EVALUATION OF DOLICHOS BEAN (*Lablab purpureus* (L.) Sweet.) ACCESSIONS (POLE TYPE) FOR YIELD AND QUALITY

By

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(2018-12-002)

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2020

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THESIS

Submitted in partial fulfilment of the
requirement for the degree of

MASTER OF SCIENCE IN HORTICULTURE

(VEGETABLE SCIENCE)

Faculty of Agriculture

Kerala Agricultural University, Thrissur

DEPARTMENT OF VEGETABLE SCIENCE
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA

2020

DECLARATION

I hereby declare that this thesis entitled **"Evaluation of Dolichos bean (*Lablab purpureus* (L.) Sweet.) accessions (pole type) for yield and quality"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other university or society.

Vellanikkara

Date: 22-10-2020

NIDHIN RAJ

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CERTIFICATE

Certified that this thesis entitled **"Evaluation of Dolichos bean (*Lablab purpureus* (L.) Sweet.) accessions (pole type) for yield and quality"** is a bonafide record of research work done independently by **Mr. Nidhin Raj (2018-12-002)** 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 him.

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CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Nidhin Raj (2018-12-002)**, a candidate for the degree of **Master of Science in Horticulture** with major field in Vegetable Science, agree that this thesis entitled **"Evaluation of Dolichos bean (*Lablab purpureus* (L.) Sweet.) accessions (pole type) for yield and quality"** may be submitted by **Mr. Nidhin Raj** in partial fulfillment of the requirement for the degree.

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ACKNOWLEDGEMENT

This thesis is the end of my journey in gaining my degree on M.Sc. (Hort.) Vegetable Science, fulfilling my passion towards the subject. It is a pleasant task to express my thanks to all those who made contribution in this memoir of hard work and effort.

First and foremost, I bow my head before the **Almighty God** *for showering his boundless grace on me which enabled me to successfully complete the thesis work in time.*

I would primarily like to express sincere gratitude whole-heartedly to my esteemed guide ***Dr. P. Anitha,*** *Associate Professor, AICVIP, Department of Vegetable Science, for her unrelenting and inspiring guidance, untiring help, patience, encouragement, constructive criticism, precious suggestions and gracious approach throughout the course of study and the period of the investigation and preparation of the thesis. I consider myself being fortunate in having the privilege of being guided by her.*

I extend my sincere thanks to ***Dr. T. Pradeepkumar,*** *Professor and Head, Department of Vegetable Science for his meticulous care and scientific advice. His guidance helped me throughout the course of study.*

It is with my heartfelt feelings, I wish to express my deep sagacity of gratitude and sincere thanks to ***Dr. Dicto Jose*** *for his constructive criticism, care, love and concern towards me during the past two years.*

I sincerely thank ***Dr. Beena V.I.*** *Assistant Professor and Head, RTL, Department of Soil Science and Agricultural Chemistry, College of Horticulture for her expert advice and constant inspiration during the course of study.*

It is with my heartfelt feelings, I wish to express my deep sagacity of gratitude and sincere thanks to ***Dr. P. Indira, Dr. Reshmi, Dr. Ashwini A., Dr. Sangeethakutty M., Dr. C. Laly John, Dr. Aneena, Dr. Ajithkumar*** *and* ***Dr. Jayasree Shankar*** *for their encouragement, valuable help and advice rendered during the course of study.*

I owe a great deal of appreciation and gratitude to **Joy sir, Geethu chechi, Lohithakshan chettan, Shanta chechi and Shobana chechi** *in providing their efforts during my on field and off field studies.*

With pleasure I express my heartfelt gratitude to my classmates and dear friends **Alphy, Nibin, Pavithrakumar, Shinu, Vinu, Sachin, Anju, Abhaya, Akhil K. P, Reshma, Pooja, Riya Mary, Meera, Riya K, Sarin, Jyothish, Abinsha,** *whose constant support and encouragement could never be forgotten.*

I would like to express my sincere thanks to my loving and caring seniors and juniors **Shilpa chechi, Archana chechi, Anju chechi, Athulya chechi, Divya checi, Remzeenitha, Anita chechi, Minnu chechi, Sadanand bhayya, Anulatha, Arya S** *and* **Arya K. S.** *of Department of Vegetable Science.*

I duly acknowledge the encouragement and timely persuasions and precious suggestions by my seniors **Sharathettan, Sameerikka, Anjalichechi, Anirudhettan, Sajayettan , Alanettan** *and* **Athirachechi**.

I would like to express my great pleasure to extend indebtedness to **Dr. Sharon C. L.**, *P.G. academic officer, College of Horticulture for her whole-hearted co-operation and gracious help rendered during the last two years.*

I express my sincere gratitude to the entire staff of the Library and Students Computer club of College of Horticulture. I acknowledge the whole-hearted co-operation and gracious help rendered by each and every member of the **College of Horticulture** *during the period of study.*

*Finally, yet importantly, I extend my heartiest and sincere sense of gratitude to my beloved father Mr.***Raju P. R.**, *mother Mrs.***Geetha**, *brother* **Naveen** *for their prayers and mental support for the tough days. For the whole journey, my head bows to Kerala Agricultural University for letting my dreams come true...*

NIDHIN RAJ

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Introduction

1. INTRODUCTION

Legume vegetable crops are the world's primary source of dietary protein and are very important for people in the developing countries (Wang *et al.*, 2003). They contain diverse micronutrients and amino acids which are useful and necessary for the human body for its growth and development, thus serving the functions of enhancing positive health and removing hidden hunger caused by micronutrient malnutrition.

Legumes are the members of Fabaceae family which are characterized by their dehiscent pod structure, flower morphology and capacity for symbiotic nitrogen fixation. Most of the members of this family are annuals and are cultivated for their fresh pods. Only some legumes like garden pea and French bean are popular and extensively cultivated while others remain under exploited. The uniqueness of legumes lies in their irreplaceable role in nutrition of humans and animals, fixing nitrogen in the soil, adaptation to conditions of stress and providing agricultural production systems with sustainability. Thus, there exists very good potential for their widespread cultivation for expanding the food basket and commercialization.

Dolichos bean (*Lablab purpureus* (L.) Sweet), 2n=20, 22, 24, belonging to family Fabaceae is a native of India and it is cultivated in both subtropical and tropical conditions (Rai and Yadav, 2005). Pole as well as bush type plants are present in dolichos. The pole types are photosensitive whereas, the bushy are photo-insensitive. There is not much difference between the pods of both types of plant. The tender as well as shelled pods are used as vegetable and the dried seeds as pulse. Leaves are cooked and consumed. Their foliage provides fodder and manure.

Dolichos bean is commonly referred to as lablab bean, Indian bean, Hyacinth bean, Egyptian Kidney bean, *Sem* (Hindi), *Avarai* (Tamil), *Capparadavare* (Kannada) and *Amarappayar* (Malayalam). It is one of the oldest legume crops known to man. In India, it is popular in Karnataka, Tamil Nadu, Eastern and North-eastern states where it is used as vegetable, pulse and fodder (Raghu *et al.*, 2018). It prefers comparatively cool season and majority of the traditional cultivars are photosensitive to short day conditions for flowering. It can withstand drought better than other legumes like common bean and cowpea.

Despite its multi-utility and multiple benefits, its cultivation is done in limited area only. The efforts for genetic enhancement of this crop also has been limited. The major constraints limiting dolichos bean production are extreme viny growth habit, photosensitive nature, lack of diverse genetic material, low flowering and pod setting abilities, susceptibility to pests and diseases and lack of tolerance to excess moisture level. Being a self-pollinated crop, the variability observed is less. This is a constraint in genetic improvement.

In India, more than 90 per cent of cultivation is in Karnataka. Dolichos bean can easily fit into existing cropping systems of other parts of the country too. In Kerala, it is cultivated mainly in the districts of Thrissur and Palakkad. Thus, there is immense scope to expand the cultivation to non-conventional regions of the state which will assure nutritional and income security for farmers. In a developing country like India which is primarily agriculture based, increasing crop diversity and productivity are the keystones for overall development of the economy.

Breeding methodology for crop improvement involves two stages (1) genetic cataloguing the available germplasm and (2) studying the variability for yield and yield contributing characters and identifying the suitable lines for further breeding programme. For identification of superior genotypes, knowledge about the magnitude and nature of variation in the available material is necessary. Also their biochemical characters *viz.*, calcium, iron, protein, fibre and presence of antinutritional factors need to be determined. Hence, the present study was carried out with the following objectives:

1. To find out the genetic variability, genetic divergence and character associations among dolichos bean accessions for yield and yield contributing traits.

2. To evaluate dolichos bean accessions for quality traits.

Review of Literature

2. REVIEW OF LITERATURE

Dolichos bean is a popular leguminous vegetable having high nutritive value cultivated for human consumption. The young pods are consumed as fresh vegetables and mature dry seeds (18–36 per cent protein) are important in the diet of the vegetarian population in India. Though many workers have reported variability and correlation studies in dolichos bean, crop improvement works in the crop is rather scanty. Available literature related to genetic variability, correlations, path coefficients and genetic divergence is being reviewed under the following headings in this chapter.

1.1. Genetic variability studies

1.2. Correlations

1.3. Path coefficient analysis

1.4. Genetic divergence studies

2.1. Genetic variability studies

Biju (2000) studied 44 accessions of hyacinth bean and reported that GCV was high for the characters like pod weight, number of pods per plant, pod thickness, length of the pod and pod yield per plot.

Chetia *et al.* (2000) analyzed seeds of five cultivars of hyacinth bean for nutritional factors. Considerable variation was shown by the cultivars in their composition. The per cent of crude protein ranged from 22.06 to 28.34, crude fibre from 6.02 to 10.63, crude fat from 1.62 to 2.22 and total carbohydrates from 57.51 to 64.70.

High heritability accompanied with high genetic advance in vegetable cowpea was observed for number of pods per plant, pod weight, pod length and yield of vegetable pods per plant (Vidya *et al.,* 2002).

Kumari *et al.* (2003) reported based on evaluation of fifty genotypes of cowpea for variability and heritability that the character plant height showed maximum range of variation.

Pan *et al.* (2004) reported high extend of genetic variability for the characters such as pod yield, breadth of the pod and weight of the pod and these characters recorded high heritability and high genetic advance in dolichos bean which indicated their possibility for improvement through selection.

Considerable genetic variability was observed for yield and its contributing traits in a study conducted by Resmi *et al.* (2004) in thirty genotypes of cowpea. High phenotypic coefficient of variance and genotypic coefficient of variance were recorded for green pod yield, number of pods per kg, number of inflorescence per plant and pod weight.

In an exploration done by Mohan and Aghora (2006) in central Tamil Nadu, 97 pole hyacinth bean types were collected and evaluated. Maximum pod width was recorded in IIHR 049 and pod length in IIHR 0486. Highest average pod weight was recorded in IIHR 013 (18 g).

Gnanesh *et al.* (2006) studied the genetic parameters of field bean and reported the existence of high significant differences among the 64 genotypes studied and indicated considerable inter-varietal variability in dolichos bean. The estimates of variability revealed a higher phenotypic coefficient of variation than genotypic coefficient of variation for the characters.

Maximum variability was observed for the character seed yield per plant followed by pods per plant, plant height, branches per plant and 100-seed weight in field pea. High heritability coupled with high genetic advance was observed for the characters seed yield per plant, pods per plant and plant height. (Singh and Singh, 2006).

Sreekanth (2007) evaluated 25 genotypes of dolichos bean for 20 characters and reported that all the characters showed significant differences among the accessions. High GCV and PCV were obtained for number of pods per plant followed by yield per plot and high heritability coupled with genetic gain was noted for all qualitative, morphological and reproductive characters under study.

Mohan *et al.* (2009) evaluated 57 dolichos bean genotypes (pole type) and reported wide variability for pod colour, pod length, ten pod weight, number of pods per plant and pod maturity.

In a study conducted by Upadhyay and Mehta (2010), high heritability estimates were recorded for pod weight, pod width, hundred seed weight and number of pods per inflorescence. The highest genotypic coefficient of variation was recorded for pod width and lowest in number of seeds per pod.

Singh *et al.* (2011) evaluated seventy three hyacinth bean genotypes and observed that high heritability was noted for first flowering, first picking, length of pod and yield per plant.

Mahalingam *et al*. (2013) reported significant difference among genotypic coefficient of variation and phenotypic coefficient of variation in dolichos bean genotypes for all the characters. High genotypic coefficient of variation and heritability estimates were associated with greater genetic advance for the traits such as percentage of pod set, number of pods per plant, number pods per cluster, green pod length, green pod width, green pod weight, pod yield, crude protein and crude fibre which indicated that these characters possessed additive gene effect. Hence selection is effective for improvement of the crop.

Parmar *et al.* (2013) evaluated 30 genotypes of dolichos bean for eleven characters and observed that the genotypes showed considerable amount of variability for all the characters studied. High heritability and genetic advance was observed for the characters such as days to 50 per cent flowering, pod length, pod width and ten green pod weight which suggested the presence of additive gene action in these characters.

Pawar and Prajapathi. (2013) evaluated 58 genotypes of dolichos bean for twelve characters and the analysis of variance revealed significant differences for all the characters under study. High heritability was observed for the characters days to 50 per cent flowering, protein content, days to maturity, plant height, number of inflorescence per plant, pod length and plant height. High heritability and high genetic advance was shown by plant height and pod length.

Verma *et al.* (2014) observed more variability, heritability and genetic advance for the characters *viz.,* plant height, number of secondary branches, mean pod weight, number of pods per inflorescence, number of inflorescence per plant, number of pods per plant, 100 seed weight and pod yield per hectare in dolichos bean.

Chandran *et al.* (2015) reported high phenotypic coefficient of variation, genotypic coefficient of variation and high heritability for all important traits except days to 50 per cent flowering and number of seeds per pod in 90 genotypes of dolichos bean.

Inamdar *et al.* (2015) evaluated 37 genotypes of pole dolichos bean and observed that green pod yield per plant, pod yield per plot, pod yield per hectare, average weight of 10 pods and number of pods per vine have high genotypic coefficient of variation and these characters also showed high heritability, genetic advance and genetic advance as percentage of mean.

Vir *et al.* (2015) observed wide variability for characters plant height, pod yield per plant, number of pods per plant, number of clusters, pod yield and number of pods per cluster in cluster bean. High heritability and genetic advance was reported for number of pods per cluster and number of clusters per plant.

Ravinaik *et al.* (2015) assessed nine dolichos bean genotypes for performance and reported significant difference among all the characters studied. At all the growth stages, the plant height differed significantly with each other. PD-31 showed maximum height in all the growth stages. Pod yield per plant showed significant difference between the genotypes. The maximum number of pods per cluster was observed in PD-31 (20.27) and pod yield in PD-31 (3.27 kg).

The analysis of variance studies in 38 dolichos bean genotypes showed significant differences between them suggesting that all characters tested had ample variability (Dewangan *et al*., 2017).

Kujur *et al.* (2017) conducted an experiment to study the genetic variability, heritability and genetic advance for 17 traits in thirty genotypes of dolichos bean. Wide variability, high heritability and high genetic advance was observed for the characters no. of pods per inflorescence, pod width, 100 seed weight, pod weight, pod length, days to first harvest, vine length, pod yield, days to first flowering, seeds per pod, number of harvests and days to last harvest.

Sadak peer *et al.* (2018) evaluated 29 genotypes of field bean to study the genetic variability for yield and 18 yield contributing attributes. The range, genotypic and phenotypic coefficient of variation, heritability, genetic advance and correlation were calculated and wide range of variability was reported for pod yield per plant, seed yield per plant, days to 50 per cent flowering and days to first pod set.

Sahu and Bahadur (2018) conducted an experiment to study the genetic variability, heritability and genetic advance for 18 traits in 40 dolichos bean genotypes. The highest genotypic coefficient of variation and phenotypic coefficient of variation was recorded for pod weight (33.99, 34.36). The highest heritability was recorded for the characters 100 seed weight, days to first flowering, green pod yield per plot and days to 100 per cent flowering.

Afsan and Roy (2019) evaluated eleven genotypes of Indian bean for four years in a row to study the variability among four characters *viz.,* number of flowers per plant, number of pods per plant, number of seeds per pod and pod weight (g). Genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean was estimated and the range of variation was highly notable in all the studied characters.

Mahesh *et al.* (2019) evaluated 25 dolichos bean genotypes for 16 characters and reported that significant differences were observed for all the characters studied. The highest pod yield per plant was obtained for Arka Jay followed by COGB-14.

Gamit *et al.* (2020) assessed genetic variability of 36 genotypes of dolichos bean and the analysis of variance revealed that the mean sum of squares due to genotypes were highly significant for all the twelve characters studied. High phenotypic and genotypic coefficients of variations and high heritability and genetic advance were observed for number of primary branches, the number of pods per plant, pod length, 10-green pod weight, green pod yield per plant and length of twig.

2.2. Correlations

Biju (2000) reported that significant and positive correlation was observed for green pod yield with number of seeds per plant and fruit setting percentage both phenotypically and genotypically in dolichos bean.

Rai *et al.* (2003) observed that number of pods per plant and 100 pod weight had positive and strong correlation with yield in dolichos bean both phenotypically and genotypically.

Correlation studies by Bagade *et al.* (2004) revealed that the seed yield per plant was positively and significantly correlated with pods per plant and negatively associated with plant height in dolichos bean.

Narayankutty *et al.* (2005) evaluated 63 accessions of cowpea and reported highest positive correlation for the character number of pods/plant with plant yield.

Correlation studies in 114 genotypes of dolichos bean revealed that days to 50 per cent flowering, number of green pods per plant, test weight and percentage of shelling had significant positive association with yield of pod and yield of seed (Savitha, 2008).

Mishra *et al.* (2009) observed positive, significant correlation of characters such as branches per plant, inflorescence per plant, green pods per plant, green pod length, green pod weight, pod girth and protein content of green pod with green pod yield in yard long bean.

Chattopadhyay and Dutta (2010) evaluated twelve genotypes of dolichos bean and observed significant positive correlation of pod yield with days to 50 per cent flowering and number of seeds per pod. Non-significant positive correlation was observed between yield and number of pods per plant, pod weight and 100 dry seed weight.

Goud (2010) observed that there is a significant, positive correlation among number of pods per cluster, days to flower initiation, vegetable pod yield, number of pods per plant and seed yield in cluster bean.

Islam *et al.* (2011) conducted a study on forty four accessions of hyacinth bean and reported that green pod yield had highly significant and positive association with number of pods per plant, individual pod weight and harvest duration.

Pathak *et al.* (2011) reported significant, positive correlation of seed yield per plant with number of pods per plant, number of seeds per pod, number of secondary branches, plant height and number of primary branches.

A study on forty eight genotypes of dolichos bean revealed that pod yield per plant had significant positive association with no. of pods per plant, days to last harvest, no. of inflorescence, pod length, pod width, pod weight, 100 seed weight, no. of seeds per pod and protein content. (Chaitanya *et al*., 2014)

Verma *et al.* (2014) evaluated 34 genotypes of pole type french bean and observed that all the characters except vitamin C, pod width and days to 50 per cent flowering were positively correlated with pod yield per plant.

Chandran *et al.* (2015) evaluated 90 genotypes of dolichos bean and reported that the green pod yield was positively and significantly correlated with branches per plant, green pods per plant, green pods per branch, green pod length, green pod weight and seeds per pod.

Chatale (2015) reported positive significant correlation for yield per plot with number of primary branches, 50 pod weight and number of pods per cluster whereas, negative significant correlation was observed with days to 50per cent flowering, days to first harvest and duration of the crop in cluster bean.

Devi *et al.* (2015) reported positive, significant correlation of pod yield with days to flowering, average pod weight, branches per plant, pods per plant and plant height in the French bean.

Hemavathy *et al.* (2015) reported a positive correlation with seed yield in mung bean for the characters number of clusters per plant, number of pods per plant, 100 seed weight and number of seeds per pod.

According to Choudhary *et al.* (2016), traits like pod yield per hectare, seed yield, plant height, days to first flowering, days to first picking, days to last picking, ten pod weight, number of green pods per plant, pod length, pericarp thickness, moisture percentage and seed yield per plant showed positive correlation both genotypically and phenotypically with yield infield bean.

