GENETIC VARIABILITY AND CORRELATION ANALYSIS OF COUNTRY BEAN (*Lablab purpureus L.*)

BY

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CERTIFICATE

*This is to certify that thesis entitled, "**GENETIC VARIABILITY AND CORRELATION ANALYSIS OF COUNTRY BEAN (Lablab purpureus L.)** " submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **GENETICS AND PLANT BREEDING**, embodies the result of a piece of bonafide research work carried out by **Robiul Islam**, Registration No. **04-01391** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2010
Place: Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED
PARENTS

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LIST OF ABBREVIATED TERMS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
And others	*et al.*
Accessions	ACC
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
Centimeter	cm
Co-efficient of Variation	CV
Etcetera	etc.
Figure	Fig.
Genotype	G
Genetic Advance	GA
Genotypic Co-efficient of Variation	GCV
Genotypic Variance	δ^2_g
Gram	g
Heritability in broad sense	h^2b
Journal	j.
Kilogram	Kg
Meter	M
Mean Sum of Square	MSS
Millimeter	Mm
Muriate of Potash	MP
Number	No.
Percent	%
Phenotypic Co-efficient of Variation	PCV
Phenotypic variance	δ^2_p
Randomized Complete Block Design	RCBD
Replication	R
Research	Res.
Sher-e-Bangla Agricultural University	SAU
Standard Error	SE
Square meter	m^2
Triple Super Phosphate	TSP

GENETIC VARIABILITY AND CORRELATION ANALYSIS OF COUNTRY BEAN (*Lablab purpureus L.*)

BY

ROBIUL ISLAM

ABSTRACT

An experiment was conducted with 37 country bean lines at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, during September 2008 to March 2009. The objectives of the study were to measure the variability among the genotypes for yield and yield contributing characters, estimate genetic parameters, association among the characters and their contribution to yield. There was a great deal of significant variation for all the characters among the genotypes. Considering genetic parameters high genotypic co-efficient of variation (GCV) was observed for yield per plant, pod weight and number of inflorescence per plant whereas low genotypic co-efficient of variation (GCV) was observed days to first flowering and number of flower per plant. In all cases, phenotypic variances were higher than the genotypic variance. High heritability with low genetic advance in percent of mean was observed in days to first flowering which indicated that non-additive gene effects were involved for the expression of this character and selection for such trait might not be rewarding. High heritability with high genetic advance in percent of mean was observed for yield per plant indicated that this trait was under additive gene control and selection for genetic improvement for this trait would be effective. The results obtained, showed that yield per plant had high positive and high significant relation with number of pod per plant. Correlation studies revealed that highest significant association of yield per plant with fruit diameter and number of fruit per plant at genotypic level. Considering all the characters the G21, G3, G8, G35 and G19 were selected for future breeding programme.

CHAPTER I

INTRODUCTION

The country bean (*Lablab purpurious* L.), known as "seem" is a popular vegetable of Bangladesh. It is also called Indian bean or lablab bean or hyacinth bean. It is one of the important legume vegetables cultivated in India and Bangladesh. The tender green pods and immature green seeds are used as vegetables and dry seeds are used as pulse. Besides, this crop is grown world wide for various purposes. In South and South East Asia, hyacinth bean is traditionally used as a pulse crop and the immature pods serve as a vegetable (Duke *et al.*, 1981). Similarly, in Africa both the grain and the immature pods are a minor human food source (Smartt, 1985) and it has become an important annual forage crop in Australia (English, 1999) and America (Maass *et al.*, 2003). Despite its wide distribution in the tropics, its adaptability and diversity, it is considered as a neglected crop with underused potential (NAS, 1979; Smartt, 1985).

The present nutritional situation of Bangladesh is a matter of great concern. The prime nutritional problem of the country is that of protein-energy malnutrition. Most of our people are suffering from malnutrition. There are two sources of protein, viz. animal and plant protein. Leguminous crops play an important role to meet up the protein deficiency problem. Pulses and bean contain 20-30% protein on a dry weight basis which is nearly three times that in most cereals (Ramanujam, 1979). Vegetables can play an important role in human nutrition. Lablab bean *[Lablab purpureus* L. (Sweet)], commonly known as 'Seem' or Country bean hyacinth bean, is an indigenous vegetable of Indo-Bangladesh region (Ahmed, 1982). It is a self-pollinated crop and belongs to the

family leguminosae, sub-family papilionaceae. This crop is grown in a few countries like Bangladesh, India, Philippines, Malaysia, Japan, Egypt and Sudan. Some people believe that this crop is originated in Africa (Rashid, 1976). Katyak and Chadha, 1985 and Chowdhury *et al.* 1989 mentioned that India to be the place of its origin from where it is spread to the other parts of the world. Lablab bean is a suitable companion forage crop. It is of economic importance for seed and pod in Bangladesh. It is a nutritional vegetable. Its green pods provide good amount of protein in addition to vitamins and minerals (Gopalan *et al,* 1982). One hundred grams of young pods contain 83% water, 4.50 g protein, 10.00 g carbohydrate, 1.00 g fat, 2.00 g fiber, 0.05 mg thiamine, 0.01 mg riboflavin and little amount of vitamin C. the dry seed contains 8% water, 25.00 g protein. 60.00 g carbohydrate, 0.80 g fat, 1.40 g fiber, 100 IU of vitamin A, 0.50 mg thiamine, 0.10 mg riboflavin, 1.80 mg niacin and slight amount of vitamin C (Rashid, 1976).

In Bangladesh, India and some other countries, the young pods developed unripe seeds are used as vegetables and the ripe seeds are used as pulse. Both the pod and seeds are delicious and are liked by all Bangladeshi people. This crop has the potential to reducing the protein deficiency of our people. People, in Bangladesh consume 104 g vegetable per head per day (Anon, 1991) but the minimum requirement is 200 g (Rashid, 1993). Although the vegetable production is increasing day by day it fails to keep place with the requirement. So, it is necessary to take massive vegetable production program to meet up the gap.

Yet no comprehensive systematic research has been done in this crop in Bangladesh. Present harvestable yield of country bean is very low (3.72 t/ha, BBS, 2003) due to unavailability of high yielding varieties. Country bean is monoecious and highly cross-pollinated in nature. Such pollination mechanism can be exploited for hybrid seed production commercially. Moreover, there is a great scope of development of open pollinated varieties utilizing the existing variability. As a minor vegetable, country bean did not get proper attention for its genetic improvement in the past. Considering the availability of genetic variability, its scope of yield improvement and export potential, the present investigation was undertaken with the following objectives:

- To know the yield potentiality of genotypes,
- To know the association of traits with yield and its contributing traits and
- To study the genetic variability among the genotypes

CHAPTER II

REVIEW OF LITERATURE

Country bean is one of the most important vegetables in Bangladesh. Although this crop originated in the Indian subcontinent, very little scientific research has been done on its growth, yield and nutrition. Country bean is a good source of protein and carbohydrate. The seeds of this bean have high nutritive value and are good source of protein and carbohydrate (Newaz, 1991). The chemical composition of bean is influenced by the variety, the age of the pods and certain external and internal factors. Information of biochemical composition is also scanty. However, an attempt has been made to review available information related to the present study.

Growth habit is one of the most important characteristics for classifying bean varieties from the agronomic viewpoint. Beans are morphologically classified as determinate or indeterminate depending on whether the terminal meristem is reproductive (determinate) or vegetative (indeterminate). This characteristic is genetically controlled. International Centre for Tropical Agriculture has designed a widely accepted classification scheme based on the former characteristic and on the type of plant development.

Seasonal influence on yield contributing characters of lablab bean was observed by Uddin (2003). He reported that every delay in planting was associated with decreased in yield, irrespective of genotypes, so that the yield reduction reached to the extend of 63 to 96 %. This reduction due to delayed planting was accounted for by the detrimental

influence of environmental factors like high temperature, high humidity and high rainfall on anther quality, pollination, pollen tube growth, etc. these, in turn, lead to reduce number of pod set, reduce pod size and reduce number of pods per inflorescence, and ultimately reduced pod yield.

According to Chakravarty (1986) and Rashid (1976) a well- managed country bean crop might produce a yield of five to nine tons of green pods per hectare and Rashid (1976) conducted an experiment with 54 genotypes of field bean (*Lablab purpurious* L. Sweet) to find out the best genotypes. He concluded that plant spread and number of pods per plant had the highest positive and direct effects on green pod yield per plant.

Rashid (1976) stated that flowering of most of the hyacinth beans are influenced by day length. Since most of these beans are short day plants they can produce flower and fruits only in the winter in areas other than the places near equator. He further stated that Bangladeshi farmers usually sow the seeds of hyacinth beans during the period from July to September. For getting an early crop the varieties should be sown early. Since the late varieties will not flower until it receives the right photoperiod it would be useless to show their seed early for obtaining an early harvest. Some of varieties do not flower until December, irrespective of date of sowing.

Some of the hyacinth bean varieties can produce flower about 6 weeks after sowing (Purseglove, 1977). Chowdhury and Ali (1987) and Sultana (2001) also reported the similar result. Chowdhury (1989) found that hyacinth beans are mostly photosensitive but one variety was able to produce flowers and pods at any day lengths from eight to

fourteen hours. According to Ahmed (1976) the proper time of sowing is from the month of June to August and fruits are obtained during the month of November to March. Country bean start to become available in Bangladesh market from the month of November and a plant may continue to flower and pod for more than 3 months (Rashid, 1976).

Rahman (1988) reported that support is essential for lablab bean production. Bamboo matcha, branches of the plants etc. are commonly used as support. Rahman and Hapue (1992) observed that among supporting materials bamboo matcha (trellis) was best for the support of hyacinth bean.

Rahman *et al.* (1985) studied the morphological characters and yield performance of 20 different collections or accessions of country bean. Significant variations among the materials with respect to opening of first flower, number of pods per plant, pod length and breadth and green pod yield were found. The accessions CB-14, CB-15, CB-18, CB-5 and CB-7, took the shorter period (84-94 days) to flower. The early accession CB-18 gave the highest green pod yield (14.5 kg per plant) followed by CB-4 (11.6 kg per plant), a medium late accession.

Bhadwaj *et al.* (1994) reported that French bean yield decreases with delay in sowing date. The number of pods per plant and 1000 seed weight also decreased with the shift of time in the fall. Vays *et al.* (1990) also stated that seed yield varied with various sowing dates. In case of this crop the highest seed yield was obtained from mid September sowing and the lowest from mid December sowing.

The common bean (*Phseolus vulgaries* L.) is practically sensitive to vagaries of weather. Under moderate temperature most of the pod development of snap bean is associated with cessation of flower bud production with enhanced abscission of flower buds. Raising night temperature from 17^0 C to 27^0 C strongly reduces pod production, mature pod size and seeds per pod. Under $32/27^0$ C day/night temperature reduction in pod set was due to enhanced abscission of flower buds, flowers and young pods (Konsens *et al.* 1991) leading to low yield. This low yield stability under non-optimal conditions is one of the main obstacles to the expansion of bean cultivation into regions or seasons in which transient climatic conditions, adverse for pod and seed set frequently occur. Periods of hot weather imposing temporary heat and/or drought stress during productive development are usually associated with large decrease in yield, and these have been attributed to enhanced flower and pod abscission. In the field, pod set is negatively correlated with daily maximal temperature during anthesis (Davis, 1945; Smith and Pryor, 1962). Pod set is unaffected by raising the day/night temperature from $24/15^0$ C to $29.5/21^0$ C, but no mature pod is produced at $35/26.5^0$ C probably due to fertilization failure.

