffi and Nath (2004) observed that, numbers of pods per plant, pod length, number of seeds per plant they have direct effect on yield. Days to 50 per cent flowering had a positive but non-significant direct effect on yield. Days to maturity and plant height had negative direct effect on yield in French bean.

Path coefficient analysis revealed that, number of pods per plant, pod length was most important traits contributing towards yield of French bean (Bhushan *et al.,* 2005).

Path analysis indicated that pods per plant, days to 50 per cent flowering, plant height and pod length had positive direct effect on seed yield per plant. Those traits could therefore be of useful for yield improvement programme of bush bean (Roy *et al.*, 2006).

Rai *et al*. (2006) reported that in French bean, maximum direct effect was observed in pod weight followed by number of pods per plant towards yield.

Path coefficient at genotypic level revealed that, number of branches per plant and pod width showed higher direct effect on green pod yield. High positive indirect effect on green yield was recorded by plant height and plant spread, number of branches per plant, pod length and days to first picking in hyacinth bean (Golani *et al.,* 2007).

Nawab *et al.* (2008) revealed that, days to 50 per cent flowering exhibited positive direct effect on green pod yield per plot (1.4831) whereas pod length (-2.8041), days to emergence (-2.1703) and pods weight per plant (-1.7951) had negative direct effect on green pod yield per plot. Days to emergence, days to 50 per cent flowering and pods weight per plant showed maximum positive indirect effects through number of pods per plant on green pod yield per plot. Pod length showed maximum negative direct effect on green pod yield per plot in pea.

Mishra *et al*. (2009) reported that, green pod yield per plant had negative association with days to 50 per cent flowering in French bean.

Singh *et al.* (2010) evaluated 44 genotypes of cluster bean and reported that, biological yield per plot had direct positive effect on seeds per pod followed by harvesting index, pods per plant and days to 50 per cent flowering.

Yadav *et al.* (2010) studied the direct and indirect effect of yield contributing traits on yield and revealed that, the maximum positive direct effect was exhibited by pods per plant followed by days to maturity and pod length, while days to flowering, number of primary branches and plant height had negative direct effect on yield in pea.

Makhdoomi and Dar (2011) reported in French bean plant height, pods per plant and pod length are the major yield components by path coefficient analysis.

Path analysis revealed that, number of pods per plant, pod length and pod width had positive, while days to first flowering had negative direct effect on pod yield per plant. The highest indirect effect on number of pods per plant (0.761) on pod yield was obtained through days to first flower (0.148), days to first picking (0.142) and per cent fruit set per cluster (0.095) in hyacinth bean (Singh *et al.*, 2011).

Angadi *et al.* (2012a) studied the 12 genotypes of French bean for path coefficient analysis. Path coefficient analysis revealed that, leaf area, pod weight, number of pods per plant, pod length and pod width exerted maximum direct effect on pod yield per hectare at both genotypic and phenotypic level. Leaf area index had highest indirect effect on pod yield per hectare through leaf area at genotypic level and pod length had highest indirect effect on pod yield per hectare through weight of 10 pods at phenotypic level.

Gangadhara (2012) revealed that number of branches per plant at 60 DAS and pod length were the most influencing factors on pod yield per plant in French bean.

Girish *et al*. (2012) reported that, in cluster bean dry pod yield per plant (0.574 and 0.879), green pod yield per plot (0.377 and 0.057) and dry pod yield per plot (0.242 and 0.055) had high direct effect on green pod yield per plant at both genotypic and phenotypic level respectively.

According to Kulaz and Ciftci (2012) there were strong direct effects of the biological yield, 1000-seed weight, seed yield per plant, plant height and number of seeds per plant respectively in 12 dry bean cultivars.

Pal and Singh (2012) revealed that, days to maturity of green pods had highest positive and direct effect (38.052) on green pod yield per plant followed by pod width (6.466), number of primary branches per plant (4.666), days to first flower emergence (2.98). Days to 50 per cent flower emergence (-23.501) had highest negative effect on green pod yield per plant followed by days to first pod set (-13.438), pod length (-6.246), number of pods per plant (-4.189) at genotypic level. Whereas, days to 50 per cent flower emergence (-1.068) had highest negative direct effect on green pod yield per plant followed by pod length (-0.408) at phenotypic level in pea.

Mehra and Singh (2012) evaluated 70 germplasm of French bean for their direct and indirect effects on pod yield per hectare during January-May at Pantnagar. Path coefficient analysis revealed that, the pod yield per plant had highest (0.9225) direct effect on pod yield per hectare followed by number of pods per cluster(0.1640), days to 50 per cent maturity (0.0566), number of primary branches per plant (0.0461) and number of pods per plant (0.0102). The positive direct effect of pod yield per plant on pod yield per hectare was enhanced by its positive indirect effect *via* number of pods per cluster (0.7516), number of pods per plant (0.7087), days to 50 per cent flowering (0.2845), pod length (0.1806), plant height (0.1134) and number of primary branches per plant (0.1015).

Tiwari and Lavanya (2012) noticed that, days to maturity, plant height and pod length showed high positive direct effect on yield. Selection for plant height, days to 50 per cent flowering, number of pods per plant, pod length and days to maturity give good response in field pea yield improvement.

Ahmed and Kamaluddin (2013) path analysis was studied in 57 germplasm lines of rajmash beans for yield and yield contributing traits. Significant variations were observed for plant height, number of pods per plant and yield. They noticed that, Days to 50 per cent flowering, number of pods per plant and pod length had maximum positive direct effect on yield. Plant height had negative direct effect on yield.

Bahadur *et al.* (2013) in dolichos bean, seed germination per cent, number of inflorescence per plant, number of flowers per inflorescence, number of pods per plant, days to first picking after sowing, pod length and pod weight had positive direct effect both at genotypic and phenotypic path level.

According to Magalingam *et al.* (2013) the days to maturity, pod length, plant height, green pod width and number of pods per cluster had negative direct effect on yield per plant in field bean.

Path analysis for green pod yield per plant revealed that traits like number of pods per plant and pod weight exhibited high positive direct effects on green pod yield per plant in French bean (Kumar *et al*., 2014).

Genotypic path analysis shows that, yield per plant exhibited positive direct effect (1.138) and had strong positive association with yield per hectare (rG=0.905). The positive indirect effects were through days to 50 per cent flowering (0.015), pods per cluster (0.035) and pod breadth (0.046). Phenotypic path coefficient shows that yield per plant had high positive direct effect (0.879) and strong degree of association (0.787) for pod yield per hectare in cluster bean (Rai and Dharmatti, 2014).

Shanko *et al.* (2014) revealed that, yield per plant exerted the maximum positive direct effect on yield followed by number of pods per plant, while number of secondary branches per plant, days to flowering, days to maturity and number of seed per pod exhibited negative direct effect phenotypically. In addition, genotypic path analysis revealed that, maximum direct effect on yield was exerted by number of pods per plant and yield per plant. However, days to 50 per cent flowering, days to maturity, number of secondary branches per plant and number of seed per pod exerted negative direct effect on yield.

Path coefficient analysis showed that, pod length and pods per plant had maximum direct effect on pod yield per plant. The high direct effect of the trait indicated its true relationship with pod yield and hence selection would be rewarding in yield improvement (Sheela *et al.,* 2014).

Field experiment was conducted by Alemu *et al.* (2017) to study the nature and extent of association among 16 traits in snap bean genotypes. Genotypic path analysis showed that pod number per plant exerted the maximum positive direct effect (0.688) on green pod yield followed by single green pod weight (0.539) while plant height exhibited maximum negative direct effect (-0.458).

III. MATERIAL AND METHODS

The present investigation on Evaluation of vegetable soybean (*Glycine max* (L.) Merrill) genotypes for horticultural traits in eastern dry zone of Karnataka was carried out at College of Horticulture, UHS campus, GKVK (Post), Bengaluru from August 2016 to November 2016. Experiment was conducted to find out the best performing genotype for vegetable type soybean for eastern dry zone of Karnataka and to study its growth, yield and acceptance parameters. The details of the experiment conducted and the methods followed for analysis of the data are presented in this chapter along with an account of the general cultural practices adopted during the period of the experiment.

3.1 Geographical location and Climate

The field experiment was carried out at Vegetable Science Research Block, College of Horticulture, UHS Campus, GKVK (Post), Bengaluru, Karnataka. The research farm is situated between 13.05º latitude and 77º East longitudes at an altitude of 924 m above mean sea level.

3.2 Experimental details

3.2.1 Experimental material

Seventeen genotypes of vegetable soybean collected from Department of Biotechnology and Crop Improvement, College of Horticulture, Bengaluru formed the experimental material. The list of genotypes collected and used in the experiment are given below

Sl. No.	Name of the genotypes used
1.	COHBSBM-26
2.	COHBSBM-8
3.	IC 501197
4.	COHBSBM-66
5.	COHBSBM-49
6.	COHBSBM-54
7.	IC 25763
8.	AGS 433
9.	W - 80
10.	EC 24207
11.	AGS 432
12.	EC 95286
13.	Karune
14.	IC 501164
15.	GC 99013-5
16.	GC 110318
17.	EC 103153

The 17 vegetable soybean genotypes were collected from the Dept. of Biotechnology, College of Horticulture, Bengaluru.

3.2.2 Design and experimental layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each replication consists of 17 treatments and are replicated randomly in all the three replications. Each treatment consists of six rows of 66 plants in a plot.

The experimental details are as follows:

1. Crop : Vegetable soybean
2. Number of genotypes : 17
3. Number of replications : Three
4. Plot size : 2.20 m × 2.70 m
5. Spacing between rows : 45 cm
6. Spacing between plants : 20 cm
7. Statistical design : Randomised Complete Block Design (RCBD)
8. Season : *Kharif,* 2016
9. Location : Vegetable Science Block, College of Horticulture, UHS Campus, GKVK (Post), Bengaluru, Karnataka.

Table 1: List of genotypes used for the study

T_1 - COHBSBM-26	T_{10} - EC 24207
T_2 - COHBSBM-8	T_{11} - AGS 432
T_3 - IC 501197	T_{12} - EC 95286
T_4 - COHBSBM-66	T_{13} - Karune
T_5 - COHBSBM-49	T_{14} - IC 501164
T_6 - COHBSBM-54	T_{15} - GC 99013-5
T_7 - IC 25763	T_{16} - GC 110318
T_8 - AGS 433	T_{17} - EC 103153
T_9 - W-80	

3.3 Cultural operations

The cultural operations constitute the following sequence of work.

3.3.1 Preparation of experimental plot

The experimental plot was brought to a fine tilth by repeated ploughing and harrowing. The plots of required dimensions were prepared as per the field layout. A space of 0.5 m was kept between the replications for taking observations and to carried out intercultural operations.

3.3.2 Sowing and gap filling

Ridges and furrows are opened at a distance of 45 cm apart. Before one day of sowing, furrows are irrigated sufficiently and then seeds were sown at a distance of 20 cm in the furrows during *kharif* season 2016.

3.3.3 Fertilizer application

The recommended dose (62.5:100:75 NPK kg ha^{-1}, FYM 25 t ha^{-1}) were applied in the form of urea, Di-Ammonium Phosphate (DAP) and Murite of Potash (MOP) respectively at the time of sowing. According to the fertilizer schedule full dose of P and K and half dose of nitrogen was applied at the time of sowing and the remaining half dose of nitrogen was applied 30 days after sowing.

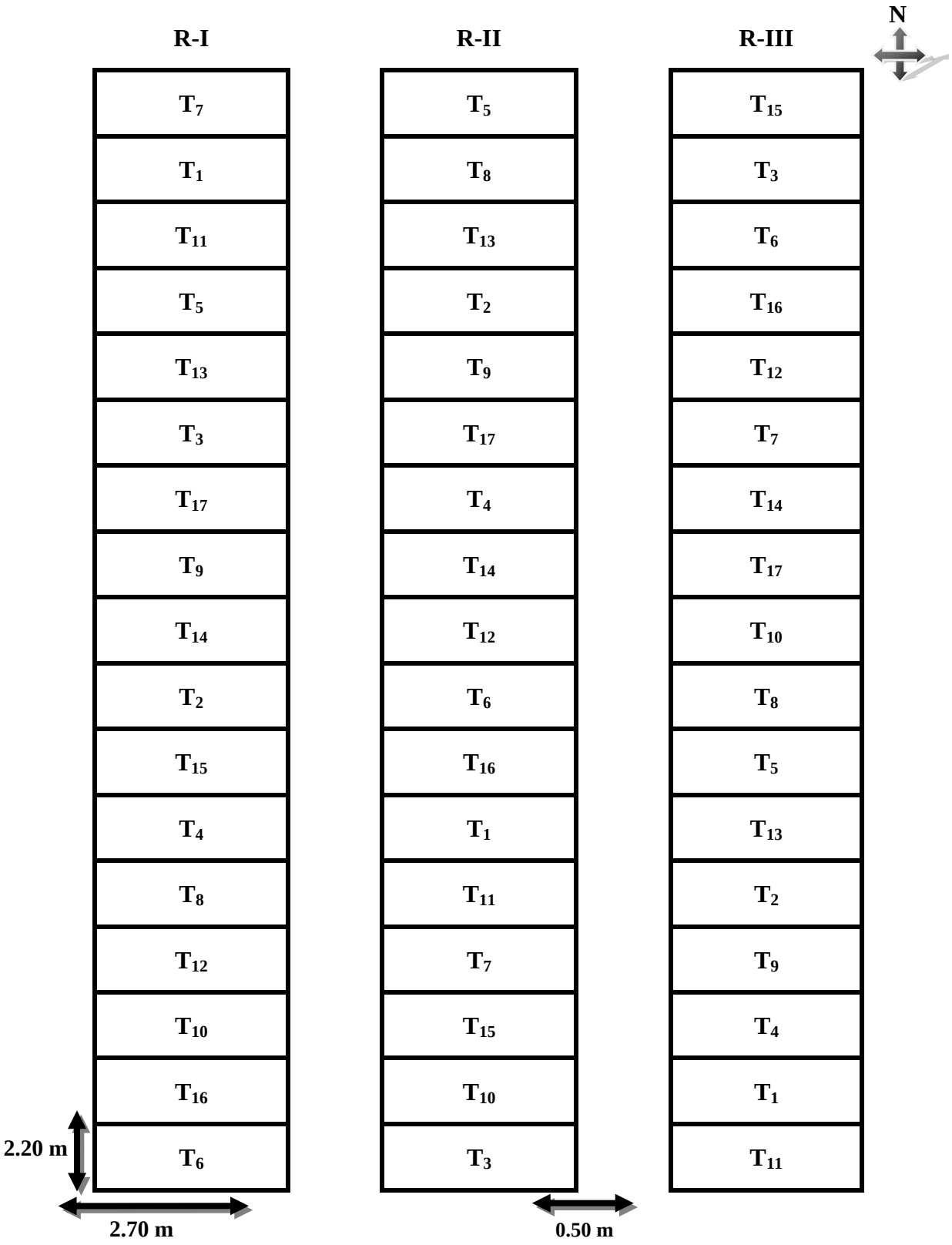

Fig. 1: Layout of experimental plot

Plate 1: General view of the experimental plot of vegetable soybean

3.3.3 Weeding

The plots were kept weed free by 2-3 hand weedings and earthing up was done at 45 days after sowing.

3.3.4 Irrigation

Irrigation was given at an interval of 3-5 days during experimentation, depending on the soil moisture status and climatic conditions.

3.3.5 Plant protection

The incidence of pests like stem fly, thrips, whitefly and leaf eating caterpillars were noticed during crop season. For effective management Chloropyriphos (2 ml l^{-1}), Acephate (1.5 g l^{-1}), Dimethoate (1.5 ml l^{-1}) and Dichlorovos (1 ml l^{-1}) were sprayed at different stages of growth.

3.3.6 Harvesting

For vegetable type soybean pods were harvested at R6 stage i.e. 65-70 days after seed sowing.

3.4 Observations recorded

For recording various observations, five plants in each treatment or genotype selected randomly by avoiding border plants from the plots. The selected plants were tagged for taking observations on various growth and yield parameters.

