GENETIC DIVERGENCE FOR POD QUALITY, YIELD AND YIELD ATTRIBUTES IN DOLICHOS BEAN (*Dolichos lablab* L. var. *typicus* Prain) GERMPLASM

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JULY, 2017

CERTIFICATE

Ms. K. JYOTHI REDDY has satisfactorily prosecuted the course of research and that the thesis entitled **"GENETIC DIVERGENCE FOR POD QUALITY, YIELD AND YIELD ATTRIBUTES IN DOLICHOS BEAN (*Dolichos lablab* L. var. *typicus* Prain) GERMPLASM"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any university.

Date: **(Dr. B.NEERAJA PRABHAKAR)**

Place: Hyderabad **Chairman**

CERTIFICATE

This is to certify that the thesis entitled **"GENETIC DIVERGENCE FOR POD QUALITY, YIELD AND YIELD ATTRIBUTES IN DOLICHOS BEAN (*Dolichos lablab* L. var. *typicus* Prain) GERMPLASM"** submitted in partial fulfillment of the requirements for the degree of **Master of Science in Horticulture (Vegetable Science)** of **Sri Konda Laxman Telangana State Horticultural University,** Rajendranagar, is a record of the bonafide research work carried out by **Ms. K. JYOTHI REDDY** under our guidance and supervision.

No part of thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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(K.JYOTHI REDDY)

DECLARATION

I, **K. JYOTHI REDDY** hereby declare that the thesis entitled "**GENETIC DIVERGENCE FOR POD QUALITY, YIELD AND YIELD ATTRIBUTES IN DOLICHOS BEAN (*Dolichos lablab* L. var. *typicus* Prain) GERMPLASM"** submitted to Sri Konda Laxman Telangana State Horticultural university, Rajendranagar, for the degree of Master of Science in Horticulture in the major field of Vegetable Science is the result of original research work done by me. I further declare that no material in the thesis or part there of has not been published earlier in any manner.

Date: **(K.JYOTHI REDDY)**

Place: Hyderabad **RHM/2015-07**

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LIST OF SYMBOLS AND ABBREVIATIONS

ANOVA	:	Analysis of variance
CD (p=0.05%)	:	Critical difference at 5 percent level
CD (p=0.01%)	:	Critical difference at 1 percent level
cm	:	centimeter
mm	:	millimeter
m	:	meter
ml	:	milliliter
m^2	:	meter square
et al.	:	and others
Fig.	:	Figure
g	:	gram
mg	:	milligram
LOS	:	Level of significance
Viz.	:	Namely
/	:	per
SD	:	Standard deviation
GCV	:	Genotypic coefficient of variation
PCV	:	Phenotypic coefficient of variation
ECV	:	Environmental coefficient of variation
GA	:	Genetic advance
FYM	:	Farm Yard Manure

GAM	:	Genetic advance as percent of mean
h^2b	:	Heritability in broad sense
df	:	Degrees of freedom
RBD	:	Randomized Block Design
%	:	Per cent
σ^2g	:	Genotypic variance
σ^2p	:	Phenotypic variance
No.	:	Number
MSS	:	Mean Sum of Squares
RSS	:	Replicated sum of squares
ESS	:	Error sum of squares
^oC	:	Degree Celsius
AOAC	:	Association of official analytical chemists
ARI	:	Agricultural Research Institute
NBPGR	:	National Bureau of Plant Genetic Resources
TV	:	Titre value
HCL	:	Hydrochloric acid
rg	:	Genotypic correlation
rp	:	Phenotypic correlation
NaOH	:	Sodium Hydroxide
H_2SO_4	:	Sulphuric Acid
S.E	:	Standard Error of mean

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ABSTRACT

A field experiment entitled "Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L.var. *typicus* Prain*)* germplasm" was carried out to study genetic divergence, genetic variability parameters and yield component analysis through correlation and path analysis. Thirty two genotypes of dolichos bean germplasm along with three checks were evaluated in Randomized Block Design with two replications, during August, 2016 to March, 2017 at Vegetable Research Station, ARI, Rajendranagar, Hyderabad with the objective to identify divergent genotypes and use as donor parents in hybridization programmes.

The analysis of variance revealed significant differences between genotypes indicating presence of sufficient amount of variability in all the 19 characters studied. Wide range of variability was observed for pod yield per plant (46487.040), vine length (15234.210) and number of pods per plant (2379.014) indicating the scope for selection of initial breeding material for further improvement.

On the basis of mean performance, genotype IC-546387 was found superior for pod yield per plant (805.23g), more number of pods per plant (175.66), vine length (462.17cm) and pod attributes like medium pod width (1.29cm) followed by IC-427428, which was found significantly superior over the check variety RND-1 with regard to pod yield per plant (667.07g), number of pods per plant (92.76), for earliness in days to first flowering (86.00), days to first pod harvest (104.50), and pod attributes like pod length (12.61cm), pod width (2.03cm) and protein content (24.76%).

Mahalanobis D^2 statistical analysis, revealed that pod yield per plant, fiber and protein content, number of pods per plant, days to last pod harvest, pod length, 100 dry seed weight, vine length, number of seeds per pod, seed length, 100 fresh seed weight and pod weight contributed towards genetic divergence and 35 genotypes were partitioned into six clusters based on Tocher's method. Maximum divergence was observed between cluster III and VI

(D^2=1780.19), while minimum was observed between cluster II and cluster IV (333.46). The maximum intra cluster distance was shown by cluster IV (D^2=249.64).

The clusters showing high genetic divergence could be effectively utilized in heterosis breeding programme. If a breeding programme is used at improving protein content, cluster II (PSRJ-13039) showing maximum protein content (25.09%) can be utilized in breeding programme.

GA as *per cent* of mean, GCV and PCV values were on par with each other for most of the characters which indicated that the influence of the environment on the trait (s) was very negligible. The recorded values were not influenced by the environment. It is a true reflection of the homeostasis effect or buffer reaction of the gene. Thus, the true reflection of the trait is exhibited.

A true agreement with the GCV and PCV values in the present investigation for the 19 characters was noticed, indicating additive genetic variance governing the high heritability with high genetic advance *as per cent* of mean. Thus, a breeder can employ a simple selection process which will be a rewarding one to improve the yield attributing characters and protein content. High heritability coupled with moderate genetic advance as percent of mean was observed for days to 50% flowering, days to first pod harvest and days to pod maturity. Moderate heritability coupled with moderate genetic advance as *per cent* of mean observed for number of primary branches per plant indicates non additive action controlling the traits.

From correlation studies, it was observed that pod yield per plant has exhibited highly significant and positive association with vine length (0.511), number of pods per plant (0.494), pod weight (0.485), seed breadth (0.389), seed length (0.349), 100 dry seed weight (0.325), primary branches per plant (0.291), days to 50 percent flowering (0.254), days to first flowering (0.244) and pod length (0.240).

Path analysis revealed that maximum positive direct effect on pod yield per plant was exhibited through pod weight (0.440) followed by protein content (0.235). Positive direct effect of primary branches per plant (0.229) on pod yield per plant was moderate.

Dolichos bean genotypes exhibited high variability for all qualitative traits *viz*., plant growth characters, leaf characters, flower characters, pod characters and seed characters. Therefore, it is emphasized to lay attention on the traits *viz*., number of pods per plant, pod weight, days to last pod harvest, pod length, protein content and less fiber content in crop improvement programme of dolichos bean in future.

Considering mean performance, heritability, variability, genetic advance as percent of mean and correlation analysis, two genotypes *i.e*. IC-427428 and IC-546387 were identified as best genotypes compared to check. Hence, these may be utilized for multilocation trials for further yield exploitations as they are attributed with high mean performance with many useful genes for majority of traits studied. They can also used in further breeding programmes and may be released as a variety after multi location trails.

CHAPTER-I

INTRODUCTION

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INTRODUCTION

Dolichos bean (*Dolichos lablab* L. var. *typicus* Prain) (2n=2x=22) belongs to family Leguminaceae sub-family Faboideae, tribe Phaseoleae and sub-tribe Phaseolinae which is commonly known as Indian bean, Hyacinth bean, sem, Egyptian kidney bean, bonavist bean, avarai and avari chikkudu is one of the most popular traditional vegetables extensively cultivated in India. Based on historical evidences, India is considered as origin and primary centre of diversity for dolichos bean and from there it was introduced to China, Western Asia and Egypt (Chaudhary, 1972).

In India, dolichos bean distributed in Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana, Tamil Nadu and North eastern states. It occupies a unique position among the legume vegetables with the consumption of the immature green pods as a vegetable and dry seed as a pulse. The crop prefers relatively cool season, starts flowering in August-September and fruiting in winter (October) and continues indeterminately in spring (February) (Savitha, 2008)

The pods are naturally rich in carbohydrates, proteins, fat and fibers, as well as minerals which include Ca, P and Fe (Naeem *et al.* 2009). The protein content of pods and seeds ranges from 10-19% and 15-25% respectively. Among the legumes, dolichos bean constituents an important source of therapeutic agents used in the modern as well as traditional system of medicine (Morris, 2009). In fact it is considered as a multipurpose crop since it is used for forage, soil improvement, soil protection and weed control (Mass, 2005). It is one of the major sources of protein in the dietary of working class especially of the southern part of India (Murphy, 1998). It is also an ideal crop to withstand long distance transportation.

It is potentially an herbaceous perennial but cultivated as an annual with bushy, erect or climbing races. The dry seeds are also used for various vegetable preparations and foliage of the crop provides hay, silage and green manures (Bose *et al.*, 1993). It is sensitive to photoperiodism and both short day and long day types are available and recently some day neutral types are also reported. It cannot with stand in waterlogged condition.

It is mostly a self pollinated crop.Despite many good attributes, the crop has remained unexploited owing to low productivity, long duration, photosensitivity and an indeterminate growth habit. There is no single variety/cultivar which has occupied a large area in Telangana .Only local types, traditional farmer collections and cultivars are being cultivated. The consumer preference also varies with respect to pod size, pod shape, pod color and aroma. The efforts of improving the crop by utilizing indigenous and exotic germplasm have been useful in breaking the yield barriers (Shivashankar *et al.*, 1993) resulting in developing compact plant type with reduced duration and photo-insensitivity. Hence, comprehensive germplasm evaluation by identification of suitable genotypes for pure crop is essential.

In any crop improvement programme, basic information with respect to variability present in the crop is essential. Yield being a complex trait, is collectively influenced by various component characters, which are polygenically inherited and highly influenced by environmental variations. The progress of breeding in bean depends on the nature, extent of genetic variability and also on magnitude and interrelationship of phenotypic and genotypic variation in yield and yield attributing characteristics. One of the main thrust in any crop improvement programme is to enhance yield.

Genetic variability, character association and path coefficient are pre-requisite for improvement of any crop for the selection of superior genotypes and improvement of any triats. It has also been observed in dolichos bean, the existence of a wide phenotypic variability which is represented at genetic level in a limited way (Mass, 2005 and Venkateshan *et al.*, 2007). Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character in future generations.

Knowledge of correlation between yield and its contributing characters are basic and for most endeavor to find out guide lines for plant selection. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective. There is a constant need to evaluate the germplasm to identify the genetically diverse lines with desirable characters.

D^2 analysis helps the breeders in grouping of genotypes possessing similar characters in different clusters and to identify genotypically diverse and desirable genotypes. Since wide genetic diversity exists with the bean for almost all the characters (Ismunadji and Arsyad 1990), there is a need for information on the nature and magnitude of the variation available in the materials and role played by the environment in expression of different characters.

Heritability of a metric character is a parameter of particular significance to the breeder as it measures the degree of resemblance between the parents and the off-springs and its magnitude indicates the efficacy with which a genotype can be identified by its phenotypic expression, while genetic advance aids in exercising the necessary selection pressure (Burton *et al*., 1953).

The correlation analysis is a biometrical technique to find out the nature and degree of association between various morphological traits indicating yield, while path coefficient analysis splits the correlation coefficient into direct and indirect effects so as to measure the relative contribution of each variable towards the yield (Al- Jibouri *et al.*, 1958).

Keeping in view of the above facts, the present investigation entitled **"Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L. var. *typicus* Prain) germplasm"** was carried out at Vegetable Research Station, Rajendranagar Hyderabad with following objectives:

1. To study genetic divergence in Dolichos bean germplasm.
2. To investigate variability parameters.
3. To study correlation of yield and yield attributes.
4. To assess path coefficient of yield and yield parameters

CHAPTER-II

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

The literature related to the present study entitled **"Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L. var. *typicus* Prain) germplasm"** on genetic variability, genetic diversity, character association and character contribution in dolichos bean has been reviewed and presented under the following headings.

2.1 GENETIC DIVERGENCE

2.2 GENETIC VARIABILITY AND GENETIC PARAMETERS

2.3 CHARACTER ASSOCIATIONS

2.4 PATH COEFFICIENT ANALYSIS

2.5 QUALITATIVE TRAITS

2.1 GENETIC DIVERGENCE

Genetic improvement in any crop mainly depends upon the amount of genetic variability present in the population. The importance of genetic diversity in crop plants was first realized by Darwin (1859) and the term "morphism" employing genetic morphs was given by Huxley (1955) which means the existence of distinct genetic forms in balance in a population. Mahalanobis D^2 statistics is a powerful tool in quantifying the degree of divergence between biological populations at genetic level and provides a quantitative measure of association between geographic and genetic diversity based on generalized distance (Mahalanobis, 1936).

Estimation of degree of divergence between populations and contribution of different characters to total divergence is done by Mahalanobis D^2 statistic (Maurya and Singh, 1977) which is a more reliable method in selection of parents for hybridization programme.

A brief review of studies on genetic divergence in dolichos bean is presented here under Table 2.1

2.2 GENETIC VARIABILITY AND GENETIC PARAMETERS

2.2.1 Genetic variability

Knowledge on the nature and magnitude of genotypic and phenotypic variability present in any crop species plays a vital role in formulating successful breeding programme for evolving superior cultivars. It is essential to partition the overall variability into heritable and non heritable components. Genetic parameter like phenotypic and genotypic coefficient of variation enables isolation of superior genotypes by selection if considerable genetic variation exists within the population.

2.2.2 Genetic parameters

2.2.2.1 Heritability

Heritability is the measure of transmission of characters from generation to generation. Hanson *et al*. (1956) defined heritability in broad sense, as the ratio of genotypic variance to the total phenotypic variance in the non-segregating populations. Heritability (h^2) measures the relative amount of the heritable portion of variability.

2.2.2.2 Genetic Advance as percent of mean

It is a measure of genetic gain under selection. Genetic advance is defined as the difference between the mean genotypic value of the selected lines and the mean genotypic value of the parental population. The genetic advance is usually expressed as percentage of mean.

The available literature on genetic variability and genetic parameters is summarized and presented in Table 2.2

2.3 ASSOCIATION OF YIELD AND COMPONENTS

Correlation studies are useful in developing an effective basis of phenotypic selection in plant population. Study of character association has considerable use in plant breeding because selection for one character may bring about simultaneous effect on other, depending on the intensity of association between the two traits under consideration. A knowledge of genetic correlation among the characters contributing to the yield leads to the most effective method of selection. By this way combination of favourable characters could be brought out by minimizing the effect of antagonistic relations.

Yield component characters exhibits association among themselves and with yield. Unfavorable associations between the desired attributes under selection may limit genetic advance. Hence, study of association of component characters with yield would aid in planning of an effective selection programme. Hence brief review of literature on association is presented in Table 2.3.1

Table 2.3.1 Review of literature on the association of yield component characters with pod yield in dolichos bean

Character	**Positive association**	**Negative association**
Vine length (cm)	Singh *et al*. (2015)	Pawar and prajapathi (2013) Magalingam *et al.* (2013) Gadakh *et al.* (2016)
Number of primary branches per plant	Pawar and prajapathi *et al.* (2013) Magalingam *et al.* (2013)	Gadakh *et al.* (2016)
Days to first flowering	Salim *et al.* (2013) Gadakh *et al*. (2016)	Singh *et al*. (2011) Chaitanya *et al*. (2014) Verma *et al*. (2015)
Days to 50%flowering	Pawar and prajapathi (2013)	Chaitanya *et al*. (2014)

Contd....

Character	Positive association	Negative association
Days to 50%flowering	Magalingam *et al.* (2013) Sharma *et al*. (2014) Verma *et al*. (2015)	
Days to first pod harvest	Singh *et al*. (2011) Chaitanya *et al*. (2014)	
Days to first pod harvest	Sharma *et al*. (2014) Singh *et al*. (2015)	
Days to last pod harvest	Chaitanya *et al.* (2014) Verma *et al*. (2015)	
Days to pod maturity		Magalingam *et al.* (2013) Pawar and prajapathi (2013) Singh *et al.* (2015)
Pod length (cm)	Patel *et al*. (2011) Singh *et al*. (2011) Upadhyay *et al*. (2012) Salim *et al.* (2013)	Magalingam *et al.* (2013) Pawar and prajapathi (2013) Chaitanya *et al.*(2014) Savitha *et al*. (2014) Sharma *et al*. (2014) Singh *et al*. (2015)
Pod width (cm)	Singh *et al*. (2011) Parmar *et al*. (2013) Singh *et al*. (2015)	Patel *et al*. (2011) Upadhyay *et al*. (2012) Magalingam *et al.* (2013) Chaitanya *et al.* (2014) Sharma *et al*. (2014)
Pod weight (g)	Magalingam *et al.* (2013) Chaitanya *et al.* (2014)	
Seed length (mm)		Singh *et al.* (2011)
Seed breadth (mm)	Singh *et al.* (2011)	

Contd....

Character	Positive association	Negative association
Number of seeds per pod	Singh *et al*. (2011) Salim *et al.* (2013) Pawar and prajapathi (2013) Chaitanya *et al.* (2014) Singh *et al*. (2015) Gadakh *et al*. (2016)	Upadhyay *et al*. (2012) Sharma *et al*. (2014)
Number of pods per plant	Patel *et al*. (2011) Magalingam *et al.* (2013)	
	Pawar and prajapathi (2013) Chaitanya *et al.* (2014) Verma *et al*. (2015) Gadakh *et al*. (2016)	
100 seed weight (g)	Patel *et al*. (2011) Salim *et al.* (2013) Chaitanya *et al.* (2014) Verma *et al*. (2015) Gadakh *et al*. (2016)	Singh *et al*. (2011)
Protein content (%)	Magalingam *et al.* (2013) Pawar and prajapathi (2013) Gadakh *et al*. (2016)	Chaitanya *et al.* (2014) Verma *et al.* (2015)
Fiber content (%)	Magalingam *et al.* (2013)	

Yield components exhibits association with other yield component characters. Hence, study of association of yield component characters on other yield component characters which contributes effective yield and their association helps in planning of an effective selection programme. Hence brief review of literature on association of yield components on other yield component characters contributing yield are presented in the Table 2.3.2

Table 2.3.2 Review of literature on the association among the yield component characters with pod yield in dolichos bean

Vine length with		
Character	**Positive association**	**Negative association**
Number of primary branches per plant	Magalingam *et al.* (2013) Gadakh *et al.* (2016)	Pawar and Prajapathi (2013)
Days to first flowering		Gadakh *et al.* (2016)
Days to 50 per cent flowering		Singh *et al.* (2015)
Days to first pod harvest	---	Singh *et al.* (2015)
Days to pod maturity	Singh *et al.* (2015) Gadakh *et al.* (2016)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013)
Pod length (cm)	Pawar and Prajapathi (2013) Singh *et al.* (2015)	Magalingam *et al.* (2013)
Number of seeds per pod		Pawar and Prajapathi (2013) Singh *et al.* (2015) Gadakh *et al.* (2016)
100 seed weight (g)	Gadakh *et al.* (2016)	Pawar and Prajapathi (2013)
Protein content (%)	Magalingam *et al.* (2013)	Gadakh *et al.* (2016)

Contd....

Character	Positive association	Negative association
Protein content (%)	Pawar and Prajapathi (2013)	
Fiber content (%)	Magalingam *et al.* (2013)	
Number of primary branches per plant		
Vine length (cm)	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)	
Days to first flowering	Gadakh *et al.* (2016)	
Days to pod maturity	Magalingam *et al.* (2013)	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
Pod length (cm)	Pawar and Prajapathi (2013)	Magalingam *et al.* (2013)
Pod width (cm)	Magalingam *et al.* (2013)	
Number of seeds per pod	Gadakh *et al.*(2016)	Pawar and Prajapathi (2013)
Number of pods per plant	Pawar and Prajapathi (2013)	Magalingam *et al.* (2013) Gadakh *et al.* (2016)
100 seed weight (g)	Pawar and Prajapathi (2013)	Gadakh *et al.* (2016)
Protein content (%)	Gadakh *et al.* (2016)	Magalingam *et al.* (2013)
Fiber content (%)	Magalingam *et al.* (2013)	
Days to first flowering		
Vine length (cm)	Gadakh *et al.* (2016)	
Number of primary branches per plant		Gadakh *et al.* (2016)

Contd....

Character	**Positive association**	**Negative association**
Days to 50% flowering	Sharma *et al.* (2014)	Salim *et al.* (2013) Chaitanya *et al.* (2014) Verma *et al.* (2015)
Days to last pod harvest	Chaitanya *et al.* (2014) Verma *et al.* (2015)	
Pod length (cm)	Singh *et al.* (2011) Chaitanya *et al.* (2014) Sharma *et al.* (2014)	Salim *et al.* (2013)
Pod width (cm)	Singh *et al.* (2011) Chaitanya *et al.* (2014) Sharma *et al.* (2014)	
Pod weight (g)		Chaitanya *et al.* (2014)
Days to pod maturity	Gadakh *et al.* (2016)	
Number of pods per plant	Salim *et al.* (2013)	
	Chaitanya *et al.* (2014) Verma *et al.* (2015)	Singh *et al.* (2011)
Seed length(mm)	Singh *et al.* (2011)	------
Seed width(mm)	Singh *et al.* (2011)	--------
100 seed weight (g)	Singh *et al.* (2011) Verma *et al.* (2015) Gadakh *et al.* (2016)	Salim *et al.* (2013) Chaitanya *et al.* (2014)
Protein content (%)		Chaitanya *et al.* (2014) Verma *et al.* (2015)
Days to 50% flowering		
Vine length (cm)		Magalingam *et al.* (2013) Pawar and Prajapathi (2013)

Character	**Positive association**	**Negative association**
Days to first flowering	Sharma *et al* .(2014) Verma *et al.* (2015)	
Days to first pod harvest	Sharma *et al.* (2014) Singh *et al.* (2015)	Chaitanya *et al.* (2014)
Days to last pod harvest	Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Days to pod maturity	Pawar and Prajapathi (2013) Singh *et al.* (2015)	
Pod length (cm)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013) Chaitanya *et al.* (2014)	Salim *et al.* (2013) Sharma *et al.* (2014) Singh *et al.* (2015)
Pod width (cm)	Magalingam *et al.* (2013) Chaitanya *et al.* (2014)	Singh *et al.* (2015)
Pod weight (g)		Chaitanya *et al.* (2014)
Number of pods per plant	Salim *et al.* (2013) Magalingam *et al.* (2013) Pawar and Prajapathi (2013) Chaitanya *et al.* (2014) Singh *et al.* (2015)	Verma *et al.* (2015)
No. of seeds per pod	Chaitanya *et al.* (2014) Singh *et al.* (2015)	Pawar and Prajapathi (2013) Salim *et al.* (2013) Sharma *et al.* (2014)
100 seed weight (g)		Salim *et al.* (2013)

Contd....

Character	Positive association	Negative association
100 seed weight (g)		Pawar and Prajapathi (2013) Verma *et al.* (2015)
Protein content (%)	Chaitanya *et al.* (2014)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013) Verma *et al.* (2015)
Fiber content (%)	Magalingam *et al.* (2013)	
Days to first pod harvest		
Vine length (cm)		Singh *et al.* (2015)
Days to first flowering	Singh *et al.* (2011)	Salim *et al.* (2013)
Days to first flowering	Chaitanya *et al.* (2014) Sharma *et al.* (2014) Verma *et al.* (2015)	Savitha *et al.* (2014)
Days to 50%flowering	Sharma *et al.* (2014) Chaitanya *et al.* (2014) Singh *et al.* (2015) Verma *et al.* (2015)	
Days to last pod harvest		Chaitanya *et al.* (2014) Verma *et al.* (2015)
Days to pod maturity		Singh *et al.* (2015)
Pod length (cm)	Sharma *et al.* (2014)	Singh *et al* .(2011) Salim *et al.* (2013) Chaitanya *et al.* (2014) Singh *et al.* (2015)
Pod width (cm)	Sharma *et al.* (2014)	Singh *et al.* (2011) Chaitanya *et al.* (2014) Singh *et al.* (2015)

Contd....

Character	**Positive association**	**Negative association**
Pod weight(g)		Chaitanya *et al.* (2014)
Seed breadth (mm)		Singh *et al.* (2011)
Number of pods per plant	Singh *et al.* (2011) Salim *et al.* (2013) Singh *et al.* (2015)	Chaitanya *et al.* (2014) Verma *et al.* (2015)
No. of seeds per pod	Sharma *et al.* (2014) Singh *et al.* (2015)	Singh *et al.* (2011) Salim *et al.* (2013)
100 seed weight (g)	Chaitanya *et al.* (2014)	Singh *et al.* (2011) Salim *et al.* (2013) Verma *et al.* (2015)
Protein content (%)	Chaitanya *et al.* (2014) Verma *et al.* (2015)	
Days to last pod harvest		
Days to first flowering	Verma *et al.* (2015)	Chaitanya *et al.* (2014)
Days to 50% flowering	Verma *et al.* (2015)	Chaitanya *et al.* (2014)
No. of pods per plant		Verma *et al.* (2015)
Days to first pod harvest	Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Pod length (cm)	Chaitanya *et al.* (2014)	Savitha *et al.* (2014)
Pod width (cm)	Chaitanya *et al.* (2014)	
Pod weight (g)	Chaitanya *et al* .(2014)	
Number of seeds per pod	Chaitanya *et al.* (2014)	
Number of pods per plant	Chaitanya *et al.* (2014)	
100 seed weight (g)	Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Protein content (%)	Chaitanya *et al.* (2014) Verma *et al.* (2015)	
Days to pod maturity		
Plant height (cm)	Gadakh *et al.* (2016)	Magalingam *et al.* (2013)

Contd....

Character	Positive association	Negative association
Plant height (cm)		Singh *et al.* (2015)
No. of primary branches per plant	Pawar and Prajapathi (2013)	Magalingam *et al.* (2013) Gadakh *et al.* (2016)
Days to first flowering		Gadakh *et al.* (2016)
Days to 50%flowering	Singh *et al.* (2015)	
Days to first pod harvest	Singh *et al.* (2015)	
Pod length (cm)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013)	Singh *et al.* (2015)
Pod width (cm)	Magalingam *et al.* (2013)	Singh *et al.* (2015)
No. of pods per plant	Magalingam *et al.* (2013) Pawar and Prajapathi (2013) Singh *et al.* (2015)	Gadakh *et al.* (2016)
No. of seeds per pod	Singh *et al.* (2015)	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
100 seed weight (g)		Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
Protein content (%)	Pawar and Prajapathi (2013)	Magalingam *et al.* (2013)
Protein content (%)		Gadakh *et al.* (2016)
Fiber content (%)		Magalingam *et al.* (2013)
Pod length (cm)		
Vine length (cm)	Pawar and Prajapathi (2013)	Magalingam *et al.*(2013)

Contd....

Character	Positive association	Negative association
Vine length (cm)		Singh *et al.* (2015)
No.of primary branches per plant	Magalingam *et al.* (2013)	Pawar and Prajapathi (2013)
Days to 50%flowering	Chaitanya *et al.* (2014) Sharma *et al.* (2014) Singh *et al.* (2015)	Salim *et al.* (2013)
Days to last pod harvest		Chaitanya *et al.* (2014)
Days to pod maturity	Pawar and Prajapathi (2013)	Singh *et al.* (2015)
Pod width (cm)	Patel *et al.* (2011) Singh *et al.* (2011) Chaitanya *et al.* (2014) Sharma *et al.* (2014) Singh *et al.* (2015)	Upadhyay *et al.* (2012) Magalingam *et al.* (2013)
Pod weight (g)		Chaitanya *et al.*(2014)
No. of seeds per pod	Singh *et al.*(2011) Pawar and Prajapathi (2013) Salim *et al.* (2013)	Upadhyay *et al.* (2012)
No. of seeds per pod	Singh *et al.* (2015)	Chaitanya *et al.* (2014) Sharma *et al.* (2014)
100 seed weight (g)	Patel *et al.* (2011) Singh *et al.* (2011) Pawar and Prajapathi (2013) Salim *et al.* (2013)	Upadhyay *et al.* (2012) Chaitanya *et al.* (2014)
Seed length (mm)	Singh *et al.* (2011)	
Seed breadth (mm)	Singh *et al.* (2011)	

Contd....

Character	Positive association	Negative association
Protein content (%)		Magalingam *et al.* (2013) Chaitanya *et al.* (2014)
Pod width (cm)		
Vine length (cm)		Magalingam *et al.* (2013) Singh *et al.* (2015)
Number of primary branches per plant		Golani *et al.* (2007) Magalingam *et al.* (2013)
Days to first flowering	Chaitanya *et al.* (2014) Sharma *et al.* (2014)	Singh *et al.* (2011)
Days to 50% flowering	Chaitanya *et al.* (2014) Sharma *et al.* (2014)	Singh *et al.* (2015)
Days to first pod harvest	Chaitanya *et al.* (2014) Sharma *et al.* (2014)	Singh *et al.* (2011) Singh *et al.* (2015)
Days to last pod harvest		Chaitanya *et al.* (2014)
Days to pod maturity	Magalingam *et al.* (2013) Singh *et al.* (2015)	
Pod length (cm)	Singh *et al.* (2011) Upadhyay *et al.* (2012) Magalingam *et al.* (2013) Sharma *et al.* (2014) Singh *et al.* (2015)	Patel *et al.* (2011) Chaitanya *et al.* (2014)
Pod weight(g)	Chaitanya *et al.* (2014)	
100 seed weight (g)	Patel *et al.* (2011) Upadhyay *et al.* (2012) Chaitanya *et al.* (2014)	Singh *et al.* (2011)
Number of pods per plant	Singh *et al.* (2011)	Singh *et al.* (2011)

Contd....

Character	Positive association	Negative association
Number of pods per plant	Singh *et al.* (2015)	Magalingam *et al.* (2013) Chaitanya *et al.* (2014)
Number of seeds per pod	Singh *et al.* (2011) Upadhyay *et al.* (2012) Chaitanya *et al.* (2014)	
Seed length (mm)	Singh *et al.* (2011)	
Seed width (mm)	Singh *et al.* (2011)	
Protein content (%)		Magalingam *et al.* (2013) Chaitanya *et al.* (2014)
Fiber content (%)		Magalingam *et al.* (2013)
Pod weight		
Vine length (cm)		Magalingam *et al.* (2013)
No. of primary branches per plant		Magalingam *et al.* (2013)
Days to first flowering	Chaitanya *et al.* (2014)	
Days to 50% flowering	Chaitanya *et al.* (2014)	Chattopadyay and Dutta (2010) Magalingam *et al.* (2013)
Days to first pod harvest		Chaitanya *et al.* (2014)
Days to last pod harvest	Chaitanya *et al.* (2014)	
Days to pod maturity	Magalingam *et al.* (2013)	
Pod length (cm)	Chaitanya *et al.* (2014)	Magalingam *et al.* (2013)
Pod width (cm)		Magalingam *et al.* (2013)
Pod width (cm)		Chaitanya *et al.* (2014)
100 seed weight (g)	Chaitanya *et al.* (2014)	
Number of pods per plant		Magalingam *et al.* (2013) Chaitanya *et al.* (2014)

Contd....

Character	**Positive association**	**Negative association**
Number of seeds per pod	Chaitanya *et al.* (2014)	
Protein content (%)	Chaitanya *et al.* (2014)	Magalingam *et al.* (2013)
Fiber content (%)	Magalingam *et al.* (2013)	
Number of pods per plant		
Vine length (cm)	Magalingam *et al.* (2013)	Pawar and Prajapathi (2013) Singh *et al.* (2015) Gadakh *et al.* (2016)
Number of primary branches per plant	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)	Magalingam *et al.* (2013)
Days to first flowering	Singh *et al.* (2011) Salim *et al.* (2013) Gadakh *et al.* (2016)	Chaitanya *et al.* (2014) Verma *et al.* (2015)
Days to last pod harvest	Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Days to 50% flowering	Salim *et al.* (2013) Singh *et al.* (2015)	Chaitanya *et al.* (2014) Verma *et al.*(2015)
Days to first pod harvest	Singh *et al.* (2011) Singh *et al.* (2015)	Chaitanya *et al.* (2014) Savitha *et al.* (2014) Verma *et al.* (2015)
Days to pod maturity	Savitha *et al.* (2014) Gadakh *et al.* (2016)	Magalingam *et al.* (2013) Verma *et al.* (2015)
Days to pod maturity		Pawar and Prajapathi (2013) Singh *et al.* (2015)
Pod length (cm)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013)	Singh *et al.* (2011) Salim *et al.* (2013)

Contd....

Character	Positive association	Negative association
Pod width(cm)	Patel *et al.* (2011) Magalingam *et al.* (2013) Chaitanya *et al.* (2014) Singh *et al.* (2015)	
Pod weight (g)		Chaitanya *et al.* (2014)
100 seed weight (g)	Verma *et al.* (2015) Gadakh *et al.* (2016)	Patel *et al.* (2011) Singh *et al.* (2011) Pawar and Prajapathi (2013) Salim *et al.* (2013) Chaitanya *et al.* (2014)
Number of seeds per pod	Singh *et al.* (2011) Chaitanya *et al.* (2014) Singh *et al.* (2015)	Pawar and Prajapathi (2013) Salim *et al.* (2013) Gadakh *et al.* (2016)
Seed length (mm)	Singh *et al.* (2011)	
Seed breadth (mm)		Singh *et al.* (2011)
Protein content (%)	Chaitanya *et al.* (2014)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013) Verma *et al.* (2015)
Fiber content (%)		Magalingam *et al.* (2013)
Number of seeds per pod		
Vine length (cm)	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)	Singh *et al.* (2015)

Contd....

Character	**Positive association**	**Negative association**
Number of primary branches per plant		Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
Days to first flowering	Singh *et al.* (2011) Sharma *et al.* (2014)	Salim *et al.*(2013) Chaitanya *et al.* (2014)
Days to 50% flowering	Sharma *et al.* (2014) Singh *et al.* (2015)	Salim *et al.* (2013) Chaitanya *et al.* (2014)
Days to first pod harvest	Singh *et al.* (2011) Sharma *et al.* (2014) Singh *et al.* (2015)	Chaitanya *et al.* (2014)
Days to last pod harvest	Chaitanya *et al.* (2014)	
Days to pod maturity	Pawar and Prajapathi (2013)	Singh *et al.* (2015) Gadakh *et al.* (2016)
Pod length (cm)	Upadhyay *et al.* (2012) Salim *et al.* (2013) Chaitanya *et al.* (2014) Sharma *et al.* (2014)	Singh *et al.* (2011) Pawar and Prajapathi (2013) Singh *et al.* (2015)
Pod width(cm)	Upadhyay *et al.* (2012) Sharma *et al.* (2014)	Singh *et al.* (2011) Chaitanya *et al.* (2014) Singh *et al.* (2015)
Pod weight (g)	Chaitanya *et al.* (2014)	
100 seed weight (g)		Singh *et al.*(2011)
100 seed weight (g)	Chaitanya *et al.* (2014) Gadakh *et al.* (2016)	Upadhyay *et al.* (2012)

Contd....

Character	Positive association	Negative association
Number of pods per plant	Chaitanya *et al.* (2014) Singh *et al.* (2015)	Singh *et al.* (2011) Pawar and Prajapathi (2013) Salim *et al.* (2013)
Seed length (mm)		Singh *et al.* (2011)
Seed breadth (mm)		Singh *et al.* (2011)
Protein content (%)	Pawar and Prajapathi (2013) Chaitanya *et al.* (2014) Gadakh *et al.* (2016)	
Seed length (mm)		
Days to first flowering		Singh *et al.*(2011)
Days to first pod harvest	Singh *et al.* (2011)	
Number of pods per plant	Singh *et al.* (2011)	
Pod length (cm)	Singh *et al.* (2011)	
Pod width (cm)	Singh *et al.* (2011)	
No. of seeds per pod	Singh *et al.* (2011)	
Seed breadth (mm)	Singh *et al.* (2011)	
100 seed weight (g)	Singh *et al.* (2011)	
Seed breadth (mm)		
Days to first flowering		Singh *et al.* (2011)
Days to first pod harvest		Singh *et al.* (2011)
Number of pods per plant		Singh *et al.* (2011)
Pod length (cm)	Singh *et al.* (2011)	
Pod width (cm)	Singh *et al.* (2011)	
No. of seeds per pod	Singh *et al.* (2011)	

Contd....

Character	Positive association	Negative association
Seed length	Singh *et al.* (2011)	
100 seed weight (g)	Singh *et al.* (2011)	
100 seed weight (g)		
Vine length (cm)	Pawar and Prajapathi (2013)	Gadakh *et al.*(2016)
Number of primary branches per plant	Gadakh *et al.* (2016)	
Days to first flowering	Singh *et al.* (2011) Salim *et al.* (2013) Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Days to 50% flowering	Chaitanya *et al.* (2014)	Salim *et al.* (2013) Verma *et al.* (2015)
Days to first pod harvest	Singh *et al.* (2011) Chaitanya *et al.* (2014)	Verma *et al.* (2015)
Days to last pod harvest	Chaitanya *et al.* (2014) Verma *et al.* (2015)	
Days to pod maturity	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)	
Pod length (cm)	Patel *et al.*(2011) Upadhyay *et al.* (2012) Salim *et al.* (2013) Chaitanya *et al.* (2014)	Singh *et al.* (2011) Pawar and Prajapathi (2013)
Pod width(cm)	Chaitanya *et al.* (2014)	Singh *et al.* (2011) Patel *et al.* (2011) Upadhyay *et al.* (2012)
Pod weight (g)	Chaitanya *et al.* (2014)	

Contd....

Character	**Positive association**	**Negative association**
Number of seeds per pod	Pawar and Prajapathi (2013)	Singh *et al.* (2011) Upadhyay *et al.* (2012)
Number of seeds per pod	Salim *et al.* (2013) Chaitanya *et al.* (2014)	Gadakh *et al.* (2016)
Number of pods per plant	Singh *et al.* (2011) Verma *et al.* (2015) Gadakh *et al.* (2016)	Pawar and Prajapathi (2013) Salim *et al.* (2013) Chaitanya *et al.* (2014)
Seed length		Singh *et al.* (2011)
Seed width		Singh *et al.* (2011)
Protein content (%)	Chaitanya *et al.* (2014)	Verma *et al.* (2015) Gadakh *et al.* (2016)
Protein content (%)		
Vine length (cm)	Gadakh *et al.* (2016)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013)
No. of primary branches per plant	Pawar and Prajapathi (2013)	Magalingam *et al.* (2013)
No. of primary branches per plant		Gadakh *et al.* (2016)
Days to first flowering	Salim *et al.* (2013)	Chaitanya *et al.* (2014) Verma *et al.* (2015) Gadakh *et al.* (2016)
Days to 50% flowering		Verma *et al.* (2015) Chaitanya *et al.* (2014)
Days to first pod harvest		Chaitanya *et al.* (2014) Verma *et al.* (2015)

Contd....

Character	Positive association	Negative association
Days to last pod harvest	Verma *et al.* (2015)	Chaitanya *et al.* (2014)
Days to pod maturity		Magalingam *et al.* (2013)
Days to pod maturity		Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
Pod length (cm)	Magalingam *et al.* (2013) Pawar and Prajapathi (2013)	Chattopadyay and Dutta (2010) Chaitanya *et al.* (2014)
Pod width(cm)	Chattopadyay and Dutta (2010) Magalingam *et al.* (2013)	Chaitanya *et al.*(2014)
Pod weight (g)		Chaitanya *et al.* (2014)
Number of seeds per pod	Pawar and Prajapathi (2013) Gadakh *et al.* (2016)	Chaitanya *et al.* (2014)
Number of pods per plant	Verma *et al.* (2015)	Magalingam *et al.* (2013) Chaitanya *et al.* (2014) Pawar and Prajapathi (2013) Gadakh *et al.* (2016)
100 seed weight	Verma *et al.* (2015)	Chaitanya *et al.* (2014) Gadakh *et al.* (2016)
Fiber content	Magalingam *et al.* (2013)	
Fiber content (%)		
Vine length (cm)		Magalingam *et al.* (2013)
No. of branches per plant	Magalingam *et al.* (2013)	
Days to pod maturity		Magalingam *et al.* (2013)

Character	Positive association	Negative association
Pod length (cm)	Magalingam *et al.* (2013)	
Pod width(cm)	Magalingam *et al.* (2013)	
Protein content (%)	Magalingam *et al.* (2013)	

2.4 PATH COEFFICIENT ANALYSIS

Yield being a complex polygenic character, direct selection may not be a reliable approach on account of being highly influenced by environmental factors. Therefore, it becomes essential to identify the component characters through which yield improvement could be obtained. Though correlations give information about the components of a complex character like yield, but it could not provide an exact picture of relative importance of the direct and indirect contributions of the component characters to yield. In this context, path coefficient analysis is an important method in partitioning the correlation coefficients into direct and indirect effects of an independent variable on dependence variable. Thus, correlation in conjunction with path analysis would give a better insight into cause and effect relationship between different pairs of characters (Wright, 1921).

Path coefficient is simply a standardized partial regression coefficient and as such, measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects (Dewey and Lu, 1959). The review of literature on direct and indirect effects of yield contributing characters on yield in dolichos bean is summarized and presented in Tables 2.4.1 and 2.4.2.

Tables 2.4.1 Review of literature on direct effects of yield contributing characters on marketable pod yield in dolichos bean

Character	Degree and direction of direct effect	Reference
Vine length (cm)	-0.51(H)	Magalingam *et al.* (2013)
	0.10(L)	Singh *et al.* (2015)

Contd....