Flower abortion, and to some extent pod abortion, is particularly high in field beans (*Vicia faba*) and normally more than 75% of the floral buds fail to produce mature pods. In some conditions, usually of very high rainfall, almost all the flowers can abort. This is considered as major-limiting factor of yield in that crop (Rowland *et al.,* 1983).

Furthermore flower abortion has been considered a post-fertilization phenomenon caused by embryo abortion (Rowland, 1960).

The reproductive process such as flower formation (Aung, 1976; Charles and hairs, 1972), pollen grain and ovule formation (Fujii, 1948; style elongation (Abdulla and Verkesk, 1968), pollen germination (Fujii, 1948) and fertilization and seed formation are generally affected by high temperature. The impairment of any one of these physiological processes can result in reduced fruit set. In field beans, unreliability in seed could be due to variation in frequency of fertilization (Rowland *et al.,* 1983).

A decreased in seed yield of faba beans with delay in sowing after the end of April was reported by Marcellos and Constable (1986). They mentioned that late sowing increases the likelihood of yield loss through foliar disease. Krarup (1983) also found similar results. He observed that seed yield of 2.75 t/ha in mid-August sowing was reduced to 0.76 t/ha in mid-October sowing.

Nandi *et al.* (1997) showed that pod weight and pod girth were positively and significantly correllated with green pod yield/plant. The number of pods/plant was closely associated with green pod yield/plant.

Highest seed yield of faba bean were obtained from 3 April sowing in 1986 and 24 February in 1987. Earlier sown crops had larger canopies at pod filling. This may be reflected the influence of temperature on expansion and senescence of leaves during development (Pilbeam *et al,.* 1989).

Mauk (1987) studied the flower and pod abscission in snap bean as influenced by inflorescence position, raceme node, and irrigation and plant density. He reported that a sharp rise in reproductive abscission was observed after 3 days period when the maximum daily temperatures exceeded 34^0C. This early rise in abscission was reduced by highly irrigation and low plant density. Abscission of flowers at white bud stage or at anthesis was relatively low. The majority of the reproductive organs were shed after anthesis. Low plant density also postponed abscission of reproductive organs at node 2, but had less effect at node 6.

According to Diaz *et al.* (1986) pod abscission percentage differed between varieties and sowing dates. Two varieties with growth type- 1 (in which mature pods are concentrated on branches, 2-4) suffered more pod abscission than the variety with growth type II (in which mature pods are found at stem nodes 5-9 on branches 1-3). Application of 0.001% of the gibberellic acid GA_3 at the start of flowering had no significant effects.

Weis and Webster (1990) assumed that the probability of bud or pod abortion in tepery bean (*P. acutifolius*) from the basal bud and the rate of abortion were highest in buds and proximal to the apex. Buds that never reached anthesis aborted in the green bud stage of development and aborting buds ceased development with the first 25% increase in pod length. In non- aborting fruits the rate of seed abortion 6%. A marked increase in abscission of all buds and fruits at all raceme nodes occurred before cessation of flowering.

Information on physical and chemical properties of this bean is limited. Therefore, review related to nutritive value of lablab bean and other beans are presented below.

An experiment was conducted on seasonal variations in flower and fruit drops of country bean (IPSA-1 and IPSA-2) at the Bangabandhu Sheik Mujibur Rahman Agricultural University (BSMRAU) and it was observed that country bean pods (on weight basis) contained protein 11.60%, phosphorus 0.28%, potassium 0.98%,magnesium 0.218% and calcium 0.164%. At the same university similar experiment was conducted by Uddin (1993) on yield, nutritive value and post harvest loss of ascorbic acid in photosensitive lablab bean and found that protein content on dry weight basis varied from 17.92 to 19.59 % in pods and 25.96 to 27.43 % in seeds. He observed that in general dry matter, total sugar and carotene contents increased with pod maturity. However, reducing sugar and ascorbic acid were the maximum at 15 days after anthesis.

In lablab bean, dry matter content increased with time of maturity and it was reported that protein content of pod wall decreases and that of seed increases with pod or seed age (Newaz, 1991).

Due to its potential for use as a vegetative cover, soil improvement qualities, ability to fix nitrogen and control weeds, the legume lablab (*Lablab purpureus*) is an important species in the American tropics. Lablab can be used in a pasture environment or can be fed as a supplement to animals on poor quality diets during the dry season (Hendricksen and Minson 1985). A summary of available literature reports indicates that *Lablab purpureus* contains an average of 17% protein, 46% Neutral Detergent Fiber, 41% Acid Detergent

Fiber and an average Dry Matter Digestibility of 53% (Murphy and Colucci, 1999). These nutritional characteristics coupled with the other environmental benefits make lablab a suitable fodder crop for the Tropics. At present, in-depth knowledge of the nutritional characteristics of this legume at different stages of growth and maturity is lacking. It is probable that the dearth of information about this species is preventing the use of lablab to its full potential. Recent work in Honduras comparing two forage systems during the dry season, has shown an improvement in milk production (per animal and per ha.) and body condition of cows grazing a mixture of maize stover/lablab as compared with the traditional maize stover system (Sinclair, 1996).

According to Rashid (1976) in general one hundred grams of young lablab bean pods contains 83 g water, 4.5 g protein, 10 g carbohydrate, 1.0 g fat, 2.0 g fiber, 0.05 mg thiamine, 0.01 mg riboflavin little of vitamin C. the dry seeds of lablab bean contain 8 g water, 25.0 g protein, 60 g carbohydrate, 0.8 g fat, 1.4 g fiber, 100 IU vitamin A, 0.5 mg thiamine, 0.1 mg riboflavin, 1.8 mg niacin and slight vitamin C.

Purseglove (1968) mentioned in his book Tropical Crop Dicotyledons that immature jack bean contained 75.2% water, 6.9% protein, 3.3 % fiber and 0.8% ash. The ripe dried seed contained 11.0 % water, 23.4 % protein, 4.9% fiber and 4.2 % ash.

Bamiro *et al.* (1994) assessed the nutritive value of Nigerian jack beans. He reported that jack bean seeds (dry basis) contained 24.66 % crude protein, 9.90 % crude fiber, 59.31 % carbohydrate. Total energy content was 353.79 k cal/g. In seeds potassium, sodium, calcium, iron and magnesium were 1.44, 0.26, 0.04, 0.15 and 0.08 g/100g, respectively.

Biochemical evaluation of some Nigerian legume seeds showed that the crude protein of all raw legume seeds varied from 20.6-27.7 %, crude fiber 3.2-9.5 %, other extract 1.3-6.7 % and ash 3.0-4.8 %. Potassium was the most abundant mineral ranging from 9.9 in jack bean to 16.4 g/kg in lima bean TPL 88. Phosphorus was also appreciably high while sodium concentration was low. Iron contents were highest in kidney beans (Apata and Ologhobo, 1994).

Newaz (1991) studied the biochemical composion of lablab bean and found that an increased dry matter content in lablab bean with time of maturity. She also reported that protein content of pod wall decreases and that of seed increases with pod or seed age. She further reported that protein content of immature seeds was higher compared to mature seeds which agree well with the report of Worthington and Burn (1971) who worked on other beans.

During maturity sugar content of pea decreases rapidly and there is an increase in starch and other polysaccharides and insoluble nitrogenous compound such as protein (Thompson and Kelly, 1957). Sinaga (1986) reported that in tomato sugar content increased during maturation from the green mature to the red ripe stages. Total soluble solids and reducing sugars increases throughout the development of tomato fruit (Boe *et al.* 1967). Sharfuddin and Siddque (1985) reported that ascorbic acid is synthesized in presence of light. Therefore, the highest ascorbic acid is obtained from plant growth in the highest light.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the major information regarding materials and methods that were used in conducting the experiment. It consists of a short description of locations of the experimental site, characteristics of soil, climate, materials, layout and design of the experiment, land preparation, manuring and fertilizing, transplanting of seedlings, intercultural operations, harvesting, data recording procedure, economic and statistical analysis etc., which are presented as follows:

3.1. Experimental site

The research work relating to determine the genetic diversity of country bean was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka-1207 during August 2008 to march 2009.

3.2 Geographical Location

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004). The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in (Appendix I).

3.3 Climate

Area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Meteorological information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period was presented in Appendix II.

3.4 Characteristics of soil

Soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.0-6.6 and had organic matter 0.84%. Experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The analyses were done by Soil Resource and Development Institute (SRDI), Dhaka. Physicochemical properties of the soil are presented in (Appendix III).

3.5 Planting materials

Thirty seven genotypes of country bean were used for the present research work. The purity and germination percentage were leveled as around 100 and 80, respectively. The genetically pure and physically healthy seeds of these genotypes were collected from Plant Genetic Resources Centre (PGRC) of Bangladesh Agricultural Research Institute (BARI). (Table 1).

3.6 Design and layout of the experiment

The experiment was laid out Randomized Complete Block Design (RCBD) with three replications figure1. The genotypes were distributed into the every plot of each block of the prepared layout of the experiment. The individual plot was 3 m × 1 m in size. The twenty genotypes of the experiment were assigned at random into plots of each replication. The distance maintained spacing row to row 50 cm and plant to plant 2 m. The distance maintained between two blocks was 1 m.

Table 1. List of genotypes

SL No.	Lines	Genotype No	Source
1	BD-82	G-1	PGRC
2	BD-90	G-2	PGRC
3	BD-100	G-3	PGRC
4	BD-113	G-4	PGRC
5	BD-117	G-5	PGRC
6	BD-122	G-6	PGRC
7	BD-130	G-7	PGRC
8	BD-132	G-8	PGRC
9	BD-135	G-9	PGRC
10	BD-808	G-10	PGRC
11	BD-7998	G-11	PGRC
12	BD-7999	G-12	PGRC
13	BD-8022	G-13	PGRC
14	BD-8227	G-14	PGRC
15	BD-8034	G-15	PGRC
16	BD-8725	G-16	PGRC
17	BD-137	G-17	PGRC
18	BD-8008	G-18	PGRC
19	BD-8027	G-19	PGRC
20	BD-8001	G-20	PGRC
21	BD-1805	G-21	PGRC
22	BD-1785	G-22	PGRC
23	BD-8813	G-23	PGRC
24	BD-8312	G-24	PGRC
25	BD-7974	G-25	PGRC
26	BD-1816	G-26	PGRC
27	BD-7988	G-27	PGRC
28	BD-7995	G-28	PGRC
29	BD-8752	G-29	PGRC
30	BD-8738	G-30	PGRC
31	BD-8729	G-31	PGRC
32	BD-6	G-32	PGRC
33	BD-8737	G-33	PGRC
34	BD-8034	G-34	PGRC
35	BD-8816	G-35	PGRC
36	BD-8815	G-36	PGRC
37	BD-7985	G-37	PGRC

***PGRC= Plant Genetic Resources Centre**

3.7 Poly bag preparation and raising seedling

Due to uncertain rainfall during the period of the study, the seeds were dibbled in Poly bag for higher germination percentage and to get healthy seedlings and when the seedlings the seedlings become 25 days old; those were transplanted in the main field in the pit. Seeds were sown 20th August, 2008, before sowing seeds were soaked in water for 24 hours and treated with Bavistin for 5 minutes.

