GENETIC DIVERSITY CORRELATION AND PATH ANALYSIS OF SNAKE GOURD (*Trichosanthes anguina* L.)

BY

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A Thesis

Submitted to the department of Horticulture and Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka-1207
In partial fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2008

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CERTIFICATE

This is to certify that the thesis entitled, "GENETIC DIVERSITY CORRELATION AND PATH ANALYSIS OF SNAKE GOURD (Trichosanthes anguina L.)" submitted to the Dept. of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, impartial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN HORTICULTURE, embodies the result of a piece of bona fide research work carried out by MD. KHORSHED ALAM Registration No. 00895 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 sources of information, as has been availed of during the course of this investigation has duly been acknowledged.

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ACKNOWLEDGEMENT

First for all, the author is best to express his gratitude to Almighty Allah for His ever-ending blessing to complete this work successfully.

I wish to expresses his deepest sense of gratitude and regards to his reverend teacher and research Supervisor, Dr. ASM Mahbubur Rahman Khan, Senior Scientific Officer, Biotechnology division, BARI, Gazipur, for his dynamic, invaluable, constant supervision, scholastic guidance, constructive criticism and valuable suggestion during the whole period of the research and in preparing this manuscript of the thesis.

My deepest sense of gratitude and indebtedness are due to my research co supervisor Associate Prof. Md. Hasanuzzaman Akand, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, for his valuable advice and encouragement, constant inspiration and precious suggestions and critical review in completing the research work and preparing of this manuscript.

It's my great pleasure and privilege to express deep sense of gratitude and sincere regard to the chairman of my advisory committee Prof. Ruhul Amin for taking keen interest in my thesis research, constructive criticism and kind co-operation during the research period and in preparing the manuscript.Cordial thanks are due to senior teacher Prof. A. K. M. Mahtab uddin and Prof. M.A. Mannan, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, Md. Harun-ur-Rashid, Md. Mahfuz Alam and Md. Anwar Sadat, Scientific Officer, RARS, BARI, Ishurdi, Pabna, for encouraging me in my study and research period, who always gave me their heartiest affection and love. My greatest indebted, is to my parents, brothers and sister who have made lot of sacrifices in many ways for the cause of my study and inspired me all the time. I like to express my sincere thanks all of my friends and other relatives for their blessings and encouragement for this stud.Finally, I want to mention that I am deeply debt, to my well wisher whose sacrifice and encouragement made it possible to complete my degree successfully.

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GENETIC DIVERSITY CORRELATION AND PATH ANALYSIS OF SNAKE GOURD (*Trichosanthes anguina* L.)

By

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ABSTRACT

The experiment was conducted on diversity and estimation of genetic parameter, correlation and path analysis of 30 accessions of snake gourd at the experimental farm of Regional Agricultural Research Station, Ishurdi, Pabna of Bangladesh Agricultural Research Institute, during the period from April 2007 to September 2007. Significant variations were recorded among the snake gourd accessions in respect of different parameters. The accession SNG23 showed the highest performance weight of fruits per plant and yield of fruit. The highest genotypic and phenotypic coefficients were recorded in yield (88.70% and 88.72%) and second highest was recorded from weight of fruits per plant (88.61% and 88.65%). However, days to anthesis of first male flower (43.18% and 43.23%), days to anthesis of first female flower (26.49% and 26.75%), node number of first male flower anthesis (31.08% and 31.43%), node number of first female flower anthesis (24.43% and 24.77%), number of fruits per plant (73.37% and 73.55%), days to first harvest (19.54% and 19.88%), days to last harvest (11.65% and 12.25%), average fruit weight (51.33% and 51.36%) and 100 seed weight (23.25% and 23.35%) recorded moderate GCV and PCV. Correlation coefficient indicated that fruit yield per plant was highly significant and there was a positive association with days to anthesis of first male flower, days to anthesis of first female flower, node number of first male flower anthesis, number of fruits per plant, days to first harvest, days to last harvest, weight of fruits per plant, average fruit weight and yield (t/ha). In respect of path analysis number of fruits per plant, weight of fruit per plant directly contributed to the yield of snake gourd accessions. The accessions were also tested for genetic divergence utilizing the multivariate analysis. The accessions were grouped into four clusters.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

Acronyms	**Abbreviations/ Symbols**
Agro Ecological Zone	AEZ
Analysis of Variance	ANOVA
Bangladesh Bureau of statistics	BBS
Bangladesh Agricultural Research Institute	BARI
Bangladesh Agricultural University	BAU
Bangabandhu Sheikh Mujibur Rahman Agricultural University	BSMRAU
Centemeter	cm
Conservation of Vegetable and Fruits in Bangladesh	CVFB
Coefficient of Variation	CV
Canonical Vector Analysis	CVA
Degree of freedom	Df
and others(at elli)	*et al.*
Error mean square	EMS
Figure	Fig.
Genotypic coefficient of variation	GCV
Least significant difference	LSD
Metric ton	mt
Muriate of Potash	MP
Nitrogen	N
Organic carbon	O.C
Open pollinated	OP
Percentage	%
Phosphorus	P
Phenotypic coefficient of variation	PCV
Regional Agricultural Research Station	RARS
Randomized Complete Block Design	RCBD
Randomly Applied Polymorphic DNA	RAPD
Restriction Fragment Length Polymorphism	RFLP
Sher-e-Bangla Agricultural University	SAU
Snake gourd	SNG
Sulphur	S
Sum	$\sum$
Standard error	SE
Ton per hectare	t/ha
Triple Super Phosphate	TSP
Zinc	Zn

Chapter I

INTRODUCTION

Snake gourd (*Trichosanthes anguina* L.) is one of the most important and widely used cucurbitaceous summer vegetables in Bangladesh . It belongs to the family Cucurbitace (Chakrabarti, 1982), sub family Cucurbitoideae, tribe trichosanthae. The members of this tribe are almost entirely confined to old world. Two genera, Trichosanthes and Edgaria have been studied in detail cytologically(Tsuchiya and Gupta, 1991). There are about 44 species under the genus Trichosanthes, primarily originated in Indo-Malayan region. Snake gourd had probably originated in Indo-Malaya region and distributed in South East Asia, extending through Malaya to North Australia in one direction and China to Japan in another. Out of these species *T. anguina* and *T. dioica* are cultivated and others are wild.

It is a popular and relatively costly vegetable. In Bangladesh, snake gourd is grown during summer and available in the market from March to October. From nutritional point of view, snake gourd can be considered as nutrition rich vegetable. It contains considerable amount of protein (0.5%), fat (0.3%), minerals (0.5%), fiber (0.5%) and carbohydrates (3.3%) (Gopalan *et al.*,1982). Ripe fruits are rich in vitamin A. The red pulp of the ripen fruit is very rich in carotene (Vitamin A) which is cooked as vegetable in many place of our country (Rashid, 1993). Present harvestable yield of snake gourd is very low (4.24 t/ha) due to lack of high yielding variety. Other countries like India and Thailand developed some high yielding OP and hybrid varieties of snake gourd. India recommended the varieties H-8, H-371 and H-375 for Madras, IHR-16 for Banglore and TA for Tamilnadu (Chadha and Kallo, 1993). Hybrid and mutant varieties having high yield potentiality was also developed in India (Nataranjan *et al.*, 1984 and Datta, 1987). Recently Thailand has also developed one high yielding hybrid variety.

In Bangladesh, vegetable production is not uniform round the year due to climate and edaphic factors and most of the vegetables are produced in winter. So, there is a scarcity of vegetables during summer or rainy season and only a small amount of vegetables are produced during the months of April to October. Among these, snake gourd contributes a significant portion of vegetable production during lean period of vegetable supply in summer season of Bangladesh.

