EVALUATION OF BUSH DOLICHOS BEAN [*Lablab purpureus* (L.) Sweet] FOR YIELD AND QUALITY

By

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(2018-12-019)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **" EVALUATION OF BUSH DOLICHOS BEAN [*Lablab purpureus* (L.) Sweet] FOR YIELD AND QUALITY"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **"EVALUATION OF BUSH DOLICHOS BEAN [*Lablab purpureus* (L.) Sweet] FOR YIELD AND QUALITY"** is a record of research work done independently by Ms. Maneesha P.K (2018-12-019) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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LIST OF ABBREVIATIONS

ANOVA	: Analysis of variance
CD (0.05)	: Critical difference at 5 % level
cm	: Centimetre
CRD	: Completely Randomized Block Design
DAS	: Days after sowing
d.f.	: Degrees of freedom
et al.	: Co-workers/ Co-authors
Fig.	: Figure
g	: Gram
GA	: Genetic advance
GCV	: Genotypic coefficient of variation
H^2	: Heritability
ha^{-1}	: Per hectare
i.e	: That is
KAU	: Kerala Agricultural University
kg	: Kilogram
l	: Litre
m	: Meter
PCV	: Phenotypic coefficient of variation
POP	: Package of practices
SEm	: Standard error mean
t	: Tonnes
viz.,	: Namely

LIST OF SYMBOLS

^{o}C	:	Degree Celsius
%	:	Per cent
@	:	at the rate of

1. INTRODUCTION

Dolichos bean [*Lablab purpureus* (L.) Sweet] is an important leguminous vegetable belonging to the family Fabaceae, known by various names, *viz*. lablab bean, hyacinth bean, common bean, field bean, Egyptian bean, bonavist bean, Indian bean *etc*. and 'amarapayar' in malayalam. "Dolichos" is a Greek word meaning "long" and "lablab" is an Arabic or Egytian word meaning "dull rattle of the seed inside the dry pod". It occupies a unique position as vegetable among the leguminous crops, due to its high nutritive value, a good source of proteins, minerals and vitamins (Ananth and Kumar, 2018). It is primarily grown for green pods, which are cooked as vegetable like other beans. The dry seeds are also used for various vegetable preparations. The foliage of the crop provides hay, silage and green manure.

Dolichos bean (2n=22) is one of the ancient crops widely distributed in Indian subcontinent, Africa, and Southeast Asia, where it has been used as a grain legume and vegetable for more than 3500 years. It is one of the most diverse domesticated legume species, with largest agro-morphological diversity in South Asia. It is a tropical crop mainly grown in South Asia (specifically India, Nepal and Bangladesh), South East Asia and Africa. The wild forms of Indian bean are believed to have originated in India and were introduced into Africa from South East Asia during the eighth century. India is the centre of origin and center of diversity of dolichos bean and large number of indigenous strains are available in northern India (Chathopadhyay and Dutta, 2010). It is mainly grown in Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, some parts of Gujarat and Karnataka.

Edible pods of lablab bean provide substantial amount of protein in addition to vitamin A, vitamin C, riboflavin, potassium, sulphur, iron and sodium. The protein content of pods and seeds ranges from 10-19% and 15-25% respectively. Among the legumes, dolichos bean constitutes an important source of therapeutic agents used in the modern as well as traditional system of medicine (Morris, 2009). The flavonoid overlaid in lablab bean play a role in the prevention of cancer and as a chemotherapeutic and/or chemo preventive agent for head and neck cancer.

Polyphenol oxidase like tryrosinase, present in plant tissue of lablab bean, has potential for the treatment of hypertension in humans. Thus mature seeds provide a cheaper source of protein, that is consumed both as cooked and fried. The seeds are used as a laxative, diuretic, anthelmintic, antispasmodic, aphrodisiac, digestive, carminative, febrifuge and stomachic. It is considered as a multipurpose crop since it is used for forage, soil improvement, soil protection and weed control. Being a legume, it can also fix atmospheric nitrogen to the extent of 170 kg ha^{-1} besides leaving enough crop residues to enrich the soil with organic matter. This crop can also grow well in alkaline and saline soil, pH ranging upto 9.0.

Dolichos bean is perennial in habit, but cultivated as an annual or biennial. The plants are of two types- determinate and indeterminate. Most of the twining pole garden cultivars are indeterminate in habit and photo-sensitive. The dwarf bushy, determinate cultivars can be cultivated throughout the year, as they are photo-insensitive. Commercial cultivation of climbing types require cost intensive trellising. These are photosensitive (short day plants), hence available for a very short period, *i.e.* during december - march. Bush type dolichos bean which do not require specific short day conditions for flowering and pod set is mainly grown as a highly renumerative off-season crop during summer and rainy season for its tender pods in Madhya Pradesh (Pan *et al*., 2004).

Despite its wide distribution in the tropics and range of adaptability and diversity, it remains as an underutilized crop in many of these regions, as evidenced from limited area planted to this crop and efforts towards its genetic improvement (Ramesh and Byregowda, 2016). Long duration, photosensitivity and indeterminate growth habit also lead to underutilization of the crop. The crop has high variability and diversity among the pole and bush types (Muthiah *et al*., 2008). To initiate any improvement work, it is necessary to assess the genetic variability present in the indigenous bush type germplasm and enhance productivity. The efforts of improving the crop by utilizing indigenous and exotic germplasm have been useful in breaking

the yield barriers resulting in developing compact plant type with reduced duration and photo-insensitivity (Shivashankar *et al.*, 1993). Large scale cultivation of dolichos bean is not being undertaken in Kerala, but brought from the neighbouring states to our local markets. It is an underutilized vegetable, pole types being grown as homestead crop in Kerala. Being a short duration, highly nutritious legume with low input requirement, there is scope for cultivation of dolichos bean in Kerala. A number of bush type genotypes are grown in different regions of India.

Hence the present investigation was taken up with the objectives:

1. To assess the genetic variability present in bush type dolichos bean.
2. To evaluate different genotypes of bush dolichos bean for growth, yield and quality under Kerala conditions.
3. To identify high yielding, photo-insensitive and determinate genotypes with good quality, suitable for cultivation in Kerala.

2. REVIEW OF LITERATURE

Dolichos bean [*Lablab purpureus* L. (Sweet)] is consumed as a vegetable in several parts of Asia and it occupies a unique position as a leguminous vegetable due to its high nutritive value. Crop improvement is aimed at developing high yielding variety with quality parameters of consumer preference. Selection of high yielding dolichos genotype with quality parameters is one of the most important tools in enhancing productivity at selected locations. The efforts to improve the crop by utilizing indigenous and exotic germplasm have been useful in breaking the yield barriers resulting in developing compact plant type with reduced duration and photo-insensitivity.

In this chapter, an effort has been made to review the available literature concerning evaluation of genotypes of dolichos bean and other leguminous vegetables for growth, yield and quality attributes. The review is presented under the following sections.

2.1 GROWTH PARAMETERS

2.1.1 Vegetative Characters

2.1.1.1 Plant height

Growth response of dwarf lablab bean was studied by Kim *et al.* (1992) and observed that the plant height and number of nodes increased in plants sown from January to June, with those sown in June being the tallest and having the highest number of nodes. Chaudhari *et al.* (2013) reported that in dolichos bean, plant height ranged from 93.35 cm to 193.38 cm with a mean of 127.07 cm, whereas, Bahadur *et al.* (2013) reported a range from 66.69 cm to 1635.33 cm with a mean of 1015.38 cm.

A study on genetic divergence in Indian bean was conducted by Pawar *et al.* (2013) and reported that cluster V recorded maximum plant height of 113.49 cm in dolichos bean. Verma *et al*. (2014) reported that plant height ranged from 63.91 to 121.53 cm in bush dolichos bean.

Maximum plant height recorded at 60 DAS, at 60, 90 DAS as well as at harvest was 82.50 cm, 116.10 cm and 148.50 cm, when crop was sown on 15th October compared to 1st November. This might be due to the higher necessary temperatures at early and later stages available for the growth of the crop (Joshi and Rahevar, 2015).

The plant height of dolichos bean genotypes was assessed at 30, 60 and 90 DAS by Ravinaik *et al.* (2015). At all the growth stages, PD-31 showed maximum height (108.87, 185.33 and 196.27cm), followed by PD-22 (106.43, 179.73 and 194.27cm, respectively). The least plant height was recorded in Hebbal Avare-3 (84.00, 102.33 and 140.33 cm).

Choudhary *et al.* (2016) reported that plant height ranged from 40.17 to 242.33 cm with a mean value of 167.75cm among 64 Indian bean genotypes. The highest plant height recorded in Konkan Wal-2 (111.01 cm) and the lowest in Arka Sambhram (42.09 cm) was reported by Veerbhadreshwar (2016) in bush dolichos bean.

Maximum vine length of 8.15 m, recorded in CG-12 and minimum vine length of 4.30 cm was recorded in CG-31 as reported by Gupta *et al.* (2017) in dolichos bean. Ananth and Kumar (2018) evaluated twenty genotypes of bush dolichos bean to screen high yielding genotype suitable for coastal region of Tamilnadu. Eight genotypes *viz.*, Cuddalore local, Goldy-24, Coimbatore local, Arka Jay, Co (Gb) 14, Ankure goldy, Arka Vijay and Chidambaram local recorded higher growth attributes than the mean performance. The highest plant height recorded in Ankure goldy (76.15 cm) was on par with Arka Jay (75.25 cm) and the lowest was in Trichy local (62.13 cm).

2.1.1.2 Plant spread

Viswanath *et al.* (1971) observed that due to their compact growth, determinates facilitate high density planting to maximize their EPY (economic product yield). Twenty five bush dolichos bean accessions were evaluated by Sreekanth (2007) and recorded that plant spread was maximum in LP-4 (87.93cm)

and minimum in LP-16 (37.40) during rabi season. During summer season also, the maximum plant spread was obtained from LP-4 (72.95 cm) and minimum in LP-16 (24.79 cm). Plant spread was more during rabi season (53.12 cm) than summer (45.24 cm).

2.1.1.3 Primary branches plant^{-1}

Gnanesh *et al.* (2006) reported that primary branches plant^{-1} ranged from 2.40 to 6.33 in field bean, with a mean of 3.68. Wide range of variability was observed for number of branches plant^{-1} (3.80- 8.60) by Chaudhari *et al.* (2013) in vegetable Indian bean.

An evaluation of dolichos bean cultivars for genetic variability, heritability and genetic advance studies was done by Verma *et al.* (2015) and reported that primary branches plant^{-1} ranged from 2.50 to 4.30 with a mean of 3.31. Ravinaik *et al.* (2015) reported maximum number of branches plant^{-1} (16.27) in PD-31 in dolichos bean followed by PD-22 (15.20) and PD-05 (14.47), whereas, minimum number of branches plant^{-1} in PD-20 (11.90) at 90 DAS.

Bahadur *et al.* (2013) evaluated 20 genotypes for genetic variability, heritability and character association in dolichos bean and observed wide range of variability (2.55 to 6.67) with a mean of 4.39 for number of branches plant^{-1}. Highest number of branches plant^{-1} (6.86) was recorded in Arka Jay followed by Ankure goldy (5.12), on screening twenty bush dolichos genotypes (Ananth and Kumar, 2018).

In a study comprising of fifty diverse genotypes of Indian bean, number of branches plant^{-1} was observed to be ranging from 3.86 to 5.53 (Janaki *et al.*, 2018). Wide range of variability was observed for number of branches plant^{-1} (17.87-23.30) by Gamit *et al.* (2020) on studying the performance of 40 genotypes of Indian bean.

2.1.1.4 Leaf area

Ananth and Kumar (2018) evaluated twenty bush dolichos bean genotypes and observed that Arka Jay recorded the highest leaf area of 17.45 cm^2 and Trichy local

the lowest (12.05 cm^2). Ashwini *et al.* (2019) reported that variations in leaf area might be a varietal character which often leads to better canopy management. Leaf area determines the light interception and Co_2 assimilation capacity of a plant.

2.1.2 Flowering Characters

2.1.2.1 Days to first flowering

Islam *et al.* (2011) evaluated forty four hyacinth bean genotypes for variability, heritability, genetic advance and correlation coefficients and reported that first flowering ranged from 48 to 136 days, whereas, Bahadur *et al.* (2013) reported first flowering in 41.22 to 112.78 days with a mean of 69.61days in dolichos bean.

An investigation was carried out to study the genetic variability, heritability and expected genetic advance for 18 traits in bush dolichos bean by Verma *et al.* (2015) and reported that first flowering ranged from 40.26 to 66.88 days.

Earliness is one of the most desirable selection parameters to get high return from the market as well as to fit the genotype in multiple cropping systems (Das *et al.,* 2015). Regarding earliness of the genotype, minimum days to first flowering was observed in DOLP VAR 8 in pole type (66 days) and DOLB VAR 3 in bush type (44 days).

The genotypes ML- 09 and ML- 15 flowered at 81 days, while other early flowering genotypes were ML-22 (85.5 days), ML-27 and ML-28 (86.5 days). Based on the two years result, ML-02, ML-11, ML-19 and ML-20 flowered in 120 days, while ML-17 and ML-16 were observed extremely late flowering, which took 124 and 130 days to flower respectively (Bahadur *et al.,* 2016).

Sixty four genotypes of Indian bean were evaluated for genetic variability for green pod yield and its contributing characters by Choudhary *et al.* (2016) and reported that first flowering was observed in 35-104 days with a mean of 72.14 days.

Ananth and Kumar (2018) reported that significantly early flowering (39.45 days) was observed in genotype Arka Jay followed by Ankure goldy (40.65 days).

Gamit *et al.* (2020) noticed that genotypes of dolichos bean took 46.40 to 74.73 days to first flowering.

2.1.2.2 Days to 50% flowering

Pan *et al.* (2004) studied genetic variation and character association in photo-insensitive dolichos bean lines. Among seven bush dolichos bean lines, 50% flowering was early in CHDB-13 (56.33 days), while late in CHDB-20 (66 days).

Twelve genotypes of pole type dolichos bean were evaluated for their genetic variability and character association among nine quantitative traits by Chattopadhyay and Dutta (2010). The shortest time to 50% flowering was recorded by Gomchi Green (57days) whereas SEMVAR- 8 the longest (115 days). Chaudhari *et al.* (2013) evaluated forty vegetable Indian bean genotypes to estimate the variability, correlation and path analysis and recorded a range from 56.68 to 76.82 days for 50% flowering.

Studies on genetic variability, heritability and genetic advance were conducted with 14 genotypes of lablab bean cultivated at the Agro-ecological zone (AEZ-9) comprising the old Brahmaputra flood plain soil by Asaduzzaman *et al*. (2015) and recorded minimum days for 50% flowering as 76.83 days and maximum days for 50% flowering as 105.11days.

Das *et al*. (2015) evaluated thirteen pole and seven bush type advanced lines of dolichos bean in two consecutive years to study the genetic variability and character associationships among different quantitative characters with pod yield. Minimum days to 50% flowering was observed in DOLB VAR 8 in pole type (76 days) and DOLB VAR 3 in bush type (49 days).

2.1.2.3 Number of racemes plant^{-1}

The study of genetic parameters in 64 genotypes of field bean was done by Gnanesh *et al*. (2006) and reported that number of racemes plant^{-1} ranged from 5.86 to 36.90. Sankaran *et al*. (2007) studied genetic divergence in lablab bean and observed that number of racemes plant^{-1} ranged from 18.66 to 115.33.

Number of inflorescences plant^{-1} in 46 germplasm lines of dolichos bean ranged from 6.10 to 22.7 with more number of inflorescences plant^{-1} recorded in VKG-28/32 (Chaitanya *et al*., 2011). Verma *et al.* (2014) reported that GL 243 produced significantly more number of inflorescences plant^{-1} of 13.53.

Ananth and Kumar (2018) observed that the highest number of racemes plant^{-1} (6.98), number of flower buds raceme^{-1} (26.40) and number of flower buds plant^{-1} (184.27) were recorded in Arka Jay.

2.1.2.4 Raceme length

Bahadur *et al*. (2013) reported that in dolichos bean, raceme length ranged from 22.89 cm to 46.44 cm with a mean of 37.56 cm. Evaluation of dolichos bean germplasm for growth, flower, pod and seed traits was done by Chaitanya *et al.* (2011) and observed that length of inflorescence ranged from 5.80 to 17.53 cm, NSJ-87-1/A recording the maximum.

A study on genetic variability, heritability and genetic advance in dolichos bean genotypes was conducted by Dewangan *et al.* (2017) and recorded wide range of variability for inflorescence length from 7.08 to 19.14 cm. Peer *et al.* (2018) studied genetic divergence in twenty nine genotypes of field bean for twenty two quantitative characters and observed a range from 20.95 cm to 34.91 cm for raceme length in six cluster.

Gupta *et al.* (2017) conducted a study to estimate the correlation among quantitative traits in dolichos bean. The highest inflorescence length was recorded in CG-26 (27.48 cm) and the lowest in CG- 8 (7.25 cm).

2.1.3 Yield characters

2.1.3.1 Days to harvest

Genetic variability studies in dolichos bean was conducted by Chaudhari *et al.* (2013) and recorded a range of 64.95 to 88.62 for days to harvest. Indeterminacy is advantageous for subsistence production and consumption of dolichos bean, as it

enables harvesting of pods in multiple pickings ensuring continuous availability of pods for a longer time (Keerthi *et al.,* 2014).

Bahadur *et al.* (2016) observed that the difference in pod maturity for days to first harvest was 44.5 between early and late type genotypes. ML-15 took only 119 days for harvesting first fresh pods, other early types being ML- 22 (122.5 days), ML-27 and ML- 28 (124 days). ML- 16 was extremely late maturing type which took 165.5 days for first fresh pod harvest.

Sixty four genotypes of Indian bean were evaluated for genetic variability and correlation analysis for green pod yield and its contributing characters by Choudhary *et al.* (2016) and recorded a wide range of variability from 54.00 to 135.00 days for days to harvest.

2.1.3.2 Pod setting (%)

According to Kambal (1969), over 75% of the floral buds of field beans fail to produce pods. Uddin (2003) reported that variations in pod set among the genotypes might be due to flower drop or other embryological problems caused by adverse environmental conditions that prevailed during off-seasons.

High pod setting percentage of 40.23% was reported by Sreekanth (2007) in bush dolichos bean, grown during September- May. Uddin (2007) reported that seasons have marked influence on percentage of flowers setting pods in dolichos bean. Off-season beans grown in late summer (June- September) passes through much less favourable environment which leads to reduction in pod set percentage to more than half during other seasons.

Rai *et al.* (2009) reported wide variation for pod setting with a range from 35.67-76.00 % among 64 dolichos bean genotypes, comprising of both bush and pole types, while Singh *et al.* (2011) reported a range from 27.00 to 74.33 % with a mean of 51.98 % for fruit set cluster^{-1} in dolichos bean.

2.1.3.3 Pod length

Verma *et al.* (2015) reported a range of 4.73 to 8.55 cm for pod length, the longest being observed in Arka Jay (8.55 cm). Interrelationships among yield attributing traits in pole and bush type dolichos bean was studied by Das *et al*. (2015) and recorded that the genotype DOLP VAR 6 produced the longest pod (12.80 cm) in pole type and DOLB VAR 5 (10.90 cm) in bush dolichos bean.

Bahadur *et al.* (2016) recorded the longest pod in ML-05 (15.45 cm), followed by ML-08 (14.7 cm) and ML-4 (14.30 cm) in lablab bean, whereas the shortest in ML-09 (5.35 cm). Genetic divergence in Indian bean was studied by Sankaran *et al.* (2007) and observed that TRC-D20 recorded the highest pod length of 18.50cm, whereas, TRC-D5 and TRC-D7 recorded the lowest of 6.73 cm.

2.1.3.4 Pod girth

Chaithanya *et al.* (2011) evaluated forty six pole type vegetable dolichos bean germplasm lines and observed that pod girth ranged from 1.50 to 2.31 cm, maximum pod girth being recorded in JBT-38/36. Evaluation of dolichos genotypes under north eastern dry zone of Karnataka was conducted by Ravinaik *et al.* (2015) and reported that PD-31 recorded the highest pod width of 20.39 cm and Hebbal avare-3, the lowest (12.24 cm).

Pod width is an important criterion for greater acceptability by the consumer. The highest pod width was noticed in BCDB 1 (3.10 cm) in pole type and DOLB VAR 1 (2.60) in bush type (Das *et al.*, 2015). The widest pod was recorded among 23 indigenous pole type germplasm lines of lablab bean in ML-02 (9.11cm), followed by ML-28 (6.5 cm), ML-05 (6.3 cm) and ML-01 (6.2 cm) whereas, the shortest pod width was recorded in ML-19 (3.9 cm) (Bahadur *et al.*, 2016).

2.1.3.5 Pod weight

Pan *et al.* (2004) recorded wide range of variability for pod weight among seven photo- insensitive dolichos bean lines. The highest pod weight was recorded in CHDB-20 (9.90 g) and the lowest in CHDB-34 (4.60 g). Fifty seven pole type

vegetable dolichos bean were evaluated by Mohan *et al.* (2009) and reported that ten pod weight was ranged from 49.5 to 122 g and maximum ten pod weight was recorded in IIHR 7.

Thirty genotypes of dolichos bean were evaluated by Parmar *et al.* (2013) to study the genetic variability on yield, yield contributing and related characters. The highest mean value for weight of 10 green pods was recorded for PD-2 (64.33 g) and the lowest for PD- 29 (27.66 g).

2.1.3.6 Pod Colour

Characterisation of pole type dolichos bean was done by Chattopadhyay and Dutta (2010) and identified 4 different pod colours. Pusa Early Prolific, BCDB – 2, Swarna Utkrist, HADB- 4 and RCMDL– 1 genotypes exhibited light green pod colour, while SEMVAR– 8, KDB – 413, JIB (V) 16 and Gomchi Green exhibited green pod colour. Purple colour pod was observed in BCDB – 1 and creamy white colour in HADB – 3. Chaitanya *et al.* (2011) recorded cream, light green, green, light purple and dark purple pod colours in dolichos bean.

Genetic variability studies in dolichos bean by Bahadur *et al.* (2013) revealed that among 20 genotypes, there were 12 (52.17%) genotypes with green coloured pods, 7 (30.43%) with purple and 4 (17.39%) with white coloured pods. Study of qualitative traits in dolichos bean germplasm was conducted by Reddy *et al.* (2018) and recorded that pod colour of 25 genotypes was green, three genotypes dark green, five genotypes light green, one purple colour and one genotype dark purple. The purple colour in dolichos bean pod is associated with the pigment anthocyanin and pro- anthocyanidins, which provide a wide range of health benefits to human body acting as antioxidants, immunostimulants and anticarcinogens (Rauf *et al.,* 2019).

2.1.3.7 Pods plant^{-1}

Mohan *et al.* (2009) evaluated pole type dolichos bean germplasm for pod yield and pod related traits and reported that number of pods plant^{-1} ranged from 10 to 91, with the maximum in IIHR159 and minimum in IIHR167. Genetic variability, heritability and correlation study in hyacinth bean was conducted by Islam *et al.*

(2011) and reported that average number of pods plant^{-1} was 256.6 with a range from 122 to 425. Das *et al.* (2015) recorded that more number of pods plant^{-1} was produced by DOLP VAR 9 (1401) in pole type and DOLB VAR 4 (85) in bush type dolichos bean.

Ananth and Kumar (2018) evaluated 20 bush dolichos bean lines and observed that number of pods plant^{-1} was highest in Arka Jay (54.25) followed by Ankure goldy (53.45). Eleven genotypes of lablab bean were evaluated by Afsan and Roy (2020) and reported wide range of variability (142.42 - 306.46) for pods plant^{-1}.

2.1.3.8 Seed colour

Evaluation of 46 germplasm lines of dolichos bean revealed wide variation for seed colour. Seven seed colours were recorded, namely, black, cream, mottled, purple, brick red, orange and red. 15 lines had black seed, 6 lines had cream seeds, 1 line showed mottled seeds, 3 lines had purple seeds, 2 genotypes had brick red, 16 genotypes had orange seeds and the remaining 3 lines showed red colour seeds (Chaitanya *et al.,* 2011).

Bahadur *et al.* (2016) reported that among 23 indigenous germplasm lines of lablab bean, 12 (52.17%) had brown seed coat followed by 7 (30.43%) genotypes with black coated seeds. Two genotypes had grey black, one brown black and one with white colour seed coat.

2.1.3.9 Seeds pod^{-1}

Pan *et al.* (2004) reported that, seeds pod^{-1} in photo- insensitive dolichos bean was the highest in CHDB-20 (5.50) and the lowest in CHDB-13 (4.17). Wide variation in seed pod^{-1} was reported by Bahadur *et al.* (2013) and recorded a range from 2.32 to 6.00 with a mean value of 4.44.

Number of seeds pod^{-1} did not vary greatly among the genotypes having different growth habits (pole and bush) in dolichos bean (Das *et al.,* 2015). Bahadur *et al.* (2016) reported that maximum number of seeds pod^{-1} was recorded in ML-20,

ML-15 and ML-19 (5). The minimum number of seeds pod^{-1} was recorded in ML-11 (3) followed by ML-07 and ML-22 (4).