Gupta *et al.* (2017) conducted an experiment in thirty eight genotypes of dolichos bean and revealed that green pod yield per plant was significantly positively correlated with pod length, pod width, pod weight, seeds per pod, vine length, 100 seed weight, protein content, pod per inflorescence, while non-significant and positively correlated with carotenoids, moisture content, number of flower per inflorescence and total chlorophyll.

Kanwar *et al.* (2017) evaluated 28 genotypes of french bean and noticed that the seed yield per plant is positively and significantly correlated with all important traits except pod width at both phenotypic and genotypic level

Dewangan *et al*. (2018) studied 38 genotypes of dolichos bean and observed that pod yield per plant was positively and significantly correlated with hundred seed weight, length of the pod, width of the pod, pods per inflorescence, number of seeds per pod, weight of the pod, length of vines, number of green pod pickings and days to last pod harvest. The correlations were observed at genotypic as well as phenotypic level which revealed that direct selection for these traits is rewarding for developing superior genotypes.

2.3. Path coefficient analysis

Path coefficient analysis by Tikka *et al.* (2003) revealed that positive direct effects and positive significant associations were observed for the traits *viz.,* number of pods per plant, pod length, number of branches per plant, plant height and harvest index in dolichos bean.

Nath and Korla (2004), based on path coefficient studies in twenty eight dwarf French bean genotypes, reported that number of pods per plant, pod length and harvest index had significant positive association with pod yield.

Path coefficient studies by Sreekanth (2007) revealed that number of pods per plant had the highest direct positive effect on yield followed by pod weight. Days to 50 per cent flowering showed the highest negative direct effect on yield followed by number of primary branches.

Based on path coefficient analysis of 42 genotypes of cluster bean Buttar *et al.* (2008) reported that number of seeds per pod and number of pods per plant had the highest direct effect on seed yield.

According to Singh *et al.* (2011) number of pods per plant, pod length, pod width and seed width have a direct positive effect on yield whereas days to first flowering have a direct negative effect in hyacinth bean.

Based on path analysis studies in 48 genotypes of dolichos bean, Chaitanya *et al.* (2014) reported that number of pods per plant exhibited high positive direct effect on yield followed by pod weight and days to 50 per cent flowering.

Ninety genotypes of dolichos bean were evaluated and maximum direct effect on yield was observed for the traits green pod weight, green pods per branch, green pods per plant and branches per plant (Chandran *et al.,* 2015).

Devi *et al*. (2015) found that the number of branches per plant, pods per plant and average pod weight had maximum direct effect on pod yield in french bean.

Jain *et al.* (2015) reported that in soybean the seed yield is directly and indirectly influenced by number of pods per plant, biological yield and 100 seed weight.

Hemavathy *et al*. (2015) reported that the yield components such as pods per plant, number of pods per cluster, number of clusters per plant and 100 seed weight is having highest direct effect on yield in urd bean.

Number of pods per plant, days to flowering, pod weight and pod length had maximum direct positive effect on yield in peas (Gautam *et al.* 2017).

Pod length, number of seeds per pod, number of pods per plant, days to 50 per cent flowering, number of branches per plant and plant height showed highest positive direct effect on seed yield per plant in French bean (Kunwar *et al.* 2017).

Panchabhaiya *et al.* (2017) reported highest direct positive effect on yield was imparted by number of pods per plant and pod weight in French bean.

Patil *et al.* (2017) conducted path analysis studies in thirty seven pole type dolichos bean genotypes and reported that number of pods per inflorescence, number of pods per vine, days to 50 per cent flowering and weight of ten pods had a positive direct effect on yield and could therefore be useful for crop yield improvement programmes.

Yahaya and Ankrumah (2017) in soybean reported that number of pods per plant have highest positive direct effect on grain yield. Maximum combined contribution to grain yield is from number of pods per plant and number of seeds per pod.

Jyothireddy *et al*. (2018) reported based on path analysis on 35 genotypes of dolichos bean that positive direct effect on pod yield per plant was exhibited through pod weight followed by protein content and primary branches per plant.

Noorjahan *et al.* (2019) based on an experiment in thirty one genotypes of dolichos bean observed that green pod yield per plant had significant and positive direct effect with 50 per cent flowering, inflorescence length, number of grains per pod and pod yield per hectare.

2.4. Genetic divergence

Biju (2000), based on genetic divergence studies in forty four genotypes of hyacinth bean using D^2 technique reported that maximum statistical distance was found between cluster V and VII. The distance between cluster III and IX was the least which meant the lowest degree of divergence.

Nandi *et al.* (2000) grouped 28 genotypes of hyacinth bean into five clusters based on genetic diversity studies using Mahalanobis D^2 statistics. Cluster V recorded the highest mean pod length, pod weight, seeds per pod and green pod yield per plant.

Chaubey *et al.* (2003) conducted genetic diversity studies using Mahalanobis D^2 statistics in 30 genotypes of dolichos bean based on which the genotypes were grouped into six clusters. He reported cluster III as the best having high seed yield, 100 seed weight, plant height and harvest index.

Rai *et al.* (2003) studied genetic divergence and path analysis in 45 diverse types of hyacinth bean using D^2 technique and reported that the maximum genetic divergence was observed between cluster I and cluster V followed by cluster IV, I and III.

Sreekanth (2007) grouped 25 genotypes of dolichos bean into five clusters based on Mahalanobis D^2 analysis and observed that intra cluster distances were much lesser than inter cluster distances which meant that homogeneity existed within and heterogeneity existed between the clusters. It is possible to exploit heterosis by crossing the genotypes present in clusters showing high inter cluster distances.

Singh *et al.* (2011) evaluated seventy nine genotypes of hyacinth bean for genetic divergence. Based on this the genotypes were classified into 7 clusters. Cluster I had the maximum number of genotypes. Inter cluster distance was maximum between III and VII. Mean pod yield was maximum in cluster VII.

Upadhyay *et al.* (2011) conducted genetic divergence studies in 32 genotypes of dolichos bean using Mahalanobis D^2 analysis and grouped them into five clusters. The highest inter-cluster distance was observed for cluster III followed by cluster V. The genotypes collected from same geographical location occupied different clusters which revealed that geographical distance does not contribute to genetic divergence.

Verma *et al.* (2014) grouped 34 genotypes of pole type French bean into 5 clusters and observed that the maximum diversity was contributed by the traits Vitamin C, dry matter content and number of pods per plant.

Vaijayanthi *et al.* (2015) conducted an investigation to study the variability for 20 quantitative and 3 qualitative traits among 644 accessions of hyacinth bean. The accessions were grouped into six clusters and the means and variances of the quantitative traits differed significantly among the clusters.

Rupesh *et al.* (2016) grouped cowpea genotypes into five clusters using Mahalanobis D^2 technique and reported that very little genetic divergence existed between the genotypes based on the D^2 values obtained.

Jyothireddy *et al*. (2018) evaluated 35 genotypes of dolichos bean for genetic divergence, variability, heritability and genetic advance. The genotypes were grouped into six clusters based on the D^2 values. The maximum number of genotypes (15) occurred in cluster II. Maximum inter cluster distance was observed between cluster III and cluster VI (D^2=1780.19) and minimum inter cluster distance was between cluster II and cluster IV (D^2 =333.46). High heritability estimates were observed for 15 characters and moderate heritability was observed for primary branches per plant, number of seeds per pod, seed breadth and 100 dry seed weight.

Available literature on sensory evaluation of dolichos bean is scanty

Materials and Methods

1. MATERIALS AND METHODS

The present study entitled "Evaluation of Dolichos bean (*Lablab purpureus* (L.) Sweet) accessions (pole type) for yield and quality" was conducted in the field of the Department of Vegetable Science, College of Horticulture, Kerala Agricultural University, Vellanikkara. The experimental site was located at an altitude of 22.5 m above M.S.L, with a latitude of 70º 32´ N and 76º 16´ E longitude. The site had a warm humid climate and the soil type is laterite.

3.1. Experimental materials

The experimental material for the present study consisted of 30 accessions of dolichos bean. Accessions were catalogued as per the NBPGR Minimal Descriptor for Characterization and Evaluation of Agri-Horticultural crops (2000) as shown in Table.2.

Table.1. Source of dolichos bean accessions

Sl. No.	Genotype	Source
1	LP-1	NBPGR RS, Rajendranagar, Telangana
2	LP-2	NBPGR RS, Rajendranagar, Telangana
3	LP-3	NBPGR RS, Rajendranagar, Telangana
4	LP-4	NBPGR RS, Rajendranagar, Telangana
5	LP-5	NBPGR RS, Rajendranagar, Telangana
6	LP-6	NBPGR RS, Rajendranagar, Telangana
7	LP-7	NBPGR RS, Rajendranagar, Telangana
8	LP-8	NBPGR RS, Rajendranagar, Telangana
9	LP-9	NBPGR RS, Rajendranagar, Telangana
10	LP-10	NBPGR RS, Rajendranagar, Telangana
11	LP-11	NBPGR RS, Rajendranagar, Telangana
12	LP-12	NBPGR RS, Rajendranagar, Telangana
13	LP-13	NBPGR RS, Rajendranagar, Telangana
14	LP-14	NBPGR RS, Rajendranagar, Telangana
15	LP-15	NBPGR RS, Rajendranagar, Telangana
16	LP-16	NBPGR RS, Rajendranagar, Telangana
17	LP-17	NBPGR RS, Rajendranagar, Telangana
18	LP-19	NBPGR RS, Rajendranagar, Telangana
19	LP-21	NBPGR RS, Rajendranagar, Telangana
20	LP-22	NBPGR RS, Rajendranagar, Telangana
21	LP-24	NBPGR RS, Rajendranagar, Telangana

22	LP-27	NBPGR RS, Rajendranagar, Telangana
23	LP-28	NBPGR RS, Rajendranagar, Telangana
24	LP-29	NBPGR RS, Rajendranagar, Telangana
25	LP-30	NBPGR RS, Rajendranagar, Telangana
26	LP-31	IIVR, Varanasi
27	LP-32	IIVR, Varanasi
28	LP-33	Attappady, Palakkad
29	LP-34	KAU, Vellanikkara
30	LP-35	KAU, Vellanikkara

Table.2. Cataloguing of dolichos bean accessions

1. Floral characters		
1.1	Flower colour	White/ purple
2. Pod characters		
2.1	Pod colour	Light green/ green/purple
2.2	Pod shape	Straight/curved/intermediate

3.2. Experimental methods

The experiment was laid out using 30 accessions of dolichos bean in Randomized Block Design (RBD) in two replications with a spacing of 2.7 m x1.0 m during September 2019-April 2020. Each replication consisted of two plants. All crop management measures were followed as per "Package of Practices Recommendations-Crops (2016)" of Kerala Agricultural University (KAU).

3.3. Collection of experimental data:

Two plants were selected from each replication of all the treatments for recording biometric characters. The observations were recorded on vegetative, floral, pod set and seed characters and the average values were calculated for further analysis.

3.3.1. Morphological characters

3.3.1.1. Number of primary branches

The primary branches present in the plants were counted at pod bearing stage and expressed as number.

3.3.1.2. Days to first flowering

Number of days taken from sowing to first flowering in each accession of two replications were counted and recorded as number of days.

3.3.1.3. Flower colour

The colour of the flowers were recorded at full blossom stage in the morning hours and expressed as white/purple.

3.3.1.4. Days to first fruit set

Number of days from sowing to first fruit set in each accession was recorded.

3.3.1.5. Days to first harvest

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

3.3.1.6. Number of pods/cluster

Number of pods in ten inflorescence of the plants were counted and the average value was taken.

3.3.1.7. Green pod yield/ plant

Pod yield of plants in two replications of each accession was recorded after every harvest and expressed as gram per plant.

3.3.1.8. Number of seeds/pod

Number of seeds/pod in ten random pods of plants of two replication was recorded at full maturity stage and the average was taken.

3.3.1.9. Pod colour

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

3.3.1.10. Pod shape

Shape of pods from each plants of two replication was recorded.

3.3.1.11. Pod length (cm)

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

3.3.1.12. Pod girth (cm)

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

3.3.1.13. Pod weight (g)

Weight of ten randomly selected pods were measured and expressed as gram (g) at full maturity stage and average was taken.

3.3.1.14. Number of pods per plant

Number of pods from two plants of each replication during each harvest was recorded and the average was taken.

3.3.1.15. Number of harvests

The total number of harvests recorded at vegetable maturity in each accession was recorded.

3.3.1.16. Duration of the crop

Days taken from germination to the last harvest in each plant of each replication was recorded.

3.3.2. Qualitative characters

Biochemical analysis for estimation of calcium, iron, total phenols, crude protein, crude fibre and phytic acid were done as detailed by Sadasivam and Manickam (1992).

3.3.2.1. Calcium and Iron (mg/100g)

The dolichos bean pods were dried at 60º C in a hot air oven for 7- 9 days. The dried pods were powdered using a grinder. This powdered sample (0.2g) was used for digestion. The sample was digested in microwave digester by adding concentrated nitric acid. It was then estimated by ICP-OES. (Piper, 1996).

3.3.2.2. Total phenols (mg/100g)

Total phenols was estimated by the method suggested by Sadasivam and Manickam (1992).

Stock standard: 100 mg of catechol dissolved in 100 ml of water

Working standard: 10 ml of stock solution diluted to 100 ml

Working standards of 0.2, 0.4, 0.6 0.8, 1.0 ml and sample extract 0.2 ml were pipetted out into a series of test tubes and in each test tube the volume was made up to 3.0 ml with distilled water. 0.5 ml of Folin–Ciocalteau reagent was added to each test tube followed by 2.0ml of 20% sodium carbonate. The test tubes were then placed in boiling water bath for one minute. Test tubes were cooled and absorbance was read at 650nm. A standard graph was drawn by plotting concentration of the standards on X- axis and absorbance on Y- axis. The amount of phenol present in the sample was calculated.

3.3.2.3. Crude protein (%)

Total nitrogen in the sample was estimated by micro-kjeldahl method as per Sadasivam and Manickam (1992) and expressed in percentage.

The sample was digested by adding potassium sulphate (K_2SO_4) and conc. Sulphuric acid. Cooled the digested contents and added water along the sides of the flask in order to dissolve the solids. It is then transferred to a distillation apparatus. A conical flask containing 5 ml of boric acid solution along with a few drops of mixed indicator is placed with the tip of the condenser dipped inside this solution.

10ml sodium hydroxide-sodium thiosulphate solution is added in the apparatus through the funnel to digest it and it is rinsed with water. Distilled and collected the ammonia absorbed (minimum 15-20 ml distillate).

The tip of the condenser is rinsed with water and the distilled sample is titrated against standard H_2SO_4 (0.02N) till violet colour appears at the end point. Run a blank which is digested similarly with an equal quantity of water after washing the distillation apparatus with excess water by back suction.

The nitrogen content of the sample can be measured according to the formula:

$$\text{Nitrogen (\%)} = \frac{\text{Titre value x normality of acid x 0.014 x 100}}{\text{Weight of the sample}}$$

Crude protein content was calculated by multiplying the total nitrogen content of the sample by 6.25.

3.3.2.4. Crude fibre (%)

Crude fibre content was found out by acid-alkali digestion process as given by Sadasivam and Manickam (1992).

Two gram of dolichos bean pod was dried, defatted and boiled in 200 ml of 1.25 per cent sulphuric acid for 30min. This was filtered using a muslin cloth and then washed in boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide solution for 30 min and filtered using 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 130ºC 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 600ºC for 30 minutes, cooled using a desiccator and reweighed (W_3).

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

3.3.2.5. Phytic acid (mg/100g)

Phytic acid is the stored form of phosphorus in seeds and it is considered as an anti-nutritional factor. The extraction of phytate is done with trichloroacetic acid and then precipitated as ferric salt. Determination of iron is done by colorimetry and the content of phytate was calculated from this value (Sadasivam and Manickam, 1992).

$$\text{Phytate P (mg/100g)} = \frac{\mu\text{g Fe x 15}}{\text{Weight of sample (g)}}$$

3.4. Disease and pest incidence (%)

Pest and disease incidence on the plants during the entire growth period was recorded. It was expressed as percentage.

$$\text{Pest/Disease incidence (\%)} = \frac{\text{Number of plants infected} \times 100}{\text{Total number of plants}}$$

3.5. Sensory evaluation

A panel of 15 judges were selected using triangle test (Jellineck, 1985) and sensory qualities were evaluated using 9-point hedonic scale.

Cooked pods were evaluated using a nine-point hedonic scale to assess the colour, appearance, flavour, taste, texture and over all acceptability as per Watts *et al.* (1989). For organoleptic test, Kendall's coefficient of concordance was performed and the mean scores were taken to differentiate the best product.

3.6. Statistical methods

The data recorded on different parameters were subjected to statistical analysis for estimation of various genetic parameters and to find out degree of association among different characters and their contribution to the yield of pods. Parameters like phenotypic coefficient of variation, genotypic coefficient of variation, correlation coefficients, heritability (h^2), genetic advance (GA), genetic advance as percentage of mean (GAM) and path coefficient were computed.

I. Phenotypic, Genotypic and Environmental variances: The variance components were estimated using formula suggested by Burton (1992).

1. Phenotypic variance (Vp) = Vg + Ve

Where (Vg) = Genotypic variance

(Ve) = Environmental variance

2. Genotypic variance (Vg) = (VT – VE)/N

Where VT= Mean sum of squares of treatments

VE = Mean sum of squares due to error

N = Number of replications

3. Environmental variance (Ve) = VE

Where VE = Mean sum of squares due to error

II. Phenotypic and genotypic coefficient of variation: The phenotypic and genotypic coefficients of variation were calculated by the formula given by Burton and Devane (1953).

1. Phenotypic coefficient of variation (PCV) = $(Vp^{1/2} / \bar{X} \times 100)$

Where Vp = Phenotypic variance

X = Mean of the character under study

2. Genotypic coefficient of variation (GCV) = $(Vg^{1/2} / \bar{X} \times 100)$

Where Vg = Genotypic variance

X = Mean of the character under study

III. Heritability: Heritability (h^2) was estimated by the formula suggested by Burton and Devane (1953)

1. H = (Vg/Vp) ×100

Where Vg = Genotypic variance

Vp = Phenotypic variance

IV. Expected genetic advance: The expected genetic advance is estimated by the formula given by Lush (1949) and Johnson *et al.* (1955) at five percent selection intensity using the constant K as 2.06 given by Allard (1960).

GA = (Vg/Vp) ×K

Where Vg = Genotypic variance

Vp = Phenotypic variance

K = Selection differential

V. Genetic advance as percentage of mean (GAM)

GAM = GA/ X ×100

Where, GA = Genetic advance

X = Mean of character under study

VI. Phenotypic, genotypic and environmental covariance

The phenotypic, genotypic and environmental covariance were estimated similarly as the variance were calculated. The covariance estimation was done according to the method given by Fisher (1954).

1. Phenotypic covariance between two characters 1 and 2

$CoVp_{12} = CoVg_{12} + CoVe_{12}$

$CoVg_{12}$ = Genotypic covariance between characters 1 and 2

$CoVe_{12}$ = Environmental covariance between 1 and 2

2. Genotypic covariance between two characters 1 and 2

$CoVg_{12} = (Mt_{12} – Me_{12}) /N$

Where Mt_{12} = Mean sum of product due to treatment between characters 1 and 2

Me_{12} = Mean sum of product due to error between character 1 and 2

N = Number of replications

VII. The phenotypic, genotypic and environmental correlation coefficients:

The phenotypic, genotypic and environmental correlation coefficients between different characters were found out in all possible combinations as suggested by Johnson *et al.* (1955).

1. Phenotypic correlation coefficient between two characters (rP_{12}) = $COVp_{12}/ Vp_1 Vp_2$

Where $COVp_{12}$ = Phenotypic covariance between characters 1 and 2

Vp_1 = Phenotypic variance of character 1

Vp_2 = Phenotypic variance of character 2

2. Genotypic correlation coefficient between two characters (rG_{12}) = $COVg_{12}/ Vg_1 Vg_2$

Where $COVg_{12}$ = Genotypic covariance between characters 1 and 2

Vg_1 = Genotypic variance of character 1

Vg_2 = Genotypic variance of character 2

3. Environmental correlation coefficient between two characters (re_{12}) =$COVe_2$/ Ve_1Ve_2

Where COVe12 = Environmental covariance between characters 1 and 2

Ve1 = Environmental variance of character 1

Ve2 = Environmental variance of character 2

VIII. Path coefficient analysis

In the path coefficient analysis the correlation among cause and effect is divided into direct and indirect effects of causal factors on effect factors. The techniques suggested by wright (1921) and Li (1955) for cause and effect system were adopted for finding path coefficient using the equation by Dewey and Lu (1959).