The yield of snake gourd is very low compared to the other countries like India (4.24 t/ha, BBS, 2005). Several factors are responsible for such a low yield of snake gourd in Bangladesh, the most important one is the lack of high yielding varieties. However, many cultivars of snake gourd with a lot of variability is found in Bangladesh. Selection of a high yielding germplasm can, therefore, significantly increase the snake gourd production in Bangladesh. There is no recognized variety of snake gourd in Bangaladesh but there is a good range of variability in size, shape and color of fruits available in Bangladesh (Rashid, 1993). Therefore, there is a scope of survey to collect naturally occupying genetic variability which will ultimately help for yield improvement of this crop. Snake gourd is monoecious and highly cross-pollinated in nature. Such pollination mechanism can be exploited for the production of hybrid variety. Moreover, there is a bright scope of development of OP variety utilizing the existing variability.

The yield in snake gourd is a complex component character. In a breeding programme for increasing yield, quality, resistance to disease and pests in the exploration of genetic variability in presence of available germplasms is pre-requisite. Therefore, evaluation of germplasm under local conditions is very important. Improvement in yield depends on the nature and extent of genetic variability and genetic advance in the base population from which selection is made.

The knowledge of the interrelationships between yield and yield components is necessary; determination of correlation among plant characteristics is a matter of considerable importance in selection of correlated response. Correlation studies between yield and other traits of the crop will be of interest to breeders in planning the hybridization programme and evaluating the individual plants in segregating populations, but it does not give an exact position of the relative importance of direct and indirect effects of various traits on yield or any other attributes. Following correlation analysis, the path coefficient analysis would provide a true picture of genetic association among different traits (Bhatt, 1970). Path coefficient analysis is useful for evaluating the relative contribution of each component traits both direct and indirect to the yield. Path co-efficient analysis help specifying the cause and effect and measuring their relative significance. So, correlations in combination with the path co-efficient analysis quantify the direct and indirect contributions of one characteristic upon another (Dewey and Lu, 1959). The phenotypic and genotypic variations of the yield contributing characters are considerably high in snake gourd (Nataranjan *et al.*, 1984) which points to the possibility of developing a variety with high yield. In a hybridization program, knowledge of the interrelationship among yield and yield contributing characters are necessary.

In crop improvement program genetic diversity has been considered as an important factor which is also pre-requisite for hybridization program to obtain high yielding progenies. For planning and executing of genetic improvement program a clear understanding of the magnitudes of genetic diversities for yield and its component characteristics are important to plant breeders for both cross and self pollinated crops (Griffing and Lindstorm, 1954). Selecting genetically diverse parents for a successful hybridization programme, helps quantification of genetic diversity (Jain *et al.*, 1975).

Considering the above facts, the present study has been under taken to fulfil the following objectives:

i) To study the variability for yield and yield contributing characters of snake gourd.

ii) To determine correlations among the economic parameters and their direct and indirect effects on yield in snake gourd.

iii) To help selecting a superior genotype among the variable population and

iv) To study the genetic divergence among the available accessions.

Chapter II

REVIEW OF LITERATURE

Snake gourd (*Trichosanthes anguina* L.) is a member of the family Cucurbitaceae. It is an important summer vegetables in this country. Snake gourd is an annual monoecious climbing type herbaceous crop. A few works have been done for the improvement of this crop in Bangladesh and other countries in the world. However, research efforts on the genetic diversity, correlation and path analysis of snake gourd seem to be meager. However, information available in these aspects of snake gourd and some other cucurbit crops have been reviewed and presented in this section. The center of origin of snake gourd (*Trichosanthes anguina* L.) is not precisely known but most of the authors agree that India or Indo-Malayan region is its original home (Choudhury, 1967 ; Seshadri, 1986 and Roy *et al.,* 1991). The genus Trichosanthes consists of 44 species; as many as 20-24 species are recognized by Clarke (1879) in India. Chinese name of snake gourd is "manka" means "cucumber of the southern barbarians," which indicated that India or the Indian Archipelago is the possible centre of origin. At present snake gourd is also being cultivated in Mauritius and central and East Java. The species are distributed in South-East Asia, extending through Malaya to North Australia in one direction and China to Japan in another. Snake gourd is highly cross-pollinated due to monoecy. Flowers are small, unisexual, axillary, white; female flowers solitary, sessile; ovary long, narrow, densely hairy; male inflorescence are long, slender densely pubescent stalks (10-20 cm long), 5 to many flowered; flowers in axils of short bracts, pedicels long, filiform, densely pubescent, 1.0-2.5cm long; calyx companulate, 5 partite, densely pubescent; corolla 5 partite, ovate oblong, long fimbriate. Flowers occur in leaf axils in 3 different ways: (1) male solitary, (2) male solitary and male inflorescence and (3) female solitary and male inflorescence. Flowers bloom at early hours of night and anther dehiscence tends to go together (Peter, 1998). Deshpande *et al.* (1980) reported that anthesis begins between 17.15 hour and continued until 21.30 hour. Anther dehiscence occurs before flower opening taking 1 hour for completion. Pollen grains remain viable for 10 hour before dehiscence and 46-49 hour after dehiscence. Stigma remains receptive from 7 hour before opening till 51 hour after opening.

2.1 Variability studies of snake gourd and other related crops

The assessment of variability present in the crop helps successful utilization of plant characters in developing suitable varieties for yield and stability. In snake gourd, Joseph (1978) recorded considerable variability among 25 lines for days to first male flower anthesis (36-45 days) and days to first female flower anthesis (45-61). He also observed in his study the female flowers of snake gourd initiated at 15 to 23 nodes.

Pathak and Singh (1950) found that female flowers of pointed gourd open within 8 to 12 days and male within 13 to 16 days from their bud appearance.

High genotypic and phenotypic variances for days to flowering were found in bittergroud (Cruz and Villareal, 1970 and Pal *et al.* 1983), in snake gourd (Deshpande *et al.* 1980), in musk melon (Vijay, 1987).

High genotypic coefficient of variation and phenotypic coefficient of variation for yield per plant were also observed in water melon (Chhonkar, 1977) and muskmelon (Vijay, 1987).

Ramchandran *et al.*(1981) carried out detailed studies in 25 diverse lines of bitter gourd and observed significant variability among these genotypes.

Indiresh (1982) studied 24 lines of bitter gourd and observed high genotypic co-efficient of variations for fresh weight of fruit , yield per plant and fruit length.

Arora *et al.* (1983) found female flower at the node 8.2 in sponge gourd. Saha *et al.* (1986) reported that 5 to 9 nodes for male flower bearing and 15 to 27 nodes for female flower bearing among the pumpkin genotypes.

Vashistha *et al.* (1983) observed that low genotypic coefficient of variation and phenotypic coefficient of variation for this character in water melon (0.44 and 1.15), musk melon (0.04 and 0.07), cucumber (0.26 and 0.27) and high value (47759.63 and 55149.80) in bitter gourd.

The variability for yield per plant was also recorded in water melon (Chezhiyan, 1984), bottle gourd (Rahman *et el.* 1986), musk melon (Swamy *et al.*1984) and pumpkin (Rana *et al.* 1986 and Saha *et al.* 1992).

High genotypic co-efficient of variance and phenotypic co-efficient of variance were observed for fruits per plant by Reddy and Rao (1984), Rahman *et al.*(1986) and Saha *et al.*(1992) in ribbed gourd (75.40 and 109.38), bottle gourd(30.47 and 38.61) and pumpkin (27.94 and 33.78).

In the study of genetic variability that most of the characters showed significant variation in ribbed gourd (Kadam and Kale, 1987).

Singh and Singh (1988) studied 18 lines of pointed gourd in India for yield per plant and 10 related characters and observed that significant differences were found for all the characters fruits per plant, fruit length and yield.

