PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE

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BY

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THESIS SUBMITTED TO Dr. Y.S.R. HORTICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT

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JUNE, 2017

CERTIFICATE

Mr. SAYED SEFATULLAH has satisfactorily prosecuted the course of research and that the thesis entitled "**PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE"** 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 him for a degree of any university.

Place: Venkataramannagudem **(A.V.D.DORAJEE RAO)**

Date: **Chairman**

CERTIFICATE

This is to certify that the thesis entitled "**PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE"** submitted in partial fulfillment of the requirements for the degree of Master of Science in Horticulture (Vegetable science) of Dr. Y.S.R Horticultural University, Venkataramannagudem, is a record of the bonafide research work carried out by **Mr. SAYED SEFATULLAH** under our guidance and supervision.

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

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DECLARATION

I, SAYED SEFATULLAH, hereby declare that the thesis entitled **"PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE"** submitted to Dr. Y.S.R. Horticultural University, Venkataramannagudem, for the degree of Master of Science in Horticulture (Vegetable Science) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

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Date: **(*SAYED SEFATULLAH*)**

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
&	:	And
@	:	At the rate of
°C	:	Degrees Celsius
ANOVA	:	Analysis of Variance
CD	:	Critical Difference
cm	:	Centimeter
cm^2	:	Square centimeter
DAS	:	Days after sowing
Dist.	:	District
Dr. Y.S.R.H.U	:	Dr. Y.S.R. Horticultural University
et al.	:	And others
RBD	:	Randomized Block Design
FYM	:	Farm Yard Manure
g	:	Grams
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent over Mean
GCV	:	Genotypic Co-efficient of Variation
GV	:	Genotypic Variance
H^2	:	Heritability
ha	:	Hectare

i.e.	:	That is
K	:	Potassium
Kg	:	Kilogram
NHB	:	National Horticulture Board
No.	:	Number
P	:	Phosphorus
PCV	:	Phenotypic Co-efficient of Variation
PV	:	Phenotypic Variance
r_g	:	Genotypic correlation co-efficient
r_P	:	Phenotypic correlation co-efficient
RH	:	Relative humidity
S Em ±	:	Standard error of mean
t	:	Ton
t ha^{-1}	:	Tonnes per hectare
viz.	:	Namely

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ABSTRACT

The present investigation on the performance of seed cluster bean (*Cyamopsis tetragonoloba* L.) cultivars in Godavari zone was carried out at College of Horticulture, Venkataramannagudem,West Godavari district of Andhra Pradesh during *Kharif*, 2016-2017. The experiment was laid out in a randomized block design with 14 treatments replicated thrice. Data recorded on various parameters *viz.*, plant height (cm), number of primary branches, number of leaves per plant, leaf area (cm^2), days to flower initiation, days to 50% flowering, days taken from flowering to pod drying, number of pods per cluster, number of clusters per plant, number of pods per plant, pod length (cm), weight of dry pod (mg), 100–seed weight (g), number of seeds per pod, gum content (%), protein content (%), pod yield per plot (kg), seed yield per plot (kg) were subjected to the analyses of genetic variability, heritability, character association and path coefficients.

The analysis of variance revealed significant differences for the characters under study suggesting considerable amount of variability was existing among the genotypes. Higher magnitude of PCV and GCV (> 20%) were observed for number of pods per plant and number of clusters per plant, indicating the existence of wide range of genetic variability in the germplasm for these traits.

High heritability coupled with high genetic advance as per cent of mean was observed in case of number of cluster per plant and days to flower initiation indicating the preponderance of additive gene action, making selection based on these characters more effective. The traits like number of cluster per plant, number of pods per plant, leaf area (cm^2), number of leaves per plant and days to flower initiation exhibited a high heritability coupled with moderate genetic advance suggesting that their inheritance was controlled by both additive and non-additive gene actions.

The correlation study indicated that number of primary branches, number of seeds per pod, pod yield per plot, number of pods per cluster and leaf area had significant positive association with seed yield per plot at genotypic level. Path coefficient analysis explained 81% variation at genotypic and 58% variation at phenotypic level in the dependent variable *i.e.* seed yield per plot. A high positive direct effect on seed yield per plot was exerted by the traits *viz.*, number of primary branches, number of seed per pod, pod yield per plot, number of pods per cluster and leaf area. The high direct effect of these traits might here led to their strong association with seed yield. On the other hand, a high negative direct effect was exerted by days to flower initiation and number of leaves per plant.

Based on the present investigation, it was inferred that the cultivars HG 365, RGC 1033, HG 884, RGC 1017 and RGC 936 would be more beneficial for seed cluster bean farmers under local conditions.

Chapter I

INTRODUCTION

Cluster bean is botanically called as *Cyamopsis tetragonoloba* (L.). It belongs to the family Leguminaceae. The crop is popularly known as guar referring to its seed. India is considered as native place for guar or cluster bean. It has been used as vegetable in our country from hundreds of years. The crop is renowned as drought hardy, being deep rooted and having a low water requirement. It requires a low annual rainfall of about 400 mm to 500 mm. Guar tolerates high temperature and dry conditions, thus gaining popularity in arid and semi arid climates (Undersander *et al.*, 2006).

The term guar was evolved from its most common use in India as cattle-feed " *Gowahaar (Gow means cow and Ahaar means feed)*". It is also used as a green manure crop in agriculture. The guar seed has a shelf life of more than 3 years and needs the barest maintenance and handling environment. It has three parts, the seed coat or hull, endosperm and germ. The hull constitutes 14-17 per cent of the guar seed by weight, endosperm 35-42 per cent and germ 43-47 per cent. Unlike the seeds of other legumes, guar bean has a large endosperm. This spherical shaped endosperm contains significant amounts of galactomannan gum, which accounts for 28% to 33% of the whole seed. Galactomannan is also referred as guar gum. The refined splits of guar are derived from this part of the seed. The remaining two parts, hull and germ, are high in protein and fibre.

Guar gum powder is obtained from processing of guar gum or guar refined splits. There are several grades of guar gum powder, which is a white to creamy coloured, free flowing odourless powder, free from extraneous matter. Its ability to suspend solids, bind water by hydrogen bonding, control the viscosity of aqueous solutions and form strong tough films are the major reasons for its use in various industries. Guar gum powder is further processed to produce various derivatives according to the requirements of different end-user industries such as textile, food, pharmaceuticals, paper, petroleum (oil drilling), mining, explosives, ore flotation, *etc.*

India is the major exporter of guar gum to the world. Various forms of guar products are exported to a large number of countries like United States, China, Germany, Canada, Russia and Australia. In India, guar as a seed crop was cultivated in an area of 32 lakh hectares with an annual production of 25 lakh tonnes during the year 2012-13. India exported about 406,312 MT of guar products to the world valued at about US$4 billion. In fact, guar products became the largest agricultural export item in 2012-13, surpassing basmati rice. These developments have opened up immense opportunities for many key stake holders involved in the production, consumption and trade of guar products (Durgesh, 2015).

The growing production of guar in our country accounts for 75-80 per cent of the total guar produced in the world. Within our country, the state of Rajasthan accounts for 65-70 per cent of the total production followed by Haryana and Gujarat. In Andhra Pradesh the crop is recently catching up in area and production. Even though the exact statistics are not available, the cultivation of guar is extended in our state to arid areas with low and erratic rainfall, high temperatures and low fertility status of soils in the districts of Anantapur, Kadapa, Kurnool, Chittoor, Nellore and Krishna.

Very limited scientific information is available on local germplasm evaluation in this crop under Godavari Zone of Andhra Pradesh. Cluster bean has good germplasm collection in our country. Evaluation of the cultivars is required across different locales or agro-climatic regions to know their performance in terms of yield and its attributing characters. Based on this, promising cultivars can be identified. The cultivars that are performing well can be released as a variety(s) or they can be put to further use in the breeding programme.

Genetic variability is an important factor for any heritable improvement. Knowledge of genetic variability, its nature and degree is useful for selecting desirable cultivars from a germplasm. The value of germplasm collection depends not only on the number of accessions, but also on the genetic variability present in those accessions. Wide genetic variability that exists in the available germplasm provides ample scope for further improvement.

Correlation and path coefficient analysis furnishes information regarding the nature and magnitude of various associations and help in the measurement of direct influence of one variable on the other. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in the yield.

Evaluation of different cluster bean cultivars and identification of high yielding cultivars for a particular agro-climatic region would be very useful to growers so as to derive benefit of maximising the profitability by taking up the cultivation of suitable cultivars only.

There is a great potential for the commercial production of cluster bean under Godavari zone. Considering the importance of this crop, it is felt that there is a prime need to evaluate some of the local cultivars to study their performance and to find out the fittest one for Godavari region.

Very little work has been done in the improvement of seed cultivars and there is a great paucity of research data in *C. tetragonoloba* regarding seed yield in Godavari zone of Andhra Pradesh. Therefore, the present research work on the evaluation of cluster bean (*C.tetragonoloba* L.*)* genotypes is proposed with the following objectives.

In view of the above, the present investigation is taken up with the following objectives.

1. To evaluate the performance of seed guar cultivars for growth, yield and gum content under local agro-climatic conditions.
2. To study the character association between seed yield and its attributing characters in cluster bean.
3. To analyse the direct and indirect effects of yield contributing characters on seed yield in cluster bean.

Chapter II

REVIEW OF LITERATURE

The success of any crop improvement programme depends on the quantum of genetic variability available for exploitation. The information on the type of variation in the available genetic material and the part played by the environment on the expression of plant characters is of prime importance for the appraisal of rate and magnitude of improvement. Cluster bean is one of the important vegetables throughout the world. In cluster bean, wealth of genetic diversity is detected among the various cultivars of cultivated species. This rich source of variation has been given little attention for its proper exploitation during early stage. Therefore, the information of the available research work done regarding the genetic variability, correlation and path analysis in cluster bean has been reviewed. The pertinent literature on other related crops has also been incorporated as supplementary information.

2.1 *Per se* mean performance

2.2 Coefficient of variability, heritability and genetic advance

2.3 Correlation coefficient analysis and Path coefficient analysis

2.1 *PER SE* MEAN PERFORMANCE

2.1.1 Growth parameters

Jagdale *et al.* (2005) reported that the variety V l-63 exhibited maximum plant height of 29.93 cm which was 2.99% more than that in IIPR-96-4 and was 3.45% more than in HUR-76. Further, it was observed that the cluster bean variety VL-63 recorded the highest dry matter at final harvest as compared to the other varieties. Lakshmi Kalyani (2006) observed that among different guar cultivars tried, RGC- 986 recorded higher plant height and leaf area index as compared to RGC-1003, RGC-1017 and RGC-936. The cultivar GUAG 9703 produced the tallest plants with higher leaf area index and dry matter production as compared to RGC1003, HG 563 and RGM 112 during *kharif* season (Choudhary *et al.*, 2010).

Ayub *et al.* (2010) observed the cluster bean variety BR-99 recorded significantly higher number of branches (41.30) when compared to other varieties (2/1 and BR-90). Naik *et al.* (2013) found that chlorophyll content was high in the cultivar RGM 115 in all the seasons (summer season - 59.20; *kharif* - 56.96 and *rabi*- 28.48) both at 40 and 60 DAS. The variety RGM 114 followed the above cultivar at all growth stages.

Meena *et al*. (2015) reported that the variety RGC-936 recorded significantly higher plant height at harvest and dry matter accumulation at all the growth stages as compared to other varieties except RGC-1017, which was statistically on par with RGC-936. Kumar and Kaushik (2014) also confirmed that the variety RGC-936 recorded significantly higher dry matter accumulation at all growth stages as compared to other varieties.

2.1.2 Growth indices

Kumar and Kaushik (2014) reported that during crop growth period the variety RGC-936 recorded significantly higher relative crop growth rate at all the growth stages as compared to other varieties except RGC-1017, which was at statistically at par with RGC-936.

2.1.3 Flowering parameters

Out of 44 genotypes evaluated by Omvir and Singh (2013) under Rajasthan conditions, days taken to 50% flowering ranged from 29.0 to 57.0 days in summer and 32 to 58 days in *kharif* seasons. A total of twelve genotypes were evaluated under Dapoli conditions and it was found that days to first flowering ranged from 52.7 days (Nirmal 171) to 64.5 days (CIBH 101) and days to 50% flowering from 74.6 days (Pusa Navbahar) to 86.1 days (CIBH 101) (Thorat *et al.,* 2009). Under Bangalore conditions, earliest occurrence of 50% flowering was noticed in cluster bean variety PNB 1 (31.9 days) while the latest (33.5 days) occurrence was noticed in BG 3 (Kumar and Kaushik, 2014).

2.1.4 Yield parameters

Jagdale *et al.* (2005) reported that most of the yield contributing characters *viz*., number of pods per plant, weight of pods per plant, grain yield and straw yield (6.31, 9.69 g, 12.97 q/ha and 14.48 q/ha, respectively) were at maximum in variety VL-63 than in other varieties and the variety HUR-76 had maximum 100 grain weight (33 g) as compared to others under Hissar conditions.

Kumawat *et al.* (2006) studied the varietal performance and stated that the cluster bean variety RGC-936 was at par with RGC-197 with regard to many yield attributing characters like number of pods per plant, number of grains per pod, test weight and grain yield; but superior over local variety. Butter and Aggarwal (2006) concluded that among the different genotypes, RGM 114 produced the highest seed yield (1344 kg ha^{-1}) followed by RGM 115 and the lowest seed yield (503 kg ha^{-1}) was recorded in AVKG 37.

Lakshmi Kalyani (2006) stated that RGM 112 and HG 563 were on par with each other and recorded the values of yield attributing characters at higher magnitude as compared to those in RGC 1003 and GUAG 9703. Maximum number of pods per plant was observed in the cultivar HGS 870 as compared to RGM 115 and HGS 365; however, they did not differ significantly with regard to test weight. Significantly maximum stalk yield was obtained in the variety GAUG 9703 during *kharif* season.

Akhtar *et al*. (2012) reported that the variety S-4002 produced significantly higher grain yield (1372 kg ha^{-1}) while the varieties BR-99 and BR-99 Super stood at second and third places, respectively in respect of grain yield per ha. Satyavathi *et al*. (2014) reported that certain guar genotypes recorded highly significant difference for biomass and seed yield at harvest. The total biomass of the genotypes ranged from 21 g per plant (RGC-1066) to 103 g per plant (RGC-986) and seed yield from 4.8 g per plant (RGC-986) to 16.9 g per plant (RGC-1017).

2.1.5 Quality parameters

Butter and Aggarwal (2006) observed that the carbohydrate, crude protein and galactomannan contents were recorded at the highest in RGS 1055, HGS 365 and

RGM 114 among 20 guar varieties tested at PAU Regional Station, Bathinda. Lakshmi Kalyani (2006) stated that RGM 112 produced significantly more gum content and gum yield hectare^{-1} as compared to the varieties HG 563, RGC 1003 and GAUG 9703 under Tirupati conditions. Galactomannan content in the seed of guar genotypes as affected by growing seasons was studied and it was found that there was no significant variation in it between growing seasons and among twenty two guar genotypes. The genotype GAVG 011 recorded the highest endosperm percentage both in *kharif* (34.82%) and summer seasons (33.60%) whereas, during *rabi* season the variety RGC 1038 recorded the highest endosperm percentage (35.26%) followed by RGC 1078 (34.47%) and GAUG 011 (33.83%). The genotypes RGC 986 and RGC 1028 topped with regard to protein content (34.27%) followed by RGC 104 (33.41%) and RGC 1079 (32.56%). These varieties also recorded high net assimilation rates, which could have increased the dry matter accumulation as well as dry matter partitioning.

The highest crude protein was recorded in RGC 1088 (Raghu Prakash, 2006) and RGC 1033 (Lakshmi Kalyani, 2006) among the varieties evaluated at S.V. Agricultural College, Tirupati. The crude protein content in guar genotypes varied from 22.43% to 29.24% (Dwivedi *et al*., 1999) and 27.43 to 34.27% (Raghu Prakash, 2006) under Hissar and Tirupati conditions, respectively.

2.2 VARIABILITY, HERITABILITY AND GENETIC ADVANCE

The genetic improvement in any crop plants primarily depends on the magnitude of available genetic variability. The phenotypic variability expressed by a cultivar or a group of cultivars in any species can be partitioned into genotypic and phenotypic components. The genotypic component being the heritable part of the total variability, its magnitude on yield and its component characters influences the selection strategies to adopt by the breeders.

Heritability is an index of the transmission of characters from parents to their offspring. It is generally expressed in percentage. The estimation of heritability helps the plant breeder in selection of elite genotypes. It also measures the degree of resemblance between relative and correspondence between phenotypic and breeding value. The genetic advance is the deviation in the characters of selected population over the base population. Gain under selection or genetic advance is a measure to predict the expected progress under selection. The genetic advance helps to evaluate the selection procedures. If the value of genetic advance is more than in the succeeding generation there will be good progress over population mean. The estimation of heritability along with genetic advance is more applicable than the heritability value alone.

A summary of literature available on these aspects is presented below.

Kalaiyarasi and Palanisamy (2000) observed genotypic and phenotypic variability, heritability (BS) and genetic advance on yield and yield attributes in cowpea were studied. Seed yield plant^{-1} and number of pods plant^{-1} had high estimates of GCV followed by number of seeds pod^{-1} and plant height.

Nehra and Manjunath (2001) studied fourteen cowpea genotypes to determine genetic variability for yield and its components and reported high heritability coupled with high genetic advance expressed as per cent of mean for pods plant^{-1}. Whereas, it was moderate for plant height and yield plant^{-1}.

Bezerra *et al*. (2001) evaluated determinate cow pea accessions and found that the number of days to first flowering, number of pods plant^{-1}, pod length, number of seeds pod^{-1} exhibited significant variations.

Ramesh *et al.* (2002) revealed moderate to high heritability for plant height, pod length, number of branches and number of pods plant^{-1} indicating the role of additive gene effect in controlling these traits in cowpea.

Santosh *et al.* (2002) estimated genetic advance for certain characters in cowpea using five cultivars and reported that there was a high genetic advance for green pod yield, plant height and days to 50 per cent flowering making the selection based them as effective.

Pathak and Jamwal (2002) reported that the high genotypic coefficient of variation (GCV) was recorded for pod yield plant, moderate to high GCV were recorded for number of days to 50 per cent flowering and plant height. Whereas, it was low GCV for number of days to first picking, pod length and average pod weight.

Narayanankutty and Jaikumaran (2003) in an experiment revealed that, high phenotypic coefficient of variation and genotypic coefficient of variation were noticed for pod yield, pods plant^{-1} and pod weight in garden pea.

Pal *et al.* (2003) stated that the phenotypic coefficient of variation was greater than the genotypic coefficient of variation for most of the traits.Relatively high genotypic and phenotypic coefficients of variation were recorded for plant height, number of primary branches plant^{-1}, number of pods plant^{-1} and green pod yield plant^{-1} in cowpea.

Vineeta *et al.* (2003) reported high heritability as well as genetic gain for traits *viz*., seed yield plant^{-1} and number of pods plant^{-1} and numbers of flower clusters plant^{-1} in cowpea.

Mass *et al.* (2003) reported great diversity for flowering, maturity and biomass accumulation and growth type. Most of the accessions were early flowering. Three local materials included in the evaluation remained vegetative even after 130 days. Hence, with the new accessions evaluated, they seem to be materials suitable for the typical rain fed conditions in the Limpopo province. Early flowering types accumulated less biomass compared to the late season types in the study including 33 accessions mainly from MA types, RB-8 and RB-3 plus three local types.

Venkatesan *et al.* (2003) reported that the maximum variation was recorded for plant height. The magnitude of the phenotypic coefficient of variation (PCV) was higher than that of the genotypic coefficient of variation
(GCV). High GCV as well as PCV were recorded for plant height.

Nigude *et al.* (2004) reported that the magnitude of PCV was higher than GCV for all the characters studied. The genotypic (GCV) and phenotypic coefficients of variation (PCV) were higher for plant height and number of pods plant^{-1}.

Singh *et al.* (2004) reported high heritability (in narrow sense) estimates for pods plant^{-1}, seed yield plant^{-1} and biological yield plant^{-1}. However, high genetic advance was recorded for plant height, pods plant^{-1}, productive branches plant^{-1}, seeds pod^{-1}, biological yield plant^{-1} and seed yield plant^{-1}.

Basavarajappa and Byregowda (2004) reported wide variability in 144 genotypes for pods per plant, pod yield per plant, grain yield per plant and these characters also exhibited high heritability with high genetic advance indicating additive gene effect operating for these characters.

Dhaliwal *et al.* (2004) observed variation for days to flower initiation, pod length, pod width and green pod yield per plant and ranged from 67.4 to 108.9 days, 5.0 to 11.6 cm, 1.7 to 2.7 cm and 0.376 to 2.596 kg respectively in 15 genotypes of Dolichos bean.

Nigude *et al. (*2004) reported that heritability in broad sense was higher for all the characters. Genetic advance was highest for all characters except number of seeds pod^{-1}.

Malarvizhi *(*2005) studied variability, heritability and genetic advance in 60 genotypes of cowpea. For days to 50 per cent flowering along with twelve economic traits plant height, number of branches plant^{-1}, dry matter, yield *etc*.

Anbumalarmathi *et al.* (2005) observed high heritability as well as high genetic advance for days to 50 per cent flowering, plant height, number of branches plant^{-1}, number of clusters plant^{-1}, pods plant^{-1} pod length, seeds pod^{-1} and single plant yield in cowpea.

Ali *et al.* (2005) reported higher heritability values for number of flower per inflorescence (96.21) followed by pod weight (92.03) and number of pods per inflorescence (91.08). Maximum genetic advance expressed as percentage of mean recorded for number of pod per inflorescence (115.72) in 20 genotypes of Lablab bean, collected from different regions of Bangladesh.

Mass (2005) studied 18 *Lablab purpureus* germplasm accessions from the Australian Tropical Forage Genetic Resources Centre (ATFGRC) to determine their morphological and physiological seed characteristics. The main objective of the study was to determine the early domestication of this tropical legume crop. The seed morphology varied considerably between and within types of cultivated or domesticated and wild Hyacinth bean germplasm. Some of the seed morphological characteristics considered were seed width, length, seed mass (g/100 seeds), which varied almost 10 folds from 56 for wild materials up to about 500 for cultivated types.

Mass *et al.* (2005) made detailed study of morphological, agronomic attributes and found considerable variation in morphological attributes and a number of indigenous wild types from Africa have been identified in collection of 251 accessions of tropical legume collected from Zwai (Ethiopia, 125 accessions) and Red land Bay (Australia, 126 accessions).

Mohan and Aghora (2006) evaluated 97 pole type, vegetable podded Dolichos land races of Tamil Nadu and revealed that there is high variability for pod length, pod width, pod weight and pod colour among these land races.

Girish *et al.* (2006) studied wide range of variability for most quantitative characters. The magnitude of Phenotypic Coefficient of Variation and Genotypic Coefficient of Variation was high for seed yield plant^{-1}, number of pods plant^{-1} and plant height.

Sheela and Gpalan (2006) observed high heritability coupled with high genetic advance for characters viz., plant height, number of branches, number of leaves, leaf length, stem thickness, leaf weight, stem weight, leaf: stem ratio, green fodder yield, dry matter yield and crude protein content in cowpea.

Gnanesh *et al.* (2006) studied 64 genotypes of Field bean and revealed that the characters like inflorescences per plant, vitamin-C content, pod yield per plant, pods per plant, days to first flowering and plant height showed higher estimates of GCV and PCV. The characters like primary branches per plant, days to maturity and 100-seed weight showed moderate GCV and PCV values. Low estimates of variability were observed for pod length, seeds per pod and protein content has little scope for selection. High heritability coupled with high genetic advance as percent of mean were recorded for inflorescences per plant, pod yield per plant, days to first flowering, primary branches per plant, days to maturity and 100-seed weight.

Lal *et al.* (2007) revealed that higher estimates of heritability coupled with the higher genetic advance for number of peduncles plant^{-1}, number of days to flower, number of pods plant^{-1} and pod yield plant^{-1} indicated that heritability is mainly due to additive genetic effects in cowpea.

Suganthi and Murugan (2008) recorded high heritability for seed yield plant^{-1} followed by number of seeds pod^{-1}, pod length and 100-seed weight. Genetic advance as per cent of mean was also highest for seed yield plant^{-1} followed by number of pods plant^{-1} and number of clusters plant^{-1} in cowpea.

Bertini *et al.* (2009) evaluated cowpea cultivars for time to flowering, pod length, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seeds weight , yield plant^{-1} *etc.* The cultivars showed high levels of genetic variability for most characters. They) reported high heritability in cowpea for pod length, number of pods plant^{-1}, number of seeds pods^{-1}, weight of 100 seeds, total yield plant^{-1}. It indicates the possibility of genetic improvement in these traits.