3.4.1 Growth parameters

3.4.1.1 Plant height (cm)

The plant height was measured from ground level to the tip of the plant at 30, 60 and 90 days after sowing. The plant height was measured with the help of meter scale and average was computed and expressed in centimetres.

3.4.1.2 Number of leaves per plant

At 30, 60 and 90 days after sowing, number of trifoliate leaves per plant was counted in five randomly selected plants from the plots.

3.4.1.3 Number of branches per plant

Numbers of primary branches arising from main stem were counted at 30, 60 and 90 days after sowing and the average data was worked out.

3.4.1.4 Growth habit

Based on the plant growth growing habit is determined as determinate, indeterminate or semi determinate.

3.4.2 Yield and yield attributing characters

3.4.2.1 Days to first flowering

The day on which the first flower appeared was noted on the five randomly selected plants and the days to first flowering were counted from the date of sowing and the average was calculated and expressed as days to first flowering.

3.4.2.2 Days to 50 per cent flowering

Days to 50 per cent flowering was recorded from the five randomly selected plants and the average was worked out from date of sowing and expressed in days.

3.4.2.3 Pod Length (cm)

Pod length (cm) was measured on randomly selected ten pods at the time of harvest and expressed in centimeters.

3.4.2.4 Pod width (cm)

The width of the ten selected pods was measured at the centre of pods and average was worked out.

3.4.2.5 Number of pods per cluster

Number of pods produced on pod bearing cluster of tagged plants in each experimental plot was counted and average was worked out.

3.4.2.6 Pod yield per plant (g)

The weight of green vegetable soybean pods harvested from the tagged plants was recorded separately and the sum of all harvests was used to work out the vegetable pod yield per plant.

3.4.2.6 Pod yield per plot (kg)

The vegetable soybean pod yield per plot was computed by summing up pod yield of all the harvests in each treatment and from these data yield per plot was computed in kilograms.

3.4.2.7 Pod yield per hectare (q)

The vegetable pod yield per hectare was computed by summing up pod yield of all the harvests in each treatment and from these data yield per hectare in quintals was computed.

3.4.2.8 Number of seeds per pod

Number of seeds per pod were counted and recorded from the randomly selected plants at the harvesting stage.

3.4.2.9 Seed size (cm)

Seed length and width was measured using vernier calliper from the dry seeds and expressed in centimeters.

3.4.2.10 Hundred seed weight (g)

Weight of hundred well dried seeds selected randomly from the plants and weight was recorded using weighing balance.

3.4.2.11 Seed yield per plant (g)

Seed yield per plant was recorded by shelling the dry vegetable soybean pods after harvesting and expressed in terms of grams.

3.4.2.12 Seed yield per plot (kg)

Seed yield per plot was recorded by shelling the dry vegetable soybean pods after harvesting and expressed in kilograms.

3.4.2.13 Seed yield per hectare (q)

Seed yield per hectare was recorded by shelling the green vegetable pods after harvesting and expressed in terms of quintals.

3.4.3 Quality parameters

Vegetable soybean beans were analyzed for texture, protein, starch, total sugars (reducing and non-reducing) and trypsin inhibitory activity.

3.4.3.1 Estimation of Protein content (Lowry's method-Lowry, 1951)

Reagents

- Na_2CO_3 - 2 per cent
- NaOH - 0.1 N
- Trichloroacetic acid (TCA) - 10 per cent
- $CuSO_4$ - 0.5 per cent
- Sodium Potassium Tartarate - 2 per cent
- Folin-Ciocalteau Reagent (FCR) – 1N

3.4.3.1.1 Standard graph preparation

Standard stock: 100 mg of Bovine serum albumin was dissolved in distilled water and volume made up to 100 ml in standard volumetric flask (1 mg ml^{-1}).

Working standard: 10 ml of standard stock solution was taken and diluted to 100 ml with distilled water (100 µg ml^{-1}).

Standards were prepared by taking 0 (blank), 0.2, 0.4, 0.6, 0.8 and 1.0 ml of the working standard and volume was made to 1 ml by taking distilled water. To this 5 ml of reagent C was added and kept for 10 minutes at ambient temperature. 0.5 ml of 1 N Folin-Ciocalteau reagent was added and incubated for 30 minutes in dark at ambient temperature. The absorbance was read using UV-VIS spectrophotometer at 660 nm against blank. The standard graph was plotted by taking concentration standards on X-axis and absorbance on the Y-axis.

Preparation of sample: Take 0.1 g of sample and crush in two ml of ten per cent cold trichloro acetic acid (TCA) buffer using pestle and mortar. Centrifuge this supernatant at 5000 rpm for ten minutes and discard the supernatant and collect the pellets. Again pellets are suspended in the 1ml of ten per cent cold trichloro acetic acid and centrifuged for ten minutes at 5000 rpm. Discard the supernatant and collect the precipitate and dissolve in ten ml of 0.1 N sodium hydroxide.

The following reaction mixture was prepared.

Reagent A: 2 per cent Na_2CO_3 in 0.1 N NaOH.
Reagent B: 0.5 per cent $CuSO_4$ in 5 ml of 2 per cent sodium potassium tartarate.
Reagent C: 50 ml reagent A + 1 ml reagent B.
Reagent D: 1 N Folin-Ciocaltaeu reagent.

Procedure: Take 0.2 ml of aliquot in test tube, make up the volume to 1 ml by adding the distilled water. Then add 5 ml of reagent C to it and shake well. Leave for 10 minutes. Then add 0.5 ml of 1 N Folin-Ciocaltaeu reagent. Place it in a dark place for 30 minutes. After 30 minutes blue coloured complex will be developed. Read the intensity of blue coloured complex at 660 nm UV-VIS Spectrophotometer against reagent blank. Protein content was calculated using standard graph formula.

Calculation

$$\text{Protein (g } 100g^{-1}) = \frac{\text{Graph value} \times \text{Volume of TCA buffer}}{\text{Sample taken}}$$

3.4.3.2 Starch

3.4.3.2.1 Standard graph preparation

Standard stock: 100 mg of standard glucose stock was dissolved in distilled water and volume made up to 100 ml in standard volumetric flask (1 mg ml^{-1}).

Working standard: 10 ml of standard stock solution was taken and diluted to 100 ml with distilled water (100 µg ml^{-1}).

Prepare the standards by taking 0.2, 0.4, 0.6, 0.8 and 1ml in each tube with water. Add 4 ml of anthrone reagent to each tube. Heat for 10 minutes in a boiling water bath. Cool rapidly and read the intensity of green to dark green colour at 630 nm and glucose content in the sample was calculated by using the standard graph, multiply with a factor 0.9 to get the starch content (Sadarivam and Mahickam, 1996).

Preparation of sample: One gram of sample was crushed in ten ml of 80 per cent ethanol using pestle and mortar. The contents were centrifuged for ten minutes at 4000 rpm and the supernatant will be discarded. Then the residue is dissolved in five ml of two per cent hydrochloric acid. Heat this in a water

bath at 100° C for about 30 minutes and later make up the volume to ten ml with distilled water. Again centrifuge for ten minutes at 4000 rpm.

Preparation of ice cold anthrone reagent: Weigh 0.2 gram of anthrone reagent and dissolve in 100 ml of 72 per cent concentrated sulphuric acid and keep it in refrigerator.

Procedure: Take 0.2 ml aliquot of sample, add five ml of ice-cold anthrone reagent and shake well. Heat this mixture in on a boiling water bath for ten minutes and cool it rapidly on ice cubes. Intensity of green to dark green coloured complex will be measured in UV-VIS Spectrophotometer at 630 nm against reagent blank. Starch content was calculated using standard graph formula.

3.4.3.3 Sugars

Sugars present in the vegetable soybean samples were estimated, following the method of Lane and Eynon described by Ranganna (1986) with some modifications.

3.4.3.3.1 Reducing sugar

Preparation of sample: One gram of sample was homogenized in five ml of distilled water. The solution was then filtered through Whatman No. 1 filter paper and the filtrate was used for analysis.

Procedure : Five ml of Fehling's solution [Fehling's A (5 ml) + Fehling's B (5 ml)] with 25 to 50 ml of distilled water was taken in a conical flask, heated to boil and titrated against the filtrate sample using methylene blue as an indicator. The end point of titration was brick red colour.

Calculation

$$\text{Reducing sugar (\%)} = \frac{\text{Factor} \times \text{Volume made up}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

3.4.3.3.2 Total sugars

Total sugars were determined by Anthrone method (Dubios *et al.,* 1951).

3.4.3.3.1 Standard graph preparation

Standard stock: 100 mg of standard glucose stock was dissolved in distilled water and volume made up to 100 ml in standard volumetric flask (1 mg ml^{-1}).

Working standard: 10 ml of standard stock solution was taken and diluted to 100 ml with distilled water (100 µg ml^{-1}).

Prepare the standards by taking 0.2, 0.4, 0.6, 0.8 and 1 ml in each tube with water. Add 4 ml of anthrone reagent to each tube. Heat for 10 minutes in a boiling water bath. Cool rapidly and read the intensity of green to dark green colour at 630 nm and glucose content in the sample was calculated by using the standard graph, multiply with a factor 0.9 to get the total sugar content (Sadarivam and Mahickam, 1996).

Preparation of sample: One gram of sample was crushed in 10 ml of 80 per cent ethanol and content was centrifuged for 10 minutes at 4000 rpm, supernatant is made up to 10 ml.

Procedure: Further to the 0.1 ml of the extract, 4 ml of the anthrone solution was added and heated for 10 minutes in a boiling water and was allowed to cool at room temperature. Intensity of blue green coloured complex will be measured by the UV-VIS spectrophotometer. Total sugar content was calculated using standard graph formula.

3.4.3.3.3 Non- reducing sugars (%)

The content of non-reducing sugars was calculated using the following formula (Ranganna, 1977).

Non-reducing sugars (%) = Total sugars (%) – Reducing sugars (%)

3.4.3.4 Trypsin inhibitory activity

The trypsin activity was determined using casein as the substrate (Kempohalli and Chandrashekharaiah, 2013).

Preparation of sample: Prepare 80 ml of Na_2HPO_4 and 20 ml of NaH_2PO_4 with distilled water and make up the volume to 100 ml with distilled water. From this 25 ml of sodium phosphate buffer was taken separately and 40 µg of trypsin enzyme was added.

Procedure: Forty µg of trypsin was taken in 2 ml of sodium phosphate buffer, pH 7.6 containing 0.15 M NaCl. The reaction was initiated by the addition of 2 ml of 2 per cent casein at 37° C. The reaction was stopped after 20 minutes by the addition of 6 per cent trichloroacetic acid (6 ml) and after standing for 1 hr, the suspension was filtered through whatman no. 1 filter paper. Absorbance of the filtrate was measured at 280 nm using spectrophotometer.

Calculation

$$\text{Trypsin Inhibitory Activity } (\mu \text{ mol min}^{-1}\text{ mg}^{-1}\text{ of sample}) = \frac{\text{O. D. value} \times \text{Volume of reaction mixture (L)} \times 10^6}{\text{Extinction coefficient of trypsin (1490)} \times \text{Incubation time} \times \text{Aliquot taken} \times 50 \text{ mg}}$$

3.4.3.5 Texture

Texture of the green beans was measured by texture analyser. The force required to penetrate the beans was analysed and expressed in terms of grams.

3.4.4 Qualitative parameters

3.4.4.1 Flower colour

Flower colour was recorded during flowering period as purple, light purple, dark purple and white.

3.4.4.2 Hairiness/pubescence on pods

Pubescence density on pods was recorded as high, medium, sparse and less.

3.4.4.3 Chorophyll content

Chlorophyll content in the plants was determined by using Spad Chlorophyll Meter reading.

3.4.5 Sensory evaluation (9 point hedonic scale)

Organoleptic evaluation of vegetable soybean beans were tasted for sensory attributes such as colour, taste, hardness, surface texture and overall acceptability by a panel of four judges using a nine point hedonic scale as laid out by Ranganna (1986).

Sensory evaluation

Name: _____ Date: _____

Sample code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Colour																	
Taste																	
Surface texture																	
Hardness																	
Overall acceptability																	
Remarks																	

Note: Hedonic rating scale **Signature**

Score card

No.	Scoring for colour, taste, surface, hardness and overall acceptability	Score
1	Like extremely	9
2	Like very much	8
3	Like moderately	7
4	Like slightly	6
5	Neither like nor dislike	5
6	Dislike slightly	4
7	Dislike moderately	3
8	Dislike very much	2
9	Dislike extremely	1

3.5 Statistical analysis

The data of the experiment was subjected to statistical analysis of RCBD as described by Panse and Sukhatme (1985). The level of significance used in 'F' test was P = 0.05. Critical difference was calculated whenever the 'F' test was found significant.

3.5.1 Analysis of Variance (ANOVA)

The mean values of the genotypes were used for analysis of variance. Replication wise mean values were subjected to RCBD analysis. The significance of difference among all genotypes was tested using 'F' test.

The model of analysis of variance was given below:

Sources of variation	Degrees of freedom (d. f)	Sum of squares (SS)	Mean sum of squares (MSS)	'F' cal
Replication	r-1	RSS	RMSS	TrMSS/EMSS
Treatment	t-1	TrSS	TrMSS	
Error	(r-1)(t-1)	ESS	EMSS	
Total	rt-1	TSS		

Where,

t = Number of treatments (genotypes)
r = Number of replications
SS = Sum of square
MSS = Mean sum of square
DF = Degrees of freedom

Standard error of mean (S.Em±) and critical difference (CD) were worked out using appropriate formulae for comparing the means of the treatments.

3.5.1.1 Standard error of mean (S.Em±)

It is the measure of the mean difference between sample estimate of mean (x) and the population parameter (μ) i.e. it is the measure of controlled variation present in a sample and is denoted by S.Em.

$$\text{S.Em} \pm = \sqrt{\text{EMSS}/\text{r}}$$

3.5.1.2 Critical difference (C.D.)

Critical difference is used to compare the observed differences among different treatments. If the difference is greater than critical difference, it is considered as significant and *vice versa* and is denoted by CD.

$$\text{CD} = \sqrt{2 \times \text{S.Em} \times \text{t}}$$

Where,

S.Em = Standard error of mean
t ='t' table value at error degrees of freedom

3.5.2 Correlation analysis

The correlation co-efficient among all possible character combinations at phenotypic (rp) and genotypic (rg) level were estimated by employing formula (Al- Jibouri *et al.*, 1958).

$$\text{Phenotypic correlation } r_{xy}(p) = \frac{\text{Cov}_{xy}(p)}{V_x(p) \times V_y(p)}$$

$$\text{Genotypic correlation } r_{xy}(g) = \frac{\text{Cov}_{xy}(g)}{V_x(g) \times V_y(g)}$$

Where,

Covxy (G) = Genotypic covariance between x and y
Covxy(P) = Phenotypic covariance between x and y
Vx(G) = Genotypic variance of character 'x'
Vx(P) = Phenotypic variance of character 'x'
Vy(G) = Genotypic variance of character 'y'
Vy(P) = Phenotypic variance of character 'y'

The test of significance for association between characters was done by comparing table 'r' values at n-2 error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively.

3.5.3 Path co-efficient analysis

Path co-efficient analysis suggested by Wright (1921) and Dewey and Lu (1959) was carried out to know the direct and indirect effect of the morphological traits on plant yield. The following set of simultaneous equations were formed and solved for estimating various direct and indirect effects.

$r_1y = a + r_{12}b + r_{13}c + \ldots\ldots\ldots\ldots\ldots\ldots + r_{11}i$

$r_2y = a + r_{21}a + b + r_{23}c + \ldots\ldots\ldots\ldots\ldots + r_{21}i$

$r_3y = r_{31}a + r_{32}b + c + \ldots\ldots\ldots\ldots\ldots\ldots + r_{31}i$

$rny = rn_{11}a + r_{12}b + r_{13}c + \ldots\ldots\ldots\ldots\ldots + l$

Where,

'r_{1y}' to 'r_{ny}' = Co-efficient of correlation between causal factors '1' to 'n' with dependent characters 'y'.

r_{12}, r_{21}, r_{31},…. rni = Correlation coefficients between casual factors '1' to 'n'
a, b, c…….l = Direct effects of characters 'a' to 'l' on the dependent character 'y'

Residual effect (R) was computed as follows.

$$\text{Residual effect (R)} = 1 - \sqrt{(a^2 + b^2 + c^2 + \ldots + i^2 + 2abr_{12} + 2abr_{13} + \ldots)}$$

Lenka and Mishra (1973) have suggested a scale for the importance of direct and indirect effects values as given below:

Values of direct and indirect effects	**Rate of scale**
0.00-0.09	Negligible
0.10-0.19	Low
0.20-0.29	Moderate
0.30-0.99	High
More than 0.99	Very high

IV. EXPERIMENTAL RESULTS

The results obtained from the field experiment conducted on evaluation of vegetable soybean (*Glycine max* (L.) Merrill) genotypes for horticultural traits in eastern dry zone of Karnataka during *Kharif* 2016 are presented in this chapter.