Character	**Degree and direction of direct effect**	**Reference**
	-0.29(M)	Gadakh *et al.* (2016)
Number of primary branches per plant	0.65(H)	Magalingam *et al.* (2013)
	0.09(N)	Pawar and Prajapathi (2013)
	-0.42(H)	Gadakh *et al.* (2016)
Days to first flowering	-0.19(L)	Singh *et al.* (2011)
	0.04(N)	Salim *et al.* (2013)
	-1.09(VH)	Chaitanya *et al.* (2014)
	-0.67(H)	Verma *et al.* (2015)
Days to 50% flowering	1.20(VH)	Magalingam *et al.* (2013)
	0.30(H)	Pawar and Prajapathi (2013)
	-0.224(M)	Chaitanya *et al.* (2014)
	0.83(H)	Sharma *et al.* (2014)
	0.91(H)	Singh *et al.* (2015)
Days to pod maturity	-1.05(VH)	Magalingam *et al.* (2013)
	-0.58(H)	Pawar and Prajapathi (2013)
	-0.92(H)	Singh *et al.* (2015)
Days to first pod harvest	0.07(N)	Singh *et al.* (2011)
	1.28(VH)	Chaitanya *et al.* (2014)
	1.14(VH)	Sharma *et al.* (2014)
	0.38(H)	Verma *et al.* (2015)
Days to last pod harvest	0.14(L)	Chaitanya *et al.* (2014)
	0.39(H)	Verma *et al.* (2015)
Pod length (cm)	0.17(L)	Patel *et al.* (2011)
	0.11(L)	Singh *et al.* (2011)

Contd....

Character	Degree and direction of direct effect	Reference
Pod length (cm)	-0.76(H)	Magalingam *et al.* (2013)
	-0.74(H)	Pawar and Prajapathi (2013)
	-0.13(L)	Chaitanya *et al.* (2014)
	-1.30(VH)	Sharma *et al.* (2014)
Pod width (cm)	-0.07(N)	Patel *et al.* (2011)
	0.23(M)	Singh *et al.* (2011)
	-0.24(M)	Magalingam *et al.* (2013)
	-1.52(VH)	Sharma *et al.* (2014)
	0.20(M)	Singh *et al.* (2015)
Pod weight (g)	3.72(VH)	Magalingam *et al.* (2013)
	0.43(H)	Chaitanya *et al.* (2014)
Number of seeds per pod	-0.04(N)	Singh *et al.* (2011)
	0.73(H)	Pawar and Prajapathi (2013)
	0.15(L)	Chaitanya *et al.* (2014)
	-1.25(VH)	Sharma *et al.* (2014)
	0.72(H)	Verma *et al.* (2015)
	0.25(M)	Gadakh *et al.* (2016)
Number of pods per plant	0.54(H)	Lal *et al.* (2011)
	0.76(H)	Singh *et al.* (2011)
	1.12(VH)	Magalingam *et al.* (2013)
	0.88(H)	Pawar and Prajapathi (2013)
	0.46(H)	Salim *et al.* (2013)
	0.80(H)	Chaitanya *et al.* (2014)
	0.91(H)	Singh *et al.* (2015)
	0.39(H)	Verma *et al.* (2015)

Contd....

Character	Degree and direction of direct effect	Reference
Number of pods per plant	0.84(H)	Gadakh *et al.* (2016)
100 seed weight (g)	0.46(H)	Lal *et al.* (2011)
	-0.19(L)	Upadhyay *et al.* (2012)
	0.14(L)	Pawar and Prajapathi (2013)
	0.47(H)	Gadakh *et al.* (2016)
Seed length (mm)	-0.18(L)	Singh *et al.* (2011)
Seed breadth(mm)	0.09(L)	Singh *et al.* (2011)
Protein content (%)	0.54(H)	Magalingam *et al.* (2013)
	-0.53(H)	Verma *et al.* (20015)
Fiber content	0.06(N)	Magalingam *et al.* (2013)

Table 2.4.2 Review of literature on indirect effects of yield contributing characters on marketable pod yield of dolichos bean

Character	Degree and direction of indirect effect	Reference
Plant height		
Number of primary branches per plant	0.03(N)	Magalingam *et al.* (2013)
	0.058(N)	Gadakh *et al.* (2016)
Days to first flowering	-0.104(N)	Gadakh *et al.* (2016)
Days to 50%flowering	-0.07(N)	Singh *et al.* (2015)
	-0.004(N)	Singh *et al.* (2015)
Days to pod maturity	-0.44(H)	Magalingam *et al.* (2013)
	-0.448(H)	Pawar and Prajapathi (2013)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Days to pod maturity	0.028(N)	Gadakh *et al.* (2016)
Number of seeds per pod	-0.20(M)	Pawar and Prajapathi (2013)
	-0.24(M)	Gadakh *et al.* (2016)
Pod length (cm)	-0.28(M)	Magalingam *et al.* (2013)
	0.38(H)	Pawar and Prajapathi (2013)
Pod width (cm)	-0.06(N)	Magalingam *et al.* (2013)
	-0.20(M)	Singh *et al.* (2015)
100 seed weight (g)	-0.65 (H)	Shindae and Dumbre (2001)
No. of pods per plant	-0.48(H)	Magalingam *et al.* (2013)
No. of pods per plant	0.63(H)	Pawar and Prajapathi (2013)
	-0.30(H)	Singh *et al.* (2015)
No. of pods per plant	0.05(N)	Gadakh *et al.* (2016)
Protein content (%)	0.15(L)	Magalingam *et al.* (2013)
	0.001(N)	Pawar and Prajapathi (2013)
	-0.084(N)	Gadakh *et al.* (2016)
Fiber content (%)	0.005(N)	Magalingam *et al.* (2013)
Number of primary branches per plant		
Vine length (cm)	-0.02(N)	Magalingam *et al.* (2013)
Days to first flowering	0.02(N)	Gadakh *et al.* (2016)
Days to pod maturity	0.38(H)	Magalingam *et al.* (2013)
	-0.04(N)	Pawar and Prajapathi (2013)
	-0.166(L)	Gadakh *et al.* (2016)
Pod length (cm)	-0.12(L)	Magalingam *et al.* (2013)
	0.20(M)	Pawar and Prajapathi (2013)
Number of seeds per pod	-0.39(H)	Pawar and Prajapathi (2013)
	0.104(L)	Gadakh *et al.* (2016)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Number of pods per plant	-0.26(M)	Magalingam *et al.* (2013)
	0.16(L)	Pawar and Prajapathi (2013)
	-0.412(H)	Gadakh *et al.* (2016)
100 seed weight (g)	0.035(H)	Pawar and Prajapathi (2013)
	-0.422(H)	Gadakh *et al.* (2016)
Protein content (%)	-0.07(N)	Magalingam *et al.* (2013)
	0.068(N)	Gadakh *et al.* (2016)
Fiber content (%)	0.016(N)	Magalingam *et al.* (2013)
Days to first flowering		
Vine length (cm)	0.023(N)	Gadakh *et al.* (2016)
Days to 50% flowering	-0.005(N)	Salim *et al.* (2013)
Days to 50% flowering	-1.09(VH)	Chaitanya *et al.* (2014)
	0.02(N)	Sharma *et al.* (2014)
	-0.67(H)	Verma *et al.* (2015)
Days to first pod harvest	-0.14(L)	Singh *et al.* (2011)
	0.01(N)	Sharma *et al.* (2014)
	-0.66(H)	Verma *et al.* (2015)
Days to last pod harvest	0.18(L)	Chaitanya *et al.* (2014)
	0.44(H)	Verma *et al.* (2015)
Pod length (cm)	0.04(N)	Singh *et al.* (2011)
	-0.001(N)	Salim *et al.* (2013)
Pod length (cm)	0.16(L)	Chaitanya *et al.* (2014)
	0.26(M)	Sharma *et al.* (2014)
Pod width (cm)	0.04(N)	Singh *et al.* (2011)
	0.13(L)	Chaitanya *et al.* (2014)
	0.02(N)	Sharma *et al.* (2014)

Contd....

Character	Degree and direction of indirect effect	Reference
Pod weight (g)	-0.03(N)	Chaitanya *et al.* (2014)
Days to pod maturity	0.034(N)	Gadakh *et al.* (2016)
Number of pods per plant	-0.03N)	Singh *et al.* (2011)
	0.06(N)	Salim *et al.* (2013)
	0.22(M)	Chaitanya *et al.* (2014)
	0.29(M)	Verma *et al.* (2015)
	0.002(N)	Gadakh *et al.* (2016)
Number of seeds per pod	0.014(N)	Singh *et al.* (2011)
	-0.004(N)	Salim *et al.* (2013)
	0.20(M)	Chaitanya *et al.* (2014)
	0.04(N)	Sharma *et al.* (2014)
Seed length (mm)	0.021(N)	Singh *et al.* (2011)
Seed breadth (mm)	0.011(N)	Singh *et al.* (2011)
100 seed weight (g)	0.028(N)	Singh *et al.* (2011)
	-0.19(L)	Chaitanya *et al.* (2014)
	0.41(H)	Verma *et al.* (2015)
	0.003(N)	Gadakh *et al.* (2016)
Protein content (%)	-0.17(L)	Chaitanya *et al.* (2014)
	-0.57(H)	Verma *et al.* (2015)
Days to 50% flowering		
Vine length (cm)	-0.24(M)	Magalingam *et al.* (2013)
	-0.008(N)	Singh *et al.* (2015)
Number of primary branches per plant	-0.18(L)	Magalingam *et al.* (2013)
No. of primary branches per plant	0.012(N)	Pawar and Prajapathi (2013)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Days to first flowering	0.03(N)	Salim *et al.* (2013)
	-0.22(M)	Chaitanya *et al.* (2014)
	0.01(N)	Sharma *et al.* (2014)
Number of pods per plant	0.011(N)	Magalingam *et al.* (2013)
	0.29(M)	Pawar and Prajapathi (2013)
	0.27(M)	Singh *et al.* (2015)
	-0.01(N)	Verma *et al.* (2015)
Days to first pod harvest	-0.22(M)	Chaitanya *et al.* (2014)
	0.01(N)	Sharma *et al.* (2014)
Days to last pod harvest	0.03(N)	Chaitanya *et al.* (2014)
	-0.03(N)	Verma *et al.* (2015)
Days to pod maturity	-0.996(H)	Magalingam *et al.* (2013)
	-0.46(H)	Pawar and Prajapathi (2013)
	-0.92(H)	Singh *et al.* (2015)
Pod length (cm)	0.17(L)	Magalingam *et al.* (2013)
	0.29(M)	Pawar and Prajapathi (2013)
	-0.02(N)	Salim *et al.* (2013)
	-0.02(N)	Singh *et al.* (2015)
Pod width (cm)	0.06(N)	Magalingam *et al.* (2013)
	0.02(N)	Chaitanya *et al.* (2014)
	0.06(N)	Sharma *et al.* (2014)
Pod width (cm)	-0.02(N)	Singh *et al.* (2015)
Pod weight (g)	-0.048(N)	Chaitanya *et al.* (2014)
No. of seeds per pod	-0.23(M)	Pawar and Prajapathi (2013)
	-0.002(N)	Salim *et al.* (2013)
	-0.07(N)	Sharma *et al.* (2014)

Contd....

Character	Degree and direction of indirect effect	Reference
	0.005(N)	Singh *et al.* (2015)
100 seed weight (g)	-0.008(N)	Pawar and Prajapathi (2013)
	-0.06(N)	Salim *et al.* (2013)
	-0.03(N)	Chaitanya *et al.* (2014)
	-0.02(N)	Verma *et al.* (2015)
Protein content (%)	0.27(M)	Magalingam *et al.* (2013)
	0.002(N)	Pawar and Prajapathi (2013)
	-0.03(N)	Chaitanya *et al.* (2014)
	0.04(N)	Verma *et al.* (2015)
Fiber content (%)	0.009(N)	Magalingam *et al.* (2013)
Days to first pod harvest		
Vine length (cm)	-0.008(N)	Singh *et al.* (2015)
Days to first flowering	0.05(N)	Singh *et al.* (2011)
	-0.03(N)	Salim *et al.* (2013)
	1.28(VH)	Chaitanya *et al.* (2014)
	0.06(N)	Sharma *et al.* (2014)
Days to first flowering	0.38(H)	Verma *et al.* (2015)
Pod weight (g)	-0.02(N)	Chaitanya *et al.* (2014)
Days to 50%flowering	1.28(VH)	Chaitanya *et al.* (2014)
	0.57(H)	Sharma *et al.* (2014)
Days to 50%flowering	0.91(H)	Singh *et al.* (2015)
	0.38(H)	Verma *et al.* (2015)
Days to last pod harvest	-0.12(L)	Chaitanya *et al.* (2014)
	-0.25(H)	Verma *et al.* (2015)
Days to pod maturity	-0.92(H)	Singh *et al.* (2015)
Pod length (cm)	-0.008(N)	Singh *et al.* (201[illegible]

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Character	**Degree and direction of indirect effect**	**Reference**
	-0.27(M)	Chaitanya *et al.* (2014)
	0.68(H)	Sharma *et al.* (2014)
	-0.02(N)	Singh *et al.* (2015)
Pod width (cm)	-0.005(N)	Singh *et al.* (2011)
	-0.08(N)	Chaitanya *et al.* (2014)
	0.51(H)	Sharma *et al.* (2014)
	-0.02(N)	Singh *et al.* (2015)
Number of pods per plant	0.013(N)	Singh *et al.* (2011)
	0.03(N)	Salim *et al.* (2013)
	-0.19(L)	Chaitanya *et al.* (2014)
	0.26(M)	Singh *et al.* (2015)
	-0.14(L)	Verma *et al.* (2015)
Seed breadth (mm)	-0.006(N)	Singh *et al.* (2011)
No. of seeds per pod	-0.003(N)	Singh *et al.* (2011)
	-0.007(N)	Salim *et al.* (2013)
	-0.28(M)	Chaitanya *et al.* (2014)
	0.43(H)	Sharma *et al.* (2014)
	0.005(N)	Singh *et al.* (2015)
100 seed weight (g)	-0.004(N)	Singh *et al.* (2011)
	-0.05(N)	Salim *et al.* (2013)
	0.20(M)	Chaitanya *et al.* (2014)
	-0.24(M)	Verma *et al.* (2015)
Protein content (%)	0.19(L)	Chaitanya *et al.* (2014)
	0.35(H)	Verma *et al.* (2015)
Days to last pod harvest		
Days to first flowering	-0.02(N)	Chaitanya *et al.* (2014)

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Character	**Degree and direction of indirect effect**	**Reference**
	0.41(H)	Verma *et al.* (2015)
Days to 50% flowering	-0.02(N)	Chaitanya *et al.* (2014)
	0.41(H)	Verma *et al.* (2015)
No. of pods per plant	-0.46(H)	Verma *et al.* (2015)
Days to first pod harvest	0.40(H)	Verma *et al.* (2015)
Pod length (cm)	0.03(N)	Chaitanya *et al.* (2014)
Pod width (cm)	0.01(N)	Chaitanya *et al.* (2014)
Pod weight (g)	0.01(N)	Chaitanya *et al.* (2014)
Number of seeds per pod	0.02(N)	Chaitanya *et al.* (2014)
Number of pods per plant	0.07(N)	Chaitanya *et al.* (2014)
100 seed weight (g)	0.01(N)	Chaitanya *et al.* (2014)
	-0.53(H)	Verma *et al.* (2015)
Protein content (%)	0.28(M)	Chaitanya *et al.* (2014)
	0.44(H)	Verma *et al.* (2015)
Days to pod maturity		
Vine length (cm)	-0.20(M)	Magalingam *et al.* (2013)
	-0.041(N)	Pawar and Prajapathi (2013)
	-0.008(N)	Singh *et al.* (2015)
No. of primary branches per plant	-0.23(M)	Magalingam *et al.* (2013)
No. of primary branches per plant	0.007(N)	Pawar and Prajapathi (2013)
	-0.010(N)	Gadakh *et al.* (2016)
Days to first flowering	-0.014(N)	Gadakh *et al.* (2016)
Days to 50%flowering	0.91(H)	Singh *et al.* (2015)

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Character	Degree and direction of indirect effect	Reference
Days to first pod harvest	0.05(N)	Singh *et al.* (2015)
Pod length (cm)	0.18(L)	Magalingam *et al.* (2013)
	0.52(H)	Pawar and Prajapathi (2013)
	-0.02(N)	Singh *et al.* (2015)
Pod width (cm)	0.06(N)	Magalingam *et al.* (2013)
	-0.02(N)	Singh *et al.* (2015)
No. of pods per plant	0.05(N)	Magalingam *et al.* (2013)
	0.56(H)	Pawar and Prajapathi (2013)
	0.26(M)	Singh *et al.* (2015)
No. of seeds per pod	-0.35(H)	Pawar and Prajapathi (2013)
	0.005(N)	Singh *et al.* (2015)
	-0.002(N)	Gadakh *et al.* (2016)
100 seed weight (g)	-0.023(N)	Pawar and Prajapathi (2013)
	-0.11(L)	Gadakh *et al.* (2016)
Protein content (%)	-0.04(N)	Magalingam *et al.* (2013)
	0.002(N)	Pawar and Prajapathi (2013)
	-0.003(N)	Gadakh *et al.* (2016)
Fiber content (%)	-0.01(N)	Magalingam *et al.* (2013)
Pod length (cm)		
Plant height (cm)	-0.13(L)	Magalingam *et al.* (2013)
Days to last pod harvest	-0.02(N)	Chaitanya *et al.* (2014)
Number of primary branches per plant	0.10(L)	Magalingam *et al.* (2013)
	-0.025(N)	Pawar and Prajapathi (2013)
Days to first flowering	-0.005(N)	Salim *et al.* (2013)
	0.01(N)	Chaitanya *et al.* (2014)

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Character	**Degree and direction of indirect effect**	**Reference**
	0.31(H)	Sharma *et al* .(2014)
Days to 50% flowering	-0.001(N)	Salim *et al.* (2013)
	0.02(N)	Chaitanya *et al.* (2014)
	0.41(H)	Sharma *et al.* (2014)
	0.36(H)	Singh *et al.* (2015)
Days to first pod harvest	0.004(N)	Salim *et al.* (2013)
	0.02(N)	Chaitanya *et al.* (2014)
	0.74(H)	Sharma *et al.* (2014)
	0.02(N)	Singh *et al.* (2015)
Days to pod maturity	-0.37(H)	Singh *et al.* (2015)
	0.411(H)	Pawar and Prajapathi (2013)
Pod weight (g)	-0.09(N)	Chaitanya *et al.* (2014)
Number of pods per plant	-0.006(N)	Singh *et al.* (2011)
	-0.75(H)	Magalingam *et al.* (2013)
	-0.67(H)	Pawar and Prajapathi (2013)
	-0.05(N)	Salim *et al.* (2013)
	-0.003(N)	Chaitanya *et al.* (2014)
	0.54(H)	Singh *et al.* (2015)
100 seed weight (g)	0.04(N)	Singh *et al.* (2011)
	-0.05(N)	Upadhyay *et al.* (2012)
100 seed weight (g)	0.067(N)	Pawar and Prajapathi (2013)
	0.017(N)	Salim *et al.*(2013)
	-0.01(N)	Chaitanya *et al.* (2014)
Number of seeds per pod	0.05(N)	Singh *et al.* (2011)
	-1.48(VH)	Upadhyay *et al.* (2012)
	0.60(H)	Pawar and Prajapathi (2013)

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Character	Degree and direction of indirect effect	Reference
	0.02(N)	Salim *et al.* (2013)
	-0.48(H)	Sharma *et al.* (2014)
	0.03(N)	Singh *et al.* (2015)
Seed length (mm)	0.05(N)	Singh *et al.* (2011)
Seed breadth (mm)	0.04(N)	Singh *et al.* (2011)
Protein content (%)	-0.04(N)	Magalingam *et al.* (2013)
	-0.02(N)	Chaitanya *et al.* (2014)
Fiber content (%)	-0.01(N)	Magalingam *et al.* (2013)
Pod width (cm)		
Plant height (cm)	-0.13(L)	Magalingam *et al.* (2013)
	-0.10(L)	Singh *et al.* (2015)
Number of primary branches per plant	-0.006(N)	Magalingam *et al.* (2013)
Days to first flowering	-0.05(N)	Singh *et al.* (2011)
	0.007(N)	Chaitanya *et al.* (2014)
	0.69(H)	Sharma *et al.* (2014)
Days to 50% flowering	0.83(H)	Sharma *et al.* (2014)
	0.007(N)	Chaitanya *et al.* (2014)
	-0.12(L)	Singh *et al.* (2015)
Days to first pod harvest	-0.017(N)	Singh *et al.* (2011)
Days to first pod harvest	0.48(H)	Sharma *et al.* (2014)
	-0.007(N)	Singh *et al.* (2015)
Days to last pod harvest	-0.004(N)	Chaitanya *et al.* (2014)
Days to pod maturity	0.27(M)	Magalingam *et al.* (2013)
	0.11(L)	Singh *et al.* (2015)
Pod length (cm)	0.06(N)	Singh *et al.* (2011)

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Character	Degree and direction of indirect effect	Reference
Pod length (cm)	1.56(VH)	Upadhyay *et al.* (2012)
	-0.46(H)	Magalingam *et al.* (2013)
	-0.57(H)	Sharma *et al.* (2014)
	-0.02(N)	Singh *et al.* (2015)
Pod weight (g)	0.007(N)	Chaitanya *et al.* (2014)
100 seed weight (g)	-0.001(N)	Patel *et al.* (2011)
	0.013(N)	Singh *et al.* (2011)
	-0.03(N)	Upadhyay *et al.* (2012)
	-0.002(N)	Chaitanya *et al.* (2014)
Number of pods per plant	-0.016(N)	Singh *et al.* (2011)
	-0.58(H)	Magalingam *et al.* (2013)
	-0.01(N)	Chaitanya *et al.* (2014)
	0.29(M)	Singh *et al.* (2015)
Number of seeds per pod	0.025(N)	Singh *et al.* (2011)
	0.03(N)	Upadhyay *et al.* (2012)
	0.013(N)	Chaitanya *et al.* (2014)
	-0.24(M)	Sharma *et al.* (2014)
	-0.017(N)	Singh *et al.* (2015)
Protein content (%)	-0.15(L)	Magalingam *et al.* (2013)
	-0.007(N)	Chaitanya *et al.* (2014)
Fiber content (%)	-0.16(L)	Magalingam *et al.* (2013)
Pod weight (g)		
Vine length (cm)	-0.16(L)	Magalingam *et al.* (2013)
No.of branches per plant	-0.03(N)	Magalingam *et al.* (2013)
Days to first flowering	0.01(N)	Chaitanya *et al.* (2014)

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Character	**Degree and direction of indirect effect**	**Reference**
Days to 50% flowering	-0.24(M)	Magalingam *et al.* (2013)
	0.009(N)	Chaitanya *et al.* (2014)
Days to first pod harvest	-0.009(N)	Chaitanya *et al.* (2014)
Days to last pod harvest	0.05(N)	Chaitanya *et al.* (2014)
Days to pod maturity	0.17(L)	Magalingam *et al.* (2013)
Pod length (cm)	-0.63(H)	Magalingam *et al.* (2013)
	0.31(H)	Chaitanya *et al.* (2014)
Pod width (cm)	-0.18(L)	Magalingam *et al.* (2013)
	-0.05(N)	Chaitanya *et al.* (2014)
Number of pods per plant	-0.92(H)	Magalingam *et al.* (2013)
	-0.031(N)	Chaitanya *et al.* (2014)
100 seed weight (g)	0.09(N)	Chaitanya *et al.* (2014)
	-0.08(N)	Magalingam *et al.* (2013)
	0.05(N)	Chaitanya *et al.* (2014)
Fiber content	0.014(N)	Magalingam *et al.* (2013)
Number of pods per plant		
Vine length (cm)	0.20(M)	Magalingam *et al.* (2013)
	-0.038(N)	Pawar and Prajapathi (2013)
	-0.03(N)	Singh *et al.* (2015)
	-0.15(L)	Gadakh *et al.* (2016)
No. of primary branches per plant	-0.12(L)	Magalingam *et al.* (2013)
	0.82(H)	Gadakh *et al.* (2016)
Days to first flowering	0.14(L)	Singh *et al.* (2011)
	0.005(N)	Salim *et al.* (2013)

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Character	**Degree and direction of indirect effect**	**Reference**
	-0.16(L)	Chaitanya *et al.* (2014)
	-0.16(L)	Verma *et al.* (2015)
	0.03(N)	Gadakh *et al.* (2016)
Days to 50% flowering	0.007(N)	Salim *et al.* (2013)
Days to 50% flowering	-0.16(L)	Chaitanya *et al.* (2014)
	0.27(M)	Singh *et al.* (2015)
	-0.16(L)	Verma *et al.* (2015)
Days to first pod harvest	0.14(L)	Singh *et al.* (2011)
	-0.11(L)	Chaitanya *et al.* (2014)
Days to first pod harvest	0.016(N)	Singh *et al.* (2015)
	-0.14(L)	Verma *et al.* (2015)
Days to last pod harvest	0.42(H)	Chaitanya *et al.* (2014)
	-0.29(M)	Verma *et al.* (2015)
Days to pod maturity	-0.48(H)	Magalingam *et al.* (2013)
	-0.36(H)	Pawar and Prajapathi (2013)
	-0.27(M)	Singh *et al.* (2015)
	0.41(H)	Gadakh *et al.* (2016)
Pod length (cm)	-0.041(N)	Patel *et al.* (2011)
	-0.04(N)	Singh *et al.* (2011)
	0.51(H)	Magalingam *et al.* (2013)
	0.56(H)	Pawar and Prajapathi (2013)
	-0.001(N)	Salim *et al.* (2013)
	0.01(N)	Chaitanya *et al.* (2014)
	-0.041(N)	Singh *et al.* (2015)

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Character	**Degree and direction of indirect effect**	**Reference**
Pod length (cm)	-0.05(N)	Singh *et al.* (2011)
	0.12(L)	Magalingam *et al.* (2013)
	0.22(M)	Chaitanya *et al.* (2014)
	0.06(N)	Singh *et al.* (2015)
Pod weight (g)	-0.05(N)	Chaitanya *et al.* (2014)
Number of seeds per pod	0.03(N)	Singh *et al.* (2011)
	-0.39(H)	Pawar and Prajapathi (2013)
	-0.004(N)	Salim *et al.* (2013)
Number of seeds per pod	0.10(L)	Chaitanya *et al.* (2014)
	0.06(N)	Singh *et al.* (2015)
	-0.22(M)	Gadakh *et al.* (2016)
100 seed weight (g)	-0.04(N)	Salim *et al.* (2013)
	-0.04(N)	Chaitanya *et al.* (2014)
	-0.020(N)	Savitha *et al.* (2014)
	0.26(M)	Verma *et al.* (2015)
	0.81(H)	Gadakh *et al.* (2016)
Protein content (%)	-0.05(N)	Magalingam *et al.* (2013)
	-0.001(N)	Pawar and Prajapathi (2013)
	0.18(L)	Chaitanya *et al.* (2014)
	-0.14(L)	Verma *et al.* (2015)
	-0.13(L)	Gadakh *et al.* (2016)
Fiber content (%)	-0.003(N)	Magalingam *et al.* (2013)
Number of seeds per pod		
Vine length (cm)	0.15(L)	Pawar and Prajapathi (2013)
	-0.025(N)	Singh *et al.* (2015)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Vine length (cm)	0.20(M)	Gadakh *et al.* (2016)
Number of primary branches per plant	-0.049(N)	Pawar and Prajapathi (2013)
	-0.062(N)	Gadakh *et al.* (2016)
Days to first flowering	0.003(N)	Singh *et al.* (2011)
	-0.0025(N)	Salim *et al.* (2013)
	-0.02(N)	Chaitanya *et al.* (2014)
	0.15(L)	Sharma *et al.* (2014)
Days to 50%flowering	-0.002(N)	Salim *et al.* (2013)
	0.18(L)	Sharma *et al.* (2014)
Days to 50%flowering	0.05(N)	Singh *et al.* (2015)
Days to first pod harvest	0.002(N)	Singh *et al.* (2011)
	0.48(H)	Sharma *et al.* (2014)
	0.004(N)	Singh *et al.* (2015)
Days to last pod harvest	0.02(N)	Chaitanya *et al.* (2014)
Days to pod maturity	0.28(M)	Pawar and Prajapathi (2013)
	-0.059(N)	Singh *et al.* (2015)
	-0.025(N)	Gadakh *et al.* (2016)
Pod length (cm)	-0.022(N)	Singh *et al.* (2011)
	2.83(VH)	Upadhyay *et al.* (2012)
	-0.607(H)	Pawar and Prajapathi (2013)
	0.0046(N)	Salim *et al.* (2013)
Pod length (cm)	0.08(N)	Chaitanya *et al.* (2014)
	0.50(H)	Sharma *et al.* (2014)
Pod width (cm)	0.006(N)	Upadhyay *et al.* (2012)
	0.26(M)	Sharma *et al.* (2014)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Pod width (cm)	-0.03(N)	Singh *et al.* (2015)
Number of pods per plant	-0.48(H)	Pawar and Prajapathi (2013)
	-0.033(N)	Salim *et al.* (2013)
	0.02(N)	Chaitanya *et al.* (2014)
	0.008(N)	Singh *et al.* (2015)
	-0.06(N)	Gadakh *et al.* (2016)
No. of seeds per pod	0.066(N)	Salim *et al.* (2013)
Seed length (mm)	-0.021(N)	Singh *et al.* (2011)
Seed breadth (mm)	-0.009(N)	Singh *et al.* (2011)
Protein content (%)	0.003(N)	Pawar and Prajapathi (2013)
	0.018(N)	Chaitanya *et al.* (2014)
	0.12(L)	Gadakh *et al.* (2016)
Seed length (mm)		
Days to first flowering	-0.023(N)	Singh *et al.* (2011)
Days to first pod harvest	0.001(N)	Singh *et al.* (2011)
Number of pods per plant	0.006(N)	Singh *et al.* (2011)
Pod length (cm)	0.081(N)	Singh *et al.* (2011)
Pod width (cm)	0.09(N)	Singh *et al.* (2011)
No. of seeds per pod	0.07(N)	Singh *et al.* (2011)
100 seed weight (g)	0.04(N)	Singh *et al.* (2011)
Seed breadth (mm)		
Days to first flowering	-0.005(N)	Singh *et al.* (2011)
Days to first pod harvest	-0.008(N)	Singh *et al.* (2011)
	0.035(N)	Singh *et al.* (2011)
Pod width (cm)	0.043(N)	Singh *et al.* (2011)
No.of seeds per pod	0.016(N)	Singh *et al.* (2011)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
100 seed weight (g)	0.023(N)	Singh *et al.* (2011)
100 seed weight (g)		
Vine length (cm)	0.095(N)	Pawar and Prajapathi (2013)
	-0.051(N)	Gadakh *et al.* (2016)
No. of primary branches per plant	0.47(H)	Gadakh *et al.* (2016)
Days to first flowering	0.009(N)	Salim *et al.* (2013)
	0.002(N)	Chaitanya *et al.* (2014)
	-0.06(N)	Verma *et al.* (2015)
	0.02(N)	Gadakh *et al.* (2016)
Days to 50% flowering	-0.0016(N)	Salim *et al.* (2013)
	0.002(N)	Chaitanya *et al.* (2014)
	-0.06(N)	Verma *et al.* (2015)
Days to first pod harvest	0.002(N)	Singh *et al.* (2011)
	0.009(N)	Salim *et al.* (2013)
	0.022(N)	Chaitanya *et al.* (2014)
	-0.06(N)	Verma *et al.* (2015)
Days to last pod harvest	0.09(N)	Verma *et al.* (2015)
	0.001(N)	Chaitanya *et al.* (2014)
Days to pod maturity	0.095(N)	Pawar and Prajapathi (2013)
	0.19(L)	Gadakh *et al.* (2016)
Pod length (cm)	1.20(VH)	Upadhyay *et al.* (2012)
	-0.34(H)	Pawar and Prajapathi (2013)
	0.009(N)	Salim *et al.* (2013)
	0.002(N)	Chaitanya *et al.* (2014)

Contd....

Character	Degree and direction of indirect effect	Reference
Pod width (cm)	-0.006(N)	Patel *et al.* (2011)
	-0.06(N)	Upadhyay *et al.* (2012)
	0.007(N)	Chaitanya *et al.* (2014)
Pod weight (g)	0.003(N)	Chaitanya *et al.* (2014)
No. of pods per plant	0.009(N)	Singh *et al.* (2011)
	-0.206(M)	Patel *et al.* (2011)
	-0.197(L)	Pawar and Prajapathi (2013)
	-0.078(N)	Salim *et al.* (2013)
	-0.006(N)	Chaitanya *et al.* (2014)
	0.07(N)	Verma *et al.* (2015)
	0.44(H)	Gadakh *et al.* (2016)
Number of seeds per pod	-0.58(H)	Upadhyay *et al.* (2012)
	0.18(L)	Pawar and Prajapathi (2013)
	0.005(N)	Salim *et al.* (2013)
	0.002(N)	Chaitanya *et al.* (2014)
	-0.09(N)	Gadakh *et al.* (2016)
Seed length (mm)	-0.007(N)	Singh *et al.* (2011)
Seed breadth (mm)	-0.008(N)	Singh *et al.* (2011)
Protein content (%)	0.003(N)	Chaitanya *et al.* (2014)
	-0.07(N)	Verma *et al.* (2015)
	-0.08(N)	Gadakh *et al.* (2016)
Protein content (%)		
Vine length (cm)	-0.14(L)	Magalingam *et al.* (2013)
	-0.003(N)	Pawar and Prajapathi (2013)
	0.010(N)	Gadakh *et al.* (2016)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Days to first flowering	-0.001(N)	Chaitanya *et al.* (2014)
	-0.45(H)	Verma *et al.* (2015)
	-0.003(N)	Gadakh *et al.* (2016)
Days to 50 % flowering	-0.0014(N)	Chaitanya *et al.* (2014)
	-0.46(H)	Verma *et al.* (2015)
Days to first pod harvest	-0.0013(N)	Chaitanya *et al.* (2014)
	-0.48(H)	Verma *et al.* (2015)
Days to last pod harvest	-0.001(N)	Chaitanya *et al.* (2014)
	0.37(H)	Verma *et al.* (2015)
Days to pod maturity	-0.51(H)	Magalingam *et al.* (2013)
No. of pods per plant	-0.11(L)	Magalingam *et al.* (2013)
	-0.038(N)	Pawar and Prajapathi (2013)
	-0.0019(N)	Chaitanya *et al.* (2014)
	0.06(N)	Magalingam *et al.* (2013)
	0.19(L)	Verma *et al.* (2015)
Pod width(cm)	0.06(N)	Magalingam *et al.* (2013)
	0.001(N)	Pawar and Prajapathi (2013)
100 seed weight (g)	0.102(L)	Pawar and Prajapathi (2013)
	-0.002(N)	Chaitanya *et al.* (2014)
	0.40(H)	Verma *et al.* (2015)
	0.018(N)	Gadakh *et al.* (2016)
Fiber content (%)		
Vine length (cm)	0.01(N)	Magalingam *et al.* (2013)
No. of primary branches per plant	-0.003(N)	Magalingam *et al.* (2013)

Contd....

Character	**Degree and direction of indirect effect**	**Reference**
Days to pod maturity	0.16(M)	Magalingam *et al.* (2013)
No. of pods per plant	-0.01(N)	Magalingam *et al.* (2013)
Pod length (cm)	0.004(N)	Magalingam *et al.* (2013)
Pod width(cm)	0.14(L)	Magalingam *et al.* (2013)
Protein content (%)	0.05(N)	Magalingam *et al.* (2013)

N= Negligible (0.00 -0.09)

L= Low (0.10-0.19)

M=Moderate (0.21-0.29)

H= High (0.30-0.99)

VH= >1.00

2.5 QUALITATIVE TRAITS:

Characterization of germplasm is essential to provide information on the traits of accessions assuring the maximum utilization of germplasm collection to the final users. The recording and compilation of data on the important characteristics which distinguish accessions within a species, enables an easy and quick discrimination among the phenotypes. It allows simple grouping of gaps and retrieval of valuable germplasm for breeding programmes, resulting in better insight about the composition of the collection and its genetic diversity.

Review of literature on qualitative traits:

Islam (2009) studied a total of 88 accessions of lablab bean and recorded 15 qualitative characters such as hypocotyle colour (green, purple), epicotyle colour (green, purple), stem colour (green, purple), petiole colour (green, purple), leaf vein pigmentation (green, purple), flower colour (purple, white, greyish white), raceme position (emerging from leaf canopy, intermediate, with in foliage), growth habit (indeterminate climber, indeterminate semi climber), fresh pod colour (green, very light green, purple, purple margin), fresh pod shape (flat, elongated, elongated wavy), fresh pod curvature (straight, slightly-curved, curved), fresh pod beak shape (thick long, short, medium), seed colour (black, brown, gray-orange, black dot and brown, bicolour), seed shape (round, flat, elongated) seed texture (medium ridged, highly ridged) and reported variation among genotypes.

Chattopadyay and Dutta (2010) classified dolichos bean genotypes using seed characters *viz.*, seed colour, pod curvature, pod colour, flower colour and plant type

Chaitanya *et al.* (2014) classified dolichos bean genotypes using 13 qualitative characters such as plant growth habit (pole, bush), stem colour (green, green purple, dark green, light purple, purple, dark purple), leaf vein colour (light green, green, purple), leaf density(intermediate, sparse), flower colour (purple, white, cream), pod shape (intermediate, straight, curved), pod colour(light green, green,purple, dark purple), pod curvature (straight, slightly-curved, curved), pod beak shape (thick long, short, medium), pod surface (wrinkled, smooth),seed colour (black, brown, gray-orange, black dot and brown, bicolour), seed shape (round, flat, oblong, square, cylindrical)

CHAPTER-III

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled **"Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L. var. *typicus* Prain) germplasm"** was carried out during the period from August, 2016 to March, 2017. The details of the materials used and techniques adopted during the course of investigation are described in this chapter.

3.1 LOCATION OF THE EXPERIMENT

The present study was carried out at Vegetable Research Station, ARI, RajendraNagar Hyderabad from August, 2016 to March, 2017.

3.2 WEATHER CONDITIONS DURING THE CROP PERIOD

Hyderabad falls under semi arid tropical climate, situated at an altitude of 542.3m above the Mean Sea Level. Geographically, it lies at latitude of 17.190 N and longitude of 79.230 E. The monthly mean meteorological data recorded during the crop growth period (August, 2016 to March, 2017) at Meteorological observatory, Agricultural Research Institute, Rajendranagar, Hyderabad are presented in Appendix-I. At all the stages of the crop growth the weather was congenial for growth and development of dolichos bean.

3.3 EXPERIMENTAL MATERIAL

The experimental material for this study consisted of thirty five diverse genotypes of dolichos bean were sourced from NBPGR, Regional Station including improved varieties *viz.*, RND-1 used as standard check which was released from Vegetable Research Station, Rajendranagar, Hyderabad.

The details of genotypes and source are furnished in (Table 3.1)

Table3.1: LIST OF 35 GENOTYPES OF DOLICHOS BEAN SELECTED FOR EVALUATION STUDY

Sl.no	Accession name	Source
1.	IC-261010	NBPGR Regional Station, Hyderabad
2.	IC-383197	NBPGR Regional Station, Hyderabad
3.	IC-384066	NBPGR Regional Station, Hyderabad
4.	IC-413709	NBPGR Regional Station, Hyderabad
5.	IC-413710	NBPGR Regional Station, Hyderabad
6.	IC-424813	NBPGR Regional Station, Hyderabad
7.	IC-426988	NBPGR Regional Station, Hyderabad
8.	IC-427424	NBPGR Regional Station, Hyderabad
9.	IC-427428	NBPGR Regional Station, Hyderabad
10.	IC-427436	NBPGR Regional Station, Hyderabad
11.	IC-427462	NBPGR Regional Station, Hyderabad
12.	IC-446571	NBPGR Regional Station, Hyderabad
13.	IC-446573	NBPGR Regional Station, Hyderabad
14.	IC-446581	NBPGR Regional Station, Hyderabad
15.	IC-446583	NBPGR Regional Station, Hyderabad
16.	IC-446584	NBPGR Regional Station, Hyderabad
17.	IC-446591	NBPGR Regional Station, Hyderabad
18.	IC-546349	NBPGR Regional Station, Hyderabad
19.	IC-546376	NBPGR Regional Station, Hyderabad
20.	IC-546387	NBPGR Regional Station, Hyderabad
21.	IC-546388	NBPGR Regional Station, Hyderabad
22.	IC-565181	NBPGR Regional Station, Hyderabad
23.	IC-598467	NBPGR Regional Station, Hyderabad
24.	NSB-2010/029	NBPGR Regional Station, Hyderabad
25.	NSJ/NAIP/192	NBPGR Regional Station, Hyderabad
26.	PSR-13183	NBPGR Regional Station, Hyderabad
27.	PSRJ-13039	NBPGR Regional Station, Hyderabad

Contd....

Sl.no	Accession name	Source
28.	PSRJ-13114-2	NBPGR Regional Station, Hyderabad
29.	RJR-03	NBPGR Regional Station, Hyderabad
30.	RJR-387	NBPGR Regional Station, Hyderabad
31.	SGD-136	NBPGR Regional Station, Hyderabad
32.	SNJ-11-068	NBPGR Regional Station, Hyderabad
33.	RND-1 (check)	Vegetable Research Station, ARI, Rajendranagar, Hyderabad
34.	ARKA JAY (check)	NBPGR Regional Station, Hyderabad
35.	ARKAVIJAY (check)	NBPGR Regional Station, Hyderabad

3.4 DETAILS OF THE EXPERIMENT

The experiment was conducted during August, 2016 to March, 2017 to study the genetic divergence of dolichos bean. The experiment was laid out in a Randomized Block Design with two replications with 10 plants of each genotype per replication. Seed was sown at a spacing of 0.5 m between plants and 5.0m between rows and the plants were trained to pandal.