2.1.3.10 Hundred seed weight

Verma *et al.* (2014) reported that hundred seed weight in dolichos bean genotypes ranged from 19.68 to 61.63 g. Wide variation was observed for hundred seed weight from 22.20 to 45.50 g in pole type dolichos bean by Chattopadhyay and Dutta (2010).

Estimation of genetic divergence in lablab bean genotypes was done by Salim *et al.* (2013) and observed that maximum hundred seed weight was 83.33 g and minimum 39.67 g. Wide variation was recorded for 100 seed weight which ranged from 18.70 to 45.60 g by Bahadur *et al.* (2016), the highest being recorded in ML-18 (44.00 g) followed by ML-02 (41.20 g).

2.1.3.11 Yield Plant^{-1}

Thirty one landraces of dolichos bean were grouped into 6 clusters for analysing genetic divergence by Sankaran *et al.* (2007) and reported that yield plant^{-1} ranged from 1.42 to 10.33 kg. Verma *et al.* (2014) observed that out of 12 genotypes evaluated, GL-243 recorded the highest marketable pod yield plant^{-1} (300.83 g) and the genotype HA-4, the lowest (91.38 g).

High yield of dolichos bean genotypes could be realized through selection of more number of pods^{-1} plant in pole type and heavier pod weight in bush type (Das *et al.,* 2015). The pod yield of pole types varied from 4.50 kg (DOLP VAR 1) to 7.90 kg (DOLP VAR 9) and of bush type from 0.18 kg (DOLB VAR 5) to 0.26 kg (DOLB VAR 3).

2.1.3.12 Yield Plot^{-1}

A study on the genetic variability, heritability and genetic advance for 17 traits in dolichos bean was conducted by Dewangan *et al.* (2017) and recorded a wide range of variability from 5.56 kg to 10.28 kg with a mean of 13.42 kg for average yield plot^{-1}.

Gupta *et al.* (2017) conducted correlation studies on floral traits, yield and nutritional parameters in dolichos bean genotypes under Allahabad agro climatic zone and observed that maximum green pod yield plot^{-1} was recorded in Pusa sem 2 (13.84 kg) and minimum in CG-31 (5.74 kg).

Screening of dolichos bean genotypes for growth and yield in coastal region of Tamilnadu was done by Ananth and Kumar (2018) and highest pod yield plot^{-1} was observed in Arka Jay (4.71 kg), while the lowest in Trichy local (2.10 kg).

2.1.4 Quality Characters

2.1.4.1 Crude Protein

Joshi and Rahevar (2014) recorded significantly high protein content (22.60 %) when crop was sown in 15th October, as compared to 1st November (22.20%). The increase in protein content in 15th October sowing was 2.80 per cent over 1st November. Proper sowing time might have favoured synthesis of amino acid due to colder spell resulting in better development in terms of protein content. Genetic variability study in dolichos bean was conducted by Asaduzzaman *et al.* (2015) and recorded a range of 16.68 to 24.88 % for crude protein content.

2.1.4.2 Crude Fibre

Choudhary *et al.* (2016) conducted genetic variability studies in dolichos bean and observed wide variability for fibre content, which ranged from 0.50 to 2.59 per cent. Maximum fibre content was recorded in the genotype CG-34 (6.80) and minimum in CG-5 (3.71) in dolichos bean by Gupta *et al.* (2017).

Ananth and Kumar (2018) evaluated twenty bush dolichos bean lines and reported highest crude fibre content in Arka Jay (1.32 %) followed by Angure goldy (1.30 %) and the lowest was recorded in Trichy local (1.03 %).

2.1.4.3 Cooking quality

Organoleptic evaluation of the green pods of dolichos bean by Muthiah *et al.* (2008) revealed that CO (Gb) 14 has overall acceptability. This has more consumer preference due to its good taste and flavour.

Considering the cooking quality, taste and overall performance of fresh pods, ML-09 was found best among the dolichos bean genotypes (Bahadur *et al.*, 2016). ML-09 was preferred by consumers due to small and bold, fibreless pods.

2.2 COEFFICIENT OF VARIATION

Ali *et al.* (2005) reported that phenotypic variation was greater than that of genotypic and environmental variations among twenty lablab bean genotypes for all the characters. The greater portion of total phenotypic variation was due to the genotypic variation. The range of phenotypic coefficient of variation (PCV) was from 9.24 (pod diameter) to 166.78 (number of pods inflorescence^{-1}). The genotypic coefficient of variation (GCV) ranged from 6.15 (pod diameter) to 151.92 (number of pods inflorescence^{-1}).

A study on the genetic parameters in 64 genotypes of field bean was conducted by Gnanesh *et al.*, (2006) and recorded that inflorescences plant^{-1}, vitamin-C content, pod yield plant^{-1}, pods plant^{-1}, days to first flowering and plant height showed higher estimates of GCV and PCV.

Rai *et al*. (2009) evaluated 45 diverse types of Indian bean for genetic divergence for yield and the contributing characters. Number of pods plant^{-1} followed by pod thickness contributed maximum towards divergence. High value of genotypic coefficient of variation (GCV) was recorded for yield plant^{-1}, number of pods plant^{-1} and weight of 10 pods.

Twelve genotypes of pole type dolichos bean was evaluated for genetic variability and character association among nine quantitative traits under the Gangetic plains of eastern India by Chattopadhyay and Dutta (2010). The study revealed that

protein content of pod, number of pods plant^{-1}, breadth of pod, weight of pod and pod yield plant^{-1} exhibited high GCV and PCV.

Islam *et al.* (2011) studied forty four hyacinth bean genotypes for estimating the variability, heritability, genetic advance and correlation coefficients. High genotypic co-efficient of variation was observed for 100- green seed weight, pod yield plant^{-1}, number of pods plant^{-1} and harvesting duration. The highest PCV (40.19%) and GCV (35.34%) was observed for 100-green seed weight, while the lowest PCV (11.6%) and GCV (9.8 1%) by seeds pod^{-1}.

Singh *et al.* (2011) evaluated seventy three hyacinth bean genotypes and observed that characters namely days to first flower, number of pods plant^{-1}, pod width and pod yield plant^{-1} showed high GCV accompanied with high heritability, indicating additive gene action which offered scope for improvement through selection.

Bahadur *et al*. (2013) evaluated 20 genotypes of dolichos bean and found that phenotypic coefficient of variation (PCV) was higher than GCV for all the traits. Higher genotypic and phenotypic coefficient of variation were observed for pod yield plant^{-1}(65.90, 66.70) followed by plant height (51.22, 51.32) and the lowest was recorded by days to first picking (18.39, 18.44).

Forty vegetable Indian bean genotypes were studied to estimate the variability, correlation and path analysis by Chaudhari *et al.* (2013). The genotypic coefficient of variation was higher for the characters *viz*., number of pods cluster^{-1}, number of pods plant^{-1}, 100-fresh seed weight and green pod yield plant^{-1}.

Magalingam *et al.* (2013) recorded wide genetic variability for various traits like plant habit, branching habit, stem pigmentation, pod colour, pod characters *etc*. The difference between PCV and GCV was narrow for all characters except percentage of pod set. Moderate GCV was observed for plant height, number of branches plant^{-1}, number of flowers cluster^{-1}, number of clusters plant^{-1} and days to maturity, whereas lowest GCV was observed for days to 50 percent flowering.

The number of primary branches plant^{-1} among dolichos bean genotypes exhibited the maximum values for genotypic and phenotypic coefficients of variation (Maharnavar, 2013).The estimates of GCV and PCV were of high magnitude for length of inflorescence, pod length and number of flowers inflorescence^{-1}.

Parmar *et al.* (2013) evaluated thirty genotypes of dolichos bean to study the genetic variability in yield, yield contributing and related characters. The highest and lowest coefficient of variation was observed for single podded clusters plant^{-1} and protein content respectively. Little or no difference was observed between the phenotypic and genotypic coefficients of variability in the expression of various horticultural traits studied *viz.*, protein content, days to 50% flowering, days to first pod set, pod length, pod weight, weight of 10 green pods and days to maturity.

Chaitanya *et al.* (2014) evaluated thirty four genotypes of dolichos bean for genetic variability among characters. Genetic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were estimated for fifteen yield and yield contributing characters. The differences between PCV and GCV were low for days to first flowering, days to 50% flowering, internodal length, days to first pod harvest, pod length, pod width, pod weight, plant height and number of seeds pod^{-1} indicating that these traits are less influenced by environment and the effect of heritable components was high.

Genetic variability studies in pole type dolichos bean was done by Fattulal *et al.* (2014) and reported that green pod yield plant^{-1} (54.53, 56.40), green pod yield plot^{-1} (54.51, 56.38), inflorescence length(50.53, 51.29) and average weight of ten pods (49.01,49.57) recorded high GCV and PCV indicating the presence of good amount of variability for these characters.

Twenty genotypes and 2 commercial genotypes of dolichos bean were studied by Sharma *et al.* (2014) to find out the magnitude of genetic variability, correlation and path coefficient analysis. Maximum range of phenotypic and genotypic coefficient of variation varied from 41.90 to 69.40 % and from 40.79 to 65.95%, respectively. High phenotypic and genotypic coefficient of variation was observed for

the characters *viz*., protein per cent in pod, number of spikes plant^{-1}, pod yield ha^{-1}, pod yield plot^{-1}, pod yield plant^{-1} and number of flowers cluster^{-1}.

Verma *et al.* (2014) studied the genetic variability, heritability and genetic advance for 18 traits in dolichos bean. The experimental material comprised of 12 genotypes of dolichos bean. Among the characters studied, high PCV and GCV were observed for characters like plant height, number of secondary branches plant^{-1}, number of inflorescences plant^{-1}, number of pods inflorescence^{-1}, number of pods plant^{-1}, pod yield plant^{-1}, 100 seed weight and pod yield hectare^{-1} indicating high variability available in the germplasm for these characters for further improvement.

Thirteen pole and seven bush type advanced lines of dolichos bean was evaluated in two consecutive years to study the genetic variability and character association by Das *et al.* (2015). Higher estimates of PCV and GCV was observed for number of pods plant^{-1} and pod weight in pole and bush types, and pod length in bush type, indicating scope for improvement through selection. Number of seeds pod^{-1} in pole type and pod yield plant^{-1} in bush type recorded wider differences between PCV and GCV values indicating dominant role of environment in the expression of these traits.

Genetic variability and character association study in dolichos bean was done by Singh *et al.* (2015) and reported that GCV and PCV were slightly higher for number of pods plant^{-1} (27.84, 39.44).

Choudhary *et al.* (2016) observed that phenotypic coefficient of variation was highest for seed yield plant^{-1} (99.44) and lowest in case of moisture percentage (3.93), among sixty four genotypes of Indian bean. The genotypic coefficient of variation varied from 3.05 (moisture percentage) to 96.97 (seed yield plant^{-1}). Moderate to low GCV and PCV values were noted for the characters *viz*., days to first picking, fibre content, weight of 100 seed, pod length, days to last picking, number of seeds pod^{-1}, protein content, shelling percentage and moisture percentage.

A study on variability, heritability, genetic advance and correlation in bush type Indian bean was done by Veerbhadreshwar *et al*. (2016). The range of

phenotypic coefficient of variation (PCV) was from 7.26 (SPAD value) to 45.15 (seed yield plant^{-1}). The genotypic coefficient of variation (GCV) ranged from 8.94 (shelling percentage) to 45.75 (seed yield plant^{-1}).

Genetic appraisal of F_2 generation of dolichos bean for yield and yield attributing traits was conducted by Venkatesha *et al.* (2016). Materials used for this study consisted of F_2 and F_3 generations from two crosses namely HA-4 × CPI 31113 & HA-4 × CPI 60216. High PCV and GCV was observed for first flower initiation and seed weight plant^{-1} in both the crosses. Pod length, pod width, number of seeds pods^{-1} and 100 seed weight showed moderate GCV and PCV in both the crosses. The differences between PCV and GCV values were narrow for all the traits studied, indicating low level of environmental influence in the expression of these traits.

Study on genetic variability, heritability and genetic advance in dolichos bean genotypes was conducted by Kujur *et al.* (2017). The highest value of genotypic coefficient of variation (GCV) was recorded for number of pods inflorescence^{-1} (33.13%) followed by pod width (32.58%) and inflorescence length (32.07%). The highest value of genotypic coefficient of variation (GCV) was recorded for number of pods inflorescence^{-1} (33.13%) followed by pod width (32.58%) and inflorescence length (32.07%), number of flowers inflorescence^{-1} (29.90%), 100 seed weight (29.41%) and pod weight (28.34 %).

Nayak *et al.* (2017) conducted a study on estimation of genetic parameters and selection of parents for hybridization in dolichos bean. The highest GCV was recorded for the character pod yield plant^{-1} (51.82%) followed by pod weight (39.10%) and the lowest value for leaf length (13.79%). However, the range of PCV varied from 15.89% (leaf width) to 52.28 % (pod yield plant^{-1}). The proportion of GCV and PCV varied from 78.31% in leaf length to 99.94 % in pod weight.

The highest value of GCV was recorded for pod width (30.68%) followed by pod length (26.07%), number of pods inflorescence^{-1}(23.08%), length of inflorescence (23.07%), hundred seed weight (21.76%), number of pods plant^{-1} (20.99%) and marketable green pod yield plant^{-1} (19.27%), whereas rest of the traits exhibited moderate genotypic coefficient of variation. The magnitude of phenotypic coefficient

of variation was higher than the corresponding genotypic coefficient of variation for most of the characters (Patel *et al.,* 2017).

Fifty diverse genotypes of Indian bean were evaluated by Janaki *et al.* (2018) and reported that the highest GCV and PCV was observed for 10-green pod weight followed by green pod yield plant^{-1}, number of pods plant^{-1}, seed yield, 100-seed weight, pod width, pod length and plant height.

Vine length, pod length, pod width, pod weight, number of pods plant^{-1}, fibre content and pod yield plant^{-1} exhibited high PCV and GCV values indicating large amount of variation in dolichos bean. Moderate to low PCV and GCV values were noted for primary branches plant^{-1}, days to first flowering, days to 50 per cent flowering, number of seeds pod^{-1}, seed length, seed breadth, 100 fresh seed weight, protein content, 100 dry seed weight, days to first pod harvest, days to last pod harvest and days to pod maturity (Reddy *et al.*, 2018).

Sahu and Bahadur (2018) reported high magnitude of genotypic as well as phenotypic coefficient of variations for traits *viz.*, pod weight (10 Pods) (33.99 and 34.36), pod width (32.75 and 34.39), pod length (26.11 and 26.84), 100 seed weight (23.64 and 23.77) and inflorescence length (25.61 and 25.95) in dolichos bean.

Eleven genotypes of lablab bean were evaluated for genetic variability among characters in four consecutive years by Afsan and Roy (2020) and observed that phenotypic coefficient of variance in general, was higher than genotype for all the traits, but differences were very low, indicating low environmental effect on the expression of all the traits, suggestive of the heritable nature of the traits. Phenotypic, genotypic and within error co-efficient of variability were found to be the highest for number of pods plant^{-1}.

Number of primary branches plant^{-1} exhibited the maximum values for genotypic and phenotypic coefficients of variation followed by the number of pods plant^{-1} in a study of genetic variability and heritability in Indian bean (Gamit *et al.,* 2020).

2.3 HERITABILITY AND GENETIC ADVANCE

High heritability estimates suggest the major role of genetic constitution in the expression of the character and such traits are considered to be dependable from breeding point of view. High genetic advance indicates the possibility of selection to improve the trait.

Genetic variation and character association study in dolichos bean was conducted by Pan *et al*. (2004). Seven photo insensitive dolichos bean lines were evaluated and was found that high heritability and genetic advance was exhibited by pod yield, pod breadth and pod weight.

Ali *et al.* (2005) studied correlation and genetic variation among twenty different genotypes of lablab bean. The highest heritability in the broad sense was obtained for number of flowers inflorescence^{-1} (96.21) followed by pod weight (92.03), number of pods inflorescence^{-1} (91.08), yield plant^{-1} (88.67) and pod diameter (66.57). Expected genetic advance expressed as percentage of mean was very high for number of pods inflorescence^{-1} (115.72) followed by yield plant^{-1}(52.56), pod weight (51.81) and number of flowers inflorescence^{-1} (48.58).

Sixty four genotypes of field bean were evaluated by Gnanesh *et al*. (2006) and reported that high heritability was recorded for majority of characters. High genetic advance as per cent of mean was recorded for inflorescences plant^{-1}, vitamin-C content, pod yield plant^{-1}, pods plant^{-1}, days to first flowering, plant height, primary branches plant^{-1}, days to maturity and hundred seed weight indicating additive gene effects in their expression, whereas moderate genetic advance as per cent of mean was recorded for pod length and protein content.

Twelve genotypes of pole type dolichos bean were evaluated by Chattopadhyay and Dutta (2010) for estimating the genetic variability and character association among nine quantitative traits under the gangetic plains of eastern India. Protein content of pod (99.96%), number of pods plant^{-1}(99.61%), breadth of pod (99.12%), weight of pod (98.94%) and pod yield plant^{-1}(98.8%) exhibited high

heritability. Moderate to high genetic advance was recorded in case of days to 50% flowering, pods plant^{-1}, yield plant^{-1}, weight of pod and hundred seed weight.

Forty four hyacinth bean genotypes were evaluated by Islam *et al*. (2011) and observed highest heritability for days to first flower (98.39%) followed by days to first harvest (96.1%) and individual pod weight (89.05%). Days to first flower, number of pods plant^{-1}, individual pod weight, pod yield plant^{-1} and hundred-green seed weight showed high genetic advance.

Singh *et al.* (2011) evaluated fifteen genotypes of dolichos bean and observed high heritability for days to flower initiation (99.97%), green pod yield plant^{-1} (99.1%), pod length (98.9%) and days to first picking (98.8%). The expected genetic advance expressed as percent of mean along with high heritability was observed for pods plant^{-1} (56.02) followed by days to first flower (46.58).

Bahadur *et al.* (2013) studied twenty dolichos genotypes and found that heritability was noticed high for all the traits *viz.* plant height, days to initial flowering, pod weight, pod width, pod length, days to first picking, pod yield plant^{-1}, number of pods inflorescence^{-1}, number of inflorescence plant^{-1} except days to germination. Higher genetic advance was observed for pod yield plant^{-1} (98.95) and number of pods inflorescence^{-1}(86.43).

Genetic variability and character association study in dolichos bean was conducted by Magalingam *et al.*(2013) and estimated high heritability with greater genetic advance for the nine traits *viz.*, percentage of pod set, number pods cluster^{-1}, number pods plant^{-1}, green pod length, green pod width, individual green pod weight, pod yield, crude protein and crude fibre.

Parmar *et al*. (2013) evaluated thirty genotypes of dolichos bean to study the genetic variability for yield, yield contributing and related characters. Heritability ranged from 59.02 to 95.09%. High heritability estimates were obtained for protein content (95.09), days to 50%. flowering (93.91), days to maturity (90.83), days to first pod set (87.38), width of pod (87.27), weight of 10 green pods (86.98), single podded cluster plant^{-1} (85.91) and pod length (84.06). Days to 50% flowering, pod length,

width of pod and weight of 10 green pods accounted for the higher heritability and higher genetic advance.

Estimation of genetic divergence in lablab bean genotypes was done by Salim *et al.* (2013) and reported that high heritability along with high genetic advance as percent of mean was observed for number of pods plant^{-1}, pod yield plant^{-1}, number of seeds plant^{-1} and seed yield plant^{-1}.

Chaitanya *et al.* (2014) evaluated thirty four genotypes of dolichos bean for growth and flowering. High heritability and genetic advance was recorded by days to first flowering, days to 50% flowering, inter node length, days to first pod harvest, pod length, pod width, pod weight, plant height and number of seeds pod^{-1}.

An investigation was carried out to study the genetic variability, heritability and expected genetic advance for 18 traits in dolichos bean by Verma *et al*. (2014) and reported that plant height, number of secondary branches plant^{-1}, number of pods inflorescence^{-1}, number of inflorescence plant^{-1}, pod weight, number of pods plant^{-1}, pod yield plant^{-1} and pod yield hectare^{-1} recorded high heritability and genetic advance.

Asaduzzaman *et al*. (2015) reported that heritability values were higher for number of racemes plant^{-1} (80.62), days to maturity (81.37), seed yield plant^{-1} (84.93), pod length (99.43), pod width (99.27), green pod yield plant^{-1} (89.29), dry shelling percentage (91.58) and protein content (98.11) indicating the better potentials of improving these characters for improvement of yield. Maximum genetic advance expressed as percentage of mean was observed for green pod yield plant^{-1} (95.22).

Evaluation of thirteen pole and seven bush type advanced lines or genotypes of dolichos bean was carried out by Das *et al.* (2015) and found that characters like pod weight, number of pods plant^{-1}, pod length and pod width were characterised by high heritability and high genetic advance in both pole and bush types of lablab bean. Moderate genetic advance was recorded for the characters like days to 50 % flowering in pole type and days to first flowering and days to 50% flowering in bush type.

Singh *et al.* (2015) reported genetic variability and character association study in dolichos bean and observed high heritability (70.97%) for plant height and pod length (64.24%). Characters like days to 50% flowering, days to first harvesting, days to maturity, pod yield plant^{-1}, pod yield (ha^{-1}) and number of pods plant^{-1} exhibited moderate heritability. High genetic advance (74.96%) was recorded for plant height while low genetic advance (2.58%) for pod length.

Sixty four genotypes of Indian bean were evaluated by Choudhary *et al.* (2016). The highest heritability estimate was observed for days to last picking (99.60 %) followed by shelling percentage (99.27%), days to first flowering (99.25%), green pod yield ha^{-1} (99.17%), green pod yield plant^{-1} (99.14%), pod width (98.61%), number of green pods plant^{-1} (98.54%), weight of 100 seed (98.53%), weight of 10 pods (98.13%), plant height (97.36%), days to first picking (96.19%), pod length (95.60%), seed yield plant^{-1} (95.09%), seed yield ha^{-1} (94.10%) and pericarp thickness (91.49%), indicating less influence of environment on the expression of these characters. High values of genetic advance was observed for the characters *viz*., seed yield plant^{-1} (194.78%) followed by green pod yield plant^{-1} (175.87%), number of green pods plant^{-1} (173.75%), seed yield ha^{-1}. (160.63%), green pod yield ha^{-1} (137.6%), pod width (93.35%), plant height (89.04%), weight of 10 pods (83.99 %), days to first flowering (68.70 %), pericarp thickness (67.40 %), days to first picking (55.21 %) and weight of 100 seed (49.15 %).

A study on variability, heritability, genetic advance and correlation in bush type Indian bean was done by Veerbhadreshwar *et al.* (2016). Heritability ranged from 28.02 to 98.62 per cent. Dry matter content was the least heritable (28.02) trait. Fibre content showed the highest heritability (98.62), followed by seed yield plant^{-1} (97.37), seed yield ha^{-1} (97.07), harvest index % (88.25) days to 50% flowering (88.89), plant height (87.14), days to first flowering (85.12) and days to 50 % pod picking (80.72). Genetic advance as per cent of mean ranged from 8.1 to 91.78 per cent. Seed yield plant^{-1} (91.78) showed highest genetic advance. It was followed by seed yield ha^{-1} (91.12), fibre content (73.14), number of spikes plant^{-1} (72.56), harvest index (43.44) and plant height (41.03).

Venkatesha *et al.* (2016) studied genetic appraisal of F_2 generation of dolichos bean for yield and yield attributing traits. Materials used for this study consisted of F_2 and F_3 generations from two crosses namely HA-4 × CPI 31113 and HA-4 × CPI 60216. High heritability was noticed for all the traits studied in both the crosses.

A study on genetic variability, heritability and genetic advance in dolichos bean genotypes revealed that highest heritability estimate was observed for days to 50% flowering (99.95%) and highest genetic advance for inflorescence length (57.76) (Dewangan *et al*., 2017).

Twenty three indeterminate genotypes of dolichos bean were evaluated for their genetic variability, character associationships and genetic divergence among ten quantitative traits by Nayak *et al.* (2017). High heritability (more than 80%) was recorded for most of the characters studied except leaf length, leaf width and raceme length. The genetic advance (GA) expressed as percentage of mean was high for all the characters studied. Days to 50% flowering, pod weight, number of pods plant^{-1}, pod width, pod thickness, pod length and pod yield plant^{-1} were characterised by high heritability and high genetic advance.