4.1 Analysis of variance
4.2 Growth parameters
4.3 Flowering parameters
4.4 Yield parameters
4.5 Quality parameters
4.6 Correlation studies
4.7 Path coefficient analysis

4.1 Analysis of variance

Analysis of variance was carried out for quantitative and qualitative characters including growth parameters, yield and yield attributing and quality characters of 17 vegetable soybean genotypes, which were evaluated in the experiment. All the genotypes showed significant (P=0.05) differences among the characters studied. The results of analysis of variance for all the characters of the study are summarized and presented in Table 2, 3, 4 and 5.

4.2 Growth parameters

4.2.1 Plant height

The data pertaining to plant height showed significant difference among the genotypes at 30, 60 and 90 days after sowing are presented in Table 6 and Figure 2. There was gradual increase in the plant height as the days advances.

Plant height varied significantly among the genotypes. At 30 DAS, genotype AGS 433 (39.95 cm) recorded maximum plant height followed by COHBSBM-8 (37.75 cm) and Karune (37.48 cm) whereas, the minimum plant height was recorded in IC 501197 (25.62 cm).

Table 2: Analysis of variance (Mean Sum of Squares) for growth parameters in vegetable soybean genotypes

Sl. No.	Source of variation	Replication (RMSS)	Treatments (TMSS)	Error (EMSS)	S.Em±	C. D. @ 5%
1.	Degrees of freedom	2.00	16.00	32.00	-	-
2.	Plant height (cm) at 30 DAS	2.17	60.51**	0.96	0.57	1.63
3.	Plant height (cm) at 60 DAS	2.89	146.57**	1.47	0.68	1.38
4.	Plant height (cm) at 90 DAS	8.57	111.43**	4.07	1.16	3.36
5.	Number of leaves per plant 30 DAS	1.65	49.26**	1.71	1.07	2.17
6.	Number of leaves per plant at 60 DAS	3.04	156.12**	1.37	0.65	1.33
7.	Number of leaves per plant at 90 DAS	9.90	73.12**	3.72	1.11	3.21
8.	Number of branches per plant at 30 DAS	0.17	1.48	1.03	0.58	NS
9.	Number of branches per plant at 60 DAS	0.04	2.50**	0.01	0.07	0.14
10.	Number of branches per plant at 90 DAS	0.55	1.75**	0.45	0.39	1.11
11	Chlorophyll content at 45 DAS	0.20	5.93**	0.85	0.51	1.05

* & ** Significant @ 5 % and 1 % respectively. DAS: Days After Sowing NS: Non-significant

Table 3: Analysis of variance (Mean Sum of Squares) for yield and yield attributing parameters in different vegetable soybean genotypes

Sl. No.	Source of variation	Replication (RMSS)	Treatments (TMSS)	Error (EMSS)	S.Em±	C. D. @ 5%
1.	Degrees of freedom	2.00	16.00	32.00	-	-
2.	Days to first flowering	0.49	4.64**	0.14	0.21	0.62
3.	Days to fifty flowering	0.41	7.95**	0.14	0.22	0.62
4.	Number of clusters per plant	0.00	10.00**	0.19	0.25	0.73
5.	Number of pods per cluster	0.01	2.08**	0.03	0.09	0.27
6.	Pod length (cm)	0.0048	0.24**	0.0074	0.05	0.14
7.	Pod width (cm)	0.0009	0.0107	0.0016	0.02	0.07
8.	Pod yield per plant (g)	0.15	2418.71**	5.33	1.33	3.84
9.	Pod yield per plot (kg)	0.01	1.76**	0.03	0.10	0.30
10.	Pod yield per hectare (q)	0.22	4.74**	0.21	0.26	0.76
11	Number of seeds per pod	0.01	0.23**	0.02	0.08	NS
12.	Seed length (cm)	0.0001	0.02**	0.0003	0.01	NS
13.	Seed width (cm)	0.0005	0.02**	0.007	0.01	NS
14.	Hundred seed weight (g)	0.01	27.62**	1.50	0.71	1.97
15.	Seed yield per plant (g)	0.35	40.17**	0.88	0.54	1.56
16.	Seed yield per plot (kg)	0.12	0.18	0.02	0.08	NS
17.	Seed yield per hectare (q)	0.61	45.77**	2.10	0.84	2.41

* & ** Significant @ 5 % and 1 % respectively.

Table 4: Analysis of variance (Mean Sum of Squares) for quality parameters in different vegetable soybean genotypes

Sl. No.	Source of variation	Replication (RMSS)	Treatments (TMSS)	Error (EMSS)	S.Em±	C. D. @ 5%
1.	Degrees of freedom	2.00	16.00	32.00	-	-
2.	Protein (g $100g^{-1}$)	0.06	3.69**	0.07	0.15	0.43
3.	Starch (g $100g^{-1}$)	0.02	0.42**	0.01	0.04	0.11
4.	Total sugars (%)	0.05	0.84**	0.01	0.04	0.12
5.	Reducing sugars (%)	0.01	0.55**	0.03	0.10	0.29
6.	Non-reducing sugars (%)	0.02	0.45**	0.01	0.07	0.20
7.	Trypsin inhibitory activity (µ mol $min^{-1}mg^{-1}$of sample)	0.0001	0.02	0.0001	0.01	0.03
8.	Texture (g)	151.64	2320.26**	30.15	3.17	9.13

* & ** Significant @ 5 % and 1 % respectively.

Table 5: Analysis of variance (Mean Sum of Squares) for sensory evaluation parameters in different vegetable soybean genotypes

Sl. No.	Source of variation	Replication (RMSS)	Treatments (TMSS)	Error (EMSS)	S.Em±	C. D. @ 5%
1.	Degrees of freedom	2.00	16.00	32.00	-	-
2.	Colour	0.09	1.76**	0.05	0.13	0.38
3.	Taste	0.01	4.79**	0.06	0.14	0.41
4.	Surface texture	0.66	2.03**	0.06	0.15	0.42
5.	Hardness	0.12	3.20**	0.05	0.13	0.36
7.	Overall acceptance	0.13	2.65**	0.04	0.12	0.33

Table 6: Plant height in different genotypes of vegetable soybean at different stages of plant growth

Sl. No.	Genotypes/Accessions	Plant height (cm)		
		30 DAS	60 DAS	90 DAS
1.	COHBSBM-26	33.11	49.67	51.45
2.	COHBSBM-8	37.75	60.63	63.60
3.	IC 501197	25.62	46.34	53.29
4.	COHBSBM-66	27.70	39.33	45.26
5.	COHBSBM-49	28.93	47.13	56.50
6.	COHBSBM-54	37.33	53.22	57.66
7.	IC 25763	33.99	55.15	57.35
8.	AGS 433	39.95	61.19	65.08
9.	W-80	27.80	42.04	47.02
10.	EC 24207	29.55	39.29	41.73
11.	AGS 432	35.41	43.41	56.02
12.	EC 95286	29.56	52.32	57.34
13.	Karune	37.48	55.31	58.08
14.	IC 501164	36.72	46.32	52.93
15.	GC 99013-5	32.07	56.69	59.00
16.	GC 110318	26.21	41.44	49.29
17.	EC 103153	31.93	50.09	52.74
	Mean	32.42	49.39	54.08
	S. Em±	0.57	0.68	1.16
	CD at 5 %	1.63	1.38	3.36

DAS: Days After Sowing

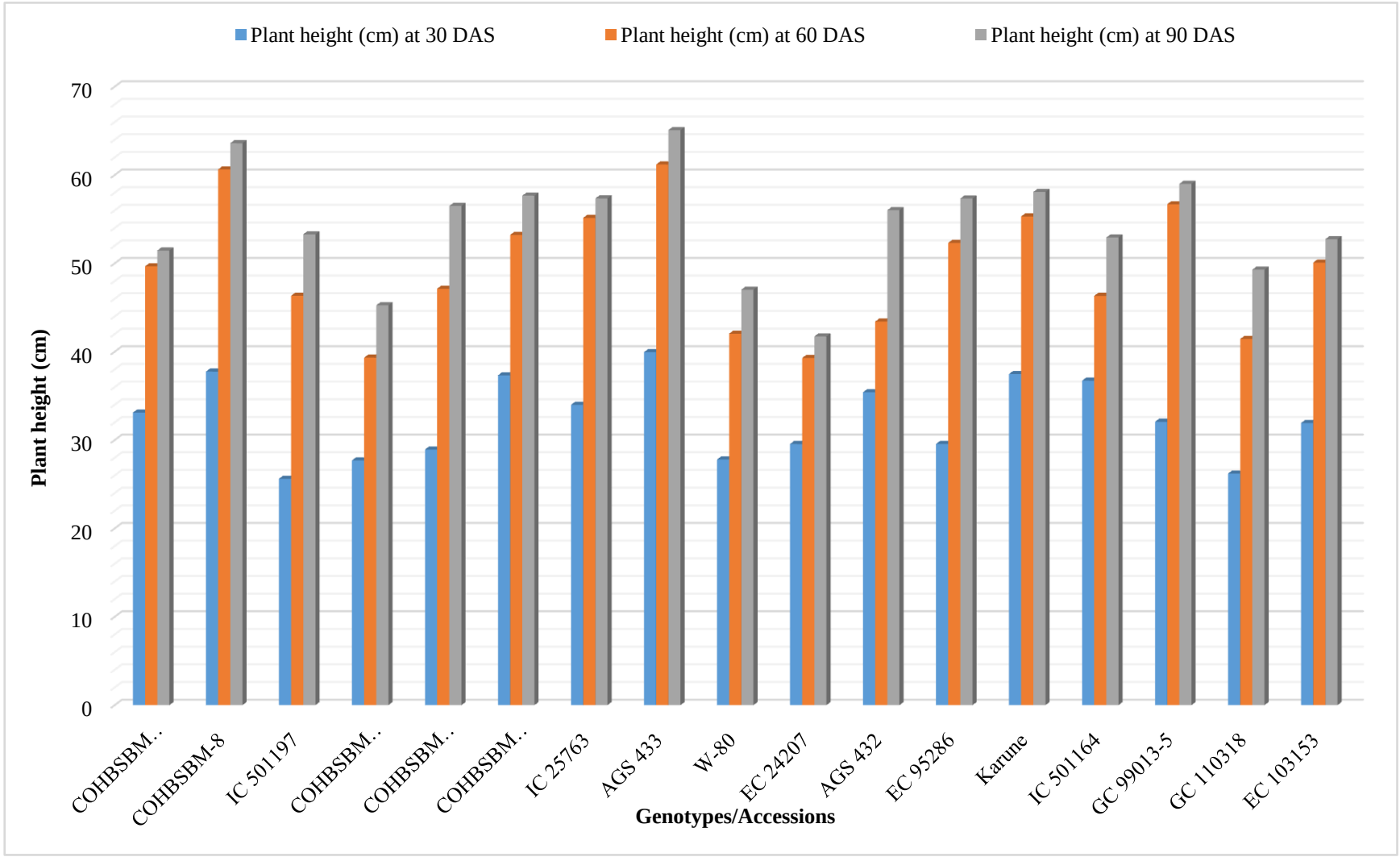

Fig. 2: Plant height (cm) at different stages of vegetable soybean genotypes

Plate 2a: Maturity stage of different vegetable soybean genotypes

Plate 2b: Maturity stage of different vegetable soybean genotypes

Plate 2c: Maturity stage of different vegetable soybean genotypes

Plant height at 60 DAS was observed in the range of 39.19 cm to 61.19 cm. The maximum plant height was recorded in AGS 433 (61.19 cm) at 60 DAS, which was significantly on par with COHBSBM-8 (60.63 cm), GC 99013-5 (56.69 cm), Karune (55.31cm) and IC 25763 (55.15 cm). Whereas, the minimum plant height of 39.29 cm was recorded in EC 24207.

At 90 DAS, maximum plant height was observed in the genotype AGS 433 (65.08 cm) which was on par with COHBSBM-8 (63.60 cm). Whereas, the genotype EC 24207 (41.73 cm) recorded minimum plant height among the 17 genotypes.

4.2.2 Number of leaves per plant

The data pertaining to number of leaves per plant in different genotypes are recorded at different stages (30, 60 and 90 DAS) of crop growth and are presented in Table 7 and Figure 3.

Number of leaves per plant varied significantly among the 17 genotypes. At 30 days after sowing, maximum number of leaves per plant 31.13 was recorded in AGS 433 which was on par with AGS 432 (24.67). The minimum numbers of leaves was recorded in the genotype EC 24207 (20.13).

While at 60 DAS, the maximum number of leaves per plant was produced in the genotype AGS 433 (52.67) which was followed by COHBSBM-49 (45.23) and EC 95286 (44.07). Whereas, the genotype GC 110318 has recorded minimum number of leaves per plant (30.03).

The numbers of leaves were found maximum in AGS 433 (55.01) followed by COHBSBM-54 (47.74) and EC 95286 (47.68). Whereas minimum leaves was recorded in GC 110318 (34.46) at 90 days after sowing.

Table 7: Number of leaves per plant in different vegetable soybean genotypes at different stages of plant growth

Sl. No.	Genotypes/Accessions	Number of leaves per plant		
		30 DAS	60 DAS	90 DAS
1.	COHBSBM-26	30.80	35.53	37.53
2.	COHBSBM-8	23.27	33.87	36.75
3.	IC 501197	23.53	36.90	40.49
4.	COHBSBM-66	23.20	42.67	46.71
5.	COHBSBM-49	25.80	45.23	45.82
6.	COHBSBM-54	20.33	44.67	47.74
7.	IC 25763	26.00	36.73	39.00
8.	AGS 433	31.13	52.67	55.01
9.	W-80	21.87	43.00	45.64
10.	EC 24207	20.13	38.33	44.90
11.	AGS 432	24.67	38.46	45.61
12.	EC 95286	29.73	44.07	47.68
13.	Karune	27.30	41.97	46.85
14.	IC 501164	25.07	32.62	37.69
15.	GC 99013-5	27.07	34.51	37.83
16.	GC 110318	21.67	30.03	34.46
17.	EC 103153	26.00	35.80	39.77
	Mean	25.15	38.88	42.67
	S. Em±	1.07	0.65	1.11
	CD at 5 %	2.17	1.33	3.21