Upadhyay and mehta (2010) studied 32 genotypes of *Dolichos lablab* collected from different parts of Chhattisgarh and a wide range of variability was reported in most of the characters. The highest GCV was recorded for pod width followed by pod length and lowest in number of seeds per pod. The highest heritability estimate was observed for marketable pod weight followed by pod width, seed index and number of pods per inflorescence. Higher heritability estimates coupled with high genetic advance as percent of mean were observed for pod width, followed by pod weight and seed index.

Choudhary *et al.* (2010) revealed that the high estimates of heritability, genetic advance in garden pea were observed for plant height, number of pods plant^{-1} and green pod yield plant$^{-1.}$

Singh *et al.* (2011) reported significant differences among varieties for days to first flowering, days to maturity, days from flowering to physiological maturity (pod filling duration), pods plant^{-1}, pod length, number of seeds pod^{-1} as well as seed size and grain yield. The results indicated that pod filling stage in cowpea can be reduced to protect the crop from insects at reproductive stage without affecting seed yield and seed size.

Prasanthi and krishna (2012) revealed that in all the 22 genotypes of cowpea, high genotypic and phenotypic coefficient of variation were reported for plant height and pods plant^{-1} while, moderately high values were recorded in pod length and seeds pod^{-1}.

Savitha *et al.* (2012) reported significant variation for all the characters in both pendal and non-pendal genotypes. The highest GCV was reported for number of green pods per plant and green pod yield per plant in both the types. High variation observed for leaf, inflorescence, flower, pod and seed characters among pendal and non-pendal genotypes.

Manggoel *et al.* (2012) observed significant variability for days to 50 per cent flowering, number of peduncles plant^{-1}, number of flowers plant^{-1}, number of pods plant^{-1}, seeds pod^{-1} and pod length. Phenotypic and genotypic coefficient of variation was high for the traits studied, except pod length and seeds pod^{-1}.

Kharde *et al*. (2014) studied the genetic variability in 20 genotypes of cowpea. The results showed significant differences among the genotypes evaluated for all the characters. A wide range of variation was observed among the genotypes for all the character. The phenotypic and genotypic coefficients of variation were higher for plant height, pod length, average pod weight, pod yield per plot, number of seeds per pod and number of pods per plant along with high heritability estimates and high expected genetic advance, indicating the additive gene effects. Selection for such traits might be useful for development of varieties.

Sapara *et al.* (2014) conducted a study on heritability and genetic advance in number of genotype of cowpea. They reported differences among the genotypes for all the characters studied except pod width indicating existence of high variability in the experimental material for all the character. They reported high heritability along with high genetic advance as percentage of mean for number of pods plant^{-1}, 100 fresh seed weight, five pod weights, green pod yield plant^{-1} and plant height.

Pandey *et al.* (2014) conducted an experiment on 43 diverse genotypes of cowpea to study the genetic variability, heritability and genetic advance. They estimated very high heritability for number of seeds per pod and number of pods per plant; and moderate genetic advance for the traits *viz.*, pod yield and plant height.

Animasaun *et al.* (2015) reported considerable variations in growth and yield characters. The cultivars NGB-06-047, IFE BROWN 2012 and IT98K-133-1-1 had optimal growth performance with respect to fruiting and seed yield parameters. Genetic Variability as estimated among the cultivars was felt to be useful for selection of cultivars with novelty in vegetative growth, yield and nutrition composition in the process of breeding programme and crop production.

2.3 CORRELATION COEFFICIENT ANALYSIS AND PATH COEFFICIENT ANALYSIS

The statistics, which measure the relationship and its extent between two or more variables, are known as correlation coefficient. Correlation

Coefficient is a statistical measure which is used to find out degree and direction of relationship between two or more variables. A positive value of correlation shows that changes of two variables are in the same direction whereas in the negative correlation movements of two variables are in the opposite direction. The knowledge of nature of association between yield and its component character is of great interest in the selection programme.

Kalaiyarasi and Palanisamy (2000) studied correlation among 9 traits in cowpea. The result indicated that seed yield plant^{-1} showed strong positive correlation with 100-seed weight, number of seed pod^{-1}, plant height, crude protein content, number of pods plant^{-1} and number of branches plant^{-1} and crude fiber content showed strong negative correlation with seed yield.

Belhekar *et al.* (2003) reported that seed yield plant^{-1} exhibited positive and significant correlation with plant height, number of pods plant^{-1} and 100 seed weight both at the genotypic and phenotypic levels.

Venkatesan *et al*. (2003) in their study on path analysis showed positive direct effect on number of pods plant^{-1}, pod length, number of clusters plant^{-1}, number of seeds pod^{-1}, and 100-seed weight on seed yield. Thus, these traits should be given more emphasis during selection for yield improvement in cowpea.

Path analysis on cowpea revealed that the number of clusters plant^{-1}, number of pods and seeds plant^{-1} and 100-seed weight showed the greatest positive direct effects on seed yield. Whereas, the number of days to maturity and flowering exhibited the greatest negative direct effects on seed yield plant^{-1} (Vineeta *et al*., 2003).

Kutty *et al.* (2003) in an experiment showed that the number of pods plant^{-1}, number of pickings, average weight of pods and pod length were positively and significantly correlated with yield plant^{-1} both at phenotypic and genotypic levels. Number of days to first picking showed significant negative correlation with number of pickings.

Venkatesan *et al.* (2003) reported that the number of branches plant^{-1}, number of clusters plant^{-1}, number of pods cluster^{-1}, number of pods plant^{-1}, and pod yield were positively correlated with seed yield at the genetic and phenotypic levels. The magnitude of genetic correlation was higher than that of phenotypic correlation in cowpea.

Singh *et al.* (2004) found that green pod yield plant^{-1} was positively and significantly associated with number of primary branches plant^{-1}, pod length, pod width, number of pod plant^{-1}, number of seeds pod^{-1} and 100-seed weight. Whereas, days to 50 per cent flowering and days to first green pod picking showed significant negative correlation with green pod yield plant^{-1}.

Xiao *et al.* (2004) revealed that positive significant and correlation was observed between the number of peduncles plant^{-1} and number of branches plant-1, and pod length and pod width.

Basavarajappa and Byregowda (2004) evaluated 144 genotypes and reported significant and positive association of grain yield with pod yield per plant, pods per plant, branches per plant, days to 50 percent flowering, days to maturity, plant height, inflorescence per plant and also 100 seed weight. Path analysis revealed that pod yield per plant exhibited highest direct effect (0.8368) followed by branches per plant (0.1058) on grain yield. Pods per plant followed by inflorescence number showed higher indirect effects on grain yield. Days to 50 per cent flowering had negative direct effect.

Nigude *et al.* (2004) observed that the biomass (dry weight) at harvest and harvest index had the highest direct effect on grain yield. Further association of biomass with grain yield was significantly positive.

Anbumalarmathi *et al.* (2005) revealed that yield plant^{-1} had positive and significant association with clusters plant^{-1}, pods plant^{-1}, pod length, seeds pod^{-1} and 100-seed weight.

Patil *et al.* (2005) revealed that seed yield plant^{-1} had positive and highly significant correlation with plant height at genotypic levels and number of pods plant^{-1} at both phenotypic and genotypic levels.

Ali *et al.* (2005) reported that pod weight showed significant positive association with pod diameter and yield per plant but showed negative significant association with flowers per inflorescence and number of pods per inflorescence. Pod length showed positive significant association with yield per plant in 20 genotypes of Dolichos bean collected from different regions of Bangladesh.

Chakraborty *et al.* (2005) revealed that 100 seed weight has the maximum direct effect on yield and has indirect effects on pod yield via nodule fresh weight plant^{-1}, total N content and number of pods plant^{-1} which were also positive.

Mittal and Singh (2005) revealed that pods plant^{-1}, pod length, 100 seed weight and days to flowering had high positive direct effects on seed yield in cowpea.

Gnanesh *et al.* (2006) reported significant and positive association of pods per plant, 100-seed weight, seeds per pod, days to first flowering, days to maturity, pod length, plant height and inflorescences per plant with pod yield. Path analysis revealed that pods per plant, 100- seed weight and seeds per pod were the important yield components having direct bearing on the improvement of pod yield in their study involving 64 genotypes of Field bean.

Lal *et al.* (2007) observed direct effect on pod yield followed by pod weight, number of peduncles plant^{-1} and pod length. Selection pressure on these traits may lead to an overall increase in pod yield plant^{-1}.

Sharma *et al.* (2009) revealed that there is highly positive direct effects through on pods plant^{-1}, plant height and pod length. Therefore, these traits may be considered as the most reliable selection indices for effective improvement in green pod yield in garden pea.

Alege and Mustapha (2007) reported that positive correlations were obtained between leaf number and stem diameter, leaf number and number of seeds pod^{-1}, number of branches and plant height.

Dahiya *et al.* (2007) in their study revealed that the seed yield plant^{-1} showed significant and positive association with number of clusters plant^{-1}, number of pods plant^{-1}, pod length, number of seeds pod^{-1}, 100-seed weight and harvest index while, it was negatively correlated with plant height.

Eswaran *et al*. (2007) investigated that Seed yield plant^{-1} had high significant positive correlation with total dry matter production and harvest index both at phenotypic and genotypic levels.

Nawab *et al*. (2008) revealed that 100-seed weight, number of pods plant^{-1}, number of seeds pod^{-1}and days to 50 per cent flowering exhibited maximum positive direct effect on green pod yield plot^{-1}. It indicated that these are main contributors towards yield.

Suganthi and murugan (2008) reported that the seed yield had a positive and significant association with pod length in cowpea.

Sharma *et al*. (2009) in their study on path analysis exhibited that pods plant^{-1} recorded highest positive direct effect on pod yield plant^{-1} followed by node at which first flower appears and plant height. Direct contribution of these traits indicated that by making selection for these traits, the yield can be substantially improved.

Upadhyay and Mehta (2010) reported highest significant positive correlation of marketable pod weight with hundred seed weight (0.771), followed by pod length (0.651) and pod width (0.402) whereas, marketable green pod yield per plant was exhibited positive correlation with pod length (0.499) and marketable pod weight (0.400). Moreover, number of seeds per pod exhibited positive correlation with pod length (0.439) and marketable pod weight (0.401). An overall observation of correlation coefficient analysis revealed that pod length and marketable pod weight exhibited the positive correlation with marketable green pod yield per plant. Path analysis revealed that selection based on pod length and length of inflorescence could be the effective in developing high yielding genotypes of in a study of 32 genotypes of *Dolichos lablab* collected from different parts of Chhattisgarh.

Correa *et al. (*2010) in their study on cowpea observed positive and significant genetic correlations between all the traits and dry bean yield; and the highest values of correlation coefficients were observed for days to flowering and mass of pods with number of seeds pod^{-1}.

Singh *et al.* (2011) reported that the numbers of pods plant^{-1}, plant height, number of primary branches plant^{-1}, 100 seed weight and number of clusters plant^{-1} were the major characters contributing to grain yield as these traits were significantly and positively associated with grain yield plant^{-1} in field pea.

Patel *et al.* (2011) revealed that number of pods per plant had highly significant and positive association with pod width, pod length and leaf length at phenotypic and genotypic level. Significant and positive correlation was observed among the pair of traits *viz.*, pod width, pod length, leaf length, number of seeds per pod, number of flowers per inflorescence, number of pods per inflorescence and number of seeds per pod at both genotypic and phenotypic levels. Path analysis revealed that green pod yield per plant (kg), hundred seed weight, number of pods per plant, number of pods per inflorescence, pod length, leaf width and inflorescence length showed high direct effect and significant positive correlation except number of flowers per inflorescence and leaf length in Dolichos bean.

Singh *et al.* (2011) reported that the number of pods plant^{-1} recorded highest positive direct effect on grain yield plant^{-1} via positive indirect effects of plant height and number of primary branches plant^{-1}.

Manggoel *et al.* (2012) studied path analysis and concluded there is high positive direct effects of number of peduncles plant^{-1}, flowers plant^{-1} and 100-seed weight in cowpea.

Savitha *et al.* (2012) reported that the correlation of green pod yield with days to 50 percent flowering, number of flower buds per raceme, number of racemes per plant, number of pods per plant, seed width (Fresh), test weight (Fresh), shelling percentage (Fresh) and test weight (Dry) were positive and highly significant. It also had positive association with raceme length. number of nodes per raceme, green pod length, number of seeds per pod, seed length (Fresh), seed length (Dry), seed width (Dry) and shelling percentage (Dry) but values were not significant, None of the characters studied showed significant negative association with green pod yield. However the traits number primary branches per plant and green pod width had non-significant negative association with green pod yield.

Upadhyay *et al.* (2012) reported highest significant positive correlation of marketable pod weight with hundred seed weight (0.771), followed by pod length (0.651) and pod width (0.402) whereas, marketable green pod yield per plant were exhibited positive correlation with pod length (0.499) and marketable pod weight (0.400). Path analysis revealed highest positive direct effect of marketable green pod yield per plant *via* pod length followed by length of inflorescence, whereas, marketable pod weight and number of seeds per pod shows highest positive indirect effect on marketable green pod yield per plant *via* pod length, while pod width and hundred-seed weight exhibited high positive and indirect effect by pod length on marketable green pod yield per plant. Apart from this, length of inflorescence observed high negative and indirect effect on marketable green pod yield per plant *via* pod length.

Manggoel *et al. (*2012) in cowpea reported positive correlation between grain yield and number of peduncles plant^{-1}, flowers plant^{-1}, pods plant^{-1} and 100 seed weight.

Cholin *et al.* (2012) found that number of clusters plant^{-1}, pods plant^{-1} had positive correlation with seed yield whereas, number of clusters plant-1, pod length and test weight had a positive direct effect on seed yield and days to maturity has negative direct effect on seed yield in cowpea.

Sapara *et al.* (2014) studied genotypic and phenotypic correlation of green pod yield with different components from 40 genotypes of vegetable cowpea and reported that the yield contributing character number of pods plant^{-1} had positive and highly significant association with green pod yield plant^{-1} at phenotypic level.

Pandey *et al*. (2014) studied character association among 43 diverse genotypes of cowpea and found that there was a significant positive phenotypic correlation between number of pods per plant, number of clusters per plant, pod yield per plant and pod weight.

Kharde *et al*. (2014) studied the genetic variability in 20 genotypes of cowpea. The results showed significant differences among the genotypes evaluated for all the characters. A wide range of variation was observed among the genotypes for all the character. The phenotypic and genotypic coefficients of variation were higher for plant height, pod length, average pod weight, pod yield per plot, number of seeds per pod and number of pods per plant along with high heritability estimates and high expected genetic advance, indicating the additive gene effects. Selection for such traits might be useful for development of varieties.

Sapara *et al.* (2014) found that the genotypic and phenotypic path analysis revealed the high to moderate direct effect of green pod yield plant^{-1} with number of pods plant^{-1} and pod length. Therefore number of pods plant^{-1} and pod length was important components for improving green pod yield in vegetable cowpea.

Meena, *et al*. (2014) study on the correlations and path coefficients for ten quantitative characters among 72 cowpea germplasm. Seed yield per plant had positive significant correlation with days to 50% flowering, plant height, primary branches per plant, pods per plant, pod length, seeds per pod and 100-seed weight at both genotypic and phenotypic levels. Path coefficient analysis revealed that primary branches per plant and 100-seed weight had high direct positive effect on seed yield per plant at both genotypic and phenotypic levels.

Pandey and Singh (2015) studied fifteen F_1 hybrids obtained by crossing 6 diverse parental lines of cowpea through diallel excluding reciprocals method were studied to investigate the extent of heterosis for yield and yield contributing characters during *kharif*, 2007 and spring summer, 2008 season. Among the various components pods per plant and seeds per pods are important factor contributing to yield. IT-97K-1042 and IT-93K-452 were observed to be the top performing parents for total seed yield per plant. The crosses IT-97K-1042 X IT-98K-1111 and IT-97K-1042 X Pusa Komal were best heterotic crosses for seed yield and other characters

Meena *et al.* (2015) experiment on the correlations and path coefficients for ten quantitative characters among 72 cowpea germplasm. Seed yield per plant had positive significant correlation with days to 50% flowering, plant height, primary branches per plant, pods per plant, pod length, seeds per pod and 100-seed weight at both genotypic and phenotypic levels. Path coefficient analysis revealed that primary branches per plant and 100- seed weight had high direct positive effect on seed yield per plant at both genotypic and phenotypic levels.

Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measure of direct and indirect effects.

Chapter III

MATERIAL AND METHODS

The present investigation entitled **PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE"** was carried out during the year 2016-17 at College of Horticulture, Dr. Y.S.R Horticultural University, Venkataramannagudem, West Godavari District. The details of material used, methodologies adopted and experimental techniques employed for the study are outlined in this chapter.

3.1 GEOGRAPHICAL LOCATION

The location of the experimental site falls under the Agro-climatic zone-10, East Coastal plain and hills (Krishna-Godavari zone) with an average rainfall of 900 mm. The site is located at an altitude of 34 m (112 feet) above mean sea level and is geographical by positioned at 16°.83'N latitude and 81°5' E longitude. It experiences hot humid summer and mild winter climate. The meteorological data for the experimental period collected from the Meteorological Observatory at COH, Venkataramannagudem is presented in Appendix I.

3.2 DETAILS OF THE EXPERIMENT

3.2.1 Title of the experiment

PERFORMANCE OF SEED CLUSTER BEAN (*Cyamopsis tetragonoloba* L.) CULTIVARS IN GODAVARI ZONE.

3.2.2 Treatment Details

A total of 14 cultivars were taken for evaluation which were sourced from Rajasthan Agriculture Research Institute, Jaipur and Hisar agriculture university, Hisar whereas, the rest of the accession were sourced from Andhra Pradesh. List of cultivars are presented in Table. 3.1

Table 3.1 List of cultivars used in the present study

Treatme	Genotypes	Source
T_1	RGC 1003	RAJASTHAN AGRICULTURE INSTITUTE
T_2	RGC 1038	RAJASTHAN AGRICULTURE INSTITUTE
T_3	RGC 1055	RAJASTHAN AGRICULTURE INSTITUTE
T_4	RGC 1002	RAJASTHAN AGRICULTURE INSTITUTE
T_5	RGC 197	RAJASTHAN AGRICULTURE INSTITUTE
T_6	RGC 1017	RAJASTHAN AGRICULTURE INSTITUTE
T_7	RGC 936	RAJASTHAN AGRICULTURE INSTITUTE
T_8	RGC 1033	RAJASTHAN AGRICULTURE INSTITUTE
T_9	RGC 986	RAJASTHAN AGRICULTURE INSTITUTE
T_{10}	HG 2-20	HISAR AGRICULTURE INSTITUTE
T_{11}	HG 870	HISAR AGRICULTURE INSTITUTE
T_{12}	HG 884	HISAR AGRICULTURE INSTITUTE
T_{13}	HG 365	HISAR AGRICULTURE INSTITUTE
T_{14}	HG 563 (check)	HISAR AGRICULTURE INSTITUTE

3.2.3 Design and Layout

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Randomization was followed in each replication.

3.2.4 Details of layout

Crop	:	Cluster bean
Number of treatments	:	14
Replications	:	03
Design	:	Randomized Block Design (RBD)
Season	:	*kharif*, 2016-17
Spacing	:	30 cm x 10 cm
Plot size	:	3.6 m x 2.4 m
Location	:	COH, Venkataramannagudem

3.2.5 Preparation of experimental plot

The experimental area was ploughed and was brought to a fine tilth. Well decomposed farm yard manure @ 25.00 tonnes per hectare, was applied and mixed well in the soil before final harrowing. The experiment at site was divided into required number of plots of 3.6 m x 2.4 m size. The main and sub-irrigation channels were laid out, taking into consideration the gradient of the site. After the layout of the plots, the treatments were assigned to the different plots in each replication by using random numbers. The layout of the experiment is depicted in Fig. 3.1.

3.2.6 Fertiliser application

The recommended dose of nutrients (50:50:25 kg NPK/ha) was applied in the form of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP). Full dose of phosphorus, potash and 50 per cent of recommended dose of nitrogen were applied at the time of sowing and the remaining dose of nitrogen was top dressed at 30 days after sowing (DAS). These fertilizers were applied in line placement method at the vicinity of plants.

3.2.7 Sowing of seeds

Healthy and bold cluster bean seeds of different cultivars were sown on second week of July 2016. Before sowing, the seeds were split into two halves to reduce the seed rate. The seeds were directly sown in the field at the spacing of 30 cm x 10 cm and the plots were irrigated immediately after sowing.

3.2.8 Thinning of seedlings

Thinning operation was taken up 20 DAS, when the seedlings were fully emerged in the field. All the excess seedlings were thinned out by maintaining a spacing of 15 cm between two plants in a line.

3.2.9 After care

Regular weeding and plant protection measures were taken up as per the standard package of practices.

3.2.10 Weeding and Irrigation

The plots were kept weed free by hand weeding at 30 and 60 DAS. Irrigation was given at an interval of five to seven days during the whole cropping period. Totally, ten irrigations were given to the experiment at plot.

3.2.11 Plant Protection

As a prophylactic measure, Methyl Demeton 25 EC was sprayed @ 1 ml/lit along with Mancozeb 2 g/lit and wettable sulphur 2 g/lit to prevent pod borer, leaf spot and powdery mildew respectively .

3.2.12 Harvesting

The crop was harvested at its right stage of maturity, *i.e.*, when the seeds became dark green to brown in colour. The whole plants were uprooted, dried and threshed. The grains were collected and dried under shade.

3.3 OBSERVATIONS RECORDED

Observations on growth and yield parameters were recorded by tagging five plants in each plot at random, avoiding border row plants.

3.3.1 Plant height (cm)

The plant height was measured at 30, 60 and 90 days after sowing (DAS) from the cotyledonary node up to the growing tip and the mean was worked out and expressed in centimetres.

N

14.6 m

R I	R II	R III
HG 884	RGC 1055	HG 365
HG 563	HG 884	RGC 986
HG 870	RGC 1003	RGC 1002
RGC 986	HG 870	RGC 1033
RGC 1033	RGC 197	HG 870
RGC 936	RGC 986	RGC 197
RGC 1017	RGC 936	HG 2-20
RGC 197	RGC 1017	HG 563
RGC 1002	HG 2-20	RGC 1055
HG 2-20	RGC 1038	HG 884
HG 365	RGC 1002	RGC 936
RGC 1038	HG 365	RGC 1003
RGC 1055	HG 563	RGC 1017
RGC 1003	RGC 1033	RGC 1038
3.6 x 2.4 m	3.6 x 2.4 m	3.6 x 2.4 m

38.1

Fig. 3.1. Layout of Experimental plot

3.3.2 Number of branches per plant

The number of branches per plant was counted at 30, 60 and 90 DAS and the mean values were expressed in pure number.

3.3.3 Number of leaves per plant

Total number of green leaves was counted at 30, 60 and 90 DAS on five sampled plants from each plot and the mean value was expressed as pure number.

3.3.4 Leaf area (cm^2)

Leaf area was measured at 30, 60 and 90 DAS for the sampled plants using LI 3000 portable leaf area meter (LICOR mode) with transparent conveyor belt (model LI 3050 A) utilizing an electronic digital display in cm^2 as the excised leaves were fed into conveyor belt assembly.

3.3.5 Days to flower initiation

The number of days required for initiation of first flower was recorded in different treatmental plots and the average value for each treatment was calculated.

3.3.6 Days to 50% flowering

The days were counted from the date of sowing to the stage at which 50% plants in a plot initiated flowering.

3.3.7 Days taken from flowering to pod maturity

The number of days taken from flowering till full maturity of pod was recorded and expressed as days taken from flowering to pod maturity

3.3.8 Number of pods per cluster

The number of pods in ten clusters, randomly sampled from five plants was counted and the means were calculated and expressed as number of pods per cluster.

3.3.9 Number of clusters per plant

The number of pod clusters in five randomly selected plants was counted in each plot and their means were calculated and expressed as number of clusters per plant.

3.3.10 Number of pods per plant

The number of pods was counted from five randomly selected plants and the mean number of pods per plant was worked out.

3.3.11 Pod length (cm)

Pod length was measured individually from tip to the base of the pod using one foot scale and mean values were expressed in centi metres.

3.3.12 Weight of dry pod (mg)

The weight of dry pods was taken from five sampled plants in each treatment weighed and the average weight of the dry pod was calculated and expressed in milli grams per pod.

3.3.13 100 -seed weight (g)

The weight of hundred seeds picked at random in each experimental plot was measured and the mean hundred seed weight was worked out and expressed in grams.

3.3.14 Number of seeds per pod

The total number of seeds per pod was calculated on ten randomly sampled pods from five labelled plants and the means were calculated.

3.3.15 Crude gum content (%)

The content of gum in guar seeds was estimated as per the procedure described by Das *et al*. (1977). Thirty grams of guar seeds was taken and subjected to wet processing (2% NaOH) with vigorous boiling at 98^{o}C for 5 minutes. Solution was sieved through coarse sieve to remove excess NaOH. Leachate was discarded and wet dehusked seeds were acidified slightly for 10 minutes in 0.1 N HCl and washed with water. Dehusked seeds were air dried for 2 to 3 days.