A study on genetic variability, heritability and genetic advance in dolichos bean genotypes was conducted by Kujur *et al.* (2017). Highest heritability estimate was observed for pod width (99.98 %) followed by days to first flowering (99.75%), days to first green pod harvest (99.69%), days to 50% flowering (99.58 %), 100 seed weight (99.53%), pod length (99.34%), days to last green pod harvest (99.03%), inflorescence length (98.53%), pod weight (97.75%), number of flowers inflorescence^{-1} (91.17%), pod yield plant^{-1} (87.73%), pod yield plot^{-1} (87.73%), pod yield hectare^{-1} (87.73%) plant vine length (86.57%) and number of pods inflorescence^{-1} (85.20%). The highest genetic advance as percent of mean was observed for pod width (67.10) followed by inflorescence length (65.59), number of pods inflorescence^{-1} (62.99), 100 seed weight (60.44), number of flowers inflorescence^{-1} (58.81), pod weight (57.73), pod length (42.14), days to first flowering (34.10), days to 50 % flowering (32.79), green pod yield plant^{-1} (31.73), green pod

yield plot^{-1} (31.73), pod yield hectare^{-1} (31.73), days to first green pod harvest (30.86) and vine length (30.85).

High heritability in broad sense estimates was observed for all the characters except number of seeds pod^{-1}, which recorded had moderate heritability and number of branches plant^{-1}, which had low heritability as reported by Janaki *et al.* (2018).

Thirty five genotypes of dolichos bean were evaluated by Reddy *et al.* (2018) and recorded that heritability ranged from 45 % to 96 %. Higher heritability estimates were observed for number of pods plant^{-1} (96 %), fibre content (95 %), pod yield plant^{-1} (94 %), vine length (91 %), pod length (91 %), protein content (90 %), days to pod maturity (84 %), pod weight (83 %), days to first pod harvest (82 %) and days to last pod harvest (81 %). The genetic advance as per cent of mean ranged from 11.54 (100 dry seed weight) to 91.64 (number of pods plant^{-1}). High values of genetic advance as per cent of mean was observed for the characters like pod weight (91.64 %), pod yield plant^{-1} (74.73 %), pod width (63.31 %), pod length (57.39 %), fibre content (50.48 %), vine length (47.52 %), pod weight (42.43 %), protein content (29.61 %), 100 fresh seed weight (27.53 %), seed length (26.91 %), seed breadth (24.52 %) and days to first flowering (21.16 %).

The highest heritability was recorded for the characters like days to first flowering and hundred seed weight (91.23%) among 40 genotypes of dolichos bean (Sahu and bahadur *et al.,* 2018). High magnitude of genetic advance was recorded for days to first flowering (28.43), while lowest genetic advance was recorded by green pod yield plant^{-1} (0.70).

High broad sense heritability coupled with genetic advance in percentage was observed for number of flowers plant^{-1}, number of pods plant^{-1} and average pod weight which indicate that these characters are under additive gene action (Afsan and Roy, 2020).

Gamit *et al*. (2020) conducted a study on genetic variability and heritability in Indian bean. High heritability (> 60%) was observed for all the 12 characters studied. The maximum heritability estimates were observed for the number of primary

branches plant^{-1} followed by twig length, pod length, 10 green pod weight, days to 50% flowering, green pod yield plant^{-1}, pod width, number of pods plant^{-1}, days to first flowering, number of pickings, days to first picking and days to last picking. Genetic advance expressed as per cent of mean was the highest for the number of primary branches plant^{-1} followed by the number of pods plant^{-1}, pod length, 10 green pod weight, twig length, green pod yield plant^{-1}, pod width and number of pickings.

2.4 CORRELATION

Correlation study in dolichos bean conducted by Tikka *et al*. (2003) revealed that days to first picking and last picking exhibited positive and significant association at both genotypic and phenotypic levels with plant height, days to first flowering, days to last picking, pod length, number of seed pod^{-1}, green pod yield plant^{-1}, green pod yield ha^{-1}, seed yield ha^{-1}, weight of 10 pod, weight of 100 seed, moisture percentage, pericarp thickness, number of green pod plant^{-1} and seed yield plant^{-1}.

Correlation analysis among growth, yield and quality characters in lablab bean was conducted by Bagade *et al.* (2004) and recorded that days to first flowering exhibited positive and significant correlation at both genotypic and phenotypic levels with plant height, days to first picking, days to last picking, pod length, number of seed pod^{-1}, green pod yield plant^{-1}, green pod yield ha^{-1}, seed yield ha^{-1}, weight of 10 pod, weight of 100 seed, moisture percentage, pericarp thickness, number of green pod plant^{-1} and seed yield plant^{-1}.

Pan *et al.* (2004) found that in dolichos bean pod yield was positively and significantly correlated with pod weight, which could be considered as one of the important selection criteria in improvement of pod yield.

Correlation and genetic variation of twenty different genotypes of lablab bean for six characters was assessed by Ali *et al.* (2005). In general, the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients. Pod weight at harvest showed significant positive correlation with pod diameter and yield plant^{-1} but negative correlation with flowers inflorescence^{-1} and number of pod inflorescence^{-1}. Pod length and number of flowers inflorescence^{-1}

displayed positive significant phenotypic and genotypic correlation with the yield plant^{-1}.

Number of branches plant^{-1} possessed high correlation with green pod yield plant^{-1} and positive direct effects in dolichos bean (Desai *et al*., 2005). Plant height had negative significant correlation with green pod yield plant^{-1} due to its negative direct effects.

Lal *et al.* (2005) stated that yield plant^{-1} is the most important economic trait in Indian bean and exhibited positive association with pod weight (0.31) and number of pods plant^{-1} (0.41). High and positive correlation was observed for pod length with pod weight (0.58) and seeds pod^{-1} (0.56).

Correlation study conducted by Nahar and Newaz (2005) revealed that weight of 10 pod exhibited positive and significant association with plant height, days to first flowering, days to first picking, days to last picking, weight of 100 seed, pod length, pod width, green pod yield plant^{-1}, green pod yield ha^{-1}, number of seed pod^{-1}, moisture percentage and pericarp thickness at both genotypic and phenotypic levels.

Gnanesh *et al*. (2006) stated that there is ample scope in the improvement of yield in field bean by selecting a genotype having higher pod number and 100 seed weight since they are highly correlated. The vitamin-C content had no significant positive association with pod yield, whereas protein content was significantly and negatively associated with pod yield. Number of green pod plant^{-1} recorded positive and significant correlation with plant height, days to first flowering, days to first picking, days to last picking, green pod yield plant^{-1}, green pod yield ha^{-1}, seed yield plant^{-1} and seed yield ha^{-1} at both genotypic and phenotypic levels.

Chattopadhyay and Dutta (2010) reported significant positive association of green pod yield plant^{-1} with days to 50% flowering and number of seeds pod^{-1} in pole type dolichos bean. Interrelationship between component traits exhibited that days to 50% flowering was significantly and positively correlated with 100 dry seed weight and weight of pods. On the other hand, pod weight exhibited significant negative interrelationship with pods plant^{-1} and protein content.

Correlation analysis among forty four hyacinth bean genotypes was conducted by Islam *et al.* (2011) and found that yield of green pods showed highly significant and positive association with number of pods plant^{-1}, individual pod weight and harvesting duration.

Singh *et al.* (2011) stated that pod yield plant^{-1} showed maximum positive and significant association with number of pods plant^{-1} (0.708) at both genotypic and phenotypic levels, in hyacinth bean. The days to first flower showed positive correlation with days to first picking (0.763).

Correlation studies suggested that earliness in flowering, increased leaf area, number of racemes plant^{-1}, number of pods, pod length and pod weight are to be considered as vital parameters to choose a variety for high yield in dolichos bean (Anburani and Shalini, 2013).

Bahadur *et al.* (2013) studied genotypic and phenotypic correlation among different traits like plant height, number of primary branches plant^{-1}, number of inflorescence plant^{-1}, number of flowers inflorescence^{-1}, number of pods inflorescence^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, pod length, pod width and pod weight showed positive significant correlation with pod yield plant^{-1} at genotypic and phenotypic level.

Forty vegetable Indian bean genotypes were tested for variability, correlation and path analysis by Chaudhari *et al.* (2013). Green pod yield was significantly and positively correlated with number of branches plant^{-1}, number of pods cluster^{-1} and number of pods plant^{-1} at both the genotypic and phenotypic levels. The character protein content was positively correlated with days to last picking and number of seeds pod^{-1}, while negatively with 100-fresh seed weight and shelling percentage. Number of seeds pod^{-1} had positive and highly significant correlation with pod length and 100-fresh seed weight.

Magalingam *et al.* (2013) studied 23 genotypes of dolichos bean for correlation analysis. They reported that the individual green pod weight, percentage of pod set, number of flowers cluster^{-1} and number of pods plant^{-1} exhibited significant

positive correlation on yield. Negative correlation was observed for days to 50 percent flowering and days to maturity. Increased percentage of pod set and increased number of pods cluster^{-1} as well as number of pods plant^{-1} were negatively correlated with green pod length, green pod width and individual green pod weight.

Significant positive phenotypic correlations between yield and yield components including days to first pod set (24.46), days to 50% flowering, number of pods plant^{-1}, weight of 10 green pods and length of pod was reported by Parmar *et al.* (2013). In contrast, the correlation between yield and protein content of pods (-0.332) was significant and negative.

Salim *et al.* (2013) reported that seed yield plant^{-1} was positively and significantly correlated with days to first flowering, days to 50% flowering, days to first pod setting, number of pods plant^{-1}, pod yield plant^{-1} and seeds pod^{-1} and number of seeds plant^{-1} in Indian bean.

Fourteen genotypes of Lablab bean were tested for yield and yield contributing characters by Asaduzzaman *et al.* (2014). Seed yield plant^{-1} showed positive and significant correlation with days to maturity, number of raceme plant^{-1}, raceme length, pod length, green pod yield plant^{-1}, green test weight and shelling percentage and significant negative correlation with days to maturity, number of seeds pod^{-1} and protein content at both phenotypic and genotypic levels.

Kiran *et al.* (2014) stated that number of pods plant^{-1}, pod width, pod weight and pod length had positive correlation with pod yield plant^{-1}. The traits like number of branches and leaf length showed positive relation with yield at the same time days to 50% flowering and days to first picking showed negative effect on yield.

Sharma *et al.* (2014) indicated chances for upgrading dolichos bean genotypes by simultaneous selection through spikes plant^{-1}, days taken to first flowering, days taken to 50% flowering, days taken to first pod harvest, 25 pods weight, pod length, pod width, pod girth and 1000 seed weight. Highly significant and positive correlation of pod yield was recorded with number of spikes plant^{-1} and days taken to first flowering. Weight of 25 pods also expressed significant and positive correlation with

most of the characters. Pod girth, pod width, and 1000 seed weight recorded significant positive association with pod yield ha^{-1}, pod yield $plot^{-1}$ and pod yield $plant^{-1}$.

Das *et al.* (2015) reported that interrelationship among component characters and pod yield revealed a significant and positive correlation with number of pods $plant^{-1}$ at genotypic level in pole type and none of the traits in bush type. However, positive correlation with pod yield was depicted by pod length, pod width and number of seeds pod^{-1} in pole type and by number of pods $plant^{-1}$ in bush type. Interestingly, negative genotypic correlation exists between pod yield $plant^{-1}$ and pod weight in pole type, and between pod weight and number of seeds pod^{-1} with pod yield $plant^{-1}$ in bush type dolichos bean.

The seed yield $plant^{-1}$ exhibited highly significant and positive association with number of pods $plant^{-1}$, number of primary branches $plant^{-1}$, hundred seed weight, days to maturity and number of peduncles $plant^{-1}$ at both phenotypic and genotypic levels in lablab bean. The seed yield $plant^{-1}$ also showed highly significant positive association with days to first flowering at phenotypic level only while seed yield $plant^{-1}$ had significant but negative association with number of seeds pod^{-1} (Kambale *et al.*, 2015).

Pod yield $plant^{-1}$ was significant and positively correlated with plant height, number of branches $plant^{-1}$, number of flowers $cluster^{-1}$, number of pods $cluster^{-1}$, pod weight, pod length, pod width, number of seeds pod^{-1} and number of pods $plant^{-1}$ at both phenotypic and genotypic levels as reported by Ravinaik *et al.* (2015). But days to 50 per cent flowering had significant and negative correlation with pod yield $plant^{-1}$ at both genotypic and phenotypic levels.

Correlation analysis among twenty four dolichos bean genotypes was conducted by Singh *et al.* (2015) and reported that pod yield $plant^{-1}$ was positively and significantly correlated with pod length (0.48, 0.61), number of seeds pod^{-1} (0.39, 0.76), number of pods $plant^{-1}$ (0.89, 1.02) and pod yield $plant^{-1}$ (0.97, 1.01) at genotypic and phenotypic levels.

Choudhary *et al.* (2016) reported that green pod yield plant^{-1} exhibited positive and significant correlation with green pod yield ha^{-1}, seed yield ha^{-1}, plant height at 60 days, days to first flowering, days to first picking, days to last picking, weight of 10 pod, weight of 100 seed, number of green pod plant^{-1}, pod length, pericarp thickness, moisture percentage and seed yield plant^{-1} at both genotypic and phenotypic levels.

A study on variability, heritability, genetic advance and correlation in bush type Indian bean was conducted by Veerbhadreshwar *et al.* (2016). Spike length had significant and positive genotypic correlation with pod length (0.710), weight of 10 pods (0.690) and dry matter content (0.588). Negative and significant genotypic association was noted with plant height (-0.873), branches plant^{-1} (-0.859) and days to 50% flowering (0.810).

Correlation study of floral traits, yield and nutritional parameters in dolichos bean genotypes under Allahabad agro climatic zone was conducted by Gupta *et al.* (2017) and recorded that green pod yield plant^{-1} had significant and positive correlation with pod inflorescence^{-1}, pod length, pod width, pod weight, seeds pod^{-1}, vine length, 100 seed weight, protein content and pods inflorescence^{-1}, while non-significant and positive correlation with carotenoids, moisture content, number of flower inflorescence^{-1}, chlorophyll ‘a’ and total chlorophyll.

Number of pods plant^{-1}, pod weight, pod length and pod diameter exhibited significant positive correlations with pod yield plant^{-1} at both genotypic and phenotypic levels. Besides, the characters like pod thickness, leaf length and leaf width also showed positive but non-significant correlations with pod yield plant^{-1} (Nayak *et al.*, 2017).

According to Patel *et al.* (2017), in dolichos bean, pericarp thickness exhibited positive and significant correlation at both genotypic and phenotypic levels with plant height at 60 days, days to first flowering, days to first picking, days to last picking, moisture percentage, green pod yield plant^{-1}, pod length, green pod yield ha^{-1}, weight of 100 seed and weight of 10 pod.

Character association and path analysis studies in pole type dolichos bean was conducted by Patil *et al.* (2017). Green pod yield was positively and significantly correlated with number of pods vine^{-1}, pod length, pod width and average weight of 10 pods both at genotypic and phenotypic levels. The pod setting percentage was positively and non- significantly correlated with pod length (0.114) at genotypic level and pod width (0.061&0.063) and green pod yield plot^{-1} (0.043&0.008) at both genotypic as well as phenotypic levels.

Ananth and Kumar (2018) reported that correlation of data on growth and yield attributes revealed that there exist a linear negative correlation between days to first flowering and yield parameters. Occurrence of early flowering (days to 50 % flowering) contributed to the increased number of racemes plant^{-1} and flower buds racemes^{-1}. Correlation studies suggested that earliness in flowering and increased leaf area, number of racemes plant^{-1}, number of pods, pod length and pod weight are to be considered as vital parameters to choose a variety for high yield.

Correlation studies in dolichos bean was conducted by Noorjahan *et al*. (2019). Pod yield recorded positive significant association with pod yield hectare^{-1}, number of pods inflorescence^{-1} and pod length at both levels of significance.

2.5 PATH ANALYSIS

Path coefficient analysis splits total correlated coefficient of different characters into direct and indirect effects on pod yield plant^{-1} in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation.

Gnanesh *et al*. (2006) reported that pods plant^{-1} exerted the highest positive direct effect on pod yield plant^{-1} and could be taken as a major component for the improvement of yield in field bean. Moderate positive direct effects were exerted by 100 seed weight on pod yield. However, low positive direct effects of seeds pod^{-1}, plant height, vitamin-C content and days to maturity were observed on pod yield. On the contrary, protein content, days to first flowering, primary branches plant^{-1}, pod length and inflorescences plant^{-1} exhibited negative direct effect on pod yield. Tikka *et al.* (2003) reported that pods plant^{-1} had the highest direct effect on pod yield.

Path analysis is useful in determining the direct and indirect association among various variables (Rai *et al.*, 2009). Number of pods plant^{-1}, weight of ten pods and fruit set percentage had positive and strong correlation with yield where as the direct effect of seed width, number of flower set, and number of fruit set on yield was negative.

According to Chattopadhyay and Dutta (2010), among the eight yield component traits, pod weight showed highly positive direct effect on green pod yield in pole type dolichos bean on path analysis. The negative direct effects of days to 50% flowering and number of seeds pod^{-1} on pod yield have been observed. Significant amount of positive effect of number of pods plant^{-1} and 100 dry seed weight towards pod yield plant^{-1} has also been observed.

Seventy three hyacinth bean genotypes were grouped into seven clusters depending upon the genetic architecture and characters uniformity (Singh *et al*., 2011). Path analysis revealed positive association with number of pods plant^{-1}, pod length, pod width and seed length, while days to first flowering had negative direct effect on pod yield plant^{-1}.

Path coefficient analysis study in vegetable Indian bean was conducted by Chaudhari *et al.* (2013) and reported that high positive direct effect for number of pods plant^{-1} followed by number of seeds pod^{-1} and number of days to last picking. The character pod length exhibited high negative direct effect on green pod yield plant^{-1} followed by days to 50% flowering, plant height and days to first picking.

Individual green pod weight exhibited very high direct positive effect (3.72) on pod yield plant^{-1} in dolichos bean. In addition, percentage of pod set, number of clusters plant^{-1}, pods plant^{-1}, flowers cluster^{-1} and days to 50 percent flowering also showed very high direct positive effect on pod yield plant^{-1} as reported by Magalingam *et al.* (2013).

Salim *et al.* (2013) reported that days to first flowering, days to 50% flowering, number of pods plant^{-1}, twenty pod weight, pod yield plant^{-1}, pod length,

number of seeds pod^{-1}, number of seeds plant^{-1} and hundred seed weight influenced seed yield plant^{-1} in Indian bean directly in positive direction.

Path coefficient analysis of fourteen different genotypes of lablab bean was conducted by Assaduzzman *et al.* (2014) and revealed that green pod length exhibited high positive direct effect on number of racemes plant^{-1}, raceme length, green pod width, dry test weight and shelling percentage. The direct negative effects on seed yield was recorded by days to maturity, number of flower buds raceme^{-1}, green pod yield plant^{-1}, green test weight and protein content.

Number of pods plant^{-1} and pod weight exercised maximum positive direct effect on yield plant^{-1} as reported by Kiran *et al.* (2014) in dolichos bean, indicating that these characters are the main contributors to pod yield. Negative direct effect of days to 50% flowering on pod yield was also observed.

Path coefficient analysis revealed that there is ample scope for the improvement of pod yield in dolichos bean by selecting a genotype having higher pod weight, early flowering and pod harvesting, pods cluster^{-1}, spikes plant^{-1}, long pod, pod width and bold seed size as reported by Sharma *et al.* (2014). Path coefficient analysis revealed that 25 pods weight had the highest positive direct effect on pod yield plant^{-1} followed by days taken to first pod harvest.

Verma *et al.* (2015) reported that path analysis revealed the true relationship between yield and number of secondary branches plant^{-1}, number of pods inflorescence^{-1} and number of pods plant^{-1}. Days to first flowering showed very high negative direct effect on pod yield plant^{-1}.

Path analysis of pole and bush types of dolichos bean genotypes was conducted by Das *et al.* (2015) and suggested that yield of dolichos bean could be improved through direct selection for number of pods plant^{-1} and pod weight in pole type and number of pods plant^{-1}, pod weight and number of seeds pod^{-1} in bush type.

Singh *et al.* (2015) reported that the traits like pod yield plant^{-1}, number of pods plant^{-1}, pod width and days to 50% flowering exercised maximum direct effect

on pod yield (ha^{-1}) at genotypic and phenotypic levels on path coefficient analysis in dolichos bean.

Genetic appraisal of F_2 generation of dolichos bean for yield and yield attributing traits was conducted by Venkatesha *et al*. (2016). Among the characters studied, 100 seed weight recorded highest positive direct effect towards seed weight $plant^{-1}$ followed by number of seeds pod^{-1}. Significant correlation of 100 seed weight with seed weight $plant^{-1}$ was due to high direct effect whereas other characters had low indirect effect. Positive correlation of number of seeds pod^{-1} with seed yield was mainly due to positive direct effect and negative indirect effect through 100 seed weight.

Nayak *et al*. (2017) evaluated twenty three indeterminate genotypes of dolichos bean for their genetic variability, character associationships and genetic divergence among ten quantitative traits. The direct selection for number of pods $plant^{-1}$ and pod weight was found beneficial for yield improvement of dolichos bean.

Maximum positive direct effect on green pod yield $plant^{-1}$ in dolichos bean was exhibited by number of pods $plant^{-1}$ followed by hundred seed weight, number of pods $inflorescence^{-1}$, pod length and leaf width (Patel *et al.*, 2017).

Path analysis revealed that number of pods $inflorescence^{-1}$ (1.320) exhibited maximum positive direct effects on yield $plot^{-1}$ due to number of pods $vine^{-1}$ (0.977), followed by days to 50 per cent flowering (0.762) and weight of 10 pods (0.547) (Patil *et al*., 2017). On the contrary, days to first harvest (-0.958), inflorescence length (-0.236), number of flowers $inflorescence^{-1}$ and pod setting percentage (-0.856) exhibited negative direct effect on green pod yield.

Path coefficient analysis study in dolichos bean was conducted by Dewangan *et al*. (2018). The study revealed that hundred seed weight showed highest direct positive effect on green pod yield $plant^{-1}$ followed by number of pods $inflorescence^{-1}$, days to last green pod harvest, pod length, days to first flowering, vine length, pod width and seeds pod^{-1}.

3. MATERIALS AND METHODS

The present investigation entitled “Evaluation of bush dolichos bean [*Lablab purpureus* (L.) Sweet] for yield and quality” was carried out at the Department of Vegetable Science, College of Agriculture, Vellayani, during 2019-2020. The study aimed to evaluate bush type dolichos bean genotypes in Kerala for growth, yield and quality and thereby its adaptability.

3.1 EXPERIMENTAL SITE

The experimental plot was located at 8.5^{o} North latitude and 76.9^{o} East longitude, at an altitude of 29.00 m above mean sea level. Predominant soil type of experimental site was red loam belonging to Vellayani series, texturally classified as sandy clay loam. The area enjoys warm and humid tropical climate. Weather data for the cropping period is given in Figure 1 and Appendix 1.

3.2 MATERIALS

Seeds of twenty five genotypes of bush type dolichos bean were collected from public and private sectors. The details of the dolichos bean genotypes used for the experiment are given in Table 1.

3.3 METHODS

3.3.1 Design and Layout

Seeds of 25 genotypes of bush type dolichos bean were sown under open field conditions.

The experiment was laid out as follows:

Design : RBD

Treatments : 25 genotypes

Replications : 2

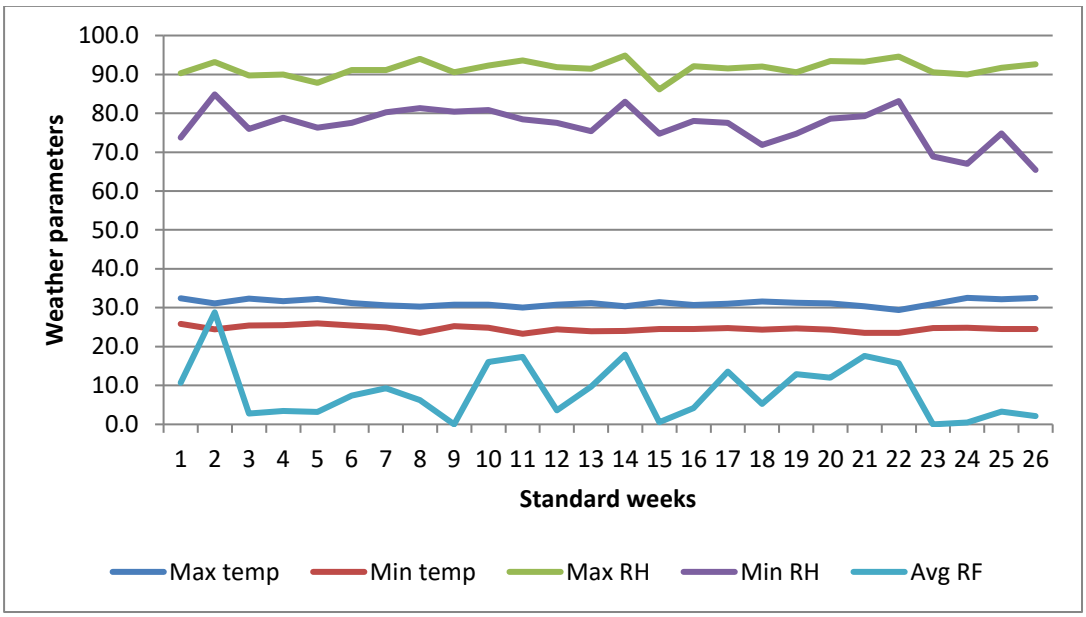


Fig. 1. Weather parameters in open field during the cropping period from June to November 2019

Spacing : 60 cm x 45 cm

Plot size : 5.40 m^2

Plants/ plot : 20

Season : June 2019- November 2019

3.3.2 Cultivation

Seeds were sown in protrays filled with growing media composed of coir pith and vermicompost in the ratio 1:1. Fifteen days old seedlings were transplanted in the main field at 60 cm x 45 cm spacing (Plate1). The crop was raised according to the package of practices recommendations (KAU, 2016). General view of the experimental field is shown in Plate 2.