3.8 Land preparation

The experiment plot was prepared by several ploughing and cross ploughing followed by laddering and harrowing with tractor and power tiller to bring about good tilth in the middle week of September 2008. Weeds and other stables were removed carefully from the experimental plot and leveled properly.

3.9 Pit preparation

After final land preparation, pits of 50 cm × 50 cm × 45 cm were prepared in each plot with a spacing of a spacing of 3 m × 1.25 m. Pits were kept open in the sun for 7 days to kill harmful insect and microorganisms. To control field cricket 5 mg Furadan was also mixed with the soils of each pit before making it ready for dibbling.

3.10 Manure and fertilizers application

The following doses of manure and fertilizers were applied to the plots for ridge gourd cultivation (Anonymous, 1991). Total cowdung, half of TSP and one third MOP were applied in the field during final land preparation. Remaining TSP and one third MOP and whole gypsum and zinc oxide and one third of urea were applied in pit one week prior to transplantation. Remaining urea and MOP were applied as top dressing in four

installments at 20, 40, 60 and 75 days after transplanting (Table 2) showing dose of manure and fertilizers used in the study.

Table 2. Dose of manure and fertilizers used in the study

Sl. No.	Fertilizer/Manure	Dose
1.	Cowdung	10 ton/ha
2.	Urea	150 kg/ha
3.	TSP	100 kg/ha
4.	MOP	150 kg/ha
5.	Gypsum	80 kg/ha
6.	Zinc Oxide	8 kg/ha

3.11Transplanting of seedlings

Germination of seeds was completed within 12 days and the seedlings of different accessions were planted in the pit on 12th. September, 2008. In each pit two seedlings were planted and the soil around the plant was firmly pressed by hand.

3.12 Intercultural operations

The following intercultural operations were done from time to time throughout the cropping season for proper growth and development of the plants.

3.12.1 Thinning and gap filling

Only one healthy seedling was kept per pit for the proper development and avoid crowd environment. For this whatever its need thinning and gap filling was done.

3.12.2 Weeding and mulching

Several weeding and mulching were done as per requirement. At the very first stage weeding was done for ease of aeration and less competition seedling growth and mulch was provided after an irrigation to prevent crust formation and facilitate good aeration.

3.12.3 Irrigation and after-care

In the early stage irrigation was done twice daily by water cane. In mature stage flood irrigation was done when ever it's necessary.

3.12.4 Pesticide application

At the seedling stage red pumpkin beetle attacked tender leaves and also after the initial stage they attacked plants several times for this Malathion and Ripcord was sprayed in the field. In mature stage pod fly caused severe damage to the pod. For protection from pod fly, MSGT (Mashed Sweet Gourd Trap) and Pheromone bait was used along with ripcord, sevin powder. The field view of the experiment shown in Plate 1a, Plate 1b and 1c.

3.13 Harvesting

Pods were picked on the basis of horticultural maturity, size, colour and age being determined for the purpose of consumption as the pod grew rapidly and soon get beyond the marketable stage, frequent picking was done throughout the harvesting period. Pods were picked with sharp knife and care was taken to avoid injury of the vine.

3.14 Data recording

Data were recorded on following parameters from the studied plants during the experiment. The details of data recording are given below on individual plant basis.

3.14.1 Days to first flowering

The number of days required for first flower flowering was counted for three replication separately and average data was recorded.

3.14.2 Number of inflorescence per plant

The number of inflorescence per plant was counted and average data was recorded.

3.14.3 Number of flower per inflorescence

The number of flower per inflorescence was counted and average data was recorded.

3.14.4 Inflorescence length (cm)

Inflorescence length measured in centre meter in main inflorescence and average data was recorded.

3.14.5 Number of pod per plant

The number of pod per plant was counted and average data was recorded.

3.14.6 Pod length (cm)

Pod length was measured in 3-5 pods of different plants in cm and average data was recorded during pod harvest for vegetable use.

3.14.7 Pod diameter (cm)

Pod diameter was measured in 3-5 pods of different plants in cm and average data was recorded during pod harvest for vegetable use.

3.14.8 Weight per pod (g)

Weight of 3-5 pods of different plants during harvest for vegetable use was measured in gram (g).

3.14.9 Thousand seed weight (g)

Weight of 1000 seed of different plants during harvest for vegetable use was measured in gram (g).

3.14.10 Yield per plant (g)

Weight of edible pod pods of selected plants from each accession was weighted in kilogram (g).

3.15.1 Statistical analysis

Mean data of the characters were subjected to multivariate analysis. Univariate analysis of the individual character was done for all characters under study using the mean values (Singh and Chaudhury, 1985) and was estimated using MSTAT-C computer programme. Duncan's Multiple Range Test (DMRT) was performed for all the characters to test the differences between the means of the genotypes. Mean, range and co-efficient of variation (CV %) were also estimated using MSTAT-C. Multivariate analysis was done by computer using GENSTAT 5.13 and Microsoft Excel 2000 software through four techniques viz., Principal Component Analysis (PCA), Principal Coordinate Analysis (PCO), Cluster Analysis (CA) and Canonical Vector Analysis (CVA).

3.15.1.1 Estimation of genotypic and phenotypic variances

Genotypic and phenotypic variances were estimated according to the formula given by Johnson *et al.* (1955).

$$\text{Genotypic variance } (\sigma^2_g) = \frac{GMS - EMS}{r}$$

Where,

GMS = Genotypic mean sum of squares

EMS = Error mean sum of square

r = number of replications

Phenotypic variance (σ^2_{ph}) $= \sigma^2_g$ + EMS

Where,

σ^2_g = Genotypic variance

EMS = Error mean sum of square

3.15.1.2 Estimation of genotypic and phenotypic correlation co-efficient

For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1958), Johnson *et al.* (1955) and Hanson *et al.* (1956) were adopted.

The genotypic co-variance component between two traits and have the phenotypic co-variance component were derived in the same way as for the corresponding variance components. The co-variance components were used to compute genotypic and phenotypic correlation betweens replicated Characters as follows:

Genotypic correlation (r_{gxy}) $= \dfrac{cov_g xy}{\sqrt{gvx\ gvy}}$

Where,

$cov_g xy$ = Genotypic co-variance between the traits x and y

$_g vx$ = Genotypic variance of the trait x

$_g vy$ = Genotypic variance of the trait y

Phenotypic correlation (r_{pxy}) $= \dfrac{cov_p xy}{\sqrt{_p vx\ _p vy}}$

Where,

cov_pxy = Phenotypic covariance between the traits x and y

$_pVx$ = Phenotypic variance of the trait x

$_pVy$ = Phenotypic variance of the trait y

3.15.1.3 Estimation of genotypic and phenotypic co-efficient of variation

Genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1952)

$$\text{Genotypic co-efficient of variation (GCV \%)} = \sqrt{\frac{\sigma^2_g}{\bar{x}}} \times 100$$

Where,

σ^2_g = Genotypic variance

$\bar{x}$ = Population mean

Similarly,

The phenotypic co-efficient of variation was calculated from the following formula.

$$\text{Phenotypic co-efficient variation (PCV)} = \sqrt{\frac{\sigma^2_{ph}}{\bar{x}}} \times 100$$

Where,

σ^2_{ph}= Phenotypic variance

$\bar{x}$ = Population mean

3.15.1.4 Estimation of heritability

Broad sense heritability was estimated (Lush, 1943) by the following formula, suggested by Johnson *et al.* (1955).

$$h^2_b\% = \frac{\sigma^2_g}{\sigma^2_{ph}} \times 100$$

Where,

h^2_b = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.15.1.5 Estimation of genetic advance

The expected genetic advance for different characters under selection was estimated using the formula suggested by Lush (1943) and Johnson *et al.* (1955).

Genetic advance (GA) = K. h^2_b. σ_{ph}

$$GA = K.\frac{\sigma^2_g}{\sigma^2_{ph}}.\sigma_{ph}$$

Where,

K = Selection intensity, the value which is 2.06 at 5% selection intensity

σ_{ph} =Phenotypic standard deviation

h^2_b = Heritability in broad sense

σ^2_g = Genotypic variance

σ^2_{ph} = Phenotypic variance

3.15.1.6 Estimation of genetic advance mean's percentage

Genetic advance as percentage of mean was calculated from the following formula as proposed by Comstock and Robinson (1952):

$$\text{Genetic advance (\% of mean)} = \frac{\text{Genetic Advance (GA)}}{\text{Population mean } (\bar{x})} \times 100$$

3.15.2 Multivariate analysis

The genetic diversity among the genotypes was assessed by Mahalanobis's (1936) general distance (D^2) statistic and its auxiliary analyses. The parents selection in hybridization programme based on Mahalanobis's D^2 statistic is more reliable as requisite knowledge of parents in respect of a mass of characteristics is available prior to crossing. Rao (1952) suggested that the quantification of genetic diversity through biometrical procedures had made it possible to choose genetically diverse parents for a hybridization programme. Multivariate analysis viz. Principal Component analysis, Principal Coordinate analysis, Cluster analysis and Canonical Vector analysis (CVA), which quantify the differences among several quantitative traits, are efficient method of evaluating genetic diversity. These are as follows:

3.15.2.1 Principal Component analysis (PCA)

Principal Component analysis, one of the multivariate techniques, is used to examine the inter-relationships among several characters and can be done from the sum of squares and products matrix for the characters. Thus, PCA finds linear combinations of a set variate that maximize the variation contained within them, thereby displaying most of the original variability in a smaller number of dimensions. Therefore, Principles components were computed from the correlation matrix and genotypes scores obtained for first components (which has the property of accounting for maximum variance) and succeeding components with latent roots greater than unity. Contribution of the different morphological characters towards divergence is discussed from the latent vectors of the first two principal components.

3.15.2.2 Principal Coordinate analysis (PCO)

Principal Coordinate analysis is equivalent to PCA but it is used to calculate inter unit distances. Through the use of all dimension of p it gives the minimum distance between each pair of the n points using similarity matrix (Digby *et al.*, 1989).

3.15.2.3 Cluster analysis (CA)

Cluster analysis divides the genotypes of a data set into some number of mutually exclusive groups. Clustering was done using non-hierarchical classification. In Genstat, the algorithm is used to search for optimal values of chosen criterion proceeds as follows. Starting from some initial classification of the genotypes into required number of groups, the algorithm repeatedly transferred genotypes from one group to another so long as such transfer improved the value of the criterion. When no further transfer can be found to improve the criterion, the algorithm switches to a second stage which examines the effect of swooping two genotypes of different classes and so on.