Lalta *et al.* (1988) studied the genetic variability of water melon among 9 germplasms for 14 characters. They reported high values for phenotypic and genotypic co-efficient of variation for fruits per plant, average fruit weight, seeds per fruit, fruit yield per plant.

Sureshbabu (1989) studied 50 genotypes of pumpkin and observed considerable variability for days to first male flower anthesis (41-73 days), days to first female flower anthesis (41-84 days) and first female flower initiation at 24-78 nodes. Lowest Phenotypic co-efficient of variance for days to first male flower anthesis (13.08) and lowest genotypic co-efficient of variance was found in female flower initiation.

Mondal *et al.* (1989) studied the genetic variability of 31 water melon genotypes and observed a wide range of variability for days to first fruit harvest, fruit length, fruit diameter, number of fruits per plant and fruits yield per plant.

In 9 local germplasms of ash gourd Hamid *et al.* (1989) found a wide range of variability among the lines in respect of their vine growth , flowering habit , fruit bearing , weight and size of fruit.

Sarkar *et al*. (1989) noted in pointed gourd that mean node number for the emergence of first female flower was 37.4 .

Vahab (1989) found low phenotypic co-efficient of variance for node at first female flower initiation (8.18) in bitter gourd.

Prasad and Singh (1989) found low genotypic and phenotypic variance for node order of first male flower open (2.68-7.42) in ribbed gourd.

Prasad and Singh (1989) noted high value of genotypic and phenotypic variances for number of fruits per plant in ribbed gourd (202.26 and 475.98) whereas Vijay (1987), Rahman *et al*. (1986), Abusaleha and Dutta (1990) reported low value in muskmelon (91.71 and 1.90), bottle gourd (1.43 and 3.10), cucumber (1.15 and 1.24) and bitter gourd (99.02 and 10.45).

Singh and Prasad (1989), Varghese (1991) and Saha *et al*. (1992) recorded high genotypic coefficient of variation and phenotypic coefficient of variation for yield in pointed gourd (46.50 and 64.10), in snake gourd (30.06 and 31.33) and pumpkin (28.82 and 31.21) respectively.

Rahman *et al*. (1990) also reported that significant differences for days to flowering among the different entries of ribbed gourd, bitter gourd, bottle gourd and sweet gourd.

Significant variation among the cultivars for fruits per plant was also found in ribbed gourd and sweet gourd (Rahman *et al*. 1990).

Abusaleha and Dutta (1990) carried out an experiment in India to assess the genetic variation of 65 ridge gourd accessions. Significant variability was observed for all the characters at phenotypic as well as genotypic level with a very wide range of values.

Sharma and Dhankhar (1990) also reported that higher estimates of genotypic co-efficient of variances and phenotypic co-efficient of variances (13.54 and 14.00) for days to first female flower opening in bottle gourd.

Twelve genotypes of pointed gourd were evaluated at the Central Horticulture Experiment Station, Ranchi, India during 1985-86 and 1987-88 growing seasons when the genotypes exhibited significant differences in all traits (Krishnaprasad and Singh, 1991).

Saha *et al.* (1991) reported wide genetic variations among six genotypes of teasle gourd in respect of days to flowering, individual fruit weight and number of fruits per plant.
Chigwe (1991) observed considerable variability for fruit yield while evaluating more than 100 pumpkin landraces.

High genotypic coefficient of variation and phenotypic coefficient of variation were reported (39.55 and 41. 00) by Saha *et al.* (1992); (30.2 and 36.4) by Doijode and Sulladmath (1986) for fruit weight in pumpkin. Rana *et al.* (1986) also observed high value for this trait in pumpkin.

Mannan (1992) reported narrow difference between genotypic coefficient of variation and phenotypic coefficient of variation for this trait in bitter gourd indicating less environmental influence on this character.

Ahmed *et al.* (2000) studied the different genetic variability in snake gourd at the experimental field of BSMRAU during February to July, 1997. Eight fruit morphotypes of snake gourd were studied to measure the variability. Among the morphotypes, all the characters except node number of first flower showed significant variation. The highest genetic variability was observed for fruit length, fruit yield per plant showed maximum differences between genotypic and phenotypic coefficient of variation indicating highest environmental influences.

Miah *et al.* (2000) studied 30 genotypes of bitter gourd and observed the highest genotypic as well as phenotypic coefficient of variation for fruit length followed by days to female flowering, fruit weight per plant and single fruit weight.

Banik (2003) reported that in snake gourd 100 -seed weight ranges from 21.97g to 34.47g. She also found genotypic co-efficient of variation and genotypic co-efficient of variation to be 10.07 and 10.52 respectively.

2.2 Path analysis and correlation between yield and yield contributing characters

Fruit yield in snake gourd is the character which is contributes by a complex chain of interrelating characters. Association of these yield contributing characters with yield and among its components is important for making selection in the breeding programme. Such correlation studies may also differ due to agro ecological variation from year to year.

Singh *et al.* (1986) stated that yield was positively and significantly correlated with fruits per plant (r = 0.95) and vine length (r = 0.60) in pointed gourd. Days to flowering and days to fruit set were negatively correlated with all the other characters with the exception of a positive correlation between days to flowering and fruit weight.

Rahman *et al.* (1986) reported negative but significant correlation between yield per plant and fruit length (r = 0.588) and strong positive significant correlation with fruit diameter (r = 0.571) in bottle gourd. Path analysis revealed that fruit length and diameter had high positive direct effect on yield and number of fruits per plant had also considerable positive direct effect on yield per plant in bottle gourd.

Abusaleha and Dutta (1988) carried out path coefficient analysis in 75 cucumber varieties. They reported that fruits per vine and fruit length had the greatest direct effect on yield.

Sarkar *et al.* (1989) carried out an experiment in India to study correlation and path analysis of 16 divergent types of pointed gourd which indicated that fruit weight , fruit diameter and number of primary branches / plant were positively and significantly correlated with yield / plant at genotypic and phenotypic levels. The path analysis revealed that fruit volume followed by fruit weight and fruit diameter have maximum positive direct effects on yield. The indirect effects of all the components through fruit volume were relatively high in magnitude in respective of direction. Therefore, emphasis should be given on fruit weight followed by fruit diameter, fruit volume and number of primary branches / plant in selecting good genotype for improvement of yield in pointed gourd.

Krishnoprasad and Singh (1991) found a positive correlation between yield and late flowering in pointed gourd.

Saha *et al.* (1992) found positive but non-significant association between fruit yield and fruit length (r = 0.375) where there existed as strong positive and significant association between fruit yield and fruit diameter (r = 0.609) indicating selection of fruit diameter in pumpkin.

Path analysis of yield and its components revealed that vine length (1.21) ,days to female flower appearance (0.752) , fruit weight (6.126) and fruit length (1.082) had positive direct effect on yield in cucumber (Prasad and Singh , 1992).

Matsuura and Fujita (1995) observed correlation among 98 cucumber (*Cucumis sativus*) cultivars. Morphological characters were not correlated with the number of fruits produced. However, the number of fruits was correlated with leaf size.

Kumaran *et al.* (1998) carried out an experiment on correlation and path analysis studies in pumpkin. They found that positive and significant correlation of vine length, mean fruit weight, number of fruit per plant and number of seeds per fruit with fruit yield per plant. They also found that number of fruit per plant exhibited the highest direct effect on yield. High positive indirect effects were exerted by number of fruit per plant and mean fruit weight.

Miah *et al.* (2000) noted that fruit yield showed significant positive association with average fruit weight, fruit breadth and number of nodes per vine in genotypic and phenotypic correlation with days to male flowering in bitter gourd. Path analysis revealed that average fruit weight, number of fruits per plant, days to male flowering and fruit length had positive direct effect on fruit yield.