3.4 OBSERVATIONS

The observations were recorded from five randomly selected plants from each plot in each replication for the following characters.

3.4.1 Vegetative Characters

3.4.1.1 Plant Height (cm)

Plant height from the ground level to the tip of the plant was measured with the help of meter scale and average recorded in centimetres.

3.4.1.2 Plant spread (cm)

Canopy spread of the plant was measured at the full maturity of the plant in north-south and east-west directions in centimetres using meter scale and the average recorded.

3.4.1.3 Primary branches $plant^{-1}$

Number of branches originating from the main stem was counted and average worked out.

Table1. Details of bush dolichos bean genotypes

Treatment number	Accession number	Name of genotype	Source
T1	LP 1	Arka Sambram	IIHR, Bengaluru
T2	LP 2	Arka Amogh	IIHR, Bengaluru
T3	LP 3	Arka Jay	IIHR, Bengaluru
T4	LP 4	Co (Gb) 14	TNAU, Coimbatore
T5	LP 5	HA-4	GKVK, Bengaluru
T6	LP 6	HA-3	GKVK, Bengaluru
T7	LP 7	Hassan	Karnataka
T8	LP 8	Kiyoni	Karnataka
T9	LP 9	Samrat	Karnataka
T10	LP 10	Blady	Karnataka
T11	LP 11	NS 600	Namdhari Seeds, Bengaluru
T12	LP 12	Victor	Trivandrum
T13	LP 13	Vikram	Trivandrum
T14	LP 14	VRBSEM- 744	IIVR, Varanasi
T15	LP 15	Arka Soumya	IIHR, Bengaluru
T16	LP 16	Arka Vijay	IIHR, Bengaluru
T17	LP 17	VRBSEM- 18	IIVR, Varanasi
T18	LP 18	VRBSEM- 207	IIVR, Varanasi
T19	LP 19	VRBSEM- 3	IIVR, Varanasi
T20	LP 20	VRBSEM- 15	IIVR, Varanasi
T21	LP 21	VRBSEM- 8	IIVR, Varanasi
T22	LP 22	VRBSEM- 9	IIVR, Varanasi
T23	LP 23	Konkan bushan	IIVR, Varanasi
T24	LP 24	VRBSEM- 19	IIVR, Varanasi
T25	LP 25	Arka Suvarna	IIVR, Varanasi

Plate 1. Land preparation, formation of ridges and furrows and transplanting of seedlings

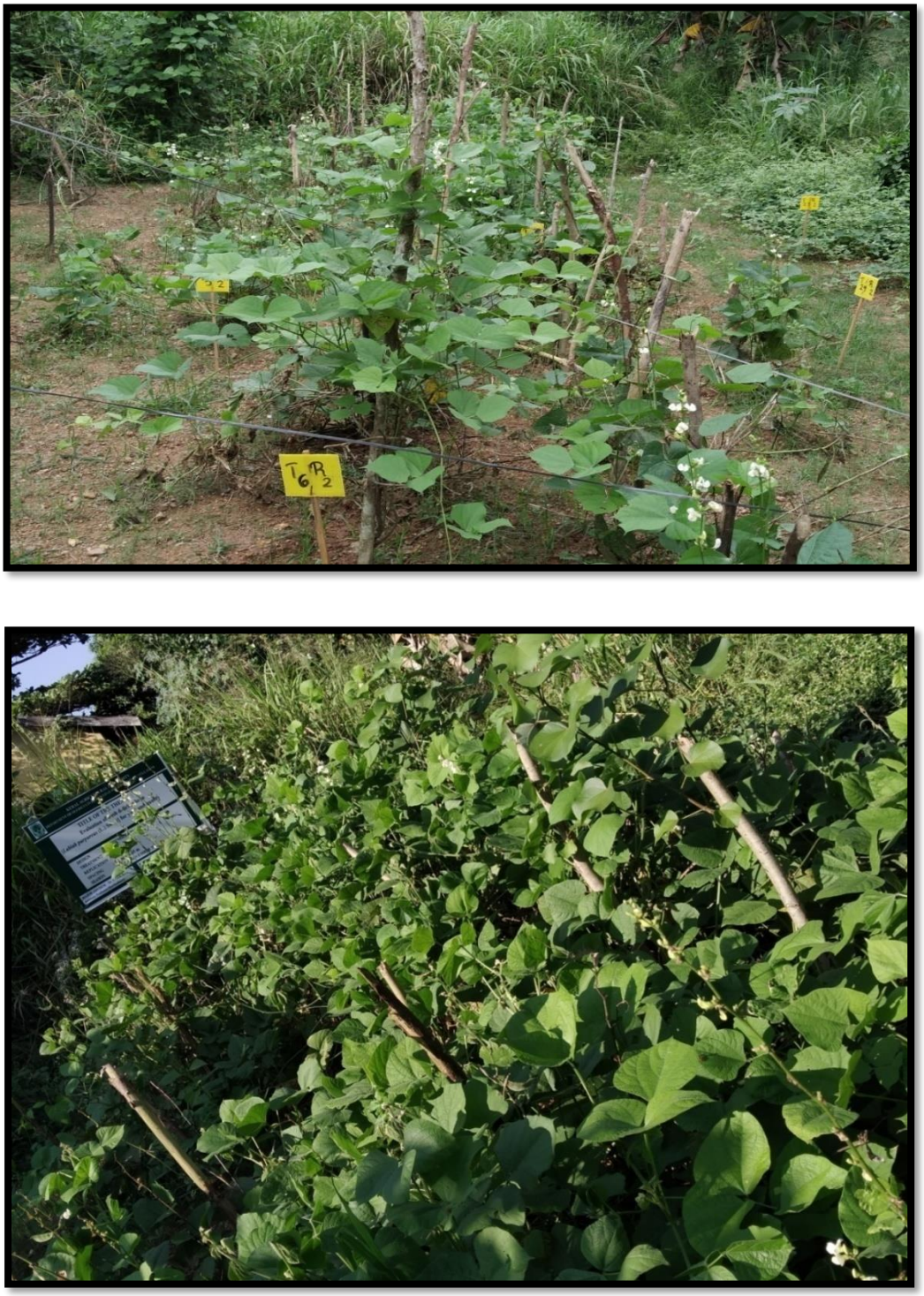


Plate 2. General view of experimental field

3.4.1.4 Leaf area (cm^2)

Leaf area was measured by millimeter graph method and expressed in centimetre square.

3.4.2 Flowering characters:

3.4.2.1 Days to first flowering

Number of days taken from sowing to the first flowering was counted and recorded as number of days.

3.4.2.2 Days to 50% flowering

Number of days taken from sowing to the appearance of flowers in 50 per cent of the plants was counted and recorded as number of days.

3.4.2.3 Number of racemes $plant^{-1}$

Number of racemes produced was counted and the average recorded.

3.4.2.4 Raceme length (cm)

Length of five randomly selected inflorescences from tagged plants was measured, recorded and the average taken and expressed in centimetre.

3.4.3 Pod characters

3.4.3.1 Days to harvest

Number of days from sowing to the first harvest of pods at vegetable maturity was recorded and expressed as number of days.

3.4.3.2 Pod setting (%)

Ten flowers were tagged at random on the plant and number of pods set was recorded. The percentage of pod set was then worked out.

3.4.3.3 Pod length (cm)

Length of ten random pods were measured, recorded and the average was taken and expressed in centimetre.

3.4.3.4 Pod girth (cm)

Girth of ten randomly selected pods were measured at full maturity stage and expressed in centimetre.

3.4.3.5 Pod weight (g)

Weight of ten randomly selected pods were measured at full maturity stage and expressed in gram.

3.4.3.6 Pod colour

The observation on pod colour was recorded at fully mature stage of the pods and expressed as green/light green/ red.

3.4.3.7 Pods plant^{-1}

Number of pods from the plant at each harvest was recorded, the total till last harvest worked out and the average was taken.

3.4.3.8 Seed colour

The observation on seed colour was recorded at fully maturity stage of the pods and expressed as red/light brown/ black.

3.4.3.9 Seeds pod^{-1}

Number of seeds pod^{-1} in ten random pods of the plant was recorded at full maturity stage and the average was taken.

3.4.3.10 Hundred seed weight (g)

One hundred seeds were selected randomly from each genotype and the weight was taken in a digital balance. The average of seed weight was noted as test weight or weight of 100 seeds in gram.

3.4.3.11 Yield plant^{-1} (g)

Pod yield of the plant was recorded after every harvest, the total till last harvest worked out and expressed as gram plant^{-1}.

3.4.3.12 Yield plot^{-1} (kg)

Weight of all pods harvested from each plot was recorded and expressed as kilo gram plant^{-1}.

3.7.4 Quality attributes

3.7.4.1 Crude protein content (%)

Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour. Protein content in the pods was calculated by multiplying nitrogen concentration (%) by the factor 6.25 (A.O.A.C., 1960).

0.5g of plant sample was taken in digestion flask. 25 ml of H_2SO_4 and 3g digestion mixture (K_2SO_4 + $CuSO_4$) were added and the content was digested on kel

plus-kes-12 digestion at 360-410º C for 6 hours. The digested samples were distilled off on kel-plus automatic nitrogen analyzer by adding concentrate 40 %, 10 ml NaOH and steamed for 10 minutes. 20 ml standard boric acid with drop of methyl red indicator was mixed into the solution. Titration was done with 0.1N HCl till the solution turned to blue colour.

$$\%N = \frac{14 \times 0.1N \times \text{Titrate value}}{\text{Sample weight}} \times 100$$

3.7.4.2 Crude Fibre content (%)

Crude fibre was estimated by acid alkali digestion method as suggested by Sadasivam and Manickam (1992).

Two gram of dolichos bean pod was dried, defatted and boiled with 200 ml of 1.25 per cent sulphuric acid for 30 min. This was filtered through muslin cloth and washed with boiling water until the washings were no longer acidic and again boiled with 200 ml of 1.25 per cent sodium hydroxide solution for 30 min and filtered through muslin cloth and washed with 25 ml of 1.25 per cent sulphuric acid, 50 ml water and 25 ml of alcohol. The residue was transferred to a pre-weighed ashing dish (W_1) and dried at 130º C for 2 hours in hot air oven. The ashing dish was cooled in a desiccator and weighed (W_2). Then ignited in a muffle furnace at 600º C for 30 minutes, cooled in a desiccator and reweighed (W_3).

$$\% \text{ crude fibre in ground sample} = \frac{(W2 - W1) - (W3 - W1) \times 100}{\text{Weight of the sample}}$$

3.7.4.3 Cooking quality

Five pods from each accession of the two replications were cleaned and placed on a saucepan to which water was added. They were boiled to acceptable tenderness using gas cylinder. A small quantity of salt and chilli powder was added in between the boiling. Each sample was served on five plates for evaluation. The entire samples

were tasted, one at a time rinsing mouths with tap water in between the tasting to prevent carry over effect.

3.4.4 Pest and Disease Incidence

The crop was monitored for the incidence of major pests and diseases and corrective measures were taken.

3.5 STATISTICAL ANALYSIS

Statistical analysis was carried out for the genotypes using MS-Excel, WASP 2.0, OPSTAT and WINDOSTAT. For estimation of different statistical parameters, following procedure and formulae were adopted:

3.5.1 Analysis of Variance

The mean values observed for vegetative, flowering and yield characters of five plants were recorded and tabulated. The observations recorded were subjected to ANOVA (Panse and Sukhatme, 1985) for comparison among various treatments and to estimate variance components.

ANOVA for each character

Sources of variation	Degrees of freedom	Mean sum of squares	F ratio
Replication	r-1	MSR	MSR/MSE
Treatment	t-1	MST	MST/MSE
Error	(r-1) (t-1)	MSE	
Total	rt-1		

Where,

r = number of replications

t = number of treatments

MSR= mean sum of replication

MST= mean sum of treatments

MSE= mean sum of error

Critical difference CD = tα √2MSE/ r

Where, tα = Student's 't' table value at error degrees of freedom at α level of significance.

3.5.2 Estimation of Genetic Parameters

3.5.2.1 Genetic component of variance

The phenotypic and genotypic variances were calculated by utilizing the respective mean square values (Johnson *et al*., 1955).

i) Genotypic variance (VG)

$$VG = \frac{MST - MSE}{r}$$

ii) Environmental variance (VE)

VE = MSE

iii) Phenotypic variance (VP)

VP = VG + VE

3.5.2.2 Coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated as per Burton (1952).

i) Phenotypic coefficient of variation (PCV)

$$PCV\ (\%) = \frac{\sqrt{VP} \times 100}{\bar{X}}$$

ii) Genotypic coefficient of variation (GCV)

$$GCV\ (\%) = \frac{\sqrt{VG} \times 100}{\bar{X}}$$

Where, $\bar{X}$ = General mean of characters

Categorization of the range of variation was followed as proposed by Sivasubramanyan and Menon (1973).

Low : Less than 10 per cent

Moderate : 10 to 20 per cent

High : More than 20 per cent

3.5.2.3 Heritability

Heritability in the broad sense refers to the proportion of genotypic variance to the total observed variance in the total population. Heritability in broad sense was estimated for various characters and expressed in percentage (Allard, 1960).

$$\text{Heritability } (h^2) = \frac{VG \times 100}{VP}$$

As suggested by Johnson *et al.* (1955) heritability in broad sense estimates were categorized as,

Low : Less than 30 per cent

Moderate : 30 to 60 per cent

High : More than 60 per cent

3.5.2.4 Genetic Advance

Genetic advance refers to the expected genetic gain or improvement in the next generation by selecting superior individuals under a certain amount of selection pressure. It depends upon standardized selection differential, heritability and phenotypic standard deviation (Allard, 1960). The genetic advance was calculated in per cent by the formulae suggested by Johnson *et al*. (1955).

Genetic advance (GA) = $k \times h^2 \sqrt{V_P}$

GA as percentage of mean = $\frac{GA}{\bar{X}} \times 100$

Where, k = standardized selection differential (2.06 at 5% selection intensity)

h^2 = heritability

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al.* (1955).

Low : Less than 10 per cent

Moderate : 10 to 20 per cent

High : More than 20 per cent

3.5.2.5 Correlation Analysis

Phenotypic and genotypic correlation coefficients were calculated using the respective variance and covariance of the characters which showed significant variation in ANOVA.

Phenotypic correlation coefficient, $(rPX,Y) = \frac{Covp\ (X, Y)}{\sqrt{(VP(X), VP(Y))}}$

Genotypic correlation coefficient, $(rGX,Y) = \frac{CovG\ (X, Y)}{\sqrt{(VG\ (X), VG(Y))}}$

Where, CovP (X, Y) = phenotypic variance between two traits X and Y

CovG (X, Y) = genotypic variance between two traits X and Y

VP (X) and VP (Y) = phenotypic variance for X and Y respectively

VG(X) and VG(Y) = genotypic variance for X and Y respectively

3.5.2.6 Path Coefficient Analysis

To study the cause and effect relationship of yield and its component characters, direct and indirect effects were analyzed using path coefficient analysis as suggested by Dewey and Lu (1959).

3.5.3 Selection Index

The selection index developed by Smith (1937) using the discriminant function of Fisher (1936) was used to discriminate the genotypes based on selected characters.

The selection index is described by the function, $I = b_1 x_1 + b_2 x_2 + \ldots\ldots + b_k x_k$ and the merit of a plant is described by the function, $H = a_1 G_1 + a_2 G_2 + \ldots\ldots + b_k G_k$ where $x_1, x_2 \ldots\ldots x_k$ are the phenotypic values and $G_1, G_2 \ldots .. G_k$ are the genotypic values of the plants for the characters, $x_1, x_2, \ldots\ldots x_k$ and H is the genetic worth of the plant. It is assumed that the economic weight assigned to each character is equal to unity *i.e*, $a_1, a_2 \ldots . a_k = 1$

The regression coefficients (b) are determined such that the correlation between H and I is maximum. The procedure will reduce to an equation of the form, $b = p^{-1} Ga$ where, P is the phenotypic variance- covariance matrix and G is the genotypic variance- covariance matrix.

4. RESULTS

The present investigation was conducted at the Department of Vegetable science, College of Agriculture, Vellayani from June 2019 to November 2019 to evaluate the performance of bush type dolichos bean genotypes for yield and quality characteristics. The experimental data were analyzed statistically and the results are presented below.

4.1 MEAN PERFORMANCE OF BUSH DOLICHOS GENOTYPES

The results pertaining to the analysis of variance (ANOVA) for the experimental design indicated that the mean square (MS) due to genotypes were significant at $P \leq 0.05$ for all the characters studied. The mean sum of squares for characters of twenty five genotypes of bush dolichos is presented in Table 2.

4.1.1 Vegetative Characters

The mean performance of 25 bush dolichos bean genotypes for vegetative characters like plant height, plant spread, primary branches plant^{-1} and leaf area were recorded and are presented in Table 3.

4.1.1.1 Plant height (cm)

Significant difference was observed among the treatments for plant height. The average plant height ranged from 23.35 cm to 65.75 cm. The highest plant height was recorded in HA-4 (65.75 cm) and the lowest by Arka Suvarna (23.35 cm).

4.1.1.2 Plant spread (cm)

The genotypes varied significantly for plant spread, which ranged from 18.75 to 48.95 cm. HA-3(48.95 cm) recorded the highest plant spread, while Arka Suvarna the lowest (18.75cm).

Table 2. Mean performance of bush dolichos genotypes

Source of variation	Replication	Genotypes	Error
Plant height (cm)	102.96	141.11	2.070
Plant spread (cm)	38.544	155.28	0.979
Primary branches plant^{-1}	0.461	2.306	0.039
Leaf area (cm^2)	0.130	7.607	0.071
Days to first flowering	6.266	373.44	0.177
Days to 50% flowering	8.570	382.27	0.251
Number of racemes plant^{-1}	0.044	2.392	0.002
Raceme length (cm)	2.218	44.841	0.762
Days to harvest	373.191	70.928	0.661
Pod setting (%)	11.38	18.867	7.900
Pod length (cm)	7.220	6.673	0.213
Pod girth (cm)	0.196	0.235	0.009
Pod weight (g)	0.325	1.683	0.072
Pods plant^{-1}	147.78	191.824	1.255
Seeds pod^{-1}	0.696	0.337	0.022
Hundred seed weight	41.806	22.997	0.019
Yield plant^{-1} (g)	2526.35	2304.44	41.14
Yield plot^{-1} (kg)	1.006	0.921	0.016
Crude protein (%)	0.429	2.660	0.001
Fibre content (%)	0.049	0.309	0.001

Data represent mean sum of squares; * significant at P$\leq$ 0.05; **significant at P$\leq$0.01

Table 3. Mean performance of bush dolichos bean genotypes for vegetative characters

Genotypes		Plant height(cm)	Plant Spread (cm)	Primary branches plant^{-1}	Leaf area (cm^2)
T1	Arka Sambram	40.28	31.20	4.60	8.38
T2	Arka Amogh	54.90	41.55	5.35	11.40
T3	Arka Jay	56.20	37.40	5.65	11.70
T4	Co (Gb) 14	46.50	33.75	5.00	9.45
T5	HA-4	65.75	46.45	5.70	13.35
T6	HA-3	62.65	48.95	5.55	12.65
T7	Hassan	43.90	43.75	4.40	11.40
T8	Kiyoni	40.70	31.85	3.20	8.45
T9	Samrat	40.00	28.65	3.40	9.25
T10	Blady	35.70	29.15	3.50	6.35
T11	NS 600	43.80	39.20	4.85	11.65
T12	Victor	39.90	23.25	4.25	8.75
T13	Vikram	38.70	25.35	3.75	9.70
T14	VRBSEM- 744	37.35	23.15	3.25	7.70
T15	Arka Soumya	39.40	20.85	3.45	8.75
T16	Arka Vijay	40.45	23.45	3.85	9.35
T17	VRBSEM- 18	35.25	20.85	3.55	10.35
T18	VRBSEM- 207	29.75	21.50	3.10	5.45
T19	VRBSEM- 3	27.85	23.20	2.70	7.55
T20	VRBSEM- 15	23.75	19.15	2.00	8.65
T21	VRBSEM- 8	46.80	34.35	5.20	10.50
T22	VRBSEM- 9	32.25	29.20	3.65	7.35
T23	Konkan bushan	33.40	35.40	3.95	7.25
T24	VRBSEM- 19	27.40	26.00	2.50	8.50
T25	Arka Suvarna	23.35	18.75	2.30	8.65
Mean		36.55	30.25	3.95	9.30
SEm (+=)		0.997	0.685	0.137	0.185
CD(0.05)		2.057	1.415	0.283	0.381

4.1.1.3 Primary branches plant^{-1}

There was significant difference among the genotypes for the number of primary branches plant^{-1}. The highest number of primary branches plant^{-1} was recorded by HA-4 (5.70), Arka Jay (5.65) and HA-3 (5.55) were on par with it. Minimum number of primary branches plant^{-1} was noticed in VRBSEM- 15 (2.00).

4.1.1.4 Leaf area (cm^2)

Significant difference was observed among the treatments for leaf area. HA-4 recorded the highest leaf area of 13.35 cm^2, while VRBSEM-207 recorded the lowest (5.45 cm^2).

4.1.2. Flowering Characters

Mean values for flowering characters like days to first flowering, days to 50% flowering, number of racemes plant^{-1} and raceme length are furnished in Table 4. Flowering in bush dolichos bean is shown in Plate 3.

4.1.2.1 Days to first flowering

There was significant difference among the genotypes with respect to days to first flowering. Number of days ranged from 22.95 to 67.00 days with a mean of 43.89 days. Earliest flowering was observed in the genotype VRBSEM- 15 (22.95 days), while first flower appearance was late in HA- 4 (67.00 days).

4.1.2.2 Days to 50% flowering

The mean value for days to 50% flowering was found to be 46.99 days. Fifty percent flowering was earliest in Arka Suvarna (27.85 days), whereas late in HA-4 (71.50 days).

4.1.2.3 Number of racemes plant^{-1}

The genotypes differed significantly for the number of racemes plant^{-1} with a mean of 4.00. The highest number of racemes plant^{-1} was recorded in HA-4 (6.46) and the lowest in VRBSEM- 15 (1.97).

Table 4. Mean performance of bush dolichos bean genotypes for flowering characters

Genotypes		Days to first flowering	Days to 50% flowering	Number of racemes plant^{-1}	Raceme length (cm)
T1	Arka Sambram	53.20	56.20	4.49	19.62
T2	Arka Amogh	60.90	63.90	5.19	24.50
T3	Arka Jay	64.90	67.90	5.37	34.35
T4	Co (Gb) 14	56.85	59.85	4.84	29.05
T5	HA-4	67.00	71.50	6.46	19.85
T6	HA-3	63.00	66.00	5.30	19.90
T7	Hassan	51.05	54.55	4.43	17.60
T8	Kiyoni	39.85	42.35	3.78	16.30
T9	Samrat	42.10	45.10	4.14	17.30
T10	Blady	32.00	35.00	3.28	16.40
T11	NS 600	54.85	58.85	4.78	16.75
T12	Victor	48.95	51.95	4.30	17.25
T13	Vikram	44.95	47.95	4.20	15.20
T14	VRBSEM- 744	29.95	32.95	3.19	13.15
T15	Arka Soumya	36.15	39.15	3.48	17.25
T16	Arka Vijay	46.95	49.95	4.25	15.15
T17	VRBSEM- 18	43.15	46.15	4.17	14.20
T18	VRBSEM- 207	28.50	31.50	2.87	15.15
T19	VRBSEM- 3	27.50	30.50	2.68	17.65
T20	VRBSEM- 15	22.95	25.95	1.97	14.25
T21	VRBSEM- 8	59.05	62.05	5.15	18.20
T22	VRBSEM- 9	34.05	37.05	3.39	15.20
T23	Konkan bushan	38.05	41.05	3.59	17.30
T24	VRBSEM- 19	26.45	29.45	2.49	19.80
T25	Arka Suvarna	24.85	27.85	2.28	16.40
Mean		43.89	46.99	4.00	18.31
SEm (+=)		0.291	0.347	0.031	0.605
CD(0.05)		0.601	0.717	0.065	1.248

Plate 3. Flowering in bush dolichos bean

4.1.2.4 Raceme length (cm)

Significant difference was observed among the treatments for raceme length, the mean value being 18.31 cm. The longest raceme was observed in the variety Arka Jay (34.35 cm) and the shortest in VRBSEM-744 (13.15 cm).