3.15.2.4 Canonical Vector analysis (CVA)

Canonical vector analysis (CVA) finds linear combination of original variabilities that maximize the ratio of between group to within group variation, thereby giving functions of the original variables that can be used to discriminate between the groups. Thus, in this analysis a series of orthogonal transformations sequentially maximizing of the ratio of among groups to the within group variations. The canonical vector are based upon the roots and vectors of WB, where W is the pooled within groups covariance matrix and B is the among groups covariance matrix.

3.15.2.5 Calculation of D^2 values

The Mahalanobis's distance (D^2) values were calculated from transformed uncorrelated means of characters according to Rao (1952), and Singh and Chaudhury (1985). The D^2 values were estimated for all possible combinations between genotypes. In simpler form D^2 statistic is defined by the formula

$$D^2 = \sum_{i}^{x} d_i^2 = \sum_{i}^{x} (Y_i^j - Y_j^k) \qquad (j \neq k)$$

Where,

Y = Uncorrelated variable (character) which varies from i = 1 to x

x = Number of characters.

Superscript j and k to Y = A pair of any two genotypes.

3.15.2.6 Computation of average intra-cluster distances

Average intra-cluster distances were calculated by the following formula as suggested by Singh and Chuadhury (1985).

$$\text{Average intra-cluster distance} = \frac{\sum D_i^2}{n}$$

Where,

D_i^2 = the sum of distances between all possible combinations (n) of genotypes included in a cluster.

n = Number of all possible combinations between the populations in cluster.

3.15.2.7 Computation of average inter-cluster distances

Average inter-cluster distances were calculated by the following formula as suggested by Singh and Chowdhury (1985).

$$\text{Average inter-cluster distance} = \frac{\sum D_{ij}^2}{n_i \times n_j}$$

Where,

$\sum D_{ij}^2$ = The sum of distances between all possible ombinations of the populations in cluster i and j.

n_i = Number of populations in cluster i.

n_j = Number of populations in cluster j.

3.15.2.8 Cluster diagram

Using the values of intra and inter-cluster distances ($D = \sqrt{D^2}$), a cluster diagram was drawn as suggested by Singh and Chowdhury (1985). It gives a brief idea of the pattern of diversity among the genotypes included in a cluster.

3.15.2.9 Selection of varieties for future hybridization programme

Divergence analysis is usually performed to identify the diverse genotypes for hybridization purposes. The genotypes grouped together are less divergent among themselves than those, which fall into different clusters. Clusters separated by largest statistical distance (D^2) express the maximum divergence among the genotypes included into these different clusters. Variety (s) or line(s) were selected for efficient hybridization programme according to Singh and Chowdhury (1985).

According to them the following points should be considered while selecting genotypes for hybridization programme:

i. Choice of cluster from which genotypes are selected for use as parent (s)
ii. Selection of particular genotype(s) from the selected cluster(s)
iii. Relative contribution of the characters to the total divergence
iv. Other important characters of the genotypes performance

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the findings obtained from the study. The data pertaining to 20 country bean genotypes as well as yield and its contributing characters were computed and statistically analyzed and the results thus obtained are discussed below under the following heads:

1. Genetic parameters
2. Correlation co-efficient
3. Multivariate analysis

4.1 GENETIC PARAMETERS

The analysis of variance indicated the existence of highly significant variability for all the characters studied. The mean sum of square, mean, range, variance components, coefficients of genotypic and phenotypic variations, heritability estimates, genetic advance and genetic advance in percent of mean (GAPM) are presented in (Table 3). The results are discussed character wise as follows:

4.1.1 Days to first flowering

Mean sum of square for days to first flowering was highly significant (ANOVA Table) indicating existence of considerable difference for this trait. The maximum days to first flowering was found 85.00 and the minimum was recorded 54.00 with mean value 73.17 (Appendix IV). The genotypic variance (73.85), phenotypic

Table 3. Genetic parameters of 10 vegetative and yield contributing characters of thirty seven country bean genotypes

Character	MS value	% CV	Mean	Gen.Var	Phe.Var	Env.Var	GCV	PCV	ECV	Herit. (%)	G.A (5%)	GAPM (5%)
Days of first flowering	222.55	1.36	73.17	73.85	74.85	1	11.74	11.82	1.36	98.67	17.58	24.03
No. of inflorescence	127.34	4.37	24.05	42.08	43.18	1.11	26.98	27.33	4.37	97.44	13.19	54.86
No. of flowers per inflorescence	15.34	11.93	13.64	4.23	6.88	2.65	15.08	19.23	11.93	61.53	3.32	24.37
No. of pods per inflorescence	19.95	13.28	9.74	6.09	7.76	1.67	25.34	28.61	13.28	78.45	4.5	46.24
Pod length (cm)	16.07	16.91	10.11	4.38	7.3	2.92	20.7	26.73	16.91	59.96	3.34	33.01
Pod width (cm)	0.66	19.73	2.37	0.15	0.37	0.22	16.27	25.58	19.73	40.47	0.5	21.32
Pod weight (gm)	153.21	5.01	21.77	50.68	51.87	1.19	32.7	33.08	5	97.71	14.5	66.59
Thousand seed weight (gm)	13.47	9.85	9.32	4.21	5.05	0.84	22	24.11	9.85	83.29	3.86	41.37
Inflorescence length (cm)	44.78	4.10	14.57	14.81	15.16	0.36	26.41	26.73	4.1	97.64	7.83	53.77
yield/plant (kg)	4308.17	2.49	70.82	1435.02	1438.13	3.11	53.49	53.54	2.49	99.78	77.95	110.06

Here, MS= Mean sum of squares du genotypes, CV= Co-efficient of Variation, Gen. Var= Genotypic variance, Phe.Var= phenotypic variance, Env. Va= Environmental variance, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, ECV= Environmental coefficient of variation, Herit= Heritability, GA= Genetic advance, GAPM= Genetic advance in percent of mean

variance (1.00), genotypic co-efficient of variation (11.74) and phenotypic co-efficient of variation (11.82) were close to each other indicating less environmental influence in case of days to first flowering (Table 3). Heritability estimates for this trait was very high (98.67%) but genetic advance (17.58) and genetic advance in percent of mean (24.03) was found low, indicated that selection for this character would be less effective. Singh *et al.* (2002) also found phenotypic co-efficient of variation higher than genotypic co-efficient of variation in respect to days to first male flower opening. Emaduddin (2008) found similar results in case of days to first male flowering.

4.1.2 Number of Inflorescence per plant

Mean sum of square for number of inflorescence per plant was highly significant (ANOVA Table) indicating existence of considerable difference for this trait. The maximum number of inflorescence per plant was found 38.00 and the minimum was recorded 10.00 with mean value 24.05 (Appendix IV). The genotypic variance (42.08), phenotypic variance (1.11), genotypic co-efficient of variation (26.98) and phenotypic co-efficient of variation (27.33) were close to each other indicating less environmental influence in case of number of infloresecnce per plant. Heritability (97.44%) estimates for this trait were moderate together with considerable moderate genetic advance (13.19) and moderately high genetic advance in percent of mean (54.86) indicated that selection for this character would be more effective.

4.1.3 Number of flowers per inflorescence

Mean sum of square for number of flowers per inflorescence was highly significant (Table 3) indicating existence of considerable variability for this trait. The maximum number of flowers per inflorescence was found 20.00 and the minimum was recorded 10.00 with mean value 13.64 (Appendix IV). The genotypic variance (4.23), phenotypic variance (2.65), genotypic co-efficient of variation (15.08) and phenotypic co-efficient of variation (19.23) were close to each other indicating less environmental influence in case of number of flowers per inflorescence. Heritability (61.53%) estimates for this trait was moderate genetic advance (3.32) and genetic advance in percent mean (34.37) was also found low, indicated that selection for this character would be less effective.

4.1.4 Length of inflorescence (cm)

Mean sum of square for length of inflorescence was highly significant (ANOVA Table) indicating existence of considerable difference for this trait. The maximum length of inflorescence was found 21.33 (cm) and the minimum was recorded 7.00 (cm) with mean value 14.57 (cm) (Appendix IV). The genotypic variance (14.81), phenotypic variance (0.36), genotypic co-efficient of variation (26.41) and phenotypic co-efficient of variation (26.73) were close to each other indicating less environmental influence in case of length of inflorescence. Heritability (97.64%) estimates for this trait were moderate together with considerable moderate genetic advance (7.83) and moderately high genetic advance in percent of mean (53.77) indicated that selection for this character would be more effective.

4.1.5 Number of pod per plant

Mean sum of square for number of pod per plant was highly significant in Country bean (Table 3) indicating existence of considerable variability for this trait. The maximum number of pod per plant was found 16.00 and the minimum was recorded 6.33 with mean value 9.74 (Appendix IV). The genotypic variance (6.09), phenotypic variance (1.67), genotypic co-efficient of variation (25.34) and phenotypic co-efficient of variation (28.61) were close to each other indicating less environmental influence in case of no. of pod per plant. Heritability (78.45) estimates for this trait was high, genetic advance (4.5) was found moderate and genetic advance in percent of mean (46.24) was found moderately high, indicated that selection for this character would be effective. Roy *et al.* (1993) found similar results in country bean. Sanwal *et al.* (2008), Prasad *et al.* (1988) also reported in related to number of pods per plant in chow-chow and water melon respectively.

4.1.6 Pod length (cm)

Mean sum of square for pod length was highly significant due to genotypes in Country bean (Table 3) indicating existence of considerable difference for this trait. The maximum pod length was found 13.33 and the minimum was recorded 6.00 with mean value 10.11 (Appendix IV). The genotypic variance (4.38), phenotypic variance (2.92), genotypic co-efficient of variation (20.7) and phenotypic co-efficient of variation (26.73) were close to each other indicating less environmental influence in case of pod length. Heritability (59.96%) estimates for this trait was moderately high, genotypic advance (3.34) and genotypic advance in percent of mean (33.01) was found moderately high, indicated that selection for this character

would be effective. Roy *et al.* (1993) found similar results in country bean. Miah *et al.* (2000) reported the highest genotypic as well as phenotypic co-efficient of variations for pod length in country bean.

4.1.7 Pod diameter (cm)

Mean sum of square pod diameter was highly significant due to genotypes in Country bean (Table 3) indicating existence of considerable variation for this trait. The maximum pod diameter was found 4.00 and the minimum was recorded 1.67 with mean value 2.63 (Appendix IV). The genotypic variance (0.15), phenotypic variance (0.22), the genotypic co-efficient of variation (16.27) and phenotypic co-efficient of variation (25.58) were close to each other indicating less environmental influence in case of pod diameter. Heritability (40.47%) estimates for this trait was high, genetic advance (0.5) was found moderately high and genetic advance in percent of mean (21.32) was found very high, indicated that selection for this character would be more effective.