DAS: Days After Sowing

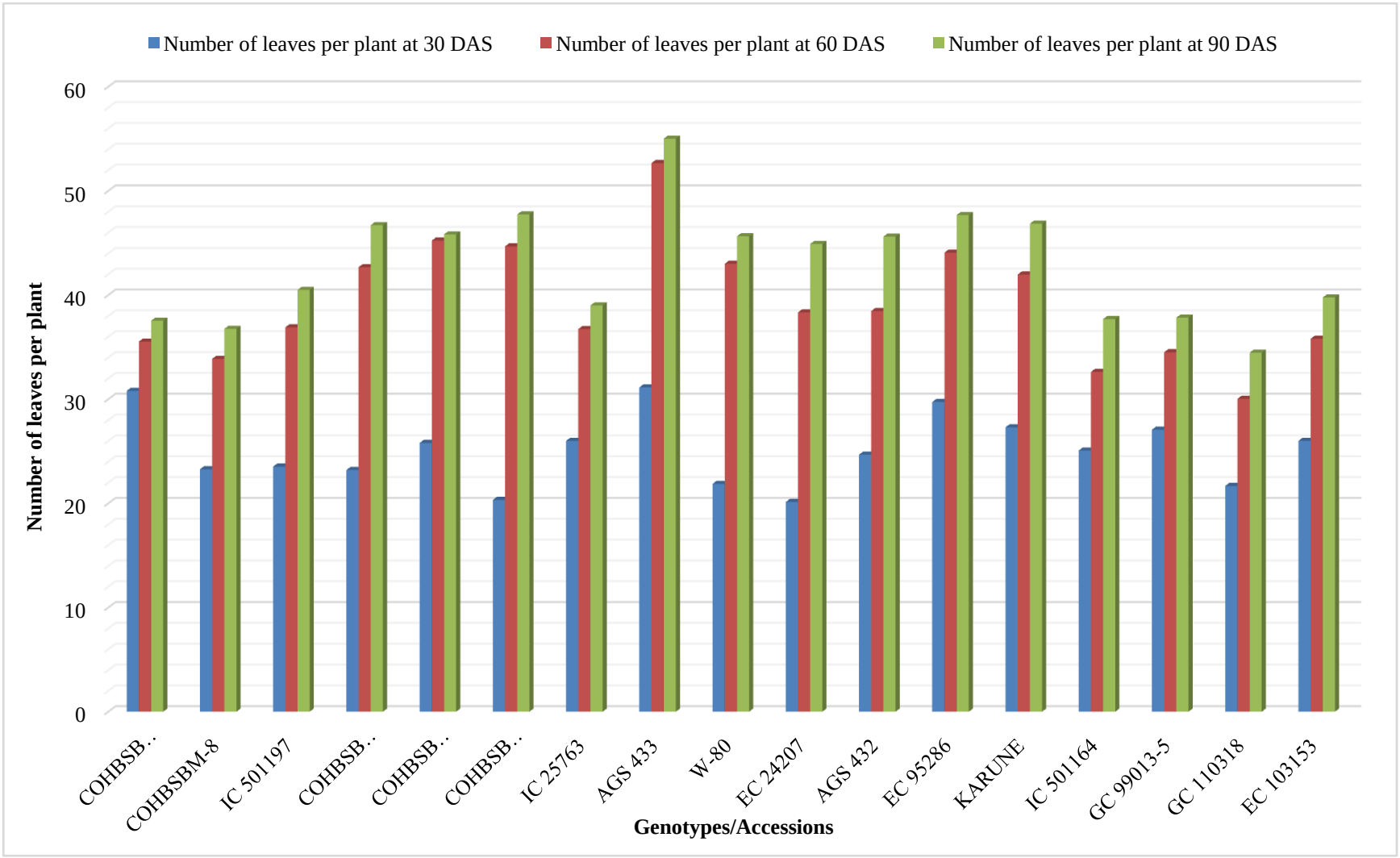

Fig. 3: Number of leaves per plant at different stages of vegetable soybean genotypes

4.2.3 Number of branches per plant

Data pertaining to number of branches per plant differed significantly in different genotypes are recorded at 30, 60 and 90 DAS (Table 8 and Figure 4).

At 30 DAS, maximum number of branches per plant was recorded in genotype AGS 433 (5.33) which was on par with Karune (4.87), IC 25763 and EC 95286 (4.67 each), COHBSBM-66 (4.40), COHBSBM-8 and GC 99013-5 (4.33 each), GC 110318 and COHBSBM-26 (4.27 each). While, the minimum number of branches per plant was recorded in IC 501197 (2.93).

At 60 DAS, the maximum number of branches per plant was recorded in genotype AGS 433 (6.80) which was on par with EC 95286 (6.33), IC 25763 (6.07), IC 501197 (6.60), AGS 432 (6.13), Karune and GC 99013-5 (6.20 each). While, the minimum number of branches per plant was recorded in COHBSBM-54 (4.13).

While at 90 DAS, highest number of branches per plant was recorded in genotype AGS 433 (7.20) which was on par with IC 501197 (6.60), Karune (6.54), EC 95286 (6.40), GC 99013-5 (6.35), AGS 432 (6.33) and minimum number of branches per plant was recorded in EC 24207 (4.60).

4.2.4 Days to first flowering

Data pertaining to days to first flowering, days to 50 per cent flowering and chlorophyll content was differed significantly for different vegetable soybean genotypes are presented in Table 9.

Among the 17 genotypes studied, genotype COHBSBM-26 (33.67 days) has recorded less number of days to first flowering which was on par with COHBSBM-66 and AGS 432 (34 days each), GC 99013-5 (34.11 days) and AGS 433 (34.33 days) compared to other genotypes. The genotype IC 25763 (37.33 days) has recorded more number of days to first flowering.

Table 8: Number of branches per plant in different genotypes of vegetable soybean at different stages of plant growth

Sl. No.	Genotypes/Accessions	Number of branches per plant		
		30 DAS	60 DAS	90 DAS
1.	COHBSBM-26	4.27	5.73	5.87
2.	COHBSBM-8	4.33	5.67	5.97
3.	IC 501197	2.93	6.60	6.60
4.	COHBSBM-66	4.40	5.07	5.07
5.	COHBSBM-49	5.07	5.80	5.80
6.	COHBSBM-54	4.00	4.13	4.73
7.	IC 25763	4.67	6.07	6.07
8.	AGS 433	5.33	6.80	7.20
9.	W-80	3.53	4.80	4.80
10.	EC 24207	3.20	4.60	4.60
11.	AGS 432	4.13	6.13	6.33
12.	EC 95286	4.67	6.33	6.40
13.	Karune	4.87	6.20	6.54
14.	IC 501164	2.98	5.60	5.91
15.	GC 99013-5	4.33	6.20	6.35
16.	GC 110318	4.27	5.67	5.97
17.	EC 103153	3.07	4.67	4.87
	Mean	4.12	5.67	5.83
	S. Em±	0.58	0.07	0.39
	CD at 5 %	NS	0.14	1.11

DAS: Days After Sowing

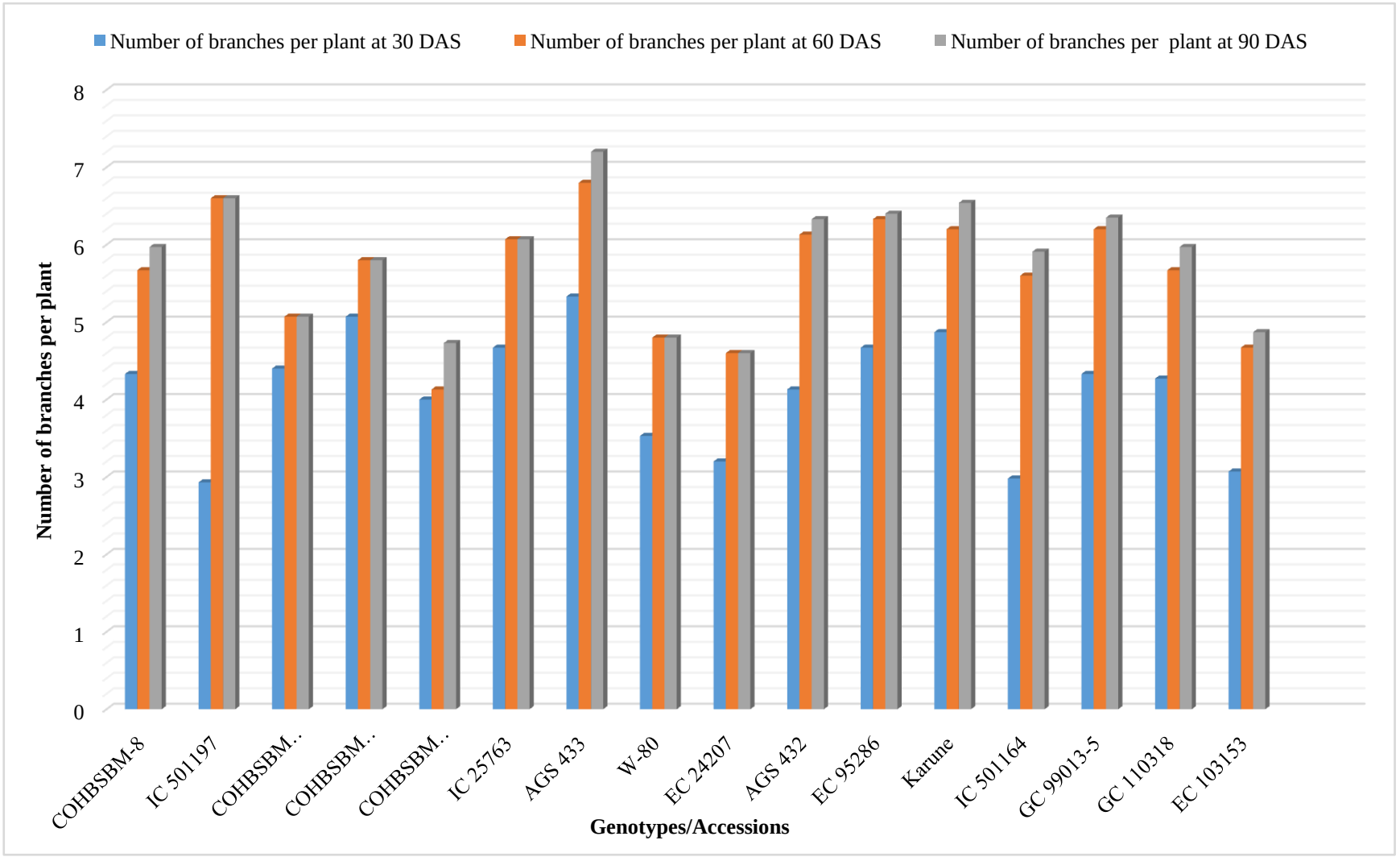

Fig. 4: Number of branches per plant at different stages of vegetable soybean genotypes

4.2.5 Days to 50 per cent flowering

The genotype COHBSBM-26 (37.00 days) has recorded minimum number of days to 50 per cent of flowering followed by AGS 432 (37.33 days) and GC 99013-5 (37.67 days) compared to other genotypes. The genotype IC 25763 (43.00 days) has recorded maximum number of days to 50 per cent flowering.

4.2.6 Chlorophyll content (SPAD)

At 45 DAS, the highest chlorophyll content was recorded in the genotype Karune (46.80) which was followed by COHBSBM-49 (44.98) and EC 24207 (43.92) and the lowest chlorophyll content was recorded in the genotype W-80 (41.08).

4.3 Yield parameters

Data pertaining to number of clusters per plant, number of pods per cluster, pod length, pod width, number of seeds per pod, pod yield per plant, pod yield per plot and pod yield per hectare of different vegetable soybean genotypes are differed significantly and are presented in Table 10 and 11.

4.3.1 Number of clusters per plant

Among the different genotypes of vegetable soybean, the maximum number of clusters per plant was observed in AGS 433 (19.43) which was on par with COHBSBM-8 (17.09). The minimum number of clusters per plant was observed in IC 501164 (9.40).

4.3.2 Number of pods per cluster

Among the different genotypes of vegetable soybean, the maximum number of pods per cluster was noticed in AGS 433 (6.69) which was on par with COHBSBM-26 (5.94). The minimum number of pods per cluster was recorded in W-80 (3.49).

4.3.3 Pod length

The maximum pod length was recorded in the genotype IC 25763 (5.57 cm) however, it was on par with GC 110318 (5.37 cm) and AGS 433 (5.18 cm) and lowest pod length was recorded in EC 103153 (4.10 cm).

Table 9: Performance of different vegetable soybean genotypes for days to first flowering, days to 50 per cent flowering and chlorophyll content

Sl. No.	Genotypes/Accessions	Days to first flowering	Days to 50 per cent flowering	Chlorophyll content (SPAD)
1.	COHBSBM-26	33.67	37.00	42.93
2.	COHBSBM-8	36.00	40.00	41.56
3.	IC 501197	37.00	40.67	43.52
4.	COHBSBM-66	34.00	38.33	42.36
5.	COHBSBM-49	35.33	38.33	44.98
6.	COHBSBM-54	36.33	41.33	42.12
7.	IC 25763	37.33	43.00	42.41
8.	AGS 433	34.33	39.00	43.87
9.	W-80	36.33	40.00	41.08
10.	EC 24207	35.00	40.00	43.92
11.	AGS 432	34.00	37.33	43.15
12.	EC 95286	34.67	40.00	41.27
13.	Karune	36.00	39.67	46.80
14.	IC 501164	37.00	40.00	43.74
15.	GC 99013-5	34.11	37.67	42.29
16.	GC 110318	36.33	40.67	41.89
17.	EC 103153	37.00	42.00	43.91
	Mean	35.56	39.71	43.05
	S. Em±	0.21	0.22	0.51
	CD at 5 %	0.62	0.62	1.05

4.3.4 Pod width

Among the genotypes pod width was ranged from 0.92 cm to 1.16 cm. Genotype COHBSBM-54 (1.16 cm) has recorded the maximum pod width which was on par with IC 25763 (1.10), IC 501197 (1.01) and GC 990135-5 (1.00 cm). While, genotype EC 103153 has recorded minimum pod width of 0.92 cm.

4.3.5 Number of seeds per pod

The data pertaining to number of seeds per pod showed significant difference among the genotypes are presented in Table 11.

Number of seeds per pod differed significantly among the genotypes and it was ranged from 2.00 to 3.00. Genotype IC 501197 (3.00) has recorded the more number of seeds per pod which was on par with Karune (2.80) and EC 103153 (2.53). While, GC 110318 (2.00) has recorded less number of seeds per pod.

4.3.6 Pod yield per plant (g)

The data pertaining to pod yield per plant has showed significant difference among the genotypes are presented in Table 11 and Figure 5.

The results of analysis of variance for pod yield per plant revealed significant difference among the genotypes and it was ranged from 31.54 to 70.55 g with a mean of 51.33 g. The maximum pod yield per plant was recorded in AGS 433 (70.55 g) which was on par with COHBSBM-54 (66.29 g) and AGS 432 (63.58 g). The lowest pod yield per plant was recorded in GC 99013-5 (31.54 g).

4.3.7 Pod yield per plot (kg)

The maximum pod yield per plot was recorded in AGS 433 (4.52 kg) which was on par with COHBSBM-54 (4.49 kg) and AGS 432 (4.29 kg). The lowest pod yield per plot was recorded in EC 103153 (2.28 kg) among the vegetable soybean genotypes.

Table 10: Performance of different vegetable soybean genotypes for pod characters under eastern dry zone

Sl. No.	Genotypes/ Accessions	Number of clusters per plant	Number of pods per cluster	Pod length (cm)	Pod width (cm)
1.	COHBSBM-26	14.15	5.94	5.03	0.99
2.	COHBSBM-8	17.09	5.58	5.05	1.03
3.	IC 501197	11.47	3.69	4.64	1.01
4.	COHBSBM-66	9.82	3.70	4.66	1.07
5.	COHBSBM-49	16.03	4.97	4.84	1.05
6.	COHBSBM-54	14.33	4.02	5.29	1.16
7.	IC 25763	14.70	5.20	5.57	1.10
8.	AGS 433	19.43	6.69	5.18	1.03
9.	W-80	13.93	3.49	5.11	0.93
10.	EC 24207	16.03	3.92	5.12	0.97
11.	AGS 432	13.13	4.89	5.10	1.07
12.	EC 95286	10.25	4.30	4.68	0.93
13.	Karune	15.79	3.91	4.87	0.94
14.	IC 501164	9.40	3.99	4.88	1.02
15.	GC 99013-5	10.90	3.92	4.90	1.00
16.	GC 110318	9.90	5.89	5.37	1.06
17.	EC 103153	13.94	4.20	4.10	0.92
	Mean	13.55	4.61	4.96	1.02
	S. Em±	0.25	0.09	0.05	0.02
	CD at 5 %	0.73	0.27	0.14	0.07

4.3.8 Pod yield per hectare (q)

The maximum pod yield per hectare was recorded in AGS 433 (78.40 q) which was on par with COHBSBM-54 (72.84 q). The lowest pod yield per hectare was recorded in GC 99013-5 (35.00 q).

4.3.9 Dry seed yield parameters

Data pertaining to seed length, seed width, hundred seed weight, seed yield per plant, seed yield per plot and seed yield per hectare are presented in Table 12.