4.1.3. Pod Characters

Mean values for pod and yield characters like days to harvest, pod setting, pod length, pod girth, pod weight, pod colour, pods plant^{-1}, seed colour, seeds pod^{-1}, hundred seed weight, yield plant^{-1} and yield plot^{-1} are furnished in Table 5. Pods of bush dolichos bean genotypes are shown in Plate 4.

4.1.3.1 Days to harvest

The genotypes varied significantly for days to harvest, which ranged from 61.30 days to 80.90 days. Arka Sambram was the earliest to harvest (61.30 days) followed by Arka Soumya (61.80 days), which were on par. The genotype NS 600 took maximum number of days for harvest (80.90).

4.1.3.2 Pod setting (%)

Significant difference could be observed among the genotypes for pod setting. The highest percentage of pod setting was recorded in HA-4 (14.85) and the lowest in VRBSEM-15 (3.75).

4.1.3.3 Pod length (cm)

There was significant difference among the genotypes for pod length, with a mean value of 5.44 cm. The longest pod was recorded in the genotype Co (Gb) 14 (10.63 cm), while the shortest in Arka Vijay (3.53 cm).

4.1.3.4 Pod girth (cm)

The genotypes differed significantly for pod girth with a mean value of 1.63 cm. Pod girth was the highest in Co (Gb) 14 (2.60 cm) and the lowest in VRBSEM-18 and VRBSEM- 744 (1.25 cm).

4.1.3.5 Pod weight (g)

Significant difference was observed among the treatments for pod weight, 3.70 cm being the mean value. The highest pod weight was recorded by Co (Gb) 14 (6.75 g), whereas the lowest by Hassan (1.69 g).

4.1.3.6 Pod colour

Among the twenty five genotypes, nineteen genotypes *viz.* Arka Sambram, Arka Amogh, Arka Jay, HA- 4, HA- 3, Hassan, Kiyoni, Samrat, Blady, Victor, Vikram, VRBSEM- 744, Arka Soumya, VRBSEM- 18, VRBSEM- 207, VRBSEM- 3, VRBSEM- 8, VRBSEM- 9 and Arka Suvarna exhibited light green pod colour, five *viz*. Co (Gb) 14, NS 600, Arka Vijay, VRBSEM- 15 and Konkan Bhushan exhibited dark green pod colour and VRBSEM- 19 exhibited reddish green pod colour.

4.1.3.7 Pods plant^{-1}

There was significant difference among the genotypes for pods plant^{-1} with a mean value of 20.28. The highest number of pods plant^{-1} was found in HA-4 (47.75), whereas the lowest was in VRBSEM- 15 (10.25).

4.1.3.8 Seed colour

The seed colour of eleven genotypes *viz.* Arka Sambram, Arka Amogh, Co (Gb) 14, Kiyoni, Blady, NS 600, VRBSEM- 18, VRBSEM- 207, Konkan Bhushan, VRBSEM- 19 and Arka Suvarna was red, eight *viz*. HA-4, HA- 3, Hassan, Arka Soumya, VRBSEM- 3, VRBSEM- 15 and VRBSEM- 9 was pale white, three *viz*. Arka Jay, Victor and VRBSEM- 744 white, two *viz*. Vikram and VRBSEM-8 black and Arka Vijay light brown.

4.1.3.9 Seeds pod^{-1}

Significant difference could be observed among the genotypes for seeds pod^{-1}. The mean number of seed pod^{-1} was found to be 3.46. The highest number of seeds

Table 5. Mean performance of bush dolichos bean genotypes for pod characters

Genotypes		Days to harvest	Pod setting (%)	Pod length (cm)	Pod girth (cm)
T1	Arka Sambram	61.30	7.75	5.07	1.30
T2	Arka Amogh	67.90	8.35	8.63	1.40
T3	Arka Jay	75.70	11.50	7.93	1.20
T4	Co (Gb) 14	70.60	7.05	10.63	2.60
T5	HA-4	77.80	14.85	5.80	2.05
T6	HA-3	74.65	1.50	5.25	2.20
T7	Hassan	76.90	5.65	5.23	1.71
T8	Kiyoni	80.60	4.65	4.53	1.67
T9	Samrat	75.75	4.45	4.73	1.45
T10	Blady	77.70	5.05	7.83	1.70
T11	NS 600	80.90	4.25	5.53	1.60
T12	Victor	70.85	5.70	4.23	1.70
T13	Vikram	67.55	4.45	4.63	1.55
T14	VRBSEM- 744	65.70	4.72	3.80	1.25
T15	Arka Soumya	61.80	5.10	4.23	1.65
T16	Arka Vijay	63.75	4.67	3.53	1.45
T17	VRBSEM- 18	69.90	3.76	3.83	1.25
T18	VRBSEM- 207	75.90	3.85	3.73	1.53
T19	VRBSEM- 3	76.65	4.90	4.43	1.43
T20	VRBSEM- 15	71.75	3.75	4.10	1.45
T21	VRBSEM- 8	66.90	7.20	4.63	1.20
T22	VRBSEM- 9	63.65	4.50	4.43	1.63
T23	Konkan bushan	67.20	7.62	4.83	1.81
T24	VRBSEM- 19	75.90	5.80	8.33	2.20
T25	Arka Suvarna	65.40	4.70	6.30	1.80
Mean		71.30	6.35	5.44	1.63
SEm (+=)		0.563	0.398	0.319	0.065
CD(0.05)		1.163	0.820	0.659	0.134

Table5.Mean performance of bush dolichos bean genotypes for pod characters (contd.)

Genotypes		Pod weight(g)	Pod colour	Pods plant^{-1}	Seed colour
T1	Arka Sambram	3.53	Light green	24.70	Red
T2	Arka Amogh	3.48	Light green	26.56	Red
T3	Arka Jay	4.20	Light green	35.56	White
T4	Co (Gb) 14	6.75	Dark green	22.71	Red
T5	HA-4	3.11	Light green	47.75	Pale white
T6	HA-3	1.95	Light green	45.70	Pale white
T7	Hassan	1.69	Light green	22.96	Pale white
T8	Kiyoni	3.25	Light green	15.30	Red
T9	Samrat	4.31	Light green	13.46	Pale white
T10	Blady	4.00	Light green	16.25	Red
T11	NS 600	4.25	Dark green	13.15	Red
T12	Victor	3.55	Light green	17.75	White
T13	Vikram	3.90	Light green	11.35	Black
T14	VRBSEM- 744	3.26	Light green	13.45	White
T15	Arka Soumya	3.58	Light green	17.05	Pale white
T16	Arka Vijay	3.65	Dark green	18.70	Light brown
T17	VRBSEM- 18	4.11	Light green	10.85	Red
T18	VRBSEM-207	3.50	Light green	11.95	Red
T19	VRBSEM- 3	3.55	Light green	16.85	Pale white
T20	VRBSEM- 15	3.00	Dark green	10.25	Pale white
T21	VRBSEM- 8	4.00	Light green	21.80	Black
T22	VRBSEM- 9	3.70	Light green	14.95	Pale white
T23	Konkan bushan	3.98	Dark green	21.35	Red
T24	VRBSEM- 19	4.68	Reddish green	19.35	Red
T25	Arka Suvarna	3.55	Light green	17.45	Red
Mean		3.70		20.28	
SEm (+=)		0.185		0.776	
CD(0.05)		0.383		1.601	

Table 5. Mean performance of bush dolichos bean genotypes for pod characters(contd.)

Genotypes		Seeds pod^{-1}	Hundred seed weight	Yield plant^{-1} (g)	Yield plot^{-1} (kg)
T1	Arka Sambram	2.85	30.35	86.96	1.739
T2	Arka Amogh	3.35	27.95	92.51	1.845
T3	Arka Jay	4.25	31.95	148.82	2.976
T4	Co (Gb) 14	4.35	35.45	152.87	3.057
T5	HA-4	4.10	28.90	148.52	2.970
T6	HA-3	3.35	28.45	88.73	1.774
T7	Hassan	3.45	27.50	38.30	0.766
T8	Kiyoni	3.35	27.95	50.04	1.001
T9	Samrat	3.45	25.85	58.38	1.167
T10	Blady	3.25	23.75	65.20	1.304
T11	NS 600	3.45	29.90	56.47	1.129
T12	Victor	3.55	27.25	63.94	1.279
T13	Vikram	3.35	28.80	44.46	0.885
T14	VRBSEM- 744	3.45	24.35	44.05	0.881
T15	Arka Soumya	3.35	26.70	61.14	1.223
T16	Arka Vijay	3.30	27.75	68.47	1.369
T17	VRBSEM- 18	3.35	23.18	44.59	0.891
T18	VRBSEM- 207	3.30	23.70	41.97	0.839
T19	VRBSEM- 3	3.25	25.50	60.33	1.206
T20	VRBSEM- 15	2.75	21.35	30.74	0.614
T21	VRBSEM- 8	4.25	23.25	87.48	1.749
T22	VRBSEM- 9	3.35	21.40	55.17	1.103
T23	Konkan bushan	3.25	28.75	84.91	1.698
T24	VRBSEM- 19	3.35	31.08	90.67	1.813
T25	Arka Suvarna	3.25	29.50	61.76	1.235
Mean		3.46	27.22	73.06	1.461
SEm (+=)		0.104	0.094	4.444	0.089
CD(0.05)		0.214	0.195	9.172	0.183

Arka Sambram

Arka Amogh

Arka Jay

Co (Gb) 14

HA-4

HA-3

Hassan

Kiyoni

Samrat

Blady

NS 600

Victor

Plate 4. Pods of bush dolichos bean genotypes

Vikram

Arka Soumya

VRBSEM- 744

Arka Vijay

VRBSEM- 15

VRBSEM- 3

Konkan bushan

VRBSEM- 8

VRBSEM- 207

VRBSEM- 9

VRBSEM- 18

Arka Suvarna

VRBSEM- 19

Plate 4. Pods of bush dolichos bean genotypes (contd.)

pod^{-1} was in Co (Gb) 14 (4.35), which was on par with Arka Jay (4.25). The lowest number of seeds per pod was recorded in VRBSEM- 15 (2.75).

4.1.3.10 Hundred seed weight (g)

The genotypes differed significantly for hundred seed weight. The mean 100 seed weight was observed to be 27.22 g. The highest weight of 100 seeds was recorded by Co (Gb) 14 (35.45 g). 100 seed weight was the lowest in VRBSEM- 9 (21.40g).

4.1.3.11 Yield Plant^{-1}

There was significant difference among the genotypes for yield plant^{-1} with a general mean of 73.06 g. The highest yield of 152.87 was recorded by Co (Gb) 14 which was on par with Arka Jay (148.82g) and HA-4 (148.52g). The lowest yield of 30.74 g was recorded by VRBSEM- 15.

4.1.3.12 Yield Plot^{-1}

Significant difference was observed among the genotypes for yield plot^{-1}. The highest yield plot^{-1} of 3.057 kg was recorded by Co (Gb) 14. Two genotypes, *viz*., Arka Jay (2.976 kg) and HA-4 (2.970 kg) were on par with it. The lowest yield plot^{-1} was observed in VRBSEM- 15 (0.614 kg).

4.1.4 Quality Characters

Mean values for quality characters like crude protein, crude fibre and cooking quality are furnished in Table 6.

4.1.4.1 Crude Protein

There was significant difference among the genotypes for crude protein. The highest crude protein content of 21.40 per cent was recorded by Co (Gb) 14. The lowest crude protein content was observed in Arka Soumya (16.60 %).

Table 6. Mean performance of bush dolichos bean genotypes for quality characters

Genotypes		Crude protein (%)	Fibre content (%)	Cooking quality
T1	Arka Sambram	19.70	0.955	Good
T2	Arka Amogh	18.30	1.185	Good
T3	Arka Jay	20.30	1.170	Good
T4	Co (Gb) 14	21.40	1.270	Good
T5	HA-4	19.30	1.025	Good
T6	HA-3	18.30	1.015	Good
T7	Hassan	17.20	0.850	Good
T8	Kiyoni	18.20	0.450	Good
T9	Samrat	17.30	0.550	Good
T10	Blady	18.20	0.250	Good
T11	NS 600	17.50	1.015	Good
T12	Victor	17.30	1.190	Good
T13	Vikram	18.00	0.550	Good
T14	VRBSEM- 744	17.20	1.200	Good
T15	Arka Soumya	16.60	1.015	Good
T16	Arka Vijay	17.15	1.215	Good
T17	VRBSEM- 18	18.00	0.960	Good
T18	VRBSEM- 207	19.00	1.055	Good
T19	VRBSEM- 3	17.30	1.040	Good
T20	VRBSEM- 15	18.20	1.055	Good
T21	VRBSEM- 8	19.15	1.150	Good
T22	VRBSEM- 9	18.15	0.850	Good
T23	Konkan bushan	18.14	2.025	Good
T24	VRBSEM- 19	19.20	2.050	Good
T25	Arka Suvarna	20.00	1.020	Good
Mean		18.363	1.044	
SEm (+=)		0.017	0.023	
CD(0.05)		0.035	0.048	

4.1.4.2 Crude Fibre

Significant difference was observed among the genotypes for crude fibre content. The highest crude fibre content of 1.270 per cent was recorded in Co (Gb) 14. The lowest crude fibre content was noted in VRBSEM- 15 (0.850 %).

4.1.4.3 Cooking quality

The cooking quality of all the twenty five genotypes were found to be good.

4.2 PEST AND DISEASE INCIDENCE

The crop was monitored for the incidence of pests and diseases during the cropping period. At the initial stage of crop growth, incidence of leaf webber was noticed (Plate 5.A) and was effectively controlled by spraying Ekalux @ 3 ml litre^{-1}. Anthracnose disease incidence was noticed at the later stage (Plate 5.B) and was controlled by SAAF 2 g litre^{-1}+ Blitox 2 g litre^{-1}.

4.3 GENETIC VARIABILITY PARAMETERS

The genetic variability parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance of twenty five genotypes were studied. The population means, range, GCV, PCV, heritability and genetic advance are presented in Table 7.

4.3.1 Vegetative Characters

Moderate estimates of PCV (22.98) and GCV (20.81) were recorded for plant height. This trait also exhibited high heritability (98.53 per cent) and moderate genetic advance (46.64).

PCV and GCV values were moderate (29.12 and 28.03 respectively) coupled with high heritability (99.37) and high genetic advance (59.62) was evident for plant spread.

Plate 5A. Leaf webber

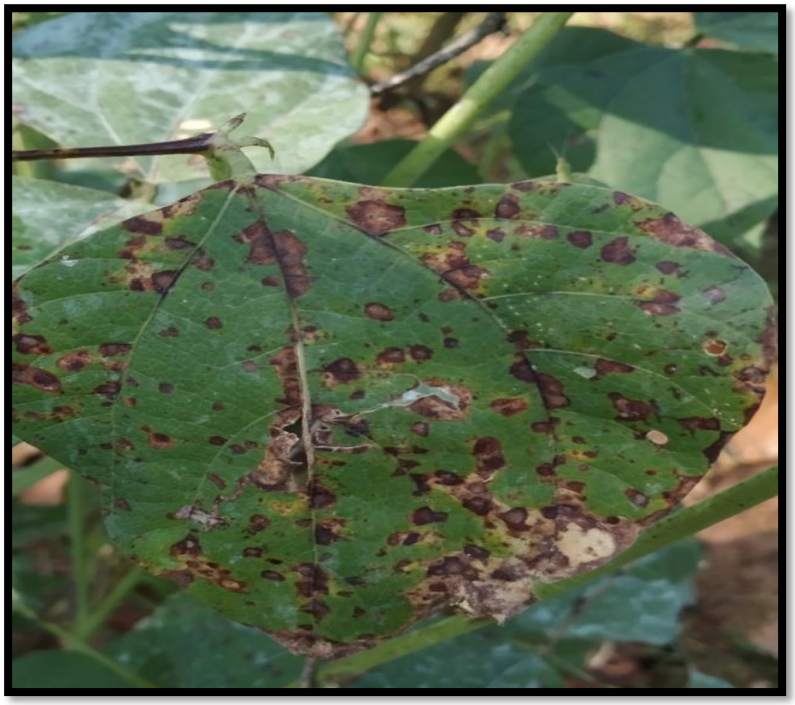


Plate 5B. Anthracnose

Moderate PCV and GCV values (27.20 and 26.96 respectively) coupled with high heritability (98.30 per cent) and high genetic advance (55.07) was evident for number of primary branches plant^{-1}.

Leaf area exhibited moderate PCV (20.97) and GCV (18.87) values with high heritability (99.07 per cent) and moderate genetic advance estimates (42.79).

4.3.2. Flowering Characters

High PCV and GCV values with narrow difference between them (31.13 and 30.13 respectively) coupled with high heritability (99.95) and high genetic advance (64.11) were recorded for days to first flowering.

Days to 50% flowering exhibited a moderate PCV (29.42) and GCV (27.41) with high estimates of heritability (99.93 per cent) and high genetic advance (60.57).

Moderate PCV and GCV values (27.32 and 26.30) coupled with high heritability (99.92 %) and high genetic advance (56.22) were recorded for number of racemes plant^{-1}.

For raceme length, moderate PCV and GCV were noticed (25.86 and 22.64 respectively) with high heritability (98.30 per cent) and moderate genetic advance (48.73).

4.3.3. Pod Characters

Low PCV and GCV were noticed (8.35 and 7.31 respectively) with high heritability (99.07 per cent) and low genetic advance (17.04) for days to first harvest.

Pod setting exhibited high PCV (48.36) and GCV (47.93) along with high heritability estimates (98.26 per cent) and high genetic advance (97.89).

A high PCV of 33.55 and GCV of 30.01 were recorded for pod length. The estimates of heritability was high (96.81 %) with high genetic advance (66.91).

Pod girth exhibited a moderate PCV (21.02) and GCV (20.62) with high estimates of heritability (96.24 per cent) and moderate estimates of genetic advance (41.67).

Moderate estimates of PCV (24.79) and GCV (21.26) along with high estimates of heritability (95.75 %) and moderate genetic advance (48.90) was observed for pod weight.

High PCV and GCV with (48.27 and 46.12 respectively) along with higher heritability (99.35 per cent) and genetic advance (98.79) was expressed for pods plant^{-1}.

Low estimates of PCV (11.85) and GCV (10.45) was observed for seeds pod^{-1}. High heritability (93.33 per cent) and low genetic advance (22.79) were also recorded.

For hundred seed weight, low PCV of 12.46 and GCV of 9.45 were recorded. The estimates of heritability was high (99.92 %) with low genetic advance (25.64 %).

The PCV and GCV estimates were high (46.46 and 44.05 respectively) for yield plant^{-1}. A high heritability of 98.21 per cent and genetic advance of 94.01 per cent were noticed.

High PCV (46.48) and GCV (45.06) were noticed with high heritability (98.22 %) and a higher genetic advance as per cent of mean (94.04) for yield plot^{-1}.

4.3.4. Quality Characters

The PCV and GCV estimates were low (6.28 and 5.28 respectively) for crude protein. A high heritability of 99.98 per cent and low genetic advance of 12.93 were noticed.

A high estimate of PCV (37.66) and GCV (35.59) was recorded along with high heritability (99.63 per cent) and high genetic advance (77.29) for fibre content.

Table 7. Estimates of genetic parameters for various characters in bush dolichos bean

Character	Range	Mean	PCV	GCV	Heritability (%)	Genetic advance	GA as per cent of mean
Plant height (cm)	42.4	36.56	22.98	20.81	98.53	17.05	46.64
Plant spread (cm)	30.2	30.25	29.12	28.03	99.37	18.04	59.62
Primary branches plant^{-1}	3.7	3.95	27.20	26.96	98.30	2.17	55.07
Leaf area (cm^2)	7.9	9.30	20.97	18.87	99.07	3.98	42.79
Days to first flowering	44.05	43.89	31.13	30.13	99.95	28.14	64.11
Days to 50% flowering	43.65	46.99	29.42	27.41	99.93	28.46	60.57
Number of racemes plant^{-1}	4.49	4.00	27.32	26.30	99.92	2.25	56.22
Raceme length (cm)	21.2	18.31	25.86	22.64	98.30	9.59	52.37
Days to harvest	19.6	71.31	8.35	7.31	99.07	12.15	17.04
Pod setting (%)		6.3508	48.36	47.93	98.26	6.21	97.89
Pod length (cm)	7.1	5.44	33.55	30.01	96.81	3.64	66.91
Pod girth (cm)	1.35	1.63	21.02	20.62	96.24	0.68	41.67
Pod weight (g)	5.06	3.70	24.79	21.26	95.75	1.81	48.90
Pods plant^{-1}	37.5	20.29	48.27	46.12	99.35	20.04	98.79
Seeds pod^{-1}	0.71	3.46	11.85	10.45	93.33	0.789	22.79
Hundred seed weight	14.05	27.22	12.46	9.45	99.92	6.98	25.64
Yield plant^{-1} (g)	122.13	73.06	46.46	44.05	98.21	68.68	94.01
Yield plot^{-1} (kg)	2.362	1.461	46.48	45.06	98.22	1.37	94.04
Crude protein (%)	4.8	18.36	6.28	5.28	99.98	2.37	12.93
Fibre content (%)	0.42	1.044	37.66	35.59	99.63	0.807	77.29

4.4 CORRELATION ANALYSIS

Genotypic and phenotypic correlation coefficients between yield and various yield components and interrelationship among the traits were computed and are presented in Table 8 and Table 9. In general, genotypic correlation coefficients were higher than the phenotypic correlation coefficients.

4.4.1 Genotypic Correlation

Yield plant^{-1} had significant positive association at genotypic level with raceme length (0.858), plant height (0.744), pod length (0.695), primary branches plant^{-1}(0.682), number of racemes plant^{-1} (0.630), days to first flowering (0.649), plant spread (0.535), pod setting (0.535), pod girth (0.440) and pod weight (0.433).

Plant height had a significant positive genotypic correlation with primary branches plant^{-1}(0.989), days to first flowering (0.974), number of racemes plant^{-1} (0.960), plant spread (0.828), pod setting (0.828), yield plant^{-1} (0.744), seeds pod^{-1} (0.687), raceme length (0.676) and pod length (0.373).

Significant positive genotypic correlation was exhibited by plant spread with pod setting (0.865), plant height (0.828), primary branches plant^{-1} (0.827), days to first flowering (0.787), number of racemes plant^{-1} (0.777), raceme length (0.483), seeds pod^{-1} (0.475), pod length (0.372), while it had non significant negative association with pod weight (-0.2290).

The primary branches plant^{-1} exhibited significant positive genotypic correlation with plant height (0.989), days to first flowering (0.975), number of racemes plant^{-1} (0.961), plant spread (0.827), pod setting (0.827), seeds pod^{-1} (0.636) and raceme length (0.611).

Significant positive genotypic correlation was exhibited by days to first flowering with number of racemes plant^{-1} (0.979), primary branches plant^{-1}(0.975), plant height (0.974), plant spread (0.787), pod setting (0.787), raceme length (0.602) and seeds pod^{-1} (0.596).

Table 8. Genotypic correlation coefficients between yield and yield components

Character	Plant height	Plant spread	Primary branches plant^{-1}	Days to first flowering	Number of racemes plant^{-1}	Raceme length	Pod setting	Pod length	Pod girth	Pod weight	Seeds pod^{-1}	Yield plant^{-1}
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1	0.828**	0.989**	0.974**	0.960**	0.676**	0.820**	0.373**	0.1660	0.0070	0.687**	0.744**
X2		1	0.827**	0.787**	0.777**	0.483**	0.865**	0.372**	0.314*	-0.2290	0.475**	0.535**
X3			1	0.975**	0.961**	0.611**	0.820**	0.338*	0.1160	0.0150	0.636**	0.682**
X4				1	0.979**	0.602**	0.787**	0.299*	0.0890	0.0040	0.596**	0.649**
X5					1	0.515**	0.770**	0.2340	0.080	0.0000	0.551**	0.630**
X6						1	0.483	0.783**	0.2310	0.424**	0.637**	0.858**
X7							1	0.370**	0.314*	-0.2290	0.475**	0.535**
X8								1	0.536**	0.559**	0.399**	0.695**
X9									1	0.290*	0.2710	0.440**
X10										1	0.2300	0.433**
X11											1	0.575
X12												1

The number of racemes plant^{-1} exhibited a highly significant positive correlation with days to first flowering (0.979), primary branches plant^{-1} (0.961), plant height (0.960), plant spread (0.777), pod setting (0.777), seeds pod^{-1} (0.551) and raceme length (0.515) at the genotypic level.

Raceme length manifested a highly significant positive genotypic correlation with plant height (0.676), pod length (0.783), seeds pod^{-1} (0.637), primary branches plant^{-1} (0.611), days to first flowering (0.602), number of racemes plant^{-1} (0.515), plant spread (0.483), pod setting (0.483) and pod weight (0.424).

At genotypic level, pod setting had highly significant positive correlation with plant spread (0.865), plant height (0.820), primary branches plant^{-1} (0.820), days to first flowering (0.787), number of racemes plant^{-1} (0.770), raceme length (0.483), seeds pod^{-1} (0.475) and pod length (0.370).