4.1.8 Weight per pod (g)

Mean sum of square for weight per pod was highly significant in Country bean(Table 3) indicating existence of considerable difference for this trait. The maximum weight per pod was found 41.87 and the minimum was recorded 10.00 with mean value 21.77. (Appendix IV). The genotypic variance (50.68), phenotypic variance (1.19), genotypic co-efficient of variation (32.7) and phenotypic co-

efficient of variation (33.08) were close to each other indicating less environmental influence in case of weight per pod. Heritability (97.71%) estimates for this trait was low together with considerable high, genetic advance (14.5) and genetic advance in percent of mean (66.59) indicated that selection for this character would be less effective. Chowdhury and Sharma (2002), Rumaran *et al.* (1997) also reported in respect to average pod weight in ridge gourd and pumpkin respectively.

4.1.9 Thousand seed weight (g)

Mean sum of square for thousand seed weight was highly significant in Country bean (Table 3) indicating existence of considerable difference for this trait. The maximum thousand seed weight was found 14.33 and the minimum was recorded 5.33 with mean value 9.32. (Appendix IV). The genotypic variance (4.21), phenotypic variance (0.84), genotypic co-efficient of variation (22) and phenotypic co-efficient of variation (24.11) were close to each other indicating less environmental influence in case of thousand seed weight. Heritability (83.29) estimates for this trait was low together with considerable high, genetic advance (3.86) and genetic advance in percent of mean (41.37) indicated that selection for this character would be less effective.

4.1.10 Yield per plant (g)

Mean sum of square for yield per plant (kg) was highly significant in Country bean (Table 3) indicating existence of considerable difference for this trait. The maximum yield per plant was found 183.00 gm and the minimum was recorded 21.00 gm with mean value 70.82 (Appendix IV). The genotypic variance (1435.02), phenotypic

variance (3.11), genotypic co-efficient of variation (53.49) and phenotypic co-efficient of variation (53.54) were close to each other indicating less environmental influence in case of yield per plant. The heritability value (99.78%) as well as genetic advance (77.95) and genetic advance in percent of mean (110.06) were observed very high. The very high heritability with moderate genetic advance in percentage of mean provided opportunity for selecting high valued genotypes for breeding programme. This finding also supported Abusaleha and Dutta (1990) findings in cucumber.

4.2 CORRELATION CO-EFFICIENT

Yield is a complex product being influenced by several interdependent quantitative characters. Selection for yield may not be effective unless the other yield components influencing it directly or indirectly are taken into consideration. When selection pressure is exercised for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated traits. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeder for making improvement through selection provide a clear understanding about the contribution in respect of establishing the association by genetic and non genetic factors. Higher genotypic correlations than phenotypic one might be due to modifying or masking effect of environment in the expression of the character under study (Nandpuri *et al.* 1973). The results are discussed under the following heads:

Results of genotypic and phenotypic correlation co-efficient of different genotypes yield and its contributing traits of country beanare shown in Table 4 and discussed characterwise as follows:

4.2.1 Days to first flowering

Days to first flowering found to display highly significant negetive relationships with number of inflorescence, number of flower, number of pod per plant at genotypic level (Table 4) and significant negative relationships with number of inflorescence, number of flower, number of pod per plant at phenotypic level (Table 5). The character reflected highly significant negative association with number of inflorescence, number of flower, number of pod per plant, pod length, at genotypic and phenotypic level and highly significant negative association with weight per pod at phenotypic level. It appeared from the results that increasing days to first flowering caused the plant to produce lesser length and pod length. This character also showed insignificant positive correlation with yield per plant both levels. It also showed insignificant negative correlation with pod diameter and no. of pod per plant both at genotypic and phenotypic level at phenotypic level. Khan *et al.* (2008) reported almost similar result in 64 genotypes of Country bean.

Table 4. Genotypic correlation nine vegetative characters of 37 country bean genotypes

Character	No. of inflorescence	No. of flowers per inflorescence	No. of pods per inflorescence	Pod length (cm)	Pod diameter (cm)	Pod weight (g)	Thousand seed weight(gm)	Inflorescence length (cm)	Yield/plant (g)
Days of first flowering	-0.023	-0.204	-0.074	-0.145	-0.209	-0.4	-0.036	-0.241	0.203
No. of inflorescence		-0.333	-0.389	0.007*	0.062*	0.014*	-0.81	0.106	-0.314
No. of flowers per inflorescence			0.711*	0.269*	-0.216	0.255*	0.137*	0.318	0.221
No. of pods per inflorescence				-0.009	-0.05	0.173	0.143	0.263	0.55
Pod length (cm)					-0.031	0.146	-0.287	0.168	-0.371
Pod diameter (cm)						0.604	0.121*	0.532	0.125
Pod weight (gm)							0.261*	0.404	0.03
Thousand seed weight (gm)								0.107	0.252
Inflorescence length (cm)									-0.035

Table 5. Phonotypic correlation nine vegetative characters of 37 country bean genotypes

Character	No. of inflorescence	No. of flowers per inflorescence	No. of pods per inflorescence	Pod length (cm)	Pod diameter (cm)	Pod weight (g)	Thousand seed weight (g)	Inflorescence length (cm)	Yield/plant (g)
Days of first flowering	-0.022	-0.155	-0.07	-0.109	-0.14	-0.392	-0.038	-0.234	0.202
No. of inflorescence		-0.258	-0.345	0.006	0.035	0.01	-0.076	0.105	-0.309
No. of flowers per inflorescence			0.554	0.141	-0.072	0.206	0.053	0.251	0.173
No. of pods per inflorescence				0.003	-0.029	0.159	0.115	0.233	0.483
Pod length (cm)					0.009	0.104	-0.235	0.123	-0.291
Pod diameter (cm)						0.375	0.101	0.333	0.089
Pod weight (gm)							0.244	0.422	0.031
Thousand seed weight (gm)								0.094	0.232
Inflorescence length (cm)									-0.035

4.2.2 Number of Inflorescence per plant

Number of inflorescence showed highly significant positive correlation with pod length, pod diameter pod weight and length of inflorescence at genotypic level at both the levels and significant at phenotypic level for pod length (Table 4 & Table 5). This result revealed that with increasing the number of inflorescence per plant, pod length. This character also showed highly significant negative association with number of flower and number of pod per plant and yield per pod both at genotypic and phenotypic level. This result implies that the interrelationship between these traits was governed by environment.

4.2.3 Number of flower per plant

Number of flower per plant showed highly significant positive correlation with number of pod per plant, pod length, pod weight, thousand seed weight, length of inflorescence at genotypic level and yield per plant at both the levels and significant at phenotypic level for pod length (Table 4 & Table 5). This result revealed that with increasing the number of flower per plant, pod length and yield per plant. This character also showed highly significant negative association with pod diameter both at genotypic and phenotypic level. This result implies that the interrelationship between these traits was governed by environment.

4.2.4 Number of pod per plant

Number of pod per plant showed highly significant positive correlation with yield per plant at both genotypic and genotypic level (Table 4 & Table 5). This result revealed that with more number of pod per plant would have increase yield per plant. It also

showed that highly significant positive correlation with weight per pod , thousand seed weight and length of inflorescence at genotypic level and yield per plant at phenotypic level. It also showed that insignificant negative correlation with pod length and pod diameter at genotypic level. It also showed that insignificant positive correlation with pod length at phenotypic level.

4.2.5 Pod length (cm)

Pod length showed highly significant positive correlation with weight per pod and length of inflorescence both at genotypic and phenotypic level (Table 4 & Table5). It also showed significant negative correlation with thousand seed weight and yield both at genotypic and phenotypic level. Significant negative association between thousand seed weight and yield per plant indicates that the traits are not governed by same gene by pleiotropic effect and simultaneous improvement would not be effective. It also showed that insignificant positive correlation with pod diameter at phenotypic level. It also showed that insignificant negetive correlation with pod diameter at genotypic level. Insignificant association indicated that the association between these traits is largely influenced by environmental factors. Miah *et al.* (2000) reported the highest genotypic as well as phenotypic coefficient of variations for pod length in country bean.

4.2.6 Pod diameter (cm)

Pod diameter showed highly significant positive association with weight of pod and yield at both levels. This result revealed that with increase pod diameter would have increase large size of pod (Table 4 & Table 5). It also showed highly significant positive correlation with thousand seed weight and length of inflorescence at genotypic level and at phenotypic level.

Plate 1a: Filed view of Country bean plants.