Dora *et al.* (2002) conducted an experiment to determine the important yield attributing characters required for the selection of high yielding types from 11 selections of pointed gourd collected from different parts of Orissa and Bihar, India. Fruit retention percentage and the number of fruit per plant were the most important yield attributing characters. Hence, these two characters must be given emphasis in the selection of high yielding types.

2.3 Genetic diversity

D^2 analysis originally outlined by Mahalanobis (1936) and extended by Rao (1952) is one of potential methods of estimating the degree of genetic diversity. It also enables to quantify the relative contributions of different characters to the total diversity.

Mahalanobis D^2 statistics of multivariate analysis (Jeshwani *et al.* 1970 and Mital *et al.* 1975) is a useful tool in quantifying the degree of divergence between the biological population of different components to the total divergence, both at inter and intra cluster levels.

Selection of genetically diverse parents for a successful hybridization program is now possible through biometric procedure, which helps quantification of genetic diversity (Jain *et al.* 1975).

Genetic diversity is one of the important tools to quantify genetic variability in both self and cross-pollinated crops (Guar *et al.* 1978).

Ramchandran *et al.* (1981) grouped 25 bitter gourd germplasm into 10 clusters based on their D^2 values. The inter-cluster distance values observed were higher between cluster VI and VIII (8569.31) and the minimum was between cluster II and III (393.62). The coefficient of variation estimated for different characters among the 10 clusters showed greater role for yield per plant (38.84), fruit per plant (25.68), female flowers per plant (19.82) and fruit length (19.05) in determining the inter-cluster distance. It was further observed that the characters yield per plant, fruits per plant, female flowers per plant and fruit length contributed predominantly to divergence.

A study involving 45 diverse lines of *Cucumis melo* revealed high diversity as indicated by the range of D^2 values for 2.52 to 210.14 among the lines (Kalloo *et al.* 1982). Depending on the genetic divergence, the 45 strains were grouped into 14 clusters. The maximum distance at inter-cluster level was 14.50 followed by 13.29. The intra-cluster distance ranged from 9.36 to 19.86. It was also found that the genotypes usually did not cluster according to the geographical origin.

The magnitude of D^2 indicated closeness among the varieties. The characters, fruits per plant contributed maximum to total divergence (80%). Seeds per fruit did not contribute to the total divergence; selection of botanical varieties based on fruits per plant would be a logical step in the selection of divergent parents in any hybridization programme as reported by Mathew *et al.* (1986).

Kadam and Kale (1987) observed highly significant difference between cultivars suggesting considerable divergence among 30 ridge gourd cultivars. Thirty cultivars were grouped into 20 clusters based on their D^2 values. Cluster A having two cultivars had the lowest intra-cluster D^2 values (8.22) while cluster I which had two cultivars with the highest intra-cluster value of 18.59. The highest inter cluster distance was observed between clusters V and XIII (387.11) and it was minimum between cluster IV and VIII (19.79).

The relative contribution of a trait, however, depends on the population and also on the environmental conditions in which the population is grown (Akhter, 1990).

The relative contribution of character, however, depends on the population and also on the environmental conditions in which the population is grown (Akhter, 1990).

Tomooka (1991) reported that evaluation of genetic diversity is important to know the source of gene for a particular trait within the available germplasm.

Masud *et al.* (1995) grouped 27 genotypes of pumpkin into seven clusters. No relationship was found between genetic divergence and geographic distribution of the genotypes. The results of PCA revealed that in vector I (Z_1) the important characters responsible for genetic divergence in the major axis of differentiation were yield per plant, fruit length, fruit weight and fruits per plant. In vector, II (Z_2) fruits per plant and yield per plant played a major role while rest of the characters played a minor role in the second axis of differentiation. The clustering pattern of the genotypes revealed that the genotypes collected from the same place did not form a single cluster. Thus genetic diversity and geographic distribution were not directly related. They studied the genetic distance among five botanical varieties of *Cucumis melo*. The genetic distance was calculated for nodes to first female flower, fruit weight seeds per fruit and fruits per plant. Total D^2 was estimated according to Mahalanobis (1936).

Ram (2001) grouped 167 diverse accessions of pointed gourd (*Trichosanthes dioica* Roxb.) on the being genetic divergence, in to 8 non- overlapping clusters. Cluster 8 and cluster 5 were most diverse as indicated by maximum intercluster distance between them (6.049). Considerable variation in cluster means was observed for most of the characters. The minimum distance was observed between cluster I and cluster VII (1.676), indicating close relationship among accessions. The intra-cluster distance ranged from 1.258 to 1.655. They also found that the first principle component had highest eigen roots and also showed highest proportion of total variation (47.92 %), followed by second component with the variation of 22.52 %. The first five components accounted for more than 95 % variations. Thus, the five components were used for non hierarchical euclidean cluster analysis.

While studying 19 genotypes of sponge gourd (*Luffa cylindrica*) collected from local and exotic sources Masud *et al.* (2001) grouped the genotypes into five clusters. The genetic divergence of the genotypes did not follow their geographical distribution and was at random. There was no evidence of close relationship between geographical distribution and genetic divergence as estimated by D^2 statistics. Maximum inter cluster distance (45.9) was observed between cluster II and V and minimum (10.3) between cluster II and IV. Fruit length and diameter were significant contributors to genetic divergence.

Prasad *et al.* (2001) used D^2 analysis in 60 inbred lines of cucumber to select a suitable germplasm for a hybridization program. Thirteen characteristics involving growth, flowering, fruiting ability and yield were used and found ten different clusters irrespective of their allelic relationship and geographical areas of collections. The node number followed by number of branches and node at which first female flower appeared to contribute maximum to genetic divergence.

Genetic divergence using Mahalanobis D^2 statistics was studied for seven quantitative characters including yield per vine in a collection of twenty diverse cultivars of bottle gourd by Badade *et al.* (2001). The cultivars differed significantly for almost all the characters and were grouped into 10 clusters based on the similarities of D^2 value. Considerable diversity within and between clusters was noted and it was observed for the characters viz. vine length, number of branches, fruit per vine, length and diameter of fruit and yield per vine.

Hazra *et al.* (2003) grouped 167 accessions of pointed gourd into eight non-overlapping clusters, with cluster IV comprising the highest number of accessions (37 accessions) and cluster VI comprising of the lowest number of genotypes (6 accessions). Intracluster distance ranged from 1.25 in cluster I to 1.65 in cluster VII. Cluster VII and V were the most diverse as indicated by the maximum intercluster distance between them (6.04).

From the above review it has been revealed that wide degree of variation for yield and yield contributing characters are observed in snake gourd by different author. The difference in the range of characters reported can be due to the difference in genetic materials used and the environment where they were grown.

Chapter III

MATERIALS AND METHODS

3.1 Experimental site

The field experiment was conducted at the Regional Agricultural Research Station of Bangladesh Agricultural Research Institute (BARI), Ishurdi, Pabna. The site of the field experiment was situated between 24.03^0 N latitude and 89.05^0 E longitudes at the elevation of 16 m above the sea level.

3.2 Climate

The experimental area was under the sub-tropical climatic zone and characterized by moderate rainfall, high temperature, high humidity and relatively long days during the Kharif season (April to September) and scanty rainfall, low humidity, low temperature and short day during Rabi season (October to March).

3.3 Soil

The soil of the experimental plot was clay loam in texture belonging to the High Ganges River Flood Plain under AEZ 11 (Anonymous, 1971). The selected plot was well-drained high land with pH 8.5. Soil was analyzed before conducting the experiment at the Regional Laboratory of Soil Resources Development Institute, Rajshahi. Details of the soil characteristics are shown in Appendices 1.

3.4 Plant materials used

Thirty snake gourd accessions were collected from different parts of Bangladesh. The places from where these snake gourd accessions have been collected are given in Table 2.