Pod length exhibited significant positive correlation with raceme length (0.783), pod weight (0.559), pod girth (0.536), seeds pod^{-1} (0.399), plant height (0.373), plant spread (0.372) and pod setting (0.372) at genotypic level.

Pod girth showed a positive significant correlation for pod length (0.536), plant spread (0.314), pod setting (0.314) and pod weight (0.290).

At genotypic level pod weight had highly significant positive correlation with pod length (0.559), raceme length (0.424) and pod girth (0.290).

Seeds pod^{-1} exhibited significant positive correlation with plant height (0.687), raceme length (0.637), primary branches plant^{-1} (0.636), number of racemes plant^{-1} (0.551), plant spread (0.475), pod setting (0.475) and pod length (0.399).

4.4.2 Phenotypic Correlation

Yield plant^{-1} had significant positive association at phenotypic level with raceme length (0.822), plant height (0.721), pod length (0.672), primary branches plant^{-1} (0.660), days to first flowering (0.636), number of racemes plant^{-1} (0.618), plant spread (0.522), pod setting (0.522), seeds pod^{-1} (0.514), pod weight (0.438) and pod girth (0.399).

Plant height had a significant positive phenotypic correlation with primary branches plant^{-1}(0.9681), days to first flowering (0.9622), number of racemes plant^{-1} (0.9483), plant spread (0.8143), pod setting (0.8143), raceme length (0.6441), seeds pod^{-1} (0.6264) and pod length (0.3659).

Plant spread exhibited significant positive phenotypic correlation with plant height (0.8143), primary branches plant^{-1} (0.8143), days to first flowering (0.7827), number of racemes plant^{-1} (0.7723), raceme length (0.4663), pod length (0.3634) and seeds pod^{-1} (0.4450) while, it showed negative correlation with pod weight (-0.2175).

Primary branches plant^{-1} had significant positive phenotypic correlation with plant height (0.9681), days to first flowering (0.9597), number of racemes plant^{-1} (0.9458), plant spread (0.8143), pod setting (0.8143), raceme length (0.6037) and seeds pod^{-1} (0.5790).

Days to first flowering had significant positive phenotypic correlation with number of racemes plant^{-1} (0.9780), plant height (0.9622), primary branches plant^{-1}(0.9597), plant spread (0.7827), pod setting (0.7827), raceme length (0.5898) and seeds pod^{-1} (0.5580).

Number of racemes plant^{-1} exhibited a highly significant correlation with days to first flowering (0.9780), plant height (0.9483), primary branches plant^{-1} (0.9458), plant spread (0.7723), pod setting (0.7723), seeds pod^{-1} (0.5176) and raceme length (0.5019) at the phenotypic level.

Raceme length manifested a highly significant positive phenotypic correlation with pod length (0.7346), plant height (0.6441), primary branches plant^{-1} (0.6037), days to first flowering (0.5898), seeds pod^{-1} (0.5774), number of racemes plant^{-1} (0.5019), plant spread (0.4663), pod setting (0.4663) and pod weight (0.3693).

Table 9. Phenotypic correlation coefficients between yield and yield components

Character	Plant height	Plant spread	Primary branches plant^{-1}	Days to first flowering	Number of racemes plant^{-1}	Raceme length	Pod setting	Pod length	Pod girth	Pod weight	Seeds pod^{-1}	Yield plant^{-1}
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	1	0.8143**	0.9681**	0.9622**	0.9483**	0.6441**	0.8143**	0.3659**	0.1443	0.0267	0.6264**	0.721**
X2		1	0.8143**	0.7827**	0.7723**	0.4663	0.865	0.3634**	0.2975*	-0.2175	0.4450**	0.522**
X3			1	0.9597**	0.9458**	0.6037**	0.8143**	0.3250*	0.0999	0.0112	0.5790**	0.660**
X4				1	0.9780**	0.5898**	0.7827**	0.2926*	0.0841	0.0058	0.5580**	0.636**
X5					1	0.5019**	0.7723**	0.2305	0.076	0.0037	0.5176**	0.618**
X6						1	0.4663**	0.7346**	0.2314	0.3693**	0.5774**	0.822**
X7							1	0.3634	0.2975*	-0.2175	0.4450**	0.522**
X8								1	0.5064**	0.5250**	0.3419*	0.672**
X9									1	0.2299	0.2448	0.399**
X10										1	0.2215	0.438**
X11											1	0.514**
X12												1

At phenotypic level, pod setting had highly significant positive correlation with plant height (0.8143), primary branches plant^{-1} (0.8143), days to first flowering (0.7827), number of racemes plant^{-1} (0.7723), raceme length (0.4663), pod length (0.3634), seeds pod^{-1} (0.4450). The phenotypic correlation was significant and negative with pod weight (-0.2175).

Pod length exhibited significant positive correlation with raceme length (0.7346), pod weight (0.5250), pod girth (0.5064), plant height (0.3659), plant spread (0.3634) and pod setting (0.3634) at phenotypic level.

Pod girth showed a positive significant correlation for pod length (0.5064), plant spread (0.2975), pod setting (0.2975) at phenotypic level.

Pod weight exhibited significant positive phenotypic correlation with pod length (0.5250) and raceme length (0.3693) while, it showed negative correlation with pod setting (-0.2175).

Seeds pod^{-1} exhibited a highly significant correlation with plant height (0.6264), primary branches plant^{-1} (0.5790), raceme length (0.5774), days to first flowering (0.5580), number of racemes plant^{-1} (0.5176), plant spread (0.4450) and pod setting (0.4440) at the phenotypic level.

4.5 PATH COEFFICIENT ANALYSIS

Genotypic correlation between yield and it's contributing characters were partitioned into different components to find out the direct and indirect contribution of each character on plant yield. Plant height, plant spread, primary branches plant^{-1} , number of racemes plant^{-1}, raceme length, days to first flowering, pod length, pod girth, and pod weight, seeds pod^{-1} and yield plant^{-1} were selected for path coefficient analysis in bush dolichos bean. The results are furnished in Table 10.

Among the various yield components, raceme length exerted the highest positive direct effect (0.9760) on yield plant^{-1} followed by number of racemes plant^{-1} (0.9728) and primary branches plant^{-1} (0.6472), plant height (0.5366), pod girth (0.4170) and pod weight (0.0108) also had positive direct effect on yield. Plant spread

(-0.3343), pod length (-0.2357), seeds pod^{-1} (-0.2845) and days to first flowering (-1.5778) exhibited negative direct effect on yield plant^{-1}.

Regarding the indirect effects, plant height had positive effects through primary branches plant^{-1} (0.5306), days to first flowering (0.5224), number of racemes plant^{-1} (0.5154), plant spread (0.4441), seeds pod^{-1} (0.3687), pod length (0.2003), pod girth (0.0889) and pod weight (0.0037).

Plant spread exerted positive indirect effect through pod weight (0.0765) and negatively through plant height (-0.2767), primary branches plant^{-1} (-0.2763), days to first flowering (-0.2631), number of racemes plant^{-1} (-0.2596), raceme length (-0.1614), pod length (-0.1243), pod girth (-0.1049) and seeds pod^{-1} (-0.1588).

Indirect influence of primary branches plant^{-1} on yield was observed through plant height (0.6399), days to first flowering (0.6307), number of racemes plant^{-1} (0.6217), plant spread (0.5349), raceme length (0.3953), seeds pod^{-1} (0.4117), pod length (0.2190), pod girth (0.0750) and pod weight (0.0098) in the positive direction.

The indirect effect of days to first flowering was negative through pod weight (-0.0057), pod girth (-0.1397), pod length (-0.4722), seeds pod^{-1} (-0.9409), raceme length (-0.9502), plant spread (-1.2421), plant height (-1.5359), primary branches plant^{-1} (-1.5378) and number of racemes plant^{-1} (-1.5441).

Indirect effect of number of racemes plant^{-1} was positive through days to first flowering (0.9520), primary branches plant^{-1} (0.9345), plant height (0.9343), plant spread (0.7557), seeds pod^{-1} (0.5359), raceme length (0.5005), pod length (0.2277) and pod girth (0.0779).

Raceme length positively influenced yield indirectly through pod length (0.7642), plant height (0.6599), seeds pod^{-1} (0.6218), primary branches plant^{-1} (0.5961), days to first flowering (0.5877), number of racemes plant^{-1} (0.5021), plant spread (0.4712), pod weight (0.4135) and pod girth (0.2257).

Table 10. Direct and indirect effects of yield components on pod yield

Character	Plant height	Plant spread	Primary branches plant^{-1}	Days to first flowering	Number of racemes plant^{-1}	Raceme length	Pod length	Pod girth	Pod weight	Seeds pod^{-1}	Genotypic correlation with yield
Plant height	**0.5366**	0.4443	0.5306	0.5224	0.5154	0.3628	0.2003	0.0889	0.0037	0.3687	0.7437
Plant spread	-0.2767	**-0.3343**	-0.2763	-0.2631	-0.2596	-0.1614	-0.1243	-0.1049	0.0765	-0.1588	0.5352
Primary branches plant^{-1}	0.6399	0.5349	**0.6472**	0.6307	0.6217	0.3953	0.2190	0.0750	0.0098	0.4117	0.6820
Days to first flowering	-1.5359	-1.2421	-1.5378	**-1.5778**	-1.5441	-0.9502	-0.4722	-0.1397	-0.0057	-0.9409	0.6487
Number of racemes plant^{-1}	0.9343	0.7557	0.9345	0.9520	**0.9728**	0.5005	0.2277	0.0779	0.0000	0.5359	0.6298
Raceme length	0.6599	0.4712	0.5961	0.5877	0.5021	**0.9760**	0.7642	0.2257	0.4135	0.6218	0.8582
Pod length	-0.0879	-0.0876	-0.0797	-0.0705	-0.0552	-0.1845	**-0.2357**	-0.1263	-0.1316	-0.0939	0.6950
Pod girth	0.0001	0.1308	0.0483	0.0369	0.0334	0.0964	0.2235	**0.4170**	0.1211	0.1128	0.4397
Pod weight	-0.1955	-0.0025	0.0002	0.0000	0.0000	0.0046	0.0060	0.0031	**0.0108**	0.0025	0.4325
Seeds pod^{-1}	0.7437	-0.1352	-0.1810	-0.1697	-0.1567	-0.1813	-0.1134	-0.0770	-0.0654	**-0.2845**	0.5753

Residual effect = 0.021

Bold letters = Direct effect

Pod length exerted negative indirect effect through number of racemes plant^{-1} (-0.0552), days to first flowering (-0.0705), primary branches plant^{-1} (-0.0797), plant spread (-0.0876), plant height (-0.0879), pod weight (-0.1316), seeds pod^{-1} (-0.0939), pod girth (-0.1263), pod weight (-0.1316) and raceme length (-0.1845).

The indirect effect of pod girth was positive through pod length (0.2235), plant spread (0.1308), pod weight (0.1211), seeds pod^{-1} (0.1128), raceme length (0.0964), plant height (0.0690), primary branches plant^{-1}(0.0483), days to first flowering (0.0369) and number of racemes plant^{-1} (0.0334).

Pod weight exhibited positive indirect effect through pod length (0.0060), raceme length (0.0046), pod girth (0.0031), seeds pod^{-1}(0.0025), primary branches plant^{-1} (0.0002) and plant height (0.0001).

Seeds pod^{-1} negatively influenced yield indirectly through pod weight (-0.0654), pod girth (-0.0770), pod length (-0.1134), plant spread (-0.1352), number of racemes plant^{-1}(-0.1567), days to first flowering (-0.1697), primary branches plant^{-1}(-0.1810) and plant height (-0.1955).

4.6 SELECTION INDEX

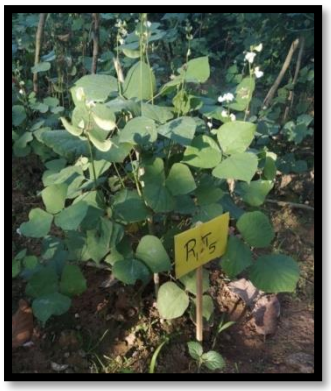
Discriminant function analysis was adopted for the construction of selection index. Selection index was computed based on 6 characters *viz*., plant height (X_1), primary branches plant^{-1} (X_2), number of racemes plant^{-1} (X_3), raceme length (X_4), pod girth (X_5), and pod weight (X_6).

The index value for each treatment was determined and they were ranked. The values obtained for the treatments based on the selection index are given in Table 11.

Based on selection index, HA-4 ranked first with a value of 136.72, followed by Co (Gb) 14 (124.27). HA-3 and Hassan local obtained the next two positions with indices of 123.29 and 107.66 respectively (Plate 6). Minimum value was obtained for VRBSEM- 15 (83.69).

Table 11. Bush dolichos genotypes ranked according to selection index

Treatments	Selection index score	Rank
Arka Sambram	104.232	6
Arka Amogh	101.261	7
Arka Jay	99.363	11
Co (Gb) 14	124.273	2
HA-4	136.720	1
HA-3	123.292	3
Hassan	107.663	4
Kiyoni	95.583	17
Samrat	96.517	15
Blady	86.558	23
NS 600	96.513	16
Victor	93.583	19
Vikram	93.312	20
VRBSEM- 744	87.322	22
Arka Soumya	97.036	14
Arka Vijay	92.616	20
VRBSEM- 18	89.184	21
VRBSEM- 207	86.237	24
VRBSEM- 3	95.010	18
VRBSEM- 15	83.694	25
VRBSEM- 8	105.117	5
VRBSEM- 9	100.540	8
Konkan bushan	97.708	13
VRBSEM- 19	98.298	12
Arka Suvarna	100.355	9



HA- 4

Co (Gb) 14

HA- 3

Plate 6. Superior genotypes

5. DISCUSSION

The present investigation was carried out at the Department of Vegetable Science, College of Agriculture, Vellayani, during 2019-2020 to evaluate bush dolichos bean accessions for adaptability in Kerala based on growth, yield and quality. The extent of variability, heritability of the commercially important characters, genetic advance under selection and correlations among the traits were assessed with a view to suggest measures to bring about genetic improvement for yield and its components. The salient results of the present investigation are discussed under the following headings.

5.1 Mean performance of genotypes

5.2 Coefficient of variation

5.3 Heritability and Genetic advance

5.4 Correlation

5.5 Path analysis

5.6 Selection index

5.1 MEAN PERFORMANCE OF GENOTYPES

5.1.1 Vegetative Characters

In the present study, variation was recorded for all the vegetative characters *viz.* plant height, plant spread, primary branches plant^{-1} and leaf area.

There was significant difference among the treatments for plant height with a range of 23.35 cm to 65.75 cm and the highest plant height was recorded in HA-4 (65.75 cm). Ananth and Kumar (2018) reported variation in plant height in bush dolichos bean with a range from 62.13 to 76.15 cm, the highest being recorded by Ankure Goldy (76.15 cm) which was on par with Arka Jay (75.25 cm). Varietal variation in plant height might be attributed to the inherent genetic makeup of the plant and it’s expression to the growing soil and environmntal conditions.

The genotypes varied significantly for plant spread, which ranged from 18.75 to 48.95 cm. Similar varietal variation in plant spread was also reported by Sreekanth (2007) in bush dolichos bean. Viswanath *et al.* (1971) reported that due to their compact growth, determinates facilitate high density planting to maximize their EPY (economic product yield).

The highest number of primary branches plant^{-1} was recorded by HA-4 (5.70), Arka Jay (5.65) and HA-3 (5.55) were on par with it. Similar varietal variation in primary branches plant^{-1} was also reported by Janaki *et al*. (2018) in dolichos bean. According to Adams (1982) determinate types produce larger number of branches compared to their indeterminate counter parts in dolichos bean.

In the present study, significant difference was observed among the treatments for leaf area and HA-4 recorded the highest leaf area of 13.35 cm^2. Significant variation among twenty dolichos bean genotypes for leaf area was earlier reported by Ananth and Kumar (2018), the highest being recorded by Arka Jay (17.45 cm^2).

5.1.2 Flowering and Yield Characters

Significant difference was noticed among the genotypes for flowering and yield characters such as days to first flowering, days to 50% flowering, number of racemes plant^{-1}, raceme length, days to harvest, pod setting, pod length, pod girth, pod weight, pod colour, pods plant^{-1}, seed colour, seeds pod^{-1}, hundred seed weight, yield plant^{-1} and yield plot^{-1}.

Earliness is one of the most desirable selection parameters to get high return from the market as well as to fit the genotype in multiple cropping systems. In the present study, earliest flowering was observed in the genotype VRBSEM- 15 (22.95 days), while HA- 4 recorded late flowering (67.00 days). Similar range from 40.26 to 66.88 days for first flowering was reported in bush dolichos bean by Verma *et al.* (2015). Das *et al.* (2015) reported that DOLB VAR 3 produced first flowering within 44 days among seven bush dolichos genotypes.

Fifty percent flowering was earliest in Arka Suvarna (27.85 days), whereas late in HA-4 (71.50 days). This agrees with the results of Verma *et al.* (2014) that

fifty percent flowering ranged from 42.38 to 68.90 days. Earliest fifty percent flowering in 66 days for CHDB-20 was reported by Pan *et al*. (2002) and in 49 days for DOLB VAR 3 by Das *et al.* (2015). This conforms to the findings of Ravinaik *et al.* (2014) that 50 per cent flowering was observed earliest in 48.67 days (PD-16) and late in 53 days (Hebbal Avare-3).

The highest number of racemes plant^{-1} was recorded in HA-4 (6.46) and the lowest in VRBSEM-15 (1.97). This is in agreement with the findings of Ananth and Kumar (2018) that the number of racemes plant^{-1} ranged from 3.82 to 6.98 among twenty bush dolichos genotypes. On the contrary, Veerbadhreshwar (2016) reported a range from 5.21 to 24.53 for number of racemes plant^{-1} among 25 bush dolichos genotypes.

In the present study, the longest raceme was observed in the variety Arka Jay (34.35 cm) and the shortest in VRBSEM-744 (13.15 cm). Significant variation for raceme length which ranged from 22.89 to 46.44 cm was reported by Bahadur *et al.* (2013). Chaithanya *et al.* (2011) reported that length of inflorescence ranged from 5.80 to 17.83 cm and NSJ-87-1/A recorded the longest raceme.

The genotypes varied significantly for days to harvest, which ranged from 61.30 days to 80.90 days. Similar range from 68.46 to 90.16 days for days to harvest was reported in bush dolichos bean by Chaudhari *et al.* (2013). Choudhary *et al.* (2016) reported sufficient variation for days to harvest with a range from 54.00 to 135.00 days in 64 dolichos bean genotypes, comprising of both bush and pole types.

The highest percentage of pod setting of 14.85 % was recorded in HA-4. Rai *et al.* (2009) reported wide variation for pod setting with a range of 35.67-76.00 in 64 dolichos bean genotypes, comprising of both bush and pole types. On the contrary, high pod setting percentage of 40.23% was reported by Sreekanth (2007) in bush dolichos bean, grown during September- May. According to Kambal (1969), over 75% of the floral buds of field beans fail to produce pods. Uddin (2007) reported that seasons have marked influence on percentage of flowers setting pods. Off-season beans grown in late summer (June- September) passes through much less favourable environment which leads to reduction in pod set percentage to more than half during

other seasons. Uddin (2003) reported that variations in pod set among the genotypes might be due to flower drop or other embryological problems caused by adverse environmental conditions that prevailed during off-seasons. These findings are also in agreement with those of Rowland *et al.* (1983) that very high rainfall is a major limiting factor causing abortion of almost all the flowers in dolichos bean and limiting yield.

Long pod is an important criterion for greater consumer acceptability. The longest pod was recorded in the genotype Co (Gb) 14 (10.63 cm), while the shortest in Arka Vijay (3.53 cm) (Fig 2). Similar varietal variation for pod length was reported by Verma *et al*. (2014) with a range from 4.73 cm to 7.66 cm and Chaudhari *et al.* (2013) with a range from 4.37 cm to 11.20 cm. Das *et al.* (2015) also reported shortest pod in Arka Vijay (6.8 cm) in a study of the yield attributing traits among seven bush dolichos bean genotypes and recorded a range from 6.8 cm to 10.9 cm for pod length. A higher range for pod length from 8.26 cm to 12.06 cm was reported by Pan *et al.* (2004) in bush doliochos bean and 7.15 to 15.05 cm by Chattopadhyay and Dutta (2010) in pole type.

Pod girth also contributes towards greater consumer acceptability along with pod length. Pod girth was the highest in Co (Gb) 14 (2.60 cm). The highest pod girth of 2.60 cm was also reported by Das *et al.* (2015) in DOLB VAR 1 in bush dolichos bean. Similar varietal variation for girth was also reported by Chaithanya *et al*. (2011) and Gamit *et al*. (2019) in dolichos bean.

Significant difference was observed among the treatments for pod weight, 3.70 cm being the mean value. The highest pod weight was recorded by Co (Gb) 14 (6.75 g), whereas the lowest by Hassan (1.69 g). Sufficient variation for pod weight in dolichos bean was reported by Bahadur *et al.* (2013) with a range from 1.83 to 10.13 g and Sankaran *et al*. (2007) with a range from 4.44 to 12.76 g.

In the present study, the pod colours observed were light green, dark green and reddish green. Among the twenty five genotypes, nineteen genotypes exhibited light green pod colour, five exhibited dark green pod colour and one reddish green pod colour. Chattopadhay and Dutta (2010) reported light green, green, purple and cream

white pod colours. Evaluation of forty six germplasm lines of dolichos bean was done by Chaitanya *et al.* (2011) and reported creamish white, light green, green, dark green, light purple, purple and dark purple pod colours. The purple colour in pod is associated with the pigment anthocyanin and pro- anthocyanidins, which provide a wide range of health benefits to human body acting as antioxidants, immunostimulants and anticarcinogens (Rauf *et al.,* 2019).

The highest number of pods plant^{-1} was observed in HA-4 (47.75), whereas the lowest was in VRBSEM- 15 (10.25) (Fig. 3). Das *et al.* (2015) recorded a range from 36 to 85 pods plant^{-1} among bush dolichos bean genotypes. The highest number of pods plant^{-1} (227.33) was reported in LP-26 among 25 bush dolichos accessions by Sreekanth (2007). Number of pods plant^{-1} ranged from 122 to 425 and more number of pods plant^{-1} was recorded in RJR-150 (Islam *et al.,* 2011). Relative performance of determinate and indeterminate dolichos bean genotypes were studied by Udaykumar *et al.* (2017) and reported that growth habit affects the productivity of pods indicating the superiority of indeterminate genotypes over determinate counterparts for pod yield.

In the present study, the seed colours observed were red, pale white, white, black and light brown. Among the twenty five genotypes, eleven genotypes were red, eight pale white, three white, two black and one light brown in colour. Chattopadhay and Dutta (2010) reported seed colours red, black, yellow, brown and orange in pole type dolichos bean. Chaithanya *et al.* (2011) reported black, cream, mottled, purple, brick red, orange and red seed colour in dolichos bean.

The mean number of seeds pod^{-1} was found to be 3.46. The highest number of seeds pod^{-1} was in Co (Gb) 14 (4.35), which was on par with Arka Jay (4.25). Similar range from 2.16 to 4.30 for seeds pod^{-1} was reported in dolichos bean by Gnanesh *et al.* (2006). Variation in seeds pod^{-1} from 2.67 to 6.00 was reported by Salim *et al.* (2013), among 66 pole genotypes of dolichos bean.