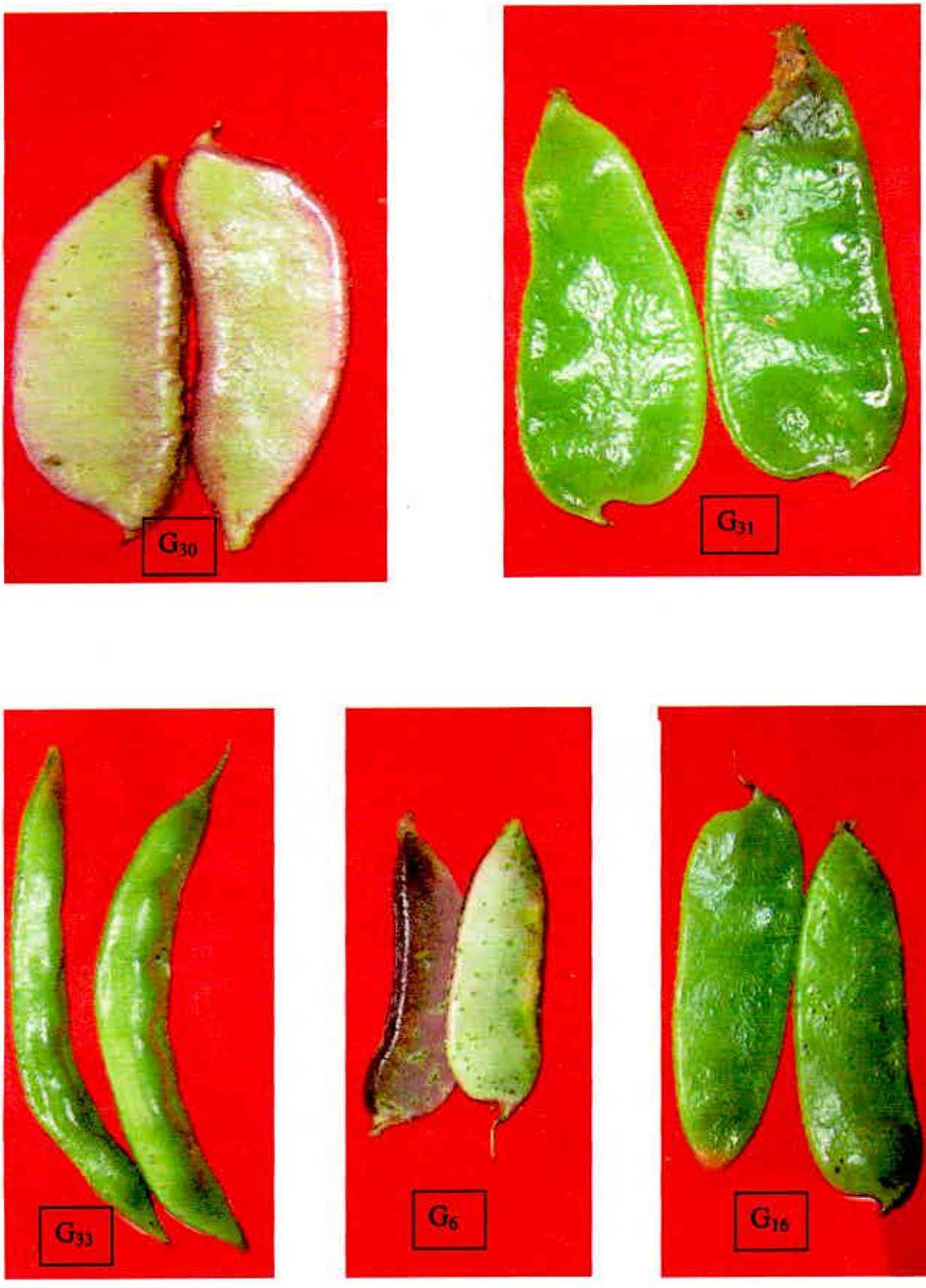

Plate 1b. Showing Variation in pod among different Country bean genotypes

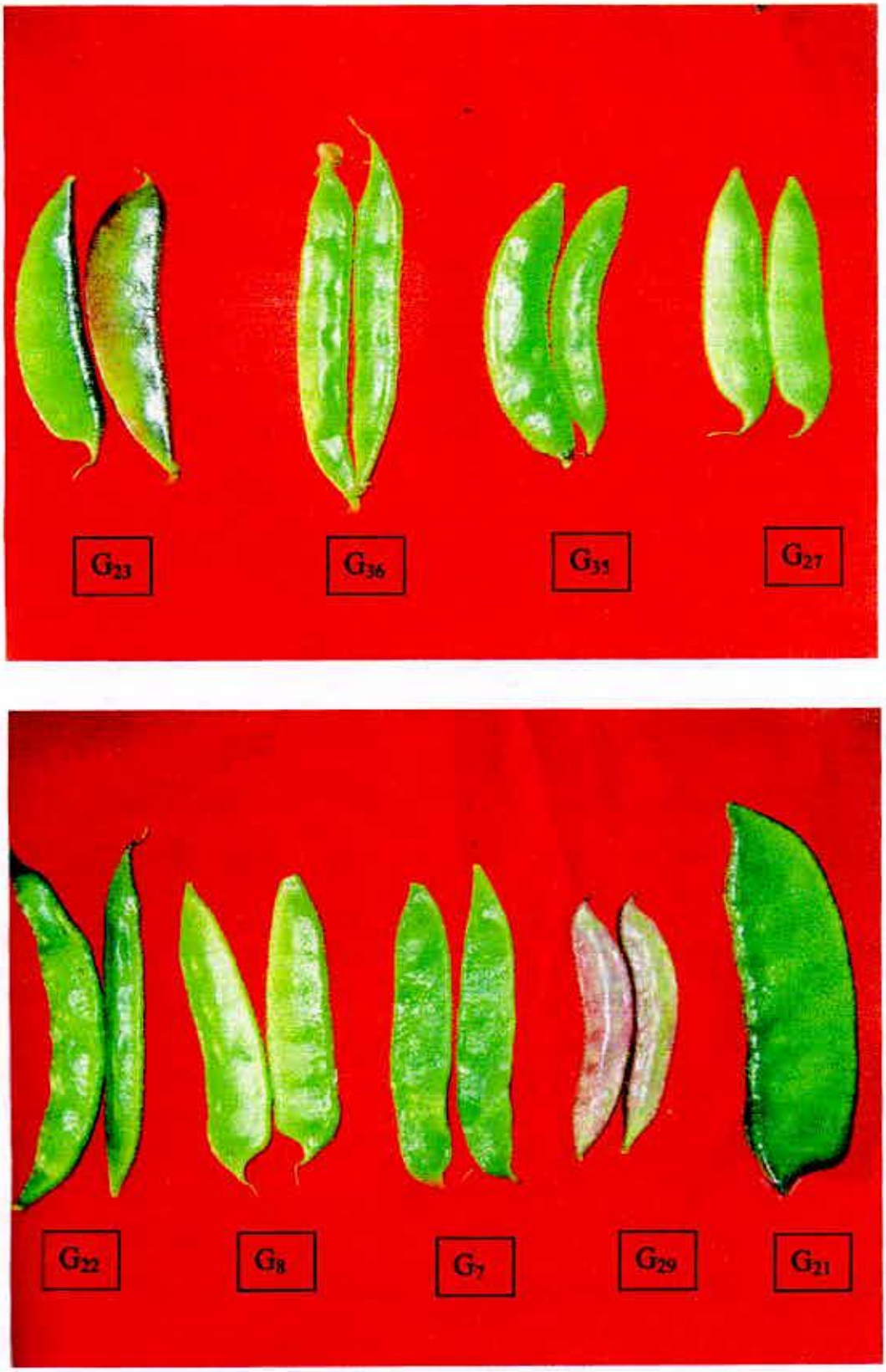

Plate 1c. Showing Variation in pod among different Country bean genotypes

4.2.7 Weight per pod (g)

The trait, weight per pod showed significant positive correlation with yield per plant at both genotypic level and phenotypic level indicated that the association between these two traits is largely influenced by environmental factors (Table 4 & Table 5). It also showed highly significant positive correlation with thousand seed weight and length of inflorescence at genotypic level and at phenotypic level. Chowdhury and Sharma (2002), Rumaran *et al.* (1997) also reported in respect to average pod weight in ridge gourd and pumpkin, respectively.

4.2.8 Thousand seed weight (g)

The trait, thousand seed weight showed significant positive correlation with yield per plant at both genotypic level and phenotypic level. This result revealed that with maximum weight of seed would have increase yield per plant (Table 4 & Table 5). It also showed highly significant positive correlation with length of inflorescence at genotypic level and at phenotypic level.

4.2.9 Length of inflorescence

The trait, length of inflorescence showed significant negative correlation with yield per plant at genotypic level and at phenotypic level indicated that the association between these two traits is largely influenced by environmental factors (Table 4 & Table 5).

4.3 MULTIVARIATE ANALYSIS

4.3.1 Principal component analysis (PCA)

Principal component analysis was carried out with 37 genotypes of country bean. First 3 Eigen values for 3 principal coordination axes of genotypes accounted for 54.16% variation (Table 6). A two dimensional scattered diagram Fig. 1 was developed on the basis of the principal component score, Z_1 and Z_2 score (Appendices VI).

4.3.2 Principal coordinates analysis (PCO)

The results obtained from principal coordinate analysis showed that the highest inter genotypic distance was observed between genotypes G-4 and G10 (2.748) followed by G1 and G10 (2.698) and the lowest distance was observed (0.744) between genotypes G11 and G13 followed by the distance (.748) between genotypes G4 & G6 (Table 7). The difference between the highest and the lowest inter genotypic distance indicated the moderate variability among the 37 genotypes of country bean. The highest intra-cluster distance was recorded in cluster II (1.010) containing four genotypes BD-8027, BD-8752, BD-8816, BD-8815 (Table 8 and Table 9. The lowest intra-cluster distance was observed in cluster VI (0.809) having Twelve genotype viz. BD-90, BD-135, BD-808, BD-7998, BD-7999, BD-8034, BD-137, BD-8008, BD-8001, BD-8729, BD-8737 and BD-8034. It favored to decide that intra-group diversity was the highest in cluster II and the lowest in cluster VI. Cluster III having ten genotypes viz. BD-82, BD-122, BD-8022, BD-8227, BD-8725, BD-1785, BD-7988, BD-7995, BD-8738, and BD-6 and had an intra-cluster distance 1.007. Cluster IV having three genotypes BD-7974, BD-1816 and BD-7985 and had an intra-cluster distance 0.846. The cluster V consisted four genotype viz. BD-113, BD-117, BD-8813 and BD-8312 and had an intra-cluster distance 0.836 (Table 8 and Table 9).

Table 6. Eigen value and percent contribution of 10 yield contributing characters of thirty seven country bean genotypes

Character	Eigen Value	% variation	% cumulative variation
Days of first flowering	3.27	23.36	23.36
No. of inflorescence	2.45	16.07	39.43
No. of flowers per inflorescence	2.06	14.73	54.16
No. of pods per inflorescence	1.39	9.91	64.07
Pod length (cm)	1.21	8.62	72.69
Pod width (cm)	0.83	5.93	78.62
Pod weight (gm)	0.7	4.97	83.59
Thousand seed weight(gm)	0.53	3.81	87.4
Inflorescence length (cm)	0.44	3.15	90.55
Yield/plant (kg)	0.42	3.03	93.58

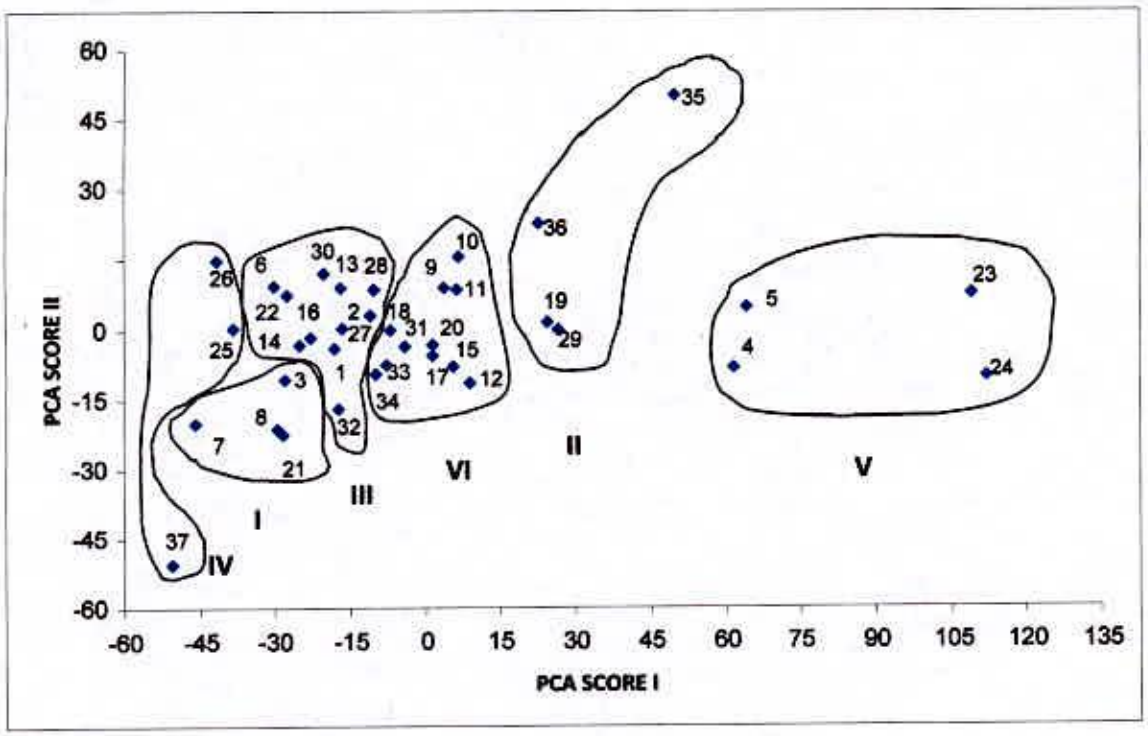

Fig. 1. Scattered diagram of thirty seven county bean genotypes superimpose cluster.