IX. Assessment of Genetic divergence and grouping of genotypes

The genetic distances among 30 genotypes were calculated by adopting Mahalanobis D^2 (Mahalanobis,1928). Values between every pair of quantitative characters was estimated. The genotypes were grouped into different clusters by Tocher's method (Rao, 1952).

Plate.1. General view of the field

Results

1. RESULTS

The present study entitled "Evaluation of dolichos bean (*Lablab purpureus* (L.) Sweet) accessions (pole type) for yield and quality" was carried out with the objective of evaluating the performance of dolichos bean accessions and to estimate the genetic variability and correlations among yield and its components. The results obtained from the present study are presented below.

4.1. Cataloguing of dolichos bean accessions

The dolichos bean accessions were catalogued based on NBPGR Minimal Descriptor for Characterization and Evaluation of Agri-Horticultural crops (2000). Morphological characters like flower colour, pod colour and pod shape were recorded and accessions were catalogued as given in Table. 3.

The flower colour varied from white to purple. The accessions LP-2, LP-3, LP-11, LP-12, LP-19, LP-22, LP-27, LP-29, LP-33 and LP-35 had purple flowers whereas, all the other accessions had white flowers.

The pod colour varied from light green, green to purple. Green pods with red border were observed in LP-2, LP-12, LP-19, LP-31, LP-32 and LP-35. Purple pods were observed in LP-11, LP-17 and LP-22.

The shape of the pods varied from straight, intermediate to curved. Curved pods were observed in LP-2, LP-4, LP-8, LP-16, LP-17, LP-21, LP-29, LP-30, LP-31, LP-33, LP-34 and LP-35. Intermediate shaped pods were observed in LP-10, LP-12, LP-13, LP-15 and LP-27. All the other accessions had straight pods.

Based on the reaction to bacterial wilt disease, the accessions were categorized into susceptible and resistant as shown in Table.4. The susceptible accessions wilted before entering into flowering stage. Five accessions, LP-1, LP-5, LP-6, LP-9 and LP-14 were highly susceptible, showed 100 per cent bacterial wilt incidence. Hence, genetic variability, correlation and path coefficient studies were conducted in the twenty five accessions which survived.

Table.3. Morphological characters in dolichos bean accessions

No.	Accession	Flower colour	Pod colour	Pod shape
1	LP-2	Purple	Green, purple border	Curved
2	LP-3	Purple	Light green	Straight
3	LP-4	White	Green	Curved
4	LP-7	White	Light green	Straight
5	LP-8	White	Light green	Curved
6	LP-10	White	Green	Intermediate
7	LP-11	Purple	Purple	Straight
8	LP-12	Purple	Green, purple border	Intermediate
9	LP-13	White	Green	Intermediate
10	LP-15	White	Light green	Intermediate
11	LP-16	White	Light green	Curved
12	LP-17	White	Purple	Curved
13	LP-19	Purple	Green, purple border	Straight
14	LP-21	White	Green	Curved
15	LP-22	Purple	Purple	Straight
16	LP-24	White	Light green	Straight
17	LP-27	Purple	Green	Intermediate
18	LP-28	White	Green	Straight
19	LP-29	Purple	Green	Curved
20	LP-30	White	Light green	Curved
21	LP-31	White	Green, purple border	Curved
22	LP-32	White	Green, purple border	Straight
23	LP-33	Purple	Green	Curved
24	LP-34	White	White	Curved
25	LP-35	Purple	Green, purple border	Curved

Plate.2. Variability in flower colour

Plate.3. Variability in pod colour

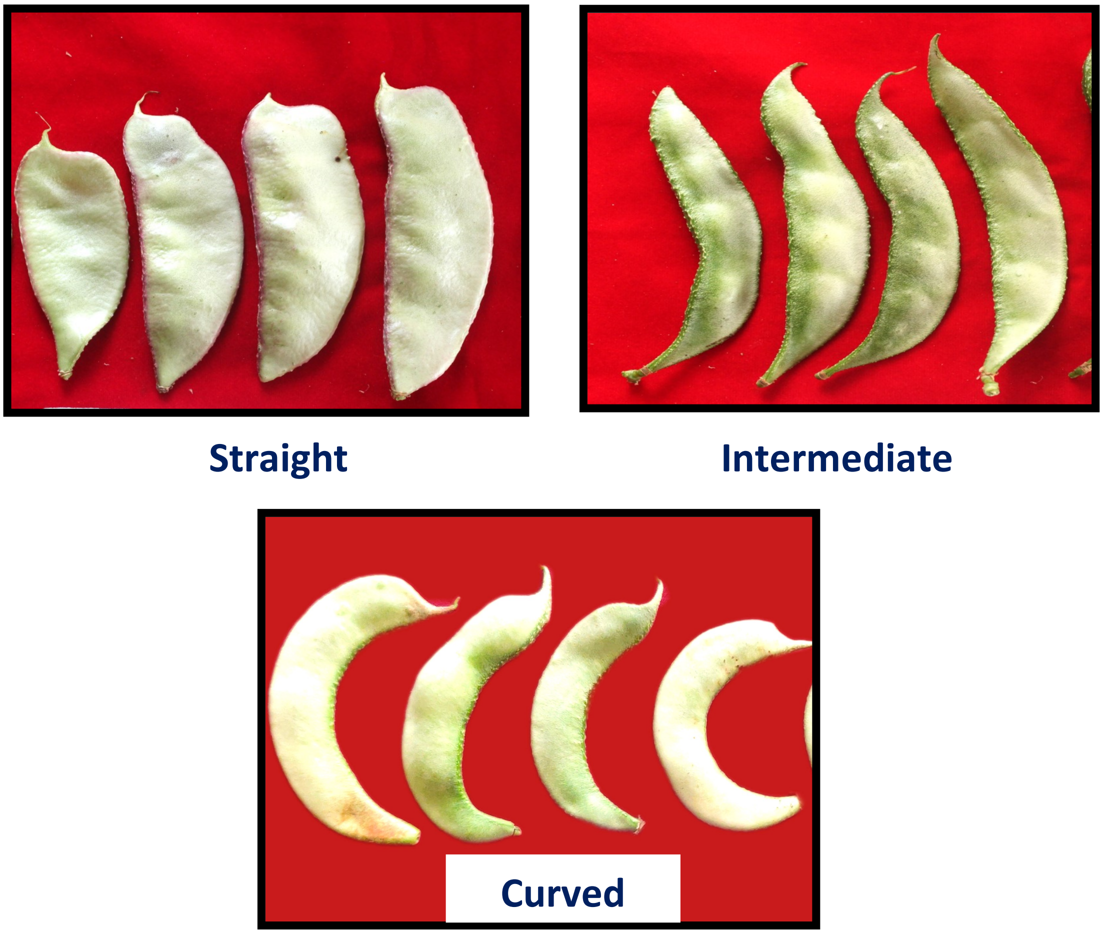

Plate.4. Variability in pod shape

Plate.5. Variability in pod shape, size and colour

Table.4. Reaction of accessions to bacterial wilt

Sl. No.	Accession	Susceptible/Non-susceptible	Incidence (%)
1	LP-1	Susceptible	100
2	LP-2	Non-susceptible	0
3	LP-3	Non-susceptible	0
4	LP-4	Susceptible	25
5	LP-5	Susceptible	100
6	LP-6	Susceptible	100
7	LP-7	Non-susceptible	0
8	LP-8	Susceptible	25
9	LP-9	Susceptible	100
10	LP-10	Non-susceptible	0
11	LP-11	Non-susceptible	0
12	LP-12	Susceptible	25
13	LP-13	Non-susceptible	0
14	LP-14	Susceptible	100
15	LP-15	Non-susceptible	0
16	LP-16	Non-susceptible	0
17	LP-17	Non-susceptible	0
18	LP-19	Non-susceptible	0
19	LP-21	Susceptible	25
20	LP-22	Non-susceptible	0
21	LP-24	Non-susceptible	0
22	LP-27	Non-susceptible	0
23	LP-28	Non-susceptible	0
24	LP-29	Non-susceptible	0
25	LP-30	Susceptible	25
26	LP-31	Non-susceptible	0
27	LP-32	Non-susceptible	0
28	LP-33	Non-susceptible	0
29	LP-34	Non-susceptible	0
30	LP-35	Non-susceptible	0

4.2. Genetic variability

The analysis of variance of 25 accessions of dolichos bean showed significant differences among them for all traits as shown in Table.5. The population mean, range, genotypic variance (GV), phenotypic variance (PV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability [broad sense (h^2)], genetic advance (GA) and genetic advance as percentage of mean (GAM) for all the traits for 25 accessions are given in the Table.6.

4.2.1. Variability in morphological characters

4.2.1.1. Number of primary branches

Number of primary branches ranged from 2.25 (LP-17) to 4.25 (LP- 22) with a mean of 3.14. The GV (0.19) and PV (0.39) were low for the character. GCV (13.82) and PCV (19.77) were moderate. Low GA (0.63), moderate heritability (48.87%) and GAM (19.90) were noted.

4.2.1.2. Days to first flowering

The days to first flowering ranged from 59.5 (LP-7) to 96.5 (LP-24) with a mean of 71.60. GV (74.52) and PV (83.35) were high. PCV (12.75) and GCV (12.06), GA (16.82) and GAM (23.49) were moderate whereas, high heritability (89.41%) was observed.

4.2.1.3. Days to first fruit set

The days to first fruit set ranged from 71.5 (LP-2) to 110 (LP-24) with a general mean of 83.86. GV (82.21), PV (94.81) and heritability (86.35%) were high whereas, GA (17.09) and GAM (20.38) were moderate; PCV (10.65) and GCV (11.46) were low.

4.2.1.4. Days to first harvest

The days to first harvest ranged from 84.5 (LP-7) to 123.5 (LP-24) with a general mean of 97.24. The GV (80.86), PV (89.94) and heritability (89.90%) were high whereas, GA (17.56), GAM (18.06) were moderate; GCV (10.65) and PCV (11.46) were low.

Table.5. Mean performance of dolichos bean accessions for growth and quality characters

	Accessions	1	2	3	4	5	6	7	8	9	10	11	12	13
1	LP-2	3.00^{cdef}	60.50^{k}	71.50^{i}	85.50^{i}	6.15^{ab}	4.70^{cdef}	10.50^{d}	4.81^{efg}	4.93^{cd}	241.75^{ef}	6.75^{bcdef}	173.50^{fghij}	1.20^{de}
2	LP-3	2.50^{ef}	67.00^{ghij}	76.50^{ghi}	90.50^{ghi}	4.90^{cdefgh}	5.00^{cd}	12.37^{c}	4.82^{efg}	4.92^{cde}	164.75^{hij}	7.25^{abcde}	184.50^{bcdefg}	0.83^{f}
3	LP-4	3.25^{bcde}	71.50^{cdefg}	84.00^{cdef}	97.00^{cdef}	5.80^{bc}	4.40^{efg}	7.53^{kl}	3.88^{jkl}	4.77^{cde}	130.25^{jkl}	6.50^{cdefg}	179.00^{efghi}	0.64^{gh}
4	LP-7	3.50^{abcd}	59.50^{k}	72.00^{i}	84.50^{i}	6.85^{a}	3.30^{ijk}	9.35^{ghi}	3.53^{mn}	5.24^{c}	49.25^{m}	6.00^{defgh}	171.50^{fghij}	0.27^{i}
5	LP-8	4.00^{ab}	63.00^{jk}	74.50^{hi}	85.00^{i}	4.35^{fghij}	4.35^{efg}	10.10^{defg}	4.10^{ijk}	4.11^{efghi}	303.00^{d}	6.75^{bcdef}	163.50^{ij}	1.20^{de}
6	LP-10	3.75^{abc}	67.50^{ghij}	81.00^{efgh}	97.00^{cdef}	5.00^{cdefgh}	3.40^{ijk}	8.63^{ij}	3.71^{lmn}	3.04^{klm}	223.25^{efg}	7.50^{abcd}	197.00^{abc}	0.69^{fgh}
7	LP-11	2.50^{ef}	64.50^{hijk}	77.50^{fghi}	92.50^{fgh}	4.40^{fghij}	3.60^{hij}	9.54^{fgh}	7.37^{b}	4.96^{cd}	52.75^{m}	6.25^{cdefgh}	168.50^{fghij}	0.28^{i}
8	LP-12	2.50^{ef}	71.00^{defg}	82.00^{defg}	94.00^{efg}	5.25^{bcdef}	4.50^{defg}	10.34^{def}	3.54^{mn}	3.93^{fghij}	302.75^{d}	6.75^{bcdef}	182.00^{cdefgh}	1.18^{de}
9	LP-13	3.25^{bcde}	68.50^{bc}	80.00^{efgh}	94.00^{efg}	4.90^{cdefgh}	6.79^{a}	14.15^{b}	4.66^{fg}	4.41^{defgh}	309.00^{d}	7.75^{abc}	194.00^{abcde}	1.38^{bc}
10	LP-15	4.00^{ab}	77.50^{bc}	90.00^{bc}	101.00^{bcd}	5.20^{bcdefg}	3.40^{ijk}	6.79^{l}	3.93^{ijkl}	2.34^{mn}	468.75^{b}	7.00^{abcde}	195.00^{abcde}	1.10^{e}
11	LP-16	3.25^{bcde}	77.00^{bcd}	88.50^{bcd}	102.00^{bc}	4.75^{defghi}	3.35^{ijk}	10.20^{def}	4.22^{hi}	3.64^{hijk}	143.25^{ijk}	6.50^{cdefg}	196.00^{abcd}	0.54^{h}
12	LP-17	2.25^{f}	77.00^{bcd}	89.50^{bc}	104.00^{b}	4.20^{ghij}	4.90^{cde}	9.70^{defgh}	3.49^{n}	3.33^{ijk}	90.25^{klm}	5.25^{fgh}	174.00^{fghij}	0.30^{i}
13	LP-19	3.25^{bcde}	69.50^{efghi}	83.00^{cdefg}	98.00^{bcdef}	4.00^{hij}	5.70^{b}	15.35^{a}	3.04^{q}	3.21^{jkl}	210.25^{efgh}	6.75^{bcdef}	186.00^{bcdef}	0.69^{fgh}
14	LP-21	2.50^{ef}	74.50^{bcdef}	86.50^{bcde}	101.50^{bc}	5.00^{cdefgh}	4.30^{fg}	7.35^{l}	3.84^{klm}	3.79^{ghijk}	189.50^{fghi}	6.25^{cdefgh}	183.50^{cdefgh}	0.74^{fg}
15	LP-22	4.25^{a}	75.50^{bcde}	89.00^{bcd}	103.00^{bc}	5.20^{bcdefg}	3.00^{k}	8.35^{jk}	6.52^{c}	6.79^{b}	36.25^{m}	5.75^{efgh}	179.00^{efghi}	0.25^{i}

1.No. of primary branches
2.Days to first flowering
3.Days to first fruit set
4. Days to first harvest
5.No. of pods/cluster
6.No. of seeds/pod
7. Pod length(cm)
8. Pod girth (cm)
9. Pod weight (g)
10. No. of pods/plant
11. No. of harvests
12. Duration of the crop
13. Pod yield/plant(kg)

Table.5. contd…

	Accessions	1	2	3	4	5	6	7	8	9	10	11	12	13
16	LP-24	3.25^{bcde}	96.50^{a}	110.00^{efgh}	123.50^{a}	4.40^{fghij}	3.70^{hi}	12.30^{c}	4.54^{gh}	4.61^{cdef}	129.50^{jkl}	5.25^{fgh}	183.50^{cdefgh}	0.61^{gh}
17	LP-27	2.50^{ef}	68.00^{ghij}	80.50^{efgh}	93.00^{fg}	5.35^{bcdef}	2.30^{l}	5.47^{m}	4.18^{ij}	2.04^{n}	579.00^{a}	7.25^{abcde}	187.00^{bcdef}	1.18^{de}
18	LP-28	3.25^{bcde}	64.50^{hijk}	76.50^{ghi}	94.00^{efg}	5.85^{abc}	3.10^{jk}	5.63^{m}	4.86^{ef}	2.45^{lmn}	612.75^{a}	8.50^{a}	200.00^{ab}	1.51^{ab}
19	LP-29	3.75^{abc}	93.50^{a}	107.00^{a}	118.50^{a}	3.80^{ij}	4.05^{gh}	8.49^{j}	4.54^{g}	3.16^{jkl}	175.00^{ghij}	6.50^{cdefg}	206.50^{a}	0.57^{h}
20	LP-30	2.75^{def}	74.50^{bcdef}	85.00^{bcde}	100.00^{bcde}	4.35^{fghij}	3.25^{ijk}	8.96^{hij}	4.75^{fg}	3.04^{klm}	451.00^{bc}	8.25^{ab}	206.00^{a}	1.38^{bc}
21	LP-31	3.00^{cdef}	63.50^{ijk}	77.50^{fghi}	92.00^{fgh}	4.50^{efghij}	4.50^{defg}	10.42^{de}	5.10^{e}	3.79^{fghijk}	75.25^{lm}	5.00^{gh}	162.50^{j}	0.29^{i}
22	LP-32	3.00^{cdef}	68.50^{fghij}	83.00^{cdefg}	95.00^{defg}	3.50^{j}	3.60^{hij}	9.98^{defg}	8.21^{a}	7.72^{a}	195.00^{fghi}	7.50^{abcd}	195.00^{abcde}	1.55^{a}
23	LP-33	3.25^{bcde}	79.50^{b}	92.00^{b}	104.00^{b}	5.60^{bcd}	5.15^{bc}	9.61^{efgh}	5.76^{d}	4.55^{cdefg}	144.00^{ijk}	4.75^{h}	168.00^{hij}	0.66^{gh}
24	LP-34	2.75^{def}	70.50^{efgh}	82.00^{defg}	95.00^{defg}	5.85^{abc}	4.75^{cdef}	14.56^{ab}	4.93^{ef}	4.99^{cd}	256.50^{de}	7.00^{abcde}	190.50^{abcde}	1.27^{cd}
25	LP-35	3.25^{bcde}	67.00^{ghij}	77.50^{fghi}	86.50^{hi}	5.50^{bcde}	4.45^{defg}	12.27^{c}	3.08^{op}	3.24^{jkl}	396.00^{c}	7.25^{abcde}	180.00^{defgh}	1.30^{cd}
	CD (0.05)	0.92	6.13	7.33	6.22	1.05	0.56	0.84	0.32	0.82	56.78	1.71	16.25	0.15
	SE	0.44	2.97	3.55	3.01	0.51	0.27	0.41	0.16	0.40	27.51	0.83	7.87	0.07
	CV	14.14	4.15	4.23	3.10	10.17	6.58	4.10	3.35	9.63	11.60	12.42	4.27	8.53

1.No. of primary branches
2.Days to first flowering
3.Days to first fruit set
4. Days to first harvest
5.No. of pods/cluster
6.No. of seeds/pod
7. Pod length(cm)
8. Pod girth (cm)
9. Pod weight (cm)
10. No. of pods/plant
11. No. of harvests
12. Duration of the crop
13. Pod yield/plant(kg)