Table 2 Accession number and Source of 30 snake gourd germplasm

Accession number	Source
SNG01	Rangpur
SNG02	Rangpur
SNG03	Rangpur
SNG04	Rangpur
SNG05	Rangpur
SNG06	Rangpur
SNG07	Rajshahi
SNG08	Rajshahi
SNG09	Pabna
SNG10	Rajshahi
SNG11	Rajshahi
SNG12	Bogra
SNG13	Bogra
SNG14	Bogra
SNG15	Rajshahi
SNG16	Rajshahi
SNG17	Pabna
SNG18	Bogra
SNG19	Bogra
SNG20	Pabna
SNG21	Kushtia
SNG22	Kushtia
SNG23	Dinajpur
SNG24	Dinajpur
SNG25	Dinajpur
SNG26	Dinajpur
SNG27	Dinajpur
SNG28	Dinajpur
SNG29	Kushtia
SNG30	Pabna

3.5 Land, bed and pit preparation

The land selected for the experiment was opened 15 days before planting of the crop with a disc plough. It was then thoroughly prepared by ploughing and cross ploughing with a power tiller followed by laddering to obtain good tilth. During land preparation, weeds and stubbles were collected and removed from the field and the clods were broken with the help of hand. The surface of the land was leveled. Finally irrigation and drainage channels were made around the plots. Final land preparation was done one week before pit preparation. Beds were made on the plots. Plant spacing was 1.0m x 1.0m. Each bed was 1.0m x 5m in size. A space of 0.75m was kept between two beds. Pits of 50cm × 50cm × 30cm size were prepared in each bed and plant to plant spacing maintained was 1.0m.

3.6 Seedling raising and transplanting of seedling

Seeds were sown in polybags having compost mixed soil on 15th April, 2007 for germination and seedling rising. Two seeds were sown in each polybag. The polybags were kept in shady place. They were watered regularly during the seedling raising period. When the seedlings (14 days old) attained 4-6 leaves and hard enough, they were transplanted in the main field on 30 April, 2007. Every morning watering was done after transplanting.

3.7 Treatments and experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatment comprised of thirty snake gourd accessions. The size of a unit plot was 1.0m x 5.0m, which accommodated 5 plants at a spacing of 1m x 1.0 m.

3.8 Application of manure and fertilizer

Recommended doses of manure and fertilizer at the following rates were applied in the experimental field (Rashid, 1993) shown. (Table 3).

Table 3 Doses of manures and fertilizers and their methods of application

Manure/ Fertilizer	Doses(Kg/ha)	Basal dose (Kg/ha)	Top dressing (Kg/ha)	
			First installment*	Second installment**
Cow dung	5000	Total	-	-
Urea	120	60	30	30
Triple Super Phosphate	80	Total	-	--
Muriate of Potash	60	Total	-	-
Gypsum	80	Total	-	-
Zinc Oxide	8	Total	-	-

* 15 days after transplanting   ** 40 days after transplanting

Half of the quantity of cowdung was applied during land preparation. The remaining half of cowdung, the entire quantity of TSP, MP, Zinc sulphate, Gypsum and half of the urea were applied as basal dose during pit preparation. The remaining amount of urea was applied in two installments in pits.

3.9 Intercultural Operations

The plants were always kept under careful observation. After transplanting of seedling, different intercultural operations as mentioned below were accomplished.

3.10 Trilling

During the growing period, bamboo stick was used to support the plants, and the plants were allowed to creep on a bamboo pandal. Bamboo pandal helped the plants for proper growth and to protect the fruits from getting damaged by soil pathogens. It also helped easy harvesting of the fruits.

3.11 Irrigation

Irrigation was given as and when necessary depending on soil moisture status and crop conditions and particularly after each application of fertilizers.

3.12 Weeding and mulching

Weeding and mulching were accomplished as and when required to keep the crop free from weeds and to keep the soil loose for proper aeration. Mulching was done after irrigation at appropriate time to break the soil crust and to make the soil loose.

3.13 Plant protection measures

Diazinon 60 EC @ 3.5 ml/lit. of water was sprayed at an interval of 10 days from the beginning of infestation for controlling Epilachna beetle. After fruit setting, Neembicidin @ 0.2% was sprayed at an interval of 10 days for controlling fruit flies.

3.14 Harvesting

Fruits were harvested regularly when they attained physiological maturity, ie. Immediately before hardness of seeds.

3.15 Data collection

Data on the yield components and yield *viz.* (i) Days to anthesis of first male flower, (ii) Days to anthesis of first female flower, (iii) Node number of first male flower anthesis, (iv) Node number of first female flower anthesis, (v) Number of fruits per plant, (vi)Days to first harvest, (vii) Days to last harvest, (viii) weight of fruits per plant, (ix) Average fruit weight, (x)100 seed weight and (xi) yield (t/ha) were recorded from two randomly selected plants of each accession.

The parameters estimated were variances, correlation, Path coefficient and genetic divergence. The methods of data collection are described briefly below:

(i) Days to anthesis of first male flower

Number of days was counted from the date of sowing to date of first male flower opened.

(ii) Days to anthesis of first female flower

Number of days was counted from the date of sowing to date of first female flower opened.

(iii) Node number of first male flower anthesis

Number of nodes was counted from the first node to the node at which first male flower opened.

(iv) Node number of first female flower anthesis

Number of nodes was counted from the first node to the node at which first female flower opened.

(v) Number of fruits per plant

Number of fruits in each plant was harvested at edible stage.

(vi)Days to first harvest

The number of days required from sowing to edible maturity.

(vii) Days to last harvest

Total days required from flowering last harvest were recorded.

(viii) Weight of fruits per plant

The total weight of all the harvested fruits from each plant was recorded.

(ix) Average fruit weight

The total weight of fruit was counted from 10 fruits randomly harvested from every plot and the average was worked out.

(x) 100 seed weight and

The number of 100 seeds was counted from fruits harvested from every plant.

(xi) Yield (t/ha)

Total weight of all the harvested fruits from each plant was recorded and fruit yield per plant was calculated.

3.16 Statistical analysis

The collected data on yield contributing characters and yield under study were statistically analyzed to find out the significance of difference among treatment means. The means for all the treatments were calculated.

i. Analysis of variance (ANOVA)

The mean of values of all the characters for all the genotypes were subjected to ANOVA and significance test among the means was performed by F- variance test by least significance difference (LSD) test for the interpretation of the results according to (Gomez and Gomez, 1984).

ii. Component of variance

The genotypic and phenotypic variances were calculated according to Johnson *et al.* (1955) using following formula:

$$\sigma^2 g = \frac{VMS - EMS}{r}$$

Where, *VMS* and *EMS* are the varietals and error mean squares and r is the number of replications.

The phenotypic variance (δ^2ph) was derived by the following formula:

$$\sigma^2 ph = \sigma^2 g + \sigma^2 e$$

Where, σ^2g is the genotypic variance and σ^2e is the effective error mean square.

Estimation of genotypic and phenotypic coefficient of variation was calculated according to Burton (1952) as follows:

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\delta g \times 100}{\bar{x}}$$

Where, δg = Square of genotypic variance and

$\bar{x}$ = Population mean.

Similarly the phenotypic coefficient of variation was calculated by the following formula:

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\delta ph \times 100}{\bar{x}}$$

Where, δ*ph* = Square of phenotypic variance and

$\bar{x}$ = Population mean

iii. Estimation of simple correlation coefficient

Simple correlation coefficient (r) among eleven important characters of snake gourd accessions was estimated with the following formula (Singh and Chaudhury, 1985).

$$r = \frac{\sum xy - \frac{\sum x . \sum y}{N}}{\sqrt{\{\sum x^2 - \frac{(\sum x)^2}{N}\}\{\sum y^2 - \frac{(\sum y)^2}{N}\}}}$$

Where, ∑ = Summation

x and y are two variables correlated

N = Number of observation

iv. Estimation of path coefficient

Path co-efficient analysis was done according to the procedure reported by Dewey and Lu (1959) using simple correlation values. In path analysis, correlation co-efficient was partitioned into direct and indirect effects of independent variable on the dependent variable.