DETAILS OF THE LAYOUT

1. Location: Vegetable Research Station, ARI, Rajendranagar, Hyderabad.
2. Design : Randomized Block Design (RBD)
3. Number of treatments : 35 (including checks)
4. Replications : 2
5. Number of checks : 3
6. Season : August, 2016 to March, 2017
7. Plot size per each accession : 5.0 m x 5.0 m
8. Spacing : 5.0 mx0.5 m
9. Number of plants per accession per row per replication : 10
10. Gross experimental plot size:2000 m^2

LAYOUT OF THE EXPERIMENTAL PLOT

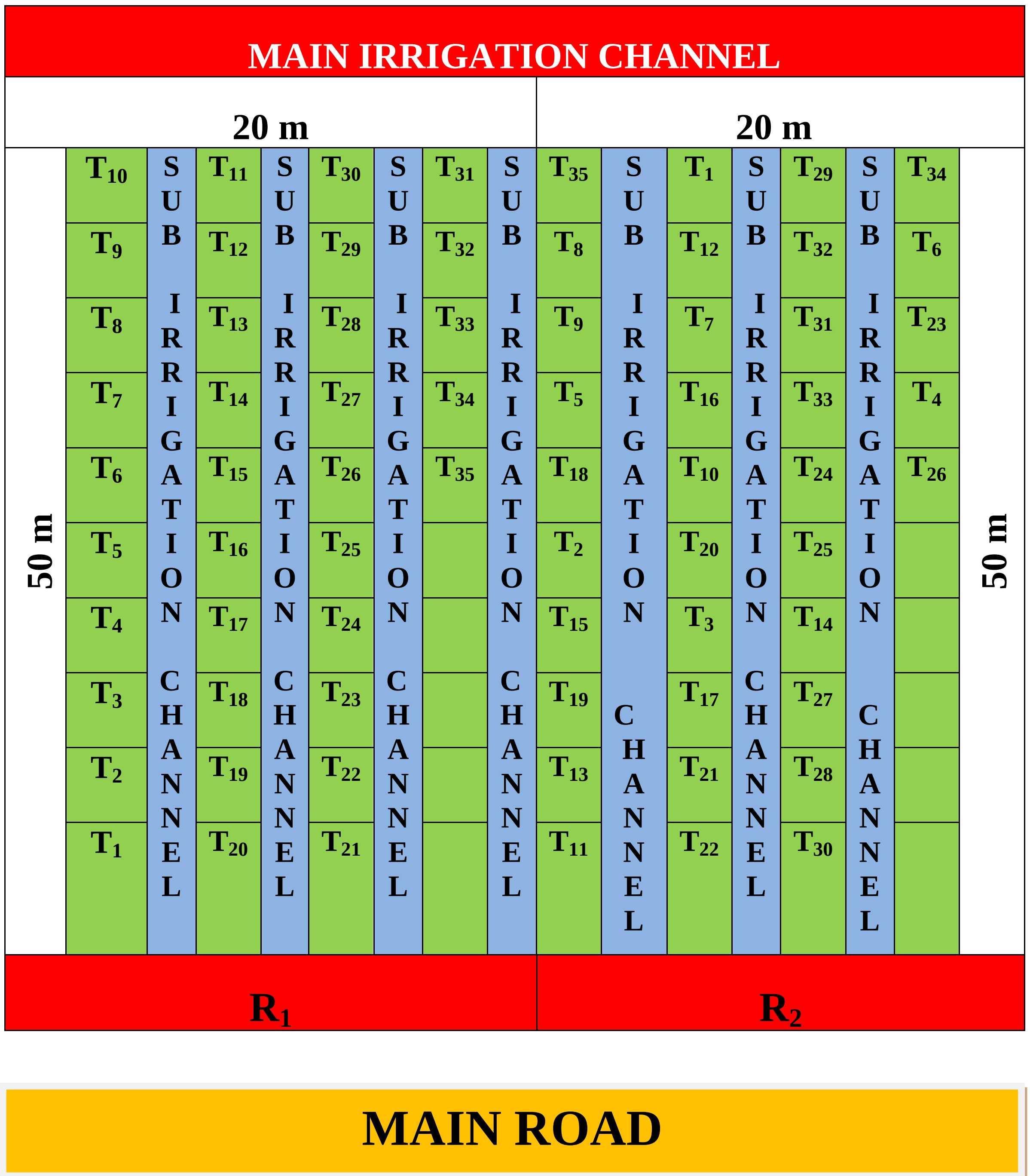

Plate 3.1: Layout of the experimental plot of dolichos bean

3.5 CULTURAL PRACTICES:

3.5.1 LAND PREPARATION

The experimental area was thoroughly ploughed and brought to a fine tilth. One tonne of FYM and the recommended basal dose of fertilizers were incorporated in the soil before final harrowing. The entire plot was divided into two blocks. The main and sub irrigation channels were laid out taking into account the gradient of the site.

3.5.2 Manures and fertilizers:

The recommended dosage of Nitrogen (N), Phosphorus (P), Potassium (K) (75:60:30 kg per ha) were applied in the form of urea, single super phosphate and murate of potash respectively. Nitrogen was applied in two splits, the first dose as basal application and other as split dose at 30 days after planting. The entire dose of phosphorus and potash were applied at the time of sowing as basal dose.

3.5.3 Sowing

After the lay out, the treatments were assigned to different plots in each replication by using randomization. The seeds of each genotype were sown by dibbling two to three seeds per hill. The gap filling was done by resowing within a week after germination.

3.5.4 Thinning of excess seedlings

The weak seedlings were thinned out leaving only one vigorous seedling per hill 25 days after sowing. The remaining 37.5 kg of nitrogen was top dressed at 30 DAS. All recommended cultural practices and need based plant protection measures were taken up to raise a good dolichos bean crop.

3.5.5 Irrigation:

During the initial stages the plot was irrigated with rose can and later occasional light irrigation was given at an interval of 4-6 days depending on the soil moisture condition.

3.5.6 Harvesting

Pods were harvested at tender stage before they become fibrous. Harvesting started from November, 2016 and extended up to March, 2017.

3.6 Observations recorded:

The data recorded on five randomly selected equally competitive plants in each genotype in each replication for all the quantitative characters yield and yield related traits for one season *i.e*. from August 2016 to March 2017. Recorded values of five plants were averaged and expressed as mean of the respective characters. The data on qualitative and quantitative characters were recorded as per minimal descriptors of NBPGR (Srivastava *et al*. 2001). The characters studied and techniques adopted to record the observations are given below.

3.6.1 Quantitative characters

3.6.1.1 Plant height (cm)

Plant height was measured at final harvest from ground level to the tip of the main axis and mean of five plants presented in centimeters.

3.6.1.2 Number of primary branches per plant

Total number of primary branches arising from the main axis at final harvest was recorded and mean of five plants were calculated.

3.6.1.3 Days to first flowering

Number of days taken from the date of sowing to the day when the first flower was appeared in a plot was counted as days to first flowering.

3.6.1.4 Days to 50 percent flowering

Number of days taken from the date of sowing to the day when 50 per cent of the plants in a plot flowered was counted as days to 50 percent flowering.

3.6.1.5 Days to first pod harvest

Number of days taken from the date of sowing to the date of first picking of the marketable pods was counted.

3.6.1.6 Days to last pod harvest

Number of days taken from the date of sowing to the date of last pod picking at marketable stage was counted.

3.6.1.7 Days to pod maturity (dry)

Number of days taken from the date of sowing to the date of pod maturity was counted.

3.6.1.8 Pod length (cm)

The length of the ten pods harvested at edible maturity stage for culinary purpose was measured and mean was expressed in centimeters.

3.6.1.9 Pod weight (g)

Weight of the ten fresh sample pods collected from each replication was weighed using precision electronic balance. The average fresh weight per pod was computed and expressed in grams.

3.6.1.10 Pod width (cm)

The mean width of ten random matured pods from each of the selected tagged plants was measured from the center of the pod and mean was expressed in centimeters.

3.6.1.11 Seed length (mm)

Twenty five randomly selected seeds from each genotype from each replication and seed length was measured by using vernier calipers and the mean was computed.

3.6.1.12 Seed breadth (mm)

Twenty five randomly selected seeds from each genotype from each replication and seed breadth was measured by using vernier calipers and the mean was computed

3.6.1.13 Number of seeds per pod

Number of seeds per pod was counted from ten randomly selected pods of a genotype from each replication and the mean was computed.

3.6.1.14 Number of pods per plant

Number of well filled pods on each sample plant was counted and the mean value of the tagged plants was recorded as the number of pods per plant.

3.6.1.15 Hundred fresh seed weight (g)

A random sample of one hundred well developed fresh seeds was collected per accession per plot per replication weighed and expressed in grams.

3.6.1.16 Hundred dry seeds weight (g)

A random sample of one hundred well developed dried seeds was collected per accession per plot per replication weighed and expressed in grams.

3.6.1.17 Marketable pod yield per plant (g)

Weight of green, tender and marketable pods per plant from each sample plant was recorded to get the pod yield per plant and it was expressed in grams.

3.6.2 Qualitative characters

Qualitative data on 13 traits were recorded on ten randomly selected plants in each genotype and the details of trait, classification and stage of scoring are presented in Table 3.2.

Table 3.2: Classification and stage of scoring of 13 qualitative traits in dolichos bean

S.No.	Qualitative trait	Classification	Stage of scoring
1.	Plant growth habit	Bush Semi pole Pole	At flowering stage
2.	Leaf vein colour	Light Green Green Purple Others	Fully developed primary leaves on inner surface
3.	Leaf density	Sparse Intermediate Dense	Vegetative growth stage
4.	Stem colour	White Light green Green Dark green	Vegetative growth stage

Contd....

S.No.	Qualitative trait	Classification	Stage of scoring
		Purple Dark purple Greenish purple	
5.	Flower colour	White Cream Purple Dark purple Blue	Fully developed flower bud before it start anthesis
6.	Pod shape	Straight Intermediate Curved	Fresh matured pod
7.	Pod colour	White Cream Light green Green Dark green Light purple Purple Dark purple	Fresh matured pod
8.	Pod beak	Short Medium Long	Fresh matured pod
9.	Pod curvature	Straight Curved Highly curved Others	Fresh matured pod
10.	Pod suture colour	White	Fresh matured pod

Contd....

S.No.	Qualitative trait	Classification	Stage of scoring
		Cream Green Purple Others	
11.	Pod surface	Smooth Wrinkled Others	Fresh matured pod
12.	Seed colour	Black Brown Cream Yellow Purple Brick red Brown yellow Mottled Others	Dry matured pod
13.	Seed shape	Cylindrical Round Flat Square Oblong Elliptical	Dry matured pod

3.6.2.2 Protein content:

The crude protein content of the sample was estimated according to the micro Kjeldhal method AOAC. (2005), calculated as protein nitrogen product and multiplied with 6.25 to obtain the protein content.

Procedure:

- Powdered extrudates of 0.5g were weighed into the digestion tubes and 5.0g of digestion mixtures (98g of potassium sulphate + 2 g of copper sulphate) plus 10.0 ml of concentrated H_2SO_4 were added carefully. The samples were placed in the digestion unit for $1^{1/}{}_{2}$ hr at 375°C.
- In a 100 ml conical flask, 40.0 ml of 4%boric acid was added along with few drops of mixed indicator containing (1.0 ml of 0.2% bromocresol green + 3.0 ml of 0.2% methyl red).
- Distillation was done for 10 minutes in the Kjeldhal distillation apparatus adding 10.0 ml of distilled water, 15.0 ml of 40% NaOH and steaming for 10 seconds.
- The contents collected in conical flask were blue in color after distillation was completed.
- Titration was done with standard 0.1N HCl till the contents of the flask turned to pink color. A blank was run simultaneously.

CALCULATIONS:

$$\text{Protein (\%)} = \frac{\text{(Sample TV-Blank TV) x 0 0.0014 x0.1N OF HCl x100 x 6.25}}{\text{Weight of the sample (g)}} \text{ X 100}$$

3.6.2.3 Estimation of fiber content:

The fiber content of samples was determined by boiling with 1.25% dilute H_2SO_4, washed with water, further boiled with 1.25% dilute NaOH and the remaining residue after digestion was taken as crude fiber AOAC. (1990).

Procedure:

- 1.0 g of moisture and fat free powdered extrudates were weighed and placed in the fiber bags.
- The glass spacer was kept into the bags.
- The bags were loaded in the sample carousel at the previewed positions 1-6.
- The sample carousel was put into the glass container carefully and added with 500.0 ml of 1.25% dilute H_2SO_4.
- The glass container axial was heated for 30 min.
- After completion of time, the bags were washed by boiling with 500.0ml distilled water for 30 min and then 500.0ml of 1.25% NaOH was added and left for another 30 min for heating.
- Later again 500.0 ml of distilled water was added and boiled for further 30 min.
- The residue was transferred to empty crucible and weighed as (W_1), then dried at 100°C for 4 hrs in hot air oven , transferred to dessicator for cooling and weighed (W_2).
- The crucible was incinerated in a muffle furnace at 600°C for 3 hrs. Then crucible was cooled in dessicator and weighed (W_3).

Calculation

$$\text{Fiber content (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

W_1 = Weight of the sample (g)

W_2 = Weight of the crucible + sample after heating at 100°C (g)

W_3 = Weight of the crucible + sample after heating at 600°C (g)

$W_2 - W_3$ = Weight of crude fiber (g)

3.7 STATISTICAL ANALYSIS

The mean replicated data collected on 19 quantitative traits was subjected to biometrical analysis following appropriate biometrical procedures.

3.7.1 Analysis of Variance

The data obtained in respect of all the characters was subjected to the following statistical analysis. The data were analyzed by the methods outlined by Panse and Sukhatme (1985) using the mean values of five random plants in each replication from all genotypes to find out the significance of genotypes effect.

The model analysis of variance table adopted is given below. The data for different characters were statistically analysed on the basis of the model suggested by Cochran and Cox (1957) for randomized block design.

$$Y_{ij} = \mu + b_i + t_j + e_{ij}$$

Where,

Y_{ij} = Performance of the j^{th} genotype in the i^{th} block

μ = General mean

b_i = True effect of i^{th} block

t_j = True effect of j^{th} genotype

e_{ij} = Random error associated with i^{th} block and j^{th} genotype.

The analysis of variance for each character was carried out as indicated below:

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F ratio
Replications	r-1	RSS	RMSS	RMSS/EMSS
Treatments	t-1	T_r SS	T_rMSS	T_rMSS/EMSS
Error	(r-1)(t-1)	ESS	EMSS	
Total	(rt-1)	TSS	TMSS	

Where,

R = Number of replications

T = Number of genotypes or treatments

df = Degrees of freedom

SS = Sum of squares

MSS = Mean sum of squares

RSS = Replication Sum of squares

T_rSS = Treatment sum of squares

ESS = Error sum of squares

TSS = Total sum of squares

RMSS = Mean sum of squares due to replications

T_rMSS = Mean sum of squares due to treatments

EMSS = Mean sum of squares due to error

The test of significance was carried out against the corresponding error degrees of freedom by using 'F' table values given by Fisher and Yates (1963).

3.7.2 Critical difference (C.D)

In order to compare the means of various entries CD was calculated by using the formula.

Critical difference (CD) = S.E (d) x t

$$S.E\ (d) = \sqrt{\frac{2 \times \text{error MSS}}{r}}$$

Where,

t = Table value at 5 per cent probability level

r = Number of replications.

3.7.3 ESTIMATION OF GENETIC PARAMETERS

The genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense and genetic advance for different characters were worked out by following the standard procedures for all the genotypes under study.

3.7.3.1 Genetic diversity

The D^2 analysis suggested by Mahalonobis (1936) was used for estimating the divergence among the 35 genotypes. The inverse of the error variance as covariance matrix was used to derive a set of equations by which the correlated variables transformed to an uncorrelated set of variables. This transformation was done by the pivotal condensation of Rao (1952). All possible D^2values n (n-1)/2 were worked out by taking sum of difference between pairs of corresponding 'Y' values, taking two genotypes at a time. The D^2 values were estimated using computer with GENRES statistical package.

3.7.3.2 Determination of group constellation or clusters

Based on the degree of divergence (D values) between any two genotypes, grouping of genotypes was done using Tocher's method (Singh and Choudary 1977). In this method the populations were arranged in order of their relative distance (D^2 values) from each other and a table was formed. In the table, the values were arranged in the descending order of magnitude.

Two population having smallest distance from each other was considered first to which a population having a smallest average D values from the first two populations was added. Then the nearest third population was added and it goes on. At certain stage, after adding a particular population if there was no abrupt increase in the average D values then that population was not added in that cluster. Similarly a second cluster was formed. Thus the process is continued till all the populations were added in one or the other cluster.

3.7.3.3 Intra and inter cluster distance

After establishing the clusters, the intra and inter cluster distances were worked out by taking the average of the component genotype in that cluster. The average inter cluster distance was arrived at by taking into consideration of the component D^2 values possible among the members of the two cluster considered.

The square root of the average D2 values gave the genetic distance D between clusters. Based on the D values (inter cluster distances), the following scale of rating the distance was adopted (Rao, 1952).

Category	**D values**
Less divergent (L)	Below 99
Moderately divergent (M)	Between 100 to 200
Highly divergent (H)	Above 200

3.7.3.4 Ranking of componenet characters for divergence

Ranking was done as per the method obtained by Singh and Choudhary (1977). Each character is ranked based on the transformed correlated 'Y' values. The relative contribution towards genetic divergence was worked out by using computer software.

3.7.3.5 Contribution of individual characters towards genetic divergence

The character contribution towards genetic divergence was computed using method by Singh and Chaudhary (1985). In all the combination, each character is ranked on the basis of $di=y_i^j-y_i^k$ values.

Where,

Di= mean deviation

y_i^j = mean values of the j^{th} genotype for the i^{th} character.

y_i^k= mean values of the k^{th} genotype for the i^{th} character.

Rank '1'is given to the highest mean difference and rank 'p' is given to the lowest mean difference

Where,

P is the lowest number of characters.

Finally, number of times that each character appeared in the first rank is computed and percent contribution of characters towards divergence was estimated.

3.7.3.6 Genotypic and phenotypic coefficients of variation

Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953) by using the following formulae.

$$PCV = \frac{\sqrt{\sigma^2_p}}{\overline{X}} \times 100$$

$$GCV = \frac{\sqrt{\sigma^2_g}}{\overline{X}} \times 100$$

Where,

σ_g^2 = Genotypic variance $= \frac{T_r MSS - EMSS}{r}$

σ_e^2 = Environment variance $= \frac{EMSS}{r}$

σ_p^2 = Phenotypic variance $= \sigma_g^2 + \sigma_e^2$

$\overline{X}$ = General mean

Categorization of PCV and GCV was based on the ranges of variation as reported by Sivasubramanian and Menon (1973) was followed.

Low = 0-10 %

Moderate = 11- 20 %

High = 21% and above

3.7.3.7 Heritability in Broad sense [h^2_b]

Heritability in broad sense was estimated as per the formulae suggested by Lush (1940) and expressed in percent.

σ_g^2

$$h^2{}_b = \frac{\quad}{\sigma_p^2} \times 100$$

Where,

h^2 (b) = Heritability estimates in broad sense

σ_g^2 = Genotypic variance

σ_p^2 = Phenotypic variance

As suggested by Johnson *et al.* (1955), h^2_b estimates were categorised as

Low = 0-30 %

Medium = 31-60 %

High = 61 % and above

3.7.3.8 Genetic advance (GA)

This was estimated as per the formula proposed by Lush (1940) and Johnson *et al.* (1955).

$$GA = K \times \sigma_p \times h^2 (b)$$

Where,

K = Selection differential at 5 per cent selection intensity which accounts to a constant value 2.06

h^2 (b) = Heritability in broad sense

σ_p = Phenotypic standard deviation

3.7.3.9 Genetic advance as per cent of mean (GAM)

Genetic advance over mean (GAM) was calculated using the following formula and was expressed in percentage.

$$GAM = \frac{GA}{\bar{X}} \times 100$$

Where,

GA = genetic advance

$\overline{X}$ = general mean of the character

The genetic advance as per cent over mean was categorized as suggested by Johnson *et al.* (1955) and is mentioned below:

Low = 0-10 %

Moderate = 11-20 %

High = 21 % and above

3.8 CORRELATION STUDIES

To determine the association of characters with yield and also among the yield components, the correlation coefficient was calculated.

Phenotypic and genotypic correlations were worked out by using formula suggested by Al-jibouri *et al.* (1958)

Phenotypic coefficient of correlation (r_p)

$$r(x_i.x_j)_p = \frac{COV(x_i.x_j)_p}{\sqrt{V(x_i)_p . V(x_j)_p}}$$

Where,

$r(x_i.x_j)_p$ = Phenotypic correlation between i^{th} and j^{th} character.

$COV(x_i.x_j)_p$ = Phenotypic covariance between i^{th} and j^{th} character.

$V(x_i)_p$ = Phenotypic variance of i^{th} character.

$V(x_j)_p$ = Phenotypic variance of j^{th} character.

Genotypic coefficient of correlation (r_g)

$$r(x_i.x_j)_g = \frac{COV(x_i.x_j)_g}{\sqrt{V(x_i)_g . V(x_j)_g}}$$

Where,

$r(x_i.x_j)_g$ = Genotypic correlation between i^{th} and j^{th} character.

$COV(x_i.x_j)_g$ =Genotypic covariance between i^{th} and j^{th} character.

$V(x_i)_g$ = Genotypic variance of i^{th} character.

$V(x_j)_g$ = Genotypic variance of j^{th} character

3.8.1 TEST OF SIGNIFICANCE

Significance of correlation coefficients was tested by comparing phenotypic correlation coefficients with the table values (Fisher and Yates, 1963) at (n-2) degrees of freedom at 5 % and 1 % level where 'n' denotes the total number of pairs of observations used in the calculation.

$$t = \frac{\sqrt{n-2}}{\sqrt{1-r^2}}$$

t = Test of significance

r = Correlation coefficient

n = Number of paired observations

3.9 PATH COEFFICIENT ANALYSIS

The direct and indirect contribution of various characters to yield were calculated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959). The following simultaneous equations were formed and solved for estimating various direct and indirect effects.

Path coefficients were obtained by solving the following simultaneous equations.

$$r_{ly} = P_{ly} + r_{12}P_{2y} + r_{13} P_{3y} + \ldots\ldots\ldots + r_{lk} P_{ky}$$

Where,

r_{ly} = Simple correlation coefficient between x_1 and y, the dependent Character

P_{ly} = Direct effect of x_1 on y, the dependent character

$r_{12}P_{2y}$ = Indirect effect of x_1 on y through x_2.

r_{12} = Correlation coefficient between x_1 and x_2.

$r_{lk}P_{ky}$ = Indirect effect of x_1 only through k^{th} variable.

In the same way, equations for r_{2y}, r_{3y}, r_{4y}, upto r_{ky} were obtained. The direct and indirect effects were calculated by solving the simultaneous equations.

Besides the direct and indirect effects, the residual effect was computed by using the formula given below.

Residual effect (Pr_y) = $1-R^2$

Where,

$R^2 = P_{ly}r_{ly} + P_{2y}r_{2y} + P_{3y}r_{3y} + \ldots\ldots\ldots\ldots P_{iy}r_{iy}$

P_{ly} = Direct effect of x_1 on y.

r_{1y} = Correlation coefficient between x_1 and y

P_{2y} = Direct effect of x_2 on y

r_{2y} = Correlation coefficient between x_2 and y.

P_{3y} = Direct effect of x_3 on y

r_{3y} = Correlation coefficient between x_3 and y

P_{iy} = Direct effect of x_i on y

r_{jy} = Correlation coefficient between x_i and y

$$Pry = \sqrt{1 - P_{1y}\, r_{1y} + P_{2y}\, r_{2y} + \ldots\ldots P_{ky}\, r_{ky}}$$

Where,

P_{ry} = residual effect

P_{ly} = direct effect of x_1 only

r_{ly} = correlation coefficient between x_1 only

Scales for path coefficients

Values of direct (or) indirect effects	**Rate (or) scale**
0.00 to 0.09	Negligible
0.10 to 0.19	Low
0.20 to 0.29	Moderate
0.30 to 0.99	High
> 1.00	Very high

CHAPTER-IV

RESULTS AND DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

The present investigation entitled "**Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L.var. *typicus* Prain*)* germplasm**" to evaluate 35 dolichos bean germplasm for 19 characters was carried out from August, 2016 to March, 2017 at Vegetable Research station, ARI, Rajendranagar, Hyderabad. The data collected for 19 characters *viz.,* vine length (cm), number of primary branches per plant, days to first flowering, days to 50 *per cent* flowering, days to first pod harvest, days to last pod harvest, days to pod maturity, number of seeds per pod, number of pods per plant, pod yield per plant (g), pod length (cm), pod width (cm), pod weight (g), seed length (mm), seed breadth (mm), 100 fresh seed weight (g), 100 dry seed weight (g), protein content (%), fiber content (%) were subjected to the appropriate statistical analysis for drawing valid conclusions.

The objective of any breeding programme is mostly be oriented towards the improvement of the yield and earliness. Since, the yield is dependent upon different growth and yield contributing characters, it is necessary to understand growth and yield contributing characters and genetic potential of yield must be probed through the study of its component characters by employing the useful biometrical tools. Some of these parameters include genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV), heritability, and genetic advance, genotypic and phenotypic correlation and path coefficient helps to base selection procedure to a required balance when two opposite desirable characters affecting the principle characters are also being selected. It helps to improve different characters simultaneously.

The magnitude of heritable variability is the most important component in any breeding material as it has a close bearing in response to selection. Therefore, occurrence of adequate genetic variability is an essential pre requisite for all the crop improvement programmes. Knowledge of the amount of variability and heritability aids the crop breeder for affecting improvement in any crop by choosing suitable breeding technique. The source material for genetical improvement would be identified by studying the amount of variability available in the gene pool or germplasm. This necessitates the evaluation of the assemblage for various requirements in the single environment. Accordingly, dolichos bean genotypes were evaluated for their genetic potential in respect of yield and yield attributes.The results of the present investigation are presented under following headings.

4.1 ANALYSIS OF VARIANCE

4.2 MEAN PERFORMANCE OF GENOTYPES

4.3 GENETIC DIVERGENCE ANALYSIS

4.4 GENETIC VARIABILITY PARAMETERS

4.5 CORRELATION COEFFICIENT ANALYSIS

4.6 PATH COEFFICIENT ANALYSIS

4.7 QUALITATIVE TRAITS

4.1 ANALYSIS OF VARIANCE

Analysis of variance revealed significant differences among the genotypes with respect to all the characters studied at one percent and five percent level of significance. Highly significant differences among the genotypes were observed indicating the presence of sufficient amount of variability among genotypes studied.

The results of analysis of variance for 35 genotypes in dolichos bean are furnished in Table 4.1

The analysis of variance revealed significant differences between genotypes for all the characters indicating presence of sufficient amount of variability in all the 19 characters studied. Wide range of variability was observed for pod yield per plant (46487.040), vine length (15234.210) and number of pods per plant (2379.014) indicating the scope for selection of initial breeding material for further improvement based on these characters.

4.2 MEAN PERFORMANCE OF GROWTH PARAMETERS

The mean performance of 35 genotypes of dolichos bean in respect of yield and yield attributes and quality attributes are described character wise are furnished below.

The mean values of 19 growth parameters *viz.*, vine length (cm), number of primary branches per plant, days to first flowering, days to 50 percent flowering, days to first pod harvest, days to last pod harvest, days to pod maturity, pod length (cm), pod width (cm), pod weight (g), number of pods per plant, number of seeds per pod, seed length (mm), seed breadth (mm), 100 fresh seed weight (g), 100 dry seed weight (g), protein content (%), fiber content (%) and pod yield per plant (g) of 35 genotypes are presented in the Table 4.2

4.2.1 Vine length (cm)

Vine length was ranged (Table 4.2) from 57.98 cm to 462.17 cm with a total mean of 353.91 cm. Significantly higher vine length was recorded in IC-546387 (462.17 cm) and minimum vine length (260.20 cm) was recorded in IC-546349 among the pole types. IC-427428 (413.32 cm), PSRJ-13039 (419.60 cm), SGD-136 (432.57 cm), RND-01 (437.33 cm), IC-427424 (438.77 cm) and IC-598467 (448.23 cm) recorded statistically at par values with the higher value IC-546387 (462.17 cm). Among 35 genotypes studied, twenty two genotypes were significantly taller than the grand mean. Three genotypes IC-427424 (438.77 cm), IC-546387 (462.17 cm) and IC-598467 (448.23 cm) recorded significantly more vine length than the check variety RND-1 (437.33 cm). These results are in concurrence with the findings of those reported by Chaitanya *et al.* (2014)

4.2.2 Number of primary branches per plant

Number of primary branches per plant (Table 4.2) in dolichos bean genotypes was ranged from 2.21 to 3.83 with a grand mean of 2.85. Among the genotypes, minimum number of primary branches per plant was recorded in NSB-2010/029 (2.21), while the maximum number of branches was recorded in IC-383197 (3.83). Five genotypes *viz*., RJR-387 (3.32), ARKA JAY (3.38), IC-546387 (3.40), IC-427424 (3.41) and RND-01 (3.51) recorded statistically at par values with the higher value IC-383197 (3.83). Out of 35 genotypes studied, twelve genotypes exhibited significantly higher number of primary branches per plant compared to total mean. Two genotypes *i.e.* IC-383197 (3.83) and IC-427436 (3.58) recorded significantly more number of primary branches than the check variety RND-1 (3.51). The results pertaining to this trait are in accordance with the studies conducted by Mohan *et al*. (2014).

4.2.3 Days to first flowering

Days to first flowering exhibited a range (Table 4.2) of 54.00 to 105.50 days with a total mean of 90.80 days. Earliest flowering was recorded in IC-261010 (80.00 days) compared to check RND-1 (95.00 days) in pole type genotypes. Among 35 genotypes studied, 22 genotypes flowered significantly late when compared to grand mean. Nine genotypes IC-446571 (105.00), IC-446583 (96.50), IC-546376 (105.50), IC-546387 (105.00), IC-546388 (101.50), PSR-13183 (98.00), PSRJ-13039 (99.50), RJR-03 (99.50) and SNJ-11-068 (97.50) were significantly late to first flowering than check variety RND-1 (95.00 days). The information pertaining to these traits is in accordance with the studies conducted by Sharma *et al*. (2014) and Choudhary *et al.* (2016).

4.2.4 Days to 50 *per cent* flowering

The character days to 50 *per cent* flowering exhibited a range of 67.50 days to 122.50 days with a grand mean of 106.30 days (Table 4.2). Among the genotypes evaluated, IC-261010 (89.50 days) took minimum days to 50 *per cent* flowering, while maximum was recorded in IC-546387 (122.5 days). Out of 35 genotypes studied, twenty genotypes were significantly late to 50 percent flowering compared to grand mean. Nine genotypes *viz.*, IC-446571 (117.00), IC-546376 (120.00), IC-546387 (122.50), IC-546388 (119.00), IC-565181 (119.00), PSR-13183 (116.50), PSRJ-13039 (118.50), RJR-03 (115.00) and SNJ-11-068 (118.00) were significantly late to 50 *per cent* flowering than check variety RND-1 (113.50 days). Chattopadhyay and Dutta (2010) also reported the similar results in dolichos bean.

4.2.5 Days to first pod harvest

Days to first pod harvest was ranged ((Table 4.2) from 87.50 days to 145.50 days with a grand mean of 130.68 days. Among the genotypes, less number of days for first pod harvest was recorded in IC-427436 (119.00 days), while more number of days for first pod harvest was recorded in IC-565181 (145.50 days).

Out of 35 genotypes, 21 genotypes recorded significantly more number of days for first pod harvest than the grand mean. Twenty five genotypes IC-383197 (130.50), IC-384066 (131.50), IC-413709 (133.50), IC-413710 (130.50), IC-424813 (132.50), IC-427424 (132.00), IC-446571 (142.00), IC-446573 (131.00), IC-446581 (130.50) , IC-446583 (140.00), IC-446591 (131.50) , IC-546376 (134.00) , IC-546387 (142.50), IC-546388 (139.00), IC-565181 (145.50), IC-598467 (135.50), NSB-2010/029 (132.50), NSJ/NAIP/192 (132.50), PSR-13183 (141.50), PSRJ-13039 (144.50), PSRJ-13114-2 (139.00), RJR-03 (140.00) , RJR-387(136.00), SGD-136 (132.00) and SNJ-11-068 (145.00) genotypes were significantly late for first pod harvest compared to check variety RND-1 (130.00 days). The present findings support the result of Singh *et al*. (2011) and Sharma *et al*. (2014).

4.2.6 Days to last pod harvest

Days to last pod harvest was ranged (Table 4.2) from 154.50 days to 209.00 days with a grand mean of 180.97 days. Among the pole types, significant and less number of days for last pod harvest significantly recorded in IC-427436 (154.50 days), while significant and more number of days for last pod harvest was recorded in IC-446583 (209.00 days). Six genotypes *i.e.* IC-565181 (197.50), PSR-13183 (199.00), IC-384066 (202.50), IC-413710 (202.50), IC-413709 (204.50) and IC-546387 (205.00) recorded statistically at par values with IC-446583 (209.00). Out of 35 genotypes, twenty one genotypes recorded significantly more number of days for last pod harvest than the grand mean. Thirteen genotypes (IC-383197 (196.50), IC-384066 (202.50), IC-413709 (204.50), IC-413710 (202.50), IC-446573 (190.50), IC-446583 (209.00), IC-546387 (205.00), IC-546388(195.00), IC-565181 (197.50), IC-598467(193.50), PSR-13183 (199.00), PSRJ-13039 (195.00) and SNJ-11-068 (191.50) recorded significantly more number of days for last pod harvest compared to check variety RND-1(190.00days). The results pertaining to this trait are in collaboration with Choudhary *et al.* (2016)

4.2.7 Days to pod maturity

Days to pod maturity were ranged (Table 4.2) from 176.00 to 222.50 days with a grand mean of 205.20 days. Among the pole types, less number of days for pod maturity was recorded in IC-427436 (176.00 days), while more number of days were recorded in IC-546387 (222.50 days). Out of 35 genotypes, eighteen genotypes recorded significantly more number of days to pod maturity than the grand mean. Eight genotypes *i.e*. IC-383197 (218.00), IC-384066 (220.50), IC-413709 (220.50), IC-413710 (222.00), IC-446583 (220.50), IC-546387 (222.50), PSR-13183 (221.00) and SNJ-11-068 (216.50) taken significantly more number of days to pod maturity when compared to check variety RND-1 (215.50 days).

Pole type genotypes took longer period for days to first flowering, 50 *per cent* flowering, first pod harvest, last pod harvest and pod maturity than bushy genotypes.

4.2.8 Pod length (cm)

Length of the pod (Table 4.2) was ranged from 5.95 cm to 17.11 cm with a total mean of 10.06 cm. The maximum length of the pod was recorded in IC-427462 (17.11 cm). While significantly minimum was recorded in IC-546349 (6.09 cm). None of the genotypes recorded statistically at par values with the highest value of IC-427462 (17.11 cm). Out of 35 genotypes studied 16 genotypes produced significantly more lengthy pods when compared to grand mean. Thirteen genotypes *viz.,* IC-261010 (14.64 cm), IC-383197 (11.04 cm), IC-384066 (12.30 cm), IC-413710 (11.78 cm), IC-426988 (14.67 cm), IC-427424 (13.16 cm), IC-427428 (12.61 cm), IC-427436 (15.47 cm), IC-427462 (17.11 cm), NSJ/NAIP/192 (12.18 cm), PSRJ-13114-2 (11.67 cm), RJR-387 (13.88 cm) and SNJ-11-068(11.95 cm) recorded significantly more lengthy pods when compared to the check variety RND-1 (10.90 cm). The results pertaining to this trait are in accordance with the studies conducted by Rai *et al.* (2009), Chattopadhyay and Dutta (2010), Singh *et al*. (2011), Chaitanya *et al.* (2014), Mohan *et al*. (2014), Sharma *et al*. (2014) and Choudhary *et al.* (2016).

4.2.9 Pod width (cm)

Width of the pod (Table 4.2) was ranged from 1.11 cm to 4.34 cm with a total mean of 1.80cm. The maximum width of the pod was recorded in IC-383197(4.34 cm), while the minimum was recorded in SNJ-11-068 (1.14 cm). None of the genotypes recorded statistically on par values with the highest value of IC-383197(4.34 cm). Eleven genotypes produced significantly more width pods when compared to grand mean. Eighteen genotypes *i.e.* IC-383197 (4.34 cm), IC-384066 (3.28 cm), IC-413710 (2.59 cm), IC-426988 (2.24 cm), IC-427424 (3.45 cm), IC-427428 (2.03 cm), IC-427436 (2.27 cm), IC-427462 (2.10 cm), IC-446583 (1.58 cm), IC-446584 (2.23 cm), IC-446591 (2.18 cm), IC-546349 (2.30 cm), IC-546376 (1.69 cm), IC-598467 (1.59 cm), NSB-2010/029 (2.20 cm), PSR-13183 (1.61 cm), RJR-03 (1.57 cm) and RJR-387 (1.56 cm) recorded significantly more width pods when compared to the check variety RND-1 (1.44 cm). The conclusions pertaining to this trait are in accordance with the studies conducted by Chattopadhyay and Dutta (2010), Chaitanya *et al.* (2014) and Verma *et al.* (2015)

4.2.10 Pod weight (g)

Weight of the pod was ranged from 3.91 to 9.25 g with a total mean of 6.46 g (Table 4.2). The maximum weight of the pod was recorded in IC-384066 (9.25 g), while the minimum was recorded in IC-546349 (3.91g). Six genotypes *viz.*, IC-427436 (8.00 g), PSRJ-13039 (8.00 g), PSRJ-13114-2 (8.33 g), IC-261010 (9.20 g), IC-383197 (9.21 g), and RND-01 (8.21 g) recorded statistically at par values with IC-384066 (9.25 g). Out of 35genotypes, sixteen genotypes produced, significantly more weighed pods compared to grand mean. Four genotypes *viz*., IC-261010 (9.20 g), IC-383197 (9.21 g), IC-384066 (9.25 g), and PSRJ-13114-2 (8.33 g) recorded significantly higher pod weight when compared to the check variety RND-1 (8.21 g). The results pertaining to this trait are in collaboration with Chattopadhyay and Dutta (2010) and Chaitanya *et al.* (2014).

4.2.11 Number of pods per plant

Number of pods per plant was ranged (Table 4.2) from 26.68 to 175.66 with a total mean of 75.33. The significantly maximum number of pods per plant (175.66) was recorded in IC-546387, while the significantly minimum number of pods per plant was recorded in PSR-13183 (26.68). Out of 35 genotypes, 16 genotypes produced significantly more number of pods per plant when compared to grand mean. Fifteen genotypes *i.e*. IC-413709 (87.31), IC-413710 (91.97), IC-424813 (87.74), IC-427428 (92.76), IC-427436 (86.63), IC-446573 (140.76), IC-446583 (89.23), IC-446584 (125.42), IC-546387 (175.66), IC-565181 (83.00), NSB-2010/029 (164.96), PSRJ-13039 (95.76), RJR-03 (82.10), RJR-387 (96.42), and SNJ-11-068 (80.82) recorded significantly more number of pods per plant when compared to the check variety RND-1 (78.34). The results pertaining to this trait are in collaboration with Chattopadhyay and Dutta (2010) and Chaitanya *et al.* (2014).

4.2.12 Number of seeds per pod

Number of seeds per pod (Table 4.2) was ranged from 3.02 to 6.14 with a total mean of 4.89. The maximum number of seeds per pod (6.14) was recorded in RND-1, while the minimum number of seeds per pod was recorded in IC-446591 (3.02). Out of 35 dolichos bean genotypes, 22 genotypes produced significantly more number of seeds per pod when compared to grand mean. None of the genotypes recorded significantly more number of seeds per pod compared to the check variety RND-1 (6.14). The results pertaining to this trait are in accordance with the studies conducted by Rai *et al.* (2009), Chattopadhyay and Dutta (2010), Singh *et al*. (2011), Chaitanya *et al.* (2014), Mohan *et al*. (2014), Sharma *et al*. (2014) and Choudhary *et al.* (2016).

4.2.13 Seed length (mm)

Length of the seed (Table 4.2) in dolichos bean genotypes was ranged from 7.25 to 13.35 mm with a total grand mean of 9.31 mm. The maximum and significant length of the seed (13.35 mm) was recorded in IC-384066, while the minimum length of the seed was recorded in IC-446571 (7.25 mm). Four genotypes *viz.*, IC-383197 (11.11 mm), IC-261010 (11.13 mm), IC-427424 (12.10 mm) and IC-427428 (12.25 mm) recorded statistically at par values with IC-384066 (13.35 mm). When compared to grand mean fourteen genotypes produced significantly more lengthy seeds. Seven genotypes *viz.*, IC-261010 (11.13 mm) , IC-383197 (11.11 mm), IC-384066 (13.35 mm), IC-426988 (10.64 mm), IC-427424 (12.10 mm), IC-427428 (12.25 mm) and IC-446591(10.58 mm) recorded significant and more lengthy seeds when compared to the check variety RND-1 (10.46 mm).

These results are in concurrence with the findings of those reported by Singh *et al*. (2011).

4.2.14 Seed breadth (mm)

Seed breadth in dolichos bean genotypes was ranged (Table 4.2) from 5.28mm to 9.31 mm with a total grand mean of 6.80 mm. Among the genotypes, maximum breadth of the seed was recorded in IC-384066 (9.31 mm), while the minimum was recorded in IC-446584 (5.28 mm). Eight genotypes *viz.*, IC-413710 (7.66 mm), RND-01 (7.69 mm), IC-546376 (7.84 mm), IC-427436 (7.95 mm), IC-427428 (8.29 mm), IC-565181 (8.57 mm), IC-261010 (8.83 mm) and IC-383197 (8.84 mm) recorded statistically at par values with IC-384066 (9.31 mm). Out of 35 dolichos bean genotypes, fourteen genotypes produced significantly more seed breadth when compared to grand mean. Nine genotypes *i.e*. IC-261010 (8.83 mm), IC-383197 (8.84 mm), IC-384066 (9.31 mm), IC-413709 (7.11 mm), IC-413710 (7.66 mm), IC-427424 (9.11 mm), IC-427428 (8.29 mm), IC-427436 (7.95 mm) and IC-565181 (8.57 mm) recorded significantly more seed breadth when compared to the check variety RND-1 (7.69 mm). These results are in concurrence with the findings of those reported by Singh *et al*. (2011).