Dehusked seeds were pulverized to get endosperm splits and germ meal. Germ meal was discarded by using 1 mm sieve. Weight of the pure endosperm splits was recorded and the endosperm percentage is given as

$$\text{Endosperm (\%)} = \frac{\text{Weight of endosperm split}}{\text{Initial weight of seed (30g)}} \times 100$$

Endosperm splits were soaked in distilled water in 1:5 proportion and kept for 4-5 hours. Soaked splits were ground in a blender to get viscous solution of thick consistency and it was kept overnight. Thick solution was disturbed by using glass rod and 50 – 100 ml of isopropanol was added to it. The gum was precipitated on the top. Excess isopropanol was removed from the gum (lumps) and lumps were vacuum dried. Dried lumps were powdered in a blender and gum content was calculated by the following formula.

$$\text{Gum (\%)} = \frac{\text{Weight of gum powder}}{\text{Initial weight of seed taken}} \times 100$$

3.3.16 Crude Protein content (%)

The nitrogen content of grains was estimated in per cent, through Microkjeldhal method (Juliano *et al.*, 1973) and the value was multiplied with a factor 6.25 to arrive at the protein content.

3.3.17 pod yield per plot (kg)

The weight of dry pods harvested from each plot was measured and the average dry pod yield was expressed in kilograms per plot.

3.3.18 Seed yield per plot (kg)

The weight of seed harvested from each plot was measured and the average seed yield was expressed in kilograms per plot.

3.4 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 cultivars to find out the significance of cultivars 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 (1950) for randomized block design.

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

Where,

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

μ = General mean

b_i = True effect of i^{th} block

t_j = True effect of j^{th} cultivars

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

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

Sources of variation	**Degrees of freedom**	**SS**	**MSS**	**F ratio**
Replications	r-1	RSS	RMSS	RMSS/EMSS
Treatments	t-1	T_rSS	T_rMSS	T_rMSS/EMSS
Error	(r-1) (t-1)	ESS	EMSS	
Total	(rt-1)	TSS		

Where,

r= Number of replications

t= Number of cultivars 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).

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

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

Where,

t = Table value at 5 per cent probability level

r = Number of replications

3.5 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 cultivars under study.

3.5.1 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.

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

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

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 = $\sigma_g^2 + \sigma_e^2$

$\bar{X}$ = 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

3.5.2 Heritability in Broad sense [h^2_b]

Heritability in broad sense was estimated as per the formulae suggested by Allard (1960).

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

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

3.5.3 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

3.5.4 Genetic advance as per cent of mean (GAM)

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

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

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

3.6 CORRELATION STUDIES

Phenotypic and genotypic correlations were worked out by using formula suggested by Falconer (1964).

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.

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.

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

t = Test statistic

r = Correlation coefficient

n = Number of paired observations

3.7 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}, up to 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

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

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

The present experiment with the title **"Performance of seed cluster bean (*Cyamopsis tetragonoloba* L.) cultivars in Godavari zone"** was conducted during the period from July to October, 2016 at College of Horticulture, Dr.Y.S.R Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh. The results obtained along with relevant discussion are presented in this chapter under the following sub-headings.

4.1 Analysis of variance

4.2 Mean performance of cultivars

4.3 Variability, heritability and genetic advance

4.4 Correlation coefficient analysis

4.5 Path coefficient analysis

4.1 ANALYSIS OF VARIANCE

The analyses of variance for 18 characters among 14 cultivars of cluster bean are presented in Table 4.1. The differences among the cultivars were found to be significant at 5% level with respect to the characters *viz.*, plant height, number of pods per cluster, pod yield per plot, number of seeds per pod, days taken from flowering to pod drying. Whereas, the rest of the characters under study were found to vary with a highly significant difference at 1% level indicating the presence of great amount of variability among the cultivars. The results on analysis of variance showed that the variance values due to the cultivars were found significant in respect of number of pods per cluster, pod yield per plot, number of seeds per pod and the number of days taken from flowering to pod drying; and highly significant due to the rest of the characters under study. This shows that the cultivar had a profound influence on these characters rather than the environment. The results described below are giving us further in sight on how these characters exhibited co-variance with respect to ranking in the values of the different characters studied. This indicates that there is ample scope for selection of cultivars for yield and its components.

4.2 *PER SE* PERFORMANCE OF CULTIVARS

The data presented in Table nos. from 4.2 to 4.12. clearly showed mean performance of cluster bean cultivars and check, for all 18 characters studied *viz.*, plant height (cm) at 30, 60 and 90 DAS, number of primary branches per plant at 30, 60 and 90 DAS, number of leaves at 30, 60 and 90 DAS, leaf area (cm^2), days to flowering initiation, days to 50% flowering, number of pods per cluster, pod length (cm), average weight of dry pod, pod yield per plot, number of seeds per pods, 100-seed weight, seed yield per plot, gum content (%), protein content (%), number of clusters per plant, number of pods per plant and days from flowering to pod maturity.

4.2.1 Plant height (cm)

Significant differences were observed among the cultivars with respect to plant height at all stages of growth (Table 4.2 and Fig 4.1). The mean plant height increased from 27.03 cm at 30 days after sowing (DAS) to 59.59 cm at 90 DAS. The plant height at maturity was found highest in the cultivar RGC 986 (68.68 cm) which was on par with HG 365 (67.99 cm). The minimum plant height was recorded by HG 2-20 (55.52 cm). Out of 14 cultivars of cluster bean, four had taller plants compared to local check HG 563 (59.75 cm). Significant variations in plant height were noticed by Akhtar *et al.* (2012) among the varieties of french bean and attributed the same to their genetic variability.

4.2.2 Number of primary branches per plant

The number of primary branches per plant showed significant differences among the cultivars at all stages of plant growth (Table 4.3, Fig 4.2, Plate 2a and 2b). The mean number of primary branches increased from 6.51 at 30 DAS to 21.25 at 90 DAS. The cultivar RGC 1033 recorded maximum number of primary branches per plant (24.79) and was on par with HG 365 (24.70) at 90 DAS. These two cultivars showed significantly higher number of primary branches per plant when compared to the check HG 563

(21.79). The cultivar HG 870 registered the lowest number of primary branches per plant (19.63).

A perusal of results on plant height and number of branches indicated that the growth was more significant during the period from 30 DAS to 60 DAS as compared to the later stage (60 DAS to 90 DAS) perhaps due to the diversion of assimilates into the reproductive parts in the later stage. An examination of top five and least five cultivars in respect of plant height and number of branches brings a fact into light that the cultivar HG 365 could maintain reasonably higher number of branches along with higher plant height at 90 DAS on par with the highest performers in these characters. On other hand the cultivar HG 870 was the one among the poorest three cultivars in respect of plant height and at the same time it happens to be the poorest branching plant among the other cultivars under study. Similar differences were also reported by Prabhavathi (2005).

4.2.3 Number of leaves per plant

The variation observed in number of leaves per plant among the cultivars was found significant at all stages of plant growth (Table 4.4). The mean number of leaves per plant increased from 30.70 at 30 DAS to 68.61 at 60 DAS, after which they decreased to 64.40 at maturity. The maximum number of leaves at 60 DAS and at maturity (72.42) was recorded by the cultivar HG 870 which was on par with HG 2-20 (71.59). Whereas minimum number of leves per plant was recorded with RGC 936 (61.07). The number of leaves per plant was superior in a total of six cultivars as compared to the check HG 563 (63.69).

4.2.4 Leaf area (cm^2)

The data for leaf area per plant ranged from 316.05 cm^2 (HG 870) to (357.47 cm^2) HG 365 with mean value of 324.50 cm^2 (Table 4.5, Fig 4.3 and Plate 3). The maximum value of leaf area per plant was recorded for HG 365 (357.47) cm^2 on par with RGC 1017 (357.27) cm^2 followed by HG 884 (321.40) cm^2,Whereas the minimum leaf area per plant was found in HG 870 (316.05) cm^2 followed by RGC 197 (317.04) cm^2 and HG 2-20 (317.43) cm^2.

The first five rankers in respect of number of leaves per plant were HG 870, HG 2-20 and HG 365 at 90 DAS, however in respect of leaf area per plant the highest value was registered by the cultivar HG 365 indicating that this had the advantage of maximum photo synthetic area over the other cultivars. It is also interesting to note that the cultivars HG 870 and HG 2-20 were having the greater numbers of leaves even though they did not record the highest leaf area per plant indicating that probably their size leaf was very small relative to the other cultivars under study.

4.2.5 Days to flower initiation

The data for days to first flowering ranged from 16.65 days (RGC 1033) to 23.01 days (HG 2-20) and showed mean value of 18.90 days (Table 4.6). exhibited first flowers in 17.01 days next only to RGC 1033 and followed by HG 884 (17.15 days) and RGC 1017 (17.17 days), whereas cultivars HG 2-20 (23.01 days) and RGC 197 (23.00 days) took the longest period for first flowering. The earlier flower initiation was observed in six cultivars as compared to the check HG 563 (18.09 days).

4.2.6 Days to 50% flowering

Days to 50% flowering exhibited a mean value of 21.22 days which varied from 25.38 days (HG 365) to 19.26 days in RGC 1002 and RGC 986 (Table 4.6 and Fig 4.4). The cultivars RGC 1038 (20.16 days) and HG 563 (20.41 days) attained the stage of 50% flowering next only to RGC 1002 and RGC 986, whereas the cultivar HG 365 (25.38 days) showed longest duration for days to 50% flowering on par with RGC 197 (25.00 days). When compared to check HG 563 which took 20.41 days to fifty per cent flowering, nine cultivars were found to be earlier to achieve this stage.

Minimum days for first flower initiation has been observed with the cultivars RGC 1033, HG 365 and HG 884, on the other hand HG 2-20, RGC 197 and RGC 1038 were found comparatively late for showing the first flower. However, the stage of 50% flowering did not exactly occurred in the same sequence indicating that some of the cultivars though initiated flower bud took an extended period of time to gear up the transformation into reproductive phase in all the plants in a population. Thus, the cultivars RGC 986, RGC 1002, HG 870, RGC 1038, HG 563, RGC 1033 and HG 884 attained 50% flowering stage one after the other among which only RGC 1033 and HG 884 were first to initiate flowering. The other cultivar HG 365 which was also first to initiate flowering took a great amount of time to pick up and was comparatively late to achieve fifty per cent flowering stage.

4.2.7 Days taken from flowering to pod drying

The data for flowering to pod drying days per plant ranged from 73.12 days (HG 563) to 81.25 days (HG 365) with mean of 74.46 days (Table 4.7 and Fig 4.5). The maximum number of days from flowering to pod drying per plant was recorded for HG 365 (81.25 days). whereas minimum number of pods per plant was found in HG 563 (73.12 days) which was on par with RGC 197 (74.20 days), RGC 1003 (74.53 days). Seven cultivars were found to possess longer duration between flowering and pod drying as compared to the check HG 563.

The number of days taken to show the first flower was at minimum in the cultivars RGC 1033, HG 365 and RGC 884, on the other hand HG 2-20, RGC 197 and RGC 1038 were found comparatively late for showing the flower initiation. As it comes to the length of duration from flowering the pod drying the lengthiest period was observed in the same cultivars that showed the earliest flower initiation (RGC 1033, HG 365 and RGC 884) whereas the shortest phase was exhibited by the cultivars RGC 197, HG 870 and RGC 1055 which were late for flower initiation. This is clarifying a fact that the cultivars that entered late to reproductive phase under local agro-climatic conditions could not properly develop sufficient foundation for pod and seed development and in addition to this the duration from flowering to pod drying was also less in these cultivars giving an indication perhaps these cultivars may end up with poor yielding capacity under the local conditions, whereas, the other group which were earlier to initiate flower and spent a prolonged period from flowering to pod drying (for example RGC 1033, HG 365 and HG 884 had better scope to push more assimilates into reproductive sinks like pods and seeds. The results on pod and seed parameters as described above were also suggestive of the similar facts with much more lucidity.

4.2.8 Crop duration

The crop duration varied significantly among the cultivars in the present study. The range of crop duration was from 92.44 days (HG 870) to 102.15 days (HG 365) with mean of 95.66 days (Table 4.7). The crop duration was found highest in the cultivar HG 365 (102.15 days) which was on par with RGC 197 (101.32 days). The minimum duration was observed in HG 870 (92.44 days) which was on par with HG 563 (93.03 days), RGC 936 (93.09 days), RGC 1038 (93.26 days) and HG 884 (93.71 days). A total of twelve cultivars were found to show longer crop duration as compared to the check HG 563.

An examination of results on crop duration with reference to the duration between flowering and pod drying brings a fact to light that both the duration between flowering and pod drying as well as total crop duration was found highest in HG 365 making it to be in an advantageous position in the race of top ranking cultivars in respect of pod or seed yield. The cultivars RGC 1033 and HG 884 registered lesser or minimum total crop duration in spite of their maximum time period between flowering and pod drying.

4.2.9 Number of pods per cluster

The data for number of pods per cluster ranged from 2.64 (HG 2-20) to 4.88 (RGC 1017) with mean of 4.13 (Table 4.8 and Fig 4.6). The maximum number of pods per cluster was recorded for RGC 1017 (4.88) on par with HG 365 (4.81), RGC 936 (4.68) and RGC 1003 (4.61), whereas minimum number of pods per cluster was found in HG 2-20 (2.64) followed by RGC 1038 (3.34) and RGC 1055 (3.56). Seven cultivars were found superior with respect to the number of pods per cluster compared to the check HG 563 (4.26).

Similar observations were made by Selvaraj and Prasanna (2012) who studied yield attributes *viz*., number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and thousand seed weight were to be responsible for the beneficial effect on elevating the stature of all the yield attributes in cluster bean.

4.2.10 Number of clusters per plant

The range of number of clusters per plant was from 8.84 (HG 870) to 21.23 (HG 365) with a mean of 13.90 (Table 4.8). The maximum number of clusters per plant was recorded for HG 365 (21.23) followed by RGC 1017 (17.09), whereas minimum number of pods per cluster was found in HG 870 (8.84) which was on par with RGC 197 (9.91). Five cultivars were found to excel the check variety HG 563 in the number of clusters per plant (14.04).

Similar observations were made by Selvaraj and Prasanna (2012) who studied yield attributes *viz*., number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and thousand seed weight were responsible for the beneficial effect on elevating the stature of all the yield attributes in cluster bean.

4.2.11 Number of pods per plant

The data for number of pods per plant ranged from 37.37 (RGC 1033) to 83.84 (RGC 1017) with mean of 56.35 (Table 4.8). The maximum number of pods per plant was recorded for RGC 1017 (83.84) which was on par with RGC 936 (79.86), whereas the minimum number of pods per plant was found in RGC 1033 (37.37) which was on par with RGC 197 (38.47), RGC 1038 (40.38) and RGC 1003 (40.98). The check variety HG 563 produced (60.61) pods per plant next only to four cultivars *viz.,* RGC 1017, RGC 936, HG 365 and HG 884.

Among the cultivars evaluated in the present study, RGC 936, HG 365, RGC 1033, RGC 1017 and HG 884 were found to register superior values with respect to the number of pods per cluster and occupied the top five ranks. Out of these cultivars, HG 365, RGC 1017 and RGC 936 were successfully maintaining the highest numbers of clusters per plant and therefore recorded the highest ranks in respect of the number of pods per plant and also pod yield per plot in the top five positions. Thus it is interesting to note that the top five positions in respect of number of pods per plant were more or less similar with respect to the characters *viz.,* number of pods per cluster and number of clusters per plant, indicating that these characters contributed greatly to the number of pods per plant.

4.2.12 Pod length (cm)

The data for pod length ranged from 4.95 cm (RGC 1002) to 6.89 cm (HG 365) with mean of 5.51 cm (Table 4.9, Plate 4a and 4b). The maximum pod length was recorded for HG 365 (6.89 cm) which was on par with RGC 936 (6.85 cm). Whereas the minimum pod length was found in RGC 1002 (4.95 cm) followed by RGC 1003 and RGC 1055 (5.04 cm) and HG 563 (5.05 cm). A total of eleven cultivars in the present study were found superior to the check HG 563 in having longer pods.

4.2.13 Weight of dry pod (mg)

There were significant differences among the cultivars with respect to average weight of dry pod (Table 4.9). Average weight of dry pod ranged from (253.82 mg)to (314.31) mg with a mean of 275.66 mg. Maximum weight of dry pod was recorded by HG 365 (314.31 mg) and was on par with HG 884 (312.22 mg), while minimum recorded by HG 563 (253.82 mg) and it was on par with RGC 936 (253.83 mg). Twelve cultivars recorded higher average weight of dry pod compared the local check variety HG 563 (253.82 mg).

4.2.14 100–seed weight (g)

The cultivars differed significantly for the 100-seed weight (Table 4.10). Hundred seed weight ranged from a minimum of 2.19 g (HG 870) to a maximum of 3.05 g (HG 365 and RGC 986) (Table 4.10, Fig. 7, Plate 6a and 6b). The cultivars HG 365 and RGC 986 (3.05 g) recorded maximum 100–seed weight which was on par with RGC 197 (2.73 g), RGC 1055 (2.72 g), HG 884 (2.71 g), RGC 1003 (2.70 g), RGC 1017 (2.70 g), RGC 1033 (2.68 g), RGC 1002 (2.68 g) and RGC 936 (2.66 g). The cultivar HG 870 (2.19 g) recorded the minimum 100–seed weight on par with HG 563 (2.28 g), RGC 1038 (2.50 g) and HG 2-20 (2.55 g). Twelve cultivars had higher value of 100-seed weight as compared to the check variety HG 563 (2.28 g).

Rathore *et al.* (2007) found similar variations in the test weight in cluster bean and recommended this trait to be chosen as criteria for improvement in the seed yield.

4.2.15 Number of seeds per pod

Number of seeds per pod had a mean value of 7.28 and ranged from 6.48 (RGC 197) to 8.51 (HG 365) (Table 4.10). Maximum number of seeds per pod was recorded in the cultivar HG 365 (8.51) which was on par with RGC 1033 (8.46), whereas the minimum number of seeds per pod was found in RGC 197 (6.48) which showed parity with RGC 1017 (6.67), HG 563 (6.88), HG 2-20 (6.89), RGC 1055 (7.03), HG 870 (7.09), RGC 986, RGC 1033 (7.16), RGC 1002 (7.38), HG 884 (7.39), RGC 936 (7.42) and RGC 1038 (7.43). A total of eleven cultivars exhibited superior performance as compared to the check variety HG 563 in respect of the number of seeds per pod.

4.2.16 Gum content (%)

The percentage of gum varied significantly among the cultivars (Table 4.11, Fig 4.8 and plate 7). The cultivar HG 365 recorded maximum percentage of gum (25.00%) which was on par with HG 884 (24.49%), RGC 1017 (24.10%), RGC 1003 (23.26%), HG 563 (22.56%), RGC 936 (21.50%) and RGC 1033 (21.12%). The cultivar RGC 197 recorded minimum percentage of gum (17.50%) which was on par with RGC 1038 (18.00%), HG 870 (18.59%), HG 2-20 (19.46%), RGC 1055 (19.56%), RGC 986 (20.00%), RGC 1002 (20.52%) and RGC 1033 (21.12). A total of four cultivars exhibited higher gum content as compared to the check HG 563 (22.56%).

In one of the similar studies, Lakshmi Kalyani (2006) stated that among different cultivars, crude gum content varied significantly and the cultivar RGM 112 produced significantly higher gum content and yield hectare^{-1} as compared to HG 563, RGC 1003 and GAUG 9703 in cluster bean. This variation can be attributed to the genotypic differences.

A close examination of the results on gum content suggested the top ranking cultivars were HG 365, HG 884, RGC 1017, RGC 1003 and HG 563. Some of these were found in superior ranks in respect to vegetative characters like number of leaves and leaf area (for example HG 365, RGC 1017 and HG 884). They were also good in seed size as evident from the figures on hundred seed weight. Seed weight should have been in close association with gum content as seen from correlation studies also. However, pod weight was found to have only little influence on both seed weight and gum content.

4.2.17 Protein content (%)

The percentage of protein varied significantly among the cultivars (Table 4.11 and fig 4.9). The cultivar HG 365 recorded maximum percentage of protein (26.41%) which was on par with RGC 1002 (26.40%), HG 2 - 20 (23.72%), RGC 1038 (23.58%), HG 870 (23.36), HG 884 (23.22) and RGC 197 (22.86) . The cultivar RGC 986 recorded minimum percentage of gum (18.88%) which was on par with RGC 1055 (19.35%), RGC 1003 and RGC 1033 (19.80%). A total seven cultivars recorded higher protein content as compared to the check HG 563 (20.69%).

4.2.18 Pod yield per plot (kg)

The data for pod yield per plot showed a mean of 3.17 and ranged from 2.41 kg (RGC 1002) to 3.89 kg (HG 365) (Table 4.12 and Fig 4.10). Maximum pod yield per plot was recorded for HG 365 (3.89 kg) which was on par with HG 884 (3.86 kg), RGC 1017 (3.46 kg), RGC 1033 (3.45 kg), HG 563 (3.44 kg), RGC 936 (3.42) whereas minimum pod yield per plant was recorded in RGC 1002 (2.41 kg). Five cultivars registered numerically higher yield compared to check HG 563. A perusal of results on pod yield per plot releated that that HG 365 (3.89 kg), HG 884 (3.86 kg), RGC 1017 (3.46 kg), RGC 1033 (3.45kg), HG 563 (3.44 kg), RGC 936 (3.42 kg), RGC 1003 (3.34 kg) and RGC 1038 (3.25 kg) were high pod yielders in the present study.

The present findings are in agreement with the findings of Mehta *et al.* (2005) and Khatun *et al.* (2010) who reported similar variations in chick pea.

4.2.19 Seed yield per plot (kg)

The data for seed yield per plot showed mean of 1.57 kg and ranged from 1.48 kg (RGC197, RGC 986, HG 870 and HG 884 to 1.85 kg (HG 365) (Table 12 and fig 4.11). Maximum seed yield per plot was recorded for HG 365 (1.85 kg) which was on par with RGC 1033 (1.82 kg) and RGC 1003 (1.62 kg), whereas the minimum seed yield per plant was found in RGC 197 (1.48 kg) which was on par with RGC 1055 (1.49 kg), HG 2-20 (1.51 kg), RGC 1038, RGC 1002 (1.53 kg), HG 563 (1.58 kg) and RGC 1003 (1.62 kg), A perusal of mean value of yield and yield contributing characters showed that RGC 1055 (1.49 kg), HG 2-20 (1.51 kg), RGC 1002 and RGC 1038 (1.53 kg), HG 365 (1.85 kg) were found high yielding cultivars in present study. A total of five varieties were found superior to the check variety HG 563 in respect of seed yield per plot. They were RGC 936 (1.60 kg), RGC 1017 (1.61 kg), RGC 1003 (1.62 kg), RGC 1033 (1.82 kg).

It is interesting to note that both pod and seed yield exhibited more or less similar trend, since, the top ranking and least ranking cultivars appeared to be the similar ones in either higher ranks or lower ranks. Varieties that were capable of producing more pods were also showing a much higher quantum of seed per plot, perhaps due to the reason that they only were better in the number of seeds per pod and hundred seed weight as well.

4.3 VARIABILITY, HERITABILITY (h^2_b) AND GENETIC ADVANCE

The results obtained on genotypic and phenotypic variances, coefficients of variation at both genotypic and phenotypic levels (GCV and PCV), heritability, genetic advance and genetic advance as per cent of mean (GAM) values for different quantitative characters are presented in Table 4.13.

The estimates of phenotypic variance were higher than those of genotypic variance for all the traits, there by indicating the influence of environment in the expression of these traits. Since these estimates solely do not provide means to assess the nature of genetic variability, phenotypic and genotypic coefficients of variation were also computed. The PCV was significantly higher than GCV for most of the traits under study confirming the environmental intervention.

4.3.1 Plant height (cm)

The phenotypic variance (PV) and genotypic variance (GV) recorded for plant height were 28.11 and 9.96, respectively. The phenotypic coefficient of variation (PCV) (8.89) and the genotypic coefficient of variation (GCV) (5.29) was low for this character. This trait recorded moderate heritability of 35.43 with low genetic advance as per cent of mean (GAM) (8.32%). Similar results were reported by Nehra and Manjunath (2001) in cowpea.

4.3.2 Number of primary branches

The PV and GV recorded for number of primary branches per plant were 3.88 and 2.20 respectively. A low PCV (9.26) and CV (6.97) were estimated for this trait. This character exhibited moderate heritability (56.70) coupled with moderate GAM (13.84%). Similar results were also reported by Shivashankar *et al.* (1993), Uddin and Newaz (1997), Gnanesh *et al.* (2006) Upadhyay and Mehta (2010), Savitha *et al*. (2012) in Dolichos bean.

4.3.3 Number of leaves per plant

The number of leaves recorded a PV of 13.34 and GV of 10.29. Values in low range were estimated for both PCV (5.67) and GCV (4.98). A high heritability of 77.13 per cent with moderate GAM (11.54%) ware recorded for this trait. Since the characters showed a high heritability with moderate genetic advance, it might have been governed by both additive and non-additive gene effects. Bezerra *et al.* (2001) documented similar results in cowpea.