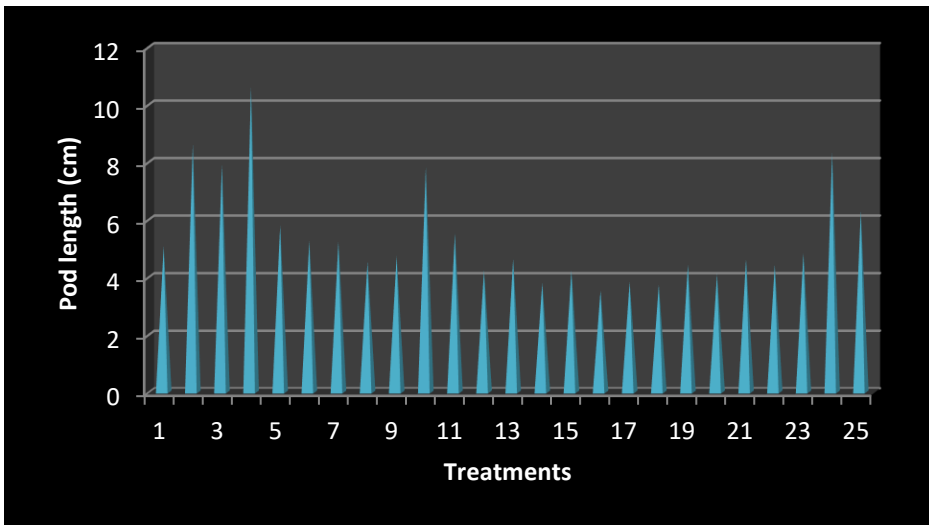


Fig.2 Mean performance of genotypes for pod length (cm)

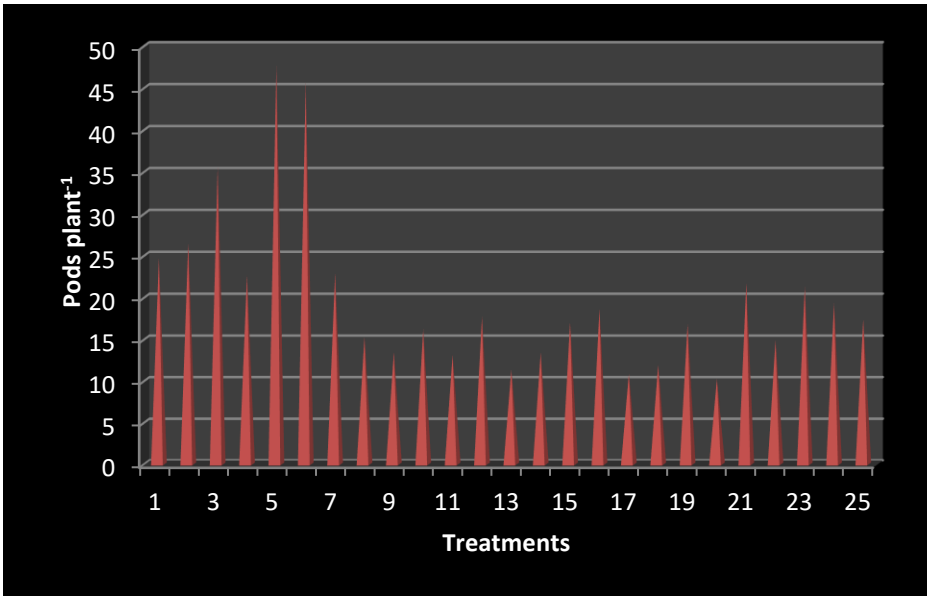


Fig.3 Mean performance of genotypes for pods plant^{-1}

X axis :

1. Arka Sambram 2. Arka Amogh 3. Arka Jay 4. Co (Gb) 14 5. HA-4 6. HA-3 7. Hassan 8. Kiyoni 9. Samrat 10. Blady 11. NS 600 12. Victor 13. Vikram 14. VRBSEM- 744 15. Arka Soumya 16. Arka Vijay 17. VRBSEM- 18 18. VRBSEM-207 19. VRBSEM- 3 20. VRBSEM-15 21. VRBSEM- 8 22. VRBSEM- 9 23. Konkan bushan 24. VRBSEM- 19 25. Arka Suvarna

The mean of 100 seed weight was observed to be 27.22 g and the highest weight of 100 seeds was recorded by Co (Gb) 14 (35.45 g). Similar variation in 100 seed weight was reported by Gupta *et al.* (2017) with maximum 100 seed weight being recorded in CG-16 (50.66 g) and minimum in CG-18 (21.20 g). Pawar *et al.* (2013) reported sufficient variation in hundred seed weight with a range from 23.26 to 28.34 g in dolichos bean.

Yield plant^{-1} is the most important horticultural trait of a crop. There was significant difference among the genotypes for yield plant^{-1} with a general mean of 73.06 g (Fig.4). The highest yield of 152.87 g was recorded by Co (Gb) 14 which was on par with Arka Jay (148.82 g) and HA-4 (148.52 g). Magalingam *et al.* (2013) reported that COGB-14 recorded the highest pod yield plant^{-1} of 221.33 g among 23 dolichos bean genotypes. Similar varietal variation among 7 bush dolichos genotypes for pod yield plant^{-1} ranging from 180 g to 260 g was also reported by Das *et al.* (2015).

The highest yield plot^{-1} of 3.057 kg was recorded by Co (Gb) 14 (Fig. 5). Two genotypes, *viz*., Arka Jay (2.976 kg) and HA-4 (2.970 kg) were on par with it. Sreekanth (2007) recorded the highest pod yield plot^{-1} of 4.5 kg in the accession LP-26 among 25 bush dolichos accessions grown during September- May. These results are in line with Nasreen (1999) that the levels of endogenous auxin in young pods of lablab bean genotypes drastically reduced in kharif compared with rabi which hampered the growth and development of pods during rabi season.

5.1.3 Quality Characters

The genotypes recorded significant difference for quality characters such as crude protein, crude fibre and cooking quality.

The highest crude protein content of 21.40 per cent was recorded by Co (Gb) 14 (Fig.6). The lowest crude protein content was observed in Arka Soumya (16.60 %). This confirms with Reddy *et al.* (2018) who reported significant variation of protein content from 15.41 to 25.09 % in dolichos bean. Similar range of protein

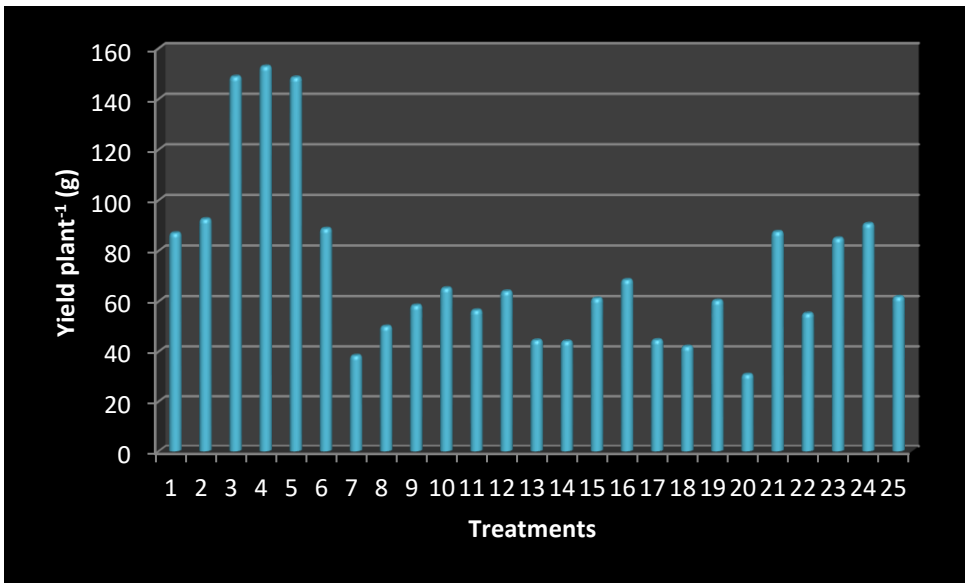


Fig.4 Mean performance of genotypes for yield plant^{-1}(g)

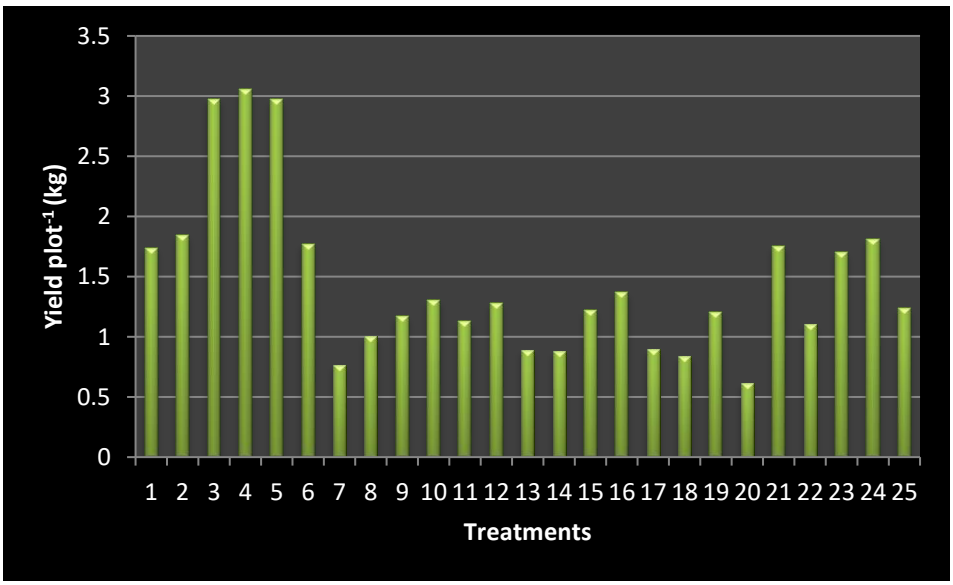


Fig.5 Mean performance of genotypes for yield plot^{-1}(kg)

X axis :

1. Arka Sambram 2. Arka Amogh 3. Arka Jay 4. Co (Gb) 14 5. HA-4 6. HA-3 7. Hassan 8. Kiyoni 9. Samrat 10. Blady 11. NS 600 12. Victor 13. Vikram 14. VRBSEM- 744 15. Arka Soumya 16. Arka Vijay 17. VRBSEM- 18 18. VRBSEM-207 19. VRBSEM- 3 20. VRBSEM-15 21. VRBSEM- 8 22. VRBSEM- 9 23. Konkan bushan 24. VRBSEM- 19 25. Arka Suvarna.

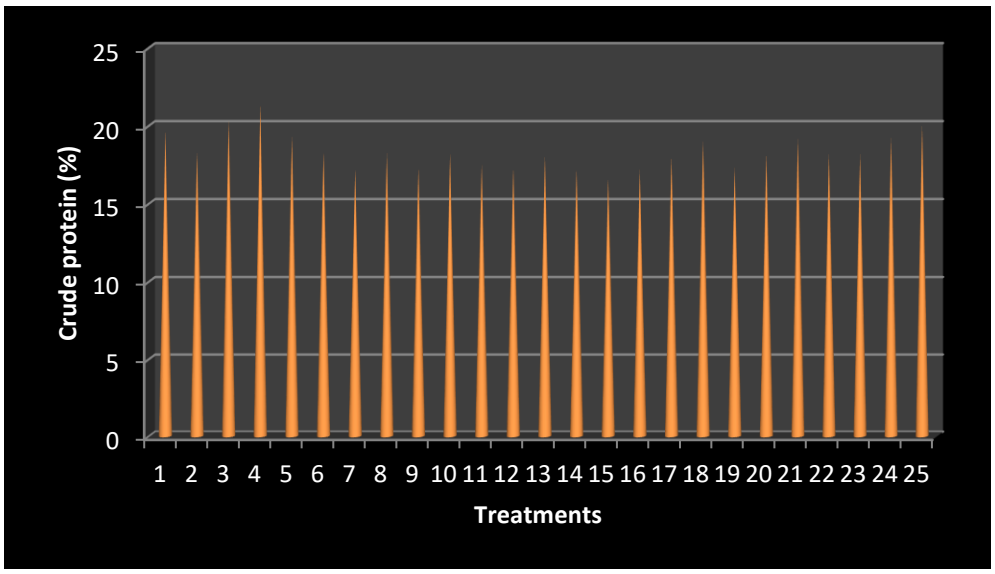


Fig. 6 Mean performance of genotypes for Crude protein (%)

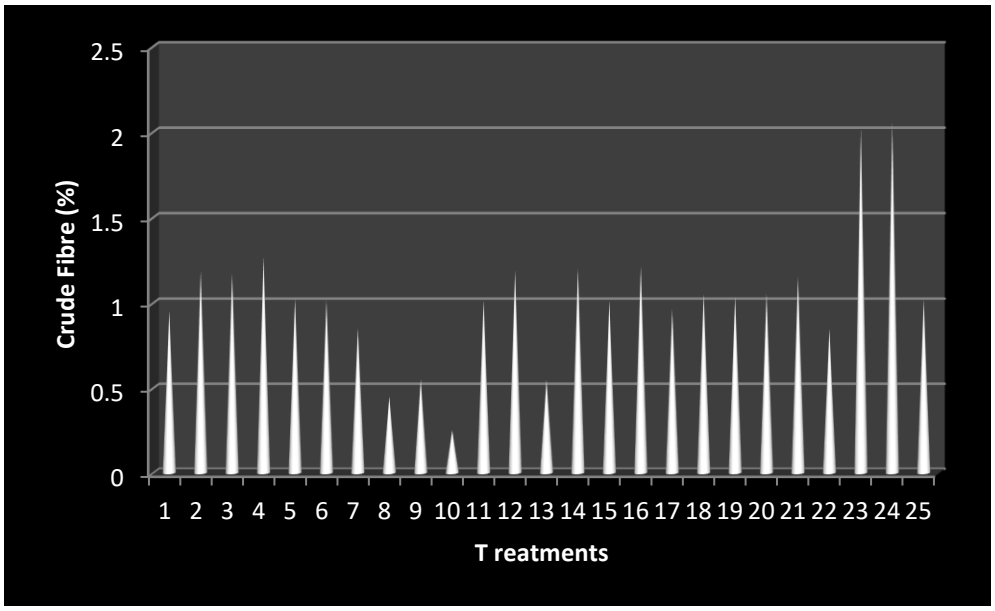


Fig. 7 Mean performance of genotypes for Crude fibre (%)

X axis :

1. Arka Sambram 2. Arka Amogh 3. Arka Jay 4. Co (Gb) 14 5. HA-4 6. HA-3 7. Hassan 8. Kiyoni 9. Samrat 10. Blady 11. NS 600 12. Victor 13. Vikram 14. VRBSEM- 744 15. Arka Soumya 16. Arka Vijay 17. VRBSEM- 18 18. VRBSEM-207 19. VRBSEM- 3 20. VRBSEM-15 21. VRBSEM- 8 22. VRBSEM- 9 23. Konkan bushan 24. VRBSEM- 19 25. Arka Suvarna.

content in dolichos bean from 20.06 to 24.22 % was recorded by Purwanthi *et al.* (2019).

Highest crude fibre content of 1.27 per cent was recorded in Co (Gb) 14 (Fig. 7). Similar variation in crude fibre content from 0.50 to 2.59 per cent was reported by Choudhary *et al.* (2016). On the other hand, Peer *et al*. (2018) reported variation for fibre content from 5.149 to 6.56 per cent. The cooking quality of all the twenty five genotypes were found to be good.

5.2 COEFFICIENT OF VARIATION

The magnitude of variability present in a population is of utmost importance as it provides the basis for effective selection. The phenotypic coefficient variation (PCV) and genotypic coefficients variation (GCV) are the components used to measure the variability present in a population. In the present study, even though phenotypic coefficient of variation was higher than the corresponding genotypic coefficient of variation for all the characters, only a slight difference was observed between PCV and GCV. This revealed greater stability of the characters against environmental fluctuation, thus making selection based on phenotypic performance reliable. A major portion of PCV was contributed by GCV for most of the characters suggesting that the observed variation was mainly due to genetic factors. This similarity between PCV and GCV was reported earlier by Chattopadhyay and Dutta (2010) and Bahadur *et al.* (2013) in dolichos bean.

Studies on genotypic coefficients of variation revealed that high genotypic coefficient of variation (GCV) was recorded for pod setting (47.93), pods plant^{-1}(46.12), yield plot^{-1} (45.06), yield plant^{-1} (44.05), fibre content (35.59), days to first flowering (30.13) and pod length (30.01) in the germplasm under study. This indicated that maximum variability exist in the genotypes for these characters and offers good scope for improvement of these traits by simple selection. This is consistent with the findings of Magalingam *et al*. (2013) and Asaduzzaman *et al*. (2015) in dolichos bean.

Moderate genotypic coefficient of variation was found for plant spread (28.03), days to 50% flowering (27.41), number of primary branches plant^{-1}(26.96), number of racemes plant^{-1} (26.30), raceme length (22.64), plant height (20.81), pod girth (20.62) and leaf area (18.87). Similar results were reported by Magalingam *et al*. (2013), that the extent of response of these traits for selection would be lesser than that of the other traits.

Seeds pod^{-1} (10.45), hundred seed weight (9.45), days to harvest (7.31), and crude protein (5.28) recorded low genotypic coefficient of variation. These results are in agreement with the findings of Choudhary *et al*. (2016) and Asaduzzaman *et al*. (2015).

During the present investigation, high phenotypic coefficient of variation (PCV) was obtained for pods plant^{-1} (48.27), yield plot^{-1}(46.48), yield plant^{-1}(46.46), fibre content (37.66), pod length (33.55) and days to first flowering (31.13). These results are similar to the findings of Gamit *et al* (2020), Gnanesh *et al*. (2006) and Verma *et al*. (2014).

Days to 50% flowering (29.42), plant spread (29.12), number of racemes plant^{-1}(27.32), number of primary branches plant^{-1}(27.20), raceme length (25.86), plant height (22.98), pod girth (21.02) and leaf area (20.97) showed moderate phenotypic coefficient of variation. Similar results were reported by Magalingam *et al*. (2013).

Low phenotypic coefficient of variation was recorded for days to harvest (8.35), seeds pod^{-1}(11.85), hundred seed weight (12.46) and crude protein (6.28). These results corroborate with the findings of Chaudhari *et al*. (2013) and Gnanesh *et al.* (2006).

5.3 HERITABILITY AND GENETIC ADVANCE

The genotypic coefficient of variation does not offer full scope to estimate the variation that is heritable and therefore, estimation of heritability becomes necessary. The knowledge of heritability along with genetic advance aid in drawing valuable conclusions for effective selection based on phenotypic performance.

In the present investigation, high heritability was observed for all the characters studied. The magnitude of heritability ranged from 93.33 to 99.98%. Highest heritability was recorded for crude protein(99.98) followed by days to first flowering (99.95), days to 50% flowering (99.93), hundred seed weight (99.92), number of racemes plant^{-1}(99.92), fibre content (99.63), pods plant^{-1} (99.35), plant spread (99.37), leaf area (99.07), days to harvest (99.07), plant height (98.53), primary branches plant^{-1} (98.30), raceme length (98.30), pod setting (98.26), yield plot^{-1} (98.22), yield plant^{-1} (98.21), pod length (96.81), pod girth (96.24), pod weight (95.75) and seeds pod^{-1} (93.33).This is in agreement with the findings of Chattopadhyay and Dutta (2010), Magalingam *et al*. (2013) and Asaduzzaman *et al*. (2015).

High heritability indicates that phenotype of the trait strongly reflects the genotype and suggests the major role of genotypic constitution in the expression of the character. Therefore, reliable selection could be made for these traits on the basis of phenotypic expression. This is in agreement with the findings of Hadawani *et al*. (2018) and Afsan and Roy (2020).

Generally high heritability accompanied with high genetic advance as per cent of mean in a character suggests that the inheritance of such character is governed mainly by additive gene effects and therefore selection based on phenotypic performance may prove useful.

High genetic advance as percent of mean observed for pods plant^{-1}(98.79), pod setting per cent (97.89), yield plot^{-1}(94.04), yield plant^{-1}(94.01), fibre content (77.29), pod length (66.91), days to first flowering (64.11), days to 50% flowering (60.57), plant spread (59.62), number of racemes plant^{-1}(56.22) and number of primary branches plant^{-1}(55.07) indicated the presence of larger number of fixable additive factors which help in improvement of these traits through simple selection procedures. These results are in line with the findings of Ali *et al*. (2005), Gnanesh *et al*. (2006) and Singh *et al*. (2011).

Genetic advance estimates were moderate in the case of pod weight (48.90), raceme length (52.37), plant height (46.64), leaf area (42.79) and pod girth (41.67). These findings corroborate with the results of Magalingam *et al*. (2013).

Low genetic advance was noted for hundred seed weight (25.64), seeds pod^{-1}(22.79), days to harvest (17.04) and crude protein (12.93). Similar results were reported by Das *et al*. (2015) and Singh *et al*. (2011) in dolichos bean.

5.3 CORRELATION

Yield is the result of interactions of a number of interrelated characters. For rational approach towards the improvement of yield, selection will be more rewarding when it is based on the components of yield. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and component characters and among themselves. Correlation coefficient analysis measures the mutual relationship between various characters and is used to determine the component character on which selection can be done for improvement of yield (Pan *et al.* 2004).

Correlation coefficient revealed the existence of varying closeness of interrelationship among the characters under study. In general, the genotypic correlation coefficients were higher than their corresponding phenotypic values for most of the characters. The characters that are positively correlated with yield are considerably important to plant breeder for selection purpose (Choudhary *et al.*, 2016).

Plant height showed significant positive genotypic and phenotypic correlation with primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, plant spread, pod setting, yield plant^{-1}, seeds pod^{-1}, raceme length, and pod length. Similar association was also reported by Bahadur *et al.* (2013), Magalingam *et al.* (2013) and Ravinaik *et al.* (2014). Results obtained in the present investigation with regard to plant spread showed positive and significant association with plant height, primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, yield

plant^{-1}, raceme length, seeds pod^{-1} and pod length at both genotypic and phenotypic levels.

Primary branches plant^{-1} exhibited significant positive genotypic and phenotypic correlation with plant height, days to first flowering, number of racemes plant^{-1}, plant spread, pod setting, seeds pod^{-1} and raceme length. Similar results were also reported by Choudhary *et al*. (2016) and Ravinaik *et al.* (2014).

Significant positive genotypic and phenotypic correlation was exhibited by days to first flowering with number of racemes plant^{-1}, primary branches plant^{-1}, plant height , plant spread, pod setting, raceme length and seeds pod^{-1}. This is in agreement with the findings of Singh *et al*. (2011) and Salim *et al*. (2013).

The number of racemes plant^{-1} exhibited a highly significant positive correlation with days to first flowering, primary branches plant^{-1}, plant height, plant spread, pod setting, seeds pod^{-1} and raceme length at both genotypic and phenotypic level. Similar findings were also reported by Bahadur *et al*. (2013) and Sharma *et al*. (2014).

Raceme length manifested a highly significant positive genotypic and phenotypic correlation with plant height, pod length, seeds pod^{-1}, primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, plant spread, pod setting, yield plant^{-1} and pod weight. These findings corroborated with the results of Bahadur *et al*. (2013) and Chaudhari *et al*. (2013).

At genotypic and phenotypic level, pod setting had highly significant positive correlation with plant height, primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, raceme length, seeds pod^{-1}, yield plant^{-1} and pod length (Magalingam *et al.* 2013).

Pod length exhibited significant positive correlation with raceme length, pod weight, pod girth, seeds pod^{-1}, plant height, plant spread, pod setting and yield plant^{-1} at both genotypic and phenotypic level. Similar association was also reported by Ali *et al*. (2005).

Pod girth showed a positive genotypic and phenotypic correlation for pod length, plant spread, pod setting and yield plant^{-1}. Similar relationship was also reported by Bahadur *et al*. (2013).

At genotypic and phenotypic level pod weight had highly significant positive correlation with pod length, raceme length and yield plant^{-1}. These findings are in agreement with those reported by Kiran *et al*. (2014) and Ali *et al*. (2005).

Yield plant^{-1} had significant positive association at both genotypic and phenotypic level with raceme length, plant height, pod length, primary branches plant^{-1}, number of racemes plant^{-1}, pod setting, plant spread, days to first flowering, pod girth and pod weight. These results are in line with the findings of Kiran *et al*. (2014), Ravinaik *et al*. (2015) and Das *et al*. (2015). Hence, there is ample scope in the improvement of yield by selecting a genotype having higher raceme length and plant height since they are highly correlated.

Seeds pod^{-1} exhibited significant positive genotypic and phenotypic correlation with plant height, raceme length, primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, raceme length, plant spread, pod setting and pod length. These findings are in line with Bagade *et al*. (2004).

5.4 PATH COEFFICIENT ANALYSIS

Correlation studies give an idea about the positive and negative associations of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained. The total correlation between yield and its component characters may sometimes be misleading, as it might be an overestimate or under-estimate of its association with other characters which are also associated with economic yield. Path coefficient analysis can provide a more realistic picture of relationships between different traits, as it takes into consideration direct as well as indirect effects of the different yield components. Determination of interrelationships between and among yield components and yield helps a plant breeder to easily identify traits that make the most significant contribution to yield.

In this study, path coefficient analysis was used to separate the genotypic correlation coefficients of yield plant^{-1} with plant height, plant spread, primary branches plant^{-1}, number of racemes plant^{-1}, raceme length, days to first flowering, pod length, pod girth, pod weight and seeds pod^{-1} into direct and indirect effects.

Among yield attributes, raceme length (0.9760) exhibited the highest positive direct effect on yield plant^{-1} followed by number of racemes plant^{-1} (0.9728). Primary branches plant^{-1}, plant height, pod girth and pod weight also showed positive correlation with yield plant^{-1}. This indicated that direct selection based on these characters would result in appreciable improvement of yield plant^{-1}. Raceme length and number of racemes plant^{-1} were the main yield contributing characters in bush dolichos bean because of its high, positive direct effect and positive correlation with yield plant^{-1}. Since these characters also have high level of heritability and genetic advance, they can be considered dependable for improvement of yield in bush dolichos bean. This is in accordance with the findings of Bahadur *et al.* (2013).

The indirect effect of days to first flowering was negative through pod weight, pod girth, pod length, seeds pod^{-1}, raceme length, plant spread, plant height, primary branches plant^{-1} and number of racemes plant^{-1}. Similar results were reported by Singh *et al*. (2011) and Verma *et al.* (2014), Rai *et al.* (2009) and Chattopadhyay and Dutta (2010).