Table.5. contd…

	Accessions	14	15	16	17	18	19
1	LP-2	128.02^{cde}	15.37^{bcdef}	2.47^{mn}	19.55^{abcd}	10.17^{hij}	768.30^{bcdef}
2	LP-3	112.83^{fg}	13.00^{ghij}	5.29^{ijk}	17.57^{efghi}	12.27^{efgh}	649.90^{ghij}
3	LP-4	117.26^{efg}	13.92^{fghi}	5.78^{hij}	17.70^{efgh}	13.45^{cdefg}	695.60^{fghi}
4	LP-7	93.28^{jk}	15.67^{bcdef}	9.42^{a}	18.28^{cdefg}	12.90^{defgh}	783.03^{bcdef}
5	LP-8	118.42^{efg}	15.29^{bcdef}	7.30^{de}	16.79^{ghi}	11.47^{fghij}	764.38^{bcdef}
6	LP-10	124.68^{def}	15.07^{bcdef}	8.43^{bc}	19.42^{abcde}	17.81^{a}	753.40^{bcdef}
7	LP-11	128.37^{cde}	18.14^{a}	9.57^{a}	17.21^{fghi}	11.76^{fghij}	906.88^{a}
8	LP-12	148.37^{ab}	16.30^{bc}	4.58^{kl}	20.65^{a}	14.76^{bcde}	814.60^{bc}
9	LP-13	152.66^{a}	14.52^{defgh}	6.61^{efgh}	19.17^{abcde}	10.83^{ghij}	725.65^{defgh}
10	LP-15	68.89^{l}	12.92^{hij}	6.08^{ghi}	17.64^{efghi}	14.06^{cdef}	645.53^{hij}
11	LP-16	94.27^{jk}	16.84^{ab}	7.08^{def}	19.40^{abcde}	11.78^{fghij}	841.90^{ab}
12	LP-17	99.89^{hij}	14.73^{cdefg}	6.08^{ghi}	15.82^{i}	8.98^{j}	736.43^{cdefg}
13	LP-19	95.93^{jk}	14.48^{defgh}	9.64^{a}	19.25^{abcde}	9.30^{ij}	723.90^{defgh}
14	LP-21	135.40^{cd}	12.10^{jk}	8.49^{b}	18.50^{bcdefg}	15.26^{abcd}	604.58^{jk}
15	LP-22	117.11^{efg}	15.75^{bcde}	5.03^{jk}	20.03^{abc}	11.87^{fghi}	787.15^{bcde}

14. Calcium (mg/100g)
15. Iron (mg/100g)
16. Total phenols (mg/100g)
17. Crude protein (%)
18. Crude fibre (%)
19. Phytic acid (mg/100g)

Table.5. contd…

	Genotypes	14	15	16	17	18	19
16	LP-24	88.55^{jk}	12.93^{hij}	5.93^{hi}	18.78^{bcdef}	13.29^{cdefg}	646.20^{hij}
17	LP-27	93.73^{jk}	11.02^{k}	4.12^{l}	16.25^{hi}	15.96^{abc}	550.90^{k}
18	LP-28	119.81^{efg}	15.96^{bcd}	3.12^{m}	19.35^{abcde}	12.99^{defgh}	797.85^{bcd}
19	LP-29	99.58^{ij}	14.18^{efgh}	6.25^{fgh}	17.97^{defgh}	14.15^{cdef}	708.63^{efgh}
20	LP-30	109.45^{ghi}	12.95^{hij}	2.06^{n}	19.30^{abcde}	17.07^{ab}	647.30^{hij}
21	LP-31	85.20^{k}	15.91^{bcde}	8.27^{bc}	18.97^{abcde}	10.74^{ghij}	795.03^{bcde}
22	LP-32	111.94^{ghi}	14.13^{efghi}	4.11^{l}	20.11^{abc}	10.37^{hij}	706.45^{efghi}
23	LP-33	112.15^{gh}	14.45^{defgh}	7.61^{cd}	19.66^{abcd}	14.16^{cdef}	722.40^{defgh}
24	LP-34	121.09^{efg}	12.37^{ijk}	6.94^{defg}	20.17^{ab}	12.04^{efghi}	618.18^{ijk}
25	LP-35	139.85^{bc}	14.16^{efgh}	6.13^{ghi}	20.29^{ab}	12.41^{efgh}	707.53^{efgh}
	CD (0.05)	12.49	1.78	0.88	1.85	2.85	88.83
	SE	6.05	0.86	0.42	0.90	1.38	43.04
	CV	5.37	5.94	6.78	4.79	10.79	5.94

14. Calcium (mg/100g)
15. Iron (mg/100g)
16. Total phenols (mg/100g)
17. Crude protein (%)
18. Crude fibre (%)
19. Phytic acid (mg/100g)

Table.6. Estimates of variance, heritability and genetic advance as percentage of mean

Characters	Range	Mean	GV	PV	GCV	PCV	h^2	GA	GAM
No. of primary branches	2.25-4.25	3.14	0.19	0.39	13.82	19.77	48.87	0.63	19.90
Days to first flowering	59.50-96.50	71.60	74.52	83.35	12.06	12.75	89.41	16.82	23.49
Days to first fruit set	71.50-110.00	83.86	82.21	94.81	10.65	11.46	86.35	17.09	20.38
Days to first harvest	84.50-123.50	97.24	80.86	89.94	9.25	9.75	89.90	17.56	18.06
No. of pods/cluster	3.50-6.85	4.99	0.49	0.75	14.09	17.38	65.72	1.17	23.53
Green pod yield/plant (kg)	0.25-1.55	0.86	0.18	0.19	49.24	49.97	97.09	0.86	99.94
No. of seeds/pod	3.00-6.79	4.14	0.91	0.98	23.04	23.96	92.46	1.89	45.63
Pod length(cm)	5.47-15.35	9.92	6.38	6.54	25.47	25.80	97.47	5.14	51.80
Pod girth(cm)	3.04-8.21	4.61	1.55	1.57	26.96	27.17	98.48	2.54	55.12
Pod weight (g)	2.04-7.72	4.11	1.64	1.80	31.13	32.59	91.27	2.52	61.27
No. of pods/plant	36.25-612.75	237.16	24987.47	25744.13	66.65	67.66	97.06	320.81	135.27
No. of harvests	5.25-8.50	6.65	0.57	1.25	11.36	16.83	45.54	1.05	15.79
Duration of the crop	162.50-206.5	184.24	126.13	188.12	6.10	7.44	67.05	18.94	10.28
Ca(mg/100g)	68.89-152.66	112.67	394.38	430.98	17.63	18.43	91.51	39.14	34.74
Iron (mg/100g)	11.02-18.14	14.48	2.28	3.02	10.42	11.99	75.44	2.70	18.64
Total phenols (mg/100g)	2.06-9.35	6.25	4.37	4.55	33.42	34.10	96.05	4.22	67.47
Crude protein (%)	15.82-20.65	18.71	1.29	2.09	6.07	7.73	61.58	1.84	9.81
Crude fibre (%)	8.98-17.07	12.79	4.16	6.04	15.94	19.25	68.58	3.48	27.20
Phytic acid (mg/100g)	550.90-906.88	724.07	5689.25	7541.66	10.42	11.99	75.44	134.96	18.64

4.2.1.5. Number of pods per cluster

The number of pods per cluster ranged from 3.50 (LP-32) to 6.85 (LP-7) with a mean of 4.99. The estimates of GV (0.49), PV (0.75) and GA (1.17) were very low. Moderate GCV (14.09), PCV (17.38) and GAM (23.53) were noted whereas, high heritability (65.72%) was observed.

4.2.1.6. Green pod yield per plant (kg)

Green pod yield per plant varied from 0.25 kg/plant (LP-22) to 1.55kg/plant (LP-32) with a mean of 0.86 kg/plant. Accessions namely, LP-2, LP-8, LP-12, LP-13, LP-15, LP-27, LP-28, LP-30, LP-32, LP-34 and LP-35 recorded high green pod yield than the general mean. Very low GV (0.18), PV (0.19); high estimates of GCV (49.24), PCV (49.97), heritability (97.09%) and GAM (99.94) were recorded.

4.2.1.7. Number of seeds per pod

Number of seeds per pod ranged from 3.00 (LP-22) to 6.79 (LP-13) with a mean of 4.14. The estimates of GV (0.91), PV (0.98) and GA (1.89) were very low. High estimates of GCV (23.04), PCV (23.96), heritability (92.46%) and GAM (45.63) were observed.

4.2.1.8. Pod length (cm)

Pod length varied from 5.47cm (LP-27) to 15.35cm (LP-19) with a mean of 9.92 cm. Accessions namely, LP-1, LP-3, LP-8, LP-12, LP-13, LP-16, LP-19, LP-24, LP-31, LP-32, LP-34 and LP-35 recorded high pod length than mean. GV (6.38), PV (6.54) and GA (5.14) were very low whereas, high GCV (25.47), PCV (25.80), heritability (97.47%) and GAM (51.80) were observed.

4.2.1.9. Pod girth (cm)

Pod girth ranged from 3.04 cm (LP-19) to 8.21 cm (LP-32) with a mean of 4.61cm. Low estimates of GV (1.55), PV (1.57), GA (2.54); high estimates of PCV (27.17), GCV (26.96), heritability (98.48%) and GAM (55.12) were noted.

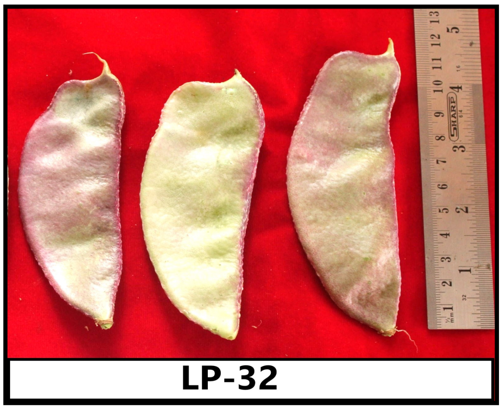

Plate.6. High yielding accessions

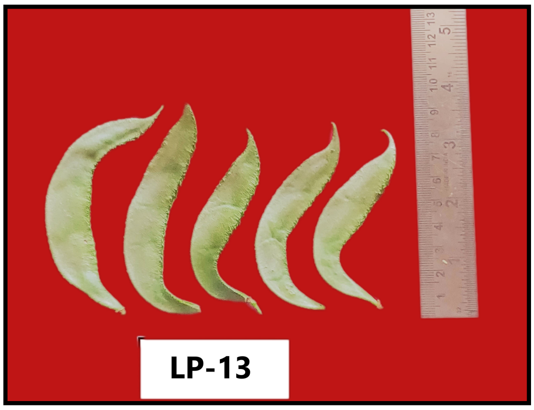

Plate.6. High yielding accessions

4.2.1.10. Pod weight (g)

Pod weight ranged from 2.04g/pod (LP-27) to 7.72g/pod (LP-32) with a mean of 4.11g/pod. The accessions viz., LP-2, LP-3, LP-4, LP-7, LP-11, LP-13, LP-22, LP-24, LP-32, LP-33 and LP-34 showed high pod weight than the mean value. Estimates of GV (1.64), PV (1.80) and GA (2.52) were low whereas, high GCV (31.13), PCV (32.59), heritability (91.27%) and GAM (61.27) were observed.

4.2.1.11. Number of pods per plant

Number of pods present per plant ranged from 36.25 (LP-22) to 612.75 (LP-28) with a mean of 237.16. The PV and GV were 25744.13 and 24987.47 respectively. High PCV (67.66), GCV (66.65), heritability (97.06%), GA (320.81) and GAM (135.27) were recorded.

4.2.1.12. Number of harvests

Number of harvests varied from 5.25 (LP-17 and LP-24) to 8.5 (LP-28) with a mean of 6.65. Very low GV (0.57), PV (1.25) and GA (1.05) were observed. The estimates of GCV (11.36), PCV (16.83) GAM (15.79) and heritability (45.54%) were moderate.

4.2.1.13. Duration of the crop

The duration of the crop ranged from 162.50 days (LP-31) to 206.50 days (LP-with a mean of 184.24. The GV (126.13) and PV (188.12) were high. Estimates of GCV (6.10), PCV (7.44), GA (18.94) and GAM (10.28) were low; heritability (67.05%) was high.

4.2.1.14. Calcium (mg/100g)

Calcium content of the pods varied from 68.89mg (LP-15) to 152.66mg (LP-13) with a mean of 112.67 mg. High GV and PV of 394.38 and 430.98 respectively were observed. Estimates of GCV (17.63) and PCV (18.43) were moderate. High GA (39.14), GAM (34.74) and heritability (91.51%) were recorded.

4.2.1.15. Iron (mg/100g)

Iron content varied from 11.02mg (LP-27) to 18.14mg (LP-11) with a mean of 14.48 mg. Estimates of GV (2.28), PV (3.02) and GA (2.70) were low. GCV (10.42), PCV (11.99) and GAM (18.64) were moderate. Heritability (75.44%) was high.

4.2.1.16. Total phenols (mg/100g)

The phenols content of the pods varied from 2.06 mg (LP-30) to 9.35 mg (LP-19) with a mean of 6.25 mg. Estimates of GV (4.37), PV (4.55), GA (4.22), GCV (33.42) and PCV (34.10) were low. However, high heritability (96.05%) and GAM (67.47) were recorded.

4.2.1.17. Crude protein (%)

The crude protein content of the pods varied from 15.82 per cent (LP-17) to20.65 per cent (LP-12) with a mean of 18.71 per cent. The estimates of GV (1.29), PV (2.09), GCV (6.07), PCV (7.73), GA (1.84) and GAM (9.81) were low. However, high heritability (61.58%) was observed.

4.2.1.18. Crude fibre (%)

Crude fibre content varied from 8.98 per cent (LP-17) to 17.07 per cent (LP-30) with a mean of 12.79 per cent. Low estimates of GV (4.16), PV (6.04), GA (3.48); moderate estimates of GCV (15.94) and PCV (19.25) were observed. Heritability (68.58%) and GAM (27.20) were high.

4.2.1.19. Phytic acid content (mg/100g)

The phytic acid content varied from 550.90 mg (LP-27) to 906.88 mg (LP-11) with a mean of 724.07 mg. GV (5689.25) and PV (7541.66) were high. Moderate estimates of GCV (10.42), PCV (11.99) and GAM (18.64) were recorded. High GA (134.96) and heritability (75.44%) were observed.