V. Analysis of genetic divergence

Genetic divergence among the genotypes was studied using Mahalanobis $\mathbf{D^2}$ statistic and its auxiliary analysis. Both techniques estimate divergences among a set of genotypes on multivariate scales.

The $\mathbf{D^2}$ value between all varieties/lines was arranged in order of relative distances from each other and was used for clusters formation, as suggested by Rao (1952).

The average intra cluster distances were calculated by the following formula as suggested by Singh and Chaudhury (1985).

$$\text{Average intra cluster } D^2 = \sum \frac{D^2 i}{n}$$

Where,

$\sum Di^2$ = Sum of distances between all possible combinations (n) of the varieties/lines included in a cluster.

n = All possible combinations.

A. Cluster analyses (CA)

Cluster analysis as performed by D^2 analysis originally outlined by Mahalanobis, (1936) and extended by Rao, (1952), which divides the genotypes based on the data set into more or less homogeneous groups. D^2 is the sum of squares of differences between any two populations for each of the uncorrelated variables Clustering was done using non-hierarchical and hierarchical classification. D^2 statistic is defined by

$$D^2x = \sum_{i}^{P} \sum_{j}^{P} (h^{ij})\, d_i d_j$$

where,

x = Number of metric traits in point

p = Number of populations or genotypes

h^{ij} = the matrix reciprocal to the common dispersion matrix

d_i d_j = the differences between the mean values of the two genotypes for the i^{th} and j^{th} characters respectively.

In simpler form D^2 statistic is defined by the formula

$$\begin{array}{lll} x & x & \\ D^2 = & d^i_2 = & (y^j_i - y^k_j) \\ i & i & \end{array}$$

Where,

y = uncorrelated variable (character) which varies from i=1 to x

x = number of characters.

Superscripts j and k to y = a pair of any two genotypes.

Cluster analysis was performed by the computer software Gestate 5.13, which used algorithm to search for potimal values of the chosen criterion. The algorithm did some initial classification of the genotypes into required number of groups and then repeatedly transfers genotypes from one group to another so long as such transfer improved the value of the criterion. When no further transfer could be found to improve the criterion, the algorithm switched to a second stage, which examined the effect of swooping of two genotypes of different groups, and so on.

B. Canonical vector analyses (CVA)

The CVA complementary to D^2-statistic is a sort of multivariate analysis where canonical vectors and roots representing different axes of differentiation and the amount of variation accounted for by each of such axes, respectively are derived. Canonical vector analysis finds linear combination of original variability that maximize the ratio of between groups to within groups 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 maximize the ratio of among groups to within group variations.

C. Computation of average intra-cluster distances

The average intra cluster distance for each cluster was calculated by taking all possible D^2 values within the members of a cluster obtained from (Principle Coordinate analysis) PCO. The formula used to measure the average intra cluster distance was:

Intra-cluster distance = D^2/n

Where,

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

The square root of the D^2 values represents the distance (D) within cluster.

D. Computation of average inter- cluster distance

The procedure for calculating inter-cluster distance between cluster II and I, between cluster III and I, and between IV and I and so on. The clusters were taken one by one and their distances from other clusters were calculated.

E. 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 are, which fall into different clusters. Clusters separated by the largest statistical distance (D^2) expressed the maximum divergence among the genotypes included into these different clusters.

The following points as suggested by Singh and Chaudhury (1985) were considered while selecting genotypes for hybridization

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).

F. Analysis of data

Mean data for each character was subjected to multivariate analysis technique viz, principal component analysis (PCA), principal coordinate analysis (PCO), cluster analysis (CA) and canonical vector analysis (CVA) were done by computer using the GENSTAT 5.13 and Microsoft Excel 2000 software.

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to study the yield performance, variability, correlation and genetic divergence of 30 snake gourd accessions. The analysis of variances of the data on different yield contributing characters and yield are given in Appendix II. The results of the present study have been presented and discussed in this chapter under the following heading.

4.1 Plant, flowers, fruits and seeds characteristics

The plant, flowers, fruits and seeds characteristics like days required to male flower anthesis, days required to female flower anthesis, number of node at male flower anthesis, number of node at female flower anthesis, days required to first harvest, days required to last harvest, number of fruits per plant, weight of fruits per plant, average fruit weight and yield of fruit ton per hectare were recorded and shown in Table 4, Table 5, Table 6 and Table 7.

4.1.A Plant and flowers characteristics

The plant and flowers characteristics like days required to male flower anthesis, days required to female flower anthesis, number of node at male flower anthesis, number of node at female flower anthesis, days required to first harvest and days required to last harvest was recorded and results are presented below (Table 4, Table 5 and plate1).

4.1. A.1 Days required to male flower anthesis

It was observed that days to male flower anthesis varied significantly among the accessions and ranged from 9 days to 29 days with the mean value of 19 days (Table 4). The plants of accession SNG17 required the minimum days to male flower anthesis (9 days). This result agree with that of Yawlkar (1985) who reported significant variation among the genotypes for days required to first flowering. Joseph (1978) observed considerable variability among 25 lines of snake gourd for days to male flower anthesis to be 36 to 45 days. In 50 genotypes of pumpkin Sureshbabu

(1989) observed considerable variability for days to first male flower anthesis (41-73 days).

Considerable differences between genotypic (68.73 days) and phenotypic (68.91days) variance as well as genotypic (43.18%) and phenotypic (43.23%) coefficient of variation were found indicating considerable environmental effect upon the expression of the character of days to first flowering (Table 5). Sureshbabu (1989) also observed lowest phenotypic co-efficient of variance for days to first male flower anthesis (13.08).

4.1.A.2 Days required to female flower anthesis

It was observed that days to female flower anthesis varied significantly among the accessions and ranged from 21 days to 36 days while the mean value was 28 days (Table 4). The plants of the accession SNG03 required the minimum days to female flower anthesis (21 days). In snake gourd, Joseph (1978) found considerable variability among 25 lines for days to female flower opening (45 to 61 days). These findings are in agreement with that the results of Yawlkar (1985) who reported significant variation among the genotypes for days required to first flowering.

Considerable differences between genotypic (51.48 days) and phenotypic (52.50 days) variance as well as genotypic (26.49%) and phenotypic (26.75%) coefficient of variation was noted indicating considerable environmental effect upon the expression of the character of days to first flowering (Table 5). Sharma and Dhankhar (1990) reported that estimates almost similar genotypic co-efficient of variances and phenotypic co-efficient of variances (13.54 and 14.00) for days to first female flower opening in bottle gourd.

4.1.A.3 Number of node at male flower anthesis

Wide variation was observed among the accessions in number of nodes at first male flower anthesis (Table 4 and 5). The maximum number of nodes per vine was recorded (16) in accession SNG25 and the minimum (7) was recorded in SNG03. Number of nodes per vine increased with increase in length of vine. Joseph (1978) recorded 15.11 to 23.44 nodes for female flower initiation in snake gourd. Arora *et al.* (1983) found first female flower opening at the node 8.2 in sponge gourd. Singh and Prasad (1989) also reported the wide range of variability in pointed gourd for number of nodes per vine.

Considerable differences between genotypic (14.30) and phenotypic (14.63) variance as well as genotypic (31.08%) and phenotypic (31.43%) coefficient of variation was found indicating considerable environmental effect upon the expression of the character of number of node at first harvest (Table 5). Prasad and Singh (1989) found low genotypic and phenotypic variance for node order of first male flower open (2.68-7.42) in ribbed gourd.