4.3.9.1 Seed length

Among the vegetable soybean genotypes higher seed length was recorded in the genotype GC 99013-5 (0.86 cm) however it was on par with genotype COHBSBM-8, COHBSBM-54 and COHBSBM-49 (0.85 cm each) and Karune (0.83 cm). Genotypes AGS 432 and W-80 had the lower seed length of 0.63 cm.

4.3.9.2 Seed width

Higher seed width was recorded in the genotype COHBSBM-8 (0.75 cm) as compared to other genotypes. However it was on par with genotypes COHBSBM-49 (0.72) and COHBSBM-54 (0.73) and lower seed width was recorded in the genotype EC 103153 (0.53 cm).

4.3.10 Hundred seed weight

Among the 17 genotypes COHBSBM-49 has recorded the highest hundred seed weight (32.37 g), which was followed by COHBSBM-54 (30.93 g) and GC 110318-5 (27.94). While, IC 501197 has recorded lowest hundred seed weight of 21.47 g.

4.3.11 Seed yield per plant (g)

The data pertaining to seed yield per plant showed significant difference among the genotypes are presented in Table 12.

Table 11: Performance of different vegetable soybean genotypes for fresh pod yield characters

Sl. No.	Genotypes/ Accessions	Number of seeds per pod	Pod yield per plant (g)	Pod yield per plot (kg)	Pod yield per hectare (q)
1.	COHBSBM-26	2.50	44.79	2.94	49.72
2.	COHBSBM-8	2.13	57.24	3.52	63.24
3.	IC 501197	3.00	53.08	3.43	58.75
4.	COHBSBM-66	2.30	40.44	2.64	44.51
5.	COHBSBM-49	2.47	48.15	3.13	53.39
6.	COHBSBM-54	2.17	66.29	4.49	72.84
7.	IC 25763	2.07	60.98	4.21	67.71
8.	AGS 433	2.50	70.55	4.52	78.40
9.	W-80	2.47	43.90	3.03	48.72
10.	EC 24207	2.40	39.39	2.50	43.73
11.	AGS 432	2.27	63.58	4.29	70.67
12.	EC 95286	2.23	50.05	3.43	55.69
13.	Karune	2.80	61.55	4.19	68.34
14.	IC 501164	2.17	43.48	2.66	48.21
15.	GC 99013-5	2.41	31.54	2.32	35.00
16.	GC 110318	2.00	59.91	3.68	66.55
17.	EC 103153	2.53	37.67	2.28	41.80
	Mean	2.38	51.33	3.37	56.86
	S. Em±	0.08	1.33	0.10	0.26
	CD at 5 %	NS	3.84	0.30	0.76

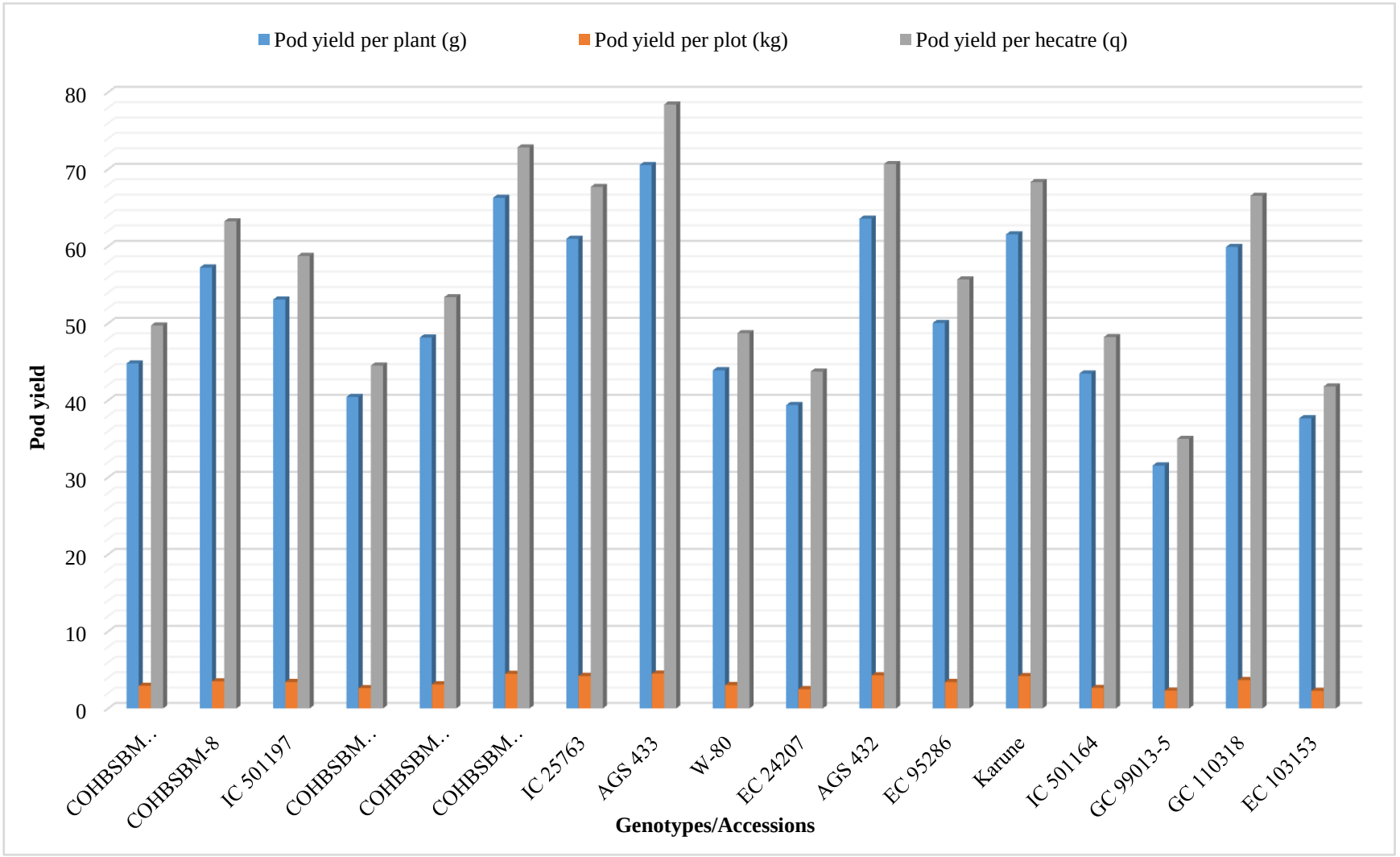

Fig. 5: Pod yield of different vegetable soybean genotypes at harvest

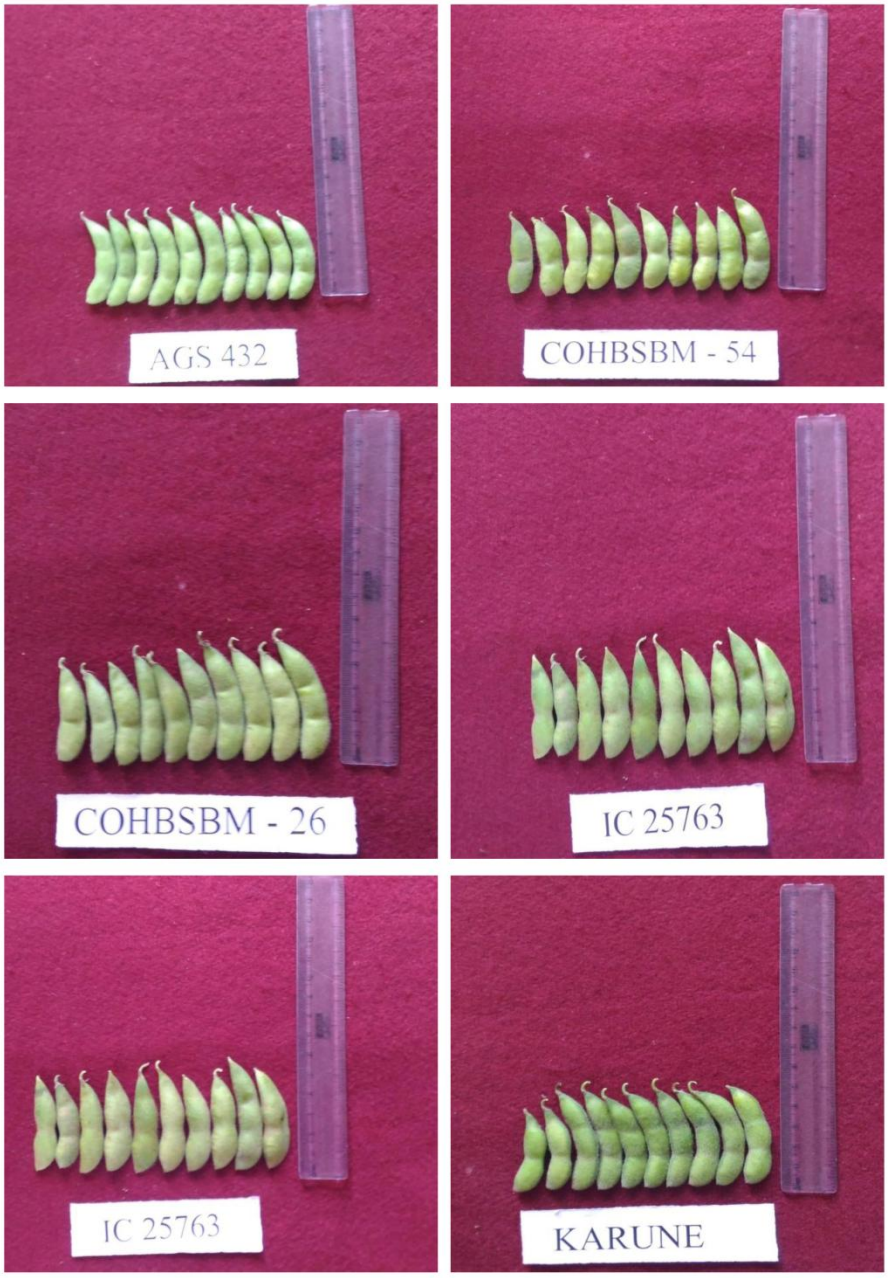

Plate 3a: Pod length (cm) of different vegetable soybean genotypes at harvest

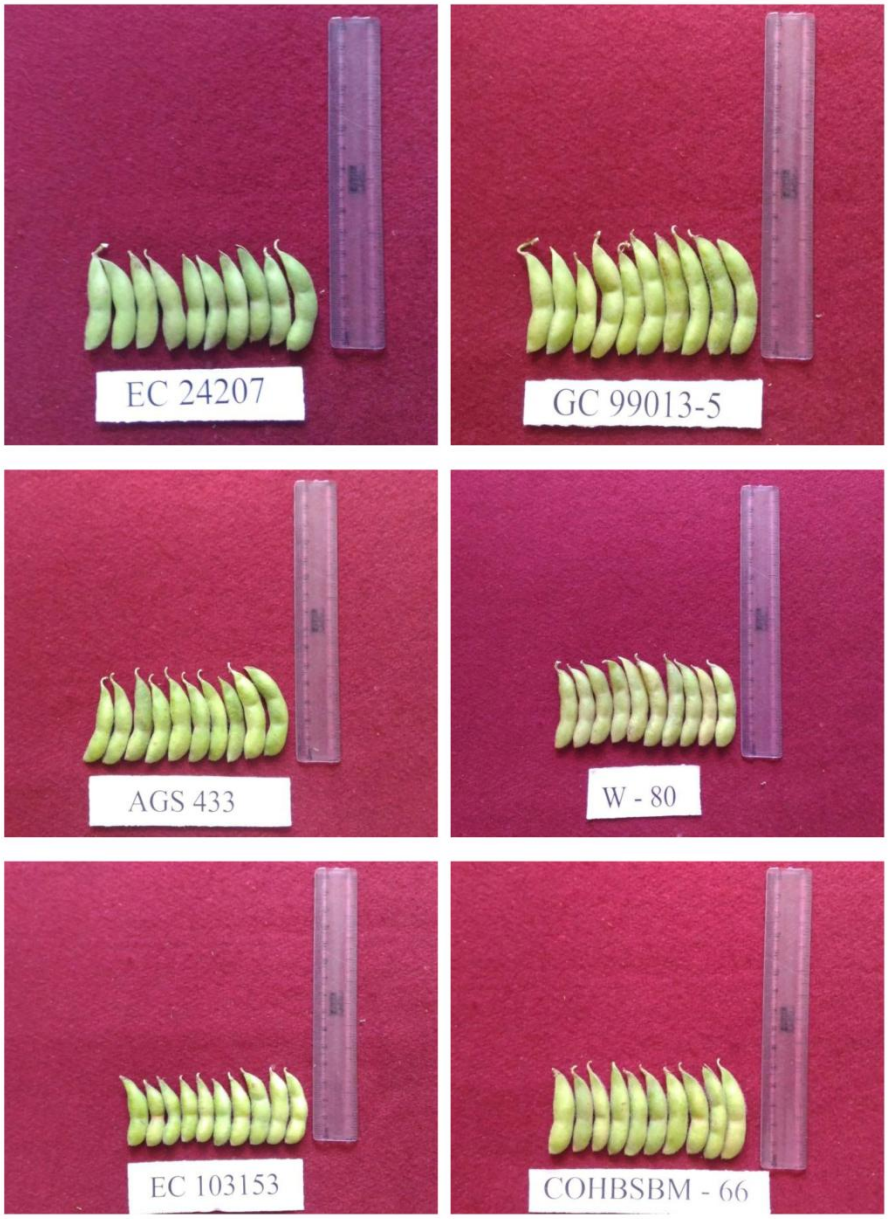

Plate 3b: Pod length (cm) of different vegetable soybean genotypes at harvest

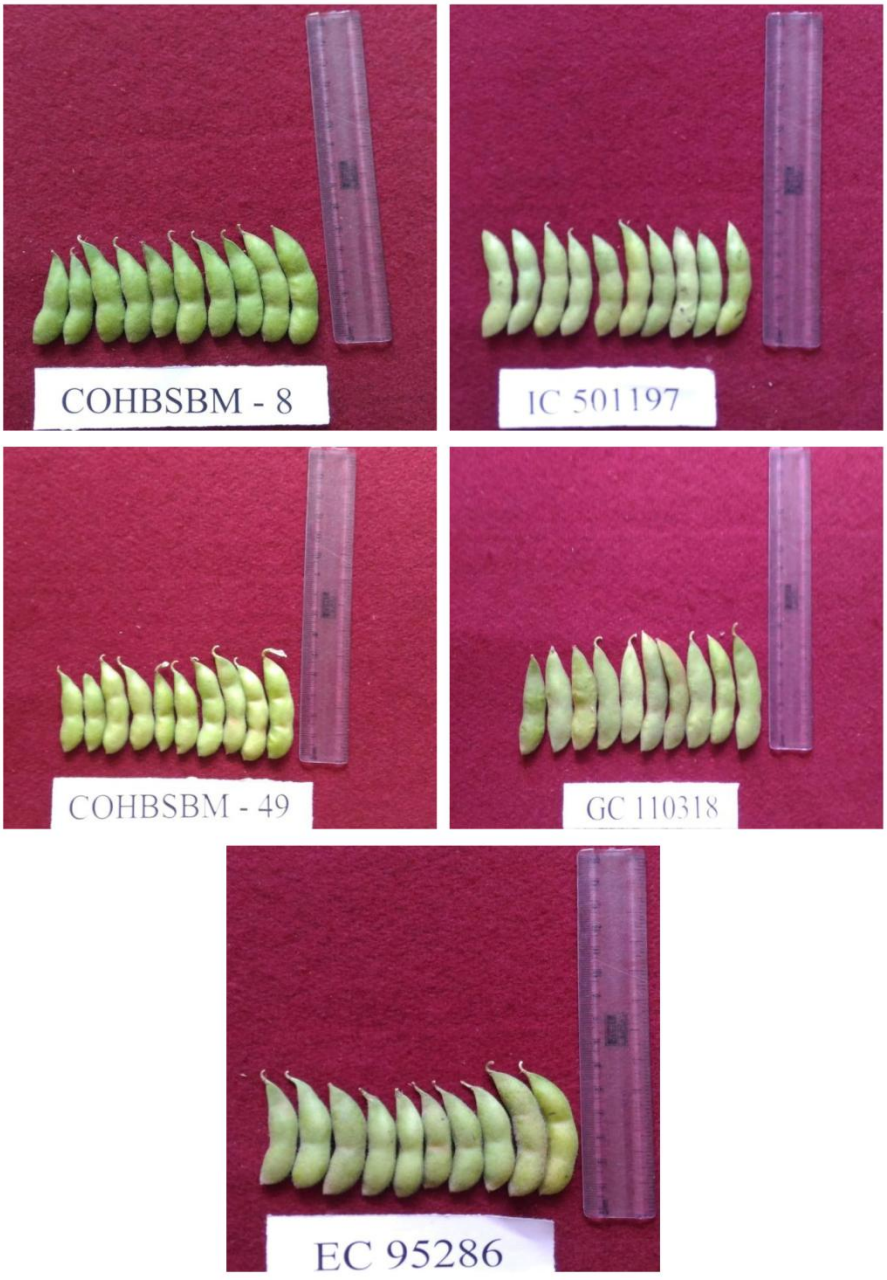

Plate 3c: Pod length (cm) of different vegetable soybean genotypes at harvest

The variation in seed yield per plant was significantly differed among the genotypes. The maximum seed yield per plant was recorded in genotype COHBSBM-8 (36.47 g) and it was on par with COHBSBM-49 (34.42 g) and the lowest seed yield per plant was recorded in GC 99013-5 (21.32 g).