4.3.4 Leaf area (cm^2)

The PV and GV recorded for leaf area were 210.42 and 189.63 respectively. A low PCV and GCV (4.47 and 4.24, respectively) ware recorded for the character. High heritability at 90.11 per cent coupled with low GAM (10.63 %) was recorded for this character. These results are in agreement with those reported by Ramesh *et al.* (2002) in cowpea.

4.3.5 Days to flowering initiation

This trait recorded PV and GV values as 5.56 and 3.80 respectively. The estimates of PCV and GCV (12.46 and 10.31, respectively) were at low range. This character exhibited high heritability (68.34%) coupled with high GAM of 22.53 per cent. It indicated that the trait might be governed by polygenic and additive inheritance. These results are in line with the findings of Shivashankar *et al.* (1993), Uddin and Newaz (1997), Gnanesh *et al.* (2006), Bhuvaneshwari (2008), Upadhyay and mehta (2010), Savitha *et al*. (2012**)** in Dolichos bean.

4.3.6 Days to 50% flowering

This trait recorded PV and GV values as 5.49 and 2.73 respectively. The estimates of PCV and GCV (11.03 and 7.77, respectively) were at low range. This character exhibited moderate heritability (49.72%) coupled with moderate GAM of 14.47 per cent. Similar results were reported by Savitha *et al*. (2012) in Dolichos bean.

4.3.7 Days taken from flowering to pod drying

The PV and GV recorded for days taken from flowering to pod drying were 6.71 and 1.82 respectively. PCV and GCV was low (3.36 and 1.75, respectively). Low heritability of 27.12 per cent and low GAM (2.41 %) were recorded for this trait. The low range values of heritability and genetic advances indicated that the trait is non-additive in its inheritance pattern. Similar result were reported by Nigude *et al*. (2004) in cowpea.

4.3.8 Number of pods per cluster

PV and GV for this character were 0.75 and 0.23 respectively. Moderate values of PCV and GCV (20.87 and 11.68, respectively) were estimated for this trait. Moderate heritability of 30.66 was recorded with moderate GAM of 17.25 per cent for this trait. Santosh *et al.* (2002) reported similar results in cowpea.

4.3.9 Number of clusters per plant

PV and GV for this character were 10.42 and 9.60, respectively. High values of PCV and GCV (23.21 and 22.27, respectively) were estimated for this trait. High heritability of 92.13 was recorded with high GAM of 56.43 per cent for this trait. Since both the estimates of heritability and GAM were in high range, this trait might be controlled by additive gene action. These values corroborated with the findings of Gnanesh *et al*. (2006) in Dolichos bean.

4.3.10 Number of pods per plant

PV and GV for this character were 248.89 and 221.33, respectively. High values of PCV and GCV (27.99 and 26.40, respectively) were estimated for this trait. High heritability of 88.92 was recorded with high GAM of 65.72 per cent for this trait suggesting that it was governed by additive inheritance. Shivashankar *et al.* (1993), Uddin and Newaz (1997), Gnanesh *et al.* (2006), Upadhyay and Mehta (2010), Savitha *et al*. (2012) expressed similar results in Dolichos bean.

4.3.11 Pod length (cm)

The phenotypic variance (PV) and genotypic variance (GV) recorded for plant height were 0.57 and 0.31 respectively. The phenotypic coefficient of variation (PCV) (13.72) for this character was moderate and the genotypic coefficient of variation (GCV) (10.10) was low. This trait recorded moderate heritability of 54.38 with moderate genetic advance as per cent of mean (GAM) (19.62). Similar results were reported by Pathak and Jamwal (2002) in cow pea.

4.3.12 Weight of dry pod (mg)

The PV and GV recorded for weight of dry pod were 566.73 and 226.01, respectively. PCV and GCV was low (8.63 and 5.45, respectively). Moderate heritability of 39.87 and low GAM (9.09%) were recorded for this trait. Since the characters, pod length and weight of dry pod exhibited moderate values of heritability and low GAM, if might be governed by non-additive gene action and oligo genic nature of inheritance pattern. Similar results were also reported by Gnanesh *et al*. (2006) in Dolichos bean.

4.3.13 Number of seeds per pod

PV and GV for this character were 0.55 and 0.23, respectively. low values of PCV and GCV (10.20 and 6.60, respectively) were estimated for this trait. Moderate heritability of 41.81 was recorded in combination with moderate GAM of 11.27 for this trait. Upadhyay and Mehta (2010) and Savitha *et al*. (2012) enunciated similar findings in Dolichos bean.

4.3.14 100-seed weight (g)

The PV and GV recorded for 100-seed weight were 0.09 and 0.04 respectively. PCV and GCV was low (11.39 and 7.14, respectively). Moderate heritability of 44.44 and moderate GAM (11.82%) were recorded for this trait. Pal *et al.* (2003) expressed similar result in cow pea.

4.3.15 Gum content (%)

The PV and GV for this trait were 9.74 and 4.14, respectively. The estimates of PCV and GCV (14.78 and 9.63, respectively) were at moderate range. This trait exhibited moderate heritability of 42.50 coupled with moderate GAM of (16.59%). Similar result were reported were by Vineeta *et al.* (2003) in cowpea.

4.3.16 Protein content (%)

The PV and GV for this trait were 10.10 and 4.76, respectively. The estimates of PCV and GCV (14.45 and 9.92, respectively) were moderate. This trait exhibited moderate heritability of 47.12 coupled with moderate GAM of (17.98%). The contents of gum and protein in the seeds exhibited moderate estimates of heritability and genetic advance and therefore might be controlled by oligogenic inheritance pattern. Similar results were reported were by Vineeta *et al.* (2003) in cowpea.

4.3.17 Pod yield per plot (kg)

The PV and GV recorded for pod yield per plot were 0.37 and 0.14, respectively. PCV and GCV was high (19.06 and 11.59, respectively). Moderate heritability of 37.83 was recorded in combination with moderate GAM (18.62%). Similar results were reported by Narayanankutty *et al.* (2003) in cowpea.

4.3.18 Seed yield per plot (kg)

The PV and GV recorded for seed yield per plot were 0.03 and 0.01, respectively. PCV and GCV was low (10.43 and 5.75, respectively). Moderate heritability of 33.33 and low GAM (8.36%) were recorded for this character. Savitha *et al*. (2012) were also reported similar findings in Dolichos bean.

4.4 CHARACTER ASSOCIATION

Crop yield is the end product of the interaction between a number of interrelated attributes. A thorough understanding of the interaction between the characters and among themselves is of great use in plant breeding. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its component characters and also among themselves. Character association provides information on the nature and extent of association between pairs of traits and helps in selection for crop improvement. The aim of correlation studies is primarily to know the suitability of various characters for indirect selection because selection of any particular trait may bring about undesirable changes in other associated characters.

Phenotypic correlation is the association between two variables which can be directly observed. It includes both genotypic and environmental effects and therefore, it differs under different environmental conditions. Genotypic correlation is the inherent or heritable association between two variables. This type of correlation may be either due to pleiotropic action of genes or due to linkage or more likely both. This type of correlation is more stable and is of paramount importance for a plant breeder to bring about genetic improvement in one character by selecting the other character of a pair that is genetically correlated.

Phenotypic and genotypic correlation coefficients were worked out on yield and its component characters among 14 cultivars of cluster bean. In general, genotypic correlations were higher than phenotypic correlations, which indicate that though there is strong inherent association between characters studied, its expression is lessened due to influence of environment. The genotypic and phenotypic correlation coefficients among yield and its component characters are presented in Table nos. 4.14 and 4.15.

The values of genotypic correlation coefficients were greater than the values of phenotypic correlation coefficients for most of the characters, which indicated thereby a strong inherent association between various traits that were quite influenced by the environment.

4.4.1 Plant height (cm)

Plant height recorded significant positive association with number of primary branches (r_g: 0.63, r_p: 0.56), 100-seed weight (r_g: 0.67, r_p: 0.43), number of clusters per plant (r_g: 0.55, r_p: 0.09) at genotypic as well as phenotypic levels. Joshi (1971) and Dahiya *et al.* (2007) also reported similar correlations in Dolichos bean.

4.4.2 Number of primary branches per plant

This character exhibited significant and positive correlation with number of pods per cluster (r_g: 0.60, r_p: 0.38), pod yield per plot (r_g: 0.57, r_p: 0.31), number of seeds per pod (r_g:0.76, r_p:0.47), seed yield per plot (r_g: 0.92, r_p: 0.41), gum content (r_g: 0.54, r_p: 0.04), number of clusters per plant (r_g: 0.65, r_p: 0.09) and days taken from flowering to pod drying (r_g: 0.78, r_p: 0.62) at genotypic as well as phenotypic levels. The character showed significant negative correlation with days to flowering initiation (r_g: -0.60, r_p: -0.42) at genotypic as well as phenotypic levels. similar findings were reported by Kalaiyarasi and Palanisamy (2000) in cowpea.

4.4.3 Leaf area (cm^2)

This character exhibited significant and positive correlation with days to 50% flowering (r_g: 0.54, r_p: 0.38), seed yield per plot (r_g: 0.56, r_p: 0.50), gum content (r_g: 0.65, r_p: 0.11) and number of clusters per plant (r_g: 0.76, r_p: 0.61) at genotypic as well as phenotypic levels. Similar results were reported by Singh *et al.* (1979) in Dolichos bean.

4.4.4. Days to flower initiation

It had significantly negative correlation with number of pods per cluster (r_g: -0.77, r_p: -0.47), pod yield per plot (r_g: -0.59 r_p: -0.45), number of seeds per pods (r_g: -0.54, r_p: -0.42), seed yield per plot (r_g: -0.57, r_p: -0.55), gum content (r_g: -0.78, r_p: -0.11), number of clusters per plant (r_g: -0.59, r_p: -0.34) and at genotypic and phenotypic levels. Similar results were reported by Belhekar *et al*. (2003) in cow pea.

4.4.5. Days to 50% flowering

This chracter exhibited significant and positive correlation with weight of dry pod (r_g: 0.53, r_p: 0.34) at genotypic as well as phenotypic levels. Similar results were reported by Singh *et al.* (1979) and Ali *et al.* (2005) in Dolichos bean.

4.4.6. Number of pods per cluster

Significant positive association was observed with seed yield per plot (r_g: 0.57, r_p: 0.25), gum content (r_g: 0.57, r_p: 0.14) and number of cluster per plant (r_g: 0.54, r_p: 0.37) at both genotypic and phenotypic level. Kalaiyarasi and Palanisamy (2000) also recorded similar findings in cowpea.

4.3.7. Number of clusters per plant

This trait had significant positive association with number of pods per plant (r_g: 0.70 r_p: 0.24) and days taken from flowering to pod drying (r_g: 0.80, r_p: 0.09) at both genotypic and phenotypic levels. Similar values were obtained by Kalaiyarasi and Palanisamy (2000) in cowpea.

4.4.8. Pod length (cm)

The character exhibited significant and positive correlation with pod yield per plot (r_g: 0.53, r_p: 0.35), number of seeds per pod (r_g: 0.57, r_p: 0.31), seed yield per plot (r_g: 0.53, r_p: 0.25), number of clusters per plant (r_g: 0.66, r_p: 0.35), days taken from flowering to pod drying (r_g: 0.72, r_p: 0.41) at genotypic as well as phenotypic levels. Similar results were reported by Biju *et al.* (2001) and Savitha *et al*. (2012) in Dolichos bean.

4.4.9. Weight of dry pod

Significant positive association was observed with pod yield per plot (r_g: 0.58, r_p: 0.51), 100-seed weight (r_g: 0.60, r_p: 0.30), gum content (r_g: 0.56, r_p: 0.11) and days taken from flowering to drying (r_g: 0.59, r_p: 0.48) at both genotypic and phenotypic levels. Similar result were reported by Belhekar *et al.* (2003) in cow pea.

4.4.10. 100- seed weight

This trait had significant positive association with number of clusters per plant (r_g: 0.57, r_p: 0.09). at both genotypic and phenotypic levels. Similar results were reported by Joshi (1971) and Dahiya *et al.* (2007) in Dolichos bean.

4.4.11. Number of seeds per pod

Significant positive association was observed with seed yield per plot (r_g: 0.79, r_p: 0.15), number of clusters per plant (r_g: 0.54, r_p: 0.00) and days taken from flowering to pod drying (r_g: 0.83, r_p: 0.51) at both genotypic and phenotypic levels. Similar results were reported by Kalaiyarasi and Palanismy (2000) in cow pea.

4.4.12. Gum content (%)

This trait had significant positive association with number of clusters per plant (r_g: 0.78, r_p: 0.02), number of pods per plant (r_g: 0.62, r_p: 0.20) and days taken from flowering to pod drying (r_g: 0.73, r_p: 0.12) at both genotypic and phenotypic levels. Similar results were reported by Biju *et al.* (2001) and Savitha *et al*. (2012) in Dolichos bean.

4.4.13. Pod yield per plot (kg)

This character exhibited significant and positive correlation with seed yield per plot (r_g: 0.58, r_p: 0.52), gum content (r_g: 0.79), number of clusters per plant (r_g: 0.67, r_p: 0.33) and days taken from flowering pod drying (r_g: 0.80, r_p: 0.25) at genotypic as well as phenotypic levels. Similar results reported by Biju *et al.* (2001), Singh *et al.* (1979), Dahiya *et al.* (2007) and Upadhyay and Mehta (2010) in Dolichos bean.

4.4.14. Seed yield per plot (kg)

This character exhibited significant and positive correlation with gum content (r_g: 0.53, r_p: 0.61), number of clusters per plant (r_g: 0.65, r_p: 0.46) and days from flowering to pod drying (r_g: 0.75, r_p: 0.32) at genotypic as well as phenotypic levels. Similar result were reported by Belhekar *et al.* (2003) in cow pea.

The top five positive values of correlation coefficients were recorded between the pair of characters *viz.,* number of branches, number of seed per pod pod yield per plot, number of clusters per plant and seed yield per plot. Similarly the highest negative associations were recorded between the pairs of characters *viz.,* gum content, number of pods per cluster, pod yield per plot, number of cluster per plant and days to flower initiation.

4.5 PATH ANALYSIS

Upon the assessment of the apparent relationship between yield and its components, it was necessary to partition the direct and indirect effects of each character on yield to understand the nature of association at genotypic and phenotypic levels. In order to fulfil this requirement, the path coefficient analysis was performed and direct and indirect effects of different characters on yield per plant were computed and the coefficients are presented in Tables 4.16 and 4.17

Path analysis was carried out at phenotypic and genotypic levels considering seed yield per plot as dependent character and its attributes as independent characters. Each component has two path actions *viz.,* direct effect on yield and indirect effect through components which are not revealed by correlation studies. Eighty one per cent of variation in the dependent variable was explained by the path analysis at genotypic level in the present study since the residual value was 18.7. Similarly, fifty eight percent variation was explained at phenotypic level. The path of cause and effect relationships has been revealed by this analysis at both phenotypic and genotypic levels.

4.5.1 Plant height

This trait displayed very high negative direct effect at genotypic level (-2.413) on seed yield per plot while it had a significant positive correlation (r_g: 0.448) with the seed yield per plot. The trait had high positive indirect effect through days to flower initiation (0.910) and very high negative indirect effect through 100-seed weight (-2.361), days taken from flowering to pod drying (-2.208) and number of seed per pods (-2.016). It is inferred by these results that the negative indirect effects were not completely neutralized by those traits contributing towards positive indirect effect and hence the net negative direct effect was shown by seed yield per plot in cluster bean. Similar results were obtained by Nandi *et al*. (1997), Biju *et al.* (2001) and Lal *et al*. (2007) in Dolichos bean.

4.5.2. Number of branches

This trait displayed very high positive direct effect at genotypic level (2.2428) on seed yield per plot while it has positive correlation (r_g: 0.9262) with the seed yield per plot. This trait had very high positive indirect effects through days taken from flowering to pod drying (2.723), number of seed per pods (2.406) and number of pods per cluster (1.944) and very high negative indirect effect through days to flower initiation (-1.692). negative indirect effect of number of primary branches per plant on seed yield per plot. Similar results were obtained by Vineeta *et al.* (2003) in cowpea.

4.5.3. Number of leaves per plant

This trait displayed high positive direct effect at genotypic level (0.319) on seed yield per plot while it has negative correlation (r_g: -0.299) with the seed yield per plot. The trait had low positive indirect effect through protein content (0.155) and days to flower initiation (0.151) and low negative indirect effect through 100-seed weight (-0.162), pod yield per plot (-0.187) and number of pods per cluster (-0.151). Similar result were obtained by Singh *et al*. (1979) in Dolichos bean.

4.5.4. Leaf area (cm^2)

This trait displayed high positive direct effect at genotypic level (0.480) on seed yield per plot while it has positive correlation (r_g: 0.562) with the seed yield per plot. This trait had high positive indirect effect through number of cluster per plat (0.381), gum content (0.377) and days taken from flowering to pod drying (0.371) and moderate negative indirect effect through days to flower initiation (-0.229). Similar result were obtained by Kutty et al. (2003) in cowpea.

4.5.5. Days to flower initiation

This trait displayed high positive direct effect at genotypic level (0.706) on seed yield per plot while it has negative correlation (r_g: -0.576) with the seed yield per plot. it had high positive indirect effect through number of leaves per plant (0.335) and high negative indirect effect through number of pods per cluster (-0.784), gum content (-0.715) and days taken from flowering to drying (-0.594). Similar results were obtained by Upadhyay *et al*. (2012) in Dolichos bean.

4.5.6. Days to 50% flowering

This trait displayed very high negative direct effects at genotypic level (-1.038) on seed yield per plot. While It has positive correlation (r_g: 0.373) with the seed yield per plot. this trait had high negative indirect effect through weight of dry pod (-0.791), 100- seed weight (-0.702) and leaf area (-0.699). It is inferred by these results that the negative indirect effects were not completely neutralized by the traits contributing towards positive indirect effect and hence the net negative and low range direct effect was shown by days to 50% germination on seed yield per plot cluster bean.

4.5.7. Days taken from flowering to pods drying

This trait displayed high positive direct effect at genotypic level (0.078) on seed yield per plot while it has positive correlation (r_g: 0.152) with the seed yield per plot. this trait had positive indirect effect through pod yield per plot (0.104), number of seeds per pods (0.097) and number of branches (0.094) and negligible negative indirect effect through days to flower initiation (-0.065) and number of leaves per plant (-0.032). Similar results were obtained by Singh *et al*. (1979) in Dolichos bean.

4.5.8. Number of pods per cluster

This trait displayed high positive direct effect at genotypic level (0.558) on seed yield per plot. While it has positive correlation (r_g: 0.570) with the seed yield per plot. This trait had high positive indirect effect through gum content (0.564), days taken from flowering to pod drying (0.537) and number of branches (0.480) and high negative indirect effect through days to flower initiation (-0.617). Similar results were obtained by Venkatesan *et al*. (2003) in cowpea.

4.5.9. Number of clusters per plant

This trait displayed very high positive direct effect at genotypic level (1.917) on seed yield per plot while it has positive correlation (r_g: 0.878) with the seed yield per plot. This trait had very high positive indirect effect through days taken from flowering to pod drying (2.156), gum content (1.817) and pod yield per plot (1.624) and high negative indirect effect through number of leaves per plant (-0.882). Similar results were obtained by Anbumalarmathi *et al.* (2005) in cowpea.

4.5.10. Number of pods per plant

This trait displayed high negative direct effect at genotypic level (-0.764) on seed yield per plot while it has positive correlation (r_g: 0.197) with the seed yield per plot. This trait had high positive indirect effect through days to flower initiation (0.354) and high negative indirect effect through protein content (-0.065), gum content (-0.591) and number of clusters per plant (-0.556).

4.5.11. Pod length (cm)

This trait displayed moderate positive direct effect at genotypic level (0.204) on seed yield per plot while it has positive correlation (r_g: 0.537) with the seed yield per plot. This trait had moderate positive indirect effect through protein content (0.024) and days taken from flowering to pod drying (0.234) and negligible negative indirect effect through days to flower initiation (-0.055) and number of leaves per plant (-0.050). The negative indirect effect could not completely antagonize the positive indirect effect and thus there was a net positive direct effect of this trait on seed yield per plot in cluster bean.

4.5.12. Weight of dry pod (mg)

This trait displayed high positive direct effect at genotypic level (0.604) eon seed yield per plot, while it has positive correlation (r_g: 0.317) with the seed yield per plot. The trait had high positive indirect effect through 100-seed weight

(0.584), gum content (0.455) and days taken from flowering to pod drying (0.454) and moderate negative indirect effect through days to flower initiation (-0.234). Similar result were obtained by Singh *et al*. (2004) in cowpea.

4.5.13. 100- seed weight (g)

This trait displayed negligible positive direct effect at genotypic level (0.743) on seed yield per plot while it has positive correlation (r_g: 0.318) with the seed yield per plot. This trait had high positive indirect effect through weight of dry pod (0.728), pod length (0.603) and days taken from flowering to pod drying (0.579) and high negative indirect effect through number of leaves per plant (-0.384).

4.5.14. Number of seeds per pod

This trait displayed negligible negative direct effect at genotypic level (-0.074) on seed yield per plot while it has positive correlation (r_g: 0.797) with the seed yield per plot. This trait had negligible positive indirect effect through days to flower initiation (0.045) and number of leaves per plant (0.022) and negligible negative indirect effect through days taken from flowering to pod drying (-083) and number of braches (-0.074). Similar results were obtained by Xiao (2004) in cowpea.

4.5.15. Gum content%

This trait displayed high negative direct effect at genotypic level (-0.663) on seed yield per plot while it has positive correlation (r_g: 0.812) with the seed yield per plot the trait had high positive indirect effect through days to flower initiation (0.671) and high negative indirect effect through days taken from flowering to pod drying (-0.774), pod yield per plot (-0.754) and number of cluster per plant (-0.628).Similar results were obtained by Upadhyay *et al*. (2012) in Dolichos bean.

4.5.16. Protein content (%)

This trait displayed negligible positive direct effect at genotypic level (0.074) on seed yield per plot while it has negative correlation (r_g: -0.022) with the seed yield per plot. This trait had negligible positive indirect effect through gum content (0.004), plant height (0.004) and number of seeds per pod (0.002) and negligible negative indirect effect through 100-seed weight (-0.016), pod yield per plot (-0.014) and number of pods per cluster (-0.010).

4.5.17. Pod yield per plot

This trait displayed high negative direct effect at genotypic level (-0.814) on seed yield per plot while it has positive correlation (r_g: 0.557) with the seed yield per plot. This trait had high positive indirect effect through days to flower initiation (0.617) and number of leaves per plant (0.4808) and very high negative indirect effect through days taken from flowering to pod drying (-1.052).

The highest direct effect on seed yield per plot was exerted by the traits *viz.*, number of primary branches, number of seeds per pod, pod yield per plot, number of pods per cluster and leaf area in positive direction; by days to flower initiation and number of leaves per plant in negative direction.