4.2.15 Hundred fresh seed weight (g)

The character 100 fresh seed weight (Table 4.2) was ranged from 37.27 g to 76.64 g with a total grand mean of 51.38 g. The genotype IC-261010 (76.64 g) recorded the maximum 100 fresh seed weight and the genotype IC-413709 (37.27 g) recorded the minimum fresh seed weight. None of the genotypes recorded statistically at par values with the highest value IC-261010 (76.64 g).Twenty one genotypes produced significantly greater 100 fresh seed weight when compared to the grand mean. Four genotypes IC-261010 (76.64 g), IC-384066 (60.82 g), IC-446581 (64.29 g) and SNJ-11-068 (59.31 g) recorded significant and greater 100 fresh seed weight over the check variety RND-1 (59.10 g). These results are in concurrence with the findings of those reported by Sankaran *et al*. (2008).

4.2.16 Hundred dry seed weight (g)

The character 100 dry seed weight (Table 4.2) was ranged from 22.00 g to 35.56 g with a total grand mean of 29.51g. The genotype IC-383197 (35.56g) recorded the maximum 100 dry seed weight and the genotype RJR-387 (22.00 g) recorded the minimum dry seed weight. The genotypes which were IC-565181 (31.87 g), IC-598467 (32.04 g), IC-546387 (32.21 g), IC-546388 (33.54 g), NSJ/NAIP/192 (34.40 g), RND-01 (34.56 g) recorded statistically at par values with IC-383197 (35.56 g). Out of 35 dolichos bean, genotypes sixteen genotypes produced significantly greater 100 dry seed weight compared to the grand mean. One genotype IC-383197 (35.56 g) recorded significant and greater 100 dry seed weight over the check variety RND-1 (34.56 g).

4.2.17 Protein content (%)

Protein content in dolichos bean genotypes was ranged from 15.41 % to 25.09 % with a grand mean of 19.51 %. The highest protein content 25.09 % was recorded in PSRJ-13039, while the lowest was recorded in IC-546388 (15.41 %). Three genotypes namely IC-427462 (24.15 %), RND-01 (24.28 %), IC-427428 (24.76 %) recorded statistically at par values with the PSRJ-13039 (25.09 %).Out of 35 dolichos bean genotypes, sixteen genotypes produced significantly highest protein content as compared to the grand mean. Two genotypes IC-427428 (24.76 %) and PSRJ-13.39 (25.09 %) recorded significantly highest protein content over the check variety RND-1 (24.28 %). These results are in concurrence with the findings of those reported by Parmar *et al.* (2013), Chaitanya *et al*. (2014) and Verma *et al.* (2015).

4.2.18 Fiber content (%)

Fiber content in dolichos bean genotypes (Table 4.2) was ranged from 10.52 % to 28.35 % with a grand mean of 19.28 %. The highest fiber content was recorded in RDG-25 (28.35 %), while the lowest fiber content was recorded in RDG-13 (10.52 %). None of the genotypes recorded statistically at par values with RDG-13 (10.52 %). Out of 35 dolichos bean genotypes, 15 genotypes produced significant and highest fiber content compared to the grand mean. Ten genotypes *i.e*. IC-413709 (24.91 %), IC-426988 (25.68 %), IC-446581 (27.12 %), IC-446591 (25.32 %), IC-546349 (23.70 %), IC-546376 (28.35 %), PSR-13183 (22.26 %), PSRJ-13039 (28.02 %), PSRJ-13114-2 (25.53 %) and RJR-03 (26.14 %) recorded significantly highest fiber content over the check variety RND-1 (21.87 %).

4.2.19 Pod yield per plant (g)

Pod yield per plant (Table 4.2) was ranged from 139.19 g to 805.23 g with a total mean of 402.85 g. The maximum pod yield per plant was recorded in IC-546387 (805.23 g), while the minimum and significant pod yield was recorded in IC-546349 (139.19 g). None of the genotypes recorded statistically on par values with the highest value IC-546387 (805.23 g). Out of 35 dolichos bean genotypes studied sixteen genotypes produced significantly maximum pod yield when compared to grand mean. Two genotypes viz., IC-427428 (667.07 g) and IC-546387 (805.23 g) recorded significantly higher pod yield when compared to the check variety RND-1 (632.57 g). The results pertaining to this trait are in accordance with the studies conducted by Chaitanya *et al.* (2014) and Sharma *et al*. (2014).

Out of 35 genotypes, two genotypes *viz.*, IC-546387 (805.23 g), IC-427428 (667.07 g) was recorded significantly higher marketable pod yield per plant than the commercial check variety RND-1 (632.57 g).

IC-546387 was found to be superior over check variety for marketable pod yield due to more number of pods per plant (175.66), the growth attributes like vine length (462.17 cm) and medium pod width(1.29 cm). Hence this can be used for further evaluation and then released as a variety.

IC-427428 was also showed significantly superior over check with regard to number of pods per plant (92.76), days to first flowering (86.00), days to first pod harvest (104.50) and pod length (12.61 cm), pod width (2.03 cm) and protein content (24.76 %).

Among the genotypes, NSB-2010/029 recorded moderate marketable pod yield with more number of pods per plant (164.96) and number of seeds per pod (5.50). PSRJ-13039 recorded at par yield (604.12 g) with check with more number of pods per plant (95.76) with high protein content (25.09 %). Hence, these genotypes can be used as donor parents for the respective characters in breeding programmes.

IC-546387 (462.17 cm) recorded maximum vine length among the genotypes compared to check variety. IC-383197 (3.83) recorded maximum number of branches per plant. IC-261010 (80.00) required less number of days for first flowering ; days to 50 percent flowering (89.50) and days to first pod harvest (115.00) among the genotypes.

IC-427436 (154.50) recorded minimum number of days to last pod harvest among the genotypes. Days to pod maturity recorded was maximum for IC-546387 (222.50). Pod length was maximum in the genotype IC-427436 (15.47 cm). Pod width was maximum in the genotype IC-383197 (4.34 cm).

Pod weight recorded was maximum in the genotype IC-384066 (9.25 g). IC-546387 (175.66) exhibited maximum number of pods per plant among the genotypes. None of the genotypes produced more number of seeds per pod than the check variety RND-1. Seed length recorded was maximum in IC-427428 (5.12 mm). Genotype IC-384066 (9.31 mm) recorded maximum seed breadth among the genotypes. IC-261010 (76.64 mm) recorded maximum 100 fresh seed weight. Hundred dry seed weight recorded maximum in IC-383197 (35.56 g). Protein content was recorded maximum in

PSRJ-13039 (25.09 %). Hence, these genotypes can be used as donor parents for the respective characters.

A much detailed analysis of yield attributing parameters, their association among themselves and their partial effects summing up to individual direct effects are also studied in the present investigation and described under correlation and path coefficient sections.

4.3 GENETIC DIVERGENCE ANALYSIS

The results of quantitative assessment of genetic divergence among 35 genotypes of dolichos bean for pod yield and other 18 yield contributing traits following Mahalanobis D^2 statistic are presented below.

4.3.1 Mahalanobis D^2 statistic

4.3.1.1Test with Wilk's criterion

Wilk's 'V' (statistic) criterion was used to test the significant differences between the genotypes based on the pooled effects of all the characters. The significance of 'V' (statistic) value was tested at 893 degrees of freedom. The 'V' (statistic) value (106.5**) was highly significant indicating that the genotypes differed significantly when all the characters were considered simultaneously.

4.3.1.2 Mahalanobis D^2 values

The correlated unstandardized means of 19 characters studied were transformed to standardized uncorrelated set of variables by using pivotal condensation method. The statistical distance (Mahalanobis D^2 value) between a pair of genotypes was obtained as sum of squares of differences between pairs of corresponding uncorrelated values of any two genotypes. These values were considered at a time and these were used for final grouping of genotypes.

Rai *et al*. (2009), Upadhyay and Mehta (2010), Lal *et al*. (2011), Singh *et al*. (2011), Chaitanya *et al*. (2013), Pawar *et al.* (2013), Salim *et al.*

(2013) and Verma *et al.* (2015) successfully utilized the Mahalanobis D^2 analysis for quantifying the genetic divergence in different dolichos bean genotypes.

Since, each genotype produce 34 combinations with all other genotypes, totally 665 D^2 values were obtained. Based on these D^2 values, per cent contribution of different characters towards genetic divergence was computed. The results on *per cent* contribution of each character towards genetic divergence are presented in Table 4.3.

4.3.1.3 PERCENT CONTRIBUTION OF DIFFERENT CHARACTERS TOWARDS DIVERSITY IN DOLICHOS BEAN.

The character pod yield per plant (g) ranked first for 156 times with a maximum contribution of 26.21 *per cent* followed by fiber content (20.67 %), protein content (19.15 %), number of pods per plant (8.57 %), days to last pod harvest (7.22 %), pod length (cm) (7.22 %), 100 dry seed weight (g) (5.71 %), vine length(cm) (2.35 %), number of seeds per pod (1.00 %), seed length (mm) (0.84 %), 100 fresh seed weight (g) (0.84 %), pod weight (g) (0.16 %). Some of the characters like no. of primary branches per plant, days to first flowering, days to 50% flowering, days to first pod harvest, days to pod maturity, pod width (cm), Seed breadth (mm) did not contribute anything towards the genetic diversity in dolichos bean germplasm.

The difference in the contributing factors for genetic divergence could be attributed to differences among the genotypes under study, which in turn might be due to environmental conditions of the locations associated and interacted with genotypes. The characters contributing maximum to the D^2 value are to be given greater emphasis for deciding on the clusters for the purpose of further selection and choice of parents for hybridization.

4.3.1.4 Clustering of D^2 values

Procedure suggested by Tocher (Rao, 1952) was used to group 35 dolichos bean genotypes into six clusters by treating estimated D^2 values as the square of the generalized distance. The pattern of distribution of 35 genotypes in to various clusters is indicated in Table 4.4. The resulting average D^2 values within (intra) and between (inter) clusters are indicated in Table 4.5. Maximum divergence was observed between cluster VI and III (D^2 = 1780.19), while minimum was between cluster IV and II (D^2 =333.46). Pattern of distribution of genotypes into six clusters is similar with the findings of Savitha (2008), Chaudhary *et al*. (2010) and Lal *et al*. (2011).

4.3.1.5 Average intra and inter cluster distances

The mean intra and inter cluster D^2 values among the six clusters are given in the Table 4.6. The intra cluster distance ranged from 0.00 (Cluster VI) to 249.64 (Cluster IV). The nearest and farthest clusters from each cluster based on D^2 values in dolichos bean germplasm.

Among six clusters, for intra clusters, Cluster I and cluster VI exhibits less divergence, Cluster II and cluster III exhibits moderate divergence and cluster IV and cluster V are highly divergent

Cluster I (21.37) consisting of two genotypes exhibited a close relation with cluster II (515.71) followed by cluster IV (614.70), while, it was distant from cluster VI (1339.90). Cluster II (178.22) consisting of 15 genotypes (largest cluster) exhibited a close relation with cluster IV (333.46) followed by cluster III (346.60), while it was distant from cluster VI (968.94).

Cluster III (144.65) consisting of six genotypes, exhibited a close relation with cluster II (346.60) followed by cluster V (556.12), while it was distant from cluster VI (1780.19). Cluster IV (249.64) consisting of 8 genotypes exhibited a close relation with cluster II (333.46) followed by cluster VI (249.64), while it was distant from cluster III (760.75).

Cluster V (237.61) consisting of three genotypes, exhibited a close relation with cluster II (41.004) followed by cluster III (556.12), while it was distant from cluster I (1221.52). Cluster VI (0.00) consisting of solitary genotype exhibited a close relation with cluster IV (464.85) followed by cluster II (968.94), while it was distant from cluster III (1780.19).

4.3.1.6 Performance of characters in cluster

The mean values of six clusters for 19 characters are presented in Table 4.7. From the data, it was observed that considerable differences existed among the characters studied.

The lowest mean value was registered by the genotypes of cluster I (60.49) for the character vine length (cm) followed by the genotypes of cluster VI. The genotypes of cluster V recorded highest mean value for the character vine length (cm) 406.48 followed by genotypes of cluster III (393.08).

The genotypes of cluster I (3.19) recorded highest mean value for the character number of primary branches per plant followed by genotypes of cluster V (3.15). The lowest mean value was recorded by the genotypes of cluster VI (2.22) followed by the genotypes of cluster II (2.72).

The genotypes of cluster I (54.50) took minimum number of days to first flowering followed by cluster III (88.33), while the genotypes of cluster II recorded maximum number of days for first flowering (95.43) followed by genotypes of cluster IV (94.00).

The lowest mean value was registered by the genotypes of cluster I (69.75) for the character days to 50 percent flowering followed by the genotypes of cluster V (98.83). The genotypes of cluster VI recorded highest mean value for the character days to 50 percent flowering (112.50) followed by the genotypes of cluster II (111.77).

The genotypes of cluster I (89.75) took minimum number of days to first pod harvest followed by the genotypes of cluster V (125.50), while the genotypes of cluster II recorded maximum number of days for first flowering (136.90) followed by genotypes of cluster IV (133.69).

The lowest mean value was registered by the genotypes of cluster V (158.33) for the character days to last pod harvest followed by the genotypes of cluster I (176.00). The genotypes of cluster II recorded highest mean value for the character days to last pod harvest (191.37) followed by the genotypes of cluster IV (190.94).

The genotypes of cluster II (211.27) recorded highest mean value for the character days to pod maturity followed by genotypes of cluster III (208.75). The lowest mean value was registered by the genotypes of cluster V (177.50) followed by the genotype of cluster VI (189.00).

The maximum pod length (cm) was recorded in the genotypes of cluster V (14.44) followed by the genotypes of cluster III (13.10). The minimum mean value for pod length (cm) was recorded in the genotypes of cluster I (6.28) followed by the genotypes of cluster VI (6.31).

The maximum pod width (cm) was recorded in the genotypes of cluster V (2.66) followed by the genotypes of cluster III (2.47). The minimum mean value for pod width (cm) was recorded in the genotypes of cluster I (1.14) followed by the genotypes of cluster II (1.55).

The genotypes of cluster III (8.48) recorded highest mean value for the character pod weight (g) followed by genotypes of cluster V (6.81). The lowest mean value for the character pod weight (g) was registered by the genotypes of cluster I (4.03) followed by the genotypes of cluster IV (5.22).

The maximum number of pods per plant was recorded in the genotypes of cluster VI (164.97) followed by the genotypes of cluster IV (104.10). The minimum number of pods per plant was recorded in the genotypes of cluster I (51.64) followed by the genotypes of cluster III (57.54).

The genotypes of cluster III (537.62) recorded highest mean value for the character pod yield per plant followed by genotypes of cluster V (395.97). The lowest mean value was registered by the genotypes of cluster I (232.39) followed by the genotype of cluster VI (355.59).

The maximum number of seeds per pod was recorded in the genotypes of cluster VI (5.50) followed by the genotypes of cluster III (5.21). The minimum number of seeds per pod was recorded in the genotypes of cluster I (4.09) followed by the genotypes of cluster V (4.78).

The maximum seed length (mm) was recorded in the genotypes of cluster III (11.22) followed by the genotypes of cluster V (10.67). The minimum mean value for seed length (mm) was recorded in the genotypes of cluster I (7.73) followed by the genotypes of cluster VI (7.91).

The maximum seed breadth (mm) was recorded in the genotypes of cluster III (8.40) followed by the genotypes of cluster V (7.90). The minimum mean value for seed breadth (mm) was recorded in the genotypes of cluster IV (6.17) followed by the genotypes of cluster I (6.25)

The genotypes of cluster III (60.47) recorded highest mean value for the character 100 fresh seed weight followed by genotypes of cluster II (52.90). The lowest mean value was registered by the genotypes of cluster I (33.22) followed by the genotypes of cluster VI (46.25).

The genotypes of cluster III (31.01) recorded highest mean value for the character 100 dry seed weight followed by genotypes of cluster II (30.11). The lowest mean value was registered by the genotypes of cluster I (25.46) followed by the genotypes of cluster IV (28.46).

The lowest mean value was registered by the genotype of cluster VI (15.74) for the character protein content followed by the genotypes of cluster V (16.74). The genotypes of cluster I recorded highest mean value for the character protein content (22.27) followed by the genotypes of cluster III (22.10).

The lowest mean value was registered by the genotype of cluster VI (13.68) for the character fiber content followed by the genotypes of cluster I (16.83). The genotypes of cluster II (21.21) recorded highest mean value for the character fiber content followed by the genotypes of cluster IV (18.89).

Cluster mean values showed a wide range of mean values among the characters studied indicating presence of wide variation among the genotypes studied. Hence, apart from selecting genotypes from the clusters which have high inter-cluster distance for hybridization, one can also think of selecting parents based on extent of genetic divergence in respect to a particular character of interest. This is to mean that, if breeders intention is to improve pod yield, breeder can select parents which are highly divergent with respect to these characters.

4.4 GENETIC VARIABILITY PARAMETERS

The success of any breeding programme depends on the availability of genetic variability present in the population, which is however, not directly measurable by itself, but has to be inferred with the phenotypic expression. The genotypic coefficient of variation measures the range of variability present among different characters. The phenotype may therefore be defined as a linear function of genotype (G) and environment (E) and genotype (G) X environment (E) interaction effect. So, the total variance should be partitioned into heritable and non-heritable components to assess the true breeding nature of that particular trait.

The range in mean values does not reflect the total variance in the material being studied. Thus, it would be erroneous to infer on the magnitude of variability based on the range of a character. Hence, actual variance has to be estimated for the characters to know the extent of variability existing among the different genotypes. The phenotypic variance indicates the amount of variance which is due to the differences in phenotypic values whereas the genotypic variance indicates the magnitude of variance arising due to the differences in genotypic values.

The absolute values of phenotypic and genotypic variances cannot be used for comparing the degree of variability for different characters because the means of character to be measured could also be different. Hence, the coefficient of variation is calculated by considering the respective means are to be used for the comparison (Johnson *et al.,* 1955).

In the present study, phenotypic coefficient of variation in general was higher than the genotypic of variation for all the traits, but the difference was very low, indicating low environmental influence on the expression of all the traits and is suggestive of the heritable nature of the traits.

In crop improvement programme, genetic variation is important. Heritability is the only component which is transmitted to the next generation. The ratio of genetic variance to the total variance *i.e.* phenotypic variance is known as heritability. Heritability estimates gives a measure of transmission of characters from one generation to the next and the consistency in the performance of progeny in succeeding generations depends mainly on the magnitude of heritable portion of variation.

It is not necessary that high heritability in broad sense will give high expected genetic advance. If the character is governed by additive and additive X additive gene actions predominantly, then only it gives response to selection. Heritability in broad sense doesn't give this picture and high heritability with high genetic advance is important for selection.

The results with regard to mean, overall range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2) and expected genetic advance as per cent of mean (GA) for all the nineteen characters are furnished in Table 4.8.The details of these variability parameters are presented below.

4. 4.1 Vine length (cm)

Very high phenotypic and genotypic variances (7953.31 and 7280.89 respectively**)** (Table 4.8) were recorded coupled with high PCV and GCV of 25.19 and 24.11 *per cent*, respectively. High estimates of PCV and GCV recorded for this trait indicates the presence of high degree of genetic variability and thus a greater scope for selection on the basis of this character These results are similar to the findings of Chaitanya *et al*. (2014), Verma *et al.* (2015), Singh *et al*. (2015) and Choudhary *et al.* (2016).

This trait showed high heritability (91 %), high genetic advance (161.18) and high GA as percent mean (47.52). High heritability in conjunction with high GAM was observed for this trait which indicates the preponderance of additive gene action governing it's the inheritance and offers the best possibility of improvement through simple selection procedure. Similar results are obtained by Magalingam *et al.* (2013), Pawar and Prajapathi (2013), Chaitanya *et al*. (2014), Singh *et al*. (2015), Verma *et al.* (2015) and Choudhary *et al.* (2016).

4.4.2 Number of primary branches per plant

This character (Table 4.8) recorded very low phenotypic and genotypic variances 0.19 and 0.11 respectively with moderate PCV (15.37 %), moderate GCV (11.66 %), moderate heritability (52 %), with low genetic advance (0.52) and moderate GA as percent mean (18.23).The results are similar findings with Magalingam *et al.* (2013), Pawar and Prajapathi (2013), Chaitanya *et al*. (2014), Mohan *et al*. (2014) and Verma *et al. (*2015)

4.4.3 Days to first flowering

Very high phenotypic and genotypic variances (133.42 and 107.45 respectively) were recorded in dolichos bean genotypes with moderate PCV (12.72 %) and GCV (11.43 %) values (Table 4.8). Days to first flowering showed high heritability (80 %), but moderate genetic advance (19.21) and high GA as percent mean (21.16).These results are similar to the findings of Salim *et al.* (2013), Chaitanya *et al*. (2014), Sharma *et al*. (2014), Verma *et al.* (2015) and Choudhary *et al.* (2016)

4.4.4 Days to 50 *per cent* flowering

This character (Table 4.8) recorded higher phenotypic and genotypic variances (167.23 and 127.82 respectively) with moderate PCV (12.15 %), GCV (10.62 %), high heritability (76 %), high genetic advance (20.36) and moderate GA as percent mean (19.13). Similar results were obtained by Parmar *et al.* (2013), Pawar and Prajapathi (2013), Salim *et al.* (2013), Chaitanya *et al*. (2014) and Verma *et al*. (2015).

4.4.5 Days to first pod harvest

Days to first pod harvest recorded (Table 4.8) high phenotypic (172.83) and genotypic (141.51) variances, moderate PCV (10.06 %), low GCV (9.10 %), high heritability (82 %), high genetic advance (22.17) and moderate GA as percent of mean (16.96). Similar results were obtained by Rai *et al*. (2008), Magalingam *et al.* (2013), Parmar *et al.* (2013), Chaitanya *et al*. (2014), Sharma *et al*. (2014), Savitha *et al*. (2014), Singh *et al.* (2015) and Verma *et al.* (2015)

4.4.6 Days to last pod harvest

Days to last pod harvest (Table 4.8) recorded high phenotypic (181.10) and genotypic (147.77) variances, low PCV (7.19 %), low GCV (6.50 %), high heritability (81 %), high genetic advance (22.62) and moderate GA as percent of mean (12.09). These results are similar with findings of Savitha *et al*. (2014).

4.4.7 Days to pod maturity

Days to pod maturity recorded (Table 4.8) high phenotypic (191.92) and genotypic (162.28) variances, low PCV (6.75 %), low GCV (6.20 %), high heritability (84 %), high genetic advance (24.13) and moderate GA as percent of mean (11.76). Similar results were recorded by Pawar and Prajapathi (2013) and Mohan *et al*. (2014).

4.4.8 Pod length (cm)

This character (Table 4.8) recorded low phenotypic and genotypic variances (9.42 and 8.61 respectively) with high PCV (30.50 %), GCV (29.15 %), high heritability (91 %), low genetic advance (5.77) and high GA as percent mean (57.39). High heritability in conjunction with high GAM was observed for this trait indicating the preponderance of additive gene action governing its inheritance and offers the best possibility of improvement through simple selection procedures. The results are similar to findings with Savitha (2008), Rai *et al*. (2009), Upadhyay and Mehta (2010), Chattopadhyay and Dutta (2010), Magalingam *et al.* (2013), Chaitanya *et al*. (2014) and Sharma *et al*. (2014).

4.4.9 Pod width (cm)

With regard to pod width, **(**Table 4.8) low phenotypic and genotypic variances (0.61 and 0.43 respectively) with high PCV (43.20 %), GCV (36.43 %), high heritability (71 %), low genetic advance (1.14) and high GA as percent mean (63.31) were recorded. These results are similar to findings of Rai *et al*. (2009), Upadhyay and Mehta (2010), Singh *et al*. (2011), Magalingam *et al.* (2013), Mohan *et al*. (2014) and Choudhary *et al.* (2016)

4.4.10 Pod weight (g)

With regard to pod weight, **(**Table 4.8) low phenotypic and genotypic variances (2.57 and 2.13 respectively) along with high PCV (24.82 %), GCV (22.61 %), high heritability (83 %), low genetic advance (2.74) and high GA as percent mean (42.43) were registered. Similar results were obtained by Chattopadhyay and Dutta (2010), Magalingam *et al.* (2013) and Chaitanya *et al*. (2014)

4.4.11 Number of pods per plant

This character (Table 4.8) recorded very high phenotypic and genotypic variances (1212.14 and 1166.86 respectively) with high PCV (46.21 %), GCV (45.34 %), high heritability (96 %), high genetic advance (69.0) and high GA as percent mean (91.64).

High heritability coupled with high GAM observed for this trait indicated that this trait was under additive gene control and direct selection for this trait would be effective for genetic improvement. Similar results were found by Rai *et al*. (2008), Savitha (2008), Chattopadhyay and Dutta (2010), Singh *et al*.(2011), Magalingam *et al.* (2013), Parmar *et al.* (2013), Pawar and Prajapathi (2013), Salim *et al*. (2013), Chaitanya *et al*. (2014), Verma *et al.* (2015) and Choudhary *et al.* (2016).

4.4.12 Number of seeds per pod

With regard to (Table 4.8) number of seeds per pod low phenotypic and genotypic variances (0.74 and 0.33 respectively) with moderate PCV (17.62 %) and GCV (11.83 %), moderate heritability (45 %), low genetic advance (0.80) and moderate GA as percent mean (16.37) were recorded. Similar results are obtained by Savitha (2008), Mohan *et al*. (2014) and Singh *et al. (*2015).

4.4.13 Seed length (mm)

This character recorded (Table 4.8) low phenotypic and genotypic variances (2.44 and 1.90 respectively) with moderate PCV (16.78 %) and GCV (14.80 %), high heritability (77 %), low genetic advance (2.50) and high GA as percent mean (26.91). Similar results were found by Rai *et al*. (2009) and Singh *et al*. (2011).

4.4.14 Seed breadth (mm)

This character (Table 4.8) recorded low phenotypic and genotypic variances (1.82 and 1.09 respectively) with moderate PCV (19.83 %), GCV (15.37 %), high heritability (60 %), low genetic advance (1.66) and high GA as percent mean (24.52). Similar results were found by Rai *et al*. (2009) and Singh *et al*. (2011).

4.4.15 Hundred fresh seed weight (g)

The character 100 fresh seed weight (Table 4.8) recorded high phenotypic and genotypic variances (87.05 and 64.07 respectively) with moderate PCV (18.15 %) and GCV (15.57 %), high heritability (73 %), moderate genetic advance (14.14) and high GA as percent mean (27.53). Similar results are found by Chaitanya *et al*. (2014)

4.4.16 Hundred dry seed weight (g)

The character 100 dry seed weight (Table 4.8) recorded low phenotypic and genotypic variances (9.88 and 5.20 respectively) with moderate PCV (10.65 %) and GCV (7.72 %), moderate heritability (52 %), low genetic advance (3.40) and moderate GA as percent mean (11.54). Similar results were found by Chaitanya *et al*. (2014)

4.4.17 Protein content (%)

This character (Table 4.8) recorded low phenotypic and genotypic variances (9.56 and 8.67 respectively) with moderate PCV (15.84 %) and GCV (15.09 %), high heritability (90 %), low genetic advance (5.77) and high GA as percent mean (29.61). Similar results were found by Chaitanya *et al*. (2014) and Verma *et al. (*2015)

4.4.18 Fiber content (%)

This character recorded (Table 4.8) high phenotypic and genotypic variances (24.75 and 23.51 respectively) with high PCV (25.79 %) and GCV (25.14 %), high heritability (95 %), low genetic advance (9.73) and high GA as percent mean (50.48).The present results are similar to the findings of Magalingam *et al.* (2013) and Choudhary *et al*. (2016).

4.4.19 Pod yield per plant

This character (Table 4.8) recorded very high phenotypic and genotypic variances (23894.64 and 22592.39 respectively) with high PCV (38.37 %) and GCV (37.31 %), high heritability (94 %), high genetic advance (301.07) and high GA as percent mean (74.73). High heritability in conjunction with high GAM was observed for this trait which indicates the preponderance of additive gene action governing the inheritance of this character and offers the best possibility of improvement through simple selection procedure. Similar results were found by Magalingam *et al.* (2013), Parmar *et al.* (2013), Pawar and Prajapathi (2013), Chaitanya *et al*. (2014), Mohan *et al*. (2014), Sharma *et al*. (2014), Singh *et al.* (2015), Verma *et al.* (2015) and Choudhary *et al.* (2016).

Among the growth attributes, genetic variability studies showed high PCV and GCV for vine length and moderate PCV and GCV for primary branches per indicating that a high degree of genetic variability is present in these characters which provides a greater scope for selection.

Among the earliness attributes, days to first flowering, days to 50 percent flowering, days to first pod harvest exhibited moderate PCV and GCV suggesting wide range of genetic variability is present in these characters which provide greater scope for selection.

Among the pod attributes, all the pod attributes exhibited high PCV and GCV values for pod length, pod width, pod weight and number of pods per plant indicating a high degree of variability is present in these characters and selection is effective to improve them. Marketable pod yield per plant had high PCV and GCV values.

Among seed attributes seed length, seed breadth, 100 fresh seed weight, 100 dry seed weight, protein content and fiber content recorded moderate to high PCV and GCV values indicating that a high degree of genetic variability is present in these characters which provide a greater scope for selection.

All the growth, pod, seed and the earliness attributes with high PCV and high GCV values suggesting high degree of genetic variability for these characters and offering a greater scope for effective selection as these characters are less influenced by the environment

In the present study, high heritability was recorded by all the characters except for number of branches per plant, 100 dry seed weight. These results indicate that these characters are under the influence of additive gene action.

High heritability coupled with high genetic advance as per cent of mean was observed for characters like number of pods per plant pod width, pod yield per plant, pod width, vine length, pod length, pod weight, fiber content, seed length, 100 fresh seed weight, days to first flowering, protein content indicating that these traits were under the strong influence of additive gene action. Hence simple selection based on phenotypic performance of these traits would me more effective

High heritability coupled with moderate genetic advance as *per cent* of mean was observed for days to 50 % flowering, days to first pod harvest and days to pod maturity.

High variability in conjunction with high genetic advance as *per cent* of mean indicating the predominance of additive gene action. These traits could be exploited through manifestation of dominance and epistatic components through heterosis breeding. Moderate heritability coupled with moderate genetic advance as *per cent* of mean observed for number of primary branches per plant

Hence, the breeder should adopt suitable breeding methodology to utilize both additive and non additive gene effects simultaneously, since varietal and hybrid development will go a long way in the breeding programmes, especially in case of dolichos bean.

4.5 Correlation coefficient analysis

Yield, being a complex character is governed by a large number of genes. The influence of each character on yield could be known through correlation studies with a view to determine the extent and nature of relationships prevailing among yield and yield attributing characters. The present investigation was carried out to study the association of different characters on yield and yield attributing traits in dolichos bean both at phenotypic levels and genotypic levels. In general, it is evident from the data recorded that genotypic correlation was higher than the phenotypic correlation indicating strong inherent association of characters, and a less influence of environmental factors and relative stability of the genotypes.

The phenotypic correlation (P) and genotypic correlation (G) coefficients were worked out for nineteen characters in 35 dolichos bean genotypes and the data is presented in Tables 4.9 (a) and 4.9(b)

4.5.1 Vine length (cm)

Vine length (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with days to first flowering (0.662 P, 0.779 G), days to 50 percent flowering (0.569 P, 0.672 G), days to first pod harvest (0.634 P, 0.692 G), pod length (0.326 P, 0.348 G), pod weight (0.471 P, 0.567 G), seed length (0.313 P, 0.384 G), 100 fresh seed weight (0.367 P, 0.412 G), 100 dry seed weight (0.401 P, 0.576 G) and pod yield per plant (0.511 P, 0.540 G) at 5% and 1% LOS. This character showed positive significant correlation with pod width (0.829 G) at 1% LOS only. Significant negative association was not observed for any of the traits involved in the study. The results of vine length exhibited positive significant correlation are similar for pod length by Pawar and Prajapathi (2013) and Singh *et al.* (2015).

4.5.2 Number of primary branches per plant

Number of primary branches per plant registered (Tables 4.9 a and 4.9 b) negative and significant correlation with days to first pod harvest (-0.239 P), fiber content (-0.252 P, -0.326 G) at 5 % and 1 % LOS.

This character exhibited positive significant correlation with pod width (0.239 P), pod yield per plant (0.291 P) at 5 % LOS for phenotypic level and with pod width (0.359 G), 100 dry seed weight (0.413 G), pod yield per plant (0.427 G) at 5% and 1% LOS for genotypic level.

The results are similar to findings of Magalingam *et al.* (2013) for pod width and for 100 dry seed weight by Pawar and Prajapathi. (2013)

4.5.3 Days to first flowering

Days to first flowering (Tables 4.9 a and 4.9 b) recorded positive and significant correlation with vine length (0.662 P, 0.779 G), days to 50 percent flowering (0.938P, 0.968 G), days to first pod harvest (0.905 P, 0.958 G), days to last pod harvest (0.418 P, 0.368 G) and days to pod maturity (0.361 P, 0.351 G) at 5% and 1% LOS for phenotypic and genotypic levels.

This character exhibited positive significant correlation with pod weight (0.279 P), 100 seed dry weight (0.295 P), fiber content (0.239 P) and pod yield per plant (0.244 P) at 5% LOS for phenotypic level. This character exhibited positive significant correlation with pod weight (0.332 G), number of seeds per pod (0.323 G), 100 fresh seed weight (0.279 G), 100 dry seed weight (0.468 G), fiber content (0.272 G) and pod yield per plant (0.251 G) at 5% LOS for genotypic level. Significant negative association was not observed for any of the traits involved in the study.

The results of days to first flowering exhibited positive significant correlation are similar findings for vine length by Bendale *et al*. (2008) and Gadakh *et al.* (2016); for days to 50 *per cent* flowering Sharma *et al.* (2014); for days to first pod harvest Sharma *et al.* (2014); for days to last pod harvest Chaitanya *et al.* (2014) and Verma *et al.* (2015); for days to pod maturity Gadakh *et al.* (2016); for number of seeds per pod Chaitanya *et al.* (2014), Verma *et al.* (2015) and Gadakh *et al.* (2016).

4.5.4 Days to 50 *per cent* flowering

Days to 50 *per cent* flowering exhibited (Tables 4.9 a and 4.9 b) positive significant correlation with vine length (0.569 P, 0.672 G), days to first flowering (0.938 P, 0.968 G), days to first pod harvest (0.926 P, 0.966 G), days to last pod harvest (0.516 P, 0.455G), days to pod maturity(0.437 P, 0.449 G), pod weight (0.302G), number of seeds per pod (0.305 G), 100 dry seed weight (0.348 P, 0.500 G), fiber content (0.324 G) at both levels. This character showed positive significant correlation with pod weight (0.281 P), 100 fresh seed weight (0.276 G), fiber content (0.282 P) and pod yield per plant (0.254 P, 0.271 G) only at 5% LOS. Negative significant correlation was noticed only with protein content (-0.239G) at genotypic level only.

The results of days to 50 *per cent* flowering exhibited positive significant correlation are similar findings for days to first flowering by Salim *et al.* (2013), Sharma *et al.* (2014) and Verma *et al.* (2015); for days to first pod harvest Sharma *et al*. (2014), Verma *et al*. (2015) and Singh *et al.*(2015); for days to last pod harvest Chaitanya *et al.* (2014); for days to pod maturity Magalingam *et al*. (2013), Pawar and Prajapathi (2013) and Singh *et al.*(2015); for pod weight by Chattopadyay and Dutta (2010); for number of seeds per pod by Chaitanya *et al.* (2014) and Singh *et al.* (2015) and for fiber content by Magalingam *et al*. (2013).

The results of days to 50 percent flowering exhibited positive significant correlation are similar findings for protein content by Magalingam *et al.* (2013), Pawar and Prajapathi (2013) and Verma *et al.* (2015).

4.5.5 Days to first pod harvest

Days to first pod harvest (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with vine length (0.634 P, 0.692 G), days to first flowering (0.905 P. 0.958 G), days to 50 percent flowering (0.926 P, 0.966 G), days to last pod harvest (0.513 P, 0.423 G), days to pod maturity (0.425 P, 0.376 G), number of seeds per pod (0.336 G), 100 fresh seed weight (0.365 G) and 100 dry seed weight (0.417 G) at both 5% and 1% LOS. This character showed positive significant correlation with pod weight (0.240 P, 0.292 G), 100 fresh seed weight (0.294 P), 100 dry seed weight (0.272 P) and pod yield per plant (0.242 G) only at 5% level of significance.

Negative significant correlation was noticed with number of primary branches per plant (-0.239 P) at phenotypic level and protein content (-0.250 G) at genotypic level only at 5% LOS.

The results of days to first pod harvest exhibited positive significant correlation are similar findings for days to first flowering by Singh *et al.* (2011), Chaitanya *et al.* (2014), Sharma *et al.* (2014) and Verma *et al.* (2015); for days to 50 *per cent* flowering by Sharma *et al.* (2014), Chaitanya *et al.* (2014), Verma *et al.* (2015) and for number of seeds per pod Sharma *et al.* (2014) and Singh *et al.* (2015).

4.5.6 Days to last pod harvest

Days to last pod harvest exhibited (Tables 4.9 a and 4.9 b) positive significant correlation with days to first flowering (0.418 P, 0.368 G), days to 50 percent flowering (0.516 P, 0.455 G), days to first pod harvest (0.513 P, 0.423 G) and days to pod maturity (0.923 P, 0.963 G) at both 5% and 1% LOS. This character also shows significant positive correlation with 100 dry seed weight (0.260 G) at genotypic level only at 5% LOS.

Negative significant correlation was noticed with pod length (-0.243 P) at phenotypic level at only 5% LOS and pod length (0.313 G) at genotypic level at both 5% and 1% LOS.

The results of days to last pod harvest exhibited positive significant correlation are similar findings for days to first flowering, and days to 50 percent flowering Verma *et al.* (2015); for days to first pod harvest Chaitanya *et al.* (2014).

4.5.7 Days to pod maturity

Days to pod maturity (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with days to first flowering (0.361 P, 0.351 G), days to 50 percent flowering (0.437 P, 0.449 G), days to first pod harvest (0.425 P, 0.376 G) and days to last pod harvest (0.923 P, 0.963 G) at both 5% and 1% LOS. This character also shows positive significant correlation with pod weight (0.253 G), 100 dry seed weight (0.236 P, 0.288 G) and protein content (0.240 P) only at 5% LOS.

Negative significant correlation was noticed with pod length (-0.243 P) at phenotypic level at only 5% LOS and pod length (0.253 G) at genotypic level only at 5% LOS are similar findings of Singh *et al.* (2015).

The results of days to pod maturity exhibited positive significant correlation are similar findings for days to 50 percent flowering Singh *et al.* (2015), for days to first pod harvest Singh *et al.* (2015) and for protein content by Pawar and Prajapathi .(2013).

4.5.8 Pod length (cm)

Pod length (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with vine length (0.326 P, 0.348 G), pod width (0.361 G), pod weight (0.394 P, 0.480 G), seed length (0.492 P, 0.590 G), seed breadth (0.3449 P, 0.463 G) and 100 fresh seed weight (0.472 P, 0.557 G) at both 5% and 1% LOS. This character exhibited significant positive correlation with pod width (0.270 P) and pod yield per plant (0.240 P, 0.279 G) only at 5% LOS.

Negative significant correlation was noticed with days to last pod harvest (-0.243 P), days to pod maturity (-0.253 G), number of pods per plant (-0.248 P, -0.241G), fiber content (-0.234 P, -0.270 G) only at 5% LOS. This character exhibited negative significant correlation with days to last pod harvest (-0.314G) at both 5 % and 1 % LOS.

The results of pod length exhibited positive significant correlation with similar findings for vine length by Pawar and Prajapathi. (2013); for pod width by Patel *et al.* (2011), Singh *et al.* (2011), Chaitanya *et al.* (2014), Sharma *et al.* (2014) and Singh *et al.* (2015) and for seed length, and seed breadth reported by Singh *et al.* (2011).

4.5.9 Pod width (cm)

Pod width exhibited (Tables 4.9 a and 4.9 b) positive significant correlation with number of primary branches per plant (0.359 G), pod length (0.361 G), pod weight (0.361 P, 0.430 G), seed length (0.497 P, 0.669 G), and seed breadth (0.491P, 0.718 G) at both 5% and 1% LOS. This character also exhibited positive correlation with vine length (0.282 G), number of primary branches per plant (0.239 P), pod length (0.270P), 100 fresh seed weight (0.214 G) and 100 dry seed weight (0.240 G) only 5% LOS.

Negative significant correlation was noticed only with number of seeds per pod (-0.319 G) at genotypic level at both 5% and 1% LOS.

The results of pod width exhibited positive significant correlation are similar findings for pod length and seed length reported by Rai *et al.* (2009) and Singh *et al.* (2011); for pod weight reported by Chaitanya *et al.* (2014) and for seed breadth reported by Singh *et al.* (2011).

4.5.10 Pod weight (g)

Pod weight exhibited significant (Tables 4.9 a and 4.9 b) positive correlation with vine length (0.471 P, 0.567 G), days to first flowering (0.3321 G), days to first pod harvest (0.292 G), pod length(0.394 P, 0.480 G), pod width (0.361 P, 0.430 G), number of seeds per pod (0.409 G), seed length (0.390 P, 0.384 G), seed breadth (0.562 P, 0.734 G), 100 fresh seed weight (0.461 P, 0.613 G), 100 dry seed weight (0.469 P, 0.621G), pod yield per plant (0.485 P, 0.534 G) at both 5% and 1% LOS. This character also exhibited positive correlation with days to first flowering (0.279 P), days to 50 percent flowering (0.281 P), days to first pod harvest (0.240 P), days to pod maturity (0.253 G) and number of seeds per pod (0.297 P) only at 5% LOS.