4.1.A.4 Number of node at female flower anthesis

Wide variation was observed among the accessions in number of nodes (Table 4and 5). The maximum number of nodes per vine was recorded (34) in accession SNG29 and the minimum (20) was recorded in SNG19. Number of nodes per vine increased with increase in length of vine. In snake gourd, Joseph (1978) recorded 15.11 to 23.44 nodes for female flower anthesis. Arora *et al.* (1983) found first female flower at the node 8.2 in sponge gourd.

Considerable differences between genotypic (37.07) and phenotypic (38.10) variance as well as genotypic (24.43%) and phenotypic (24.77%) coefficient of variation was found indicating considerable environmental effect upon the expression of the character of number of node at first harvest (Table 5). Sureshbabu (1989) found 24-78 nodes for first female flower initiation in pumpkin and observed lowest genotypic co-efficient of variance. Vahab (1989) found low phenotypic co-efficient of variance for node to first female flower initiation (8.18) in bitter gourd.

4.1.A.5 Days to first harvest

Days to first harvest varied significantly among the accessions studied and ranged from 28 to 45 with the mean value of 36 (Table 4 and 5). The highest days required for first harvest (45) was recorded in SNG10 which was significantly different from other accessions. The shortest days required for first harvest (28) was recorded in SNG03 (Table 4).

Considerable differences between genotypic (49.75) and phenotypic (51.49) variance as well as genotypic (19.54%) and phenotypic (19.88%) coefficient of variation was noted indicating considerable environmental effect upon the expression of the character of days to first harvest (Table 5). Kabir (2006) also revealed considerable differences between genotypic (51.46) and phenotypic (54.24) variance as well as genotypic (50.60%) and phenotypic (53.33%) coefficient of variation of the character of date at first harvest in pointed gourd accessions.

4.1.A.6 Days to last harvest

Days to last harvest varied significantly among the accessions studied and ranged from 46 to 63 with the mean value of 55 (Table 4 and 5). SNG10 & SNG01 took maximum duration (63 days) for last harvest which was significantly different from other accessions. The shortest days required for last harvest (46) was recorded in SNG08 (Table 4).

Considerable differences between genotypic (42.52) and phenotypic (46.96) variance as well as genotypic (11.65%) and phenotypic (12.25%) coefficient of variation was noted indicating considerable environmental effect upon the expression of the character of days to last harvest (Table 5).

Table 4 Plant and flowers characteristics of different accessions of snake gourd (*Trichosanthes anguina* L.)

Acc. No.	Days to anthesis of first Male Flower (day)	Days to anthesis of first Female Flower (day)	Node number at first Male flower anthesis (no.)	Node number at first Female flower anthesis (no.)	Days to first Harvest (day)	Days to last Harvest (day)
SNG01	27	34	13	24	42	**63**
SNG02	25	34	11	28	43	62
SNG03	15	**21**	**7**	31	**28**	51
SNG04	16	25	10	24	34	52
SNG05	15	26	10	25	34	56
SNG06	23	31	12	26	38	58
SNG07	22	26	13	25	35	57
SNG08	12	22	10	20	31	**46**
SNG09	16	28	11	24	38	54
SNG10	22	32	14	27	**45**	**63**
SNG11	19	24	15	24	32	52
SNG12	14	24	11	32	33	53
SNG13	25	30	13	24	40	57
SNG14	20	25	14.	24	36	56
SNG15	18	26	11	22	36	53
SNG16	15	23	9	21	34	54
SNG17	**9**	21	13	23	35	54
SNG18	16	24	10	24	34	55
SNG19	18	25	16	**20**	32	54
SNG20	13	21	11	25	32	54
SNG21	23	27	13	21	34	53
SNG22	23	30	13	28	39	57
SNG23	23	31	13	24	40	59
SNG24	20	28	14	21	34	55
SNG25	**29**	**36**	**16**	20	45	63
SNG26	14	23	10	24	33	54
SNG27	21	30	13	27	38	59
SNG28	22	30	16	26	37	58
SNG29	19	26	9	**34**	34	55
SNG30	23	30	12	30	40	61
CV(%)	4.83	6.47	8.23	7.06	6.34	6.52
LSD (0.01%)	1.59	3.81	2.17	3.82	4.97	7.93

Table 5 Genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, range and mean of yield and yield contributing characters of 30 snake gourd accessions

Genetic components	Days required to first male flower anthesis	Days required to first female flower anthesis	Number of node at first male flower anthesis	Number of node at first female flower anthesis	Date at first harvest	Date at last harvest
Genotypic variance	68.73	51.48	14.30	37.07	49.75	42.52
Phenotypic variance	68.91	52.50	14.63	38.10	51.49	46.96
Genotypic coefficient of variation (%)	43.18	26.49	31.08	24.43	19.54	11.65
Phenotypic coefficient of variation (%)	43.23	26.75	31.43	24.77	19.88	12.25
Range	8.67-27.00	20.67-36.00	7.00-16.00	20.00-34.00	28.00-45.00	46.33-63.33
Mean ± SE	19.200±0.4248	27.089±1.0121	12.167±0.5780	24.922±1.0159	36.100±1.3205	55.978±2.1076

SNG01

SNG02

SNG03

SNG04

SNG05

SNG06

SNG07

SNG08

SNG09

Plate1 Photographs showing different plant and fruit characters of Snake gourd accessions (SNG01-SNG09)

SNG10

SNG11

SNG12

SNG13

SNG14

SNG15

SNG16

SNG17

SNG18

Plate1 Contd. Photographs showing different plant and flower characters of Snake gourd accessions (SNG10-SNG18)

SNG19

SNG20

SNG21

SNG22

SNG23

SNG24

SNG25

SNG26

SNG27

Plate1 Contd. Photographs showing different plant and flower characters of Snake gourd accessions (SNG19-SNG27)

SNG 28

SNG 29

SNG 30

Platel Contd. Photographs showing different plant and flower characters of Snake gourd accessions (SNG28-SNG30)

4.1.B Fruit character

Fruit characteristics in respect of number of fruits per plant, weight of fruits per plant (kg), single fruit weight (g), 100- seed weight (g) and fruit yield (t/ha) were studied and results have been presented in Table 6, Table 7, Fig. 1 & plate 2.

4.1.B.1 number of fruits per plant

The number of fruits per plant differed significantly among the 30 accessions of snake gourd and ranged from 3 to 28 (Table 6). The plants of SNG24 produced the maximum number of fruits (28) where as the accession SNG07 produced the minimum number of fruits (3). Significant variation among the cultivars for fruits per plant was also found in ribbed gourd and sweet gourd (Rahman *et al.* 1990). On the other hand. Vashistha *et al.* (1983) found low range of variation (1.37 to 2.09) for fruits per plant in water melon. Prasad and Singh (1990) observed also significant variation among the genotypes of pointed gourd in respect of number of fruits per plant. The variation in number of fruits per plant might be due to genetical characteristics.

Considerable differences between genotypic (143.01) and phenotypic (143.73) variance as well as genotypic (73.37%) and phenotypic (73.55%) coefficient of variation were noted indicating considerable environmental effect upon the expression of the character of number of fruits per plant (Table 7). Prasad and Singh (1989) noted high value of genotypic and phenotypic variances for number of fruits per plant in ribbed gourd (202.26 and 475.98) whereas Vijay (1987), Rahman *et al.* (1986), Abusaleha and Dutta (1990), reported low value in muskmelon (91.71 and 1.90), bottle gourd (1.43 and 3.10), cucumber (1.15 and 1.24) and bitter gourd (99.02 and 10.45). High genotypic co-efficient of variance and phenotype co-efficient of variance were observed for fruits per plant by Reddy and Rao (1984), Rahman *et al.*(1986) and Saha *et al.*(1992) in ribbed gourd (75.40 and 109.38), bottle gourd(30.47 and 38.61) and pumpkin(27.94 and 33.78) respectively.