Table 4.1 Analysis of variance for yield and yield attributes in cluster bean

S. No.	Characters	Mean sum of squares		
		Replications (df = 2)	Treatments (df = 13)	Error (df = 26)
1	Plant height (cm)	15.10	48.03*	18.14
2	Number of primary branches	3.07	8.27**	1.68
3	Number of Leaves per plant	0.35	33.92**	3.05
4	Leaf area cm^2	39.04	589.67**	20.78
5	Days to flower initiation	2.35	13.16**	1.75
6	Days to 50% flowering	1.31	10.93**	2.76
7	Days taken from flowering to pod drying	0.61	10.34*	4.88
8	Number of pods per cluster	0.26	1.21*	0.51
9	Number of Clusters per plant	0.98	29.61**	0.82
10	Number of Pods per plant	45.51	691.56**	27.56
11	Pod length (cm)	0.21	1.91**	0.2
12	Weight of dry pod	151.15	1018.5**	340.72
13	Number of Seeds per pods	0.175	1.01*	0.32
14	100-seed weight	0.07	0.16**	0.05
15	Gum content	24.62	18.03**	5.60
16	Protein content	0.46	19.63**	5.33
17	Pod yield per plot	0.08	0.63*	0.23
18	Seed yield per plot	0.06	0.04**	0.01

*Significant at 5% level of significance ** Significant at 1% level of significance

Table 4.13 Coefficients of Variation, Heritability and Genetic Advance for yield and its attributing characters in the seed cluster bean cultivars

S. No.	Characters	GV	PV	GCV	PCV	h^2	Genetic Advance	GAM (%)
1	Plant height (cm)	9.96	28.11	5.29	8.89	35.43	4.96	8.32
2	Number of primary branches	2.20	3.88	6.97	9.26	56.70	2.94	13.84
3	Number of Leaves per plant	10.29	13.34	4.98	5.67	77.13	7.43	11.54
4	Leaf area (cm^2)	189.63	210.42	4.24	4.47	90.11	34.51	10.63
5	Days to flower initiation	3.80	5.56	10.31	12.46	68.34	4.26	22.53
6	Days to 50% flowering	2.73	5.49	7.77	11.03	49.72	3.07	14.47
7	Days taken from flowering to pod drying	1.82	6.71	1.75	3.36	27.12	1.85	2.41
8	Number of Pods per cluster	0.23	0.75	11.68	20.87	30.66	0.71	17.25
9	Number of Cluster per plant	9.60	10.42	22.27	23.21	92.13	7.84	56.43
10	Number of Pods per plant	221.33	248.89	26.40	27.99	88.92	37.03	65.72
11	Pod length (cm)	0.31	0.57	10.10	13.72	54.38	1.08	19.62
12	weight of dry pod (mg)	226.01	566.73	5.45	8.63	39.87	25.06	9.09
13	Number of Seeds per pod	0.23	0.55	6.60	10.20	41.81	0.82	11.27
14	100-seed weight (g)	0.04	0.09	7.14	11.39	44.44	0.31	11.82
15	Gum content (%)	4.14	9.74	9.63	14.78	42.50	3.50	16.59
16	Protein content (%)	4.76	10.10	9.92	14.45	47.12	3.95	17.98
17	Pod yield per plot (kg)	0.14	0.37	11.59	19.06	37.83	0.59	18.62
18	Seed yield per plot (kg)	0.01	0.03	5.75	10.43	33.33	0.13	8.36

Table 4.2 Mean performance cluster bean cultivars

S. No.	Characters / Genotypes	Plant height(cm)	Number of branches	Leaves per plant	Leaf area (cm^2)	Days to flower initiation	Days to 50% flowering	Pods in cluster	Pod length(cm)	Average weight of dry pod	Pod yield /plot	Seeds/pods	100-seed weight	Seed yield/plot	Gum content	Protein content	Cluster/plant	Pods/plant	Days taken Flowering to pods dryin
1	RGC1003	59.23	21.55	63.09	318.03	17.01	21.24	4.61	5.04	280.15	3.34	7.16	2.70	1.62	23.26	19.80	12.65	40.98	76.10
2	RGC1038	57.50	19.75	62.37	317.94	20.52	20.16	3.34	5.13	268.38	3.25	7.43	2.50	1.53	18.00	23.58	11.99	40.38	75.95
3	RGC1055	56.24	20.61	62.19	320.81	19.26	22.32	3.56	5.04	277.92	2.81	7.03	2.72	1.49	19.56	19.35	12.35	54.98	75.70
4	RGC1002	60.39	20.42	64.31	318.78	18.07	19.26	4.43	4.95	258.12	2.41	7.38	2.68	1.53	20.52	26.40	14.95	58.02	76.18
5	RGC197	58.04	19.99	63.77	317.04	23.00	25.00	3.82	5.45	276.12	2.59	6.48	2.73	1.48	17.50	22.86	9.91	38.47	74.20
6	RGC1017	58.40	21.42	62.87	357.27	17.17	22.05	4.88	5.20	280.83	3.46	6.67	2.70	1.61	24.10	20.11	17.09	83.84	76.69
7	RGC936	59.10	21.27	61.07	320.64	18.72	20.75	4.68	6.85	253.83	3.42	7.42	2.66	1.60	21.50	19.75	16.88	79.86	78.10
8	RGC1033	60.13	24.79	62.06	320.21	16.65	20.57	4.60	5.71	275.22	3.45	8.46	2.68	1.82	21.12	19.80	14.04	37.37	79.19
9	RGC986	68.68	21.69	64.08	318.93	19.81	19.26	4.10	5.66	277.03	3.02	7.16	3.05	1.48	20.00	18.88	13.92	49.96	76.32
10	HG 2-20	55.52	19.75	71.59	317.43	23.01	20.62	2.64	5.38	268.29	2.89	6.89	2.55	1.51	19.46	23.72	11.86	48.97	75.98
11	HG 870	57.05	19.63	72.42	316.05	19.26	19.44	4.32	5.11	262.98	2.62	7.09	2.19	1.48	18.59	23.36	8.84	55.31	75.50
12	HG 884	56.24	20.23	63.77	321.40	17.15	20.73	3.86	5.66	312.22	3.86	7.39	2.71	1.48	24.49	23.22	14.95	66.77	79.19
13	HG 365	67.99	24.70	64.34	357.47	17.01	25.38	4.81	6.89	314.31	3.89	8.51	3.05	1.85	25.00	26.41	21.23	73.36	81.25
14	HG 563 (check)	59.75	21.79	63.69	321.00	18.09	20.41	4.26	5.05	253.82	3.44	6.88	2.28	1.58	22.56	20.69	14.04	60.61	76.71
	Mean	**59.59**	**21.25**	**64.4**	**324.50**	**18.90**	**21.22**	**4.13**	**5.51**	**275.66**	**3.17**	**7.28**	**2.66**	**1.57**	**21.11**	**21.99**	**13.90**	**56.35**	**76.93**
	Range Lowest	55.52	19.63	61.07	316.05	16.65	19.26	2.64	4.95	253.82	2.41	6.48	2.19	1.48	17.50	18.88	8.84	37.37	74.20
	Range Highest	68.68	24.79	72.42	357.47	23.01	25.38	4.88	6.89	314.31	3.89	8.51	3.05	1.85	25.00	26.41	21.23	83.84	81.25
	S.Em±.	2.45	0.74	1.00	2.63	0.76	0.95	0.41	0.29	10.65	0.27	0.32	0.13	0.07	1.36	1.33	0.52	3.03	1.27
	C.D. 5%	7.14	2.17	2.93	7.65	2.22	2.78	1.20	0.85	30.97	0.80	0.95	0.39	0.23	3.97	3.87	1.52	8.81	3.70
	C.D. 1%	9.66	2.94	3.96	10.34	3.00	3.76	1.62	1.16	41.87	1.09	1.28	0.53	0.31	5.37	5.24	2.05	11.91	5.01

Table 4.14 Genotypic correlation coefficients between yield and its attributes in seed cluster bean

S. No.	Character	PH	NB	NL	LA	DFI	D50% F	NPC	PL	WDP	PY	NS	100-SW	SY	GC	PC	NC	NPP	FPD
1	PH	**1.000**																	
2	NB	0.635*	**1.000**																
3	NL	-0.205	-0.379	**1.000**															
4	LA	0.387	0.501	-0.174	**1.000**														
5	DFI	-0.271	-0.607*	0.418	-0.427	**1.000**													
6	D50%F	0.157	0.313	-0.216	0.544*	0.089	**1.000**												
7	NPC	0.458	0.600*	-0.389	0.493	-0.772**	0.126	**1.000**											
8	PL	0.485	0.530	-0.217	0.390	-0.167	0.400	0.334	**1.000**										
9	WDP	0.281	0.352	-0.117	0.522	-0.319	0.538*	0.098	0.354	**1.000**									
10	PY	0.246	0.575*	-0.403	0.521	-0.598*	0.230	0.345	0.535*	0.581*	**1.000**								
11	NS	0.463	0.767*	-0.217	0.256	-0.540*	0,083	0.357	0.570*	0.389	0.498	**1.000**							
12	100-SW	0.671**	0.466	-0.435	0.414	-0.146	0.432	0.206	0.503	0.600*	0.267	0.349	**1.000**						
13	SY	0.448	0.926**	-0.299	0.562*	-0.576*	0.373	0.570*	0.537*	0.317	0.587*	0.797**	0.318	**1.000**					
14	GC	0.289	0.542*	-0.296	0.651*	-0.785**	0.204	0.578*	0.364	0.561*	0.796**	0.353	0.321	0.534*	**1.000**				
15	PC	0.035	-0.129	0.396	0.168	0.137	0.196	-0.148	0.092	0.238	-0.128	0.242	-0.030	0.064	-0.015	**1.000**			
16	NC	0.556*	0.653*	-0.438	0.764**	-0.595*	0.313	0.548*	0.669**	0.443	0.679**	0.546*	0.572*	0.655*	0.784**	0.143	**1.000**		
17	NPP	0.128	0.121	-0.119	0.663**	-0.415	0.131	0.454	0.456	0.178	0.421	0.023	0.123	0.149	0.626*	0.058	0.704**	**1.000**	
18	FPD	0.431	0.784**	-0.257	0.524	-0.649	0.216	0.435	0.724**	0.592*	0.806**	0.832**	0.404	0.754**	0.730**	0.181	0.806**	0.448	**1.000**

* Significant at 5%; ** Significant at 1% level of significance

PH	Plant height	**NPC**	Number of pods per cluster	**SY**	Seed yield per plot
NB	Number of primary branches	**PL**	Pod length	**GC**	Gum content
NL	Number of leaves per plant	**WDP**	Weight of dry pod	**PC**	Protein content
LA	Leaf area	**PY**	Pod yield per plot	**NC**	Number of clusters per plant
DFI	Days to flower initiation	**NS**	Number of seeds per pods	**NPP**	Number of pods per plant
D50%F	Days to 50% flowering	**100-SW**	100-seed weight	**FPD**	Days taken from flowering to pod drying

Table 4.15 Phenotypic correlation coefficients between yield and its attributes In seed cluster bean

S. No.	Character	**PH**	**NB**	**NL**	**LA**	**DFI**	**D50% F**	**NPC**	**PL**	**WDP**	**PY**	**NS**	**100-SW**	**SY**	**GC**	**PC**	**NC**	**NPP**	**FPD**
1	PH	**1.0000**																	
2	NB	0.5625	**1.0000**																
3	NL	-0.2285	-0.3110	**1.0000**															
4	LA	0.3248	0.4242	-0.1942	**1.0000**														
5	DFI	-0.1737	-0.4267	0.3367	-0.3827	**1.0000**													
6	D50%F	0.0394	0.2835	-0.1904	0.3860	0.1641	**1.0000**												
7	NPC	0.5124	0.3877	-0.3153	0.3907	-0.4798	0.0200	**1.0000**											
8	PL	0.2681	0.2538	-0.1796	0.3125	-0.0392	0.2629	0.2432	**1.0000**										
9	WDP	0.1692	0.2811	-0.0290	0.3644	-0.2493	0.3412	0.0700	0.2941	**1.0000**									
10	PY	0.0809	0.3197	-0.2134	0.3330	-0.4527	0.1872	0.1630	0.3574	0.5184	**1.0000**								
11	NS	0.1766	0.4746	-0.1198	0.2274	-0.4290	-0.1190	0.1183	0.3118	0.2023	0.2799	**1.0000**							
12	100-SW	0.4357	0.2918	-0.3576	0.3379	-0.1854	0.2217	0.1369	0.2162	0.3006	0.0699	0.2858	**1.0000**						
13	SY	0.1325	0.4156	-0.1918	0.5090	-0.5502	0.1193	0.2568	0.2563	0.3978	0.5225	0.1586	0.0699	**1.0000**					
14	GC	0.0171	-0.0474	0.2936	0.1150	0.1124	0.1297	-0.1403	0.0620	0.1102	-0.0747	0.0953	0.1024	-0.0791	**1.0000**				
15	PC	0.4032	0.5034	-0.3982	0.7081	-0.5309	0.2361	0.3766	0.6047	0.3587	0.5177	0.4011	0.4100	0.6114	0.1053	**1.0000**			
16	NC	0.0937	0.0907	-0.1109	0.6182	-0.3405	0.1572	0.3705	0.3583	0.1101	0.3333	0.0010	0.0935	0.4682	0.0242	0.6604	**1.0000**		
17	NPP	0.1326	0.4043	-0.0646	0.3234	-0.5154	-0.0391	0.1213	0.4166	0.4883	0.5023	0.5961	0.1593	0.4392	0.2073	0.5627	0.2442	**1.0000**	0.1326
18	FPD	0.3020	0.6278	-0.0925	0.4588	-0.4374	0.1092	0.3718	0.3657	0.2380	0.2532	0.5181	0.2053	0.3287	0.1248	0.4675	0.0974	0.5209	0.3020

* Significant at 5%; ** Significant at 1% level of significance

PH	Plant height	**NPC**	Number of pods per cluster	**SY**	Seed yield per plot
NB	Number of primary branches	**PL**	Pod length	**GC**	Gum content
NL	Number of leaves per plant	**WDP**	Weight of dry pod	**PC**	Protein content
LA	Leaf area	**PY**	Pod yield per plot	**NC**	Number of clusters per plant
DFI	Days to flower initiation	**NS**	Number of seeds per pods	**NPP**	Number of pods per plant
D50%F	Days to 50% flowering	**100-SW**	100-seed weight	**FPD**	Days taken from Flowering to pod drying

Table 4.16 Genotypic path coefficient analysis (dependent variable : seed yield per plot)

S No.	Character	PH	NB	NL	LA	DFI	D50% F	NPC	PL	WDP	PY	NS	100-SW	GC	PC	NC	NPP	FPD
1	PH	**-2.418**	-1.749	0.460	-1.114	0.910	-0.721	-0.9084	-1.782	-1.034	-1.138	-2.016	-2.361	-1.188	-0.135	-1.736	-0.399	-2.208
2	NB	1.625	**2.242**	-0.971	1.253	-1.692	0.767	1.9445	1.754	0.959	1.937	2.402	1.451	1.512	-0.468	1.712	0.321	2.723
3	NL	-0.061	-0.138	**0.319**	-0.051	0.151	-0.076	-0.1522	-0.074	-0.061	-0.181	-0.092	-0.162	-0.126	0.155	-0.145	-0.039	-0.150
4	LA	0.221	0.268	-0.077	**0.480**	-0.229	0.325	0.2911	0.212	0.322	0.341	0.131	0.234	0.377	0.102	0.382	0.330	0.371
5	DFI	-0.266	-0.533	0.335	-0.323	**0.706**	0.014	-0.7842	-0.191	-0.271	-0.531	-0.462	-0.075	-0.719	0.113	-0.450	-0.327	-0.594
6	D50%F	-0.316	-0.355	0.288	-0.698	-0.025	**-1.038**	-0.2746	-0.552	-0.791	-0.291	-0.312	-0.702	-0.310	-0.272	-0.391	-0.119	-0.593
7	NPC	0.208	0.480	-0.268	0.344	-0.615	0.148	**0.5584**	0.243	0.071	0.332	0.374\	0.154	0.564	-0.089	0.412	0.311	0.537
8	PL	0.150	0.159	-0.050	0.092	-0.055	0.102	0.0984	**0.204**	0.082	0.152	0.178	0.164	0.097	0.024	0.147	0.108	0.234
9	WDP	0.257	0.257	-0.113	0.404	-0.234	0.451	0.0877	0.252	**0.604**	0.392	0.378	0.584	0.455	0.230	0.319	0.145	0.454
10	PY	-0.385	-0.706	0.480	-0.578	0.617	-0.234	-0.5055	-0.602	-0.542	**-0.814**	-0.632	-0.421	-0.934	0.160	-0.694	-0.420	-1.058
11	NS	-0.058	-0.074	0.022	-0.020	0.045	-0.023	-0.0444	-0.053	-0.042	-0.051	**-0.074**	-0.021	-0.041	-0.028	-0.047	-0.003	-0.083
12	100-SW	0.726	0.480	-0.384	0.361	-0.070	0.502	0.2124	0.603	0.728	0.384	0.314	**0.743**	0.461	-0.134	0.537	0.110	0.579
13	GC	-0.326	-0.447	0.264	-0.521	0.613	-0.192	-0.6764	-0.312	-0.500	-0.754	-0.394	-0.415	**-0.663**	-0.037	-0.628	-0.513	-0.774
14	PC	0.004	-0.015	0.031	0.015	0.011	0.018	-0.0102	0.008	0.024	-0.014	0.024	-0.016	0.004	**0.074**	0.013	0.003	0.010
15	NC	1.380	1.464	-0.882	1.524	-1.222	0.722	1.4244	1.384	1.014\	1.624	1.312	1.383	1.817	0.336	**1.917**	1.395	2.156
16	NPP	-0.126	-0.119	0.093	-0.526	0.354	-0.083	-0.4322	-0.401	-0.184	-0.394	-0.034	-0.118	-0.591	-0.065	-0.556	**-0.764**	-0.531
17	FPD	0.071	0.094	-0.032	0.060	-0.065	0.044	0.0742	0.081	0.058	0.104	0.097	0.068	0.091	0.011	0.087	0.054	**0.078**
18	SY	0.448	0.926	-0.299	0.562	-0.576	0.373	0.5704	0.537	0.317	0.557	0.797	0.318	0.812	-0.022	0.878	0.197	0.152

Significant at 5%; ** Significant at 1% level of significance

PH	Plant height	**NPC**	Number of pods per cluster	**SY**	Seed yield per plot
NB	Number of primary branches	**PL**	Pod length	**GC**	Gum content
NL	Number of leaves per plant	**WDP**	Weight of dry pod	**PC**	Protein content
LA	Leaf area	**PY**	Pod yield per plot	**NC**	Number of clusters per plant
DFI	Days to flower initiation	**NS**	Number of seeds per pods	**NPP**	Number of pods per plant
D50%F	Days to 50% flowering	**100-SW**	100-seed weight	**FPD**	Days taken from flowering to pod drying

Table 4.17 Phenotypic path coefficient analysis (dependent variable: seed yield per plot)

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S. No.	Character	**PH**	**NB**	**L/P**	**LA**	**DFI**	**D50%F**	**P/C**	**PL**	**WDP**	**PY/P**	**S/P**	**100-SW**	**GC**	**PC**	**C/P**	**NPP**	**FPD**
1	PH	**-0.24**	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24
2	NB	0.25	**0.45**	-0.14	0.19	-0.19	0.12	0.17	0.11	0.12	0.14	0.21	0.13	0.18	-0.02	0.22	0.04	0.18
3	L/P	-0.04	-0.06	**0.19**	-0.03	0.06	-0.03	-0.06	-0.03	-0.00	-0.04	-0.02	-0.07	-0.03	0.05	-0.07	-0.02	-0.01
4	LA	0.13	0.17	-0.07	**0.40**	-0.15	0.15	0.15	0.12	0.14	0.13	0.09	0.13	0.20	0.04	0.28	0.24	0.13
5	DFI	0.02	0.07	-0.05	0.06	**-0.17**	-0.02	0.08	0.00	0.04	0.07	0.07	0.03	0.09	-0.01	0.09	0.05	0.08
6	D50%F	-0.00	-0.02	0.01	-0.02	-0.01	**-0.07**	-0.00	-0.02	-0.02	-0.01	0.00	-0.01	-0.00	-0.01	-0.01	-0.01	0.00
7	P/C	0.11	0.08	-0.07	0.08	-0.10	0.00	**0.22**	0.05	0.01	0.03	0.02	0.03	0.05	-0.03	0.08	0.08	0.02
8	PL	0.07	0.07	-0.05	0.08	-0.01	0.07	0.06	**0.28**	0.08	0.10	0.08	0.06	0.07	0.01	0.17	0.10	0.11
9	WDP	-0.02	-0.04	0.00	-0.05	0.03	-0.05	-0.01	-0.04	**-0.14**	-0.07	-0.03	-0.04	-0.05	-0.01	-0.05	-0.01	-0.07
10	PY/P	-0.00	-0.01	0.00	-0.01	0.02	-0.00	-0.00	-0.01	-0.02	**-0.04**	-0.01	-0.00	-0.02	0.00	-0.02	-0.01	-0.02
11	S/P	-0.00	-0.01	0.00	-0.00	0.01	0.00	-0.00	-0.00	-0.00	-0.00	**-0.03**	-0.00	-0.00	-0.00	-0.01	0.00	-0.01
12	100-SW	0.01	0.01	-0.01	0.01	-0.00	0.00	0.00	0.00	0.01	0.00	0.01	**0.04**	0.00	0.00	0.01	0.00	0.00
13	GC	-0.00	-0.02	0.01	-0.02	0.02	-0.00	-0.01	-0.01	-0.02	-0.02	-0.00	-0.00	**-0.05**	0.00	-0.03	-0.02	-0.02
14	PC	0.00	-0.00	0.01	0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	**0.05**	0.00	0.00	0.01
15	C/P	0.02	0.03	-0.02	0.04	-0.03	0.01	0.025	0.04	0.02	0.03	0.02	0.02	0.04	0.00	**0.06**	0.04	0.03
16	NPP	-0.03	-0.03	0.04	-0.26	0.14	-0.06	-0.15	-0.15	-0.04	-0.14	-0.00	-0.03	-0.19	-0.01	-0.27	**-0.42**	-0.10
17	FPD	0.02	0.07	-0.01	0.06	-0.10	-0.00	0.024	0.08	0.09	0.09	0.11	0.03	0.08	0.04	0.11	0.04	**0.19**
18	SY	0.30	0.62	-0.09	0.45	-0.43	0.10	0.37	0.36	0.23	0.25	0.51	0.20	0.32	0.12	0.46	0.09	0.52

Significant at 5%; ** Significant at 1% level of significance

PH	Plant height	**NPC**	Number of pods per cluster	**SY**	Seed yield per plot
NB	Number of primary branches	**PL**	Pod length	**GC**	Gum content
NL	Number of leaves per plant	**WDP**	Weight of dry pod	**PC**	Protein content
LA	Leaf area	**PY**	Pod yield per plot	**NC**	Number of clusters per plant
DFI	Days to flower initiation	**NS**	Number of seeds per pods	**NPP**	Number of pods per plant
D50%F	Days to 50% flowering	**100-SW**	100-seed weight	**FPD**	Days taken from flowering to pod drying

Table 4.2 Plant height (cm) in cluster bean cultivars

S. No	Cultivars	30 DAS	60 DAS	90 DAS
1	RGC 1003	26.78	58.52	59.23
2	RGC 1038	26.53	55.50	57.50
3	RGC 1055	22.97	54.96	56.24
4	RGC 1002	29.88	58.10	60.39
5	RGC 197	30.33	57.34	58.04
6	RGC 1017	25.98	57.20	58.40
7	RGC 936	29.00	56.70	59.10
8	RGC 1033	26.12	58.76	60.13
9	RGC 986	24.45	66.98	68.68
10	HG 2-20	25.56	54.98	55.52
11	HG 870	25.77	56.00	57.05
12	HG 884	26.66	55.56	56.24
13	HG 365	31.77	66.53	67.99
14	HG 563 (Check)	26.60	57.45	59.75
	Mean	**27.03**	**58.18**	**59.59**
	S Em ±	1.60	1.93	2.45
	CD at 5%	4.57	5.53	7.14

Table 4.3 Number of branches in cluster bean cultivars

S. No	Cultivars	30 DAS	60 DAS	90 DAS
1	RGC 1003	5.77	19.83	21.55
2	RGC 1038	6.66	18.17	19.75
3	RGC 1055	5.92	18.96	20.61
4	RGC 1002	6.98	18.79	20.42
5	RGC 197	6.95	18.39	19.99
6	RGC 1017	6.12	19.71	21.42
7	RGC 936	7.00	19.57	21.27
8	RGC 1033	5.96	22.81	24.79
9	RGC 986	6.93	19.95	21.69
10	HG 2-20	6.92	18.17	19.75
11	HG 870	6.88	18.06	19.63
12	HG 884	6.10	18.61	20.23
13	HG 365	7.02	22.72	24.70
14	HG 563 (Check)	5.97	20.05	21.79
	Mean	**6.51**	**19.56**	**21.25**
	S Em ±	0.50	1.53	1.66
	CD at 5%	1.42	4.37	7.14

Table 4.4 Number of leaves in cluster bean cultivars

S. No	Cultivars	30 DAS	60 DAS	90 DAS
1	RGC 1003	32.56	73.12	63.09
2	RGC 1038	33.53	61.77	62.37
3	RGC 1055	28.88	62.12	62.19
4	RGC 1002	30.12	62.25	64.31
5	RGC 197	31.56	66.78	63.77
6	RGC 1017	33.57	69.45	62.87
7	RGC 936	29.90	70.34	61.07
8	RGC 1033	33.64	71.26	62.06
9	RGC 986	29.12	72.22	64.08
10	HG 2-20	27.98	72.45	71.59
11	HG 870	28.24	73.00	72.42
12	HG 884	28.42	69.92	63.77
13	HG 365	33.70	73.46	64.34
14	HG 563 (Check)	28.57	62.44	63.69
	Mean	**30.70**	**68.61**	**64.40**
	S Em ±	1.83	1.43	1.05
	CD at 5%	5.23	4.10	3.00

Table 4.5 Leaf area (cm^2) in cluster bean cultivars

S. No	Cultivars	30 DAS	60 DAS	90 DAS
1	RGC 1003	234.46	513.77	318.03
2	RGC 1038	233.93	436.53	317.94
3	RGC 1055	199.96	435.88	320.81
4	RGC 1002	222.64	512.90	318.78
5	RGC 197	212.73	477.92	317.04
6	RGC 1017	208.87	512.22	357.27
7	RGC 936	223.56	508.65	320.64
8	RGC 1033	235.24	510.17	320.21
9	RGC 986	216.77	436.77	318.93
10	HG 2-20	229.10	437.00	317.43
11	HG 870	230.62	502.64	316.05
12	HG 884	208.12	498.33	321.40
13	HG 365	235.87	514.20	357.47
14	HG 563 (Check)	200.00	437.07	321.00
	Mean	**220.85**	**481.00**	**324.50**
	S Em ±	3.27	4.44	2.34
	CD at 5%	9.34	12.68	6.67