Negative significant correlation was noticed only with number of seeds per pod (-0.244 P, -0.272 G) at 5% LOS. Similar results reported by Chattopadyay and Dutta (2010).

Similar results of positive correlation were reported for days to first flowering reported by Chaitanya *et al.* (2014); for pod length reported by Rai *et al.* (2009) and Chaitanya *et al.* (2014); for pod width as reported by Rai *et al.* (2009); for number of seeds per pod reported by Rai *et al.* (2009) and Chaitanya *et al.* (2014) and for seed length and seed breadth Rai *et al.* (2009).

4.5.11 Number of pods per plant

Number of pods per plant (Tables 4.9 a and 4.9 b) showed significant positive correlation only with pod yield per plant (0.495 P, 0.478 G) at both 5% and 1% LOS.

Negative significant correlation was noticed with pod length (-0.248 P, -0.241G), pod weight (-0.244 P, -0.27 G) and fiber content (-0.265 P, -0.265G) only at 5% LOS.

Similar results of negative correlation were reported for pod length by Patel *et al.* (2011), Singh *et al.* (2011), Salim *et al.* (2013) and Singh *et al.* (2015); for pod weight by Chaitanya *et al.* (2014) and for fiber content by Magalingam *et al.* (2013).

4.5.12 Number of seeds per pod

Number of seeds per pod exhibited (Tables 4.9 a and 4.9 b) positive significant correlation with days to first flowering (0.323 G), days to 50 *per cent* flowering (0.305 G), days to first pod harvest (0.333G), pod weight (0.409 G), 100 fresh seed weight (0.340 P, 0.447 G) and 100 seed dry weight (0.376 P, 0.550 G), at both 5% and 1% LOS. This character also noticed significant positive correlation with vine length (0.294 P), pod weight (0.297 P) only at 5% LOS.

Negative significant correlation was noticed with pod width (-0.319 G) at genotypic level at both 5% and 1% LOS. Similar results are reported by Chattopadyay and Dutta (2010), Singh *et al.* (2011), Chaitanya *et al.* (2014) and Singh *et al.* (2015).

Similar results of positive correlation were reported for days to first flowering , days to 50 percent flowering and days to first pod harvest Sharma *et al.* (2014) and Singh *et al.* (2015); for pod weight reported by Chaitanya *et* *al.* (2014) and for vine length Pawar and Prajapathi (2013) and Gadakh *et al.* (*2016*).

4.5.13 Seed length (mm)

Seed length (Tables 4.9 a and 4.9 b) exhibited significant positive correlation with vine length (0.313 P, 0.384 G), pod length (0.492 P, 0.590 G), pod width (0.497 P, 0.669 G), pod weight (0.390 P, 0.384 G), seed breadth (0.553 P, 0.778 G), 100 seed fresh weight (0.381 P, 0.419 G) and pod yield per plant (0.349 P, 0.415 G) at both 5% and 1% LOS.

Negative significant correlation was noticed only with fiber content (-0.238 G) at genotypic level only at 5% LOS.

Similar results of positive correlation were reported by Singh *et al.* (2011) for pod length, pod width and seed breadth.

4.5.14 Seed breadth (mm)

Seed breadth (Tables 4.9 a and 4.9 b) exhibited significant positive correlation with vine length (0.300 G), pod length (0.344 P, 0.463 G), pod width (0.491 P, 0.718 G), pod weight (0.734 P, 0.461G), seed length (0.553 P, 0.778 G), 100 fresh seed weight (0.469 G) and pod yield per plant (0.389 P, 0.539 G) at both 5% and 1% LOS. This character also exhibited positive significant correlation with 100 fresh seed weight (0.240 P) and 100 dry seed weight (0.276 G) at only 5% LOS. Significant negative association was not observed for any of the traits involved in the study.

Similar results of positive correlation were reported by Singh *et al.* (2011) for pod length, pod width and seed breadth.

4.5.15 Hundred fresh seed weight (g)

Hundred fresh seed weight (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with vine length (0.367P, 0.412G), days to first pod harvest (0.365 G), pod length (0.472 P, 0.557 G), pod weight (0.461 P, 0.613 G), number of seeds per pod (0.340 P, 0.447 G), seed length (0.381 P, 0.419

G), seed breadth (0.469G) and 100 dry seed weight (0.446G) at both 5% and 1% LOS. This character also exhibited positive significant correlation with days to first flowering (0.279 G), days to 50 percent flowering (0.276 G), days to first pod harvest (0.294 P), pod width (0.241G), seed breadth (0.240 P) and 100 dry seed weight (0.247 P) only at 5% LOS. Significant negative association was not observed for any of the traits involved in the study. Similar results of positive correlation were reported by Chaitanya *et al*. (2014)

4.5.16 Hundred dry seed weight (g)

Hundred dry seed weight (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with vine length (0.401 P, 0.576 G), number of primary branches per plant (0.413 G), days to first flowering (0.468 G), days to 50 percent flowering (0.348 P, 0.500 G), days to first pod harvest (0.417 G), pod weight (0.469 P, 0.621 G), number of seeds per pod (0.376 P, 0.500 G), 100 fresh seed weight (0.446 G) and pod yield per plant (0.325 P, 0.472 G) at both 5% and 1 % LOS. Similar results of positive correlation were reported by Chaitanya *et al*. (2014).

This trait also exhibited positive significant correlation with days to first flowering (0.295 P), days to first pod harvest (0.272 P), days to last pod harvest (0.260 G), days to pod maturity (0.236 P, 0.288 G), pod width (0.240 G), seed breadth (0.276 G) and 100 fresh seed weight (0.247 P) only at 5% LOS.

Negative significant correlation was noticed only with protein content (-0.254 G) at genotypic level only at 5% LOS.

4.5.17 Protein content (%)

Negative significant correlation was noticed (Tables 4.9 a and 4.9 b) with days to first flowering (-0.247 G), days to 50 percent flowering (-0.239 G) and 100 dry seed weight (-0.254 G) at genotypic level only at 5% LOS.

Positive significant correlation was noticed only with days to pod maturity (0.240 P) at phenotypic level only at 5% LOS.

Similar results of negative correlation were reported for days to first flowering Chaitanya *et al.* (2014), Verma *et al.* (2015) and Gadakh *et al.* (2016) and for days to 50 *per cent* flowering Verma *et al.* (2015) and Chaitanya *et al.* (2014).

4.5.18 Fiber content (%)

Fiber content exhibited positive significant correlation with days to first flowering (0.239 P, 0.272 G) and days to 50 *per cent* flowering (0.282 P) only at 5% LOS . It also exhibited positive correlation with days to 50 percent flowering (0.324 G) at both 5% and 1% LOS.

Negative significant correlation was noticed with number of primary branches per plant (-0.252 P), pod length (-0.270 G), number of pods per plant (0.265 P, 0.265 G), number of seeds per pod (-0.275 G) and seed length (-0.238 G) only at 5% LOS. This also exhibited significant negative correlation with primary branches per plant (-0.326 G) at both 5% and 1% LOS.

4.5.19 Pod yield per plant (g)

Pod yield per plant (Tables 4.9 a and 4.9 b) exhibited positive significant correlation with vine length (0.511 P, 0.540 G), number of primary branches per plant (0.427 G), pod weight (0.485 P, 0.534 G), number of pods per plant (0.494 P, 0.478 G), seed length (0.349 P, 0.415 G), seed breadth (0.389 P, 0.539 G) and 100 dry seed weight (0.325 P, 0.472 G) at both 5% and 1% LOS. This character exhibits significant positive correlation with number of primary branches per plant (0.291 P), days to first flowering (0.244 P, 0.251G), days to 50 percent flowering (0.254 P, 0.271G), days to first pod harvest (0.242 G), pod length(0.240 P, 0.279 G) and 100 fresh seed weight (0.283 G) only at 5% LOS. Significant negative association was not observed for any of the traits involved in the study.

Pod yield per plant exhibited highly significant positive association for vine length (0.511) at both levels. These finding results are in coincidence with Bendale *et al.* (2008) and Singh *et al.* (2015).

Genotypic correlation coefficients were found to be higher than phenotypic coefficients among all the characters. This indicates that there is a strong association between various characters. Among 18 characters, all the characters except fiber content are positively correlated with pod yield per plant.

The genotypic correlation of vine length and pod weight with yield was high and significant, which is the valuable index for effective selection towards higher yield.

The phenotypic and genotypic correlations between the vine length, pod weight, number of pods per plant, seed length, seed breadth and 100 dry seed weight with yield were highly significant which means that yield is largely a function of these characters.

From correlation studies, it was observed that pod yield per plant has exhibited highly significant and positive association with vine length, pod weight, number of pods per plant, seed length, seed breadth, 100 fresh seed weight, days to first pod harvest, 100 dry seed weight, pod length, days to 50 percent flowering, days to first flowering and primary branches per plant.

4.6 PATH COEFFICIENT ANALYSIS

The estimation of correlation coefficients indicates only the extent and nature of association between yield and its components, but does not show the direct and indirect effects of different effects of different yield attributes on pod yield. The technique of path analysis developed by Wright (1921) and demonstrated by Dewey and Lu (1959) facilitates in partitioning the correlation coefficients into direct and indirect contribution of various characters to the yield. Pod yield is dependent on several characters which are mutually associated; these will in turn impair the true association existing between a component and pod yield. A change in any one component is likely to disturb the whole network of cause and effect. Thus, each component has two paths of action *viz;* the direct influence on pod yield and the indirect effect, through components which are not revealed from the correlation studies.

The residual effect determines how best the causal factors account for the variability of the dependent factor. If the residual effect is high, some other factors which have not been considered. Hence, need to be included in the analysis to account fully for the variation in yield.

Path analysis was carried out at phenotypic and genotypic level considering pod yield per plant as dependent variable and its attributes *viz.*, plant height (cm), number of primary branches per plant, days to first flowering, days to 50 percent flowering, days to first pod harvest, days to last pod harvest, pod length (cm), pod width (cm), pod weight (g), number of seeds per pod, number of pods per plant, seed length (mm), seed breadth, 100 fresh seed weight (g), 100 dry seed weight (g), protein content (%) and fiber content as independent variables.

Each component has two path actions *viz.*, direct effect on yield and indirect effect at phenotypic and genotypic level through components which are not revealed by correlation studies.

The results are presented in Table 4.10 (a) and 4.10 (b) and the path showing the cause and effect relationship is shown for phenotypic level in Fig 4.13 and for genotypic level in Fig 4.14.

4.6.1 DIRECT AND INDIRECT EFFECTS

4.6.1.1 Vine length (cm)

Vine length recorded (Table 4.10 a and 4.10 b) low direct positive effect on pod yield per plant at phenotypic (0.101 P) and very high positive direct effect on pod yield per plant at genotypic level (1.695 G). Similar results were reported by Singh *et al.* (2015).

This trait exhibited negligible positive indirect effect on pod yield through primary branches per plant (0.008 P), days to first flowering (0.067 P), days to 50 *per cent* flowering (0.0576 P), days to first pod harvest (0.064 P), days to last pod harvest (0.016 P), days to pod maturity (0.013 P), pod length (0.033 P), pod width (0.020 P), pod weight (0.047 P), pods per plant (0.021 P), seeds per pod (0.029 P), seed length (0.031 P), seed breadth (0.015 P), 100 seed fresh weight (0.037 P), 100seed dry weight (0.040 P), protein content (0.015 P), fiber content (0.005 P). Similar results were obtained for days to pod maturity and pod length as reported by Singh *et al.* (2015), for pods per plant reported by Gadakh *et al.* (2016) and for protein content reported by Pawar and Prajapathi. (2013).

This trait showed low positive indirect effect through primary branches per plant (0.119 G), days to pod maturity (0.178 G) and fiber content (0.1054 G).

This trait exhibited high positive indirect effect on pod yield through pod length (0.590 G), pod width (0.479 G), pod weight (0.962 G), pods per plant (0.368G), seeds per pod (0.565 G), seed length (0.651G), seed breadth (0.509 G), 100 fresh seed weight (0.699 G) and 100 dry seed weight (0.977 G). Similar results were obtained for pod length reported by Pawar and Prajapathi. (2013).

This trait exhibited very high positive indirect effects on pod yield through days to first flowering (1.321G), days to 50 percent flowering (1.140 G) and days to first pod harvest (1.173 G). This trait exhibited moderate negative indirect effect on pod yield through protein content (-0.2638 G).

4.6.1.2 Number of primary branches per plant

This trait showed (Table 4.10 a and 4.10 b) moderate direct positive effect on pod yield per plant at phenotypic level (0.229 P) and genotypic level (0.205 G).

This trait exhibited negligible positive indirect effects on pod yield through vine length (0.018 P, 0.014 G), pod length (0.027 P, 0.012 G), pod width (0.054 P, 0.073 G), pod weight (0.030 P, 0.045G), seeds per pod (0.042 P, 0.041 G), seed length (0.024 P, 0.037 G), seed breadth (0.023 P, 0.037 G) and 100 dry seed weight (0.043 P, 0.085G). These findings are coinciding with present study for vine length reported by Pawar and Prajapathi (2013), Gadakh *et al.* (2016), and for pod width Magalingam *et al.* (2013).

This trait exhibited negligible negative indirect effects on pod yield through days to first flowering (-0.038 P, -0.015 G), days to 50 % flowering (-0.049 P, -0.023 G), days to first pod harvest (-0.054 P, -0.045 G), days to last pod harvest (-0.037 P, -0.025 G), 100 seed fresh weight(-0.022 P, -0.041 G), protein content (-0.014 P, -0.012 G) and fiber content (-0.057 P, -0.067 G).

4.6.1.3 Days to first flowering

This character showed (Table 4.10 a and 4.10 b) negligible negative direct effect on pod yield per plant at phenotypic level (-0.001 P) and very high negative direct effect at genotypic level (-3.537 G).

This trait exhibited very high negative indirect effects on pod yield through vine length (-2.755 G), days to 50% flowering (-3.42 G), days to first pod harvest (-3.3893 G), days to last pod harvest (-1.302 G), days to pod maturity (-1.243 G), pod weight (-1.074 G), seeds per pod (-1.144 G) and 100 dry seed weight (-1.658 G). Similar results were obtained for days to 50% flowering as reported by Chaitanya *et al.* (2014) and for days to first pod harvest as reported by Bendale *et al*. (2008).

This traits exhibited moderate indirect positive effect through primary branches per plant (0.260 G) and high positive indirect effect through protein content (0.876 G).

This character exhibited negligible positive and negative indirect effects on pod yield on all other characters at phenotypic level.

4.6.1.4 Days to 50 *per cent* flowering

This character (Table 4.10 a and 4.10 b) exhibited negligible positive direct effect on pod yield per plant at phenotypic level (0.064 P) and very high positive direct effect at genotypic level (3.680 G). Similar results were reported by Salim *et al.* (2013) and Verma *et al.* (2015).

This trait exhibited very high positive indirect effects on pod yield through vine length (2.475 G), days to first flowering (3.563 G), days to first pod harvest (3.558 G), days to last pod harvest (1.673 G), days to pod maturity (1.655 G), pod weight (1.11 G), seeds per pod (1.123 G), 100 fresh seed weight (1.016 G), 100 dry seed weight (1.824 G) and fiber content (1.193 G). Similar results were obtained for pod weight as reported by Chattopadyay and Dutta. (2010).

This trait exhibited negligible positive indirect effects on pod yield through vine length (0.036 P), days to first flowering (0.066 P), days to first pod harvest (0.059 P), days to last pod harvest (0.033 P), days to pod maturity (0.028 P), pod weight (0.018 P), seeds per pod (0.013 P), 100 fresh seed weight (0.014 P), 100 dry seed weight (0.0225 P) and fiber content (0.018 P). Similar results were obtained for days to first flowering and days to first pod harvest as reported by Sharma *et al.* (2014) and Verma *et al.* (2015); for days to last pod harvest and number of seeds per pod reported by Chaitanya *et al.* (2014) and for fiber content by Magalingam *et al.* (2013).

This trait exhibited negligible and low negative indirect effects on pod yield through primary branches per plant (-0.013 P), pod length (-0.003

P, -0.131G), pod width (-0.06 G), seed length (-0.001 P, -0.058 G), seed breadth (-0.002 P, -0.011 G) and protein content (-0.0098 P).

4.6.1.5 Days to first pod harvest

This trait exhibited (Table 4.10 a and 4.10 b) negligible negative direct effect on pod yield per plant at phenotypic level (-0.010 P) and very high negative direct effect at genotypic level (-1.099 G).

Days to first pod harvest exhibited negligible positive and negative indirect effects on pod yield at phenotypic level.

At genotypic level this character exhibited high negative indirect effects on pod yield through vine length (-0.760 G), days to first flowering (-1.053 G), days to 50 % flowering (-1.06 G), days to last pod harvest (-0.465 G), days to pod maturity (-0.414 G), pod weight (-0.321 G), seeds per pod (-0.366 G),100 seed fresh weight (-0.401 G), 100 seed dry weight (-0.459 G). Similar results were obtained for vine length by Bendale *et al*. (2008).

This trait exhibited moderate positive indirect effects on pod yield through primary branches per plant (0.242 G), pods per plant (0.232 G) and protein content (0.225 G). Similar results were obtained for pods per plant as reported by Singh *et al.* (2015).

4.6.1.6 Days to last pod harvest

This character exhibited (Table 4.10 a and 4.10 b) moderate negative direct effect on pod yield per plant at phenotypic level (-0.212 P) and very high negative direct effect at genotypic level (-2.109 G)

This character exhibited high positive indirect effects on pod yield through vine length (0.333 G), primary branches per plant (0.257 G), pod length (0.661 G), pod width (0.392 G), pods per plant (0.419 G) and seed length (0.391 G).

This character also exhibited negligible positive indirect effects on pod yield through vine length (0.035 P), primary branches per plant (0.034

P), pod length (0.05 P), pod width (0.028 P), pods per plant (0.037 P), seed length (0.03 P) and seed breadth (0.020 P).

At genotypic level, this trait also exhibited high negative indirect effects on pod yield through days to first flowering (-0.776 G), days to 50 % flowering (-0.961 G), days to first pod harvest (-0.894 G), days to pod maturity (-2.033 G), pod weight (-0.303 G), seeds per pod (-0.204 G), 100 fresh seed weight (-0.339 G), 100 dry seed weight (-0.550 G), protein content (-0.294 G) and fiber content (-0.236G).

At phenotypic level this trait exhibited negligible negative indirect effects on yield through days to first flowering (-0.088 P), pod weight (-0.024 P), seeds per pod (-0.018 P), 100 seed fresh weight (-0.034 P), 100 seed dry weight (-0.040 P), protein content (-0.03 P), fiber content (-0.02 P), low indirect effect on days to 50% flowering (-0.109 P), days to first pod harvest (-0.109 P) and moderate effect on days to pod maturity (-0.195 P). Similar results were obtained for days to first flowering Chaitanya *et al.* (2014).

4.6.1.7 Days to pod maturity

This character exhibited (Table 4.10 a and 4.10 b) negligible positive direct effect on pod yield per plant at phenotypic level (0.096 P) and very high positive direct effect at genotypic level (2.109 G).

This trait exhibited high positive indirect effects on pod yield through days to first flowering (0.741 G), days to 50% flowering (0.948 G), days to first pod harvest (0.794 G), days to last pod harvest (2.033 G), 100 fresh seed weight (0.364 G), 100 dry seed weight (0.609 G), protein content (0.485 G) and fiber content (0.346 G). Similar results were obtained for days to 50 percent flowering by Singh *et al.* (2015).

This trait exhibited negligible positive indirect effects on pod yield through vine length (0.025 P), days to first flowering (0.079 P), days to 50% flowering (0.085 P), days to first pod harvest (0.083 P), number of seeds per pod (0.014 P), 100 fresh seed weight (0.039 P), 100 dry seed weight (0.046

P), protein content (0.047 P) and fiber content (0.030 P). Low effects on days to last pod harvest (0.181 P). Similar results were obtained for vine length Gadakh *et al.* (2016); for days to first pod harvest by Singh *et al.* (2015) and for protein content reported by Pawar and Prajapathi. (2013)

At genotypic level, this character exhibited high negative indirect effects on pod yield through pod length (-0.695 G), pod width (-0.251 G), pod weight (-0.53 G), seed length (-0.408 G) and seed breadth (-0.039G). At phenotypic level there is negligible negative indirect effects on pod yield was observed

4.6.1.8 Pod length (cm)

Pod length exhibited (Table 4.10 a and 4.10 b) negligible positive direct effect on pod yield per plant at phenotypic level (0.053 P) and high negative direct effect at genotypic level (-0.696 G).

This character exhibited high negative indirect effects on pod yield through pod width (-0.251 G), pod weight (-0.334 G), seed length (-0.411 G), seed breadth (-0.322 G) and 100 fresh seed weight (-0.387 G).

This character exhibited positive moderate indirect effects on pod yield through days to last pod harvest (0.218 G), low positive effect on pod maturity (0.176 G), number of pods per plant (0.168 G) and fiber content (0.188 G).

This character exhibited negligible negative indirect effects on pod yield through days to last pod harvest (-0.013 P), days to pod maturity (-0.010 P), pods per plant (-0.01 P) and fiber content (-0.0125 P). Similar results were obtained for pods per plant as reported by Singh *et al.* (2011), Salim *et al.* (2013) and Chaitanya *et al.* (2014).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.017 P), pod width (0.014 P), pod weight (0.02 P), seed length (0.026 P), seed breadth (0.018 P), and 100 fresh seed weight (0.025 P). Similar results were obtained for vine length as reported by

Pawar and Prajapathi. (2013), for pod width Singh *et al.* (2011), Salim *et al.* (2013) and Chaitanya *et al.* (2014).

4.6.1.9 Pod width (cm)

This character (Table 4.10 a and 4.10 b) exhibited low negative direct effect on pod yield per plant at phenotypic level (-0.131 P) and high positive direct effect at genotypic level (0.364 G).

This character exhibited low positive indirect effects on pod yield through vine length (0.103 G), primary branches per plant (0.130 G), pod length (0.136 G) and pod weight (0.156 G).

This character exhibited negligible positive indirect effects on pod yield through days to first flowering (0.014 G), days to last pod harvest (0.017 P), days to pod maturity (0.016 P), pods per plant (0.019 P), 100 fresh seed weight (0.088 G), 100 dry seed weight (0.08 G), protein content (0.016 P) and fiber content (0.026 P). The same types of results were reported for days to first flowering Chaitanya *et al.* (2014).

This character exhibited moderate positive indirect effects on pod yield through seed length (0.243 G) and seed breadth (0.261 G).

This character exhibited negligible negative indirect effect on pod yield through vine length (-0.02 P), primary branches per plant (-0.03 P), days to first pod harvest (0.012 G), days to last pod harvest (-0.067 G), days to pod maturity (-0.064 G), pod length (-0.035 P), number of seeds per pod (-0.11 G), seed length and seed breadth (-0.06 P), protein (-0.06 G) and fiber content (-0.06 G).

4.6.1.10 Pod weight (g)

This character recorded (Table 4.10 a and 4.10 b) high positive direct effect on pod yield per plant at phenotypic level (0.4406) and genotypic level (0.7655). Similar results were reported by Rai *et al.* (2009) and Chaitanya *et al.* (2014).

This character exhibited low positive indirect effects on pod yield through primary branches per plant (0.171 G), days to first flowering (0.123

P), days to 50% flowering (0.124 P), days to first pod harvest (0.105 P), days to last pod harvest (0.110 G), days to pod maturity (0.194 G), pod length (0.173 P), pod width (0.159 P), number of seeds per pod (0.130 P) and seed length (0.172 P). Similar results were obtained for days to pod maturity by Magalingam *et al.* (2013) and number of seeds per pod by Chaitanya *et al*. (2014).

This character exhibited moderate positive indirect effects on pod yield through vine length (0.207 P), days to first flowering (0.254 G), days to 50 % flowering (0.231 G), days to first pod harvest (0.223 G), seed length (0.294 G), seed breadth (0.247 P), 100 fresh seed weight (0.203 P) and 100 dry seed weight (0.206 P).

This character exhibited high positive indirect effects on pod yield through vine length (0.434 G), pod length (0.367 G), pod width (0.329 G), seeds per pod (0.313 G), seed breadth (0.562 G), 100 fresh seed weight (0.469 G) and 100 dry seed weight (0.475 G).

This character exhibited low negative indirect effects on pod yield through number of pods per plant (-0.107 P) and moderate indirect effect on number of pods per plant (-0.208 G).

4.6.1.11 Number of pods per plant

This trait exhibited (Table 4.10 a and 4.10 b) high negative direct effect on pod yield per plant at phenotypic level (-0.691 P) and low positive direct effect at genotypic level (0.171 G).

This character exhibited low positive indirect effect on pod yield through vine length (0.146 P, 0.102 G), days to first flowering (0.110 P), days to 50% flowering (0.146 P, 0.109 G), days to first pod harvest (0.133 P) and days to last pod harvest (0.123 P). Similar results were obtained for days to first flowering and days to first pod harvest (Singh *et al*. (2011).

This character exhibited low negative indirect effects on pod yield through pod length (-0.171 P, -0.113 G), pod width (-0.101 P), pod weight (-0.169 P, -0.128 G), 100 fresh seed weight (-0.134 P, -0.103 G), protein content (-0.151 P, -0.109 G) and fiber content (-0.183 P, -0.125 G).

This character exhibited negligible positive indirect effects on pod yield through days to first flowering (0.077 G) and days to last pod harvest (0.093 G).

This character exhibited negligible negative indirect effects on pod yield through pod width (-0.097 G), seed length (-0.093 P, -0.063 G) and seed breadth (-0.097 P, 0.07 G). Similar results were obtained for pod width by Singh *et al*. (2011).

4.6.1.12 Number of seeds per pod

This character exhibited (Table 4.10 a and 4.10 b) low negative direct effects on pod yield per plant at phenotypic level (-0.137 P) and high positive direct effect at genotypic level (0.372 G). Similar results were reported by Salim *et al.* (2013) and Verma *et al.* (2015).

This character exhibited low positive indirect effects on pod yield through vine length (0.124 G), days to first flowering (0.120 G), days to 50 % flowering (0.113 G), days to first pod harvest (0.124 G), pod weight (0.152 G), 100 fresh seed weight (0.166 G) and 100 dry seed weight (0.186 G). Similar results are obtained for vine length Pawar and prajapathi. (2013); for days to first flowering and days to 50 % flowering by Sharma *et al*. (2014).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.040 P), primary branches per plant (0.074 G), days to last pod harvest (0.036 G), pod length (0.049 G), number of pods per plant (0.011 G), protein content (0.014 P) and fiber content (0.027 P). Similar results were obtained for days to last pod harvest, pod length and pods per plant Chaitanya *et al*. (2014).

This character exhibited negligible negative indirect effects on pod yield through primary branches per plant, days to first flowering , days to 50% flowering, days to first pod harvest(-0.02 P), seed length (0.02 G), 100 fresh seed weight (-0.046 P), 100 dry seed weight (-0.051 G) and fiber content (0.102G). Similar results were obtained for primary branches per plant by Gadakh *et al*. (2016); for days to first flowering Salim *et al.* (2013) and Chaitanya *et al*. (2014).

4.6.1.13 Seed length (mm)

This character exhibited (Table 4.10 a and 4.10 b) low positive direct effects on pod yield per plant at phenotypic level (0.115 P) and high positive direct effect at genotypic level (0.502 G).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.036 P), primary branches per plant (0.012 P, 0.092 G), days to first flowering (0.012 G), pod length (0.056 P), pod width (0.057 P), pod weight (0.045 P), seed breadth (0.064 P), 100 fresh seed weight (0.0441 P), 100 dry seed weight (0.02 P, 0.05 G) and protein content (0.010 P, 0.069 G). Similar results were obtained for pod length, pod width and seed breadth by Singh *et al*. (2011).

This character exhibited moderate positive indirect effects on pod yield through vine length (0.193 G), pod length (0.296 G) and pod weight (0.193 G). High positive indirect effects on pod yield through pod width (0.336 G) and seed breadth (0.391 G).

This character exhibited negligible negative indirect effects on pod yield through days to last pod harvest (-0.019 P, -0.093G), days to pod maturity (-0.019 P, -0.097 G), pods per plant (-0.015P, -0.071 G) and fiber content (-0.023 P, -0.119G).

4.6.1.14 Seed breadth (mm)

This character (Table 4.10 a and 4.10 b) recorded low positive direct effect on pod yield per plant at phenotypic level (0.152 P) and high negative direct effects at genotypic level (-0.994 G).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.023 P), primary branches per plant (0.015 P), days to first pod harvest, days to last pod harvest (0.053 G), days to pod maturity (0.018 G), pod length (0.052 P), pod width (0.075 P), pod weight

(0.086 P), seed length (0.084 P), 100 fresh seed weight (0.036 P) and 100 dry seed weight (0.024 P). Similar results were obtained for pod length and pod width as reported by Singh *et al*. (2011).

This character exhibited negligible negative indirect effects on pod yield through days to first pod harvest (-0.012 P), days to last pod harvest (-0.014 P), number of pods per plant (-0.021 P) and fiber content (-0.026 P). Similar results were obtained for days to first pod harvest and pods per plant Singh *et al*. (2011).

This character exhibited moderate negative indirect effects on pod yield through vine length (-0.298 G), 100 dry seed weight (-0.275 G) and high negative indirect effects on pod yield through pod length (-0.461 G), pod width (-0.714 G), pod weight (-0.730 G), seed length (-0.773 G) and 100 fresh seed weight (-0.466G).

4.6.1.15 Hundred fresh seed weight (g)

Hundred fresh seed weight (Table 4.10 a and 4.10 b) showed negligible positive direct effect on pod yield per plant at phenotypic level (0.036 P) and high positive direct effects at genotypic level (0.529 G).

This character exhibited low positive indirect effects on pod yield through days to first flowering (0.147 G), days to 50 % flowering (0.146 G), days to first pod harvest (0.193 G), pod width (0.128 G) where as it also registered a moderate effects on pod yield through pod length (0.295G), number of seeds per pod (0.236 G), seed length (0.22 G), seed breadth (0.248 G) and 100 dry seed weight (0.236 G). However high effects on pod yield through pod weight (0.325 G) were recorded. Similar results were obtained for pod length and pod width as reported by Singh *et al*. (2011).

This character exhibited low negative indirect effects on pod yield through primary branches per plant (-0.107 G) and pods per plant (-0.116G) were recorded.

4.6.1.16 Hundred dry seed weight (g)

Hundred dry seed weight (Table 4.10 a and 4.10 b) recorded negligible positive direct effect on pod yield per plant at phenotypic level (0.079 P) and very high negative direct effects at genotypic level (-1.12 G).

This character exhibited high negative indirect effects on pod yield through vine length (-0.647 G), primary branches per plant (-0.465 G), days to first flowering (-0.526 G), days to 50 % flowering (-0.561 G), days to first pod harvest (-0.468 G), days to pod maturity (-0.324 G), pod weight (-0.6969 G), number of seeds per pod (-0.561G) and 100 fresh seed weight (-0.510 G). Moderate negative indirect effects on pod yield through days to last pod harvest (-0.292 G) and pod width (-0.269 G) were also recorded. Low negative indirect effects on pod yield through seed length (-0.127 G) and fiber content (-0.133 G) were exerted. Similar results were obtained for pod length as reported by Singh *et al*. (2011).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.031P), primary branches per plant (0.015P), days to first flowering (0.023 P), days to 50% flowering (0.027 P), days to last pod harvest, days to pod maturity (0.01 P), pod width (0.041 P), pod weight (0.03 P), number of seeds per pod (0.029 P), seed length (0.013 P), seed breadth (0.012 P) and 100 fresh seed weight (0.01P).

4.6.1.17 Protein content (%)

This trait recorded (Table 4.10 a and 4.10 b) moderate positive direct effect on pod yield per plant at phenotypic level (0.235 P) and negligible negative direct effect at genotypic level (-0.084 G).

This character exhibited negligible positive indirect effects on pod yield through vine length (0.013 G), days to first flowering (0.020 G), days to 50 % flowering (0.020 G), days to first pod harvest (0.017 G), pod width (0.014 G), number of pods per plant (0.019 G),number of seeds per pod (0.015 G), 100 dry seed weight (0.021 G), days to last pod harvest (0.035

P), days to pod maturity (0.056 P), pod length (0.030 P), seed length (0.021 P), 100 fresh seed weight (0.023 P) and fiber content (0.017 P).

Similar results were obtained for vine length by Gadakh *et al*. (2016); for days to first flowering by Salim *et al.* (2013) and for pods per plant by Chattopadhyay and Dutta. (2010).

This character exhibited negligible negative indirect effects on pod yield through vine length (-0.035 P), primary branches per plant (-0.015 P), days to first flowering (-0.037 P), days to 50% flowering (-0.035 P), days to first pod harvest (-0.033 P), pod width (-0.028 P), number of pods per plant (-0.051 P), number of seeds per pod (-0.025 P) and 100 dry seed weight (-0.039 P). Similar results were obtained for vine length Pawar and prajapathi (2013); primary branches per plant by Gadakh *et al*. (2016) and Magalingam *et al.* (2013).

4.6.1.18 Fiber content (%)

Fiber content exhibited (Table 4.10 a and 4.10 b) negligible negative direct effects on pod yield per plant at phenotypic level (-0.047 P) and high negative direct effects at genotypic level (-0.306 G).

This character exhibited negligible positive indirect effects on pod yield through primary branches per plant (0.012 P), pod length (0.014 P, 0.083 G), pod width (0.056 G), number of pods per plant (0.012 P, 0.081 G), number of seeds per pod (0.084 G), seed length(0.073 G) and seed breadth (0.064 G). It also exhibited low positive indirect effects on pod yield through primary branches per plant (0.100). Similar results were obtained for pod length by Magalingam *et al.* (2013).

This character exhibited negligible negative indirect effects on pod yield through vine length (-0.019 G), days to first flowering (-0.011 P, -0.083 G), days to 50% flowering (-0.013 P), days to first pod harvest (-0.063G), days to last pod harvest (-0.034G), days to pod maturity (-0.053 G), pod weight (-0.020 G),100 fresh seed weight (-0.023 G), 100 dry seed weight (-0.036 G) and protein content (-0.0221 G).

Among all the pod traits under study, pod weight (0.440 P) exhibited high positive direct effect on pod yield per plant at phenotypic level and days to 50 percent flowering (3.680 G) exhibited high positive direct effect at genotypic level.

Among all attributes, days to 50 percent flowering days to pod maturity, number of primary branches per plant and vine length showed moderate positive direct effect on pod yield per plant. The characters like seed length (0.502), 100 fresh seed weight (0.529) and number of seeds per pod (0.372) recorded significant positive correlation at genotypic level on pod yield per plant. This suggested that direct selection based on these traits will be rewarding for improvement in dolichos bean.

Days to last pod harvest (-2.109) showed very high negative direct effect on pod yield followed by 100 dry seed weight (-1.122). Fiber content exhibited low negligible direct effects on pod yield per plant. Similar findings are recorded by Magalingam *et al.* (2013). However, Rest of the characters showed negligible positive and negative direct effects.

From the foregoing discussion, it can be concluded that pod weight, seed length, number of primary branches per plant, 100 fresh seed weight, days to pod maturity, days to 50 percent flowering and vine length showed the positive correlation and positive direct effect on pod yield per plant. Hence, these are identified as superior components of yield. So, the genotypes which exhibited better performance for these characters can be used in further improvement of dolichos bean.

The residual effect in the present study was high in genotypic (0.47) and phenotypic (0.427) path-coefficient analysis, indicating that there is need to include other characters in order to derive a much clear picture of the casual relationship.

Path analysis revealed that maximum positive direct effect on pod yield per plant was exhibited through pod weight followed by 100 fresh seed weight. Positive direct effect of primary branches per plant on pod yield per plant was moderate.

4.7 Qualitative traits

Thirty five genotypes of dolichos bean germplasm under present investigation were characterized based on 13 qualitative traits (Table 4.11). The present observations are similar with the findings of Chattopadhyay and Dutta. (2010) and Chaitanya *et al*. (2014).

4.7.1 Stem colour

The observations (Table 4.11) revealed that one genotype exhibited dark green stem colour, four genotypes showed purple stem colour and 30 genotypes showed green stem colour.

4.7.2 Leaf vein colour

Leaf vein colour of 28 genotypes exhibited (Table 4.11) light green in colour, five genotypes showed purple colour and 2 genotypes are green in colour**.**

4.7.3 Leaf density

Leaf density (Table 4.11) of 30 genotypes was found to be intermediate and the remaining five genotypes showed sparse leaf density.

4.7.4 Plant growth habit

The observations on plant growth habit revealed (Table 4.11) that 33 genotypes were pole type plant growth habit and remaining two genotypes were found to be bush type plant growth habit**.**

4.7.5 Flower colour

The observations (Table 4.11) revealed that 25 genotypes exhibited white flower colour, nine genotypes showed purple flower colour and one genotype showed dark purple flower colour.

4.7.6 Pod colour

Pod colour (Table 4.11) of 25 genotypes was found to be green in colour, three genotypes showed dark green in colour, five genotypes showed light green in colour, one genotype showed purple colour and remaining one genotype showed dark purple colour.

4.7.7 Pod shape

The pod shape (Table 4.11) of six genotypes was straight, two genotypes were curved and remaining 27 genotypes were intermediate with respect to it.

4.7.8 Pod surface

The study revealed (Table 4.11) that 28 genotypes had smooth pod surface and remaining seven genotypes had wrinkled pod surfaces.

4.7.9 Pod curvature

Thirty genotypes (Table 4.11) showed curved pod curvature and remaining five genotypes showed straight pod curvature.

4.7.10 Pod beak

The observations (Table 4.11) revealed that 19 genotypes were with short pod beak, 13 genotypes had medium pod beaks and remaining three genotypes with long pod beaks.

4.7.11 Pod suture colour

Thirty genotypes showed (Table 4.11) green colour pod suture and remaining five genotypes showed cream colour pod suture**.**

4.7.12 Seed colour

Sixteen genotypes seeds (Table 4.11) were found to be brown in colour, eight genotypes showed black colour seeds and remaining 11 genotypes seeds were cream in colour.

4.7.13 Seed shape

Out of 35 genotypes (Table 4.11) the seed shape of 25 genotypes was found oblong, five genotypes were round in shape and remaining five genotypes were flat in shape.

CHAPTER-V

SUMMARY AND CONCLUSIONS

CHAPTER-V

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The present investigation entitled "**Genetic divergence for pod quality, yield and yield attributes in dolichos bean (*Dolichos lablab* L.var. *typicus* Prain) germplasm"** was carried out at Vegetable Research Station, ARI, Rajendranagar from August, 2016 to March, 2017 with 35 dolichos bean genotypes (including three checks) to study the genetic variability, heritability, genetic advance as percent of mean, genetic divergence, character association and path coefficient analysis.

Thirty five dolichos bean germplasm lines along with the three checks were grown in Randomized Block Design with two replications. Observations were recorded on nineteen quantitative characters *viz.*,vine length (cm), number of primary branches per plant, days to first flowering, days to 50%flowering, days to first pod harvest, days to last pod harvest, days to pod maturity , pod length (cm), pod width (cm), pod weight (g), number of pods per plant, pod yield per plant (g), number of seeds per pod, seed length (mm), seed breadth (mm), 100 fresh seed weight (g), 100 dry seed weight (g), protein content (%) and fiber content (%) and 13 qualitative characters *viz.*, stem colour, leaf vein colour, leaf density, plant growth habit, flower colour, pod shape, pod colour, pod beak, pod curvature, pod suture colour, pod surface, seed colour and seed shape.

The material chosen differed in their genotypic make up as evidenced by the significant differences among them and in respect of all the characters studied. Phenotypic coefficient of variation estimates slightly higher than the genotypic coefficient of variation for all the traits indicating low environmental influence on the expression of all the traits. Significant differences were observed between the genotypes for all the characters.

The analysis of variance revealed significant differences between genotypes indicating presence of sufficient amount of variability in all the 19 characters studied. Wide range of variability was observed for pod yield per plant (46487.040), vine length (15234.210) and number of pods per plant (2379.014) indicating the scope for selection of initial breeding material for further improvement

On the basis of mean performance, one genotype IC-546387 was found superior over the check variety RND-1 for pod yield per plant (805.23 g), more number of pods per plant (175.66), vine length (462.17 cm) and pod width (1.29 cm) followed by IC-427428 (667.07 g) which was found significantly superior over the check variety RND-1 with regard to pod yield per plant (667.07 g), number of pods per plant (92.76), days to first flowering (86.00), days to first pod harvest (104.50), pod length (12.61 cm), pod width (2.03 cm) and protein content (24.76 %). Hence these genotypes can be used for further breeding and may be released as varieties after multi location trials.

Genetic diversity was assessed by using Mahalanobis D^2 statistics for nineteen quantitative characters. Grouping of genotypes into clusters by using Tocher's method resulted in the formation of six clusters. Maximum intracluster distance was shown by cluster IV (249.64) and minimum in cluster VI (0.00). The maximum inter cluster distance was observed between cluster III and cluster VI (1780.19). Therefore, the genotypes belonging to cluster IV (IC-546387) and cluster III (IC-427428) may be considered in hybridization programmes for getting good segregants.

The character pod yield per plant contributed maximum (26.21 %) towards divergence followed by fiber content (20.67 %), protein content (19.15 %), number of pods per plant (8.57 %), days to last pod harvest (7.22 %), pod length (7.22 %), 100 seed dry weight (5.71 %), vine length (2.35 %), number of seeds per pod (1.00 %), seed length (0.84 %), 100 fresh seed weight (0.84 %) and pod weight (0.16 %). Therefore, plant breeder may consider the above aspects while developing superior varieties and hybrids through pureline selection and hybridization, Where as no. of primary branches per plant, days to first flowering, days to 50 %flowering, days to first pod harvest, days to pod maturity, pod width (cm) and seed breadth (mm) did not contribute anything towards the genetic diversity in dolichos bean germplasm.