4.3.12 Seed yield per plot (kg)

The maximum seed yield per plot was significantly differed among the genotypes. The maximum seed yield per plot was recorded in genotype COHBSBM-8 (2.41 kg) which was followed by COHBSBM-49 (2.38 kg) and AGS 432 (2.16 kg). The lowest seed yield per plot was recorded in W-80 (1.55 kg).

4.3.13 Seed yield per hectare (q)

The variation in seed yield per hectare was significantly differed among the genotypes. The maximum seed yield per plot was recorded in genotype COHBSBM-8 (40.65 q) which was followed by COHBSBM-49 (38.50 q) and AGS 432 (37.29 q). The lowest seed yield per plot was recorded in GC 99013-5 (24.97 q).

4.4 Quality parameters

Data pertaining to quality parameters such as protein, starch, total sugars, reducing sugars, non-reducing sugars, trypsin inhibitory activity and texture differed significantly for all the vegetable soybean genotypes are presented in Table 13.

4.4.1 Protein

Protein content in vegetable soybean significantly differed among the genotypes and it ranged from 6.35 g $100g^{-1}$ to 10.00 g $100g^{-1}$. The highest protein content was recorded in the genotype EC 95286 (10.00 g $100g^{-1}$) which was on par with IC 501164 and GC 99013-5 (9.66 g $100g^{-1}$) and COHBSBM-66 (9.20 g $100g^{-1}$). Lowest protein content was reported in the genotype COHBSBM-8 (6.35 g $100g^{-1}$).

Table 12: Performance of different vegetable soybean genotypes for dry seed characters

Sl. No.	Genotypes/Accessions	Seed size (cm)		Hundred seed weight (g)	Seed yield per plant (g)	Seed yield per plot (kg)	Seed yield per hectare (q)
		Seed length	Seed width				
1.	COHBSBM-26	0.72	0.57	24.50	30.39	2.04	32.05
2.	COHBSBM-8	0.85	0.75	27.20	36.47	2.41	40.65
3.	IC 501197	0.74	0.56	21.47	27.33	1.90	31.34
4.	COHBSBM-66	0.77	0.57	26.10	30.00	1.98	32.31
5.	COHBSBM-49	0.85	0.72	32.37	34.42	2.38	38.50
6.	COHBSBM-54	0.85	0.73	30.93	32.21	2.04	34.65
7.	IC 25763	0.81	0.57	23.50	28.02	1.84	31.67
8.	AGS 433	0.75	0.63	25.20	30.83	2.13	33.54
9.	W-80	0.63	0.54	23.23	25.30	1.55	28.07
10.	EC 24207	0.65	0.57	23.87	27.73	1.76	31.63
11.	AGS 432	0.63	0.62	26.53	33.03	2.16	37.29
12.	EC 95286	0.70	0.53	20.73	26.18	1.79	31.11
13.	Karune	0.83	0.61	25.57	33.00	2.11	35.13
14.	IC 501164	0.73	0.55	24.90	25.73	1.71	28.78
15.	GC 99013-5	0.86	0.70	27.94	21.32	1.62	24.97
16.	GC 110318	0.76	0.63	22.77	30.77	2.01	32.82
17.	EC 103153	0.65	0.53	23.57	25.75	1.81	29.20
	Mean	0.75	0.61	25.32	29.32	1.95	35.57
	S. Em±	0.01	0.01	0.71	0.54	0.08	0.84
	CD at 5 %	NS	NS	1.97	1.56	NS	2.41

4.4.2 Starch

The starch content in vegetable soybean genotypes ranged from 0.56 g $100g^{-1}$ to 1.32 g $100g^{-1}$. The highest starch content was recorded in the genotype AGS 433 (1.32 g $100g^{-1}$) which was on par with EC 103153 (1.28g $100g^{-1}$) and AGS 432 (1.23 g $100g^{-1}$). Lowest starch content was found in the genotype GC 110318 (0.56 g $100g^{-1}$).

4.4.3 Total sugars

Among the 17 vegetable soybean genotypes the maximum total sugar content was recorded in the genotype COHBSBM-8 (3.60 %) which was on par with IC 501197 (3.40 %), COHBSBM-26 and EC 103153 (3.33 % each) and GC 110318 (3.27 %). The minimum total sugar content was recorded by the genotype EC 24207 (2.27 %).

4.4.4 Reducing sugars

The maximum reducing sugar content was recorded in COHBSBM-8 (2.57 %) which was on par with AGS 432 (2.45 %), AGS 433 (2.43 %) and IC 501197 (2.42 %). The minimum reducing sugar content was recorded by the genotype EC 95286 (1.05 %) as compared to other genotypes.

4.4.5 Non-reducing sugars

The maximum non-reducing sugar content was recorded in W-80 (1.56 %) followed by EC 25986 (1.35 %) and COHBSBM-26 (1.30 %). However the minimum non-reducing sugar content was recorded in genotype AGS 432 (0.42 %).

4.4.6 Trypsin Inhibitory Activity

The data pertaining to trypsin inhibitory activity showed significant differences among the 17 vegetable soybean genotypes are presented in Table 13.

Among the 17 genotypes, trypsin inhibitory activity was ranged from 0.19 µ mol min^{-1} mg^{-1} to 0.45 µ mol min^{-1} mg^{-1}. Lowest trypsin inhibitory activity was recorded in the genotype COHBSBM-26 (0.19 µ mol $min^{-1}mg^{-1}$) which was on par with Karune (0.21 µ mol min^{-1} mg^{-1}). Highest trypsin inhibitory activity was reported in the genotype COHBSBM-54 (0.45 µ mol min^{-1} mg^{-1}) which was on par with W-80 (0.44 µ mol min^{-1} mg^{-1}).

Table 13: Quality parameters of different vegetable soybean genotypes

Genotypes/Accessions	Protein (g 100^{-1})	Starch (g 100^{-1})	Sugars (%)			Trypsin Inhibitory Activity (µ mol min^{-1} mg^{-1} of sample)	Texture (g)
			Total sugars	Reducing sugars	Non-reducing sugars		
COHBSBM-26	8.56	1.22	3.33	2.03	1.30	0.19	260.17
COHBSBM-8	6.35	0.91	3.60	2.57	1.03	0.25	326.03
IC 501197	9.62	0.72	3.40	2.42	0.98	0.30	308.23
COHBSBM-66	9.20	0.65	2.63	1.93	0.70	0.39	290.33
COHBSBM-49	7.63	1.02	2.83	2.32	0.51	0.25	306.67
COHBSBM-54	8.29	0.96	2.50	1.42	1.08	0.45	258.53
IC 25763	8.74	1.22	2.37	1.79	0.58	0.34	315.13
AGS 433	7.09	1.32	2.96	2.43	0.53	0.40	288.37
W-80	7.68	0.85	2.60	1.04	1.56	0.44	327.60
EC 24207	8.62	1.08	2.27	1.16	1.11	0.30	253.60
AGS 432	7.61	1.23	2.87	2.45	0.42	0.34	310.57
EC 95286	10.00	0.74	2.40	1.05	1.35	0.39	284.20
Karune	6.53	0.90	2.63	2.02	0.61	0.21	255.63
IC 501164	9.66	1.06	2.40	1.81	0.59	0.24	240.87
GC 99013-5	9.66	1.21	3.03	2.33	0.70	0.38	311.53
GC 110318	7.78	0.56	3.27	2.24	1.03	0.29	281.73
EC 103153	8.78	1.28	3.33	2.14	1.19	0.25	262.30
Mean	8.34	1.00	2.78	2.00	0.93	0.32	287.15
S. Em±	0.15	0.04	0.04	0.10	0.07	0.01	3.17
CD at 5 %	0.43	0.11	0.12	0.29	0.20	0.03	9.13

4.4.7 Texture

The texture value of vegetable soybean genotypes was ranged from 240.87 g to 327.60 g with a mean of 287.15 g. The lower texture values was recorded by the genotype IC 501164 (240.87 g) which was followed by EC 24207 (253.60 g) and Karune (255.63 g) and higher texture values was recorded in the genotype W-80 (327.60 g).

4.5 Sensory evaluation (9 point hedonic scale)

The data pertaining to sensory evaluation scores of vegetable soybean are presented in Table 14. Stastical differences were recorded with respect to sensory evaluation scores (9 point hedonic scale) performed by panel of judges. The sensory traits *viz.,* colour, taste, surface texture, hardness and overall acceptability of 17 vegetable soybean genotypes were judged by four post graduate students. The genotype Karune registered higher overall acceptability of 8.57 (score out of 9) whereas the genotype W-80 recorded lowest overall acceptability scores of 5.60 (score out of 9).

4.6 Correlation studies

The genotypic and phenotypic correlation studies were carried out to know the nature of relationship existing between pod yield and its component characters. Higher genotypic correlation coefficients were noticed than phenotypic correlation coefficients for all the 12 characters studied (Table 15 &16).

4.6.1 Genotypic correlation

Plant height at 60 DAS showed highly significant and positive correlation with number of clusters per plant (0.56), number of pods per clusters (0.52) and number of branches per plant (0.38) whereas, positive and significant correlation with pod yield per plant (0.33).

Table 14: Sensory evaluation parameters of different vegetable soybean genotypes

Sl. No.	Genotypes/Accessions	Colour	Taste	Surface texture	Hardness	Overall acceptability
1.	COHBSBM-26	6.77	8.33	7.60	8.17	8.37
2.	COHBSBM-8	7.40	7.53	6.67	8.57	8.37
3.	IC 501197	5.33	6.47	7.33	6.47	6.47
4.	COHBSBM-66	6.57	7.60	8.37	7.37	8.17
5.	COHBSBM-49	6.53	7.50	7.27	8.60	7.37
6.	COHBSBM-54	7.27	7.30	7.37	7.60	7.40
7.	IC 25763	5.73	5.53	6.33	8.50	7.77
8.	AGS 433	6.37	8.57	8.43	8.57	8.53
9.	W-80	5.10	5.37	6.67	5.53	5.60
10.	EC 24207	5.50	4.50	6.57	6.47	7.23
11.	AGS 432	6.43	8.43	7.67	8.43	8.43
12.	EC 95286	5.70	6.37	5.40	5.70	6.27
13.	Karune	7.37	8.47	6.53	8.50	8.57
14.	IC 501164	5.43	6.60	7.53	7.47	7.47
15.	GC 99013-5	5.17	5.40	6.70	6.57	6.47
16.	GC 110318	5.90	5.63	5.77	7.37	8.50
17.	EC 103153	5.77	6.47	6.50	7.20	8.43
	Mean	7.40	8.57	8.43	8.60	8.57
	S. Em±	0.13	0.14	0.15	0.13	0.12
	CD at 5 %	0.38	0.41	0.42	0.36	0.33

Plate 4: Sensory evaluation of different vegetable soybean seeds

Number of leaves per plant at 60 DAS showed significant and positive correlation with pod yield per plant (0.34) and pod width (0.30). It also showed highly significant and negative correlation with days to first flowering (-0.43) and days to 50 per cent flowering (-0.42).

Number of branches per plant at 60 DAS showed significant and negative correlation with days to fifty per cent flowering (-0.32) and days to first flowering (-0.27) and pod width (-0.27).

Chlorophyll content in leaves showed highly significant and positive correlation with number of seeds per pod (0.59) and number of cluster per plant (0.44). It also showed significant and negative correlation with pod length (-0.32) and pod width (-0.29).

Days to first flowering showed highly significant and positive correlation with days to fifty per cent flowering (0.88). It also showed highly significant and negative correlation with number of leaves per plant (-0.43). However, it also exhibited significant and negative correlation with number of branches per plant (-0.27).

Days to fifty per cent flowering had exhibited highly significant and positive correlation with days to first flowering (0.88). It showed highly significant and negative correlation with number of leaves per plant (-0.43). However, it also exhibited negative and significant correlation with number of branches per plant (-0.32).

Pod length had exhibited highly significant and positive association with number of pods per cluster (0.58), pod width (0.50), pod yield per plant (0.49), number of leaves pr plant (0.30); positive and significant association with number of cluster per plant (0.27). However, the trait exhibited highly significant and negative correlation with number of seeds per pod (-0.61) significant and negative correlation with chlorophyll content (-0.32).

Pod width showed highly significant and positive association with pod yield per plant (0.52) and pod length (0.50) whereas, it showed positive and significant association with number of pods per cluster (0.33) and number of leaves per plant (0.30). However, the trait exhibited highly significant and negative correlation with number of seeds per pod (-0.48) and negative and significant correlation with chlorophyll content (-0.29) and number of branches per plant (-0.27).

Table 15: Genotypic correlation coefficient for yield and its component characters in vegetable soybean genotypes

	1	2	3	4	5	6	7	8	9	10	11	12
1	**1.000**	-0.122	0.385**	0.035	-0.016	0.054	0.180	0.114	0.560**	0.528**	0.005	0.330*
2		**1.000**	0.232	0.114	-0.432**	-0.424**	-0.076	0.308*	0.138	-0.165	0.083	0.344*
3			**1.000**	0.107	-0.279*	-0.321*	-0.009	-0.278*	-0.209	0.249	0.199	0.258
4				**1.000**	0.0723	-0.1081	-0.3254*	-0.294*	0.443**	-0.064	0.595**	0.074
5					**1.000**	0.885**	0.058	-0.029	-0.046	-0.235	0.010	0.157
6						**1.000**	0.187	0.064	0.030	-0.149	-0.181	0.215
7							**1.000**	0.508**	0.278*	0.581**	-0.619**	0.494**
8								**1.000**	0.082	0.334*	-0.482**	0.529**
9									**1.000**	0.502**	0.285*	0.470**
10										**1.000**	-0.336*	0.561**
11											**1.000**	-0.175
12												**1.000**

Critical r value 5% = 0.275 1% = 0.357 * Significant at 5% ** Significant at 1%

1. Plant height (cm) at 60 DAS
2. Number of leaves per plant at 60 DAS
3. Number of branches per plant at 60 DAS
4. Chlorophyll content (SPAD)
5. Days to first flowering
6. Days to fifty per cent flowering
7. Pod length (cm)
8. Pod width (cm)
9. Number of clusters per plant
10. Number of Pods per cluster
11. Number of seeds per pod
12. Pod yield per plant (g)

Number of clusters per plant had exhibited highly significant and positive correlation with number of plant height (0.56), number of pods per cluster (0.50), pod yield per plant (0.47), chlorophyll content (0.44) and significant and positive association with number of seeds per pod (0.28) and pod length (0.27).

Number of pods per cluster showed highly significant and positive correlation with pod length (0.58), pod yield per plant (0.56), plant height (0.52) and number of clusters per plant (0.50) whereas showed positive and significant association with pod width (0.33). However, this trait has exhibited negative and significant correlation with number of seeds per pod (-0.33).