Table 4.6 Flowering parameters in cluster bean cultivars

S. No	Cultivars	Days to flower Initiation	Days to 50% flowering
1	RGC 1003	17.01	21.24
2	RGC 1038	20.52	20.16
3	RGC 1055	19.26	22.32
4	RGC 1002	18.07	19.26
5	RGC 197	23.00	25.00
6	RGC 1017	17.17	22.05
7	RGC 936	18.72	20.75
8	RGC 1033	16.65	20.57
9	RGC 986	19.81	19.26
10	HG 2-20	23.01	20.62
11	HG 870	19.26	19.44
12	HG 884	17.15	20.73
13	HG 365	17.01	25.38
14	HG 563 (Check)	18.09	20.41
	Mean	**18.90**	**21.22**
	S Em ±	0.76	0.95
	CD at 5%	2.22	2.78

Table 4.7 Time taken from flowering to pod drying and crop duration in cluster bean cultivars

S. No	Cultivars	Days taken from flowering to pod drying	Crop duration (days)
1	RGC 1003	74.53	95.77
2	RGC 1038	75.95	93.26
3	RGC 1055	75.70	95.28
4	RGC 1002	76.16	95.42
5	RGC 197	74.20	101.32
6	RGC 1017	76.69	95.00
7	RGC 936	78.10	93.09
8	RGC 1033	79.19	96.10
9	RGC 986	76.88	96.24
10	HG 2-20	75.98	96.39
11	HG 870	75.50	92.44
12	HG 884	78.75	93.71
13	HG 365	81.25	102.15
14	HG 563 (Check)	73.12	93.03
	Mean	**74.46**	**95.66**
	S Em ±	0.42	0.58
	CD at 5%	1.21	1.66

Table 4.8 Number of pods per cluster, Number of cluster per plant and Number of pods per plant in cluster bean cultivars

S. No	Cultivars	Number of pods per cluster	Number of cluster per plant	Number of pods per plant
1	RGC 1003	4.61	12.65	40.98
2	RGC 1038	3.34	11.99	40.38
3	RGC 1055	3.56	12.35	54.98
4	RGC 1002	4.43	14.95	58.02
5	RGC 197	3.82	9.91	38.47
6	RGC 1017	4.88	17.09	83.84
7	RGC 936	4.68	16.88	79.86
8	RGC 1033	4.60	14.04	37.37
9	RGC 986	4.10	13.92	49.96
10	HG 2-20	2.64	11.86	48.97
11	HG 870	4.32	8.84	55.31
12	HG 884	3.86	14.95	66.77
13	HG 365	4.81	21.23	73.36
14	HG 563 (Check)	4.26	14.04	60.61
	Mean	**4.13**	**13.90**	**56.35**
	S Em ±	0.41	0.52	3.03
	CD at 5%	1.20	1.52	8.81

Table 4.9 Pod length and weight in cluster bean cultivars

S. No	Cultivars	Pod length (cm)	weight of dry pod (mg)
1	RGC 1003	5.04	280.15
2	RGC 1038	5.13	268.38
3	RGC 1055	5.04	277.92
4	RGC 1002	4.95	258.12
5	RGC 197	5.45	276.12
6	RGC 1017	5.20	280.83
7	RGC 936	6.85	253.83
8	RGC 1033	5.71	275.22
9	RGC 986	5.66	277.03
10	HG 2-20	5.38	268.29
11	HG 870	5.11	262.98
12	HG 884	5.66	312.22
13	HG 365	6.89	314.31
14	HG 563 (Check)	5.05	253.82
	Mean	**5.51**	**275.66**
	S Em ±	0.29	10.65
	CD at 5%	0.85	30.97

Table 4.10 100-seed weight and Number of seeds per pod in cluster bean cultivars

S. No	Cultivars	100-seed weight (g)	Number of seeds per pod
1	RGC 1003	2.70	7.16
2	RGC 1038	2.50	7.43
3	RGC 1055	2.72	7.03
4	RGC 1002	2.68	7.38
5	RGC 197	2.73	6.48
6	RGC 1017	2.70	6.67
7	RGC 936	2.66	7.42
8	RGC 1033	2.68	8.46
9	RGC 986	3.05	7.16
10	HG 2-20	2.55	6.89
11	HG 870	2.19	7.09
12	HG 884	2.71	7.39
13	HG 365	3.05	8.51
14	HG 563 (Check)	2.28	6.88
	Mean	**2.66**	**7.28**
	S Em ±	0.13	0.32
	CD at 5%	0.39	0.95

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Table 4.11 Seed quality in cluster bean cultivars

S. No	Cultivars	Gum content (%)	Protein content(%)
1	RGC 1003	23.26	19.80
2	RGC 1038	18.00	23.58
3	RGC 1055	19.56	19.35
4	RGC 1002	20.52	26.40
5	RGC 197	17.50	22.86
6	RGC 1017	24.10	20.11
7	RGC 936	21.50	19.75
8	RGC 1033	21.12	19.80
9	RGC 986	20.00	18.88
10	HG 2-20	19.46	23.72
11	HG 870	18.59	23.36
12	HG 884	24.49	23.22
13	HG 365	25.00	26.41
14	HG 563 (Check)	22.56	20.69
	Mean	**21.11**	**21.99**
	S Em ±	1.36	1.33
	CD at 5%	3.97	3.87

Table 4.12 Yield parameters in cluster bean cultivars

S. No	Cultivars	Pod yield per plot (kg)	Seed yield per plot (kg)
1	RGC 1003	3.34	1.62
2	RGC 1038	3.25	1.53
3	RGC 1055	2.81	1.49
4	RGC 1002	2.41	1.53
5	RGC 197	2.59	1.48
6	RGC 1017	3.46	1.61
7	RGC 936	3.42	1.60
8	RGC 1033	3.45	1.82
9	RGC 986	3.02	1.48
10	HG 2-20	2.89	1.51
11	HG 870	2.62	1.48
12	HG 884	3.86	1.48
13	HG 365	3.89	1.85
14	HG 563 (Check)	3.44	1.58
	Mean	**3.17**	**1.57**
	S Em ±	0.27	0.07
	CD at 5%	0.80	0.23

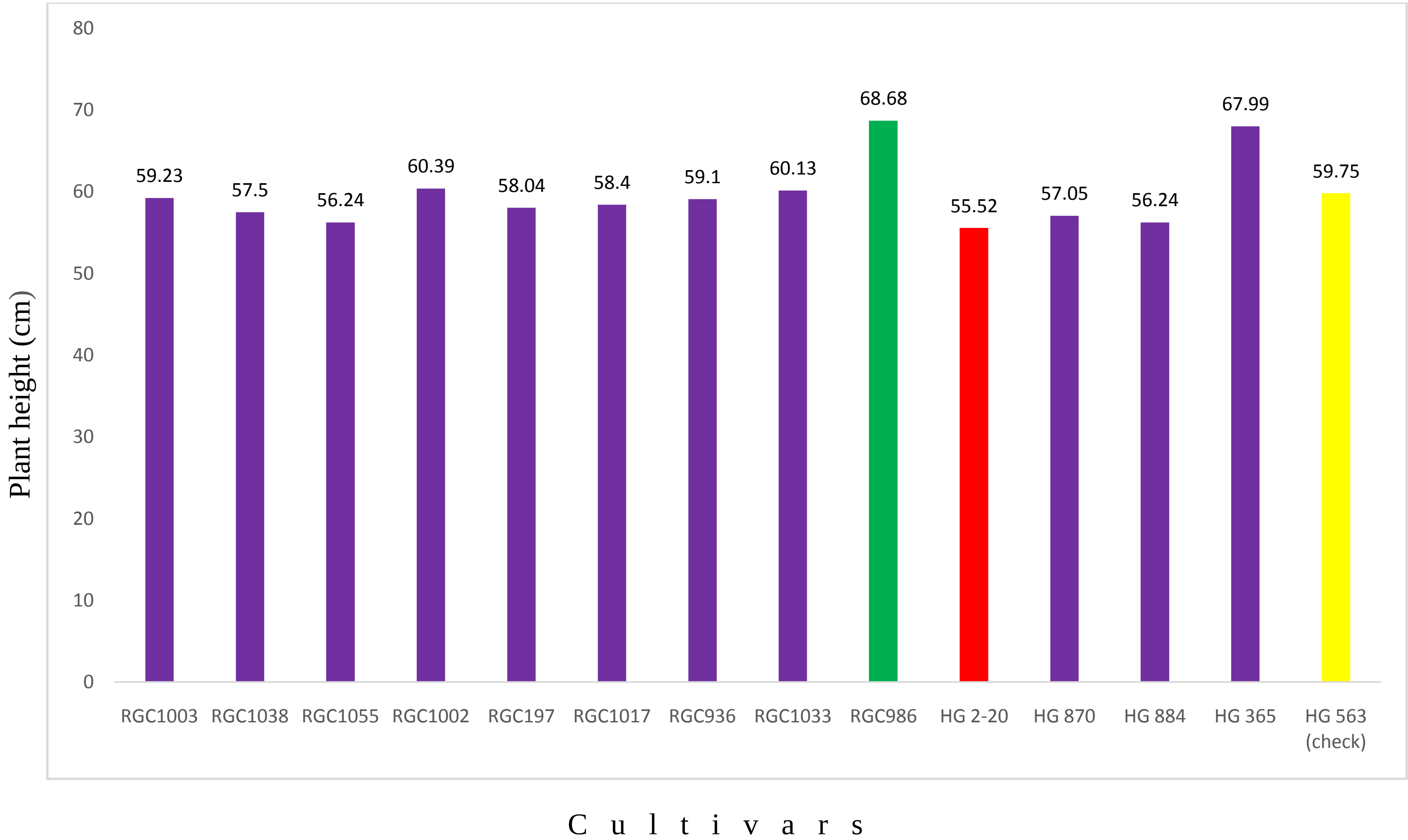


Figure 4. 1 Plant height at 90 DAS in cluster bean cultivars

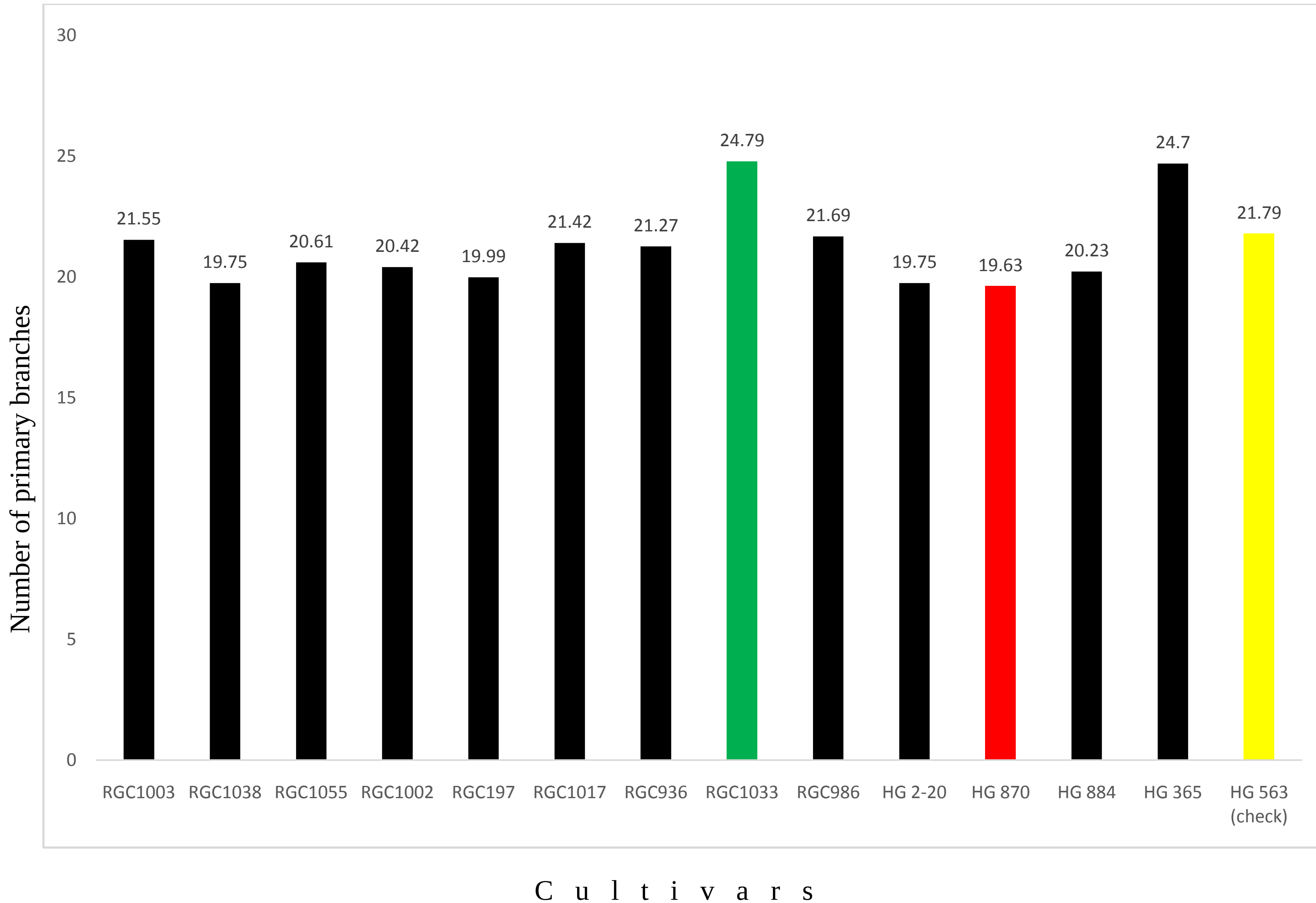


Figure 4. 2 Number of primary branches at 90 DAS in cluster bean cultivars

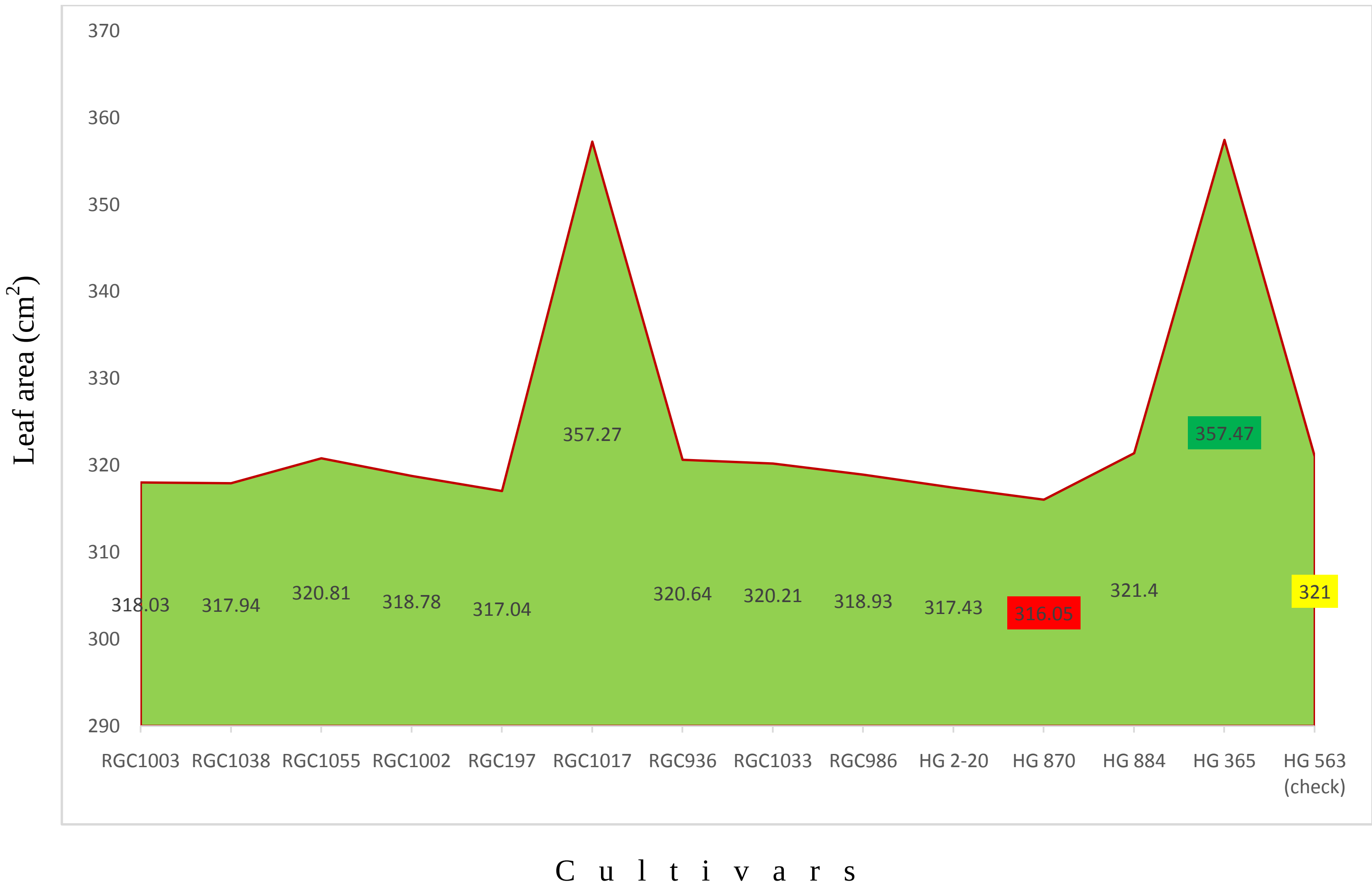


Figure 4. 3 Leaf area at 90 DAS in cluster bean cultivars

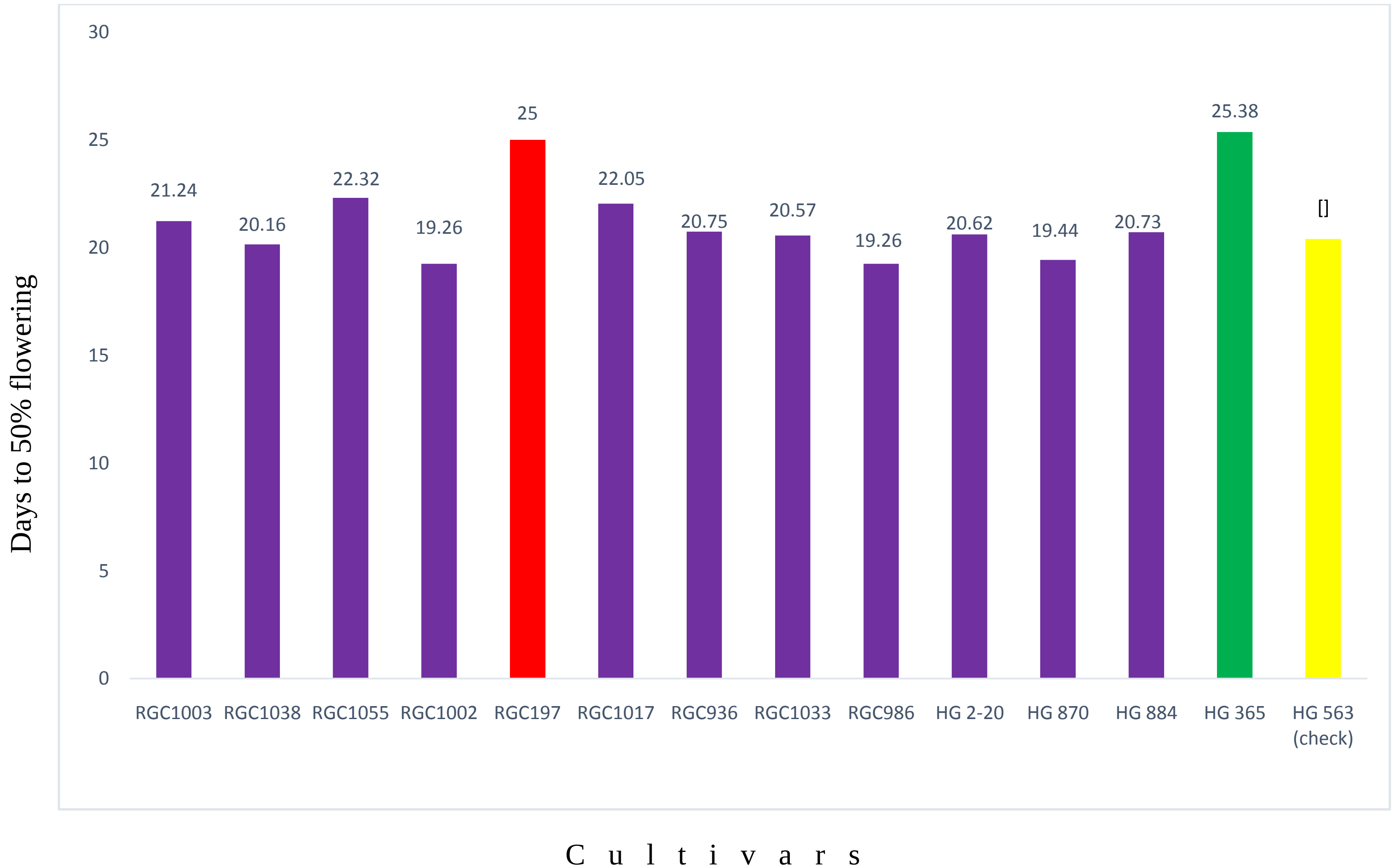


Figure 4. 4 Days to 50% flowering at 90 DAS in cluster bean cultivars

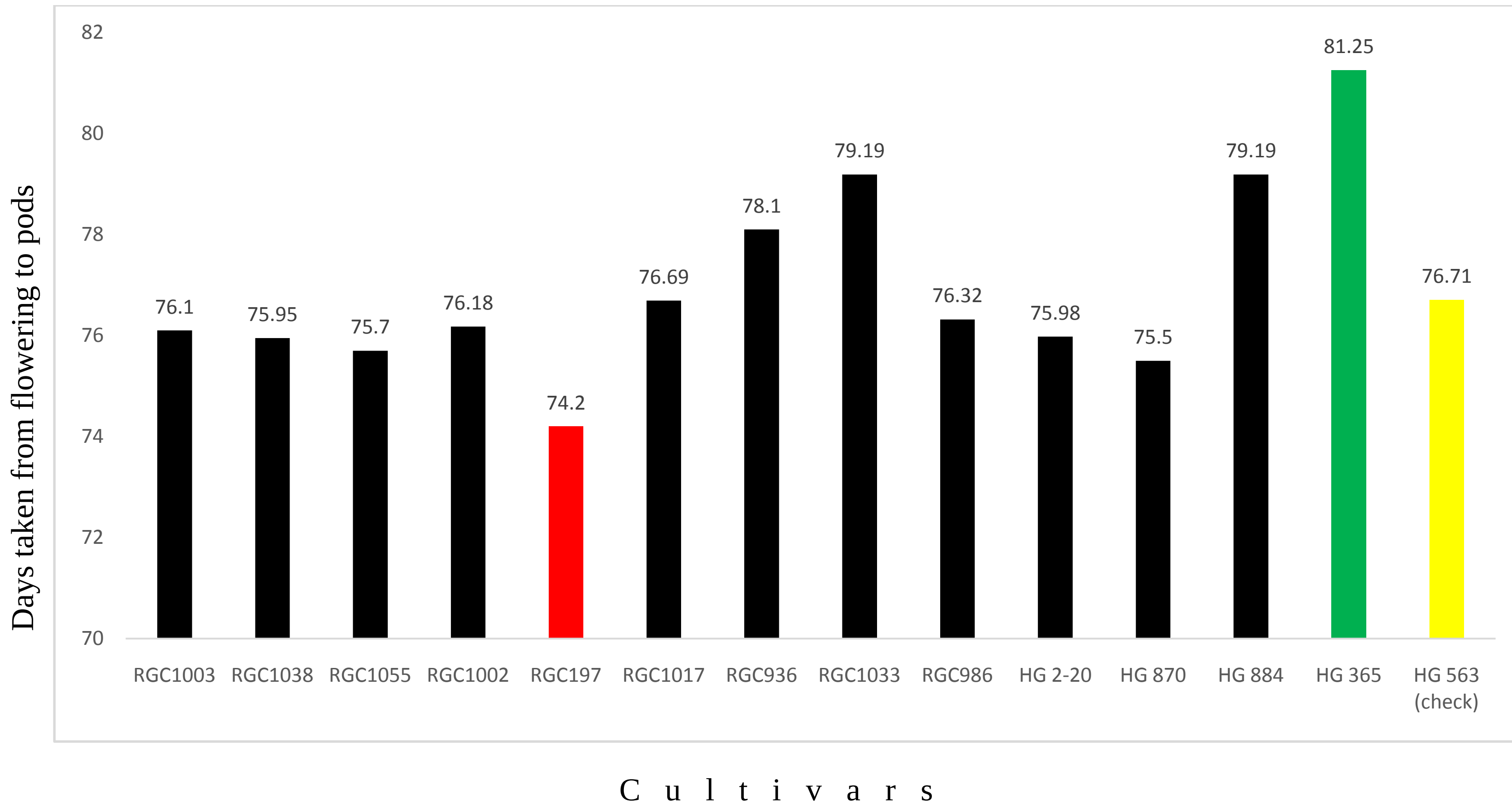


Figure 4. 5 Days taken from flowering to pods drying at 90 DAS in cluster bean cultivars