The genotypic and phenotypic coefficients of variation were high (>20 %) for number of pods per plant, pod width, marketable pod yield per plant , vine length, pod length , pod weight, fiber content and moderate (10-20%) for seed breadth, 100 seed fresh weight, protein content, number of seeds per pod, seed length, number of primary branches per plant, days to first flowering, days to 50 percent flowering, days to first pod harvest and number of seeds per pod. Low (0-10 %) GCV and PCV values were recorded for days to last pod harvest and days to pod maturity. The differences between PCV and GCV values were less indicating that these traits were less influenced by environment and could be improved by following phenotypic selection.

High heritability coupled with high genetic advance as per cent of mean was observed for number of pods per plant, pod width, marketable pod yield per plant, vine length, pod length, pod weight, fiber content, seed length, seed breadth, 100 fresh seed weight, days to first flowering and protein content.

High heritability coupled with moderate genetic advance as percent of mean was observed for days to 50 % flowering, days to first pod harvest and days to pod maturity. Moderate heritability coupled with moderate genetic advance as *per cent* of mean observed for number of primary branches per plant. High variability in conjunction with high genetic advance as percent of mean indicating the predominance of additive gene action.

From correlation studies, it was observed that pod yield per plant has exhibited highly significant and positive association with vine length (0.511), number of pods per plant (0.494), pod weight (0.485), seed breadth (0.389), seed length (0.349), 100 dry seed weight (0.325), primary branches per plant (0.291), days to 50 percent flowering (0.254), days to first flowering (0.244) and pod length (0.240).

Path analysis revealed that maximum positive direct effect on pod yield per plant was exhibited through pod weight (0.440) followed by protein content

(0.235). Positive direct effect of primary branches per plant (0.229) on pod yield per plant was moderate.

Quality traits revealed that there is a considerable variability in dolichos bean germplasm for most of the traits like stem colour (green, dark green and purple), leaf vein colour (light green and green, purple), leaf density (sparse and intermediate), flower colour (purple, white and dark purple), growth habit (pole and bush), pod shape (straight, curved and intermediate), pod colour (green in IC-383197, IC-384066, IC-424813, IC-426988, IC-427424, IC-427436, IC-446571, IC-446573 , IC-446583 , IC-446591, IC-546349, IC-546376, IC-546388, IC-565181, IC-598467, NSB-2010/029, PSR-13183, PSRJ-13114-2, RJR-03, RJR-387 , SGD-136, SNJ-11-068, RND-01, ARKA JAY and ARKA VIJAY); light green in IC-413709, IC-427462, IC-446581, IC-546387 and NSJ/NAIP/192, dark green in IC-261010, IC-427428 and PSRJ-13039, purple in IC-413710, dark purple in IC-446584, pod beak (long, short and medium), pod suture (green, dark green and purple), pod curvature (straight and curved), pod surface (smooth and wrinkled), seed colour (black , brown and cream) and seed shape (flat, round and oblong). Whereas there was no variability observed in traits like leaf vein colour, pod suture and pod beak colour.

Dolichos bean genotypes exhibited high variability for all traits like plant growth characters, leaf characters, flower characters, pod characters, seed characters and quality characters.

Conclusions :

Based on the results of the present investigation the following conclusions could be drawn: On the basis of mean performance of the genotypes for all the traits studied, two genotypes *viz.*, IC-546387 (805.23 g) and IC-427428 (667.07 g) were identified as promising for yield exploitations. Hence these genotypes tested for their stable performance in different locations by pedigree and released for commercial cultivation after multilocation trials. The selected germplasm may be as parental source for the development of superior dolichos bean varieties for commercial cultivation. Morphological and yield characters of superior genotypes are presented in the Table 5.1

Table 5.1 Morphological and yield characters of superior genotypes

Characters	**IC-427428**	**IC-546387**	**RND-1**
Vine length (cm)	413.32	462.17	437.33
Days to first flowering	86	105	95
Days to first pod harvest	130.00	142.50	130.00
Days to last pod harvest	180.00	205.00	190.00
Pod length (cm)	12.61	6.50	10.90
Pod width (cm)	2.03	1.29	1.44
Pod weight (g)	7.12	6.40	8.21
Number of pods per plant	92.76	175.66	78.34
Pod yield per plant (g)	667.07	805.23	632.57
Protein content (%)	24.76	16.75	24.28
Fiber content (%)	15.83	17.66	21.87
Flower colour	White	White	Purple
Pod colour	Dark green	Light green	Green
Seed colour	Brown	Cream	Black

Future line of work

- The character which exhibited high heritability can be utilized for crop improvement in further seasons or locations.
- Correlation of yield components with pod yield should be considered while selection of germplasm.
- The utmost importance be given for highly divergent clusters for further consideration of genotypes for breeding programmes.
- Screening of germplasm against pest and diseases may be done.

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LITERATURE CITED

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*****Original paper not seen

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APPENDICES

Plate 3.2 (a): General overview of experimental plot of dolichos bean

Plate 3.2 (b): General overview of experimental plot of dolichos bean

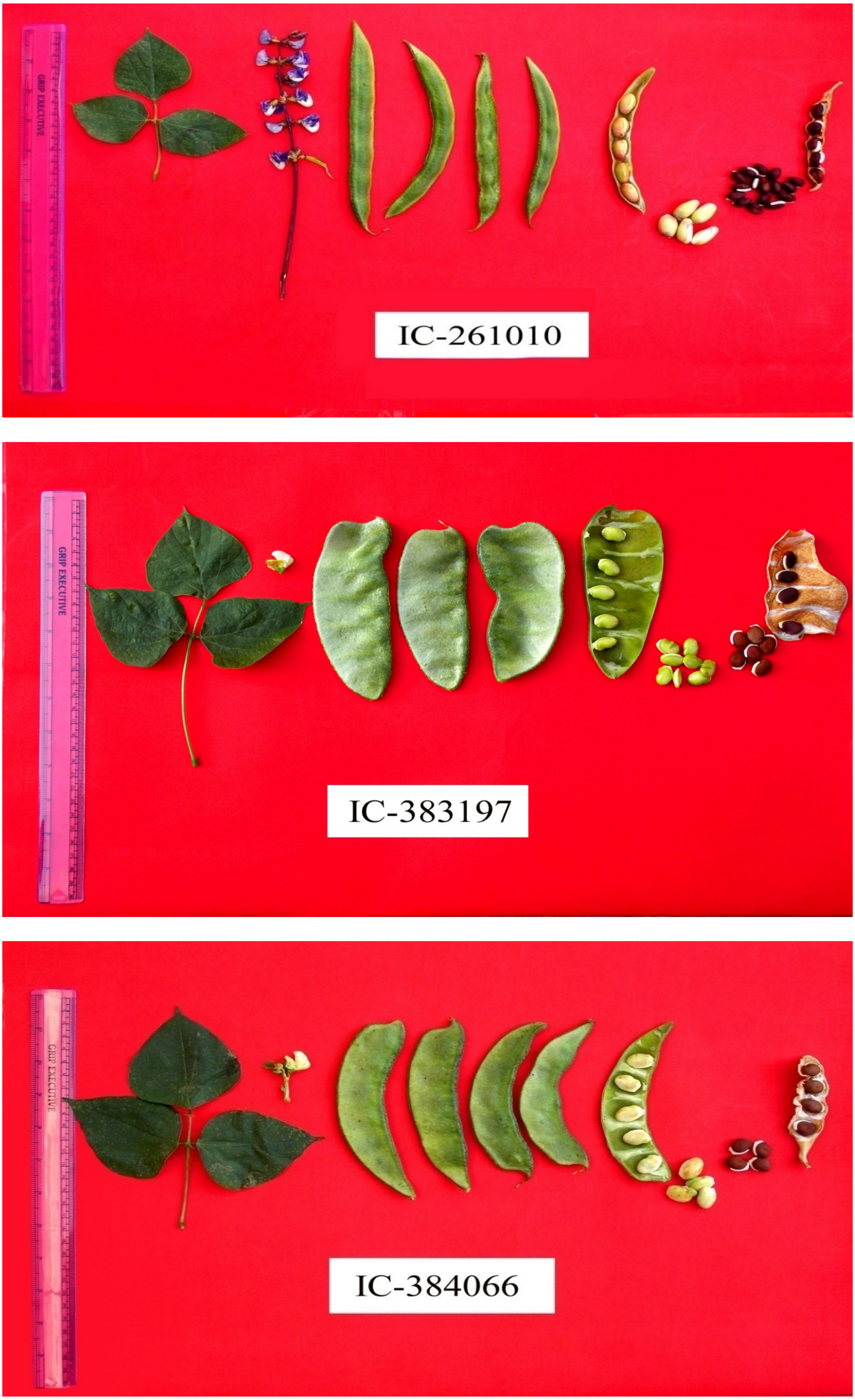

Plate 4.1 (a) : Qualitative traits of 35 genotypes of dolichos bean

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...

Plate 4.1 (a): contd...


GRIP EXECUTIVE
SGD-136


GRIP EXECUTIVE
SNJ-11-068

Plate 4.1 (b): Check varieties used in the study of dolichos bean

Plate 4.2: Variations in pods of 35 genotypes of dolichos bean including checks

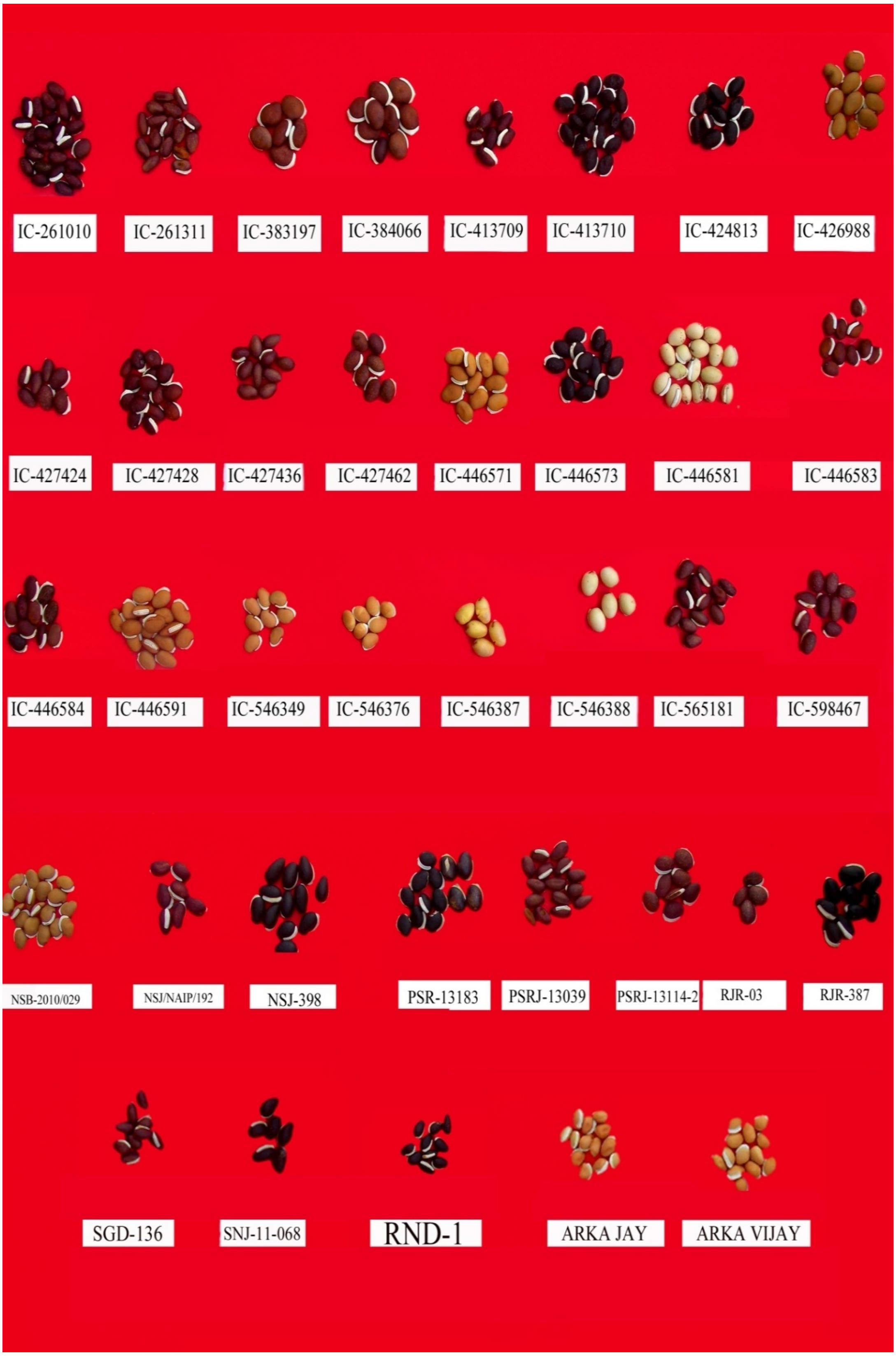

Plate 4.3: Variations in seeds of 35 genotypes of dolichos bean including checks

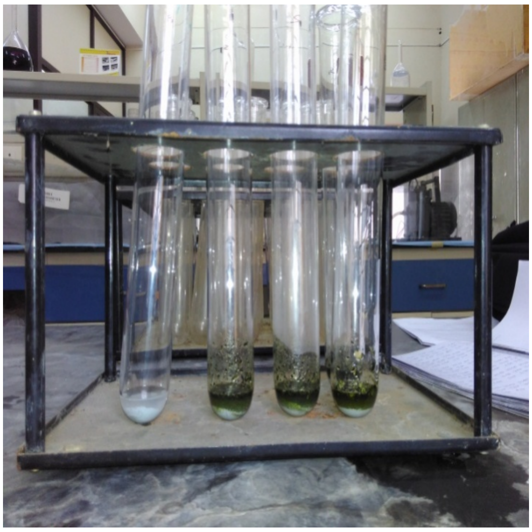

Plate:3.3 (a) Prepared sample for digestion

Plate:3.3 (b) Digestion of the sample

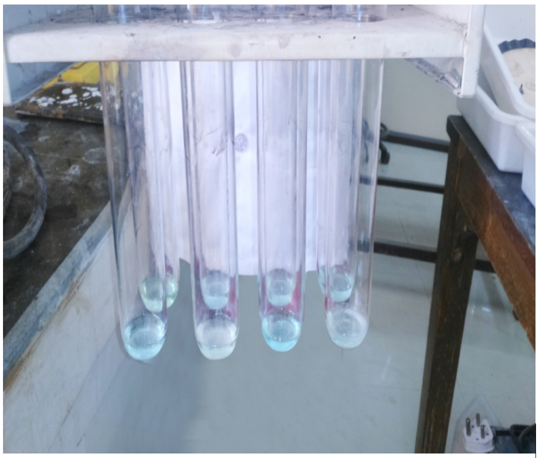

Plate:3.3 (c) sample after digestion

Plate:3.3 (d) Distillation of the sample

Plate:3.3 (e) Titration with H_2SO_4

Plate:3.3 (f) End point before and after titration

Plate:3.3 Estimation of protein content in pod in the laboratory

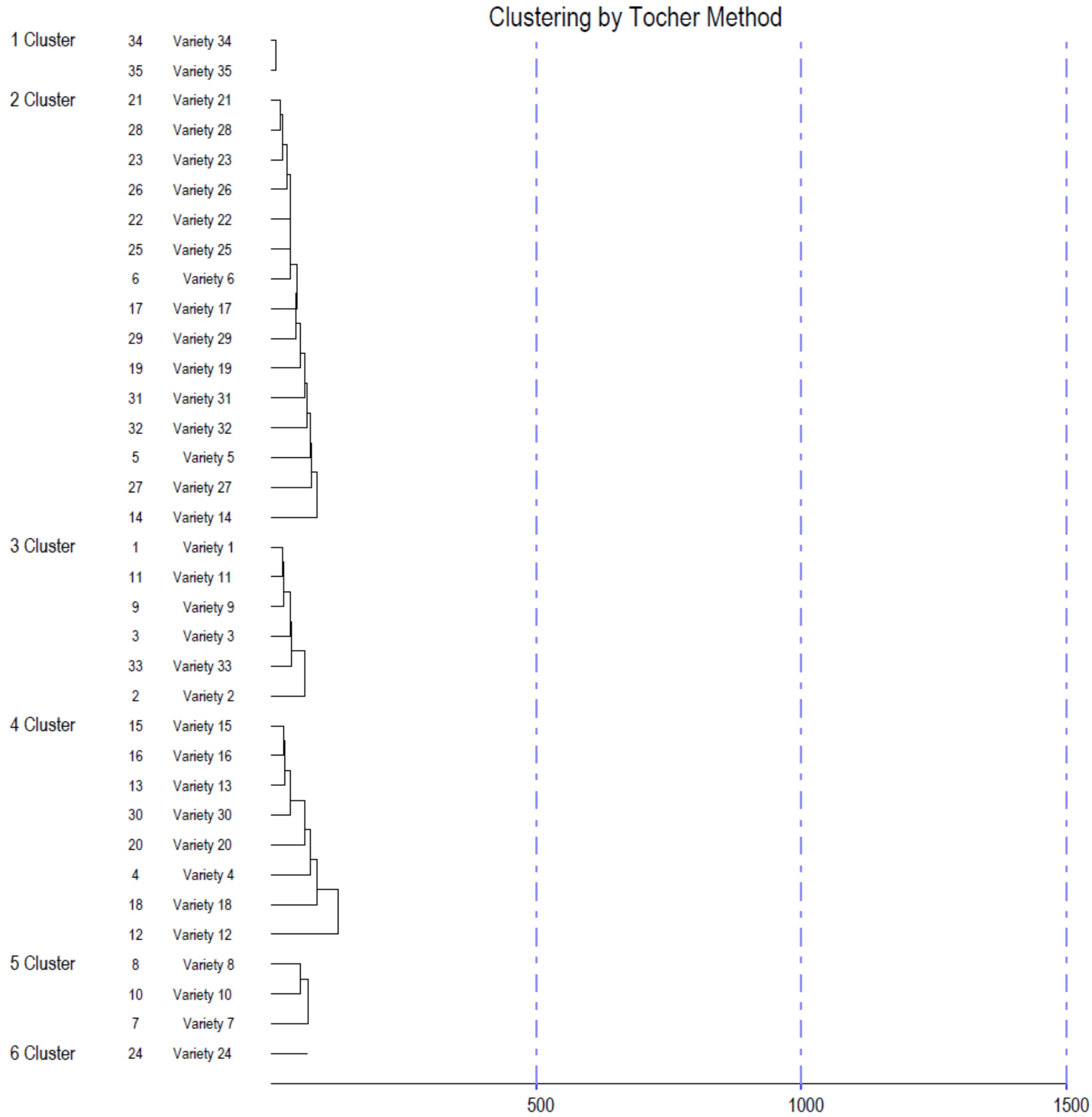

Fig.4.10: Dendrogram showing clustering pattern of dolichos bean germplasm

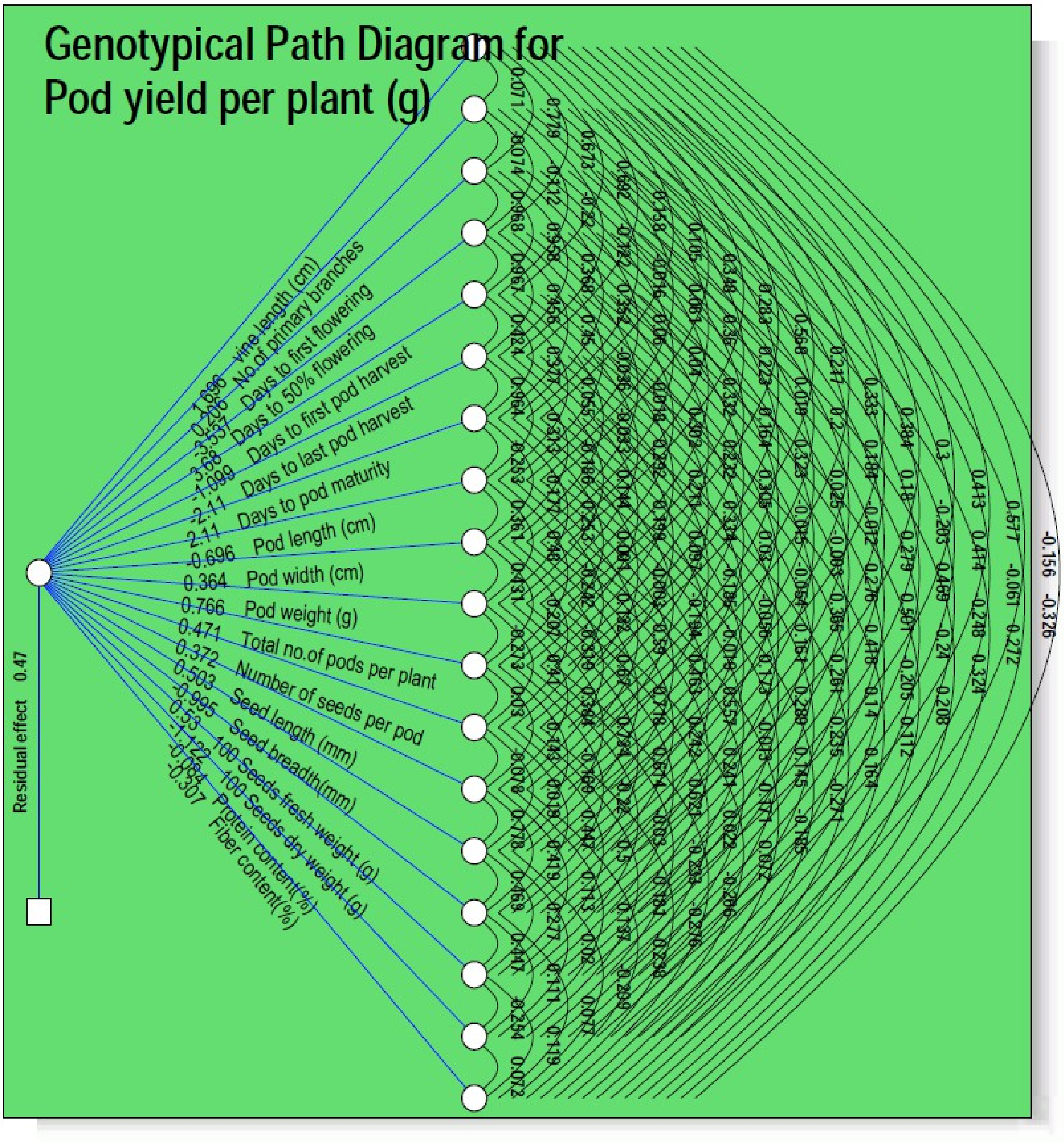

Fig.4.14: Genotypic path diagram representing direct and indirect effects for pod yield

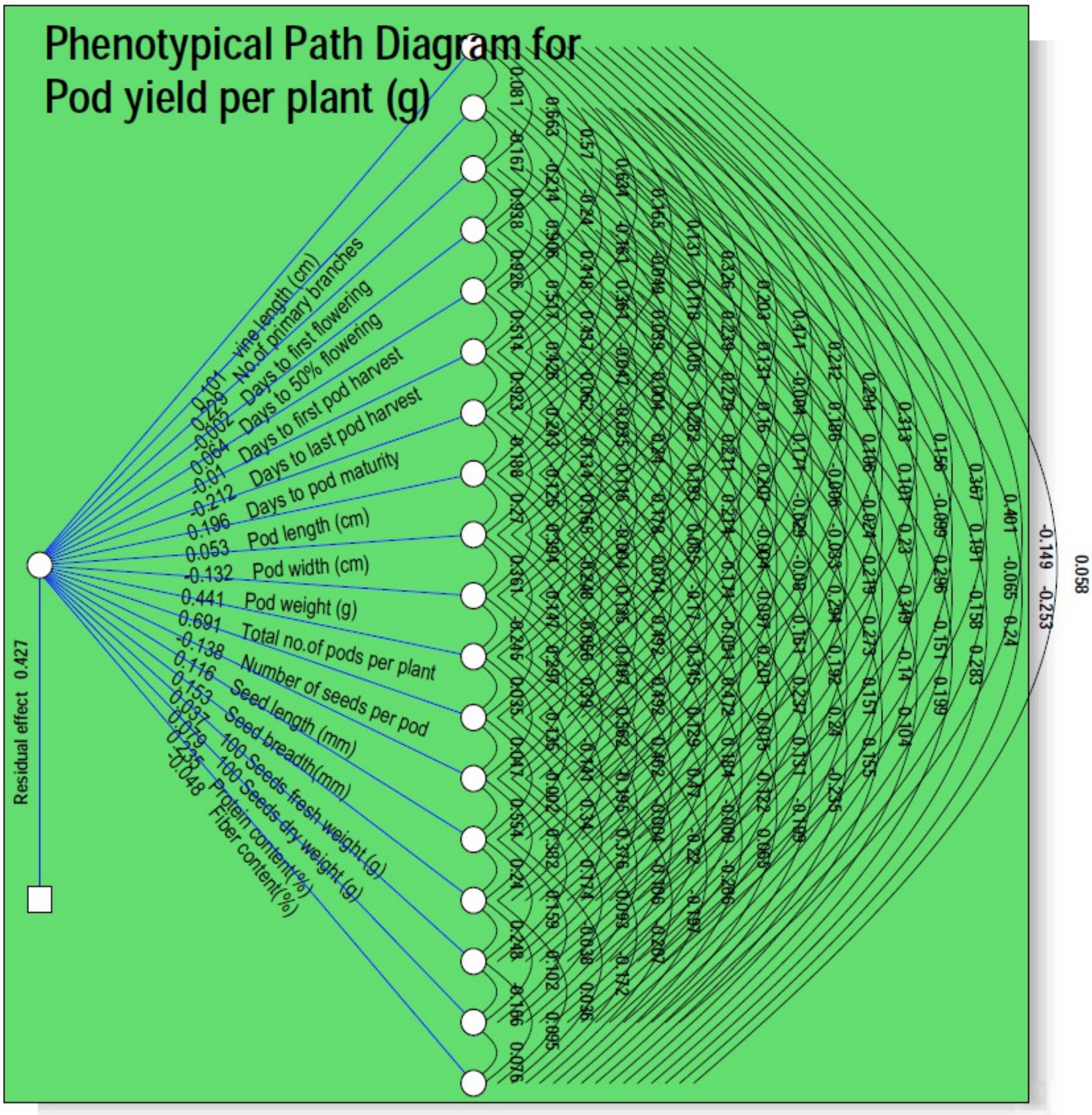

Fig.4.13: Phenotypic path diagram representing direct and indirect effects for pod yield

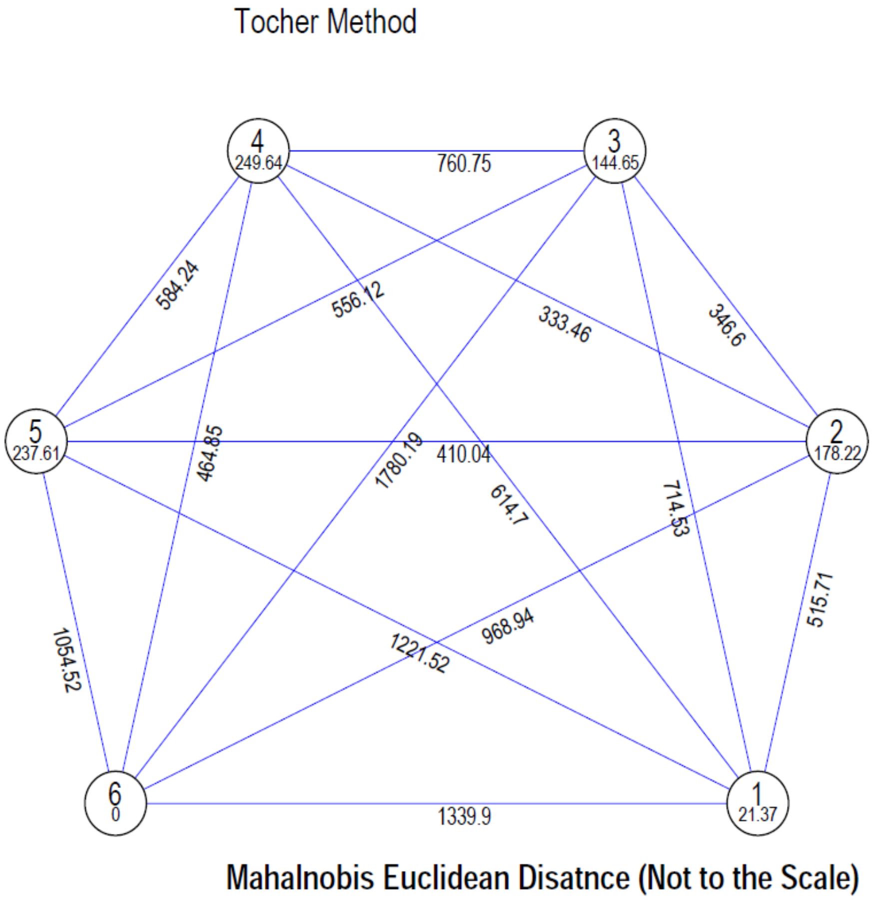

Fig.4.11: The nearest and farthest clusters from each cluster based on D^2 values (Tocher's method) in dolichos bean germplasm

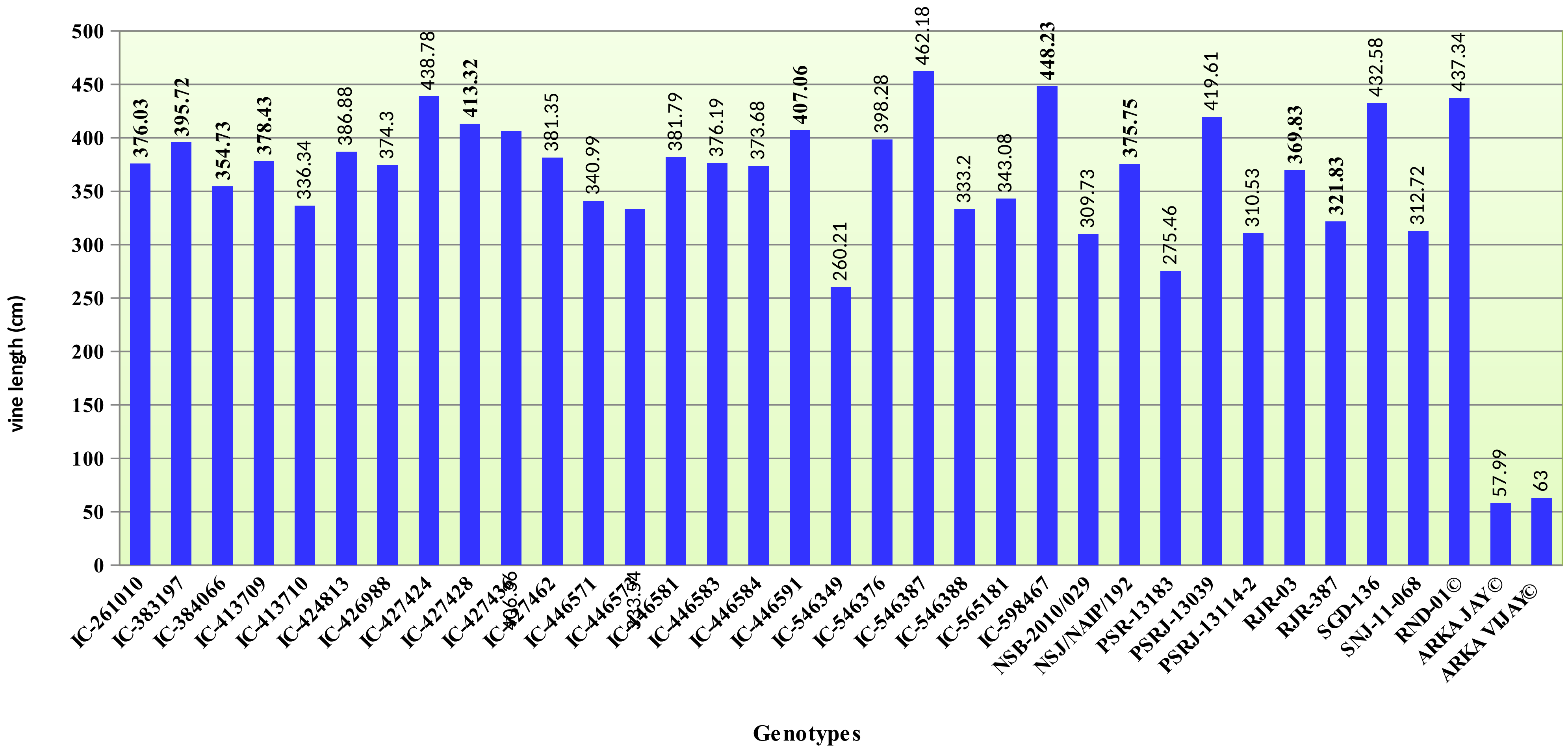

Fig.4.1: Vine length (cm) in 35 genotypes of dolichos bean including check varieties

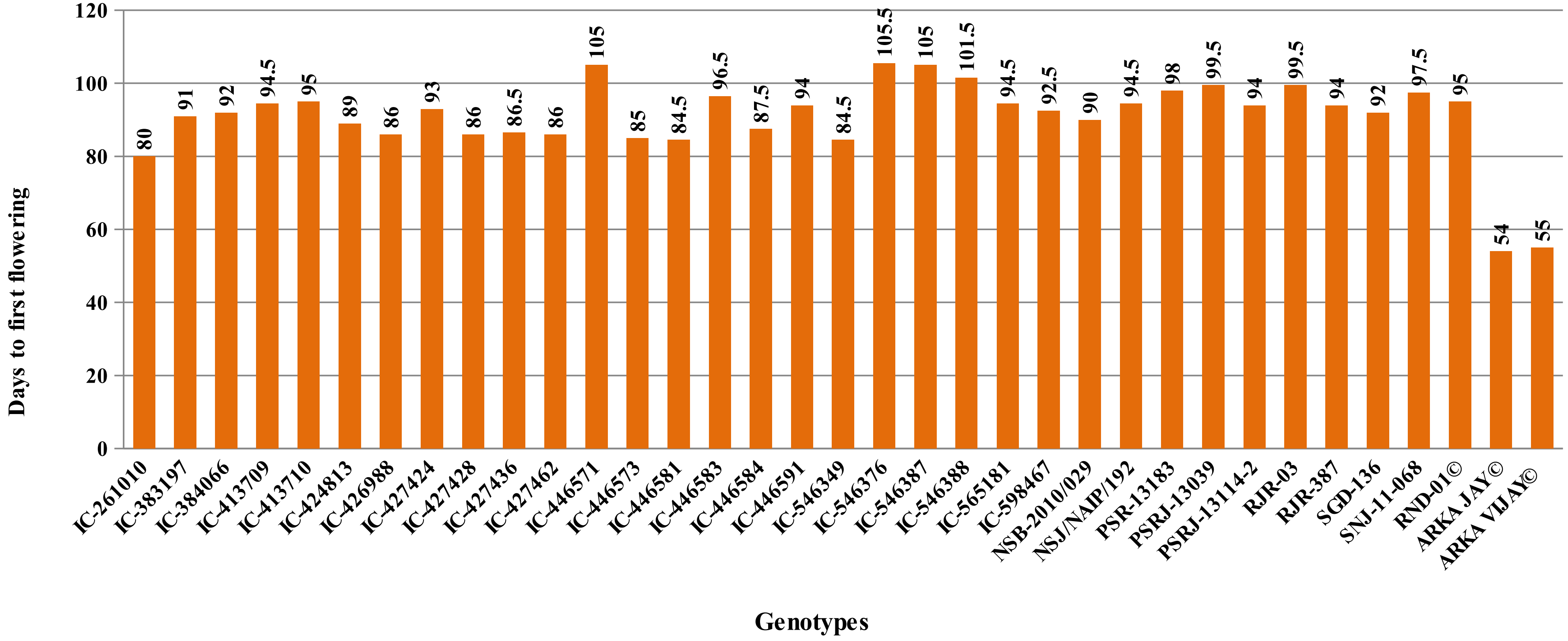

Fig.4.2: Days to first flowering in 35 genotypes of dolichos bean including check varieties

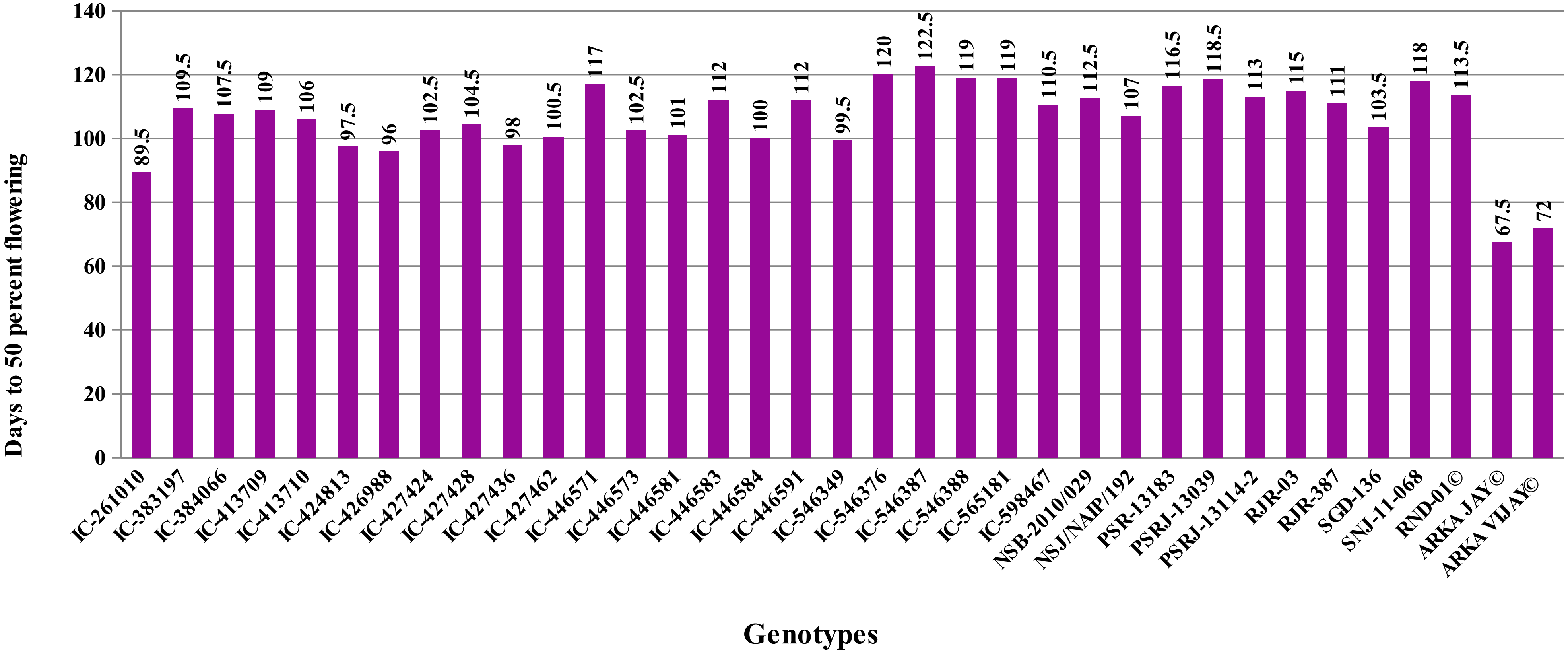

Fig.4.3: Days to 50 *per cent* flowering in 35 genotypes of dolichos bean including check varieties

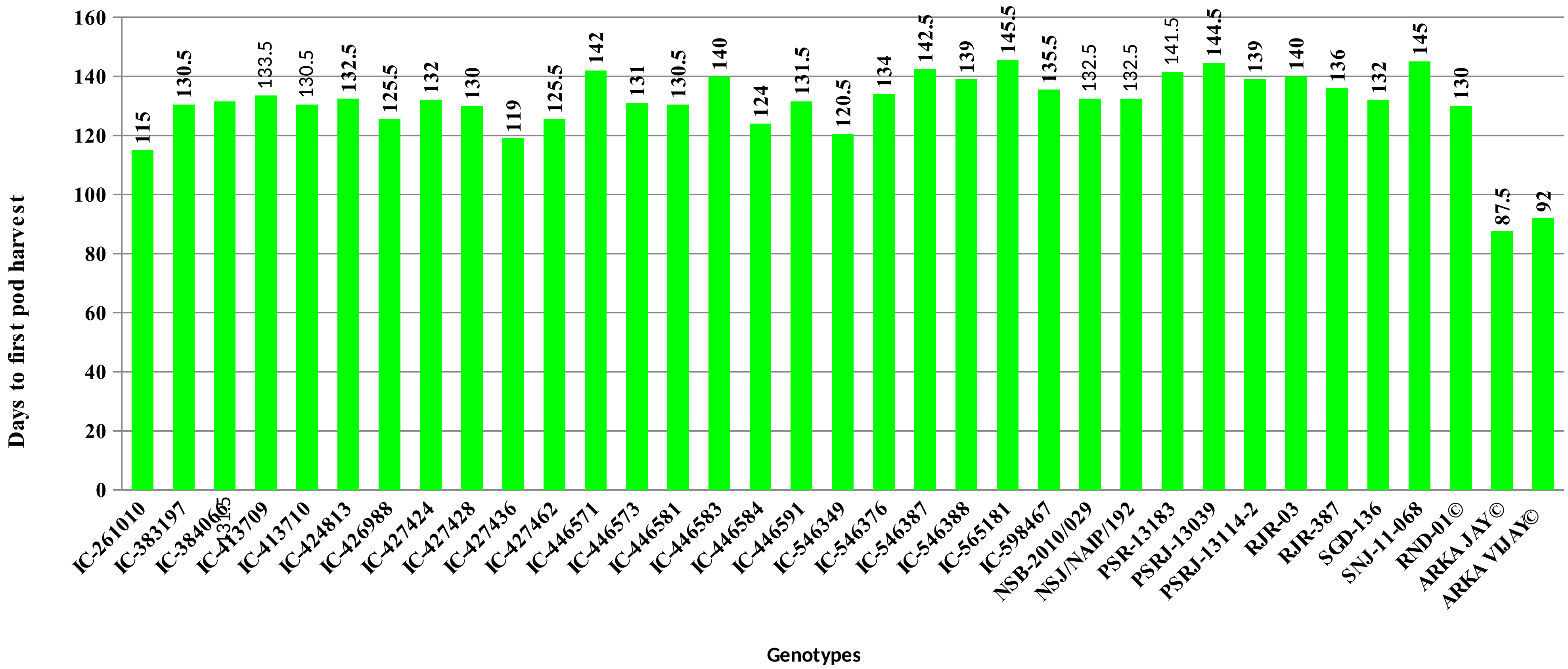

Fig.4.4: Days to first pod harvest in 35 genotypes of dolichos bean including check varieties