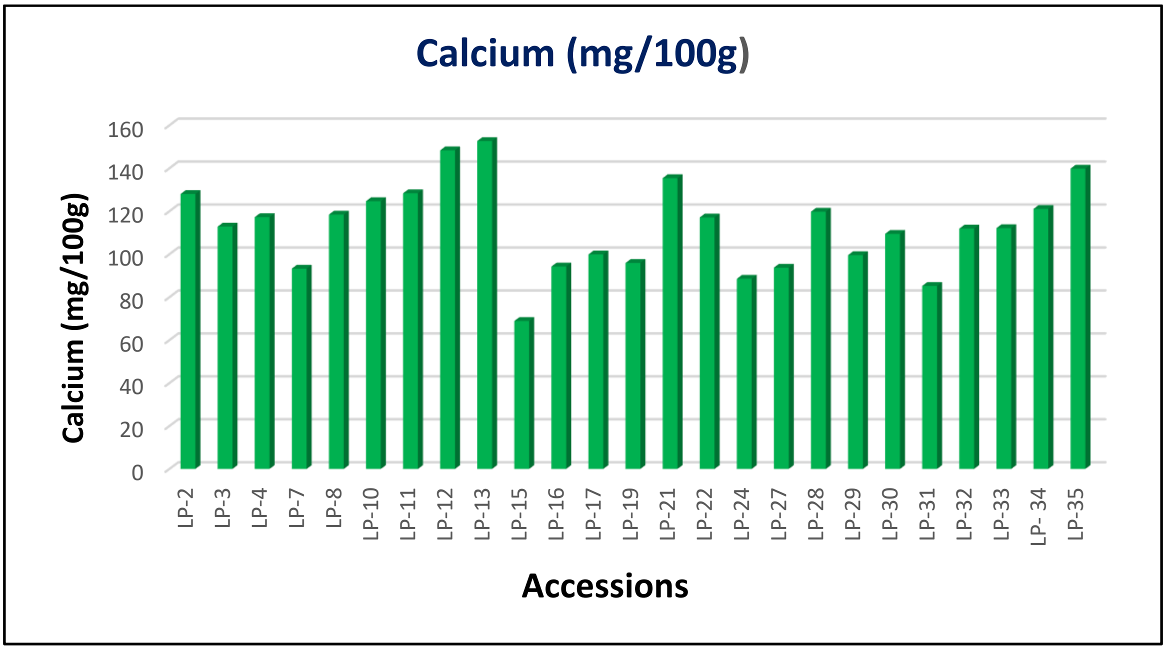

Figure.1. Calcium content in the accessions

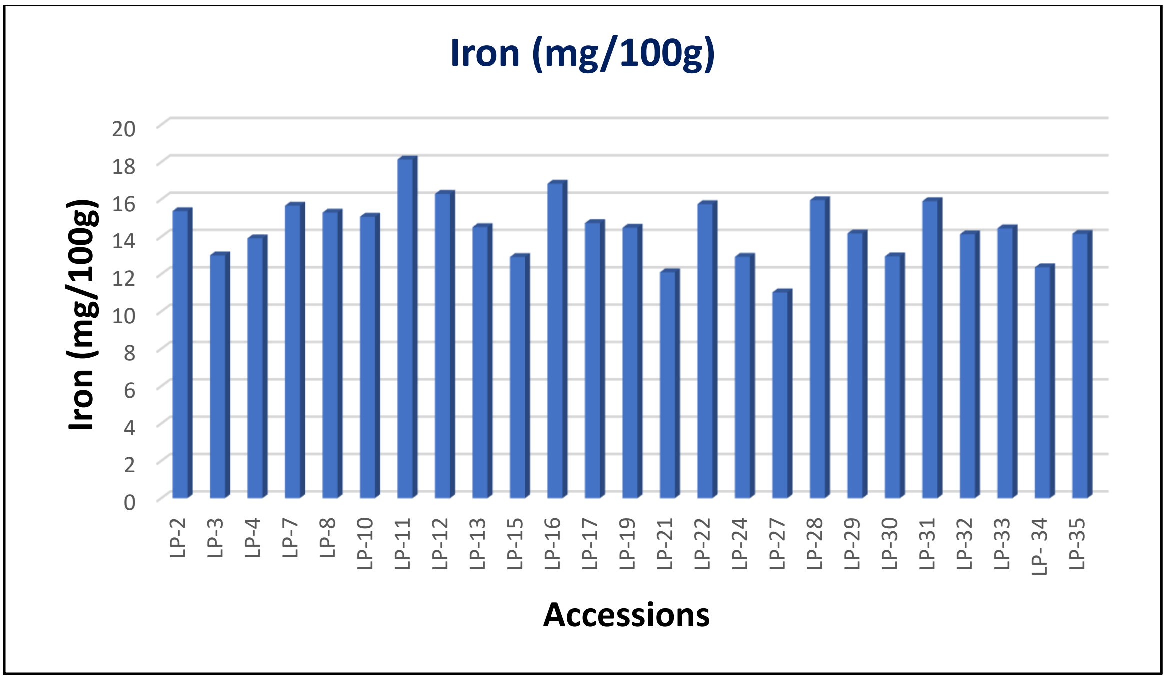

Figure.2. Iron content in the accessions

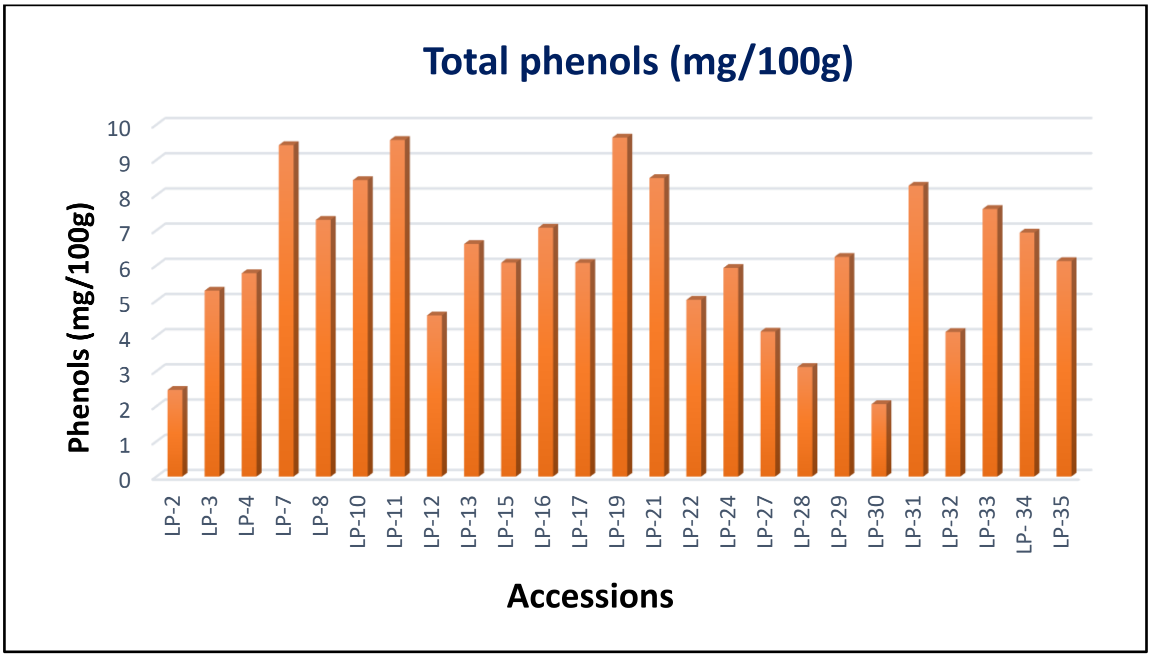

Figure.3. Total phenols in the accessions

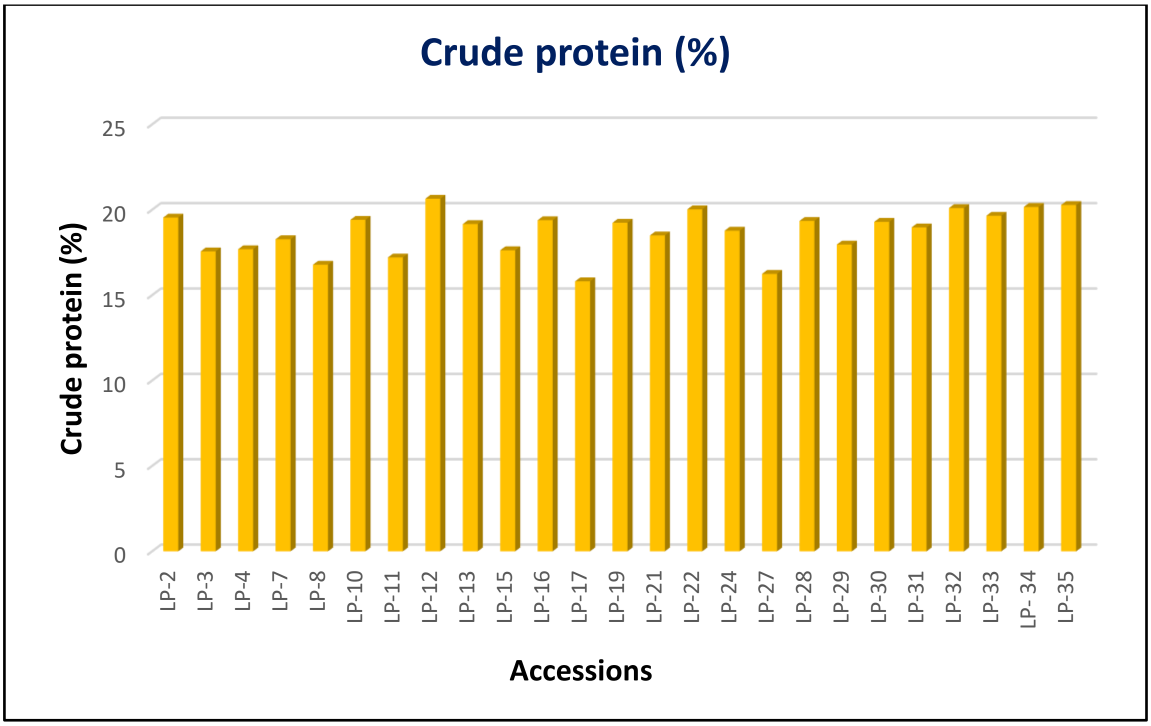

Figure.4. Crude protein content in the accessions

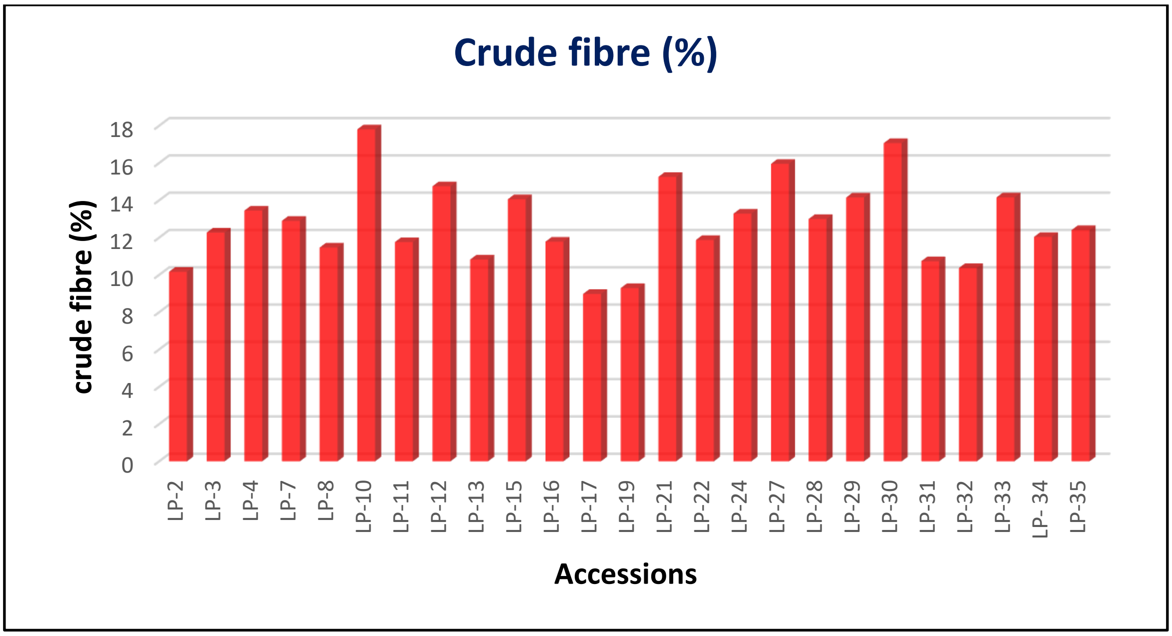

Figure.5. Crude fibre content in the accessions

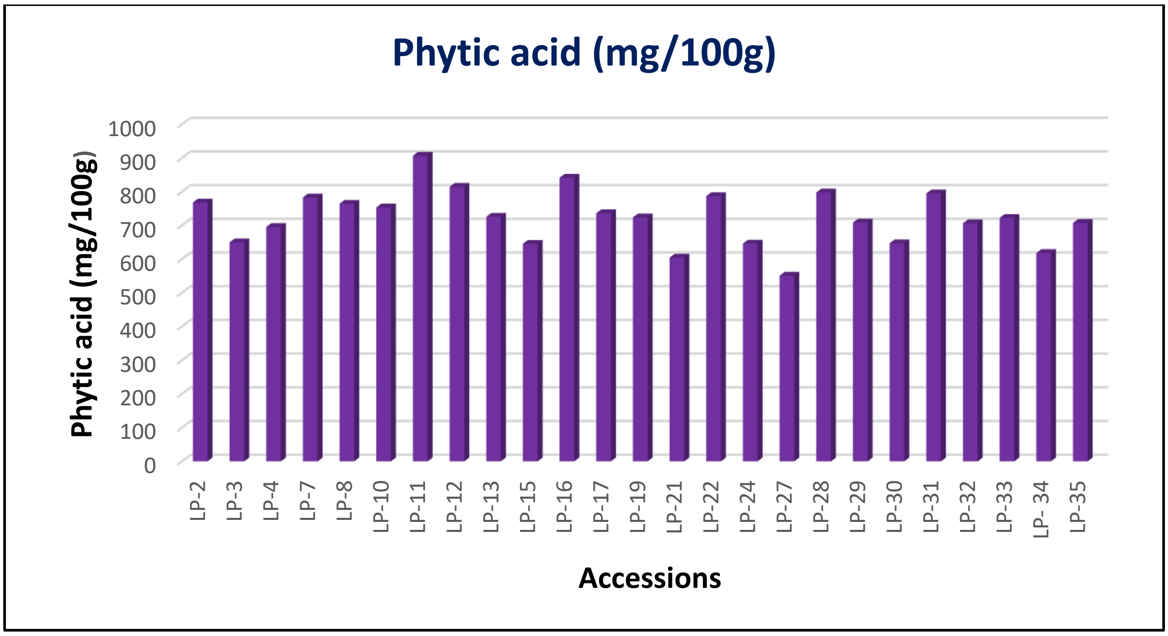

Figure.6. Phytic acid content in the accessions

4.3. Correlation studies

4.3.1. Genotypic correlations

Genotypic correlations of various yield components with yield were estimated and presented in Table.7.

Number of primary branches was significantly, positively correlated with iron and phytic acid (rG= 0.33). Days to first flowering was significantly, positively correlated with days to first fruit set, days to first harvest, duration of the crop and crude fibre content (rG= 0.99, 0.97, 0.40 and 0.28) respectively. Significant negative correlations were observed with number of pods per cluster (rG= -0.45), number of harvests (rG= -0.39), calcium content (rG= -0.34), iron content (rG= - 0.31) and phytic acid content (rG= -0.31).

Days to first fruit set was significantly, positively correlated with days to first harvest (rG= 0.99) and duration of the crop (rG= 0.39). It showed significant negative correlations with number of pods per cluster (rG= -0.49), number of harvests (rG= -0.42) and calcium content (rG= -0.39).

Significant positive correlation was observed for days to first harvest with duration of the crop (rG=0.44) and crude fibre (rG= 0.28). Significant negative correlation was observed with number of pods per cluster (rG= -0.50), number of harvests (rG= -0.38), calcium content (rG= -0.37) and green pod yield per plant (rG= -0.31).

Number of pods per cluster showed positive association with number of pods per plant (rG= 0.16), calcium content (rG= 0.20), crude protein (rG= 0.20), crude fibre (rG= 0.27) and green pod yield per plant (rG= 0.04). It showed significant negative correlation with pod girth (rG= -0.31) and duration of the crop (rG= -0.28).

Positive significant correlations were exhibited by number of seeds per pod with pod length (rG= 0.73) and calcium content (rG= 0.42) whereas, positive association was found with pod weight (rG= 0.10), total phenols (rG= 0.26), crude protein (rG= 0.16) and green pod yield per plant (rG= 0.07). It had significant negative correlation with crude fibre content (rG=-0.55).

Table.7. Genotypic correlation among yield, growth and quality characters in dolichos bean

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1																		
2	0.20	1																	
3	0.26	0.99**	1																
4	0.18	0.97**	0.99**	1															
5	0.07	-0.45**	-0.49**	-0.49**	1														
6	-0.20	-0.06	-0.09	-0.10	-0.11	1													
7	-0.11	-0.02	-0.05	-0.07	-0.20	0.73**	1												
8	-0.02	-0.03	0.02	0.05	-0.31*	-0.19	-0.08	1											
9	0.11	-0.12	-0.09	-0.11	-0.01	0.10	0.27	0.69**	1										
10	-0.03	-0.15	-0.19	-0.20	0.16	-0.23	-0.30*	-0.25	-0.61**	1									
11	-0.23	-0.39**	-0.42**	-0.38**	-0.00	-0.12	-0.06	-0.07	-0.28*	0.91**	1								
12	0.06	0.40**	0.39**	0.43**	-0.28*	-0.21	-0.12	-0.05	-0.31*	0.54**	0.68**	1							
13	-0.27	-0.34*	-0.39**	-0.37**	0.20	0.42**	0.21	0.06	0.23	0.07	0.37**	-0.07	1						
14	0.33*	-0.31*	-0.27	-0.23	-0.01	-0.02	0.04	0.25	0.24	-0.43**	-0.22	-0.35*	0.20	1					
15	0.18	-0.06	-0.01	-0.01	-0.07	0.26	0.29*	-0.16	0.01	-0.55**	-0.60**	-0.42**	-0.11	0.27	1				
16	0.25	0.02	0.01	0.01	0.20	0.16	0.40**	0.18	0.40**	-0.02	0.24	0.32*	0.42**	0.16	-0.18	1			
17	0.16	0.28*	0.27	0.28*	0.27	-0.55**	-0.58**	-0.21	-0.45**	0.43**	0.37**	0.49**	0.07	-0.43**	-0.16	0.02	1		
18	0.33*	-0.31*	-0.27	-0.23	-0.01	-0.02	0.04	0.25	0.24	-0.43**	-0.22	-0.35*	0.20	1.00**	0.27	0.16	-0.43**	1	
19	-0.10	-0.23	-0.28	-0.31*	0.04	0.07	0.05	0.02	-0.12	0.80**	0.98**	0.50**	0.36**	-0.39**	-0.62**	0.32*	0.16	-0.39**	1

1. No. of primary branches 2. Days to first flowering 3. Days to first fruit set 4. Days to first harvest 5. No. of pods/cluster 6. No. of seeds/pod
7. Pod length (cm) 8. Pod girth (cm) 9. Pod weight (g) 10. No. of pods/plant 11. Number of harvests 12. Duration of crop
13. Calcium 14. Iron 15. Total phenols 16. Crude protein 17. Crude fibre 18. Phytic acid
19. Green pod yield/plant(kg)

Significant positive correlations were recorded for pod length with total phenols (rG=0.29) and crude protein content (rG=0.40). It was significantly, negatively correlated with number of pods per plant (rG= -0.30) and crude fibre content (rG= -0.58).

Pod girth was significantly, positively correlated with pod weight (rG=0.69). No significant positive or negative correlations were observed with any other character.

Pod weight showed significant, positive correlations with crude protein (rG=0.40); significant negative correlations with number of pods per plant (rG=-0.61), number of harvests (rG=-0.28), duration of the crop (rG= -0.31) and crude fibre content (rG= -0.45).

Number of pods per plant was significantly, positively correlated with number of harvests (rG=0.91), duration of the crop (rG=0.54), crude fibre (rG=0.43) and green pod yield (rG=0.80) whereas, significant negative correlations with total phenols (rG=-0.55), iron (rG= -0.43) and phytic acid (rG= -0.43) content was observed.

Significant positive correlations were observed for number of harvests with duration of the crop (rG= 0.68), calcium (rG=0.37), crude fibre (rG=0.37) and green pod yield (rG= 0.98). It was significantly, negatively correlated with total phenols (rG= -0.60).

Duration of the crop had significant, positive correlations with crude protein (rG=0.32), crude fibre (rG=0.49) and green pod yield (rG=0.50) and had significant, negative correlations with iron content (rG= -0.35), total phenols (rG= -0.42) and phytic acid (rG=-0.35).

There existed significant, positive correlation for calcium content with crude protein content (rG=0.42) and green pod yield per plant (rG=0.36).

Iron content was significantly, positively correlated with phytic acid (rG=1.00) whereas, significantly, negatively correlated with crude fibre content (rG=-0.43) and yield (rG= -0.39).

Total phenols had positive association with phytic acid (rG=0.27) whereas, it showed significant negative correlations with pod yield per plant(rG=-0.62).

Crude protein showed significant positive correlations with pod yield per plant (rG=0.32) whereas, it had positive association with crude fibre (rG=0.02) and phytic acid (rG=0.16).

Crude fibre content was significantly, negatively correlated with phytic acid content (rG=-0.43).

Phytic acid content was significantly, negatively correlated with green pod yield per plant (rG= -0.39).

Green pod yield per plant showed significantly positive correlations with number of pods per plant (rG=0.80), number of harvests (rG=0.98), duration of the crop (rG=0.50), calcium content (rG=0.36) and crude protein content (rG=0.32). Significant negative correlations were observed with days to first harvest (rG=-0.31), iron content (rG= -0.39), total phenols (rG= -0.62) and phytic acid content (rG=-0.39).

4.3.2. Phenotypic correlations

Phenotypic correlations of various yield components with yield were estimated and presented in Table.8.

Days to first flowering was significantly, positively correlated with days to first fruit set (rP=0.99), days to first harvest (rP= 0.97) and duration of the crop (rP= 0.33). Significant negative correlations were noted with number of pods per cluster (rP= -0.36), number of harvests (rP= -0.31), calcium content (rP= -0.31), iron content (rP=-0.31) and phytic acid content (rP= -0.31).

Significant positive correlations were exhibited by days to first fruit set with days to first harvest (rP=0.98) and duration of the crop (rP=0.31) whereas, significant negative correlations were observed with number of pods per cluster (rP=-0.39), number of harvests (rP=-0.35) and calcium content (rP=-0.34).

Days to first harvest was significantly, positively correlated with duration of the crop (rP=0.34) and significant negative correlations were noted with number of pods per cluster (rP= -0.39), number of harvests (rP= -0.33), calcium content (rP= -0.34) and green pod yield per plant (rP= -0.30).

Number of pods per cluster had positive association with number of pods per plant (rP=0.15), number of harvests (rP=0.05), calcium (rP=0.16), crude protein (rP=0.16), crude fibre (rP=0.13) and green pod yield per plant (rP=0.07). It had negative association with number of seeds per pod (rP=-0.09), pod length (rP=-0.17), pod girth (rP= -0.25), pod weight (rP=-0.03), duration of the crop (rP=-0.18) and total phenols (rP= -0.07).

Number of seeds per pod was positively, significantly associated with pod length (rP=0.70) and calcium content (rP=0.36) whereas, negatively, significantly correlated with crude fibre (rP=-0.44).

Significant positive correlations were observed for pod length with total phenols (rP=0.28) and crude protein content (rP=0.31) whereas, negatively significant associations were observed with number of pods per plant (rP= -0.30) and crude fibre (rP= -0.47).

Pod girth had significant, positive correlations with pod weight (rP=0.66) and significant negative correlations with number of pods per plant (rP=-0.61) and crude fibre (rP=-0.36).

Number of pods per plant was significantly and positively correlated with number of harvests (rP=0.63), duration of the crop (rP=0.44), crude fibre (rP=0.34) and green pod yield (rP=0.79) whereas, negatively significant correlations with iron (rP= -0.35), total phenols (rP= -0.53) and phytic acid (rP= -0.35) were observed.

Number of harvests had significant positive correlations with duration of the crop (rP= 0.68), calcium content (rP=0.31) and green pod yield per plant (rP=0.66). It had significant negative correlations with total phenols (rP= -0.39).

Duration of the crop was significantly, positively correlated with green pod yield per plant (rP=0.39) and crude fibre content (rP=0.34); significantly negatively correlations with iron (rP=-0.32), total phenols (rP= -0.37) and phytic acid (rP= -0.32).

There existed significant positive correlations for calcium content with crude protein (rP=0.37) and pod yield per plant (rP=0.36).

Iron content was significantly, positively correlated with phytic acid (rP=1.00) whereas, significant negative correlations with crude fibre content (rP=0.30) and green pod yield per plant (rP= -0.32) were observed.

Total phenols had positive associations with phytic acid (rP=0.23) and it was significantly, negatively correlated with pod yield per plant (rP= -0.60).

Crude protein showed significant, positive correlations with green pod yield per plant (rP=0.30) and it had positive associations with crude fibre (rP=0.19) and phytic acid (rP=0.06).

Crude fibre was significantly, negatively correlated with phytic acid content (rP= -0.30); Phytic acid content was significantly, negatively correlated with green pod yield per plant (rP= -0.32).

Significantly positive correlations were shown by green pod yield per plant with number of pods per plant (rP=0.79), number of harvests (rP=0.66), duration of the crop (rP=0.39), calcium content (rP=0.36) and crude protein content (rP=0.30). It exhibited significant negative correlations with days to first harvest (rP= -0.30), iron content (rP= -0.32), total phenols (rP= -0.60) and phytic acid content (rP= -0.32).