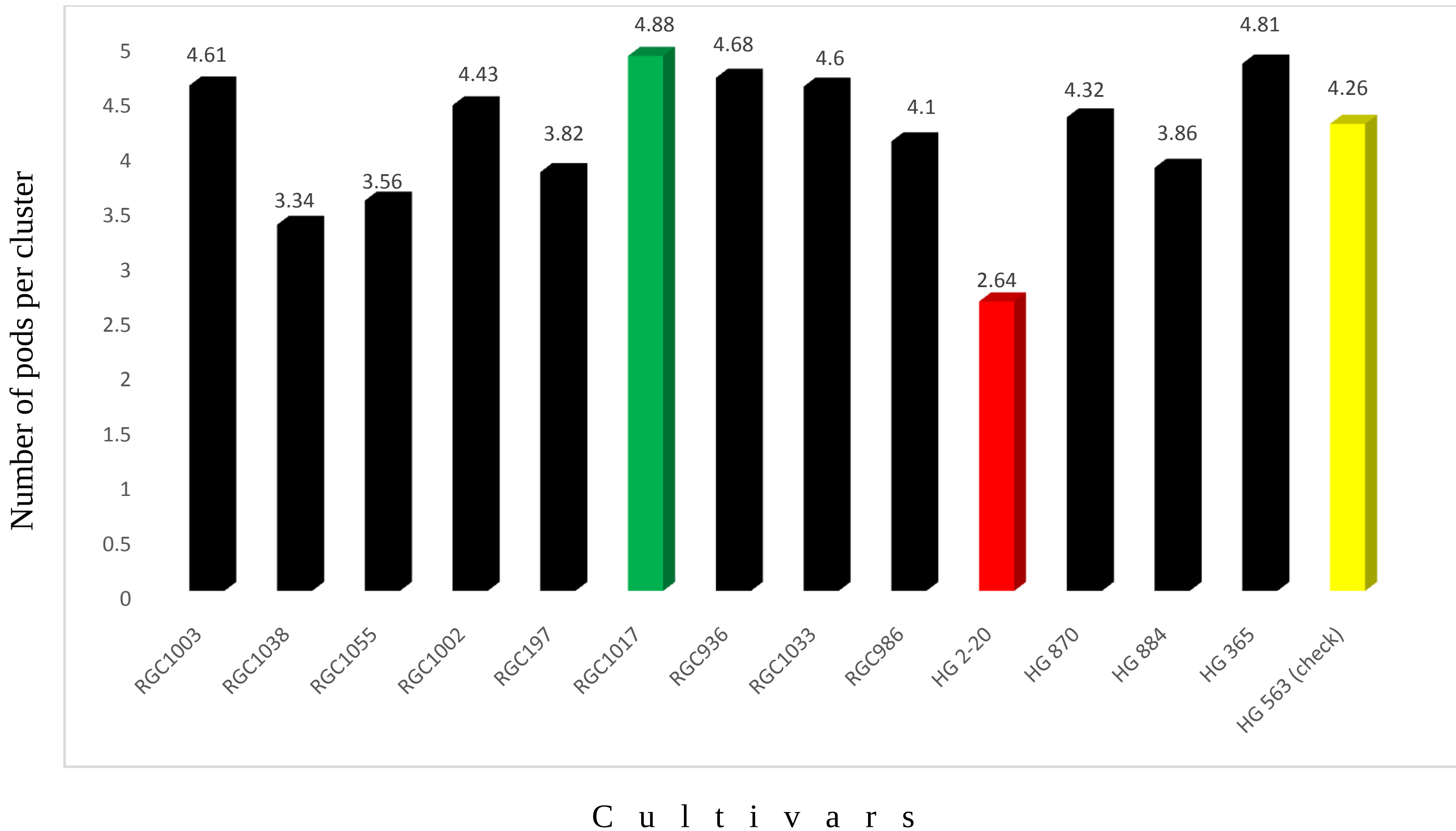


Figure 4. 6 Number of pods per cluster at 90 DAS in cluster bean cultivars

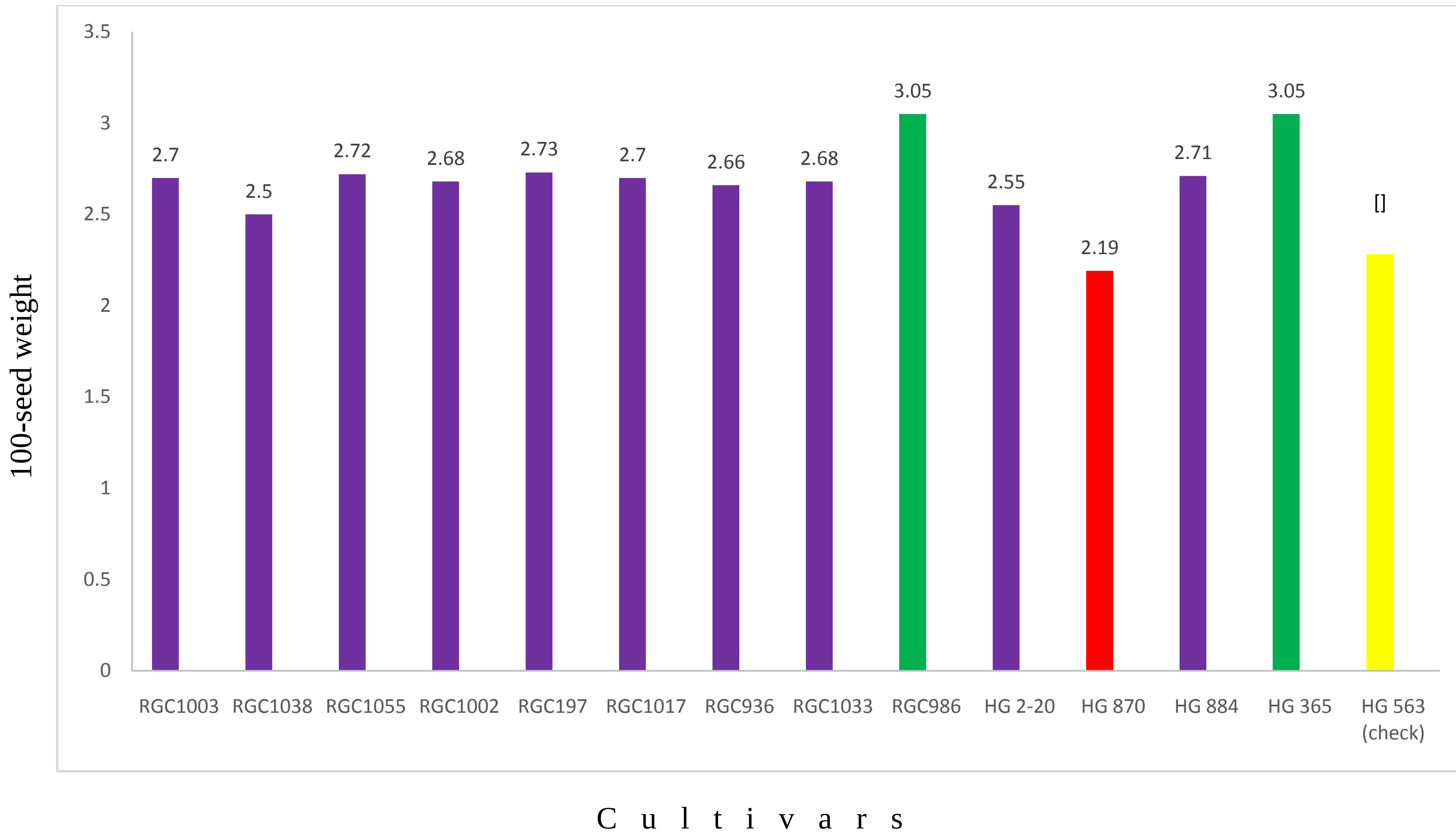


Figure 4. 7 100-seed weight at 90 DAS in cluster bean cultivars

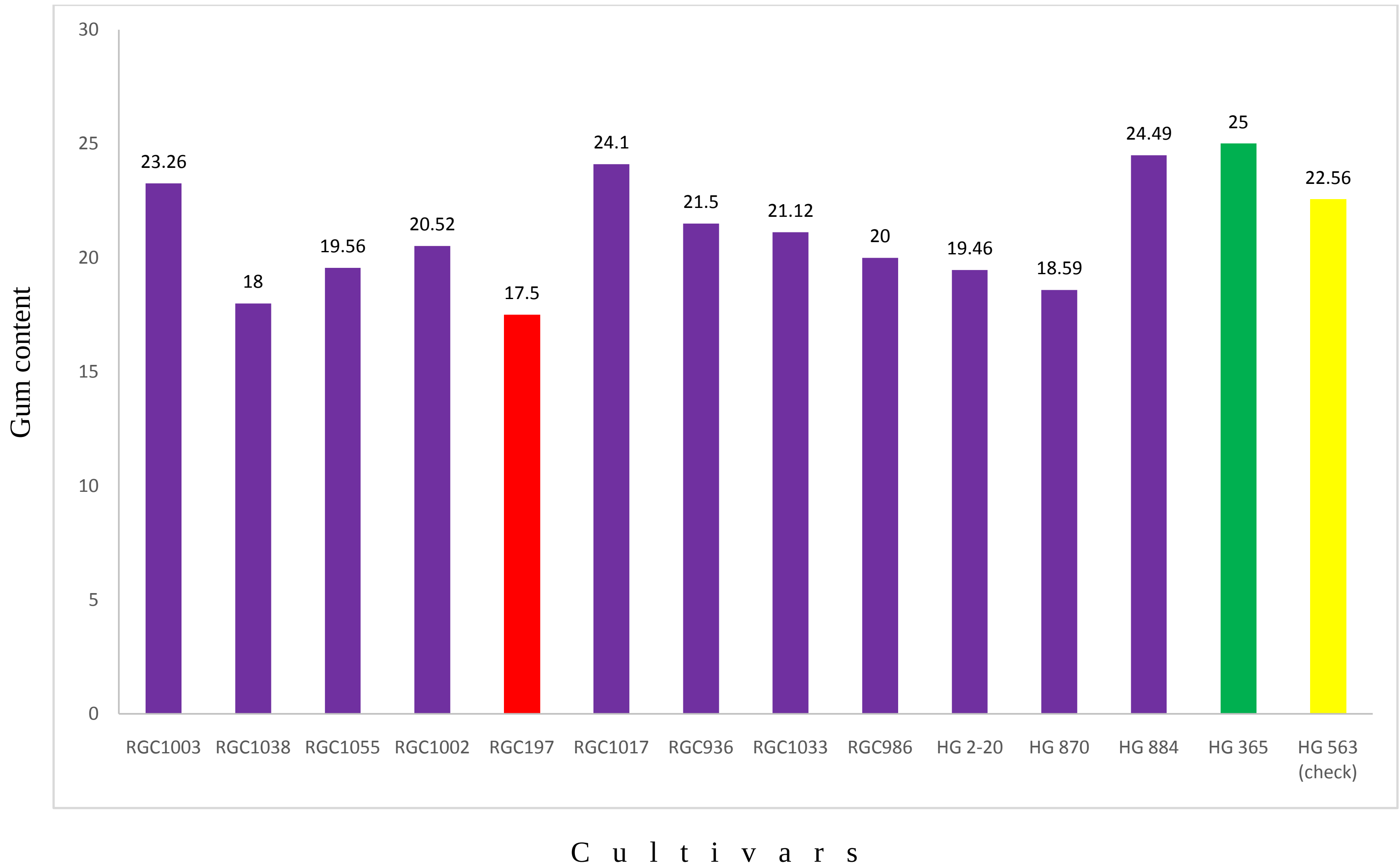


Figure 4. 8 Gum content at 90 DAS in cluster bean cultivars

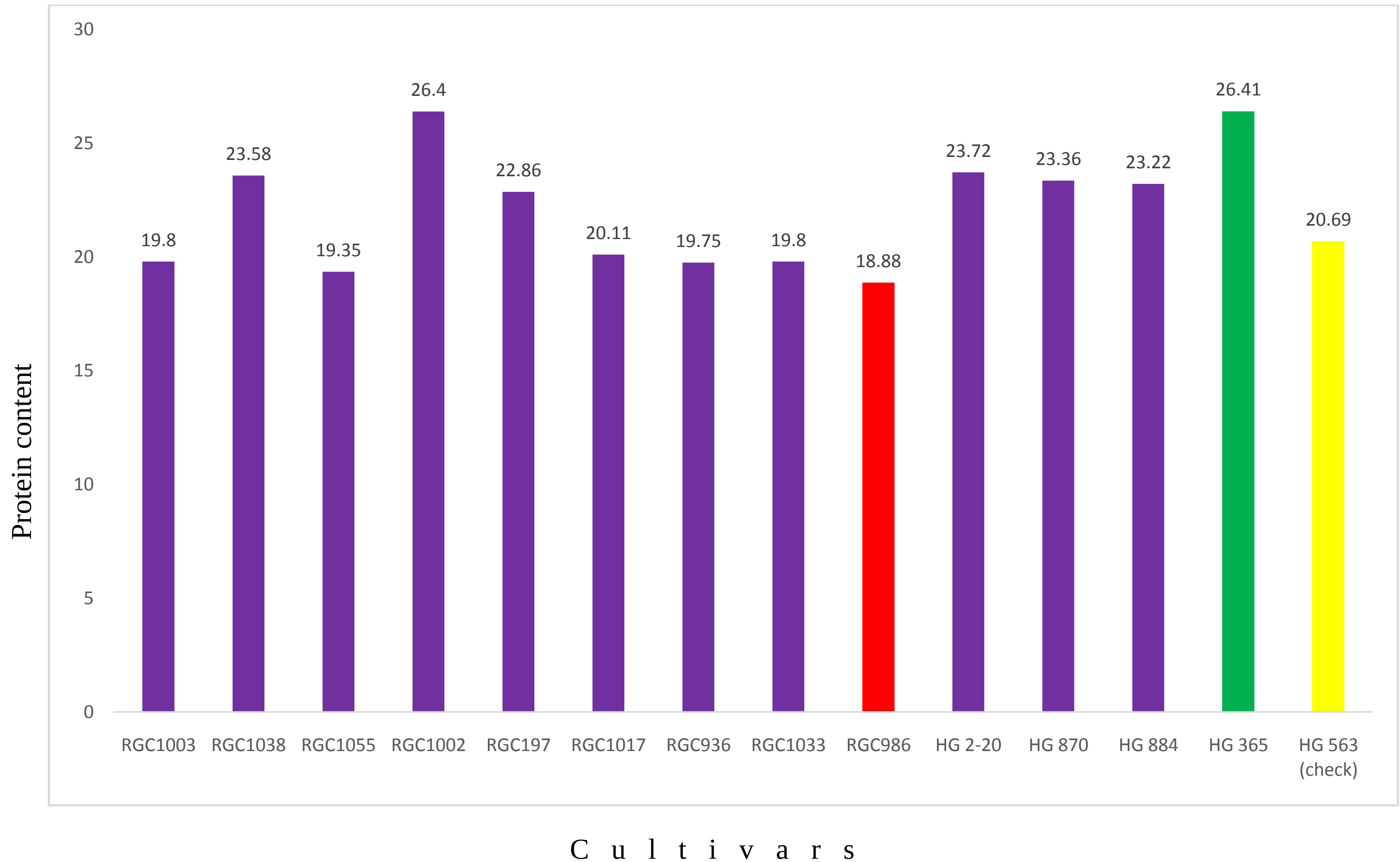


Figure 4. 9 Protein content at 90 DAS in cluster bean cultivars

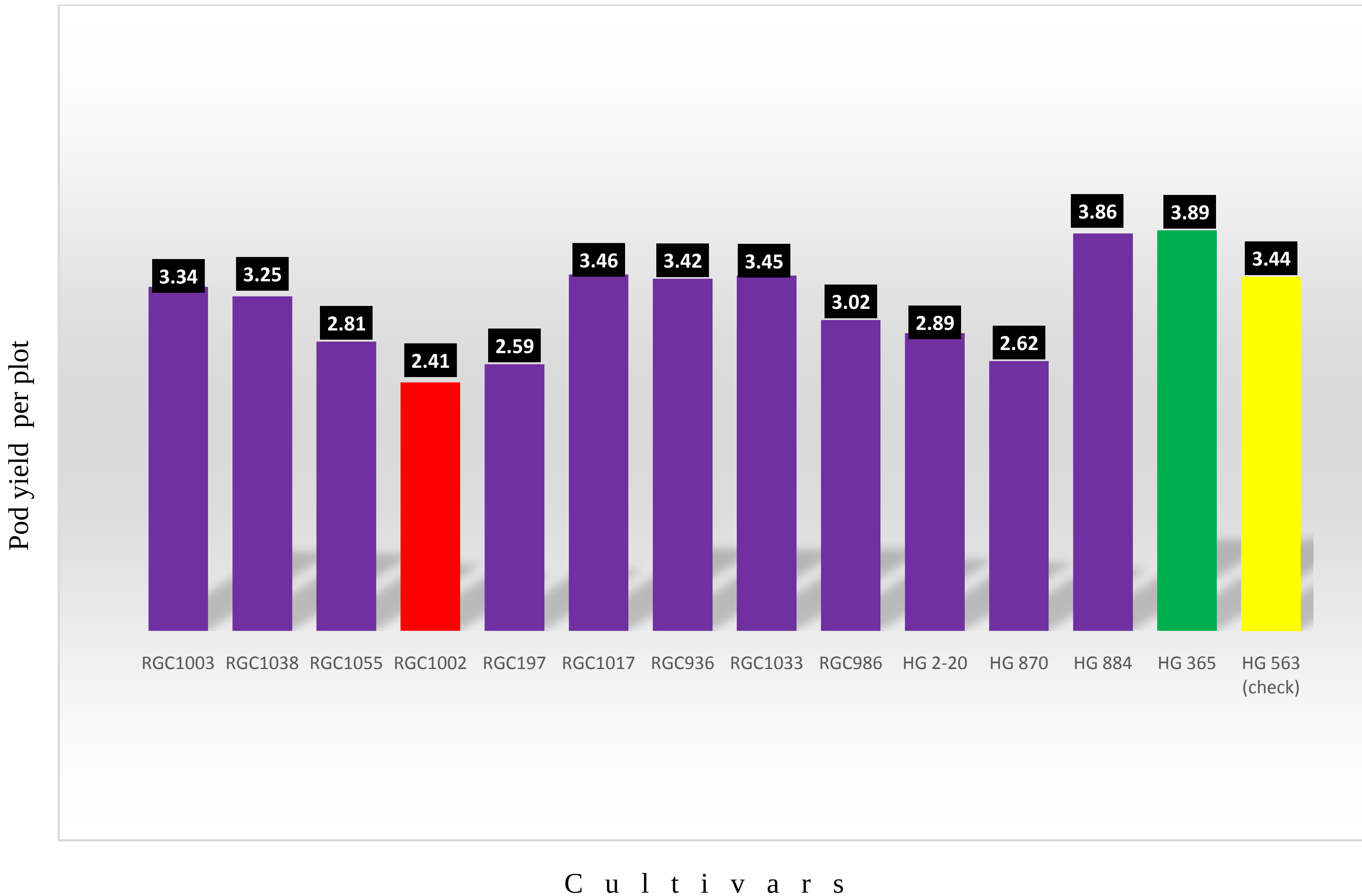


Figure 4. 10 Pod yield per plot at 90 DAS in cluster bean cultivars

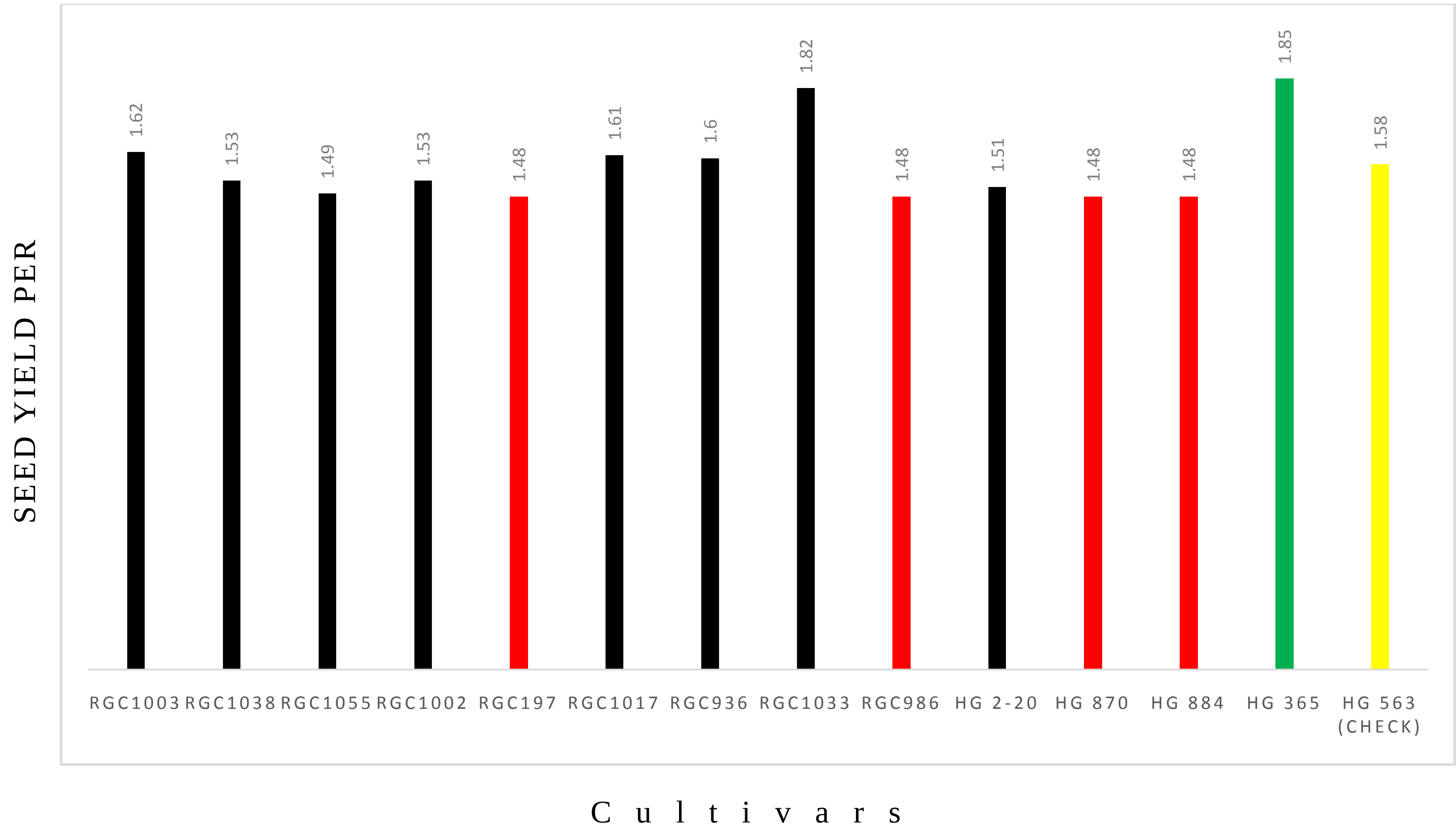


Figure 4. 11 Seed yield per plot at 90 DAS in cluster bean cultivars

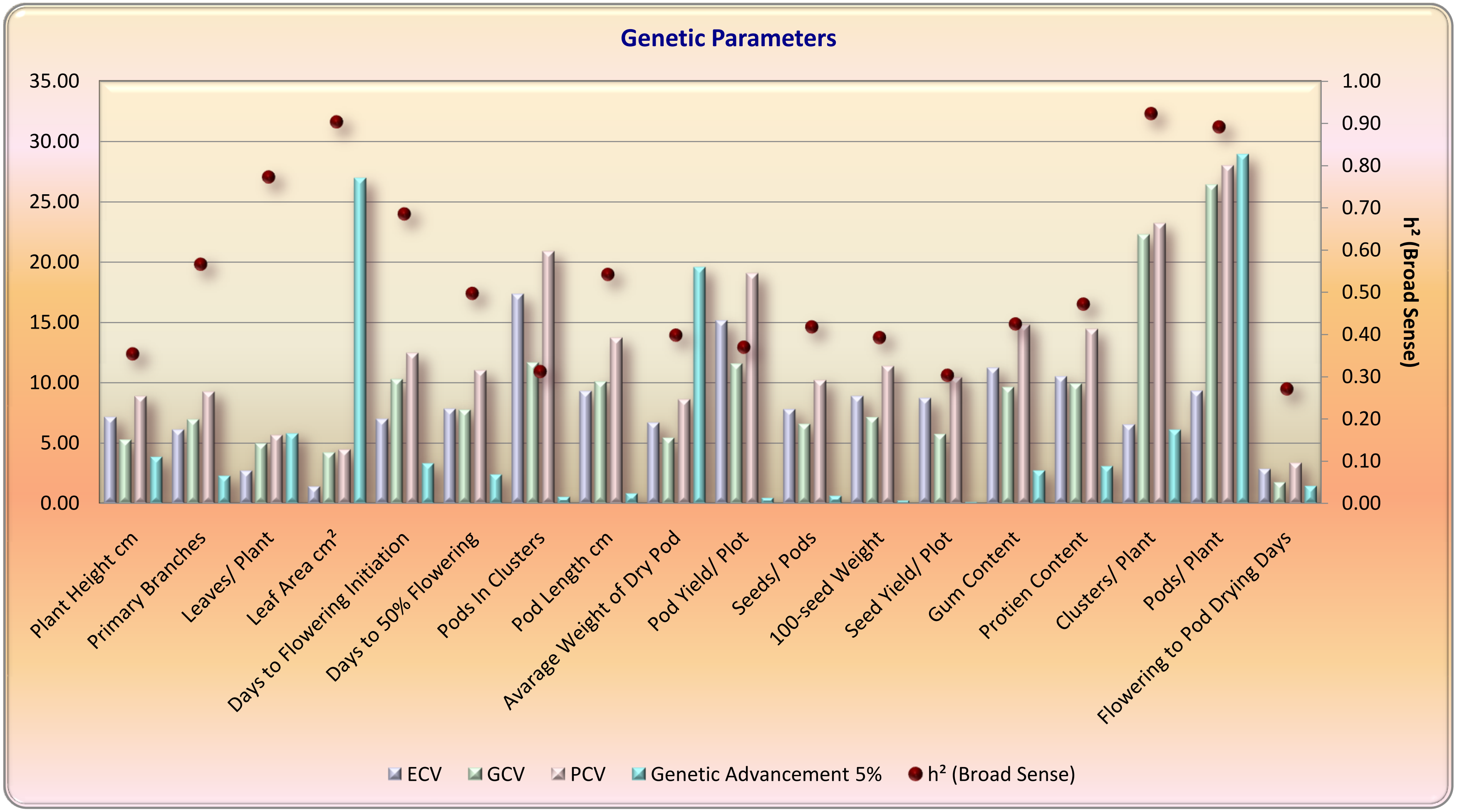


Figure 4. 12 Estimation of variability, heritability and genetic advance as percent of mean for cluster bean cultivars