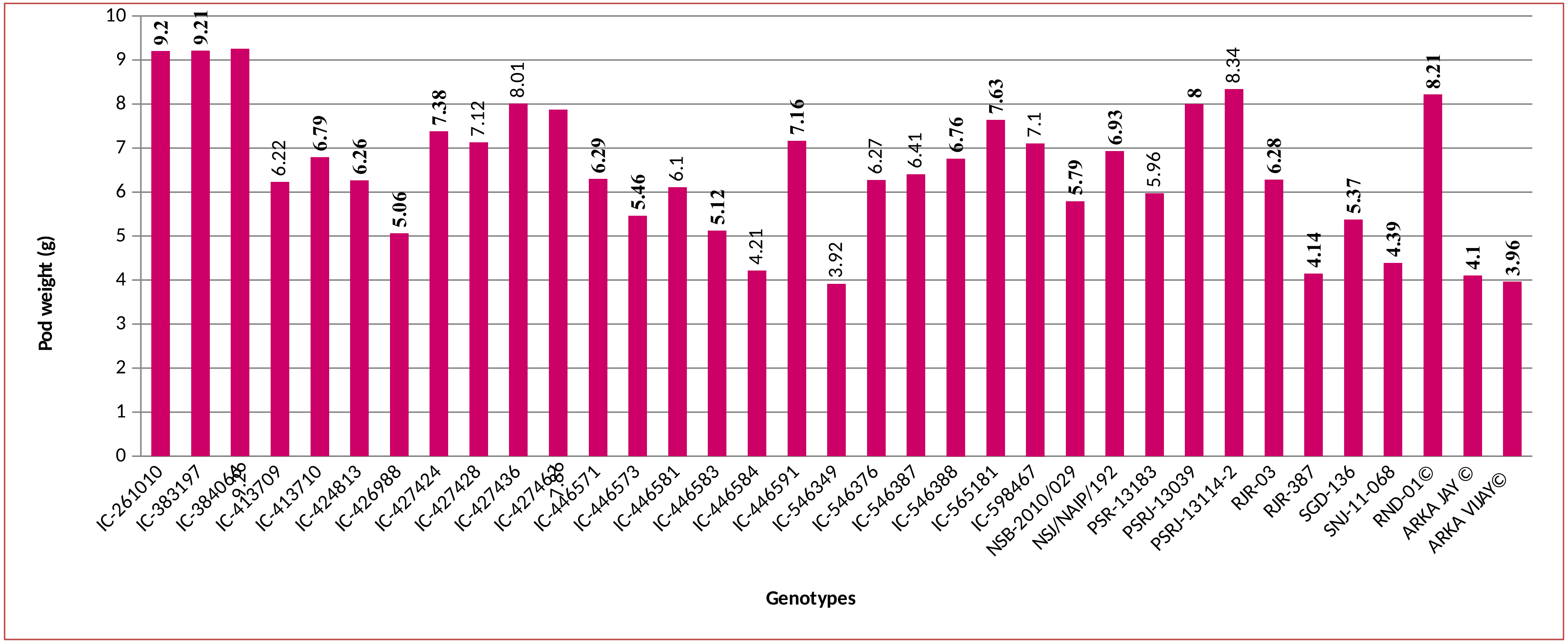

Fig.4.5: Pod weight (g) in 35 genotypes of dolichos bean bean including check varieties

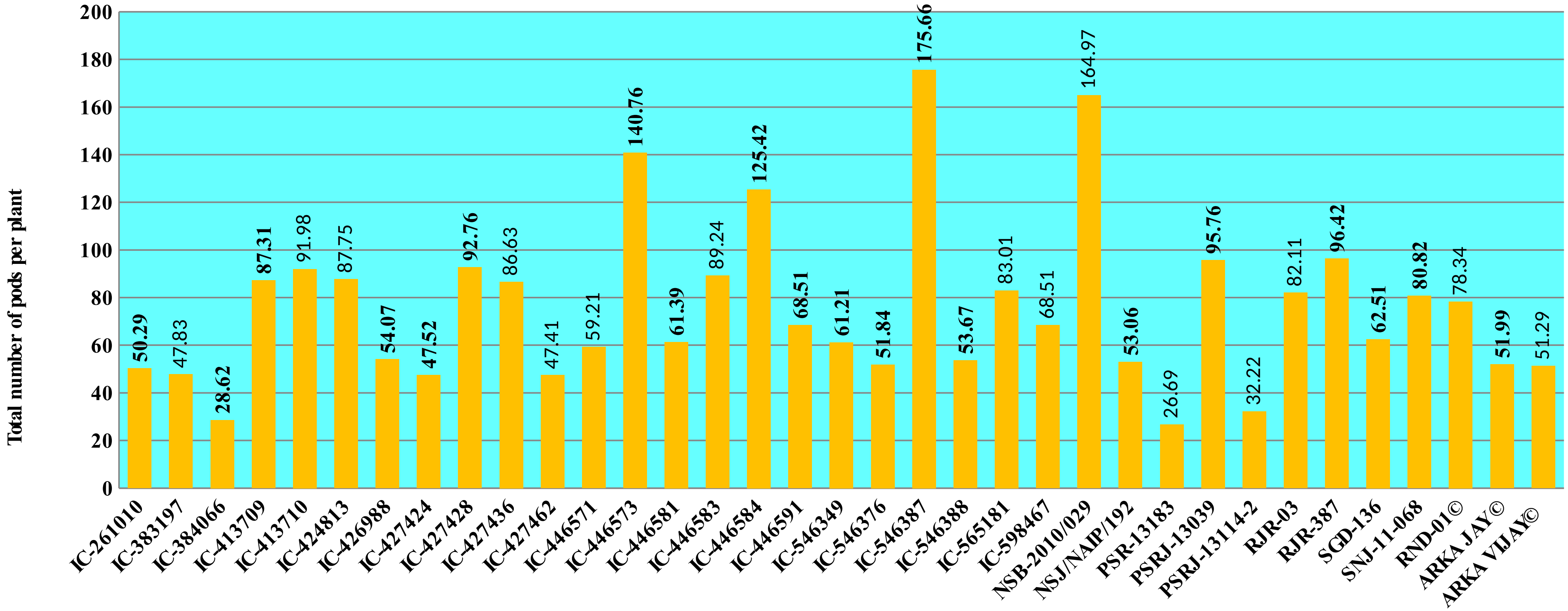

Fig.4.6: Total number of pods per plant in 35 genotypes of dolichos bean including check varieties

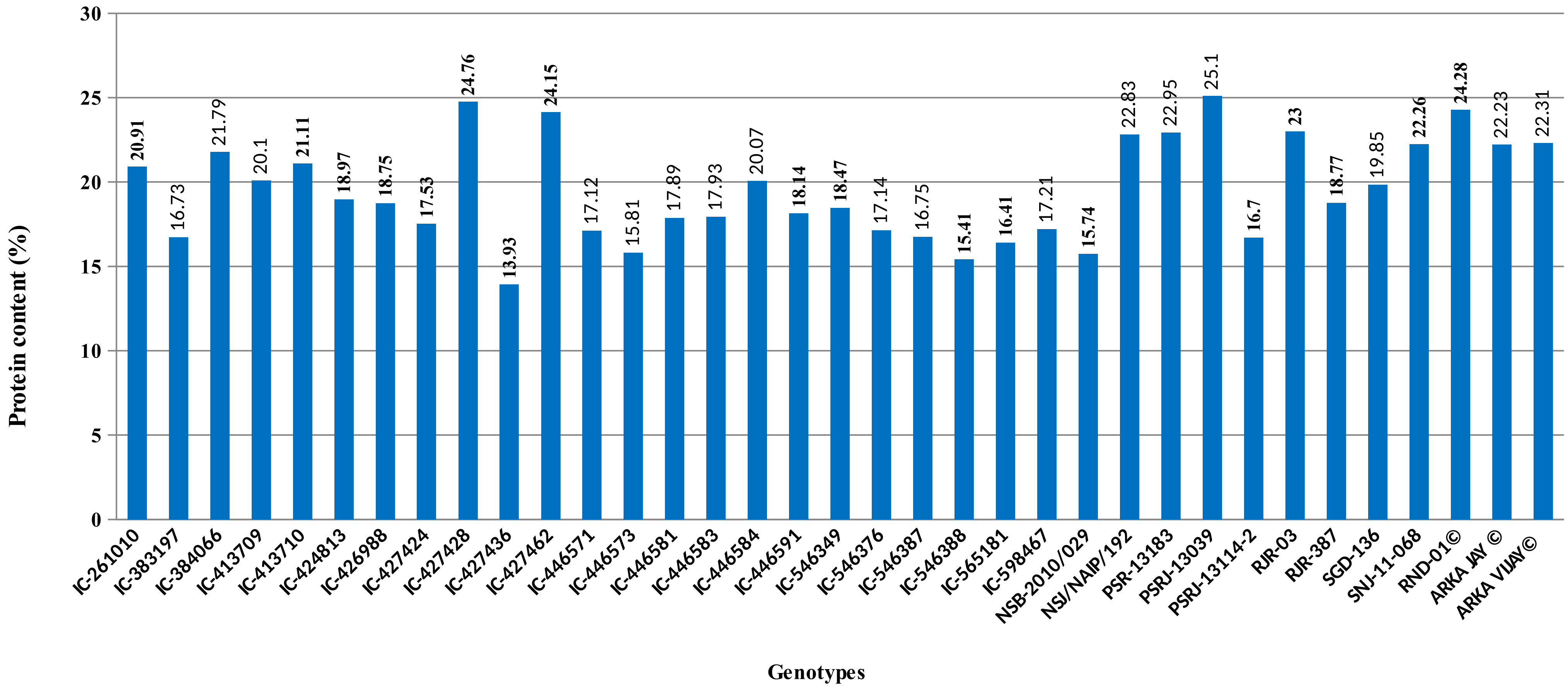

Fig.4.7: Protein content (%) in 35 genotypes of dolichos bean including check varieties

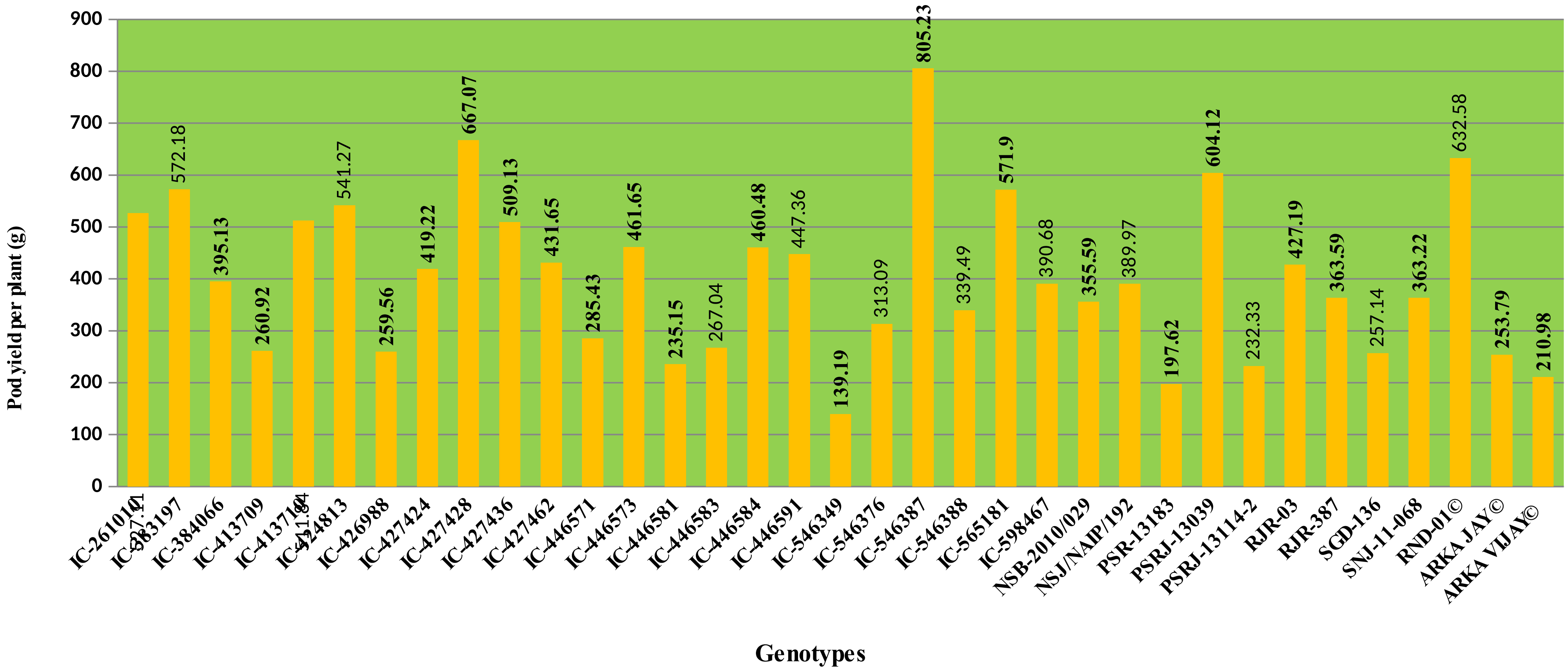

Fig.4.8: Pod yield per plant in 35 genotypes of dolichos bean including check varieties

Genotypes

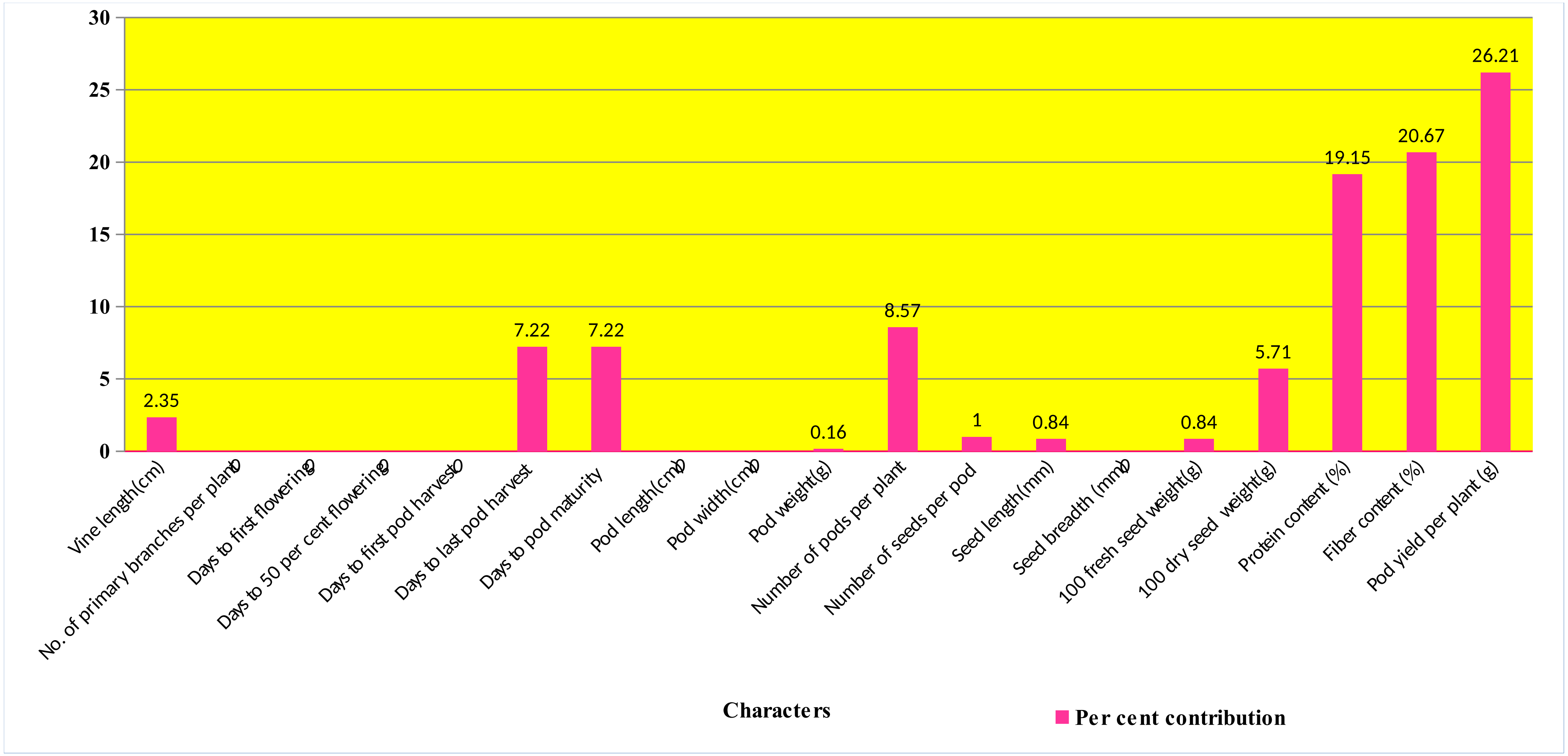

Fig.4.9: Percent contribution of 19 characters towards genetic divergence in dolichos bean genotypes

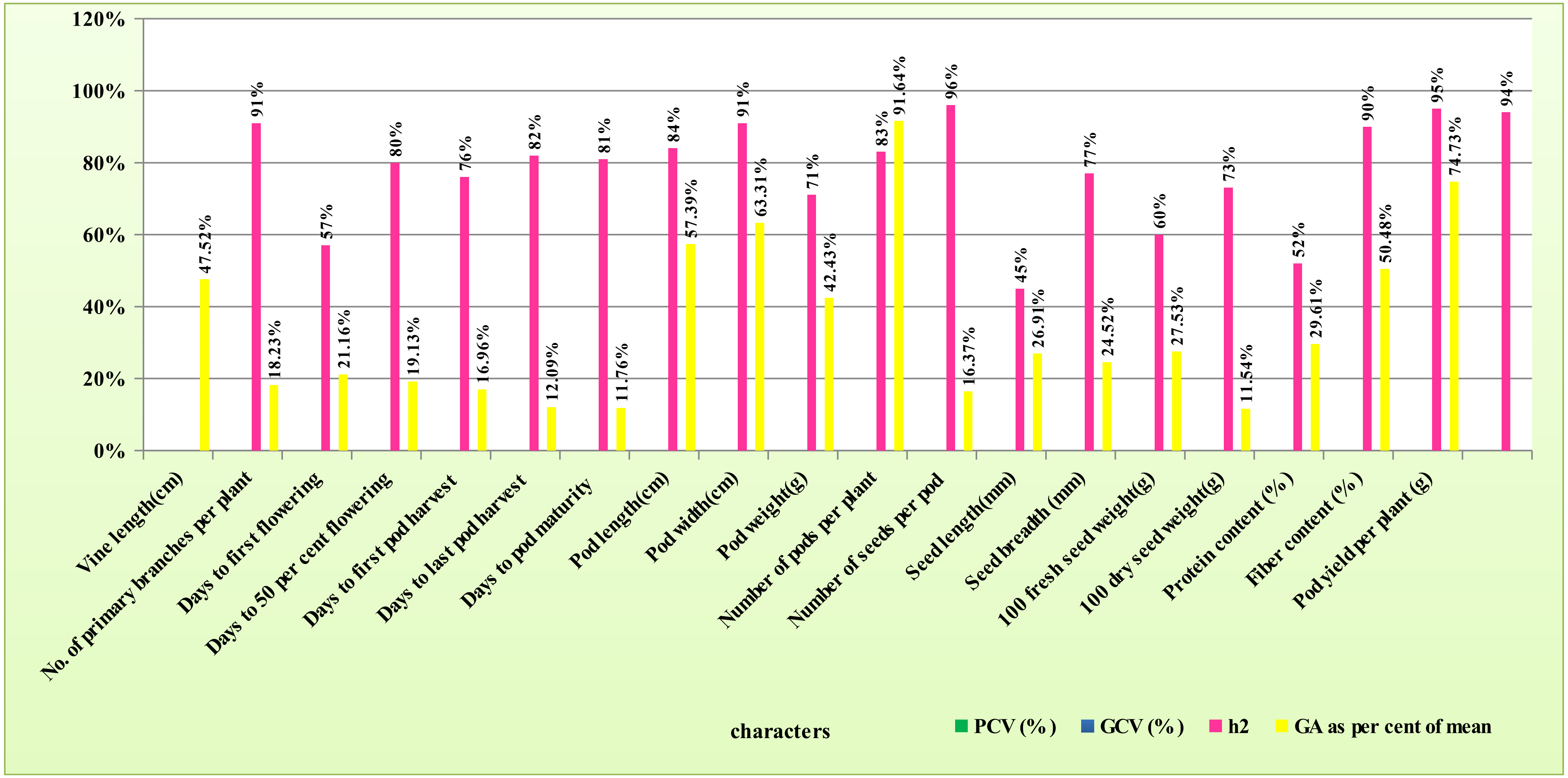

Fig.4.12: Genetic parameters for 19 characters in dolichos bean genotypes

Table 4.1 Analysis of variance for nineteen quantitative traits in 35 genotypes of dolichos bean

Sl. no	Character	Mean sum of squares		
		Replication (df=1)	**Treatments (df=34)**	**Error (df=34)**
1.	Vine length(cm)	402.672	15234.210**	672.427
2.	No. of primary branches per plant	0.137	0.304**	0.082
3.	Days to first flowering	30.229	241.182**	25.670
4.	Days to 50 *per cent* flowering	46.414	295.061**	39.414
5.	Days to first pod harvest	96.057	314.356**	31.322
6.	Days to last pod harvest	54.914	328.881**	33.326
7.	Days to pod maturity	70.00	354.212**	29.647
8.	Pod length(cm)	1.966	18.037**	0.815
9.	Pod width(cm)	0.189	1.045**	0.176
10.	Pod weight(g)	1.281	4.713**	0.438
11.	Number of pods per plant	98.319	2379.014**	45.282
12.	Number of seeds per pod	0.801	1.078**	0.408
13.	Seed length(mm)	0.001	4.345**	0.541
14.	Seed breadth (mm)	1.581	2.913**	0.728
15.	100 seed fresh weight(g)	50.813	151.127**	22.984
16.	100 seed dry weight(g)	2.133	15.090**	4.684
17.	Protein content (%)	2.662	18.241**	0.888
18.	Fiber content (%)	1.037	48.272**	1.237
19.	Pod yield per plant (g)	1874.478	46487.040**	1302.249

***and ** significant at P=0.05 and P=0.01 level of significance respectively**

Table 4.2 Mean values of the nineteen quantitative characters in 35 genotypes of dolichos bean germplasm

Genotype	Vine length (cm)	No. of 1° branches per plant	Days to first flowering	Days to 50%flowering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	No. of pods per plant	No. of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight (g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Pod yield per plant (g)
IC-261010	376.03	2.51	80.00	89.50	115.00	178.00	198.00	14.64	1.64	9.20	50.29	5.29	11.13	8.83	76.64	27.37	20.91	17.91	527.10
IC-383197	395.72	3.83	91.00	109.50	130.50	196.50	218.00	11.04	4.34	9.21	47.82	4.80	11.11	8.84	57.39	35.56	16.72	21.15	572.17
IC-384066	354.73	2.79	92.00	107.50	131.50	202.50	220.50	12.30	3.28	9.25	28.62	4.99	13.35	9.31	60.82	28.88	21.78	15.26	395.13
IC-413709	378.43	2.71	94.50	109.00	133.50	204.50	220.50	6.25	1.29	6.22	87.31	4.33	8.21	7.11	37.27	27.29	20.09	24.91	260.92
IC-413710	336.33	2.76	95.00	106.00	130.50	202.50	222.00	11.78	2.59	6.79	91.97	3.85	8.07	7.66	50.67	26.45	21.11	13.82	511.83
IC-424813	386.87	2.98	89.00	97.50	132.50	186.50	204.50	8.76	1.33	6.26	87.74	5.14	8.90	6.18	53.92	30.10	18.97	13.06	541.26
IC-426988	374.30	2.40	86.00	96.00	125.50	162.00	177.00	14.67	2.24	5.06	54.07	3.37	10.64	6.62	51.75	27.06	18.75	25.68	259.56
IC-427424	438.77	3.41	93.00	102.50	132.00	158.50	179.50	13.16	3.45	7.37	47.52	5.01	12.10	9.11	51.82	29.41	17.53	10.52	419.22
IC-427428	413.32	2.57	86.00	104.50	130.00	180.50	191.50	12.61	2.03	7.12	92.76	5.12	12.25	8.29	51.12	29.23	24.76	15.83	667.07
IC-427436	406.35	3.58	86.50	98.00	119.00	154.50	176.00	15.47	2.27	8.00	86.63	5.94	9.27	7.95	49.40	31.06	13.93	14.79	509.13
IC-427462	381.34	2.68	86.00	100.50	125.50	189.00	209.00	17.11	2.10	7.86	47.40	4.91	9.01	7.40	57.72	30.45	24.15	15.49	431.65
IC-446571	340.99	2.82	105.0	117.00	142.00	175.00	188.00	7.55	1.25	6.29	59.20	5.70	7.25	5.95	37.98	27.50	17.11	19.92	285.43
IC-446573	333.54	2.83	85.00	102.50	131.00	190.50	201.50	9.89	1.31	5.46	140.76	4.79	9.73	7.40	51.87	29.45	15.80	13.17	461.65
IC-446581	381.78	2.41	84.50	101.00	130.50	190.00	203.00	8.15	1.28	6.10	61.39	5.83	8.55	5.90	64.29	29.85	17.88	27.12	235.15
IC-446583	376.19	2.77	96.50	112.00	140.00	209.00	220.50	10.03	1.58	5.12	89.23	5.21	8.35	5.93	55.13	30.67	17.93	15.49	267.03
IC-446584	373.68	2.81	87.50	100.00	124.00	189.00	201.50	7.33	2.23	4.21	125.42	5.02	10.00	5.28	44.28	29.34	20.06	17.92	460.48
IC-446591	407.06	2.69	94.00	112.00	131.50	180.00	199.00	7.98	2.18	7.16	68.51	3.02	10.58	7.00	42.25	30.61	18.14	25.32	447.35
IC-546349	260.20	2.68	84.50	99.50	120.50	170.00	190.00	6.09	2.30	3.91	61.21	3.81	8.85	6.00	51.83	29.22	18.47	23.70	139.19
IC-546376	398.27	2.44	105.5	120.00	134.00	189.50	210.50	8.00	1.69	6.27	51.84	4.86	9.00	7.84	47.93	30.00	17.13	28.35	313.08
IC-546387	462.17	3.40	105.0	122.50	142.50	205.00	222.50	6.50	1.29	6.40	175.66	4.65	8.86	6.35	46.42	32.21	16.75	17.66	805.23
IC-546388	333.19	2.70	101.5	119.00	139.00	195.00	212.00	8.26	1.41	6.76	53.67	5.38	7.96	6.22	54.79	33.54	15.41	21.48	339.49
IC-565181	343.07	2.42	94.50	119.00	145.50	197.50	215.00	10.61	1.33	7.63	83.00	5.11	10.11	8.57	53.77	31.87	16.41	20.46	571.9
IC-598467	448.23	3.26	92.50	110.50	135.50	193.50	214.00	7.93	1.59	7.10	68.50	5.82	7.92	6.07	52.07	32.04	17.20	16.44	390.67

Genotype	Vine length (cm)	No. of 1° branches per plant	Days to first flowering	Days to 50%flowering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	No. of pods per plant	No. of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight (g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Pod yield per plant (g)
NSB-2010/029	309.73	2.21	90.00	112.50	132.50	182.50	189.00	6.31	2.20	5.79	164.96	5.50	7.91	6.26	46.25	29.16	15.74	13.67	355.59
NSJ/NAIP/192	375.75	3.17	94.50	107.00	132.50	183.50	201.00	12.18	1.30	6.93	53.06	5.74	10.06	5.31	54.44	34.40	22.82	19.89	389.96
PSR-13183	275.45	2.68	98.00	116.50	141.50	199.00	221.00	6.70	1.61	5.96	26.68	5.19	8.03	6.10	57.29	29.84	22.94	22.26	197.62
PSRJ-13039	419.60	2.89	99.50	118.50	144.50	195.00	215.00	9.13	1.35	8.00	95.76	5.00	7.75	6.27	56.26	29.22	25.09	28.02	604.12
PSRJ-13114-2	310.52	2.54	94.00	113.00	139.00	189.00	213.50	11.67	1.36	8.33	32.21	5.09	8.11	5.32	55.33	30.11	16.70	25.53	232.32
RJR-03	369.83	2.58	99.50	115.00	140.00	188.50	210.50	10.04	1.57	6.28	82.10	3.63	8.10	6.24	50.23	27.73	23.00	26.14	427.19
RJR-387	321.83	3.32	94.00	111.00	136.00	184.50	198.00	13.88	1.56	4.14	96.42	4.95	10.00	5.30	51.54	22.00	18.77	18.29	363.59
SGD-136	432.57	2.77	92.00	103.50	132.00	189.50	211.50	10.83	1.43	5.37	62.50	4.89	8.94	4.85	40.93	27.70	19.84	14.64	257.13
SNJ-11-068	312.71	2.43	97.50	118.00	145.00	191.50	216.50	11.95	1.14	4.39	80.82	4.86	9.91	6.32	59.31	28.11	22.26	15.53	363.22
RND-01 ©	437.33	3.51	95.00	113.50	130.00	190.00	215.50	10.9	1.44	8.21	78.34	6.14	10.46	7.69	59.10	34.56	24.28	21.87	632.57
ARKA JAY ©	57.98	3.38	54.00	67.50	87.50	172.50	195.00	6.59	1.11	4.10	51.99	4.00	7.85	6.21	34.59	26.03	22.22	15.17	253.79
ARKA VIJAY ©	62.99	2.98	55.00	72.00	92.00	179.50	201.50	5.95	1.15	3.96	51.28	4.17	7.60	6.28	31.84	24.88	22.30	18.49	210.98
MEAN VALUES	**353.91**	**2.85**	**90.80**	**106.38**	**130.68**	**186.97**	**205.20**	**10.06**	**1.80**	**6.46**	**75.33**	**4.89**	**9.31**	**6.80**	**51.38**	**29.51**	**19.51**	**19.28**	**402.85**
S.E of mean	**18.33**	**0.20**	**3.58**	**4.43**	**3.95**	**4.08**	**3.85**	**0.63**	**0.29**	**0.46**	**4.75**	**0.45**	**0.51**	**0.60**	**3.39**	**1.53**	**0.66**	**0.78**	**25.57**
C.D 5%	**52.69**	**0.58**	**10.29**	**12.78**	**11.37**	**11.73**	**11.06**	**1.83**	**0.85**	**1.34**	**13.67**	**1.29**	**1.49**	**1.7**	**9.74**	**4.39**	**1.91**	**2.26**	**73.33**
C.D 1%	**7.075**	**0.78**	**13.82**	**17.12**	**15.26**	**15.75**	**14.85**	**2.46**	**1.14**	**1.80**	**18.35**	**1.74**	**2.00**	**2.32**	**13.08**	**5.90**	**2.57**	**3.03**	**98.45**

Table 4.3 Percent contribution of different characters towards diversity in dolichos bean germplasm

Sl.No	Character	No. of times ranked 1st	Percent contribution
1.	Vine length(cm)	14	2.35
2.	No. of primary branches per plant	0	0.00
3.	Days to first flowering	0	0.00
4.	Days to 50 *per cent* flowering	0	0.00
5.	Days to first pod harvest	0	0.00
6.	Days to last pod harvest	43	7.22
7.	Days to pod maturity	0	7.22
8.	Pod length (cm)	43	0.00
9.	Pod width (cm)	0	0.00
10.	Pod weight (g)	1	0.16
11.	Number of pods per plant	51	8.57
12.	Number of seeds per pod	6	1.00
13.	Seed length (mm)	5	0.84
14.	Seed breadth (mm)	0	0.00
15.	100 fresh seed weight (g)	5	0.84
16.	100 dry seed weight (g)	34	5.71
17.	Protein content (%)	114	19.15
18.	Fiber content (%)	123	20.67
19.	Pod yield per plant (g)	156	26.21

Table 4.4 Clustering pattern of 35 genotypes of dolichos bean (Tocher's method)

Cluster	No. of genotypes	Genotypes
I	2	ARKA JAY (34), ARKA VIJAY (35)
II	15	IC-546388, PSRJ-13114-2, IC-598467, PSR-13183, IC-565181, NSJ/NAIP/192, IC-424813, IC-446591, RJR-03, IC-546376, SGD-136, SNJ-11-068, IC-413710, PSRJ-13039, IC-446581.
III	6	IC-261010, IC-427462 , IC-427428 , IC-384066 , RND-1, IC-383197
IV	8	IC-446583, IC-446584 , IC-446573, RJR-387, IC-546387, IC-413709, IC-546349, IC-446571
V	3	IC-427424, IC-427436 , IC-426988
VI	1	NSB-2010/029

Table 4.5 The nearest and farthest clusters from each cluster based on D^2 values in dolichos bean germplasm

Cluster No	Nearest cluster with D^2 values	Farthest cluster with D^2 values
I	515.71(II)	1339.90(VI)
II	333.46(IV)	968.94(VI)
III	346.60(II)	1780.19(VI)
IV	333.46(II)	760.75(IV)
V	410.04(II)	1221.52(I)
VI	464.85(IV)	1780.19(III)

Table 4.6 Average intra (bold) and inter-cluster D^2 values for six clusters in 35 genotypes of dolichos bean. (Tocher's method)

Cluster	I	II	III	IV	V	VI
I	**21.37**	515.71	714.53	614.70	1221.52	1339.90
II		**178.22**	346.60	333.46	410.04	968.94
III			**144.65**	760.75	556.12	1780.19
IV				**249.64**	584.24	464.85
V					**237.61**	1054.52
VI						**0.00**

Values in the parenthesis indicate D^2 values

Table: 4.7 Mean values of clusters for nineteen characters in 35 genotypes of dolichos bean (Tocher's method)

Cluster	Vine length (cm)	No.of primary branches per plant	Days to first flowering	Days to 50%flowering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	No. of pods per plant	No. of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight (g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Pod yield per plant (g)
I	60.49	3.19	54.50	69.75	89.75	176.00	198.25	6.28	1.14	4.03	51.64	4.09	7.73	6.25	33.22	25.46	22.27	16.83	232.39
II	368.75	2.72	95.43	111.77	136.90	191.37	211.27	9.60	1.55	6.62	66.65	4.90	8.80	6.39	52.90	30.11	19.66	21.21	388.16
III	393.08	2.98	88.33	104.17	127.08	189.42	208.75	13.10	2.47	8.48	57.54	5.21	11.22	8.40	60.47	31.01	22.10	17.92	537.62
IV	355.88	2.92	94.00	109.19	133.69	190.94	205.31	8.44	1.60	5.22	104.40	4.81	8.91	6.17	47.04	28.46	18.13	18.89	380.44
V	406.48	3.15	88.50	98.83	125.50	158.33	177.50	14.44	2.66	6.81	62.74	4.78	10.67	7.90	50.99	29.18	16.74	17.00	395.97
VI	309.74	2.22	90.00	112.50	132.50	182.50	189.00	6.31	2.20	5.79	164.97	5.50	7.91	6.27	46.25	29.16	15.74	13.68	355.59

Table: 4.8 Estimates of variability, heritability and genetic advance as per cent of mean for nineteen characters in 35 genotypes of dolichos bean

Sl. no	Character	Range		Mean	Variance			PCV (%)	GCV (%)	ECV (%)	h^2 (%)	Genetic advance	GA as per cent of mean
		Minimum	Maximum		Phenotypic	Genotypic	Environmental						
1.	Vine length(cm)	57.98	462.17	353.91	7953.31	7280.89	672.42	25.19	24.11	7.32	91	168.18	47.52
2.	No. of primary branches per plant	2.21	3.83	2.85	0.19	0.11	0.08	15.37	11.66	10.01	57	0.52	18.23
3.	Days to first flowering	54	105.50	90.80	133.42	107.75	25.67	12.72	11.43	5.58	80	19.21	21.16
4.	Days to 50 *per cent* flowering	67.50	122.50	106.38	167.23	127.82	39.41	12.15	10.62	5.90	76	20.36	19.13
5.	Days to first pod harvest	87.50	145.50	130.68	172.83	141.51	31.32	10.06	9.10	4.28	82	22.17	16.96
6.	Days to last pod harvest	154.00	209.00	186.97	181.10	147.77	33.32	7.19	6.50	3.08	81	22.62	12.09
7.	Days to pod maturity	176.00	222.50	205.20	191.92	162.28	29.64	6.75	6.20	2.65	84	24.13	11.76
8.	Pod length(cm)	5.95	17.11	10.06	9.42	8.61	0.81	30.50	29.15	8.97	91	5.77	57.39
9.	Pod width(cm)	1.11	4.34	1.80	0.61	0.43	0.17	43.20	36.43	23.21	71	1.14	63.31
10.	Pod weight(g)	3.91	9.25	6.46	2.57	2.13	0.43	24.82	22.61	10.24	83	2.74	42.43
11.	Number of pods per plant	26.68	175.66	75.33	1212.14	1166.86	45.28	46.21	45.34	8.93	96	69.0	91.64
12.	Number of seeds per pod	3.02	6.14	4.89	0.74	0.33	0.40	17.62	11.83	13.06	45	0.80	16.37
13.	Seed length(mm)	7.25	13.35	9.31	2.44	1.90	0.54	16.78	14.80	7.89	77	2.50	26.91
14.	Seed breadth (mm)	5.28	9.31	6.80	1.82	1.09	0.72	19.83	15.37	12.54	60	1.66	24.52
15.	100 fresh seed weight(g)	31.84	76.64	51.38	87.05	64.07	22.98	18.15	15.57	9.33	73	14.146	27.53
16.	100 dry seed weight(g)	22.00	35.56	29.51	9.88	5.20	4.68	10.65	7.72	7.33	52	3.40	11.54
17.	Protein content (%)	15.41	25.09	19.51	9.56	8.67	0.88	15.84	15.09	4.82	90	5.77	29.61
18.	Fiber content (%)	10.52	28.35	19.28	24.754	23.517	1.23	25.79	25.14	5.76	95	9.73	50.48
19.	Pod yield per plant (g)	139.19	805.23	402.85	23894.64	22592.39	1302.24	38.37	37.31	8.95	94	301.07	74.73

Table: 4.9 (a) Phenotypic (P) correlation coefficients among nineteen yield and yield attributes in thirty five genotypes of dolichos bean

	Vine length (cm)	Primary branches per plant	Days to first flowering	Days to 50%flo wering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	Number of pods per plant	Number of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight (g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Correl ation coeffici ent
VL	1.000	0.081	0.662**	0.569**	0.634**	0.165	0.131	0.326**	0.202	0.471**	0.212	0.294*	0.313**	0.155	0.367**	0.401**	-0.148	0.157	0.511**
PBPP	0.081	1.000	-0.166	-0.214	-0.239*	-0.161	-0.048	0.118	0.239*	0.130	0.004	0.185	0.105	0.101	-0.098	0.190	-0.065	-0.252*	0.291*
DFF	0.662**	-0.166	1.000	0.938**	0.905**	0.418**	0.361**	0.039	0.049	0.279*	0.160	0.170	-0.00	-0.023	0.230	0.295*	-0.158	0.239*	0.244*
D 50%F	0.569**	-0.214	0.938**	1.000	0.926**	0.516**	0.43**	-0.047	0.004	0.281*	0.211	0.206	-0.028	-0.033	0.218	0.348**	-0.151	0.282*	0.254*
DFPH	0.634**	-0.239*	0.905**	0.926**	1.000	0.513**	0.425**	0.061	-0.035	0.240*	0.193	0.214	-0.004	-0.080	0.294*	0.279*	-0.140	0.199	0.226
DLPH	0.165	-0.161	0.418**	0.516**	0.513**	1.000	0.923**	-0.243*	-0.134	0.114	0.178	0.085	-0.171	-0.096	0.161	0.192	0.151	0.103	0.159
DPM	0.131	-0.048	0.361**	0.437**	0.425**	0.923**	1.000	-0.243*	-0.134	0.114	-0.003	0.074	-0.169	-0.051	0.200	0.236*	0.240*	0.155	0.139
PL	0.326**	0.118	0.039	-0.047	0.061	-0.243*	-0.187	1.000	0.270*	0.394**	-0.248*	0.135	0.492**	0.344**	0.472**	-0.015	0.131	-0.234*	0.240*
PW	0.202	0.239*	0.049	0.004	-0.035	-0.134	-0.124	0.27*	1.000	0.361**	-0.146	-0.055	0.497**	0.491**	0.128	0.183	-0.122	-0.198	0.160
PWT	0.471**	0.130	0.279*	0.281*	0.240*	0.114	0.165	0.394**	0.361**	1.000	-0.244*	0.297*	0.390**	0.562**	0.461**	0.469**	-0.008	0.065	0.485**
NPP	0.212	-0.004	0.160	0.211	0.193	0.178	-0.003	-0.248*	-0.146	-0.244*	1.000	0.034	-0.135	-0.141	-0.194	-0.003	-0.219	-0.265*	0.495**
NSP	0.294*	0.185	0.170	0.206	0.214	0.085	0.074	0.135	-0.055	97*	0.034	1.000	0.046	-0.002	0.340**	0.376**	-0.106	-0.197	0.143
SL	0.313**	0.105	-0.006	-0.028	-0.004	-0.171	-0.169	0.492**	0.497**	0.390**	-0.135	0.046	1.000	0.553**	0.381**	0.173	0.092	-0.206	0.349**
SB	0.155	0.101	-0.023	-0.033	-0.080	-0.096	-0.051	0.344**	0.491**	0.562**	-0.141	-0.002	0.553**	1.000	0.240*	0.158	-0.037	-0.171	0.389**
100FSW	0.367**	-0.098	0.230	0.218	0.294*	0.161	0.200	0.472**	0.128	0.461**	-0.194	0.340**	0.381**	0.240*	1.000	0.247*	0.101	0.036	0.220
100DSW	0.401**	0.190	0.295*	0.348**	0.272*	0.192	0.236*	-0.015	0.183	0.469**	-0.003	0.376**	0.173	0.158	0.247*	1.000	-0.165	0.095	0.325**
PC	-0.148	-0.065	-0.158	-0.151	-0.140	0.151	0.240*	0.131	-0.122	-0.008	-0.219	-0.106	0.092	-0.037	0.101	-0.165	1.000	0.075	0.086
FC	0.057	-0.252*	0.239*	0.282*	0.199	0.103	0.155	-0.234	-0.198	0.065	-0.265*	0.197	-0.206	-0.171	0.036	0.095	0.075	1.000	-0.213
MPYP	0.511**	0.291*	0.244*	0.254*	0.226	0.159	0.139	0.240*	0.160	0.485**	0.494**	0.143	0.349**	0.389**	0.220	0.325**	0.086	-0.213	1.000

***significant at 5% LOS ** significant at 1 % LOS**

VL=vine length(cm);PBPP= Primary branches per plant ; DFF= Days to first flowering ;DFPF = Days to 50 *per cent* flowering ;DFPH= Days to first pod harvest; DLPH= Days to last pod harvest ; DPM=Days to pod maturity ; PL= Pod length (cm) ; PW=Pod width (cm) ; PWT= Pod weight (g) ; NPP= Number of pods per plant; NSP=Number of seeds per pod ; SL=Seed length (mm); SB=seed breadth (mm); 100FSW= 100 fresh seed weight; 100 DSW= 100 dry seed weight; PC= Protein content (%) ; FC=Fiber content (%); MPYP=Marketable pod yield per plant.