Indirect effect of number of racemes plant^{-1} was positive through days to first flowering, primary branches plant^{-1}, plant height, plant spread, seeds pod^{-1}, raceme length, pod length and pod girth, which is in accordance with Lal *et al.* (2005).

Raceme length positively influenced yield indirectly through pod length, plant height, seeds pod^{-1}, primary branches plant^{-1}, days to first flowering, number of racemes plant^{-1}, plant spread, pod weight and pod girth. This was in agreement with the findings of Dewangan *et al*. (2018).

Pod length exerted negative indirect effect through number of racemes plant^{-1}, days to first flowering, primary branches plant^{-1}, plant spread, plant height, pod

weight, seeds pod^{-1}, pod girth, pod weight and raceme length. Similar results were reported by Chattopadhyay and Dutta (2010).

Positive indirect effect exhibited by pod weight through pod length, raceme length, pod girth, seeds pod^{-1}, primary branches plant^{-1} and plant height observed in the study was in agreement with Kiran *et al.* (2014).

5.5 SELECTION INDEX

Selection of genotypes based on suitable index is highly efficient in any breeding programme. Discriminant function analysis developed by Fisher (1936) gives information on the proportionate weightage to be given to a yield component. Thus, selection index was formulated to increase the efficiency of selection by taking into account the important characters contributing to yield. According to Hazel (1943), a selection index was more efficient than individual selection based on individual characters.

Selection index was computed based on 6 characters *viz*., plant height, primary branches plant^{-1}, number of racemes plant^{-1}, raceme length, pod girth, and pod weight. Based on the selection index values, top ranking genotypes namely HA-4 (136.72), Co (Gb) 14 (124.27) and HA-3 (123.29) were identified as superior ones. Chattopadhyay and Dutta (2010) considered pod weight, 100 seed weight and number of pods plant^{-1} while formulating selection indices in the improvement of pole type dolichos bean.

6. SUMMARY

The present investigation entitled “Evaluation of bush dolichos bean [*Lablab purpureus* (L.) Sweet] for yield and quality” was carried out at the Department of Vegetable Science, College of Agriculture, Kerala Agricultural University, Vellayani, during 2019-2020 to evaluate bush dolichos bean for yield and quality and thereby its adaptability.

In the experiment, twenty five genotypes of bush dolichos bean, collected from public and private sectors, were evaluated for yield and quality. The evaluation was done in randomised block design with two replications. The extent of variability, heritability and genetic advance of genotypes were assessed. The degree and direction of association between various traits and direct and indirect effects of various components on yield were also analysed. The salient findings of the investigation are summarized below.

Observations were recorded on different biometric characters *viz.*, plant height (cm), plant spread (cm), primary branches plant^{-1} and leaf area (cm^2), days to first flowering, days to 50% flowering, number of racemes plant^{-1} , raceme length (cm), days to harvest, pod setting(%), pod length (cm), pod girth (cm), pod weight (g), pod colour, pods plant^{-1}, seed colour, seeds pod^{-1}, hundred seed weight (g), yield plant^{-1} (g) and yield plot^{-1} (kg). In addition, quality characters *viz*., crude protein (%), crude fibre (%) and cooking quality were also recorded.

The results pertaining to the analysis of variance for the experimental design indicated that the mean squares due to genotypes were significant for all the characters studied. The highest plant height was recorded in HA-4 (65.75 cm) and the lowest in Arka Suvarna (23.35 cm). . HA-3(48.95 cm) recorded the highest plant spread, while Arka Suvarna the lowest (18.75 cm). The highest number of primary branches plant^{-1} was recorded by HA-4 (5.70), Arka Jay (5.65) and HA-3 (5.55) being on par with it. Minimum number of primary branches plant^{-1} was noticed in VRBSEM- 15 (2.00). HA-4 recorded the highest leaf area of 13.35 cm^2, while VRBSEM-207 recorded the lowest (5.45 cm^2).

Earliest flowering was observed in the genotype VRBSEM- 15 (22.95 days), while first flower appearance was late in HA- 4 (67.00 days). Fifty percent flowering was earliest in Arka Suvarna (27.85 days), whereas late in HA-4 (71.50 days). The highest number of racemes plant^{-1} was recorded in HA-4 (6.46) and the lowest in VRBSEM-15 (1.97). The longest raceme was observed in the variety Arka Jay (34.35 cm) and the shortest in VRBSEM-744 (13.15 cm).

Arka Sambram was the earliest to harvest (61.30 days) followed by Arka Soumya (61.80 days), which were on par. The genotype NS 600 took maximum number of days for harvest (80.90). The highest percentage of pod setting was recorded in HA-4 (14.85) and the lowest in VRBSEM-15 (3.75). The longest pod was recorded in the genotype Co (Gb) 14 (10.63 cm), while the shortest in Arka Vijay (3.53 cm). Pod girth was the highest in Co (Gb) 14 (2.60 cm) and the lowest in VRBSEM-18 and VRBSEM- 744 (1.25 cm). The highest pod weight was recorded by Co (Gb) 14 (6.75 g), whereas the lowest by Hassan (1.69 g). Among the twenty five genotypes, nineteen genotypes exhibited light green pod colour, five dark green pod colour and one reddish green pod colour.

The highest number of pods plant^{-1} was found in HA-4 (47.75), whereas the lowest was in VRBSEM- 15 (10.25). The seed colour of eleven genotypes was red, eight pale white, three white, two black and one light brown. The highest number of seeds pod^{-1} was in Co (Gb) 14 (4.35), which was on par with Arka Jay (4.25). The lowest number of seeds pod^{-1} was recorded in VRBSEM- 15 (2.75). The highest weight of 100 seeds was recorded by Co (Gb) 14 (35.45 g). Hundred seed weight was lowest in VRBSEM- 9 (21.40g). The highest yield of 152.87 was recorded by Co (Gb) 14 which was on par with Arka Jay (148.82g) and HA-4 (148.52g). The lowest yield of 30.74 g was recorded by VRBSEM- 15. The highest yield plot^{-1} of 3.057 kg was recorded by Co (Gb) 14. Two genotypes, *viz*., Arka Jay (2.976 kg) and HA-4 (2.970 kg) were on par with it. The lowest yield plot^{-1} was observed in VRBSEM- 15 (0.614 kg).

The highest crude protein content of 21.40 per cent was recorded by Co (Gb) 14. The lowest crude protein content was observed in Arka Soumya (16.60 %). The

highest crude fibre content of 1.270 per cent was recorded in Co (Gb) 14. The lowest crude fibre content was noted in VRBSEM- 15 (0.850 %). The cooking quality of all the twenty five genotypes was found to be good.

High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for the characters like days to first flowering (31.13 and 30.13), pod setting (48.36 and 47.93), pod length (33.55 and 30.01), pods plant^{-1}(48.27 and 46.12), yield plant^{-1}(46.46 and 44.05), yield plot^{-1} (46.48 and 45.06) and fibre content (37.66 and 35.59). GCV was near to PCV for most of the characters, indicating a highly significant effect of genotype on phenotypic expression, with very little effect of environment. High estimates of heritability coupled with high genetic advance as per cent of mean were recorded for all the yield components, indicating additive gene effects, which will be useful in selection of these characters.

Yield plant^{-1} had a significant positive correlation at genotypic and phenotypic level with raceme length (0.858, 0.822), plant height (0.744, 0.721), pod length (0.695,0.672), primary branches plant^{-1}(0.682, 0.660), number of racemes plant^{-1} (0.649, 0.618), days to first flowering (0.649, 0.636), plant spread (0.535, 0.522), pod girth (0.440, 0.399) and pod weight (0.433, 0.438). Path coefficient analysis revealed that raceme length (0.9760) exerted the highest positive direct effect on yield plant^{-1} followed by number of racemes plant^{-1}, primary branches plant^{-1}, plant height, pod girth and pod weight. The genotypes were ranked based on selection index score considering the characters *viz*., plant height, primary branches plant^{-1}, number of racemes plant^{-1}, raceme length, pod girth and pod weight. HA-4 recorded the highest selection index score of 136.72 followed by Co (Gb) 14 (124.27).

Based on the mean performance of the genotypes for various characters and selection index score, the top ranking genotypes HA-4, Co (Gb) 14 and HA-3 were found suitable for growing under Kerala conditions.

FUTURE LINE OF WORK

The superior genotypes identified *viz.*, HA-4, Co (Gb) 14 and HA-3 can be grown in a large area for confirmation of the results and if found superior can be recommended for commercial cultivation.

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APPENDIX 1

Standard week wise weather parameters during cropping period

Standard weeks	Month	Avg RF (mm)	Max temp (°C)	Min temp(°C)	Max RH(%)	Min RH (%)
1	June 1-7	10.7	32.4	25.8	90.2	73.7
2	June 8- 14	28.8	31.1	24.5	93.1	84.8
3	June15-21	2.8	32.3	25.5	89.7	76.0
4	June22-28	3.4	31.7	25.5	90.0	78.8
5	July 29-05	3.2	32.3	26.0	87.8	76.2
6	July 6- 12	7.4	31.2	25.4	91.1	77.5
7	July 13-19	9.3	30.6	24.9	91.1	80.2
8	July 20-26	6.2	30.3	23.6	94.0	81.2
9	July 27-2	0.0	30.8	25.3	90.5	80.4
10	Aug 3-9	16.1	30.8	24.9	92.2	80.8
11	Aug 10-16	17.3	30.0	23.3	93.5	78.4
12	Aug 17-23	3.6	30.8	24.5	91.8	77.5
13	Aug 24-30	10.0	31.2	23.9	91.4	75.4
14	Aug 31-6	17.90	30.4	24.0	95.0	83.0
15	Sep 7- 13	0.6	31.5	24.5	86.1	74.7
16	Sep 14- 20	4.2	30.7	24.5	92.1	78.0
17	Sep 21-27	13.6	31.0	24.7	91.5	77.5
18	Sep 28-4	5.2	31.6	24.3	92.0	71.8
19	Oct5-11	12.9	31.3	24.7	91.0	74.7
20	Oct12-18	12.00	31.1	24.3	93.4	78.5
21	Oct19-25	17.6	30.3	23.5	93.2	79.2
22	Oct 26-1	15.7	29.4	23.6	94.5	83.1
23	Nov 2-8	0.0	31.0	24.7	90.5	69.0
24	Nov 9-15	0.5	32.5	24.9	90.0	67.0
25	Nov 16-22	3.3	32.2	24.5	91.7	74.8
26	Nov 23-29	2.1	32.5	24.5	92.5	65.4

EVALUATION OF BUSH DOLICHOS BEAN [*Lablab purpureus* (L.) Sweet] FOR YIELD AND QUALITY

By

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ABSTRACT

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ABSTRACT

The present investigation entitled "Evaluation of bush dolichos bean [*Lablab purpureus* (L.) Sweet] for yield and quality" was conducted at the Department of Vegetable Science, College of Agriculture, Vellayani, from June 2019- December 2020 to evaluate the adaptability of bush dolichos bean in Kerala based on growth, yield and quality.

The experimental material consisted of 25 bush dolichos bean genotypes. The experiment was laid out in RBD with two replications. Analysis of variance revealed significant differences among the twenty five genotypes for all the characters studied. Among the genotypes, HA- 4 recorded the highest plant height of 65.75 cm. The variety HA-3 recorded the highest plant spread of 48.95 cm. The highest number of primary branches plant^{-1} was recorded by HA-4 (5.70), Arka Jay (5.65) and HA-3 (5.55) were on par with it. HA-4 recorded the highest leaf area of 13.35 cm^2.

Earliest flowering was observed in the genotype VRBSEM- 15 (22.95 days), while first flower appearance was late in HA- 4 (67.00 days). Fifty percent flowering was earliest in VRBSEM- 15 (25.95 days). The highest number of racemes plant^{-1} was recorded in HA-4 (6.46) and the longest raceme in the variety Arka Jay (34.35 cm). Arka Sambram was the earliest to harvest (61.30 days) followed by Arka Soumya (61.80 days), which were on par. The highest per centage of pod setting was recorded in HA-4 (14.85) followed by HA-3(14.50), which were on par. Co (Gb) 14 recorded the highest pod length (10.63 cm), pod girth (2.60 cm) and pod weight (6.75 g). Among the twenty five genotypes, nineteen genotypes exhibited light green pod colour, five dark green pod colour and one reddish green pod colour. The highest number of pods plant^{-1} was found in HA-4 (47.75). The seed colour of eleven genotypes was red, eight pale white, three white, two black and one light brown. The highest number of seeds pod^{-1} was in Co (Gb) 14 (4.35), which was on par with Arka Jay (4.25) and VRBSEM- 8 (4.25). Co (Gb) 14 recorded the highest weight of 100 seeds (35.45 g). The highest yield of 152.87 was recorded by Co (Gb) 14 which was on par with Arka Jay (148.82g) and HA-4 (148.52g). The highest yield plot^{-1} of 3.057 kg was recorded by Co (Gb) 14. Two genotypes, *viz*., Arka Jay (2.976 kg) and HA-4

(2.970 kg) were on par with it. Co (Gb) 14 recorded the highest crude protein and fibre content of 21.40 and 2.050 per cent respectively. The cooking quality of all the twenty five genotypes were found to be good. Incidence of leaf webber and anthracnose disease was noticed.

High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for the characters like days to first flowering, pod setting, pod length, pods plant^{-1}, yield plant^{-1}, yield plot^{-1} and fibre content. High estimates of heritability coupled with high genetic advance as per cent of mean were recorded for the yield components. Yield plant^{-1} had a significant positive correlation at genotypic and phenotypic level with raceme length, plant height, pod length, primary branches plant^{-1}, number of racemes plant^{-1}, plant spread, days to first flowering, pod girth and pod weight. Path coefficient analysis revealed that raceme length (0.9760) exerted the highest positive direct effect on yield plant^{-1} followed by number of racemes plant^{-1}, primary branches plant^{-1}, plant height, pod girth and pod weight.

The genotypes were ranked based on selection index score considering the characters *viz*., plant height, primary branches plant^{-1}, number of racemes plant^{-1}, raceme length, pod girth and pod weight. HA-4 recorded the highest selection index score of 136.72.

Based on the mean performance of the genotypes for various characters and selection index score, the top ranking genotypes HA-4, Co (Gb) 14 and HA-3 were found suitable for growing under Kerala conditions.

സംഗ്രഹം

"കുറ്റി അമരപ്പയറിൻറെ [ലാബ്ലാബ് പർപുരിയസ് (എൽ.) സ്വീറ്റ്] വിളവ് , ഗുണ നിലവാര പ്രകടനം" എന്ന വിഷയത്തെ സംബന്ധിച്ച ഒരു പഠനം വെള്ളായണി കാർഷിക കോളേജിലെ പച്ചക്കറി ശാസ്ത്ര വിഭാഗത്തിൽ 2019 ജൂലൈ മുതൽ 2020 ജനുവരി വരെയുള്ള കാലയളവിൽ നടത്തി. വിളവ്, ഗുണ നിലവാരം എന്നിവ അടിസ്ഥാനമാക്കി കേരളത്തിൽ കുറ്റി അമരപ്പയറിൻറെ പൊരുത്തപ്പെടൽ വിലയിരുത്തുക എന്നതായിരുന്നു ഈ പഠനത്തിൻറെ ഉദ്ദേശ്യം.

കുറ്റി അമരപ്പയറിൻറെ ഇരുപത്തിയഞ്ച് ജനിതക ഇനങ്ങളാണ് പഠനത്തിനായി ഉപയോഗിച്ചത്. 25 ട്രീട്മെന്റുകൾ 2 തവണ ആവർത്തിച്ചു കൊണ്ടുള്ള റാൻഡമൈസെഡ് ബ്ലോക്ക് ഡിസൈൻ എന്ന രീതിയിലാണ് പഠനം നടത്തിയത്. പഠനവിധേയമാക്കിയ എല്ലാ പ്രതീകങ്ങൾക്കും ഇനങ്ങൾ തമ്മിൽ വ്യത്യാസം കണ്ടെത്തി. ഇനങ്ങളിൽ എച്.എ- 4 ആണ് ഏറ്റവും കൂടുതൽ ഉയരമായ 65.75 സെ.മീ. രേഖപ്പെടുത്തിയത്. എച്.എ -3 ഇനമാണ് ഏറ്റവും കൂടുതൽ ചെടി വ്യാപനമായ 48.95 സെ.മീ. രേഖപ്പെടുത്തിയത്. ഒരു ചെടിയിൽ നിന്നുമുള്ള ചില്ലകളുടെ എണ്ണം ഏറ്റവും കൂടുതൽ രേഖപ്പെടുത്തിയത് എച്.എ- 4(5.70) ആണ്.

വി.ആർ.ബി.എസ്.ഇ.എം- 15 (22.95 ദിവസം) എന്ന ഇനത്തിലാണ് ആദ്യമായി പൂവിരിഞ്ഞത്, എന്നാൽ HA-4 (67.00 ദിവസം) എന്ന ഇനത്തിലാണ് ആണ് വൈകി പൂവിരിഞ്ഞത്. വി.ആർ.ബി.എസ്.ഇ.എം- 15 (25.95 ദിവസം) ൽ ആണ് ആദ്യമായി അമ്പത് ശതമാനം പൂവിരിഞ്ഞത്. ഒരു ചെടിയിൽ ഏറ്റവും കൂടുതൽ റസീംസ് എച്ച്.എ -4 (6.46) ലും ഏറ്റവും നീളമേറിയ റസീം അർക്ക ജയിലും (34.35 സെ.മീ) രേഖപ്പെടുത്തിയിട്ടുണ്ട്. വിളവെടുപ്പിന് ആദ്യത്തേത് അർക്ക സംബ്രമും (61.30 ദിവസം) തൊട്ടുപിന്നിലുള്ളത് അർക്ക സൗമ്യയും (61.80 ദിവസം) ആയിരുന്നു. ഏറ്റവും ഉയർന്ന പോഡ് സെറ്റിങ് ശതമാനം എച്ച്.എ- 4 (14.85) ൽ രേഖപ്പെടുത്തി. ഇതിന് സമാനമായിരുന്നു എച്ച്.എ -3 (14.50). കോ (ജിബി) 14 ഏറ്റവും ഉയർന്ന കായ് നീളവും (10.63 സെ.മീ) കായ് വീതിയും (2.60 സെ.മീ) കായ് ഭാരവും (6.75 ഗ്രാം) രേഖപ്പെടുത്തി. ഇരുപത്തിയഞ്ച് ഇനങ്ങളിൽ, പത്തൊൻപത്

ഇനങ്ങൾ ഇളം പച്ച കായ് നിറവും അഞ്ച് കടും പച്ച കായ് നിറവും ഒന്ന് ചുവപ്പ് കലർന്ന പച്ച കായ് നിറവും പ്രദർശിപ്പിച്ചു. ഒരു ചെടിയിലെ കായ്കളുടെ എണ്ണം ഏറ്റവും കൂടുതൽ കണ്ടെത്തിയത് എച്ച്.എ -4 (47.75) ൽ ആണ്. പതിനൊന്ന് വിത്തിനങ്ങൾ ചുവപ്പും എട്ട് വിത്തിനങ്ങൾ ഇളം വെള്ളയും മൂന്ന്

വിത്തിനങ്ങൾ വെള്ളയും രണ്ട് വിത്തിനങ്ങൾ കറുപ്പും ഒരു വിത്തിനം ഇളം തവിട്ട് നിറവുമായിരുന്നു. വിത്തുകളുടെ എണ്ണം ഏറ്റവും കൂടുതൽ കാണപ്പെട്ടത് കോ (ജിബി) 14 (4.35) ൽ ആണ്. ഇതിന് സമാനമായിരുന്നു അർക്ക ജയ് (4.25), വി.ആർ.ബി.എസ്.ഇ.എം -8 (4.25). 100 വിത്തുകളുടെ ഭാരം ഏറ്റവും കൂടുതൽ രേഖപ്പെടുത്തിയത് കോ (ജിബി) 14 (35.45 ഗ്രാം) ആണ്. കോ (ജിബി) 14 ൽ ആണ് ഏറ്റവും ഉയർന്ന ഒരു ചെടിയിലെ വിളവായ 152.87 ഗ്രാം കാണപ്പെട്ടത്. അർക്ക ജെയ് (148.82 ഗ്രാം), എച്ച്.എ -4 (148.52 ഗ്രാം) എന്നിവ ഇതിന് സമാനമാണ്. ഏറ്റവും ഉയർന്ന പ്ലോട്ടിലെ വിളവായ 3.057 കിലോ ഗ്രാം രേഖപ്പെടുത്തിയത് കോ (ജിബി) 14 ൽ ആണ്. അർക്ക ജയ് (2.976 കിലോഗ്രാം), എച്ച്.എ -4 (2.970 കിലോഗ്രാം) എന്നിവ ഇതിന് സമാനമാണ്. കോ (ജിബി) 14 ൽ യഥാക്രമം 21.40, 2.050 ശതമാനം ക്രൂഡ് പ്രോട്ടീൻ, ഫൈബർ എന്നിവയുടെ ഏറ്റവും ഉയർന്ന അളവ് രേഖപ്പെടുത്തി. ഇരുപത്തിയഞ്ച് ഇനങ്ങളുടെയും പാചക നിലവാരം മികച്ചതാണെന്ന് കണ്ടെത്തി. ഇലപ്പുഴു , ബാക്ക്ടീരിയൽ വാട്ട രോഗം എന്നിവ ശ്രദ്ധയിൽപ്പെട്ടു.

ആദ്യമായി പൂക്കുവാൻ എടുക്കുന്ന സമയം, കായ് സെറ്റിങ് ശതമാനം, കായ് നീളം, ഒരു ചെടിയിലെ കായ്കളുടെ എണ്ണം, ഒരു ചെടിയിലെ വിളവ്, ഒരു പ്ലോട്ടിലെ വിളവ്, ഫൈബർ തുടങ്ങിയ പ്രതീകങ്ങളിൽ ഉയർന്ന ഫിനോടൈപ്പിക്, ജീനോടിപ്പിക് കോഫിഷ്യന്റ്സ് ഓഫ് വേരിയേഷൻ നിരീക്ഷിച്ചു. ഉയർന്ന ഹെറിറ്റബിലിറ്റിയും ജനറ്റിക് അഡ്വാൻസും വിളവ് ഘടകങ്ങൾക്കായി രേഖപ്പെടുത്തിയിട്ടുണ്ട്. റസീം നീളം, ചെടികളുടെ ഉയരം, കായ് നീളം, ഒരു ചെടിയിൽ നിന്നുമുള്ള ചില്ലകളുടെ എണ്ണം, ഒരു ചെടിയിലെ റസീമുകളുടെ എണ്ണം, ചെടികളുടെ വ്യാപനം, ആദ്യമായി പൂക്കുവാൻ എടുക്കുന്ന സമയം, കായ് വീതി, കായ് ഭാരം എന്നിവ ഒരു ചെടിയിലെ വിളവുമായി പോസിറ്റീവ് കോറിലേഷൻ രേഖപ്പെടുത്തി. പാത്ത്

കോഫിഫിഷ്യന്റ് വിശകലനത്തിലൂടെ റസീം നീളം (0.9760) ഒരു ചെടിയിലെ വിളവുമായി കൂടുതൽ ബന്ധപ്പെട്ടിരിക്കുന്നതായി കണ്ടെത്തി. ഒരു ചെടിയിലെ റസീമുകളുടെ എണ്ണം, ഒരു ചെടിയിൽ നിന്നുമുള്ള ചില്ലകളുടെ എണ്ണം, ചെടികളുടെ ഉയരം, കായ് വീതി, കായ് ഭാരം എന്നീ പ്രതീകങ്ങളും ഒരു ചെടിയിലെ വിളവുമായി ബന്ധപ്പെട്ടിരിക്കുന്നു.

ചെടികളുടെ ഉയരം, ഒരു ചെടിയിൽ നിന്നുമുള്ള ചില്ലകളുടെ എണ്ണം, ഒരു ചെടിയിലെ റസീമുകളുടെ എണ്ണം, റസീം നീളം, കായ് വീതി, കായ് ഭാരം എന്നിവ കണക്കിലെടുത്ത് തിരഞ്ഞെടുക്കൽ സൂചിക മാർക്ക് അടിസ്ഥാനമാക്കി ഇനങ്ങൾ റാങ്ക് ചെയ്യപ്പെട്ടു. എച്ച്.എ -4 ഏറ്റവും ഉയർന്ന തിരഞ്ഞെടുക്കൽ സൂചിക മാർക്ക് 136.72 രേഖപ്പെടുത്തി.

ശരാശരി പ്രകടനത്തിന്റെയും തിരഞ്ഞെടുക്കൽ സൂചിക മാർക്കിന്റെയും അടിസ്ഥാനത്തിൽ മികച്ച ഇനങ്ങളായ എച്ച്.എ -4, കോ (ജിബി)- 14, എച്ച്. എ -3 എന്നിവ കേരളത്തിലെ കുറ്റി അമരപ്പയർ കൃഷിക്ക് അനുയോജ്യമാണെന്ന് കണ്ടെത്തി.