Table. 8. Phenotypic correlation among yield, growth and quality characters in dolichos bean

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1																		
2	0.11	1																	
3	0.14	0.99**	1																
4	0.10	0.97**	0.98**	1															
5	0.07	-0.36*	-0.39**	-0.39**	1														
6	-0.16	-0.06	-0.09	-0.09	-0.09	1													
7	-0.12	-0.02	-0.04	-0.06	-0.17	0.70**	1												
8	-0.03	-0.03	0.02	0.04	-0.25	-0.18	-0.07	1											
9	0.05	-0.09	-0.05	-0.07	-0.03	0.10	0.27	0.66**	1										
10	-0.03	-0.15	-0.19	-0.20	0.15	-0.22	-0.30*	-0.24	-0.61**	1									
11	0.09	-0.31*	-0.35*	-0.33*	0.05	-0.13	-0.08	-0.03	-0.21	0.63**	1								
12	0.11	0.33*	0.31*	0.34*	-0.18	-0.22	-0.12	-0.04	-0.26	0.44**	0.68**	1							
13	-0.19	-0.31*	-0.34*	-0.34*	0.16	0.36*	0.21	0.07	0.20	0.08	0.31*	-0.01	1						
14	0.08	-0.31*	-0.28	-0.24	0.00	0.04	0.03	0.22	0.19	-0.35*	-0.16	-0.32*	0.19	1					
15	0.10	-0.06	-0.01	-0.01	-0.07	0.25	0.28*	-0.16	0.00	-0.53**	-0.39**	-0.37**	-0.11	0.23	1				
16	0.11	-0.06	-0.07	-0.07	0.16	0.10	0.31*	0.16	0.25	0.04	0.14	0.17	0.37**	0.19	-0.14	1			
17	-0.01	0.17	0.14	0.14	0.13	-0.44**	-0.47**	-0.19	-0.36*	0.34*	0.21	0.34*	0.02	-0.30*	-0.12	0.06	1		
18	0.08	-0.31*	-0.28	-0.24	0.00	0.04	0.03	0.22	0.19	-0.35*	-0.16	-0.32*	0.19	1.00**	0.23	0.19	-0.30*	1	
19	-0.09	-0.23	-0.27	-0.30*	0.07	0.07	0.05	0.03	-0.12	0.79**	0.66**	0.39**	0.36**	-0.32*	-0.60**	0.30*	0.10	-0.32*	1

1. No. of primary branches 2. Days to first flowering 3. Days to first fruit set 4.Days to first harvest 5. No. of pods/cluster 6. No. of seeds/pod
7. Pod length (cm) 8. Pod girth (cm) 9. Pod weight (g) 10. No. of pods/plant 11. Number of harvests 12. Duration of crop
13. Calcium 14. Iron 15. Total phenols 16. Crude protein 17. Crude fibre 18. Phytic acid
19. Green pod yield/plant(kg)

4.4. Path analysis

Path analysis by dividing the correlations of yield and its components into direct and indirect effects help to identify the direct and indirect contribution of component characters to yield. The results of path analysis are presented in Table.9. The diagonal values in the table represent the direct effects and the value on both the sides of diagonal represents the indirect effects.

4.4.1. Direct effects

The highest direct positive effect on yield was exhibited by number of pods per plant (1.112) followed by days to first flowering (0.782), pod weight (0.719), number of seeds per pod (0.230) and duration of the crop (0.186).

At the same time, the highest direct negative effect on yield was recorded by days to first harvest (-0.496), days to first fruit set (-0.445), number of pods per cluster (-0.228), pod girth (-0.171), pod length (-0.067), number of primary branches (-0.063) and number of harvests (-0.027).

4.4.2. Indirect effects.

Number of primary branches had direct negative effect on yield (-0.063) whereas, it showed indirect positive effects through days to first flowering (0.156), pod length (0.007), pod girth (0.003), pod weight (0.078), number of harvests (0.006) and duration of the crop (0.010).

Days to first flowering showed direct positive effects on yield (0.782) and indirect positive effect was expressed through number of pods per cluster (0.102), pod length (0.001), pod girth (0.004), number of harvests (0.006) and duration of the crop (0.075).

Days to first fruit set recorded direct negative effects on yield (-0.445) and indirect positive effect was through days to first flowering (0.779), number of pods per cluster (0.110), pod length (0.004), number of harvests (0.011) and duration of the crop (0.072).

Table. 9. Path coefficient analysis for pod yield and its component characters in dolichos bean

	1	2	3	4	5	6	7	8	9	10	11	12
1	**-0.063**	0.156	-0.113	-0.087	-0.015	-0.045	0.007	0.003	0.078	-0.038	0.006	0.010
2	-0.012	**0.782**	-0.442	-0.481	0.102	-0.013	0.001	0.004	-0.088	-0.163	0.010	0.075
3	-0.016	0.779	**-0.445**	-0.489	0.110	-0.020	0.004	-0.004	-0.666	-0.210	0.011	0.072
4	-0.011	0.758	-0.439	**-0.496**	0.114	-0.023	0.005	-0.008	-0.081	-0.222	0.010	0.080
5	-0.004	-0.350	0.216	0.247	**-0.228**	-0.024	0.013	0.053	-0.007	0.173	0.000	-0.053
6	0.012	-0.047	0.039	0.049	0.024	**0.230**	-0.049	0.032	0.072	-0.257	0.003	-0.039
7	0.007	-0.019	0.024	0.035	0.045	0.169	**-0.067**	0.014	0.194	-0.333	0.002	-0.021
8	0.001	-0.021	-0.010	-0.022	0.071	-0.043	0.005	**-0.171**	0.498	-0.280	0.002	-0.009
9	-0.007	-0.096	0.041	0.056	0.002	0.023	-0.018	-0.118	**0.719**	-0.676	0.008	-0.058
10	0.002	-0.115	0.084	0.099	-0.036	-0.053	0.020	0.043	-0.437	**1.112**	-0.024	0.100
11	0.014	-0.304	0.187	0.188	0.000	-0.028	0.004	0.012	-0.203	1.008	**-0.027**	0.126
12	-0.004	0.316	-0.171	-0.215	0.065	-0.048	0.008	0.008	-0.226	0.599	-0.018	**0.186**

Residual effect: 0.02743

1.No. of primary branches
2.Days to first flowering
3.Days to first fruit set
4. Days to first harvest
5.No. of pods/cluster
6.No. of seeds/pod
7. Pod length(cm)
8. Pod girth (cm)
9. Pod weight(g)
10. No. of pods/plant
11. No. of harvests
12. Duration of the crop

Days to first harvest had direct negative effects on yield (-0.496) whereas, indirect positive effects through days to first flowering (0.758), number of pods per cluster (0.114), pod length (0.005), number of harvests (0.010) and duration of the crop (0.080) was observed.

Number of pods per cluster showed direct negative effects on yield (-0.228) and indirect positive effect was through days to first fruit set (0.216), days to first harvest (0.247), pod length (0.013), pod girth (0.053) and number of pods per plant (0.173).

Number of seeds per pod had direct positive effect on yield (0.230). Indirect positive effect was noted through number of primary branches (0.012), days to first fruit set (0.039), days to first harvest (0.049), number of pods per cluster (0.024), pod girth (0.032), pod weight (0.072) and number of harvests (0.003).

Pod length showed direct negative effect on yield (-0.067) whereas, indirect positive effect was noticed through number of primary branches (0.007), days to first fruit set (0.024), days to first harvest (0.035), number of pods per cluster (0.045), number of seeds per pod (0.169), pod girth (0.014), pod weight (0.194) and number of harvests (0.002).

Pod girth had direct negative effect on yield (-0.171) and indirect positive effect was noticed on yield through number of primary branches (0.001), number of pods per cluster (0.071), pod length (0.005), pod weight (0.498) and number of harvests (0.002).

Pod weight had direct positive effect on yield (0.719). Indirect positive effect was noticed on yield through days to first fruit set (0.041), days to first harvest (0.056), number of pods per cluster (0.002), number of seeds per pod (0.023) and number of harvests (0.008).

Direct positive effects on yield (1.112) was recorded for number of pods per plant and indirect positive effect was observed through number of primary branches (0.002), days to first fruit set (0.084), days to first harvest (0.099), pod length (0.020), pod girth (0.043) and crop duration (0.100).

Number of harvests had direct negative effects on yield (-0.027). Indirect positive effects on yield was observed through number of primary branches (0.014), days to first fruit set (0.187), days to first harvest (0.188), pod length (0.004), pod girth (0.012), number of pods per plant (1.008) and duration of the crop (0.126).

Duration of the crop had direct positive effects on yield (0.186). Indirect positive effect was observed on yield through days to first flowering (0.316), number of pods per cluster (0.065), pod length (0.008), pod girth (0.008) and number of pods per plant (0.599).

4.5. Genetic divergence

Genetic divergence among 25 accessions of dolichos bean were evaluated based on 19 characters. The data obtained from evaluation was subjected to Mahalanobis D^2 analysis. Based on the results, the accessions were grouped into 6 clusters using Tocher's method. The results of divergence studies are presented in Table.10, Table.11 and Table.12.

4.5.1. Classification of dolichos bean accessions

Twenty five accessions of dolichos bean were grouped into 6 clusters by using Tocher's method (Rao, 1952). The distribution pattern of accessions into various clusters is shown in Table.10.

Cluster VI had highest number of accessions (8) followed by cluster III (6). Cluster I and II had four accessions each. There were two accessions in cluster IV and one accession in cluster V.

The accessions included in cluster I are LP-15, LP-27, LP-28 and LP-30. Cluster II consisted of the accessions LP-11, LP-22, LP-31 and LP-33. Cluster III consisted of the accessions LP-10, LP-13, LP-16, LP-24, LP-29 and LP-34. Cluster IV consisted of the accessions LP-7 and LP-19. Cluster V consisted of a single accession (LP-32). Cluster VI had accessions LP-2, LP-3, LP-4, LP-8, LP-12, LP-17, LP-21 and LP-35.

Inter and intra cluster distance among 6 clusters are given in Table.11. Intra cluster distance was maximum in cluster IV (D^2 = 1185.51). Intra cluster distance was minimum in cluster I (D^2 = 391.34). Inter cluster distance was maximum between cluster IV and V (D^2 =3929.71). Minimum inter cluster distance was observed between clusters III and VI (D^2 =871.83).

4.5.2. Mean performance of characters in clusters

Cluster means of 19 characters of dolichos bean accessions are presented in Table.12.

4.5.2.1. Number of primary branches

The highest mean number of primary branches was observed in cluster IV (3.38) followed by cluster III (3.33). The lowest mean number of branches was observed in cluster VI (2.91).

4.5.2.2. Days to first flowering

The highest mean number of days to first flowering was observed in cluster III (78.92) followed by cluster I (71.13). The lowest mean number of days to first flowering was observed in cluster IV (64.50).

4.5.2.3. Days to first fruit set

Number of days to first fruit set was the highest in cluster III (91.42) followed by cluster II (84.00). The lowest mean number of days to first fruit set was observed in cluster IV (77.50).

4.5.2.4. Days to first harvest

The highest mean number of days to first harvest was observed in cluster III (105.00) followed by cluster II (97.88). The lowest mean number of days to first harvest was observed in cluster IV (91.25).

4.5.2.5. Number of pods/cluster

Number of pods/cluster was the highest in cluster IV (5.43), followed by cluster I (5.19). The lowest mean number of pods/cluster was observed in cluster V (3.50).

4.5.2.6. Number of seeds/pod

The highest mean number of seeds/pod was observed in cluster VIII (5.75), followed by cluster VI (4.60). The lowest mean number of seeds/pod was observed in cluster I (3.01).

4.5.2.7. Pod length(cm)

Mean pod length was the highest in cluster IV (12.35) followed by cluster III (11.39). The lowest mean pod length was observed in cluster I (6.71).

4.5.2.8. Pod girth(cm)

The highest mean pod girth was in cluster V (8.21), followed by cluster II (6.19). The lowest mean pod girth was observed in cluster IV (3.28).

4.5.2.9. Pod weight (g)

The highest mean pod weight was observed in cluster V (7.72), followed by cluster II (5.02). The lowest mean pod weight was in cluster I (2.46).

4.5.2.10. Number of pods/plant

Mean number of pods/plant was the highest in cluster I (527.88), followed by cluster VI (227.28). The lowest mean number of pods/plant was observed in cluster II (77.06).

4.5.2.11. Number of harvests

The highest mean number of harvests was recorded in cluster I (7.75), followed by cluster V (7.50). The lowest mean number of harvests was observed in cluster II (5.44).

4.5.2.12. Duration of the crop

Mean duration of the crop was the highest in cluster I (197.00), followed by cluster IV (195.00). The lowest mean duration was observed in cluster II (169.50).

Table.10. Clustering pattern in 25 accessions of dolichos bean

Cluster no.	No. of accessions in each cluster	Accessions
1	4	LP-15, LP-27, LP-28, LP-30
2	4	LP-11, LP-22, LP-31, LP-33
3	6	LP-10, LP-13, LP-16, LP-24, LP-29, LP-34
4	2	LP-7, LP-19
5	1	LP-32
6	8	LP-2, LP-3, LP-4, LP-8, LP-12, LP-17, LP-21, LP-35

Table.11. Intra and inter cluster D^2 values in clusters

	I	II	III	IV	V	VI
I	391.34 (19.78)					
II	3125.14 (55.90)	586.25 (24.21)				
III	1632.14 (40.40)	1297.15 (36.02)	586.99 (24.23)			
IV	2792.72 (52.85)	1698.19 (41.21)	1165.76 (34.14)	1185.51 (34.43)		
V	2971.30 (54.51)	1546.13 (39.32)	2213.43 (47.05)	3929.71 (62.69)	0.00	
VI	1128.02 (33.59)	1689.33 (41.10)	871.83 (29.53)	1276.48 (35.73)	2602.51 (51.01)	529.63 (23.01)

Intra cluster distance : Diagonal values

Inter cluster distance : Off-diagonal values

D values : Value in paranthesis

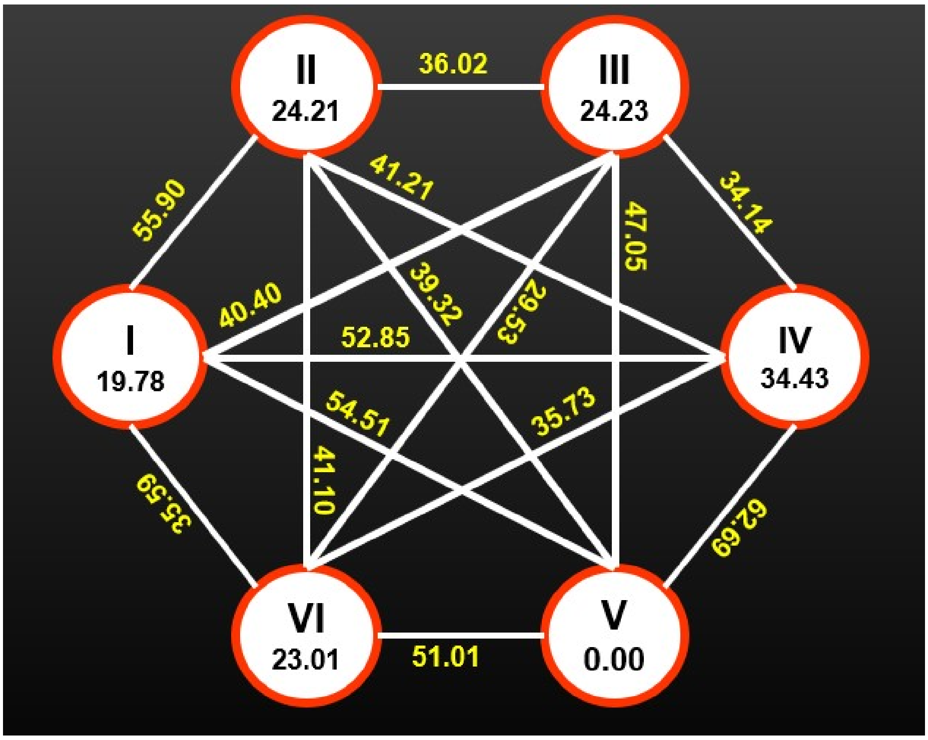

Figure. 7. Cluster diagram showing inter and intra cluster distances

Table.12. Means of variables for clusters in dolichos bean accessions

Characters / Clusters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	3.13	71.13	83.00	97.00	5.19	3.01	6.71	4.43	2.46	527.88	7.75	197.00	1.29	97.97	13.21	3.84	18.13	15.02	660.39
2	3.25	70.75	84.00	97.88	4.93	4.06	9.48	6.19	5.02	77.06	5.44	169.50	0.37	110.71	16.06	7.62	19.07	12.13	802.86
3	3.33	78.92	91.42	105.00	4.78	4.34	11.39	4.43	3.97	206.08	6.75	194.58	0.84	113.47	14.32	6.98	19.15	13.31	715.66
4	3.38	64.50	77.50	91.25	5.43	4.50	12.35	3.28	4.22	129.75	6.38	178.75	0.48	94.60	15.07	9.53	18.76	11.10	753.46
5	3.00	68.50	83.00	95.00	3.50	3.60	9.98	8.21	7.72	195.00	7.50	195.00	1.55	111.94	14.13	4.11	20.11	10.37	706.45
6	2.91	68.94	80.25	93.00	5.14	4.58	10.02	3.94	4.13	227.28	6.59	177.50	0.92	125.00	14.36	5.76	18.36	12.34	717.66

1.No. of primary branches
2.Days to first flowering
3.Days to first fruit set
4.Days to first harvest
5.No. of pods/cluster
6.No. of seeds/pod
7. Pod length(cm)
8. Pod girth (cm)
9.Pod weight (g)
10.No. of pods/plant
11. Number of harvests
12. Duration of the crop
13. Green pod yield/plant (kg)
14. Calcium (mg/100g)
15. Iron (mg/100g
16. Total phenols (mg/100g)
17. Crude protein (%)
18. Crude fibre (%)
19. Phytic acid (mg/100g)

4.5.2.13. Green pod yield per plant (kg)

The highest mean pod yield per plant was recorded in cluster V (1.55 kg), followed by cluster I (1.29 kg). The lowest mean pod yield was observed in cluster II (0.37 kg).

4.5.2.14. Calcium content(mg/100g)

Mean calcium content was the highest in cluster VI (125.00 mg)/100g), followed by cluster III (113.47 mg/100g). The lowest mean calcium content was observed in cluster IV (94.60 mg /100g).

4.5.2.15. Iron(mg/100g)

The highest mean iron content was observed in cluster II (16.06 mg/100g), followed by cluster IV (15.07 mg/100g). The lowest mean was observed in cluster I (13.21 mg/100g).

4.5.2.16. Total phenols(mg/100g)

Mean total phenols was the highest observed in cluster IV (9.53 mg/100g), followed by cluster II (7.60 mg/100g). The lowest mean was observed in cluster I (3.84 mg/100g).

4.5.2.17. Crude protein (%)

For crude protein content the highest mean was observed in cluster V (20.11 per cent), followed by cluster III (19.15 per cent). The lowest mean was observed in cluster I (18.13 per cent).

4.5.2.18. Crude fibre (%)

Mean fibre content was the highest in cluster I (15.02 per cent), followed by cluster III (13.31 per cent). The lowest mean fibre was observed in cluster V (10.37 per cent).

4.5.2.19. Phytic acid(mg/100g)

The highest mean for phytic acid was observed in cluster II (802.86 mg/100g), followed by cluster IV (753.46 mg/100g). The lowest mean phytic acid content was observed in cluster I (660.39 mg/100g).

4.6. Sensory evaluation

The sensory evaluation was done based on a nine-point Hedonics scale ranging from like extremely (9) to dislike extremely (1). Statistical analysis was done using Kendall's coefficient of concordance after converting the Hedonics scale ratings into rank scores. Mean rank obtained for each accession is listed in Table.13.

Sensory evaluation was conducted in the cooked pods of dolichos bean to evaluate them based on the sensory qualities. The accessions were scored based on their appearance, colour, flavour, texture, taste and overall acceptability.

Among the dolichos bean accessions, the highest mean score for appearance was recorded in LP-2 (18.67) followed by LP-28 (18.60) and LP-33 (17.77). Lowest mean rank was recorded in LP-15 (4.73) followed by LP-27 (7.27) and LP-24 (8.70).

Highest mean rank for colour was recorded in LP-28 (19.33) followed by LP-12 (16.43) and LP-10 (16.27). Lowest mean rank for colour was recorded in LP-15 (4.43) followed by LP-27 (7.27) and LP-24 (8.03).

With respect to flavour highest mean rank was recorded in LP-3 (18.40) followed by LP-31 (17.13) and LP- 28 (16.97). Lowest mean rank was observed in LP-27 (4.48) followed by LP-15 (5.70) and LP-17 (8.27).