Table 7. Ten highest and ten lowest inter genotypic distance among the 37 county bean genotypes.

Sl. No.	Genotypic combination	Distances
		Highest
1	G4-G10	**2.748**
2	G1-G10	2.698
3	G19-G25	2.578
4	G5-G27	2.512
5	G5-G22	2.491
6	G17-G25	2.483
7	G3-G28	2.419
8	G1-G30	2.325
9	G19-G28	2.312
10	G13-G37	2.278
		Lowest
1	G11-G13	**0.744**
2	G4-G6	0.748
3	G13-G25	.0.779
4	G15-G32	0.811
5	G6-G14	0.819
6	G7-G34	0.836
7	G24-G33	0.853
8	G14-G35	0.782
9	G9-G20	0.792
10	G6-G21	0.898

Table 8. Distribution of 37 country bean genotypes in six clusters

Cluster	No. of genotypes	Designation
I	3, 7, 8, 21 (4)	BD-100, BD-130, BD-132, BD-1805
II	19, 29, 35, 36 (4)	BD-8027, BD-8752, BD-8816, BD-8815,
III	1, 6, 13, 14, 16, 22, 27, 28, 30, 32 (10)	BD-82, BD-122, BD-8022, BD-8227, BD-8725, BD-1785, BD-7988, BD-7995, BD-8738, BD-6
IV	25, 26, 37 (3)	BD-7974, BD-1816, BD-7985
V	4, 5, 23, 24 (4)	BD-113, BD-117, BD-8813, BD-8312
VI	2, 9, 10, 11, 12, 15, 17, 18, 20, 31, 33, 34 (12)	BD-90, BD-135, BD-808, BD-7998, BD-7999, BD-8034, BD-137, BD-8008, BD-8001, BD-8729, BD-8737, BD-8034

Table 9. Average Inter and intra cluster distance of 37 country bean genotypes

Cluster	I	II	III	IV	V	VI
I	**0.964**	8.32	4.78	6.52	14.39	4.90
II		**1.010**	7.71	11.22	7.72	4.64
III			**1.007**	5.20	14.29	4.76
IV				**0.846**	**17.17**	7.30
V					**0.836**	11.05
VI						**0.809**

4.3.3 Non-hierarchical clustering

The computations from covariance matrix gave non-hierarchical clustering among 37 genotypes of country bean and grouped them into six clusters. The clustering pattern obtained coincided with the apparent grouping patterns performed by PCA. So the results obtained through PCA were confirmed by non-hierarchical clustering. Table 9 represents the clusters occupied by 37 genotypes of country bean. It explains that's cluster II contained the highest number of genotypes four, cluster IV constitute by twelve genotypes, cluster I constitute by four genotypes and cluster III constitute by ten genotype. Cluster II was composed of BD-8027, BD-8752, BD-8816, and BD-8815. The genotypes of cluster II are collected from Plant Genetic Resource Centre, BARI, Gazipur. Cluster mean for 140 traits are presented in (Table 10). Cluster VI was formed by 12 genotypes viz. BD-90, BD-135, BD-808, BD-7998, BD-7999, BD-8034, BD-137, BD-8008, BD-8001, BD-8729, BD-8737, BD-8034. They were collected from Plant Genetic Resource Centre, BARI, Gazipur . These clusters were unable to lead in respect of the highest cluster mean value for maximum characters.

Among 10 characters cluster I produced the maximum cluster mean for the six characters viz. pod length (12.33 m), pod width (2.61) , pod weight (32.69) , inflorescence length (17.83),. Similarly, cluster II ranked first for days of first flowering (78.58), no. of flowering per inflorescence (15.75) and thousand seed weight. Cluster V ranked first for no. pod per inflorescence (12.00) and yield (157.50 kg). Cluster III had ten genotypes named BD-82, BD-122, BD-8022, BD-8227, BD-8725, BD-1785,BD-7988, BD-7995,BD-8738,BD-6 are collected from Plant Genetic Resources Centre, Bangladesh Agricultural Research Institute, Gazipur.

Table 10. Latent vectors for 10 principal component characters of 37 genotypes of Country bean

Character	Latent Vector I	Latent Vector II
Days of first flowering	0.0706	0.1941
No. of inflorescence	-0.408	0.0733
No. of flowers per inflorescence	0.4527	-0.2005
No. of pods per inflorescence	0.5065	-0.2086
Pod length (cm)	0.165	0.1626
Pod width (cm)	-0.06	-0.1605
Pod weight (gm)	0.0597	-0.3062
Thousand seed weight(gm)	-0.0424	-0.3778
Inflorescence length (cm)	0.0416	-0.268
Yield/plant(g)	0.323	-0.1781

Table 11. Cluster Mean

Character	Cluster					
	I	II	III	IV	V	VI
Days of first flowering	57.00	78.58	75.80	73.33	73.50	74.42
No. of inflorescence	25.17	20.00	22.70	26.33	17.75	27.67
No. of flowers per inflorescence	14.50	15.75	13.03	11.56	14.00	13.56
No. of pods per inflorescence	9.17	11.92	9.70	6.89	12.00	9.19
Pod length	12.33	10.41	11.43	9.67	8.75	8.74
Pod width	2.61	2.58	2.37	1.83	2.37	2.34
Pod weight (g)	32.69	24.31	19.40	11.33	20.45	22.31
Thousand seed weight (g)	9.83	10.41	8.07	7.22	9.42	10.33
Inflorescence length (c)	17.83	15.00	14.63	8.33	13.33	15.25
yield(g)	38.75	101.17	50.17	27.56	157.50	70.54
Seed length(c)	13.12	12.56	12.22	12.33	12.73	12.88
Seed width (c)	9.60	9.16	9.27	8.01	9.58	9.53
Seed weight(g)	5.07	4.38	4.70	3.42	5.19	5.20
No seed per plant	3.83	4.75	4.07	4.00	4.25	5.06

4.3.4 Canonical variate analysis

The highest inter-cluster distance was observed (Table 9 or Figure 2) between cluster IV and V (17.17) followed by between cluster III and V (14.29). The intra cluster distance was the highest (1.1010) in cluster II. The lowest inter-cluster distance was observed between cluster II and VI (4.64) followed by cluster III and VI (4.76). The higher inter-cluster distances between these clusters indicate to obtain wide spectrum of segregating population if parents chosen from these distant clusters are used for hybridization program. However, the highest inter-cluster distance was observed between cluster IV and V indicated the genotypes in these clusters were far diverged than those of other clusters. Similarly, the lowest inter-cluster distance was observed between the cluster II and VI (4.64).

Moderate or intermediate distance was found between cluster II and IV (11.22), cluster V and VI (11.05). The inter cluster distances were higher than the intra cluster distances suggesting wider genetic diversity among the genotype of different groups.

Result of different multivariate analysis were superimposed in Figure 1 from which it may be concluded from the above results that different multivariate techniques supplemented and confirmed one another.

As per scatter diagram the genotypes were apparently distributed into six clusters. It was also revealed that the genotypes of cluster I were more diverse from the genotypes of cluster III. Islam et al. (2004) also similar result. It is assumed that maximum amount of heterosis will be manifested in cross combination involving the genotypes belonging to most divergent clusters. However, for a practical plant breeding, the objective is not

only high heterosis but also to achieved high-level production. In the present study the maximum distance existence between cluster V and VI. But considering the yield and duration ceosses involving cluster V and VI may be exhibit high heterosis for yield. Main and Bahl (1989) reported that the parents separated by D^2 values of maderate generally showed higher heterosis.

4.3.5 Contribution of characters towards divergence of the genotypes

The values of Vector I and Vector II are presented in Table 10. Vector I obtained from PCA expressed that days to first flowering (0.0706), number of flower per inflorescence (0.4527), no. of pods per plant (0.5065), pod length (0.165), pod weight (0.0597) and yield per plant (0.323) were major characters that contribute to the genetic divergence. It was the reflection of first axis of differentiation. In vector II days to first flowering (0.1941), no. of inflorescence per plant (0.0733), fruit length (pod) showed their important role toward genetic divergence. Negative values in both vectors for, fruit diameter and thousand seed weight had lower contribution towards the divergence.

4.3.6 Selection of genotypes as parent for hybridization programme.

Selection of genetically diverse parents is an important step for hybridization program. So the genotypes were to be selected on the basis of specific objectives. A high heteosis could be produce from the crosses between genetically distant parents.

Considering the magnitude of cluster mean and agronomic performance the genotype G21 (BD-1805) for minimum days of first flowering from cluster I: G3 (BD- 100) for maximum pod length and G8 (BD-132) for maximum pod weight and thousand seed

weight form cluster I; G35 (BD-8816) for maximum number of pod per plant and G19 (BD-8027) for maximum pod width from cluster II were found promising. Therefore considering group distance and other agronomic performance the inter genotypic crosses between G21 and G3; G8 and G35; G19 and G35: G21 and G19: G8 and G21, G21 and G35, G3and G8, G3 and G35, G3 and G19, G8 and G19 may be suggested for future hybridization programme.

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was carried out in the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to evaluate the field performance, character association, genetic variability and characterization of 37 Country bean genotypes using morphological characters.

The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different characters were recorded and analyzed statistically. The analysis of variance of all the traits was computed and significant differences were found among the accessions in respect of different characters studied. The maximum value in respect of days to first flowering (85.00 days) was observed in G_{10} and minimum days (54.00 days) to first flowering were recorded in G_{21}. Genotype number G_{10} recorded the maximum value (38) inflorescence per plant and number of inflorescence per plant (10) was recorded in G_{13}. In respect number of flowers per inflorescence, G_{36} recorded the highest value (20) and number of flowers per inflorescence. G_{19} counted the lowest value (10). Genotype no. G_{14} is the highest length of inflorescence (21.30cm) and genotype no. G_{10} is the lowest length of inflorescence (7.00cm) was counted. In case of number of pod per plant, the highest value (16) was recorded in G_{35} and the lowest value was (6.33) recorded in G_{26}. In respect of pod length, longest pod (13.33 cm) was observed in G_3 and the genotype no. G_1 had the smallest length of (6.00 cm). In case of pod diameter, the highest value (4.00 cm) was observed in G_{19} and the lowest value (1.67) was

observed in G_{26}. Genotype no. G_8 is the highest weight per pod (41.87) and genotype no. G_{37} is the lowest weight per pod (10.00) was counted. In case of average thousand seed weight, the highest value (14.33 gm) was observed in G_8 and the lowest value (5.33 gm) was observed in G_{22}. The highest average yield per plant (183gm) was in G_{24} and the lowest yield per plant (21 gm) was recorded in G_{10}.

The phenotypic variance was higher than the corresponding genotypic variance in all the characters, indicating greater influence of environment on the expression of these characters. The maximum differences between phenotypic and genotypic coefficient of variation were 42.08% and 11.82% respectively which indicated that the average number off inflorescence mostly depended on environmental effect. The highest estimated heritability among ten yield contributing characters 99.78%, 98.67%, 97.71%, 97.64 and 97.44% was in yield per plant, days to first flowering, pod weight, length of inflorescence, and number of inflorescence. The lowest heritability was 40.47% in pod diameter.