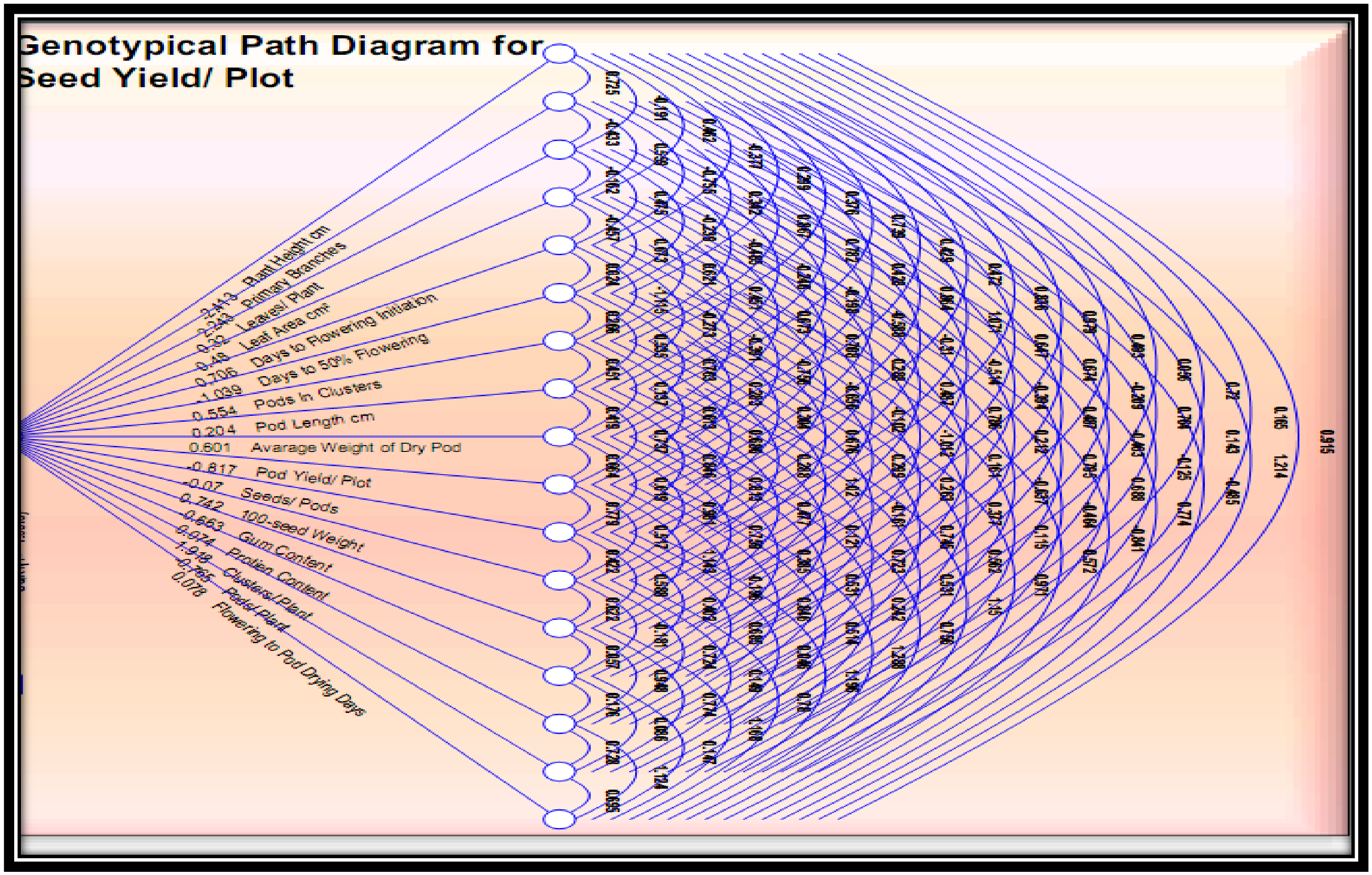


Figure 4.13 Genotypic path diagrams for seed yield per plot

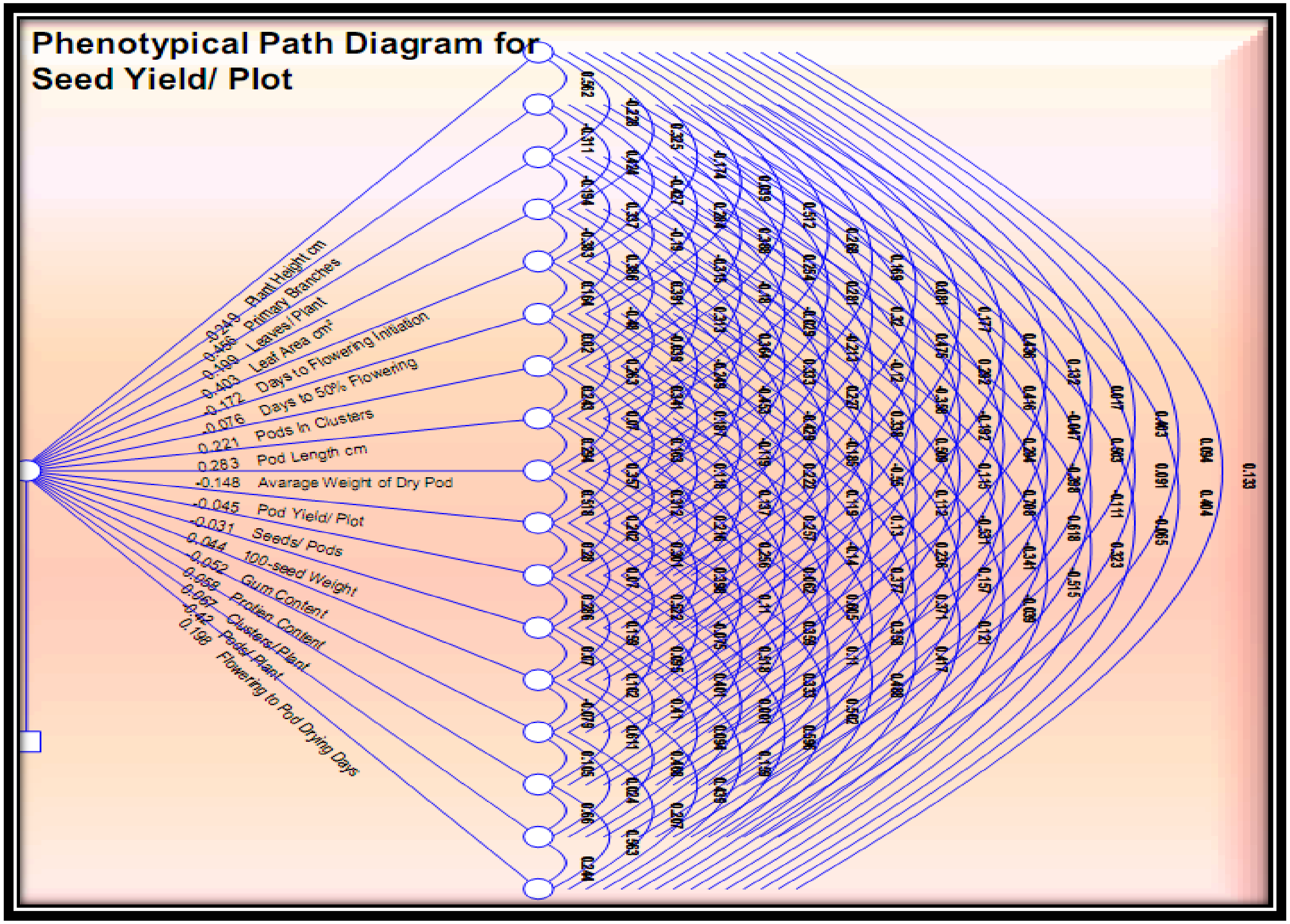


Figure 4. 14 Phenotypic path diagrams for seed yield per plot

RGC 1003

RGC 1038

RGC 1055

RGC 1002

RGC 197

RGC 1017

RGC 936

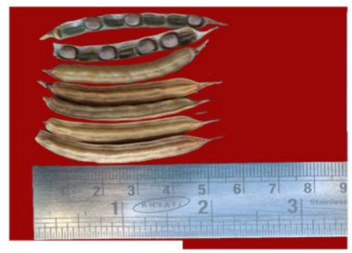
Plate 6 a 100-seed weight of seed cluster bean cultivars

RGC 1033

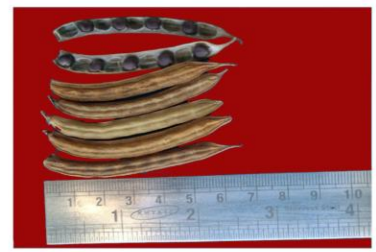
RGC 986

HG 2-20

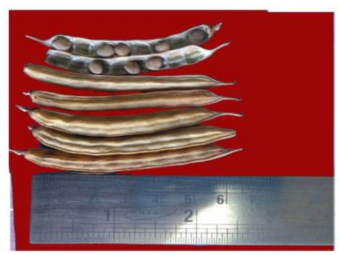
HG 870



HG 884



HG 365



HG 563

Plate 4 b Pod length of seed cluster bean cultivars

RGC 1003

RGC 1038

RGC 1055

RGC 1002

RGC 197

RGC 1017

RGC 936

Plate 4 a Pod length of seed cluster bean cultivars

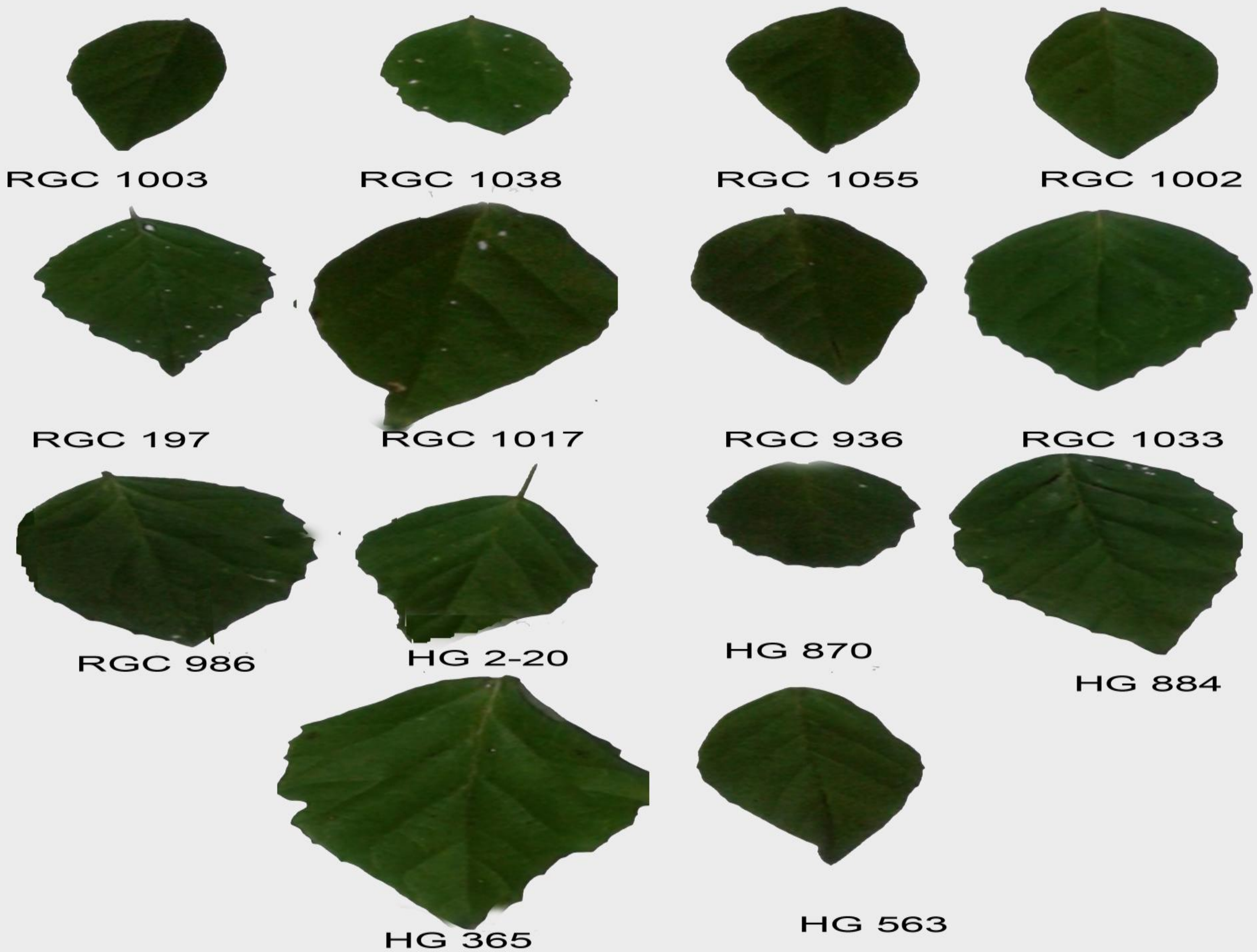
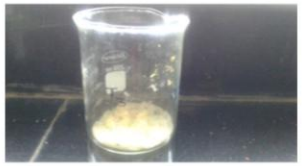


Plate 3 Leaf area of seed cluster bean cultivars

RGC 1003



RGC 1038

RGC 1055

RGC 1002

RGC 197

RGC 1017

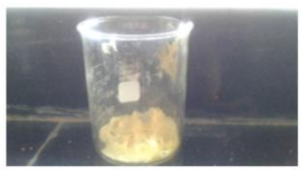
RGC 936

RGC 1033

RGC 986

HG 2-20

HG 870



HG 884

HG 365

HG 563 (check)

Plate 7 Gum content of seed cluster bean cultivars

RGC 1033

RGC 986

HG 2-20

HG 870

HG 884

HG 365

HG 563

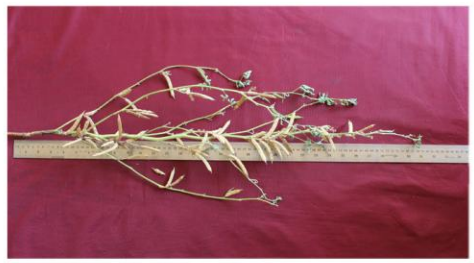
Plat 2 b Plant stature of seed cluster bean cultivars

RGC 1003

RGC 1038

RGC 1055

RGC 1002



RGC 197

RGC 1017

RGC 936

Plat 2 a Plant stature of seed cluster bean cultivars

RGC 1033

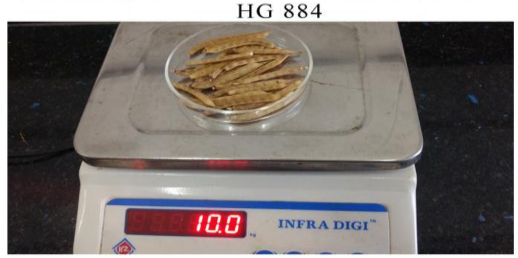
RGC 986

HG 2-20

HG 870

HG 884

HG 365



HG563

Plate 5b Pods Per 10 g of seed cluster bean cultivars

RGC 1003

RGC 1038

RGC 1055

RGC 1002

RGC 197

RGC 1017

RGC 936

Plate 5a Pods Per10 g of seed cluster bean cultivars

Before sowing

10 DAS

60 DAS

90 DAS

Plate 1 General view of the experiment

Chapter V

SUMMARY AND CONCLUSIONS

The present study on the performance of seed cluster bean (*Cyamopsis tetragonoloba* L.) cultivars in Godavari zone was carried out at College of Horticulture, Venkataramannagudem, West Godavari district of Andhra Pradesh during *kharif*, 2016-2017. The major objectives of the study were to assess the genetic variability, heritability and genetic advance for various yield attributing parameters among seed cluster bean cultivars; to study the association between yield and its attributing parameters and to carry out the path coefficient analysis for yield attributing traits on seed yield per plot of different cluster bean cultivars under local conditions. The experiment was laid out in a randomized block design with 14 cultivars replicated thrice.

Observations were recorded on eighteen traits *viz,* plant height (cm), number of primary branches, number of leaves per plant, leaf area (cm^2), days to flower initiation, days 50% flowering, days taken from flowering to pod drying, number of pods per cluster, number of clusters per plant, number of pods per plant, pod length (cm), weight of dry pod (mg), 100–seed weight (g), number of seeds per pod, gum content (%), protein content (%), pod yield per plot (kg) and seed yield per plot (kg).

Analysis of variance showed presence of considerable amount of variation among the 14 cultivars for all these characters, indicating a wide scope for further improvement. The *per se* performance of different cultivars revealed that the plant height was maximum in the cultivar RGC 986, more number of primary branches per plant were exhibited by the cultivar RGC 1033, whereas the cultivar HG 870 produced maximum number of leaves per plant. The maximum value of leaf area was recorded in the cultivar HG 365. The earliest occurrence of days to 50% flowering was observed in HG 365.

The earliest initiation of flowering occurred in the cultivar RGC 1033 Whereas, the 50% flowering stage was exhibited at the earliest by the cultivars RGC 986 and RGC 1002. Maximum number of clusters per plant in the cultivar HG 365. Maximum number of pods per plant was observed in RGC 936. The pod length was highest in HG 365, while the weight of dry pod was maximum in HG 365. Maximum 100-seed weight was observed in HG 365 and RGC 986, the cultivar HG 365 recorded highest seed yield per plot. The highest percentage of gum content in the cultivar HG 365. Highest percentage of protein content was observed in HG 365, the cultivar HG 365 recorded maximum pod yield per plot. Maximum seed yield in terms of kg per plot was noticed in HG 365.

The estimates of phenotypic variance were higher than the corresponding estimates of genotypic variance for all the traits, thereby indicating the influence of environment in the expression of these traits. Higher magnitude of PCV and GCV (> 20%) were observed for number of pods per plant and number of cluster per plant, indicating the existence of wide range of genetic variability in the germplasm for these traits.

High heritability (h_b^2) estimates (>60%) coupled with high estimates of genetic gain as percent of mean (>20%) were observed for the traits viz., number of clusters per plant and days to flower initiation indicating that they were controlled by additive gene effects and thus the chances of fixing them by selection would be more prospective. However, high heritability coupled with moderate genetic advance as per cent of mean was noticed in the traits number of cluster per plant, leaf area (cm^2), number of pods per plant, number of leaves per plant and days to flower initiation indicating that their inheritance was controlled by both additive and non-additive gene actions.

The correlation study indicated that number of primary branches, number of seeds per pods, pod yield per plot, number of pods per cluster and leaf area had significant positive association with seed yield per plot at genotypic level.

This signified the importance of these traits for selection to improve the seed yield.

Path coefficient analysis explained 81% variation at genotypic and 58% variation at phenotypic level in the dependent variable *i.e.* seed yield per plot. A high positive direct effect on seed yield per plot was exerted by the traits *viz.*, number of primary branches, number of seeds per pod, pod yield per plot, number of pods per cluster and leaf area. The high direct effect of these traits might have led to their strong association with seed yield. On the other hand, a high negative direct effect was exerted by days to flower initiation and number of leaves per plant. The magnitude of direct effects by these traits is indicative of the effectiveness of direct selection based on such traits.

Based on the present investigation, it can be conclusively stated that the cultivars HG 365, RGC 1033, HG 884, RGC 1017 and RGC 936 would be more beneficial for seed cluster bean farmers under local conditions. The crop improvement work in seed cluster bean can be concentrated on the traits like number of cluster per plant, number of pods per plant, number of leaves per plant and days to flower initiation being controlled by additive gene effects since, they had recorded a high heritability coupled with high genetic advance as per cent of mean. The character association and path analysis prompted that the selection for improvement in respect of seed yield would be more effective had it been based on the traits like number of primary branches, number of cluster per plant, gum content, number of seeds per pod and number of pods per cluster.

FUTURE LINE OF WORK

The cultivars studied in the present investigation had high variability for yield and yield attributing parameters. The cultivars HG 365, RGC 1033 and HG 884 occupied first three ranks for yield therefore; the studies mentioned below can be carried out in future.

1. Performance of promising cultivars can be tested under different locations in the state or country.
2. Characterization of cultivars may be done using molecular markers.

3. Screening of genotypes may be performed against important pests and diseases.
4. Standardization of production technology needs to be carried out for organic cultivation of seed cluster bean with an emphasis on gum content of seeds.

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Appendix-I

Weekly meteorological data recorded at COH, Venkataramannagudem, West Godavari district from July to October - 2016.

S. No	Standard week No.	Temperature (^oC)		Relative humidity (%)		Number of rainy days	Rainfall (mm)
		Max.	Min.	08:00 h	14:00 h		
1	**45** (11/07 to 15/07)	32.50	23.00	91.00	82.00	2	35.00
2	**46** (16/07 to 22/07)	25.70	21.07	92.85	87.50	0.00	0.00
3	**47** (23/07 to 29/07)	27.20	19.40	92.28	92.70	1.00	17.00
4	**48** (30/08 to 06/08)	31.10	20.70	93.28	92.40	0.00	0.00
5	**49** (07/08 to 13/08)	31.10	21.50	91.80	92.50	1.00	27.4
6	**50** (14/08 to 20/08)	31.00	19.50	92.00	92.80	0.00	0.00
7	**51** (21/08 to 27/08)	30.28	19.80	91.40	89.00	0.00	0.00
8	**52** (28/08 to 04/09)	30.70	19.10	92.14	92.80	2.00	6.8
9	**53** (05/09 to 11/09)	30.30	19.07	91.60	92.70	0.00	0.00
10	**01** (12/09 to 18/09)	29.60	19.40	91.80	91.00	0.00	0.00
11	**02** (19/09 to 25/09)	29.57	18.70	91.00	93.00	1.00	2.8
12	**03** (26/09 to 02/10)	29.10	20.07	91.70	89.00	1.00	3.5
13	**04** (03/10 to 09/10)	30.07	19.50	91.40	92.80	0.00	0.00
14	**05** (11/10 to 17/10)	30.70	19.70	91.57	97.00	0.00	0.00
15	**06** (18/10 to 24/10)	30.90	20.30	92.00	92.70	2.00	35.4
16	**07** (25/10 to 31/10)	32.50	18.10	91.28	92.00	1.00	17.2