For texture highest mean rank, score was observed for LP-31 (20.67) followed by LP-13 (17.37) and LP-2 (16.23). The lowest mean rank was recorded for LP-15(4.13) followed by LP-27 (4.70) and LP-16 (5.57).

Table.13. Sensory qualities of dolichos bean accessions

Accessions	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
LP-2	18.67	17.50	16.03	16.23	13.63	16.23
LP-3	12.50	14.57	18.40	14.73	19.87	11.80
LP-4	12.67	14.97	10.47	12.50	14.57	10.85
LP-7	11.27	11.03	12.80	15.63	14.93	12.97
LP-8	13.63	15.13	12.50	12.73	12.73	14.53
LP-10	16.77	16.27	15.93	15.03	14.13	16.00
LP-11	13.97	10.47	16.77	13.73	14.13	10.07
LP-12	15.37	16.43	13.63	14.50	16.10	16.67
LP-13	17.03	15.63	14.73	17.37	15.73	17.07
LP-15	4.73	4.43	5.70	4.13	6.30	6.20
LP-16	9.77	10.10	8.77	5.57	8.20	9.33
LP-17	10.63	11.30	8.27	9.30	9.30	9.57
LP-19	14.60	15.90	14.53	15.10	15.23	15.97
LP-21	12.37	13.53	15.13	14.33	13.10	9.30
LP-22	13.80	11.37	12.83	14.33	13.27	15.30
LP-24	8.70	8.03	11.20	10.87	13.07	11.23
LP-27	7.27	7.27	4.43	4.70	4.80	4.90
LP-28	18.60	19.33	16.97	17.50	17.30	18.20
LP-29	12.30	14.77	14.30	12.77	14.30	12.30
LP-30	13.40	15.10	13.43	10.80	13.03	12.77
LP-31	17.13	14.97	17.13	20.67	19.87	20.07
LP-32	10.80	8.63	10.10	10.80	11.77	10.70
LP-33	17.77	16.13	16.63	15.03	13.53	16.06
LP-34	11.27	10.53	11.63	12.27	10.70	10.93
LP-35	9.30	11.60	12.67	14.37	13.30	16.00

Highest mean rank for taste was recorded in LP-3 (19.87) and LP-31 (19.87) followed by LP-28 (17.3) and LP-12 (16.10). Lowest mean rank for taste was recorded for LP- 27 (4.8) followed by LP-15 (6.3) and LP-16 (8.2).

For overall acceptability, the highest mean rank was recorded in LP-31(20.07) followed by LP-28 (18.20) and LP-13 (17.07). Lowest mean rank for overall acceptability was recorded in LP-27 (4.90) followed by LP-15 (6.20) and LP-27 (9.30).

4.7. Disease and pest incidence

Though dolichos bean plants are hardy in nature, due to the vigorous vegetative growth, incidence of pod borers and sucking pests was a problem. The percentage pest and disease incidence is given in Table.14. Major sucking pests observed were aphids and pod bugs. Accessions namely, LP-13 and LP-29 were mostly affected by incidence of sucking pests. Accessions *viz.*, LP-17 and LP-29 were affected by pod borer. Bacterial wilt was the major disease observed in the crop.

Accessions LP-1, LP-5, LP-6, LP-9 and LP-14 showed 100 per cent incidence of bacterial wilt. It occurred mainly in the flowering stage of the crop and resulted in complete wilting of the affected plants. Ooze test was conducted to confirm the pathogen causing the disease as bacteria. For management of the disease, drenching with *Pseudomonas fluorescence* (20 g/l) was done at fortnightly interval and Kocide @ 2g/l along with streptocyclin (0.3g/l) was applied three times. However, the affected plant could not be revived.

Table.14. Percentage incidence of pests and diseases

Sl. No.	Accessions	Sucking pest (%)	Pod borer (%)	Bacterial wilt (%)
1	LP-1	-	-	100
2	LP-2	25	50	0
3	LP-3	0	25	0
4	LP-4	50	25	25
5	LP-5	-	-	100
6	LP-6	-	-	100
7	LP-7	0	50	0
8	LP-8	25	50	25
9	LP-9	-	-	100
10	LP-10	25	25	0
11	LP-11	0	25	0
12	LP-12	50	0	25
13	LP-13	75	50	0
14	LP-14	-	-	100
15	LP-15	25	0	0
16	LP-16	50	0	0
17	LP-17	0	75	0
18	LP-19	25	0	0
19	LP-21	25	0	25
20	LP-22	50	25	0
21	LP-24	25	0	0
22	LP-27	25	50	0
23	LP-28	0	50	0
24	LP-29	75	75	0
25	LP-30	0	25	25
26	LP-31	50	0	0
27	LP-32	25	25	0
28	LP-33	25	0	0
29	LP-34	50	25	0
30	LP-35	25	25	0

Plate.7. Confirmation of bacterial wilt by ooze test

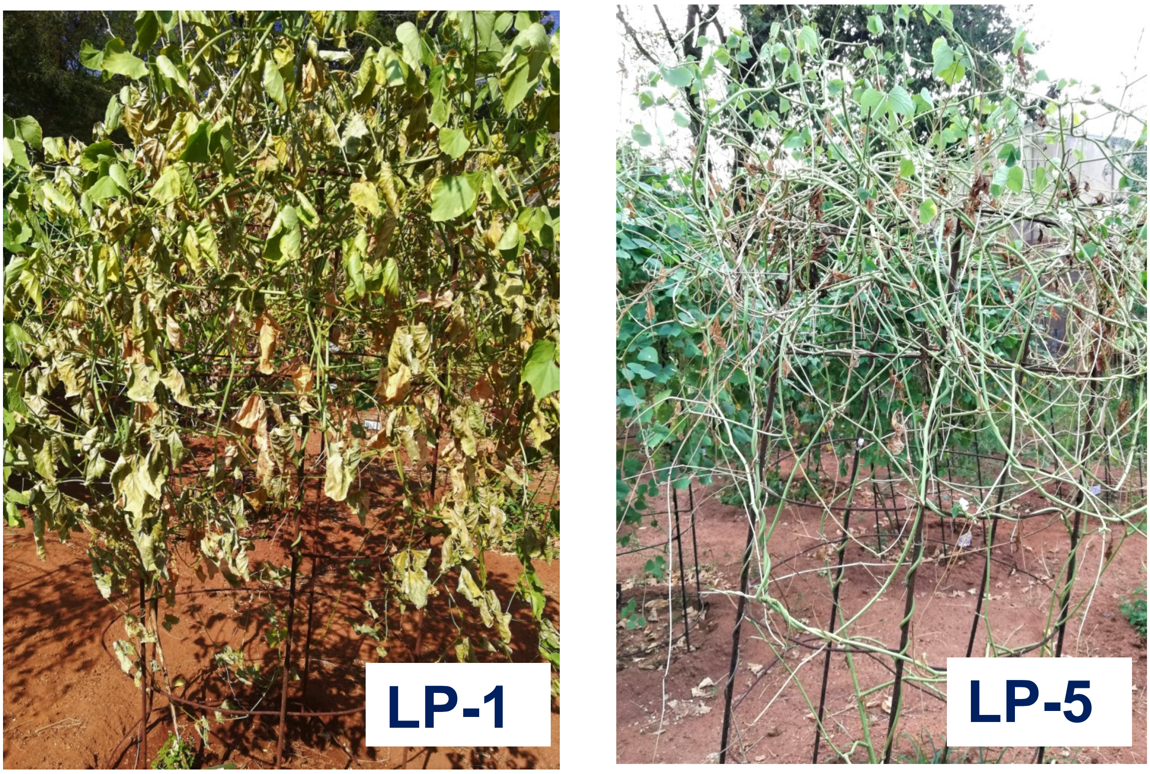

Plate. 8. Bacterial wilt affected plants

Plate.8. Bacterial wilt affected plants

Plate. 9. Aphid infestation

Plate.10. Pod bug attack

4.8. Selection criteria for dolichos bean accessions

The accessions evaluated were scored based on the characters such as green pod yield per plant, number of pods per plant, pod weight, days to first flowering and overall acceptability of sensory evaluation. The total score for a genotype was calculated from the individual scores of the characters. Based on the values of total score, the accessions were ranked (Table. 15). The top ranking accessions were selected for fixing the selection criteria for dolichos bean accessions from a population (Table. 16).

Based on the values of total score, the genotypes were ranked and the top ranking genotypes were selected. The genotypes selected were LP-28, LP-13, LP-12, LP-2 and LP-35 which were found superior for these characters. The characters of selected accessions are presented in Table.17. The green pod yield per plant ranged from 1.18kg-1.51kg, number of pods per plant ranged from 241.75-612.75, pod weight ranged from 2.45g-4.93g and the days to first flowering ranged from 50.50 to 61.00 in the selected accessions.

Table. 15. Ranking for selection of superior accessions

Sl. no	Accessions	Green pod yield/plant (kg)	Score	No. of pods/plant	Score	Days to first flowering	Score	Pod weight (g)	Score	Overall acceptability	Score	Total score	Rank
1	LP-2	1.20	3	241.75	5	50.50	4	4.93	3	16.23	5	20	4
2	LP-3	0.83	4	164.75	6	57.00	3	4.92	3	11.80	14	30	11
3	LP-4	0.64	5	130.25	6	61.50	3	4.77	3	10.85	17	34	13
4	LP-7	0.27	6	49.25	7	49.50	4	5.24	3	12.97	11	31	12
5	LP-8	1.20	3	303.00	4	53.00	4	4.11	4	14.53	10	25	8
6	LP-10	0.69	4	223.25	5	57.50	3	3.04	5	16.00	7	24	7
7	LP-11	0.28	6	52.75	7	54.50	4	4.96	3	10.07	19	39	17
8	LP-12	1.18	3	302.75	4	61.00	3	3.93	4	16.67	4	18	3
9	LP-13	1.38	2	309.00	4	58.50	3	4.41	4	17.07	3	16	2
10	LP-15	1.10	3	468.75	2	68.50	2	2.34	6	6.20	23	36	14
11	LP-16	0.54	5	143.25	6	67.00	2	3.64	4	9.33	21	38	16
12	LP-17	0.30	6	90.25	7	67.00	2	3.33	5	9.57	20	40	18
13	LP-19	0.69	4	210.25	5	59.50	3	3.21	5	15.97	8	25	8
14	LP-21	0.74	4	189.50	5	64.50	2	3.79	4	9.30	22	37	15
15	LP-22	0.25	6	36.25	7	65.50	2	6.80	2	15.30	9	26	9
16	LP-24	0.61	5	129.50	6	86.50	1	4.61	3	11.23	15	30	11
17	LP-27	1.18	3	579.00	1	58.00	3	2.04	6	4.90	24	37	15
18	LP-28	1.51	1	612.75	1	54.50	4	2.45	6	18.20	2	14	1
19	LP-29	0.57	5	175.00	6	83.50	1	3.16	5	12.30	13	30	11
20	LP-30	1.38	2	451.00	2	64.50	2	3.04	5	12.77	12	23	6
21	LP-31	0.29	6	75.25	7	53.50	4	3.79	4	20.07	1	22	5
22	LP-32	1.55	1	195.00	5	58.50	3	7.72	1	10.70	18	28	10
23	LP-33	0.66	5	144.00	6	69.50	2	4.55	3	16.06	6	22	5
24	LP-34	1.27	2	256.50	4	60.50	3	4.99	3	10.93	16	28	10
25	LP-35	1.30	2	396.00	3	57.00	3	3.24	5	16.00	7	20	4

Table 16: Selection criteria for evaluation of accessions

Parameters	Range
Green pod yield per plant (kg)	1.18-1.51
Number of pods per plant	241.75-612.75
Pod weight (g)	2.45-4.93
Days to first flowering	50.50-61.00

Table 17: Characters of selected accessions

Sl. No	Genotypes	Green pod yield per plant (kg)	Pod weight (g)	No. of pods/plant	Days to first flowering	Overall acceptability (mean score)
1	LP-28	1.51	2.45	612.75	54.50	18.20
2	LP-13	1.38	4.41	309.00	58.50	17.07
3	LP-12	1.18	3.93	302.75	61.00	16.67
4	LP-2	1.20	4.93	241.75	50.50	16.23
5	LP-35	1.30	3.24	396.00	57.00	16.00

Discussion

5. DISCUSSION

Dolichos bean is an underexploited leguminous crop which has huge potential for meeting the nutritional requirement of largely vegetarian population in India. However, attempts on crop improvement of this crop is scanty. Every successful crop improvement programme requires knowledge on the genetic variability, heritability and genetic divergence existing in the germplasm and nature, extent of associations of component characters contributing to yield. The present study entitled "Evaluation of dolichos bean (*Lablab purpureus* (L.) Sweet) accessions (pole type) for yield and quality" was conducted in 30 accessions to understand the nature and magnitude of variability and character associations so as to identify suitable ones having high yield and quality. The results obtained from the present study are discussed below.

5.1. Cataloguing of dolichos bean accessions

The extent of variability available in a population is a major factor which favours the success of any breeding programme. Dolichos bean accessions collected from different sources were catalogued based on NBPGR Minimal Descriptor for Characterization and Evaluation of Agri-Horticultural crops (2000). Wide range of variation was observed in the accessions. Pod colour ranged from light green, green to purple. The accessions LP-11, LP-17 and LP-22 had purple pods. The purple colour in pods is associated with the pigments anthocyanins and pro-anthocyanidins. These compounds provide a wide range of health benefits to human body by acting as antioxidants, immunostimulants and anticarcinogens. (Rauf *et al.*, 2019). The flower colour ranged from white to purple and the pod shape varied from straight, intermediate to curved.

5.2. Genetic variability studies

The present study revealed significant differences among the accessions for characters such as number of primary branches, days to first flowering, days to first fruit set, days to first harvest, number of pods/cluster, green pod yield/plant, number of seeds/pod, pod length, pod girth, pod weight, number of pods/plant, number of harvests, duration of the crop, iron, calcium, total phenols, crude protein, crude fibre and phytic acid.

Phenotypic, genotypic coefficient of variations give a clear picture of the amount of variability present in a germplasm. It also reveals, whether the variability is due to the genotype or due to the effects of the environment. From the present study, although the estimates of PCV were higher than GCV, a close association between PVC and GCV was observed in the traits *viz.*, days to first flowering, days to first fruit set, green pod yield/plant, number of seeds/pod, pod length, pod girth, pod weight and number of pods/plant. This indicated that variations in these traits were due to genotype and environment exerted very little effect. In addition, moderate to high estimates of heritability (h^2) and GAM indicated that these traits are highly heritable. This indicated the presence of additive gene action for these traits and hence, these can be improved through selection. Similar findings were reported by Magalingam *et al.* (2013), Chaitanya *et al.* (2014), Verma *et al.* (2014), Sahu and Bahadur (2018), Gamit *et al.* (2020) and Afsan and Roy. (2020).

Considerably wider association was observed between estimates of PCV and GCV of the traits *viz.*, number of primary branches, number of harvests and number of pods/cluster. This meant a greater degree of environmental effect on the expression of these traits. Hence, selection based on phenotypic values would not be suitable in these characters. However, moderate to high heritability (h^2) and GAM were observed for these traits.

Quality traits *viz.*, iron, calcium, total phenols, and phytic acid exhibited close association between PCV and GCV. In addition, moderate to high heritability and GAM were also observed in these traits. Thus, it could be inferred that phenotypic values were a true measure of the genotype and the improvement of these traits is possible through selection. Similar results have not been reported so far.

A wider relationship between PCV and GCV of crude fibre indicated a greater degree of environmental effect upon the expression of this trait. However, crude fibre showed high heritability and GAM which made it a highly heritable character. Similar results have not been reported so far.

Low estimates of PCV, GCV observed for crude protein indicated that there was low variability existed in the population however, close association between PCV and GCV meant that environmental effect was negligible upon the expression of the trait. Crude protein exhibited high heritability coupled with low genetic gain. It indicated the presence of non-additive gene action and selection is not effective for improvement. This result is in line with the findings of Verma *et al*. (2014) and Sadak peer *et al.* (2018).

5.3. Correlations

In every crop improvement programme, it is very important to have a thorough knowledge on the inter-relation among yield and its component traits. If two traits are positively correlated, indirect improvement of one trait is possible by improving the other.

Green pod yield per plant was significantly, positively correlated with number of pods per plant, number of harvests and duration of the crop. This is in agreement with Islam *et al.* (2011), Choudhary *et al.* (2016) and Gupta *et al*. (2017) who observed similar results in dolichos bean. From the present study, accessions LP- 2 (241.75, 1.20 kg), LP-15 (468.75, 1.10 kg), LP-27 (579, 1.18 kg), LP-28 (612.75, 1.51 kg), LP-34 (256.5, 1.27 kg) and LP-35 (396, 1.30 kg) recorded high number of pods along with high green pod yield per plant. Further, green pod yield per plant was positively correlated with number of pods per cluster, pod length, pod weight and pod girth. However, these correlations were not significant which indicated their independent nature with respect to yield.

Green pod yield per plant was also significantly, positively related with quality parameters such as calcium and crude protein. Hence, selection for the high yielding accessions would result in simultaneous improvement of calcium and crude protein in the crop. From the present study, the accessions LP-2 (1.20 kg, 128.02 mg/100g, 19.55%), LP-12 (1.18 kg, 148.37 mg/100g, 20.65%), LP-34 (1.27kg, 121.09mg/100g, 20.17%) and LP-35 (1.30kg, 139.85mg/100g, 20.29%) recorded high yield along with high calcium and crude protein content. Similar results have not been reported so far.

Significant, negative correlation was observed for green pod yield per plant with days to first harvest, iron, total phenols and phytic acid content. It was inferred that high yielding accessions take lower number of days for first harvest. In addition, such accessions contain lower amount of iron, total phenols and phytic acid. Phytic acid has been generally regarded as the primary storage form of both phosphate and inositol in plants (Cosgrove, 1966). High content of phytic acid is of nutritional significance as the phytate phosphorus is unavailable to humans and it lowers the availability of many other essential minerals such as iron, calcium and magnesium (Reddy *et al.,* 1982). The phytate could be substantially eliminated by adopting processing methods such as soaking and cooking. From the present study, the accessions LP-15 (1.10 kg, 645.75 mg/100g), LP-27 (1.18kg, 551.00 mg/100g), LP-30 (1.38kg, 647.50 mg/100g) and LP-34 (1.27 kg, 618.25 mg/100g) recorded high green pod yield per plant and low phytic acid content.

Days to first flowering was significantly, positively correlated with days to first fruit set, days to first harvest, duration of the crop and crude fibre content. It meant that accessions which flowered early, set fruits early, had shorter duration and had less fibre content. This is in accordance with the studies of Gupta *et al.* (2017). The present study revealed that the accessions LP-2, LP-7, LP-8 and LP-11 were early in flowering, fruiting and harvest.

Days to first fruit set was significantly, positively correlated with days to first harvest and duration of the crop. Hence, it was inferred that plants which set fruits early could be harvested early and they also had shorter duration. Days to first harvest was significantly, positively correlated with duration of the crop and crude fibre. This meant that in the accessions where the pods are harvested early, the duration was found to be short and these also had less crude fibre content. This is in line with the studies of Choudhary *et al.* (2016). From the present study the accessions LP-2, LP-7, LP-8 and LP-35 were early to set fruits and harvest. Days to first fruit set was significantly, negatively correlated with number of pods per cluster, number of harvests and calcium content. It could be inferred that accessions which are early to set fruits recorded high number of pods per cluster, number of harvests and calcium content. The present study revealed that the accessions LP-2, LP-28 and LP-35 showed early fruit set, high number of pods per cluster, number of harvests and calcium content. These accessions could be identified as early and high yielding with high calcium content.

Number of seeds per pod was positively, significantly associated with pod length and calcium content. It meant that as the number of seeds increased the pod length as well as calcium content also increased. Similar result was reported by Kujur *et al.* (2017) on the association of number of seeds per pod and pod length. Number of seeds per pod was negatively, significantly correlated with crude fibre content. Hence, it was inferred that as the number of seeds per pod increased the crude fibre content decreased. From the present study the accessions LP-2, LP-3, LP-13 and LP-19 had more number of seeds per pod, high pod length and low fibre content.