Table: 4.9 (b) Genotypic (G) correlation coefficients among nineteen yield and yield attributes in thirty five genotypes of dolichos bean

	Vine length (cm)	Primary branches per plant	Days to first flowering	Days to 50%flowering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	Number of pods per plant	Number of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight(g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Correlation coefficient
VL	**1.000**	0.070	0.779**	0.672**	0.692**	0.158	0.105	0.348**	0.282*	0.567**	0.217	0.333**	0.384**	0.300**	0.412**	0.576**	-0.155	0.062	0.540**
PBPP	0.070	**1.000**	-0.073	-0.112	-0.220*	-0.122	-0.016	0.061	0.359**	0.223	0.019	0.200	0.184	0.180	-0.203	0.413**	-0.060	-0.326**	0.427**
DFF	0.779**	-0.073	**1.000**	0.968**	0.958**	0.368**	0.351**	0.060	0.040	0.332**	0.164	0.323**	0.024	-0.011	0.279*	0.468**	-0.247	0.272*	0.251*
D 50%F	0.672**	-0.112	0.968**	**1.000**	0.966**	0.455**	0.449**	-0.035	-0.017	0.302**	0.232	0.305**	-0.014	-0.003	0.276*	0.500**	-0.239*	0.324**	0.271*
DFPH	0.692**	-0.220	0.958**	0.966**	**1.000**	0.423**	0.376**	0.055	-0.033	0.292*	0.211	0.333**	0.029	-0.053	0.365**	0.417**	-0.250*	0.207	0.24*
DLPH	0.158	-0.122	0.368**	0.455**	0.423**	**1.000**	0.963**	-0.31**	-0.186	0.143	0.198	0.096	-0.185	-0.055	0.160	0.260*	0.139	0.112	0.174
DPM	0.105	-0.016	0.351**	0.449**	0.376**	0.963**	**1.000**	-0.253*	-0.177	0.253**	0.000	-0.003	-0.193	-0.018	0.172	0.288*	0.234	0.164	0.172
PL	0.348**	0.061	0.060	-0.035	0.055	-0.314**	-0.253*	**1.000**	0.361**	0.480**	-0.241*	0.132	0.590**	0.463**	0.557**	-0.013	0.144	-0.270*	0.279*
PW	0.282*	0.359**	0.040	-0.017	-0.033	-0.186	-0.177	0.361**	**1.000**	0.430**	-0.207	-0.319**	0.669**	0.718**	0.241*	0.240*	-0.171	-0.185	0.178
PWT	0.567**	0.223	0.332**	0.302*	0.292*	0.143	0.253*	0.480*	0.430*	**1.000**	-0.272*	0.409**	0.384**	0.734**	0.613**	0.621**	0.021	0.071	0.534**
NPP	0.217	0.019	0.164	0.232	0.211	0.198	0.000	-0.241*	-0.207	-0.272*	**1.000**	0.030	-0.142	-0.169	-0.219	-0.030	-0.233	-0.265*	0.478**
NSP	0.133	0.200	0.323**	0.305**	0.333**	0.096	-0.003	0.132	-0.31**	0.409**	0.030	**1.000**	-0.077	0.018	0.447**	0.550**	-0.181	-0.275*	0.217
SL	0.384**	0.184	0.024	-0.014	0.029	-0.185	-0.193	0.590**	0.669**	0.384**	-0.142	-0.077	**1.000**	0.778**	0.419**	0.113	0.137	-0.238**	0.415**
SB	0.300*	0.180	-0.011	-0.003	-0.053	-0.055	-0.018	0.463**	0.718**	0.734**	-0.169	0.018	0.778**	**1.000**	0.469**	0.276*	0.020	-0.209	0.539**
100FSW	0.412**	-0.203	0.279*	0.276*	0.365**	0.160	0.172	0.557**	0.241*	0.613**	-0.219	0.447**	0.419**	0.469**	**1.000**	0.446**	0.111	0.077	0.283*
100DSW	0.576**	0.413**	0.468**	0.500**	0.417**	0.260*	0.288*	-0.013	0.240*	0.621**	-0.030	0.500**	0.113	0.276*	0.446**	**1.000**	-0.254*	0.118	0.472**
PC	-0.155	-0.060	-0.247*	-0.239*	-0.205	0.139	0.234	0.144	-0.171	0.021	-0.233	-0.181	0.137	0.020	0.111	-0.254*	**1.000**	0.072	0.107
FC	0.062	-0.326**	0.272*	0.324**	0.207	0.112	0.164	-0.270*	-0.185	0.071	-0.265*	-0.275*	-0.238*	-0.209	0.077	0.118	0.072	**1.000**	-0.218
MPYP	0.540**	0.427**	0.251*	0.271*	0.242*	0.174	0.172	0.279*	0.178	0.534**	0.478**	0.217	0.415**	0.539**	0.283*	0.472**	0.107	-0.218	**1.000**

***significant at 5% LOS ** significant at 1 % LOS**

VL=vine length(cm);PBPP= Primary branches per plant ; DFF= Days to first flowering; DFPF = Days to 50 *per cent* flowering ;DFPH= Days to first pod harvest; DLPH= Days to last pod harvest ; DPM=Days to pod maturity ; PL= Pod length (cm) ; PW=Pod width (cm) ; PWT= Pod weight (g) ; NPP= Number of pods per plant; NSP=Number of seeds per pod ; SL=Seed length(mm); SB=seed breadth (mm); 100FSW= 100 fresh seed weight; 100 DSW= 100 dry seed weight; PC= Protein content (%) ; FC=Fiber content(%); MPYP=Marketable pod yield per plant.

Table: 4.10 (a) Phenotypic direct and indirect effects of 18 characters on pod yield in thirty five genotypes of dolichos bean.

	Vine length (cm)	**Primary branches per plant**	**Days to first flowering**	**Days to 50%flowering**	**Days to first pod harvest**	**Days to last pod harvest**	**Days to pod maturity**	**Pod length (cm)**	**Pod width (cm)**	**Pod weight (g)**	**No.of pods per plant**	**No.of seeds per pod**	**Seed length (mm)**	**Seed breadth (mm)**	**100 fresh seed weight (g)**	**100 dry seed weight (g)**	**Protein content (%)**	**Fiber content (%)**	**Correlation coefficient**
VL	**0.101**	0.008	0.067	0.057	0.064	0.016	0.013	0.033	0.020	0.047	0.021	0.029	0.031	0.015	0.037	0.040	0.015	0.005	0.511
PBPP	0.01	**0.229**	-0.038	-0.049	-0.054	-0.037	-0.011	0.027	0.054	0.030	0.000	0.042	0.024	0.023	-0.022	0.043	-0.014	-0.057	0.291
DFF	-0.001	0.000	**-0.001**	-0.001	-0.001	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000	0.000	-0.000	0.244
D FPF	0.036	-0.013	0.060	**0.064**	0.059	0.033	0.028	-0.003	0.000	0.018	0.013	0.013	-0.001	-0.002	0.01	0.022	-0.009	0.018	0.254
DFPH	0.006	0.002	-0.009	-0.009	**-0.010**	-0.005	-0.004	-0.000	0.000	-0.002	0.002	-0.002	0.000	0.000	-0.003	-0.002	0.001	-0.002	0.226
DLPH	0.035	0.034	-0.088	-0.109	-0.109	**-0.212**	-0.195	0.051	0.028	-0.024	0.037	-0.018	0.036	0.020	-0.034	-0.040	-0.032	-0.022	0.159
DPM	0.025	-0.009	0.070	0.085	0.083	0.181	**0.096**	-0.036	-0.024	0.032	-0.000	0.014	-0.033	-0.010	0.039	0.046	0.047	0.030	0.139
PL	0.017	0.00	0.002	-0.002	0.003	-0.013	-0.010	**0.053**	0.014	0.021	-0.013	0.007	0.026	0.018	0.025	-0.000	0.007	-0.012	0.240
PW	-0.026	-0.031	-0.006	-0.000	0.004	0.017	0.016	-0.035	**-0.131**	-0.047	0.019	0.007	-0.065	-0.064	-0.017	-0.024	0.016	0.026	0.160
PWT	0.207	0.057	0.123	0.124	0.105	0.050	0.072	0.173	0.159	**0.440**	-0.107	0.130	0.172	0.247	0.203	0.206	-0.003	0.028	0.485
NPP	0.146	-0.002	0.110	0.146	0.133	0.123	-0.002	-0.171	-0.101	-0.169	**-0.691**	0.023	-0.093	-0.097	-0.134	-0.002	-0.151	-0.183	0.494
NSP	0.040	-0.025	-0.023	-0.028	-0.029	-0.011	-0.010	-0.018	0.007	-0.040	-0.004	**-0.137**	-0.006	0.000	-0.046	-0.051	0.014	0.027	0.143
SL	0.036	0.012	-0.000	-0.003	-0.000	-0.019	-0.019	0.056	0.057	0.045	-0.015	0.005	**0.115**	0.064	0.044	0.020	0.010	-0.023	0.349
SB	0.023	0.015	-0.003	-0.005	-0.012	-0.014	-0.007	0.052	0.075	0.086	-0.021	-0.000	0.084	**0.152**	0.036	0.024	-0.005	-0.026	0.389
100FSW	0.003	-0.003	0.008	0.008	0.010	0.005	0.007	0.017	0.004	0.017	-0.007	0.012	0.014	0.008	**0.036**	0.009	0.003	0.001	0.220
100DSW	0.031	0.0152	0.023	0.027	0.021	0.015	0.018	-0.001	0.041	0.037	-0.000	0.029	0.013	0.012	0.019	**0.079**	-0.013	0.007	0.325
PC	-0.035	-0.015	-0.037	-0.035	-0.033	0.035	0.056	0.030	-0.028	-0.002	-0.051	-0.025	0.021	-0.008	0.023	-0.039	**0.235**	0.017	0.086
FC	-0.002	0.012	-0.011	-0.013	-0.009	-0.005	-0.007	0.01	0.009	-0.003	0.012	0.009	0.009	0.008	-0.001	-0.004	-0.003	**-0.047**	-0.213

Phenotypic Residual effect=0.43; Diagonal (under lined) values indicate direct effects

VL=vine length(cm);PBPP= Primary branches per plant ; DFF= Days to first flowering ;DFPF = Days to 50 *per cent* flowering ;DFPH= Days to first pod harvest; DLPH= Days to last pod harvest ; DPM=Days to pod maturity ; PL= Pod length (cm) ; PW=Pod width (cm) ; PWT= Pod weight (g) ; NPP= Number of pods per plant; NSP=Number of seeds per pod ; SL=Seed length(mm); SB=seed breadth (mm); 100FSW= 100 fresh seed weight; 100 DSW= 100 dry seed weight; PC= Protein content (%) ; FC=Fiber content(%).

Table: 4.10 (b) Genotypic direct and indirect effects of 18 characters on pod yield in thirty five genotypes of dolichos bean.

	Vine length (cm)	Primary branches per plant	Days to first flowering	Days to 50%flowering	Days to first pod harvest	Days to last pod harvest	Days to pod maturity	Pod length (cm)	Pod width (cm)	Pod weight (g)	No. of pods per plant	No. of seeds per pod	Seed length (mm)	Seed breadth (mm)	100 fresh seed weight (g)	100 dry seed weight (g)	Protein content (%)	Fiber content (%)	Correlation coefficient
VL	**1.695**	0.119	1.321	1.140	1.173	0.268	0.178	0.590	0.479	0.962	0.368	0.565	0.651	0.509	0.699	0.977	-0.263	0.105	0.540
PBPP	0.014	**0.205**	-0.015	-0.023	-0.045	-0.025	-0.003	0.012	0.073	0.045	0.004	0.041	0.037	0.037	-0.041	0.085	-0.012	-0.067	0.427
DFF	-2.755	0.260	**-3.537**	-3.424	-3.389	-1.302	-1.243	-0.212	-0.142	-1.074	-0.580	-1.144	-0.086	0.041	-0.986	-1.658	0.876	-0.962	0.251
DFPF	2.475	-0.413	3.563	**3.680**	3.558	1.677	1.655	-0.131	-0.065	1.112	0.854	1.123	-0.053	-0.011	1.016	1.824	-0.882	1.193	0.271
DFPH	-0.760	0.242	-1.053	-1.062	**-1.099**	-0.465	-0.414	-0.060	0.036	-0.321	0.232	-0.366	-0.032	0.059	-0.401	-0.459	0.225	-0.228	0.242
DLPH	0.333	0.257	-0.776	-0.961	-0.894	**-2.109**	-2.033	0.661	0.392	-0.303	0.419	-0.204	0.391	0.117	-0.339	-0.550	-0.294	-0.236	0.174
DPM	0.222	-0.038	0.741	0.948	0.794	2.033	**2.109**	-0.696	-0.251	-0.534	0.001	-0.006	-0.408	-0.039	0.364	0.609	0.495	0.346	0.172
PL	-0.242	-0.042	-0.041	0.024	-0.038	0.218	0.176	**-0.696**	-0.251	-0.334	0.168	-0.092	-0.411	-0.322	-0.387	0.009	-0.100	0.188	0.279
PW	0.103	0.130	0.014	-0.006	-0.012	-0.067	-0.064	0.131	**0.364**	0.156	-0.07	-0.116	0.243	0.261	0.088	0.087	-0.062	-0.067	0.178
PWT	0.434	0.171	0.254	0.231	0.223	0.110	0.194	0.367	0.329	**0.765**	-0.208	0.313	0.294	0.562	0.469	0.475	0.016	0.055	0.534
NPP	0.102	0.009	0.077	0.109	0.099	0.093	0.000	-0.113	-0.097	-0.128	**0.171**	0.014	-0.067	-0.079	-0.103	-0.014	-0.109	-0.125	0.478
NSP	0.124	0.074	0.120	0.113	0.124	0.036	-0.001	0.049	-0.118	0.152	0.011	**0.372**	-0.029	0.006	0.166	0.186	-0.067	-0.102	0.217
SL	0.193	0.092	0.012	-0.007	0.014	-0.093	-0.097	0.296	0.336	0.193	-0.071	-0.039	**0.502**	0.391	0.210	0.056	0.069	-0.119	0.415
SB	-0.298	-0.179	0.011	0.003	0.053	0.055	0.018	-0.461	-0.714	-0.730	0.168	-0.018	-0.773	**-0.994**	-0.466	-0.275	-0.020	0.208	0.539
100FSW	0.218	-0.107	0.147	0.146	0.193	0.085	0.091	0.295	0.128	0.325	-0.116	0.236	0.222	0.248	**0.529**	0.236	0.058	0.040	0.283
100DSW	-0.647	-0.464	-0.526	-0.561	-0.468	-0.292	-0.324	0.014	-0.269	-0.696	0.034	-0.561	-0.127	-0.310	-0.510	**-1.122**	0.285	-0.133	0.472
PC	0.013	0.005	0.020	0.020	0.017	-0.011	-0.019	-0.012	0.014	-0.001	0.019	0.015	-0.011	-0.001	-0.009	0.021	**-0.084**	-0.006	0.107
FC	-0.01	0.100	-0.083	-0.009	-0.063	-0.034	-0.050	0.083	0.056	-0.020	0.081	0.084	0.073	0.064	-0.023	-0.036	-0.022	**-0.306**	-0.218

Genotypical Residual effect=0.47; Diagonal (under lined) values indicate direct effects

VL=vine length(cm);PBPP= Primary branches per plant ; DFF= Days to first flowering; DFPF = Days to 50 *per cent* flowering ;DFPH= Days to first pod harvest; DLPH= Days to last pod harvest ; DPM=Days to pod maturity ; PL= Pod length (cm) ; PW=Pod width (cm) ; PWT= Pod weight (g) ; NPP= Number of pods per plant; NSP=Number of seeds per pod ; SL=Seed length (mm); SB=seed breadth (mm); 100FSW= 100 fresh seed weight; 100 DSW= 100 dry seed weight; PC= Protein content (%) ; FC=Fiber content(%).

Table 4.11: Qualitative traits of 35 genotypes of dolichos bean

ACCESSION NO	Stem colour	Leaf vein color	Leaf density	Plant growth habit	Flower colour	Pod colour	Pod shape	Pod surface	Pod curvature	Pod beak	Pod suture colour	Seed colour	Seed shape
IC-261010	Green	Light green	Intermediate	Pole	Purple	Darkgreen	straight	Smooth	straight	Long	Green	Black	Oblong
IC-383197	Green	Light green	Intermediate	Pole	White	Green	Curved	Wrinkled	Curved	Short	Green	Brown	Flat
IC-384066	Green	Light green	Intermediate	Pole	White	Green	Curved	Wrinkled	Curved	Short	Green	Brown	Flat
IC-413709	Green	Light green	Intermediate	Pole	White	Light green	Intermediate	Smooth	Curved	Long	Cream	Black	Oblong
IC-413710	Purple	Purple	Intermediate	Pole	Dark purple	Purple	Intermediate	Smooth	Curved	Medium	Cream	Black	Flat
IC-424813	Green	Light green	Intermediate	Pole	Purple	Green	Intermediate	Smooth	Curved	Short	Green	Black	Oblong
IC-426988	Green	Light green	Sparse	Pole	White	Green	Intermediate	Wrinkled	Curved	Medium	Green	Cream	Oblong
IC-427424	Green	Light green	Intermediate	Pole	White	Green	Straight	Wrinkled	Curved	Short	Green	Brown	Oblong
IC-427428	Green	Light green	Intermediate	Pole	White	Dark green	Intermediate	Smooth	Curved	Short	Green	Brown	Oblong
IC-427436	Green	Light green	Intermediate	Pole	White	Green	Straight	Wrinkled	Straight	Medium	Green	Brown	Oblong
IC-427462	Green	Light green	Intermediate	Pole	White	Light green	Intermediate	Wrinkled	Curved	Short	Green	Brown	Round
IC-446571	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Cream	Cream	Flat
IC-446573	Green	Purple	Intermediate	Pole	Purple	Green	Intermediate	Smooth	Curved	Medium	Green	Black	Round
IC-446581	Green	Light green	Intermediate	Pole	White	Light green	Straight	Smooth	Straight	Medium	Green	Cream	Round
IC-446583	Green	Light green	Sparse	Pole	White	Green	Straight	Smooth	Straight	Medium	Green	Brown	Oblong
IC-446584	Purple	Purple	Intermediate	Pole	Purple	Dark purple	Intermediate	Smooth	Curved	Short	Cream	Brown	Oblong
IC-446591	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Cream	Round
IC-546349	Green	Light green	Sparse	Pole	White	Green	Intermediate	Smooth	Curved	Medium	Green	Cream	Oblong
IC-546376	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Cream	Oblong
IC-546387	Green	Light green	Intermediate	Pole	White	Light green	Intermediate	Smooth	Curved	Short	Cream	Cream	Round
IC-546388	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Cream	Oblong
IC-565181	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Brown	Oblong

Contd…

ACCESSION NO	Stem colour	Leaf vein colour	Leaf density	Plant growth habit	Flower colour	Pod colour	Pod shape	Pod surface	Pod curvature	Pod beak	Pod suture colour	Seed color	Seed shape
IC-598467	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Medium	Green	Brown	Oblong
NSB-2010/029	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Cream	Oblong
NSJ/NAIP/192	Green	Light green	Intermediate	Pole	White	Light green	Intermediate	Smooth	Curved	Short	Cream	Brown	Oblong
PSR-13183	Purple	Purple	Intermediate	Pole	Purple	Green	Intermediate	Wrinkled	Curved	Medium	Green	Black	Oblong
PSRJ-13039	Green	Light green	Intermediate	Pole	White	Dark green	Intermediate	Smooth	Curved	Medium	Green	Brown	Flat
PSRJ-13114-2	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Medium	Green	Brown	Oblong
RJR-03	Green	Light green	Intermediate	Pole	White	Green	Intermediate	Smooth	Curved	Short	Green	Brown	Oblong
RJR-387	Purple	Purple	Intermediate	Pole	Purple	Green	Intermediate	Smooth	Curved	Medium	Green	Black	Oblong
SGD-136	Green	Light green	Intermediate	Pole	White	Green	Straight	smooth	Straight	Short	Green	Brown	Oblong
SNJ-11-068	Dark green	Green	Intermediate	Pole	Purple	Green	Intermediate	Smooth	Curved	Long	Green	Brown	Oblong
RND-01©	Green	Green	Intermediate	Pole	Purple	Green	Intermediate	Smooth	Curved	medium	Green	Black	Oblong
ARKA JAY ©	Green	Light green	Sparse	Bush	Purple	Green	Intermediate	Smooth	Curved	Short	Green	Cream	Oblong
ARKA VIJAY©	Green	Light green	Sparse	Bush	White	Green	intermediate	Smooth	Curved	Short	Green	Cream	Oblong

APPENDIX-I

MONTHLY METEOROLOGICAL DATA RECORDED AT ARI, RAJENDRANAGAR FROM AUGUST, 2016 to MARCH, 2017									
MONTH	**TEMPERATURE (°C)**		**R.H.%**		**RAIN FALL**	**RAINYDAYS**	**SUN SHINE**	**EVAPORATION**	**TEMPERATURE MEAN**
	MAX	**MIN**	**8 hrs**	**14 hrs**	**(mm)**		**(hrs)**	**(mm)**	
August, 2016	30.6	22.8	87	66	180.6	6	2.7	4.7	26.7
September, 2016	28.5	22.0	94	76	391.6	17	5.9	2.9	25.25
October, 2016	30.2	18.5	91	48	32.2	4	3.0	3.7	24.35
November, 2016	30.3	12.8	88	33	0.0	0	7.1	3.6	21.55
December, 2016	29.0	11.3	90	37	2.0	2	8.2	3.3	20.15
January, 2017	29.3	12.2	87	33	0.0	0	8.0	3.7	20.75
February, 2017	32.7	13.6	79	27	0.0	0	9.6	5.2	23.15
March, 2017	35.7	18.2	73.7	24.7	5.6	0	8.4	6.5	26.95
Total	**246.3**	**131.4**	**689.7**	**344.7**	**612**	**29**	**58.1**	**33.6**	**188.85**
Mean	**30.79**	**16.43**	**86.21**	**43.08**	**76.5**	**3.62**	**7.26**	**4.2**	**23.61**

Table 2.2 Review on genetic variability and genetic parameters in dolichos bean

Character	GCV (%)	PCV (%)	Heritability (%)	GA as % of mean	References
Vine length (cm)	20.12 (H)	20.13 (H)	99.95 (H)	41.45 (H)	Ganesh (2005)
	6.67 (L)	7.66 (L)	75.70 (H)	11.95 (M)	Golani *et al*. (2007)
	15.40(M)	16.32(M)	88.99(H)	29.93(H)	Magalingam *et al.* (2013)
	19.13(M)	19.87(M)	92.64(H)	37.92(H)	Pawar and Prajapathi (2013)
	20.82(H)	23.77(H)	77.00(H)	37.56(H)	Chaitanya *et al*. (2014)
	22.40(H)	22.44(H)	99.67(H)	46.08(H)	Verma *et al.* (2015)
	23.51(H)	27.91(H)	70.97(H)	40.80(H)	Singh *et al*. (2015)
	43.80(H)	44.39(H)	97.36(H)	89.04(H)	Choudhary *et al.* (2016)
Number of primary	18.96 (M)	19.07 (M)	98.90 (H)	38.86 (H)	Ganesh (2005)
branches per plant	11.95 (M)	14.48 (M)	68.10 (H)	20.29 (H)	Golani *et al*. (2007)
	17.06 (M)	17.72 (M)	92.70 (H)	33.84 (H)	Patil and Lad (2007)
	8.25 (L)	19.25 (M)	18.40 (L)	7.38 (L)	Savitha (2008)
	11.04(M)	12.81(M)	74.27(H)	19.60(M)	Magalingam *et al.* (2013)
	15.14(M)	18.07(M)	70.14(H)	26.11(H)	Pawar and Prajapathi (2013)
	15.48(M)	18.80(M)	68.00(H)	26.11(H)	Chaitanya *et al*. (2014)
	12.63(M)	17.87(M)	33.33(M)	12.06(M)	Mohan *et al*. (2014)
Table 2.2 contd…..	16.85(M)	17.10(M)	97.19(H)	34.23(H)	Verma *et al.* (2015)
Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**

Days to first flowering	21.30(H)	21.32(H)	99.70(H)	43.81(H)	Singh *et al*. (2011)
	16.04(M)	16.20(M)	97.99(H)	32.71(H)	Salim *et al.* (2013)
	13.20(M)	13.78(M)	92.00(H)	26.02(H)	Chaitanya *et al*. (2014)
	32.84(H)	34.27(H)	91.79(H)	64.81(H)	Sharma *et al*. (2014)
	16.34(M)	16.41(M)	99.20(H)	33.53(H)	Verma *et al.* (2015)
	33.48(H)	33.60(H)	99.25(H)	68.70(H)	Choudhary *et al.* (2016)
Days to 50 *per cent* flowering	21.02 (H)	21.04 (H)	99.86 (H)	43.28 (H)	Ganesh (2005)
	20.53(H)	20.63 (H)	99. 00 (H)	42.00 (H)	Patil and Lad (2007)
	18.29 (M)	18.30 (M)	99.99 (H)	37.65 (H)	Rai *et al*. (2008)
	18.91(M)	18.92(M)	99.88(H)	38.94(H)	Chattopadhyay and Dutta (2010)
	8.01(L)	8.18(L)	97.59(H)	16.44(M)	Magalingam *et al.* (2013)
	15.76(M)	16.26(M)	93.91(H)	31.46(H)	Parmar *et al.* (2013)
	10.51(M)	10.55(M)	99.19(H)	21.56(H)	Pawar and Prajapathi (2013)
	13.06(M)	13.28(M)	96.75(H)	26.46(H)	Salim *et al.* (2013)
	13.07(M)	13.68(M)	91.00(H)	25.75(H)	Chaitanya *et al*. (2014)
	8.90(L)	1.80(L)	96.00(H)	3.54(L)	Mohan *et al*. (2014)
	36.11(H)	36.44(H)	98.15(H)	73.69(H)	Sharma *et al*. (2014)
	10.19(M)	13.97(M)	53.17(M)	15.30(M)	Singh *et al.* (2015)
Table 2.2 contd…..	16.21(M)	16.29(M)	99.02(H)	33.24(H)	Verma *et al.* (2015)
Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**

Days to first pod harvest	2.94 (L)	6.02 (L)	23.80 (L)	2.95 (L)	Golani *et al*. (2007)
	12.00 (M)	12.03 (M)	99.40 (H)	24.64 (H)	Rai *et al*. (2008)
	27.44(H)	31.04(H)	78.11(H)	49.95(H)	Magalingam *et al.* (2013)
	12.70(M)	13.59(M)	87.38(H)	24.46(H)	Parmar *et al.* (2013)
	09.56(L)	10.79(M)	78.00(H)	17.44(M)	Chaitanya *et al*. (2014)
	29.57(H)	29.99(H)	97.24(H)	60.07(H)	Sharma *et al*. (2014)
	09.07(L)	12.37(M)	53.75(M)	13.70(M)	Singh *et al.* (2015)
	09.75(L)	09.84(L)	98.12(H)	19.90(M)	Verma *et al.*(2015)
Days to last pod harvest	13.57(M)	14.83(M)	84.00(H)	25.58(H)	Chaitanya *et al*. (2014)
	11.59(H)	11.62(L)	99.41(H)	23.80(H)	Verma *et al.* (2015)
	18.27(M)	18.31(M)	99.60(H)	37.57(H)	Choudhary *et al.* (2016)
Days to pod maturity	11.27(M)	11.31(M)	99.41(H)	23.16(H)	Magalingam *et al.* (2013)
	12.32(M)	12.92(M)	90.93(H)	24.18(H)	Parmar *et al.* (2013)
	09.90(L)	09.96(L)	98.80(H)	20.27(H)	Pawar and Prajapathi (2013)
	5.83(L)	1.64(L)	93.00(H)	3.07(L)	Mohan *et al*.(2014)
	6.58(L)	8.97(L)	53.75(M)	9.93(L)	Singh *et al.* (2015)
Pod length (cm)	5.75 (L)	5.82 (L)	97.70 (H)	11.71 (M)	Ganesh (2005)
	15.79 (M)	17.92 (M)	77.6 (H)	28.64 (H)	Golani *et al*. (2007)
Table 2.2 contd…..	14.02 (M)	14.05 (M)	98.20 (H)	66.48 (H)	Rai *et al*. (2008)
Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**

Pod length (cm)	32.54 (H)	32.83 (H)	99.50 (H)	28.83 (H)	Savitha (2008)
	24.81(H)	26.25 (H)	89.30 (H)	48.24 (H)	Rai *et al*. (2009)
	28.39 (H)	34.84 (H)	66.40 (H)	47.78 (H)	Upadhyay and Mehta (2010)
	20.26(H)	20.38(H)	99.88(H)	41.51(H)	Chattopadhyay and Dutta (2010)
	19.83(M)	19.94(M)	98.90(H)	40.58(H)	Singh *et al*. (2011)
	20.87(H)	21.47(H)	94.50(H)	41.830(H)	Magalingam *et al.* (2013)
	17.23(M)	18.79(M)	84.06(H)	25.40(H)	Parmar *et al.* (2013)
	19.14(M)	19.59(M)	95.43(H)	38.52(H)	Pawar and Prajapathi (2013)
	21.06(H)	22.31(H)	89.00(H)	40.95(H)	Chaitanya *et al*. (2014)
	27.25(H)	06.30(L)	95.00(H)	12.03(M)	Mohan *et al*. (2014)
	31.5(H)	32.21(H)	95.65(H)	63.6(H)	Sharma *et al*. (2014)
	18.91(M)	23.59(H)	64.24(H)	31.22(H)	Singh *et al.* (2015)
	19.10(M)	19.92(M)	91.94(H)	37.74(H)	Verma *et al.*(2015)
	18.57(M)	18.99(M)	95.60(H)	37.39(H)	Choudhary *et al.* (2016)
Pod width (cm)	29.24 (H)	32.98 (H)	78.60 (H)	53.43 (H)	Golani *et al*. (2007)
	28.67 (H)	29.30 (H)	95.80 (H)	58.03 (H)	Rai *et al*. (2008)
	12.60 (M)	13.52 (M)	86.90 (H)	24.04 (H)	Savitha (2008)
Table 2.2 contd…..	36.36 (H)	36.67 (H)	93.50 (H)	69.94 (H)	Rai *et al*. (2009)
	35.46 (H)	38.89 (H)	87.40 (H)	70.59 (H)	Upadhyay and Mehta (2010)
Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**

Pod width (cm)	34.27(H)	35.08(H)	95.40(H)	68.88(H)	Singh *et al*. (2011)
	24.56(H)	25.76(H)	90.94(H)	48.26(H)	Magalingam *et al.* (2013)
	19.08(M)	20.43(H)	87.27(H)	36.72(H)	Parmar *et al.* (2013)
	09.59(H)	10.82(H)	79.00(H)	17.52(M)	Chaitanya *et al*. (2014)
	31.56(H)	13.06(M)	85.00(H)	22.84(H)	Mohan *et al*. (2014)
	4.62(L)	18.85(M)	06.01(L)	02.33(L)	Singh *et al.* (2015)
	10.00(L)	11.19(M)	79.86(H)	18.41(M)	Verma *et al.* (2015)
	45.63(H)	45.95(H)	98.61(H)	93.35(H)	Choudhary *et al.* (2016)
Pod weight (g)	25.31(H)	25.43(H)	98.94(H)	51.87(H)	Chattopadhyay and Dutta (2010)
	28.07(H)	28.72(H)	95.10(H)	56.26(H)	Magalingam *et al.* (2013)
	22.11(H)	23.63(H)	88.00(H)	42.63(H)	Chaitanya *et al*. (2014)
Seed length (mm)	18.11(M)	18.18(M)	99.20(H)	35.62(H)	Rai *et al*. (2009)
	12.28(M)	13.12(M)	87.5(H)	23.48(H)	Singh *et al*. (2011)
Seed breadth(mm)	17.69(M)	19.69(M)	80.70(H)	32.38(H)	Rai *et al*. (2009)
	9.40(L)	10.71(M)	77.00(H)	17.47(M)	Singh *et al*. (2011)
Number of seeds per pod	4.60 (L)	4.98 (L)	84.54 (H)	8.77 (L)	Ganesh (2005)
	5.99 (L)	10.72 (M)	98.89 (H)	37.33 (H)	Golani *et al*. (2007)
	18.22 (M)	18.33(M)	56.80 (M)	15.92 (M)	Patil and Lad (2007)
Table 2.2 contd…..	10.33 (M)	13.78 (M)	75.70 (H)	22.24 (H)	Rai *et al*. (2008)
Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**
Number of seeds per pod	12.42 (M)	14.28 (M)	35 .60 (M)	19.35 (M)	Savitha (2008)
	13.20(M)	17.76(M)	92.09(H)	26.01(H)	Chattopadhyay and Dutta (2010)

	15.03 (M)	19.30 (M)	60.70 (H)	24.08 (H)	Upadhyay and Mehta (2010)
	10.12(M)	11.91(M)	72.13(H)	17.70(M)	Singh *et al*.(2011)
	07.12(L)	09.34(L)	58.07(M)	11.17(M)	Pawar and Prajapathi (2013)
	62.98(H)	67.06(H)	88.20(H)	121.30(H)	Salim *et al*. (2013)
	10.80(M)	12.08(M)	80.00(H)	19.89(M)	Chaitanya *et al*. (2014)
	10.29(M)	11.27(M)	45.00(M)	10.41(M)	Mohan *et al*. (2014)
	09.97(L)	18.17(M)	30.08(M)	11.25(M)	Sharma *et al*. (2014)
	11.84(M)	17.95(M)	43.50(M)	16.14(M)	Singh *et al.* (2015)
	11.24(M)	11.40(M)	97.09(H)	22.81(H)	Verma *et al.* (2015)
	10.12(M)	11.91(M)	72.13(H)	17.70(M)	Choudhary *et al.* (2016)
Number of pods per plant	25.11 (H)	25.13 (H)	99.71(H)	59.67 (H)	Ganesh (2005)
	63.99 (H)	64.04 (H)	99.99 (H)	131.73 (H)	Rai *et al*. (2008)
	55.91 (H)	56.21 (H)	99.0 (H)	114.57 (H)	Savitha (2008)
	28.80(H)	28.85(H)	99.61(H)	59.21(H)	Chattopadhyay and Dutta (2010)
	62.21(H)	65.25(H)	90.9(H)	22.19(H)	Singh *et al.* (2011)
	22.38(H)	24.08(H)	86.96(H)	43.01(H)	Magalingam *et al.* (2013)
	48.05(H)	56.93(H)	71.21(H)	83.52(H)	Parmar *et al.* (2013)

Table 2.2 contd…..

Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**
Number of pods per plant	27.60(H)	33.84(H)	66.55(H)	46.38(H)	Pawar and Prajapathi (2013)
	64.58(H)	64.60(H)	99.92(H)	132.98(H)	Salim *et al*.(2013)
	52.80(H)	55.43(H)	91.00(H)	103.62(H)	Chaitanya *et al*. (2014)

	49.47(H)	04.54(L)	99.00(H)	09.26(L)	Mohan *et al*. (2014)
	27.84(H)	39.44(H)	49.83(M)	40.49(H)	Singh *et al.* (2015)
	40.00(H)	40.02(H)	99.92(H)	82.38(H)	Verma *et al.* (2015)
	84.97(H)	85.60(H)	98.54(H)	173.75(H)	Choudhary *et al.* (2016)
100 seed weight (g)	20.00(H)	20.01	99.91(H)	41.18(H)	Chattopadhyay and Dutta (2010)
	12.44(M)	13.00(M)	91.58(H)	24.52(H)	Pawar and Prajapathi (2013)
	15.33(M)	15.49(M)	97.87(H)	31.23(H)	Salim *et al*. (2013)
	18.07(M)	20.82(H)	75.00(H)	32.29(H)	Chaitanya *et al*. (2014)
	33.92(H)	34.05(H)	99.21(H)	69.60(H)	Verma *et al.* (2015)
Protein content (%)	9.15 (L)	9.29 (L)	97.03 (H)	18.57 (M)	Ganesh (2005)
	42.77(H)	42.78(H)	99.96(H)	88.1(H)	Chattopadhyay and Dutta (2010)
	22.95(H)	23.10(H)	98.73(H)	46.98(H)	Magalingam *et al.* (2013)
	7.12(L)	7.30(L)	95.09(H)	25.32(H)	Parmar *et al.* (2013)
	8.60(L)	8.64(L)	99.10(H)	15.57(M)	Pawar and Prajapathi (2013)
	14.92(M)	15.07(M)	98.00(H)	30.42(H)	Chaitanya *et al*.(2014)
	40.79(H)	41.90(H)	94.78(H)	81.83(H)	Sharma *et al*.(2014)

Table 2.2 contd…..

Character	**GCV (%)**	**PCV (%)**	**Heritability (%)**	**GA as % of mean**	**References**
Protein content (%)	15.53(M)	23.10(H)	99.34(H)	31.89(H)	Verma *et al.* (2015)
	7.19(L)	8.83(L)	66.22(H)	12.05(M)	Choudhary *et al.* (2016)
Fiber content (%)	39.53(H)	39.64(H)	99.73(H)	81.45(H)	Magalingam *et al.* (2013)
	20.45(H)	24.98(H)	67.00(H)	34.48(H)	Choudhary *et al.* (2016)

Pod yield per plant (g)	29.16 (H)	29.17 (H)	99.97 (H)	60.07 (H)	Ganesh (2005)
	17.86 (M)	24.33 (H)	53.9 (M)	27.01 (H)	Golani *et al*. (2007)
	63.38 (H)	63.51 (H)	99.6 (H)	130.38 (H)	Rai *et al*. (2008)
	36.18 (H)	36.37 (H)	98.9 (H)	74.12 (H)	Savitha (2008)
	56.16 (H)	57.68 (H)	84.90 (H)	100.93 (H)	Rai *et al*. (2009)
	25.40(H)	25.55(H)	98.80(H)	52.01(H)	Chattopadhyay and Dutta (2010)
	22.46 (H)	29.17 (H)	59.50 (M)	35.60 (H)	Upadhyay and Mehta (2010)
	60.31(H)	60.56(H)	99.1(H)	123.70(H)	Singh *et al*. (2011)
	20.02(H)	20.37(H)	96.38(H)	40.45(H)	Magalingam *et al.* (2013)
	45.26(H)	55.42(H)	66.71(H)	76.16(H)	Parmar *et al.* (2013)
	31.63(H)	36.68(H)	75.57(H)	56.64(H)	Pawar and Prajapathi (2013)
	61.21(H)	63.64(H)	93.00(H)	121.27(H)	Chaitanya *et al*. (2014)
	45.79(H)	6.44(L)	98.00(H)	13.03(M)	Mohan *et al*. (2014)
	53.23(H)	53.28(H)	99.80(H)	109.55(H)	Sharma *et al*. (2014)
	29.91(H)	40.03(H)	55.81(M)	46.02(H)	Singh *et al.* (2015)

Table 2.1 Review on genetic divergence in dolichos bean

GCV= Genotypic coefficient of variance; PCV= Phenotypic coefficient of variance; GA= Genetic advance

No. of genotypes studied	**clusters**	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**character**	
64	11	VII and IX	II and V	IV	IX	Pod yield per plant	Ganesh. (2005)
43	6	I and V	IV and VI	II	I	Length of inflorescence	Savitha. (2008)

88	7	III and VII	IV and VI	III	VII	------------	Islam. (2009)
37	3	II and I	III and II	I	III	Seed length	Rai *et al*. (2009)
32	5	III and I	IV and II	III	II	-----------	Upadhyay and Mehta (2010)
63	6	III and I	VI and II	--------	-------	Pod yield per plant	Lal *et al*. (2011)
73	7	III and VII	III	II	VII	Pod yield	Singh *et al*. (2011)
48	8	IV and VI	I and IV	V	-------	Protein content	Chaitanya *et al*. (2013)
58	7	IV and VII	II and III	I	III	Protein content	Pawar *et al.* (2013)
66	7	I and VII	II and V	VII	II	No. of pods per plant	Salim *et al.* (2013)
12	4	III	II	III	II	Pod yield per hectare	Verma *et al.* (2015)