Number of seeds per pod had exhibited highly significant and positive correlation with chlorophyll content of the leaves (0.59) and positive and significant association with number of clusters per plant (0.28). However it also exhibited highly significant and negative association with pod length (-0.61) and pod width (-0.48) and negative and significant association with number of pods per cluster (-0.33).

Pod yield per plant showed highly significant and positive correlation with number of pods per cluster (0.56), pod width (0.52), pod length (0.49), number of cluster per plant (0.47) and positive and significant correlation with number of leaves per plant (0.34) and plant height (0.33).

4.6.2 Phenotypic correlation

Plant height at 60 DAS showed highly significant and positive correlation with number of pods per clusters (0.41) and number of clusters per plant (0.40).

Number of leaves per plant at 60 DAS showed highly significant and negative correlation with days to 50 per cent flowering (-0.37) and significant and negative days to first flowering (0.34).

Table 16: Phenotypic correlation coefficient for yield and its component characters in vegetable soybean genotypes

	1	2	3	4	5	6	7	8	9	10	11	12
1	**1.000**	-0.054	0.179	-0.095	-0.012	0.061	0.158	0.228	0.404**	0.410**	-0.166	0.224
2		**1.000**	0.075	0.035	-0.344 *	-0.379 **	-0.054	0.174	0.143	-0.130	0.005	0.239
3			**1.000**	0.047	-0.151	-0.171	-0.036	-0.168	-0.109	0.256	0.163	0.171
4				**1.000**	0.033	-0.114	-0.280 *	-0.226	0.238	-0.021	0.549**	0.115
5					**1.000**	0.824**	0.044	-0.059	-0.038	-0.224	-0.038	0.139
6						**1.000**	0.143	0.070	0.034	-0.147	-0.161	0.202
7							**1.000**	0.419**	0.192	0.541**	-0.518**	0.420**
8								**1.000**	0.061	0.243	-0.358**	0.368**
9									**1.000**	0.362**	0.094	0.343*
10										**1.000**	-0.247	0.437**
11											**1.000**	-0.079
12												**1.000**

Critical r value 5% = 0.275 1% = 0.357 * Significant at 5% ** Significant at 1%

1. Plant height (cm) at 60 DAS
2. Number of leaves per plant at 60 DAS
3. Number of branches per plant at 60 DAS
4. Chlorophyll content (SPAD)
5. Days to first flowering
6. Days to fifty per cent flowering
7. Pod length (cm)
8. Pod width (cm)
9. Number of clusters per plant
10. Number of Pods per cluster
11. Number of seeds per pod
12. Pod yield per plant (g)

Chlorophyll content in leaves showed highly significant and positive correlation with number of seeds per pod (0.54). It also showed significant and negative correlation with pod length (-0.28).

Days to first flowering highly significant and positive correlation with days to fifty per cent flowering (0.82). However, it also exhibited significant and negative correlation with number of leaves per plant (-0.34).

Days to fifty per cent flowering had highly significant and positive correlation with days to first flowering (0.82). However, it also exhibited negative and highly significant correlation with number of leaves per plant (-0.37).

Pod length exhibited highly significant and positive association with number of pods per cluster (0.54), pod yield per plant (0.42) and pod width (0.41). However, the trait exhibited highly significant and negative correlation with number of seeds per pod (-0.51) meanwhile, significant and negative correlation with chlorophyll content (-0.28).

Pod width exhibited highly significant and positive association with pod length (0.41) and pod yield per plant (0.36). However, the trait exhibited highly significant and negative correlation with number of seeds per pod (-0.35).

Number of clusters per plant had highly significant and positive correlation with number of plant height (0.40), number of pods per cluster (0.36) and also showed significant and positive association with pod yield per plant (0.34).

Number of pods per cluster showed highly significant and positive correlation with pod length (0.54), pod yield per plant (0.43), plant height (0.41) and number of clusters per plant (0.36).

Number of seeds per pod had showed highly significant and positive correlation with chlorophyll content of the leaves (0.54). However it also exhibited highly significant and negative association with pod length (-0.51) and pod width (-0.35).

Pod yield per plant had showed highly significant and positive correlation with number of pods per cluster (0.43), pod length (0.42), pod width (0.36) and positive significant correlation with number of cluster per plant (0.34).

4.7 Path coefficient analysis

The correlation would only indicate the relationship of independent variable with the dependent variable without specifying causes and effects relationship. Using path coefficient analysis, it is resolve the correlation which will provide direct and indirect contribution of different quantitative traits. The genotypic path coefficient analysis was done for pod yield per plant.

The data pertaining to the genotypic path coefficients for following characters are presented in Table 17.

4.7.1 Genotypic path coefficient analysis

The path coefficient analysis for green pod yield per plant was performed with a set of eleven independent characters *viz.,* plant height, number of leaves per plant, number of branches per plant at 60

DAS, days to first flowering, days to 50 per cent flowering, pod length, pod width, number of clusters per plant, number of pods per cluster, number of seeds per pod and pod yield per plant. In the present investigation, the residual effect of path analysis for the genotypic coefficient was observed as 0.291.

4.7.1.1 Direct effect of yield contributing characters on pod yield

Among the eleven yield components number of pods per cluster (0.84), number of leaves per plant (0.68), days to fifty per cent flowering (0.44) and days to first flowering (0.31) exhibited positive and high direct effect. Whereas number of seeds per pod (0.18), number of branches per plant (0.17) and pod width (0.16) exhibit positive but low direct effect. Pod length and chlorophyll content in leaves recorded positive and negligible direct effect whereas, plant height (-0.13) had negative low effect and number of cluster per plant (-0.11) had negative and negligible effect towards pod yield per plant at genotypic level.

Table 17: Genotypic path coefficient analysis for yield and its component characters in vegetable soybean genotypes

	1	2	3	4	5	6	7	8	9	10	11	rG
1	**-0.133**	0.164	-0.051	-0.004	0.002	-0.007	-0.024	-0.015	-0.075	-0.0706	-0.0001	0.3308
2	-0.084	**0.684**	0.158	0.078	-0.296	-0.290	-0.052	0.210	0.094	-0.1129	0.0570	0.3448
3	0.067	0.040	**0.175**	0.018	-0.049	-0.056	-0.000	-0.048	-0.036	0.0438	0.0351	0.2586
4	0.000	0.001	0.001	**0.013**	0.000	-0.001	-0.004	-0.003	0.005	-0.0008	0.0077	0.0749
5	-0.005	-0.134	-0.087	0.022	**0.311**	0.275	0.018	-0.009	-0.014	-0.0734	0.0006	0.1574
6	0.023	-0.187	-0.141	-0.047	0.390	**0.441**	0.082	0.028	0.013	-0.0659	-0.0801	0.2159
7	0.002	-0.001	0.001	-0.004	0.000	0.002	**0.013**	0.006	0.003	0.0079	0.0084	0.4942
8	0.018	0.051	-0.046	-0.048	-0.004	0.010	0.084	**0.165**	0.013	0.0554	-0.0800	0.5291
9	-0.006	-0.001	0.002	-0.004	0.000	-0.000	-0.003	-0.000	**-0.011**	-0.0056	-0.0032	0.4701
10	0.446	-0.139	0.211	-0.054	-0.199	-0.126	0.491	0.282	0.424	**0.8451**	-0.2847	0.5619
11	0.000	0.015	0.036	0.107	0.000	-0.032	-0.112	-0.087	0.051	-0.0610	**0.1811**	-0.1757

Diagonal values indicates direct effect rG genotypic correlation with pod yield per plant @ characters

Residual effect = 0.292 1% = 0.357 * Significant at 5% ** Significant at 1%

1. Plant height (cm) at 60 DAS
2. Number of leaves per plant at 60 DAS
3. Number of branches per plant at 60 DAS
4. Chlorophyll content (SPAD)
5. Days to first flowering
6. Days to fifty per cent flowering
7. Pod length (cm)
8. Pod width (cm)
9. Number of clusters per plant
10. Number of pods per cluster
11. Number of seeds per pod

4.7.1.2 Indirect effect of yield contributing characters on pod yield

Plant height influenced low positive indirect effect on pod yield per plant through number of leaves per plant (0.16). However, its indirect effect through other traits is negligible.

Number of leaves had positive and moderate indirect effect on pod yield per plant through pod width (0.21) and positive low indirect effect via number of branches per plant (0.15). However, there was negative moderate indirect effect via days to first flowering and fifty per cent flowering (-0.29). Its indirect effect through other traits is negligible.

Days to first flowering had positive and moderate indirect effect on pod yield per plant through days to fifty per cent flowering. However, there was negative low indirect effect via number of leaves per plant (-0.13). Its indirect effect through other traits is negligible.

Days to fifty per cent flowering had positive and high indirect effect on pod yield per plant through days to first flowering (0.39). However, there was negative low indirect effect through number of leaves per plant (-0.18) and number of branches per plant (-0.1). Its indirect effect through other is negligible.

Number of pods per cluster had positive high indirect effect on pod yield per plant via per plant via pod length (0.49), plant height (0.44), and number of cluster per plant (0.42); positive and medium indirect effect through pod width (0.28) and number of branches per plant (0.21). Whereas, number o seeds per pod (-0.28) had moderate negative indirect effect on pod yield per plant and days to first flowering (-0.19) and number of leaves per plant (-0.13) had negative low indirect effect on pod yield plant.

Number of seeds per pod also showed positive low indirect effect on pod yield per plant through chlorophyll content of leaves (0.10) and low negative indirect effect via pod length (-0.11). Meanwhile, its indirect effect through other trait is negligible.

V. DISCUSSION

Vegetable soybean or Edamame is a specialty soybean (*Glycine max* (L.) Merrill.) harvested as a vegetable when the seeds are immature (R6 stage) and have expanded to fill 80 to 90 per cent of the pod width. Like field-dried soybeans, the seeds of edamame varieties are rich in protein and highly nutritious. Worldwide, it is a minor crop, but it is quite popular in East Asia.

Vegetable soybean is popular in Japan, Korea, China and Taiwan and consumption are increasing very rapidly. The green-shelled beans can be cooked to make a tasty and nutritious meal or snack. Grain soybean is already widely cultivated in many countries of the tropics and subtropics, so the production of vegetable soybean can be readily adopted. The cultivation practices for vegetable soybean and grain soybean are similar except that vegetable soybean is harvested when the pods are mature and green. The seeds of vegetable soybean are commonly bigger in size as compared to grain soybean.

Vegetable soybean has an excellent potential for enriching the human diet. It is a rich source of Vitamin A and a good source of carbohydrates, protein and iron. It is more nutritious than vegetable green peas. In addition to domestic consumption vegetable soybean also has export potential. Hence, an attempt is made to evaluate vegetable soybean genotypes for suitability to eastern dry zone of Karnataka.

The objective of evaluation of vegetable soybean genotypes is to select the high yielding cultivars with better crop growth, yield and quality especially for horticultural traits. Selection of genotypes/cultivars/varieties for a particular region is more important to investigate considerable variability in various characters when grown under a particular environment. The present investigation was undertaken at the experimental unit of Department of Vegetable Science, College of Horticulture, Bengaluru with 17 vegetable soybean genotypes to assess for their growth, yield and quality parameters.

In order to know the performance of the genotypes of crop plants for future breeding works, a preliminary evaluation is necessary. Therefore, the results obtained in the present investigation of evaluation of vegetable soybean genotypes are discussed here under the following headings with supporting data and available literature.

5.1 Growth parameters

Significant difference was found among the genotypes studied in terms of plant height, number of leaves per plant, number of branches per plant, growth type and chlorophyll content of the leaves.

The plant height significantly varied among the different vegetable soybean genotypes studied at all the stages of plant growth. In general, the growth of all the cultivars increased gradually as the days advanced. The genotypes AGS 433, COHBSBM-8, GC 99103-5 and Karune were vigorous in growth in terms of plant height. Genotype AGS 433 recorded maximum plant height (39.95 cm, 61.19 cm and 65.08 cm) at 30, 60 and 90 DAS respectively. Different responses to plant height might be due to genetic characteristic of genotypes and adaptability to a prevailing environment. Similar variation in plant height among the genotypes was also observed previously in French bean by Saini and Negi (1998); Anjanappa *et al.* (2000) and Smitha (2005), Verma *et al.* (2014) in French bean and Jitender *et al.* (2014) in cluster bean; Basavaraja *et al.* (2005); Poornima *et al.* (2014); Ramya and Mummigatti (2015) in vegetable soybean; Haruna *et al.* (2015) in soybean and Khan *et al.* (2013) in pea.

At 30, 60 and 90 DAS number of leaves per plant was maximum in genotype AGS 433 (31.13, 52.67 and 55.01 respectively). The differences in number of leaves per plant could be attributed to the genetic makeup of the genotypes. Similar variations for number of leaves per plant were also reported by Abdel *et al.* (2005) and Sharma *et al.* (2013) in French bean and Phom *et al.* (2014) in garden pea.

Significant differences were observed among the genotypes with respect to number of branches per plant. Genotype AGS 433 (5.33, 6.80 and 7.20) has recorded the maximum number of branches per plant. More number of branches per plant is an indication of more vegetative growth due to climatic condition and could be due to genetic variability of different genotypes. Similar variations for number of branches per plant was also obtained by Abdel *et al.* (2005), Pandey *et al*. (2011), Sharma *et al.* (2013) in French bean; Khan *et al.* (2013) and Phom *et al.* (2014) in pea; Rai *et al*. (2012) in cluster bean and Basavaraja *et al.* (2005) in vegetable soybean.

5.2 Flowering parameters

Flowering parameters including days taken to first flowering and days taken to 50 per cent flowering. It was varied significantly among the genotypes. The time taken for first flowering and for 50 per cent flowering was less in genotype COHBSBM-26 (33.67 and 37 days respectively). Hence, these cultivars were said to be early type. Late flowering was observed in the genotype IC 25763 (37.33 and 43.00 days) both for first and 50 per cent flowering. Early flowering in certain genotypes indicated adaptability of these genotypes in a particular environment, better and efficient utilization of nutrients in a relatively hostile environment which might have resulted in early termination of vegetative phase and initiation of reproductive phase as compared to late flowering genotypes. Similar results have also been reported by earlier worker in vegetable soybean by Ramya and Mummigatti (2015); Saiyad (2003), Rana and Arvind (2008) and Sofi *et al*. (2011) and Sharma *et al.* (2013) in French bean; Malaghan (2012) in cluster bean for days to first flowering. Basavaraja *et al.* (2005) in vegetable soybean; Haruna *et al.* (2015), Njoroge *et al.* (2015) in soybean; Sahu *et al.* (2005) in winged bean; Khan *et al.* (2013) in pea and Mohan *et al.* (2009) in dolichos bean for days to 50 per cent flowering.

The total chlorophyll content in leaves at 45 DAS was higher in the genotype Karune (46.80). Similar results were reported by Ramya and Mummigatti (2015), Poornima *et al.* (2014) in vegetable soybean; Basavaraja (2013) in fenugreek and Jitender *et al.* (2014) in cluster bean.

5.3 Yield parameters

Significant difference was observed for number of clusters per plant among different genotypes of vegetable soybean. The maximum number of pods per cluster was noticed in AGS 433 (19.43). This may be attributed to the inherent genetic makeup and environmental factors. These results are in confirmation with the findings of Pandey *et al.* (2006) in cowpea; Arora *et al.* (2011) and Girish *et al*. (2013) in cluster bean.

The maximum number of pods per cluster was noticed in the genotype AGS 433 (6.69). This might be due to genetic makeup of the genotypes. Similar results were reported by Parmar *et al.* (2013) in dolichos bean; Pandey *et al.* (2006) in cowpea; Arora *et al.* (2011) and Girish *et al.* (2013) in cluster bean.

Significant difference was found among the genotypes with respect to pod length. Highest pod length was recorded in the genotype IC 25763 (5.57 cm). However, it may be due to varietal character. These results are in lines with the findings of Basavaraja *et al.* (2005) and Sharma *et al.* (2013) in vegetable soybean.