Pod length was positively, significantly correlated with total phenols and crude protein content. As the pod length increased the total phenol content as well as crude protein content increased. Pod length was significantly, negatively correlated with number of pods per plant and crude fibre content. As the pod length increased, the number of pods per plant and the crude fibre content decreased. From the present study, the accessions LP-3, LP-13, LP-19 and LP-34 had long pods with high crude protein and low crude fibre content.

Pod weight was significantly, positively correlated with crude protein. This meant that pods with high weight had high protein content. Similar result was reported by Gupta *et al.* (2017). Therefore, while selecting for pods with high protein content we could select pods with high weight. From the present study, the accessions LP-2 (4.93g, 19.55%), LP-22 (6.79g, 20.03%), LP-32 (7.72g, 20.11%) and LP-34 (4.99g, 20.17%) showed high pod weight as well as crude protein content.

Duration of the crop was significantly, positively correlated with crude protein and crude fibre. As the duration of the accessions increased, crude protein content and crude fibre content were found to be high. In addition, duration of the crop was significantly, negatively correlated with iron, total phenols and phytic acid. From the present study, the accessions LP-10, LP-12 and LP-15 recorded long duration, high crude protein, high crude fibre and low phytic acid. Similar results have not been reported so far.

Calcium content was significantly, positively correlated with crude protein and green pod yield per plant. It was hence, inferred that accessions with high calcium content had high protein and high green pod yield. From the present study the accessions LP-2, LP-12, LP-32, LP-34 and LP-35 recorded high calcium, crude protein and green pod yield.

Iron content was significantly, positively correlated with phytic acid. That is, as the iron content increased the phytic acid also increased. The accessions LP-11, LP-12, LP-28 and LP-31 recorded high iron and phytic acid content. Iron content was significantly, negatively correlated with crude fibre content and green pod yield per plant. Hence, as the iron content increased the crude fibre and pod yield decreased. Similar results have not been reported so far.

Total phenols was significantly, negatively correlated with green pod yield per plant which meant that in high yielding accessions, total phenols would be low. Similar result has not been reported so far. From the present study, the accessions LP- 2, LP-27, LP- 28, LP- 30 and LP-32 were high yielding accessions with low total phenols.

Crude protein was significantly, positively correlated with green pod yield per plant. The accessions with high yield recorded high protein. This is in accordance with the findings of Parmar *et al.* (2013) and Gupta *et al.* (2017). The accessions LP- 2, LP-12, LP-32, LP-34 and LP-35 were high yielding with high protein content.

Crude fibre content was significantly, negatively correlated with phytic acid content. As the fibre content increased, phytic acid content decreased. The accessions LP-15, LP-21 and LP-27 exhibited high fibre content and low phytic acid content from the present study. Phytic acid was significantly, negatively correlated with green pod yield per plant. Thus, it could be inferred that as the phytic acid content increased green pod yield decreased. Similar results have not been reported so far in dolichos bean. From the present study, the accessions LP-15, LP-27, LP-30 and LP-34 were high yielding with low phytic acid content.

5.4. Path analysis

Path coefficient analysis is an important tool to provide an insight into the direct and indirect causes of association among component traits, thereby permitting a critical examination of the traits acting to produce a specific correlation. It also helps in measuring the relative importance of different traits. If the association of the traits with yield is due to direct effect, direct selection can be made for their improvement; if it is due to indirect effect then selection has to be done through the traits showing indirect positive effect.

In the present study, the residual effect was very low (0.02743) which meant that most of the variability present in the genotypes was explained with the traits under study.

The highest direct positive effect on green pod yield per plant was exhibited by number of pods per plant followed by days to first flowering, pod weight, number of seeds per pod and duration of the crop. Chandran *et al*. (2015) and Jyothi reddy *et al*. (2018) reported similar results in dolichos bean. This meant that accessions which had more number of pods per plant, pod weight, number of seeds per pod, duration of the crop and took more number of days to flowering were high yielders. From the present study, accessions *viz.*, LP-2, LP-13 and LP-34 could be selected as high yielders based on these traits.

Highest negative direct effect on green pod yield per plant was exhibited by days to first harvest followed by days to first fruit set and number of pods per cluster. Other traits had only negligible direct effect on green pod yield per plant. Similar results were obtained by Anburani and Shalini (2013) for negative direct effect of days to first harvest; Upadhyay and Mehta (2011) for number of pods per cluster. Number of primary branches had negative correlation with green pod yield per plant and negative direct effect on green pod yield per plant. It had positive indirect effect on green pod yield per plant through days to first flowering, pod length, pod girth, pod weight, number of harvests and crop duration.

Days to first flowering showed negative correlation and positive direct effect with green pod yield per plant. It had indirect positive effect on yield through number of pods per cluster, pod length, pod girth, number of harvests and duration of the crop. Similar result was reported by Noorjahan *et al.* (2019).

Days to first fruit set was negatively correlated with green pod yield per plant and showed negative direct effect. Indirect positive effect was observed through days to first flowering, number of pods per cluster, pod length, number of harvests and duration of the crop.

Days to first harvest had negative correlation and negative direct effect with green pod yield per plant. This is in line with the findings of Noorjahan *et al*. (2019). Indirect positive effect on yield was through days to first flowering, number of pods per cluster, pod length, number of harvests and duration of the crop.

Number of pods per cluster showed positive correlation and negative direct effect on yield. This emphasized the need for selection of number of pods per cluster through the traits *viz.*, days to first fruit set, days to first harvest, pod length, pod girth and number of pods per plant as it had indirect positive effect on yield.

Number of seeds per pod had positive correlation and positive direct effect on green pod yield per plant. It had indirect positive effect on yield through number of primary branches, days to first fruit set, days to first harvest, number of pods per cluster, pod girth, pod weight and number of harvests. Similar results on the positive effect of number of seeds per pod was reported by Chaitanya *et al.* (2014).

Pod length had positive correlation and negative direct effect on yield. Similar results were reported by Rai *et al*. (2009) and Chattopadhyay *et al*. (2010). It showed indirect positive effect on yield through number of primary branches, days to first fruit set, days to first harvest, number of pods per cluster, number of seeds per pod, pod girth, pod weight and number of harvests. Hence selection for high pod length has to be done through these traits.

Pod girth had positive correlation and negative direct effect on yield. It showed indirect positive effect on yield through number of primary branches, number of pods per cluster, pod length, pod weight and number of harvests.

Pod weight exhibited negative correlation and positive direct effect on yield. It also had indirect positive effect on yield through days to first fruit set, days to first harvest, number of pods per cluster, number of seeds per pod and number of harvests. Chaitanya *et al.* (2014) reported similar results.

Number of pods per plant showed positive correlation and direct positive effect on yield. Indirect positive effect on yield was through number of primary branches, days to first fruit set, days to first harvest, pod length, pod girth and crop duration. Similar result on the direct positive effect of the character on yield was reported by Chattopadhyay *et al.* (2010).

Number of harvests exhibited positive correlation and direct negative effect on yield. It also had indirect positive effect on yield through number of primary branches, days to first fruit set, days to first harvest, pod length, pod girth, number of pods per plant and duration of the crop.

Duration of the crop showed positive correlation and direct positive effect on yield. It had indirect positive effect on yield through days to first flowering, number of pods per cluster, pod length, pod girth and number of pods per plant. Similar results have not been reported so far.

Based on the above discussion, the traits *viz.*, number of pods per plant, days to first flowering, pod weight, number of seeds per pod and duration of the crop are the major contributors to green pod yield. Direct selection of accessions based on these traits will be highly rewarding for selecting accessions with high yield.

5.5. Genetic divergence

Genetic divergence studies allow us to evaluate the similar or divergent groups in a germplasm to identify combinations with greater heterozygosity to be used as parents in breeding programmes. Mahalanobis D^2 analysis is one of the tools used for measuring genetic divergence (Mahalanobis, 1936).

Twenty five accessions of dolichos bean were grouped into six clusters based on D^2 values. As the distance between the clusters increases the divergence between them also increases and as the distance between clusters decreases the divergence also decreases.

Highest mean value for green pod yield was in cluster V. Pod girth, pod weight and crude protein were also highest in this cluster. Calcium content was highest in cluster VI whereas, iron and phytic acid was highest in cluster II. Total phenols was highest in cluster IV whereas, fibre was highest in cluster I.

Intra cluster distance was maximum in cluster IV. Hence, greater heterogeneity existed among the accessions in this cluster. Intra cluster distance was minimum in cluster I. Hence, maximum homogeneity existed among the accessions in this cluster.

Inter cluster distance was maximum between cluster IV and cluster V followed by cluster I and cluster II. Hence, superior hybrids could be obtained by hybridization among the accessions present in these clusters. The accessions LP-7 and LP-9 were present in cluster IV; LP-32 in cluster V; LP-15, LP-27, LP-28 and LP-30 in cluster I; LP-11, LP-22, LP-31 and LP-33 in cluster II. Minimum inter cluster distance was between cluster III and cluster VI which suggested that low genetic divergence existed among the accessions present in cluster III and VI.

5.6. Selection criteria for dolichos bean accessions

Selection criteria is a better way to exploit genetic correlation which combines characters associated the most with yield. Twenty five dolichos bean accessions were scored based on the characters *viz*., green pod yield per plant (kg), number of pods per plant, pod weight (g), days to first flowering and overall acceptability of organoleptic evaluation. Based on the values of total score, the genotypes were ranked and the top ranking genotypes were found out.

The accession LP-28 was identified as the most superior one. It yielded 1.51 kg green pod per plant and produced 612.75 number of pods per plant on an average. It took 54.50 days for flowering and had a pod weight of 2.45 g. It was followed by LP-13 which yielded 1.38 kg per plant, produced an average of 309.00 pods per plant and had an average pod weight of 4.41g. The next superior accession was LP-12 which yielded 1.18 kg green pod per plant, produced 302.75 number of pods per plant with an average of 3.93g pod weight.

Using selection criteria technique indirect selection for the improvement of yield is possible. Hence it is an effective method for selection of promising genotypes from a population. The accessions LP-28, LP-13, LP-12, LP-2 and LP-35 were the most promising ones from the present study.

Summary

5. SUMMARY

The present study was carried out at the Department of Vegetable Science, College of Horticulture, Vellanikkara during September 2019- April 2020 with the objective of evaluating dolichos bean accessions to find out the superior ones with respect to yield and quality. The accessions collected were raised in randomized block design with two replications. Crop management practices were done as per "Package of Practices Recommendations- Crops (2016)" of Kerala Agricultural University (KAU). The salient findings of the study are summarized below.

Thirty dolichos bean accessions were catalogued based on "NBPGR Minimal Descriptor for Characterization and Evaluation of Agri-Horticultural crops (2000)". High variability was observed for all the morphological traits under study. Flower colour ranged from white to purple. Pod colour varied from light green, green, purple and green with red border. The accessions LP-11, LP-17 and LP-22 had purple pods. The purple colour in pods is associated with the pigments anthocyanins and pro-anthocyanidins which provides wide range of health benefits to human body by acting as antioxidants, immunostimulants and anticarcinogens. Pod shape varied from straight, intermediate to curved. Majority of the accessions had curved pods. Incidence of bacterial wilt was severe in five accessions and it accounted for 100 per cent loss in the accessions LP-1, LP-5, LP-6, LP-9 and LP-14.

Significant difference was observed for all the characters studied. Number of primary branches was highest in LP-22, followed by LP-8 and LP-15. Accessions *viz.*, LP-7, LP-2, LP-8 and LP-31 recorded lowest days to first flowering, days to first fruit set, days to first harvest and hence, were identified as early accessions.

LP-19 had the highest pod length whereas, pod girth and pod weight were highest in LP-32. Number of pods per plant was highest in LP-28, followed by LP-27 and LP-15. Green pod yield per plant was highest in LP-32 followed by LP-28, LP-13 and LP-30.

The accessions LP-2, LP-12, LP-32, LP-34 and LP-35 recorded high calcium and protein content. LP-11, LP-16 and LP-12 recorded high iron content. High fibre content was recorded in the accessions LP-10, LP- 27, LP-21 and LP-30 whereas, high phenol content was recorded in LP-19, LP-11 and LP-21. Low phytic acid was recorded in the accessions LP-27, LP-21 and LP-34. Phytic acid is of nutritional significance in humans as the phytate phosphorus is unavailable to the body and it lowers the availability of essential minerals such as iron, calcium and magnesium.

Genetic variability studies revealed high estimates of GCV and PCV for number of seeds per pod, pod length, pod girth, pod weight, number of pods per plant, total phenols and green pod yield per plant. Hence, there is high scope for improvement of these traits. In addition, a close association between GCV and PCV were observed which meant that the differences among the genotypes were due to their genetic makeup and environment had less effect on them. Hence phenotype is a true measure of genotype and selection could be practiced effectively.

Days to first flowering, days to first fruit set, number of pods per cluster, number of seeds per pod, number of pods per plant, pod length, pod girth, pod weight, green pod yield per plant, calcium, total phenols and crude fibre showed high heritability coupled with high genetic gain due to the presence of additive gene action and improvement of these traits is possible through selection.

Correlation studies revealed highly significant positive association of green pod yield with number of pods per plant, number of harvests, duration of the crop, calcium and crude protein content. Hence, improvement of these traits would improve yield. The accessions LP-2, LP-12, LP-34 and LP-35 recorded high yield along with high calcium and crude protein content.

Path coefficient analysis between yield and its component characters revealed that number of pods per plant, days to first flowering, pod weight, number of seeds per pod and duration of the crop exhibited direct positive effect on yield. Hence direct selection for these traits would improve yield. Accessions *viz.*, LP-32, LP-28, LP-7, LP-22, and LP-2 recorded high green pod yield per plant combined with pod weight and number of seeds per plant.

Genetic divergence analysis grouped the accessions into six clusters by using Mahalanobis D^2 analysis. Cluster VI had highest number of accessions (8) followed by cluster III (6). Cluster I and II had four accessions each. Intra cluster distance was maximum in cluster IV. Intra cluster distance was minimum in cluster I. Inter cluster distance was maximum between cluster IV and V. Minimum inter cluster distance was between clusters III and VI. Therefore, accessions could be selected from the clusters IV and V for hybridization programme.

Sensory qualities were evaluated based on nine point Hedonics scale. The accessions LP-31, LP-13 and LP-12 were superior in overall acceptability; LP-31, LP-3 and LP-12 were superior with respect to taste.

The characters such as green pod yield per plant, number of pods per plant, pod weight, days to first flowering and overall acceptability of sensory evaluation were used for fixing the selection criteria for dolichos bean. Based on this the accessions LP-28, LP-13, LP-12, LP-2 and LP-35 were identified as the most promising ones from the present study.

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EVALUATION OF DOLICHOS BEAN (*Lablab purpureus* (L.) Sweet.) ACCESSIONS (POLE TYPE) FOR YIELD AND QUALITY

By

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(2018-12-002)

ABSTRACT

Submitted in partial fulfilment of the
requirement for the degree of

MASTER OF SCIENCE IN HORTICULTURE

(VEGETABLE SCIENCE)

Faculty of Agriculture

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2020

Evaluation of Dolichos bean (*Lablab purpureus* (L.) Sweet) accessions (pole type) for yield and quality

Abstract

Dolichos bean (*Lablab purpureus* (L.) Sweet) is a multi-purpose crop cultivated in both tropical and sub-tropical conditions. The tender pods rich in protein, fibre, iron and calcium are used as vegetable and dried seeds as pulse. Tender leaves are cooked and consumed as vegetable. The pole types are photosensitive in nature preferring short days and comparatively cool season for flowering.

Despite of its multi-utility and multiple benefits, its cultivation is done in limited area only. Thus, there is a huge scope to expand cultivation to non-conventional regions which would assure nutritional and income security for the farmers. The efforts for genetic enhancement of this crop also has been limited.

In this context, the present study was undertaken with the objectives of determining the genetic variability, genetic divergence and character associations among dolichos bean accessions for yield and yield contributing traits and to evaluate the accessions for quality. The experiment was conducted at the Department of Vegetable Science, College of Horticulture, Vellanikkara during September 2019- April 2020.

The dolichos bean accessions were catalogued as per the NBPGR Minimal Descriptor for Characterization and Evaluation of Agri-Horticultural crops (2000). The flower colour varied from white to purple. The pod colour varied from light green, green to purple. Green pods with purple border were observed in LP-2, LP-12, LP-19, LP-31, LP-32 and LP-35. Purple pods were observed in LP-11, LP-17 and LP-22. The pod shape varied from straight, intermediate to curved. Based on the reaction to bacterial wilt disease, the accessions were categorized into susceptible and resistant. The accessions, LP-1, LP-5, LP-6, LP-9 and LP-14 were highly susceptible and showed 100 per cent bacterial wilt incidence.

The analysis of variance of the 25 accessions showed significant differences among them for all traits under study. Genetic parameters like GCV, PCV, heritability, GA and GAM were estimated to study the nature and extent of variability. High GCV, PCV, heritability and GAM were exhibited by the characters green pod yield/plant,

number of seeds/pod, pod length, pod girth, pod weight, number of pods/plant and total phenols which indicated the presence of high variability and additive gene action for these traits. Hence, these traits can be improved through selection. Quality traits *viz.*, iron, calcium, total phenols, and phytic acid exhibited close association between PCV and GCV. In addition, moderate to high heritability and GAM were observed indicating that phenotypic values were a true measure of the genotype and the improvement of these traits is possible through selection.

Green pod yield per plant was significantly, positively correlated with number of pods per plant, number of harvests, duration of the crop, calcium and crude protein. Further, green pod yield per plant was positively correlated with number of pods per cluster, pod length, pod weight and pod girth. However, these correlations were not significant which indicated their independent nature with respect to yield. Path coefficient analysis of yield and its component characters revealed that the highest direct positive effect on green pod yield per plant was exhibited by number of pods per plant followed by days to first flowering, pod weight, number of seeds per pod and duration of the crop. Hence direct selection of accessions based on these traits would improve yield. From the present study, accessions *viz.*, LP-2, LP-13 and LP-34 could be selected as promising ones based on these traits.

Twenty five accessions of dolichos bean were grouped into six clusters based on D^2 values. Cluster VI had highest number of accessions (8) followed by cluster III (6). Cluster I and II had four accessions each. There were two accessions in cluster IV and one accession in cluster V. Inter cluster distance was maximum between cluster IV and cluster V. Hence, superior hybrids could be obtained by hybridization among the accessions present in these clusters.

Sensory evaluation was conducted in the cooked pods to score the accessions based on their appearance, colour, flavour, texture, taste and overall acceptability. LP-31, LP-28 and LP-13 were superior in sensory qualities.

The selection criteria for dolichos bean was fixed by taking the characters such as green pod yield per plant, number of pods per plant, pod weight, days to first flowering and overall acceptability of sensory evaluation and the accessions LP-28, LP-13, LP-12, LP-2 and LP-35 were identified as the most promising ones based on this.

Appendices

APPENDIX- I

Abbreviations and units used

- NBPGR – National Bureau of Plant Genetic Resources
- IIVR – Indian Institute of Vegetable Research
- ICP-OES – Inductively Coupled Plasma Optical Emission Spectrometry
- GA – Genetic advance
- GAM – Genetic Advance as Percentage of Mean
- GV – Genotypic variance
- PV – Phenotypic Variance
- PCV – Phenotypic Coefficient of Variation
- GCV – Genotypic Coefficient of Variation

Units

- g : Grams
- kg : Kilograms
- % : Per cent
- ml : Milli liters
- cm : Centimetres
- m : Metres
- ^{o}C: Degree Celsius

APPENDIX-II

Monthly meteorological data during the crop period

Month	Temperature (^{0}C)		Relative Humidity (%)	Rainfall (mm)	Mean sunshine hours (hrs/day)
	Mean Maximum	Mean minimum			
September 2019	31.2	22.0	85	419.0	3.3
October 2019	32.4	21.4	80	418.4	5.5
November 2019	32.9	21.7	71	205.0	7.5
December 2019	32.3	22.1	63	4.4	6.7
January 2020	34.1	22.4	60	0	9.4
February 2020	35.5	23.2	54	0	9.5
March 2020	36.4	24.4	65	33.4	8.5
April 2020	36.4	24.7	71	44.7	8.1