The maximum genetic advance was observed in respect of yield per plant (77.95) among ten characters of country bean genotypes. The maximum genetic advance in percent of mean (GAMP) was obtained for yield per plant (110.06%) and the lowest was for pod diameter (21.32%).

Multivariate analysis was carried out through principal component analysis (PCA), principal coordinate analysis (PCO), cluster analysis, and canonical vector analysis (CVA) using Genstat 5.13 software programme. As per as PCA, D^2 and cluster

analysis using the genotypes were grouped into four different clusters. Cluster I, II, III, IV, V, and VI comprised 4, 4, 10, 3, 4 and 12 genotypes, respectively.

The maximum cluster distance was observed between cluster V and VI (17.17) followed by the distance between cluster III and V (14.29). The lowest inter-cluster distance was observed between cluster II and IV (4.510) followed by cluster I and III (6.517).

The highest intra-cluster distance was identified in cluster II (1.010) and the lowest intra-cluster distance was observed in cluster VI (0.809). the higher inter-cluster distances between these clusters indicate to obtain wide spectrum of segregating population if parents chosen from these distant clusters are used for hybridization program. However, the highest inter-cluster distance was observed between cluster V and VI indicated the genotypes in these clusters were far diverged than those of other clusters. similarly, the lowest inter-cluster distance was observed between the cluster II and VI (4.64).

Findings of the present study indicated significant variation among the genotypes for all the character studied. Considering diversity pattern and other field performances,

The genotypes G21, G3, G8 form cluster I and G35, G19 from cluster II could be best choice as suitable parents for efficient hybridization programme. The inter genotypic crosses between G21 and G3; G8 and G35; G19 and G35: G21 and G19: G8 and G21, G21 and G35, G3and G8, G3 and G35, G3 and G19, G8 and G19 may be suggested for future hybridization program.

The result of the present study revealed that a wide variability exists among the collected country bean genotypes. In addition, there was also genotypic variability of different yield contributing characters with yield of country bean. From the findings of the present study, the following conclusions could be drawn:

i. Wide range of genetic diversity existed among the country bean genotypes. That variability could be used for future breeding programme of country bean in Bangladesh.

ii. Selection procedure would be applied for desired characters such as days to first flower, increase pod length, pod diameter, number of pod per inflorescence to develop high yielding varieties.

iii. Relatively higher value and lower differences between genotypic co-efficient of variation and phenotypic coefficient of variation of different yield contributing characters like average pod weight, number of pod per infloresence, yield per plant were observed which indicates high potentiality to select these traits in future which were less affected by environmental influence.

iv. Further collection of country bean germplasm would be continued for getting more variability and desired traits in country bean.

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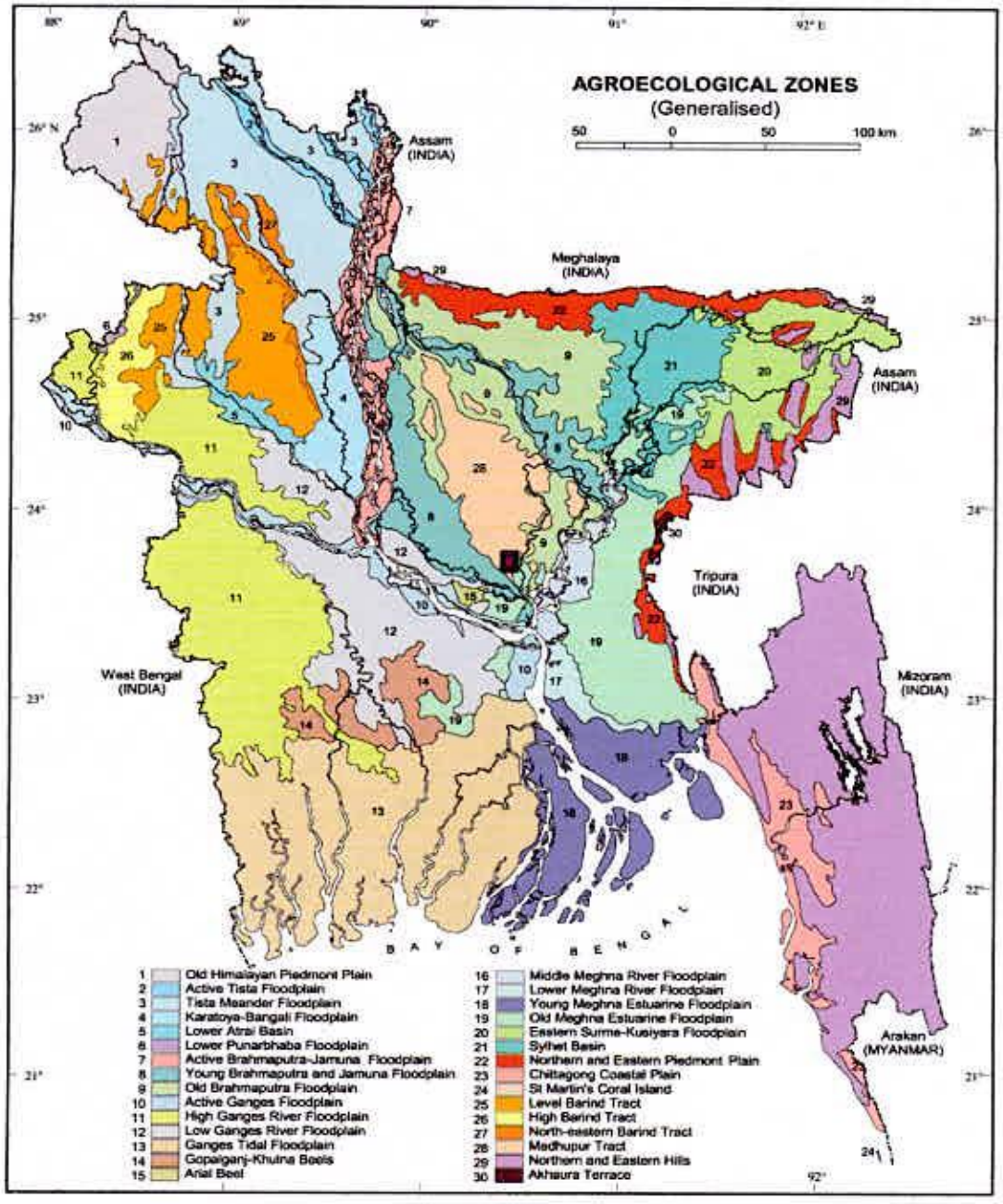
APPENDICES

Appendix I. Map showing the experimental site under the study



Appendix II. Monthly average record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from April 2008 to April 2009

Month	Air temperature (°c)		Relative humidity (%)	Rainfall (mm) (total)	Sunshine (hr)
	Maximum	Minimum			
April, 2008	36.9	19.6	64	91	8.5
May, 2008	36.7	20.3	70	205	7.7
June, 2008	35.4	22.5	80	577	4.2
July, 2008	34.0	24.6	83	563	3.1
August, 2008	36.0	23.6	81	319	4.0
September, 2008	34.8	24.4	81	279	4.4
October, 2008	34.8	18.0	77	227	5.8
November, 2008	32.3	16.3	69	0	7.9
December, 2008	29.0	13.0	79	0	3.9
January, 2009	28.1	11.1	72	1	5.7
February, 2009	33.9	12.2	55	1	8.7
March, 2009	34.6	16.5	67	45	7.3
April, 2009	35.8	20.3	65	88	8.3

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka - 1212

Appendix III. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix IV: Mean performance of different parameters of 37 Country bean genotypes

Parameters	Minimum	Mean	Maximum
Days of first flowering	54.00	73.17	85.00
No. of inflorescence	38.00	24.05	10.00
No. of flowers per inflorescence	20.00	13.64	10.00
No. of pods per inflorescence	16.00	9.74	6.33
Pod length (cm)	13.33	10.11	6.00
Pod width (cm)	4.00	2.36	1.67
Pod weight (gm)	41.87	21.77	10.00
Thousand seed weight (gm)	14.33	9.32	5.33
Inflorescence length (cm)	21.33	14.57	7.00
yield/plant (kg)	183.00	70.82	21.00

Appendix V. Principal component score 37 genotypes of Country bean

SL No.	Genotype	Z1	Z2
1	BD-82	-17.84	-4.09
2	BD-90	-11.1	3.01
3	BD-100	-28.03	-10.74
4	BD-113	61.52	-8.63
5	BD-117	64.16	4.46
6	BD-122	-30.18	9.18
7	BD-130	-45.57	-20.09
8	BD-132	-29.47	-21.45
9	BD-135	3.82	8.68
10	BD-808	6.81	15.66
11	BD-7998	6.36	8.62
12	BD-7999	8.93	-11.63
13	BD-8022	-16.82	8.96
14	BD-8227	-24.97	-3.43
15	BD-8034	5.44	-8.06
16	BD-8725	-22.77	-1.73
17	BD-137	1.43	-5.7
18	BD-8008	-7.07	-0.26
19	BD-8027	24.41	1.49
20	BD-8001	1.71	-3.26
21	BD-1805	-28.13	-22.62
22	BD-1785	-27.54	7.26
23	BD-8813	109.34	7.28
24	BD-8312	112.3	-10.47
25	BD-7974	-38.34	0.02
26	BD-1816	-41.52	14.57
27	BD-7988	-16.51	0.23
28	BD-7995	-10.31	8.45
29	BD-8752	26.53	-0.21
30	BD-8738	-20.21	11.93
31	BD-8729	-3.85	-3.85
32	BD-6	-17.31	-17.31
33	BD-8737	-7.52	-7.52
34	BD-8034	-9.72	-9.72
35	BD-8816	49.98	49.98
36	BD-8815	22.43	22.43
37	BD-7985	-50.38	-50.38

Appendix VI. Analysis of Variance (ANOVA) table

Character	MS value	% CV	Mean	SE
DTFF	222.55	1.36	73.17	0.82
NIPP	127.34	4.37	24.05	0.62
NFPP	15.34	11.93	13.64	0.25
NPPI	19.95	13.28	9.74	0.27
PL	16.07	16.91	10.11	0.26
PWd	0.66	19.73	2.37	0.06
PWt	153.21	5.01	21.77	0.68
TSWt	13.47	9.85	9.32	0.21
IL	44.78	4.10	14.57	0.37
Yld	4308.17	2.49	70.82	3.57
SL	1.84	4.98	12.59	0.09
SWd	2.89	4.85	9.30	0.10
SWt	4.25	7.56	4.82	0.12
NSPP	1.56	11.52	4.13	0.07

DTFE= Days of first flowering

NIPP= Number of Inflorescence per plant

NFPP = Number of flower per inflorescence

NPPI= No. of pods per Inflorescence

PL= Pod lenght

PWD= Pod width

PWT= pod weight

TSWT = Thousand seed weight

IL= Inflorescence Len

Yld= Yield per plant