Pod width differed significantly among the 17 vegetable soybean genotypes. Genotype COHBSBM-54 has recorded the maximum pod width of 1.16 cm. This may be due to varietal variation which is attributed to their genetic makeup. Similar variations have been reported previously by Basavaraja *et al.* (2005), Sharma *et al.* (2013) in vegetable soybean; Sarangi and De (2010), Pandey *et al*. (2011) and Kumar *et al.* (2014) in French bean.

Genotype IC 501197 (3.00) has recorded the more number of seeds per pod. Similar results for number of seeds per pod were reported by Sharma *et al.* (2013) in vegetable soybean; Obidiebube *et al.* (2013), Haruna *et al.* (2015) and Njoroge *et al.* (2015) in soybean.

Genotypes showed significant differences with respect to pod yield per plant. The maximum pod yield per plant was recorded in AGS 433 (70.55 g). Similar results were reported by Basavaraja *et al.* (2005), Poornima *et al.* (2014), Sciarappa *et al.* (2007) in vegetable soybean for pod yield per plant.

The maximum pod yield per plot was recorded in AGS 433 (4.52 kg). Sarangi and De (2010) in French bean; Dandannavar (2000) in winged bean and Girish *et al.* (2013) in cluster bean reported same results for pod yield per plot.

The maximum pod yield per hectare was recorded in AGS 433 (78.40 q). This difference in pod yield per hectare could be attributed due to the highly significant and positive relationship with increase in plant height, number of pods per cluster and number of pods per plant apart from the genetic makeup and the influence of environment. These findings are in conformity with the results of Ramya and Mummigatti (2015), Basavaraja *et al.* (2005) and Poornima *et al.* (2014) in vegetable soybean.

Genotype COHBSBM-49 has recorded the higher hundred seed weight (32.37 g). Existence of such variations in hundred seed weight among the genotypes has been reported by Marutani and Schlub (2003), Basavaraja *et al.* (2005), Sharma *et al.* (2013), Poornima *et al.* (2014), Ramya and Mummigatti (2015) in vegetable soybean; Njoroge *et al.* (2015) and Haruna *et al.* (2015) in soybean.

The maximum seed yield per plant was recorded in genotype COHBSBM-8 (36.47 g). Existence of such variation for seed yield per plant were reported by Basavaraja *et al.* (2005) and Ramya and Mummigatti (2015) in vegetable soybean.

The maximum seed yield per hectare was recorded in genotype COHBSBM-8 (40.65 q) which was followed by COHBSBM-49 (38.50 q) and AGS 432 (37.29 q). Similar findings were reported by Ali *et al.* (2013); Haruna *et al.* (2015) and Aniekwe (2015) in soybean.

5.4 Quality parameters

Protein per cent in vegetable soybean significantly differed among the genotypes and highest protein content was recorded in the genotype EC 95286 (10.00 g $100g^{-1}$). The protein percentage varies depending on genotypes, environment and growing conditions. The results are in agreement with Sharma *et al.* (2014), Salmani *et al.* (2012) and Sharma *et al.* (2013) in vegetable soybean and Sharma *et al.* (2016) in French bean.

Highest starch content was recorded in the genotype AGS 433 (1.32 g $100g^{-1}$) Starch content in vegetable soybean is a heritable trait and is highly influenced by genotypes variability. The results are in agreement with Sharma *et al.* (2013) in vegetable soybean.

The maximum total sugar was recorded in COHBSBM-8 (3.60 %). Total sugar content in vegetable soybean is a heritable trait and is highly influenced by genotypes variability. The results are confirmed with Sharma *et al.* (2013) in vegetable soybean and Sharma *et al.* (2016) in French bean.

The maximum reducing sugar per cent was recorded in COHBSBM-8 (2.57 %). The differences in reducing sugars content among different varieties may be attributed to the genetic makeup of the cultivars.

The maximum non-reducing sugar was recorded in W-80 (1.56 %) followed by EC 25986 (1.35 %) and COHBSBM-26 (1.30 %). The variation in the non-reducing sugar level among various soybean

genotypes may be attributed to adaptability potential under agro-climatic conditions of the area and may also be due to their genotypic differences.

The lowest trypsin inhibitory activity was recorded in the genotype COHBSBM-26 (0.19 µ mol $min^{-1}mg^{-1}$). The variation in the trypsin inhibitory activity among various soybean genotypes may be attributed to their genotypic differences.

5.5 Sensory evaluation

There were significant differences were observed in sensory evaluation of vegetable soybean. The genotype Karune registered higher overall acceptability of 8.57 (score out of 9). Similar results were reported by Swathi (2009) in vegetable soybean.

5.6 Correlation and path analysis

5.6.1 Correlation studies

A complex association exists among plant characters. These characters are often correlated with each other either due to pleiotrophy or due to genetic linkage (Harland, 1939). The relationship between phenotypic, genotypic and environmental correlation as entwined (Falconer, 1989) emphasising that for the characters having high heritability, the environmental correlations are generally expected to be lower than genotypic correlations. Since the phenotypic correlation includes a part of environmental correlation responding to the heritable portion of variation in two characters, it is therefore expected that for highly heritable characters, genotypic correlation would be higher than phenotypic correlation when the correlations are in the same direction. Further, Falconer (1981) stated that phenotypic correlation can exceed genotypic correlation only if the heritability of the two characters was low and environmental correlation was high. Hence, an important strategy designed to break the barriers of yield. In other words high positive correlations between two traits makes simultaneous improvement in two or more attributes. Whereas, negative association indicates the compromise between desirable characters.

The genotypic correlations were higher than the phenotypic correlations in the present study indicating high heritable nature of the traits. Also, the results showed that there was no much difference between genotypic and phenotypic correlations among characters studied. This indicates that the influence of environment is least on correlation. So, one can base their selection on phenotypic values. In the present study, yield and other components were investigated and their relationship with pod yield per plant as well as among themselves was determined using correlation analysis. The traits like, pod length, pod width, number of pods per cluster and number of clusters per plant had high positive significant correlation with pod yield per plant at both genotypic and phenotypic levels. Pod yield per plant is combination of many characters and polygenically controlled. For such traits, direct selection is difficult. Therefore, selection for any of these highly associated traits with pod yield per plant will indirectly help in selecting the genotypes or accession with high yield. Hence, it is worthwhile to have accessions with high pod length, pod width, number of pods per cluster and number of clusters per plant to get higher yields. The results are in agreement with the findings of Similar results were given by Sharma *et al.* (1977), Dursun (2007), Anjani *et al.* (2009), Angadi *et al.* (2012b) and Kumar *et al.* (2014) in French bean; Rai and Dharmatti (2014) in cluster bean; Shivastava *et al.* (2009) in pea and Bahadur *et al.* (2013) in dolichos bean, who also noticed positive association of pod length, pod width, number of pods per cluster and number of clusters per plant on pod yield per plant.

A strong association of number of branches on number of clusters per plant and number of pods per cluster was noticed. Also, it had strong and highly significant positive association with pod yield per plant. Hence, selection for more number of branches per plant on number of clusters per plant and number of pods per cluster, would indirectly improve pod yield per plant.

5.6.2 Path coefficient analysis

The correlation coefficient measures the relationship existing between pairs of characters. But, a dependent character is an interaction product of many mutually associated component characters and change in any one component will disturb whole network of cause and effect system. The path coefficient analysis, a statistical device developed by Wright (1921), as a tool of genetic analysis, the utility of which in plant selection was demonstrated by Dewey and Lu (1959). Which takes into account the cause and effect relation between the variables, is unique in partitioning the association into direct and indirect effects through other independent variables. Path analysis also measures the relative importance of causal factors involved. This is simply a standardized partial regression analysis, wherein total correlation value is subdivided into causal scheme.

Path-coefficient analysis revealed that pod yield per plant was directly influenced by number of pods per cluster, number of leaves per plant, days to fifty per cent flowering, days to first flowering, number of seeds per pod, number of branches per plant and pod width. So, selection for any of these independent traits leads to improving the genotypes for pod yield per plant. The importance of number of pods per cluster, number of leaves per plant, days to fifty per cent flowering, days to first flowering, number of seeds per pod, number of branches per plant and pod width has been highlighted by Roy *et al.* (2006), Bhushan *et al.* (2007) and Mishra *et al.* (2009) in French bean and Pal and Singh (2012), Joshi and Mehra (1984), Shinde and Dumbre (2001), Vaid *et al.* (1986), Mehra and Singh (2012), Golani *et al.* (2007) and Singh *et al.* (2011). The path analysis confirms the earlier studies that number of pods per cluster, number of leaves per plant, days to fifty per cent flowering, days to first flowering, number of seeds per pod, number of branches per plant and pod width are important traits that contribute to pod yield.

From the present path analysis study in vegetable soybean, it may be concluded that improvement in pod yield per plant could be brought by selection for component characters like number of pods per cluster, number of leaves per plant, days to fifty per cent flowering, days to first flowering, number of seeds per pod, number of branches per plant and pod width.

VI. SUMMARY

The present investigation on “Evaluation of vegetable soybean (*Glycine max* (L.) Merrill) genotypes for horticultural traits in eastern dry zone of Karnataka” for growth, yield and quality parameters was carried out at Vegetable Research Block, Department of Vegetable Science, College of Horticulture, Bengaluru, during the year 2016-2017 to study the relative performance of different vegetable soybean genotypes and select a suitable high yielding genotypes for cultivation and acceptability of vegetable soybean crop not only for eastern dry zone but for other regions of Karnataka. The experiment consisting of 17 genotypes laid out in a Randomized Complete Block Design (RCBD) with three replications. The salient findings of the investigation are summarized in this chapter.

Analysis of variance showed significant difference for growth, earliness, yield and quality parameters. Genotype AGS 433 (39.95 cm) was the tallest among the genotypes at 30 DAS. As the day progresses, the genotype AGS 433 (61.19 cm and 65.08 cm) had showed increased plant height at 60 and 90 DAS.

Number of leaves per plant varied significantly among the genotypes. The maximum number of leaves per plant was recorded in AGS 433 (31.13, 52.67 and 51.01) at 30, 60 and 90 DAS.

Genotype AGS 433 (5.33, 6.80 and 7.20) has recorded the maximum number of branches per plant at 30, 60 and 90 DAS respectively. Chlorophyll content in leaves was higher in the genotype Karune (46.80).

Among all the evaluated vegetable soybean genotypes, COHBSBM-26 was the earliest to show the first flowering (33.67 days) and the same genotype continued its early flowering behaviour and reached to fifty per cent flowering in 37.00 days after sowing followed by AGS 432 (37.33 days) and GC 99013-5 (37.67 days) compared to other genotypes.

The genotype AGS 433 recorded significantly higher number of clusters per plant (19.43) which was on par with COHBSBM-8 (17.09). Among the genotypes, maximum number of pods per cluster was noticed in AGS 433 (6.69).

The pod length varied among the genotypes due to their genetic makeup. Pod length was highest in the genotype IC 25763 (5.57 cm). The pods of genotype IC 25763 had highest pod width (1.10 cm). Number of seeds per pod was more in the genotype IC 501197 (3.00).

The genotype AGS 433 had recorded the highest pod yield per plant, per plot and per hectare of 70.55 g, 4.52 kg and 78.40 q respectively.

With respect to seed length and seed size, the genotype GC 99013-5 had higher seed length of 0.86 cm and COHBSBM-8 had the higher seed width.

Genotypes showed significant differences among themselves with respect to hundred seed weight. The genotype COHBSBM-49 has recorded the higher hundred seed weight (32.37 g).

Seed yield in vegetable soybean was significantly influenced by genotypes. The maximum seed yield per plant, per plot and per hectare was recorded in genotype COHBSBM-8 (36.47 g, 2.41 kg and 40.65 q respectively).

With respect to quality parameters, protein per cent in vegetable soybean was highest in the genotype EC 95286 (10.00 g $100g^{-1}$). Among all the genotypes, highest starch content was recorded in the genotype AGS 433 (1.32 g $100g^{-1}$). The maximum total sugar and reducing sugar was recorded in COHBSBM-8 (3.60 % and 2.57 % respectively). The maximum non-reducing sugar per cent was

recorded in W-80 (1.56 %) followed by EC 95286 (1.35 %) and COHBSBM-26 (1.30 %) and lower texture values was recorded in the genotype IC 501164 (240.87 g). Trypsin inhibitory activity soybean significantly differed among the genotypes and lowest trypsin inhibitory activity was recorded in the genotype COHBSBM-26 (0.19 µ mol $min^{-1}mg^{-1}$ of sample).

Correlation studies for vegetable pod yield per plant were carried out considering 12 independent component characters at phenotypic and genotypic level. Correlation results revealed that highly significant and positive association of pod yield per plant with pod length, pod width, number of pods per cluster and number of clusters per plant indicating the possibility of simultaneous selection for these traits to improve the pod yield.

The path coefficient analysis for vegetable pod yield per plant was carried out considering 11 independent component characters. Path coefficient analysis revealed that number of pods per cluster, number of leaves per plant, days to fifty per cent flowering, days to first flowering, number of seeds per pod, number of branches per plant and pod width were the most influencing factors. Thus, these characters deserve greater weightage during selection for yield. The direct selection for these traits would be rewarding for improvement in the pod yield per plant.

In the present investigation, an attempt was made to identify the best genotypes for yield and quality. Genotype COHBSBM-26, COHBSBM-66 and AGS 432 can be used as early types. Among the genotypes, AGS 433, AGS 432 and COHBSBM-54 were found promising in terms of pod yield under dry zone of Karnataka. With respect to quality attributes, genotypes EC 95286 and COHBSBM-8 found most promising with higher protein and total sugars content respectively and genotype Karune has higher overall acceptability compared to other genotypes. Hence, these genotypes are suitable for cultivation under eastern dry zone of Karnataka.

Future line of work

Based on the current study, the following line of work may be suggested for future investigations.

- Performance of the identified superior genotypes could be confirmed by large scale performance trial at different locations for yield stability and the best genotypes could be adopted for commercial cultivation.

- Investigations on evaluation of genotypes under different seasons of the year may be taken up as the present study was restricted to a single season only.

- Suitable agronomic practices required to be standardized for the best performing genotypes.

- Need to evaluate more number of vegetable soybean genotypes for higher yield and protein content.

- Large scale screening of different vegetable soybean genotypes or germplasm against rust and mosaic disease through resistance breeding programme.

- High yielding genotypes with protein content and resistant genotypes can be utilized for hybridisation programme.

- Quality aspects such as darker green, unblemished pods, earlier maturity, lower temperature tolerance, and a trypsin-inhibitor-free, sweet and savory flavour are major objectives need to be consider for further breeding programmes.

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*originals not seen

APPENDIX I

Descriptive qualitative parameters of different vegetable soybean genotypes

Sl. No.	Genotypes	Flower colour	Growth type	Pubescence
1.	COHBSBM-26	Light purple	Indeterminate	Medium
2.	COHBSBM-8	White	Determinate	Medium
3.	IC 501197	Dark purple	Determinate	Medium
4.	COHBSBM-66	White	Determinate	Sparse
5.	COHBSBM-49	Light purple	Determinate	Sparse
6.	COHBSBM-54	White	Indeterminate	Sparse
7.	IC 25763	White	Determinate	Intense
8.	AGS 433	White	Indeterminate	Sparse
9.	W-80	White	Determinate	Intense
10.	EC 24207	White	Determinate	Sparse
11.	AGS 432	Light purple	Indeterminate	Sparse
12.	EC 95286	White	Determinate	Medium
13.	Karune	Dark purple	Indeterminate	Medium
14.	IC 501164	White	Indeterminate	Medium
15.	GC 99013-5	White	Determinate	Medium
16.	GC 110318	White	Indeterminate	Sparse
17.	EC 103153	Light purple	Determinate	Medium

APPENDIX II

Meteorological data recorded during the period of experimentation (2016-17)

Month	Rainfall		Temperature (^{o}C)		Relative humidity (%)	
	Mm	days	Maximum	Minimum	Maximum	Minimum
Aug	20.30	2	27.50	19.40	91.90	60.10
Sep	50.70	4	27.40	19.30	92.10	59.30
Oct	0.20	0	30.80	18.00	83.30	49.80
Nov	2.40	0	28.90	17.00	86.20	33.20
Dec	63.80	3	26.20	20.70	88.70	43.70

Source: UHS Campus (RHREC & COH), Bengaluru