4.1.B.2 weight of fruits per plant

Weight of fruits per plant varied significantly among the accessions and ranged from 0.681kg to 6.42 (Table 6). The highest weight of fruits per plant (6.42kg) was found in the accession SNG23. Whereas, SNG07 produced the lowest weight of fruits per plant (0.681). Hamid *et al.* (1989) and Ahmed *et al.* (2000) found a wide range of variability among the lines in respect of weight of fruits per plant in ash gourd and snake gourd. Prasad and Singh (1990) also observed the significant variation among the genotypes of pointed gourd in respect of weight of fruits per plant.

Slight differences between genotypic (5836.18) and phenotypic (5840.60) variance as well as genotypic (88.61%) and phenotypic (88.65%) coefficient of variation were observed indicating slightly genetical, physiological or environmental effect upon the expression of the character of weight of fruits per plant (Table 7). Ahmed *et al.* (2000) observed highest yield with maximum differences between genotypic and phenotypic coefficient of variation indicating highest environmental influences it. High genotypic coefficient of variation and phenotypic coefficient of variation were reported (39.55 and 41. 00) by Saha *et al.* (1992); (30.2 and 36.4) by Doijode and Sulladmath (1986) for fruit weight in pumpkin. Mannan (1992) reported narrow difference between genotypic coefficient of variation and phenotypic coefficient of variation for this trait in bitter gourd indicating less environmental influence on this character.

4.1.B.3 single fruit weight

Single fruit weight varied significantly among the accessions and ranged from 102 g to 262.67 g (Table 6). The fruits of SNG14 had the highest single fruit weight (262.67 g). On the contrary, the lowest fruit weight (102 g) was recorded in SNG10. The variation of fruit weight could be due to the genetical, physiological, nutritional or environmental influence. Prasad and Singh (1990) reported wide range variability in respect of single fruit weight in pointed gourd.

Slight differences between genotypic (7421.93) and phenotypic (7431.32) variance as well as genotypic (51.33%) and phenotypic (51.36%) coefficient of variation were observed indicating slightly environmental effect upon the expression of the character of single fruit weight (Table 7). Miah *et al.* (2000) studied 30 genotypes of bitter gourd and observed the highest genotypic as well as phenotypic coefficient of variation for single fruit weight. Lalta *et al.* (1988) found that high values for phenotypic and genotypic co-efficient of variation for average fruit weight in watermelon.

4.1. B.4 100- seeds weight

100- Seeds weight varied significantly among the accessions and ranged from 20.77 g to 32.73 g with the mean value of 27 g (Table 6). The maximum weight of 100 -seeds was recorded in SNG13 (32.73 g). Whereas, the minimum weight of 100- seeds (20.77 g) was recorded in SNG12. Banik (2003) also reported that highest 100 -seed weight of 34.47 g and the lowest weight of 21.97 g were recorded among the snake gourd lines.

Slight differences between genotypic (35.87) and phenotypic (36.17) variance as well as genotypic (23.25%) and phenotypic (23.35%) coefficient of variation were observed indicating slightly genetical, physiological, nutritional or environmental effect upon the expression of the character of 100-seeds weight (Table 7). Banik (2003) also found phenotypic co-efficient of variation and genotypic co-efficient of variation to be 10.07 and 10.52 respectively, in snake gourd lines.

4.1. B.5 fruit yield (t/ha)

Among the 30 snake gourd accessions studied, yield of fruit varied significantly (Fig.1)The maximum yield of fruit (42.97 t/ha) was obtained in SNG23, which was statistically different from other accessions. Whereas, the minimum yield of fruit was obtained in SNG07. The range of variability for yield was also observed in water melon (Chezhiyan, 1984), bottle gourd (Rahman *et el.* 1990) and musk melon (Swamy *et al.*1984). Chigwe (1991) observed considerable variability for fruit yield while evaluating more than 100 pumpkin landraces.

Slight differences between genotypic (262.27) and phenotypic (262.39) variance as well as genotypic (88.70%) and phenotypic (88.72%) coefficient of variation were observed indicating slightly environmental effect upon the expression of the character of yield of fruit (Table 7). High GCV and PCV were also observed in water melon (Chhonkar, 1977) and muskmelon (Vijay, 1987). Singh and Prasad (1989), Varghese (1991) and Saha *et al.* (1992) recorded high GCV and PCV for yield in pointed gourd (46.50 and 64.10), in snake gourd (30.06 and 31.33) and pumpkin (28.82 and 31.21), respectively.

Table 6 Fruit and Seeds characteristics of different accessions of snake gourd (*Trichosanthes anguina* L.)

Acc. No.	Number of Fruits /Plant (no.)	Weight of Fruits / Plant (kg)	Average Fruit weight (g)	100- seeds weight (g)	Yield (t/ha)
SNG01	15	2.516	127.00	24.63	19.26
SNG02	21	3.216	115.00	32.43	21.60
SNG03	15	2.800	129.00	23.20	18.49
SNG04	21	3.705	134.00	24.10	24.93
SNG05	14	2.988	126.67	24.80	19.95
SNG06	17	3.301	146.67	24.10	21.91
SNG07	**3**	**0.681**	227.67	24.70	**4.73**
SNG08	14	1.820	195.33	22.33	11.73
SNG09	19	1.892	193.67	23.93	12.62
SNG10	13	1.402	**102.00**	23.80	9.14
SNG11	6	1.212	184.00	24.33	7.74
SNG12	25	3.743	157.00	**20.77**	24.71
SNG13	27	3.634	147.67	**32.73**	24.30
SNG14	19	2.582	**262.67**	24.03	17.31
SNG15	22	2.077	115.00	23.93	13.93
SNG16	11	2.067	184.33	24.23	13.64
SNG17	13	2.537	276.00	24.23	16.75
SNG18	12	2.017	134.00	24.07	13.31
SNG19	9	1.003	129.00	24.17	6.61
SNG20	13	2.517	144.67	24.47	16.79
SNG21	28	4.597	137.33	26.77	30.77
SNG22	27	5.208	165.67	32.27	35.02
SNG23	28	**6.420**	245.00	24.40	**42.97**
SNG24	**28**	5.620	230.33	24.45	37.46
SNG25	6	1.043	145.00	32.00	6.96
SNG26	11	1.040	114.33	32.23	7.13
SNG27	13	2.027	121.00	24.62	13.92
SNG28	9	1.937	195.67	32.40	12.93
SNG29	16	3.240	193.33	24.33	21.63
SNG30	14	2.943	255.67	24.35	19.53
CV(%)	8.99	4.22	3.16	3.68	3.31
LSD (0.01%)	3.186	2.50	11.54	2.062	1.314

Table 7 Genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, range and mean of yield and yield contributing characters of 30 snake gourd accessions

Genetic components	Number of fruits /plant	Weight of fruits / plant (g)	Average fruit weight (g)	100-seed weight (g)	Yield (t/ha)
Genotypic variance	143.01	5836.18	7421.93	35.87	262.27
Phenotypic variance	143.73	5840.60	7431.32	36.17	262.39
Genotypic coefficient of variation (%)	73.37	88.61	51.33	23.25	88.70
Phenotypic coefficient of variation (%)	73.55	88.65	51.36	23.35	88.72
Range	3.33-28.00	680.67-6420.00	102.00-262.67	20.77-32.73	4.73-42.97
Mean ± SE	16.300±0.8458	2726.211±66.466	167.822±3.0650	25.760±0.5474	18.257±0.3486

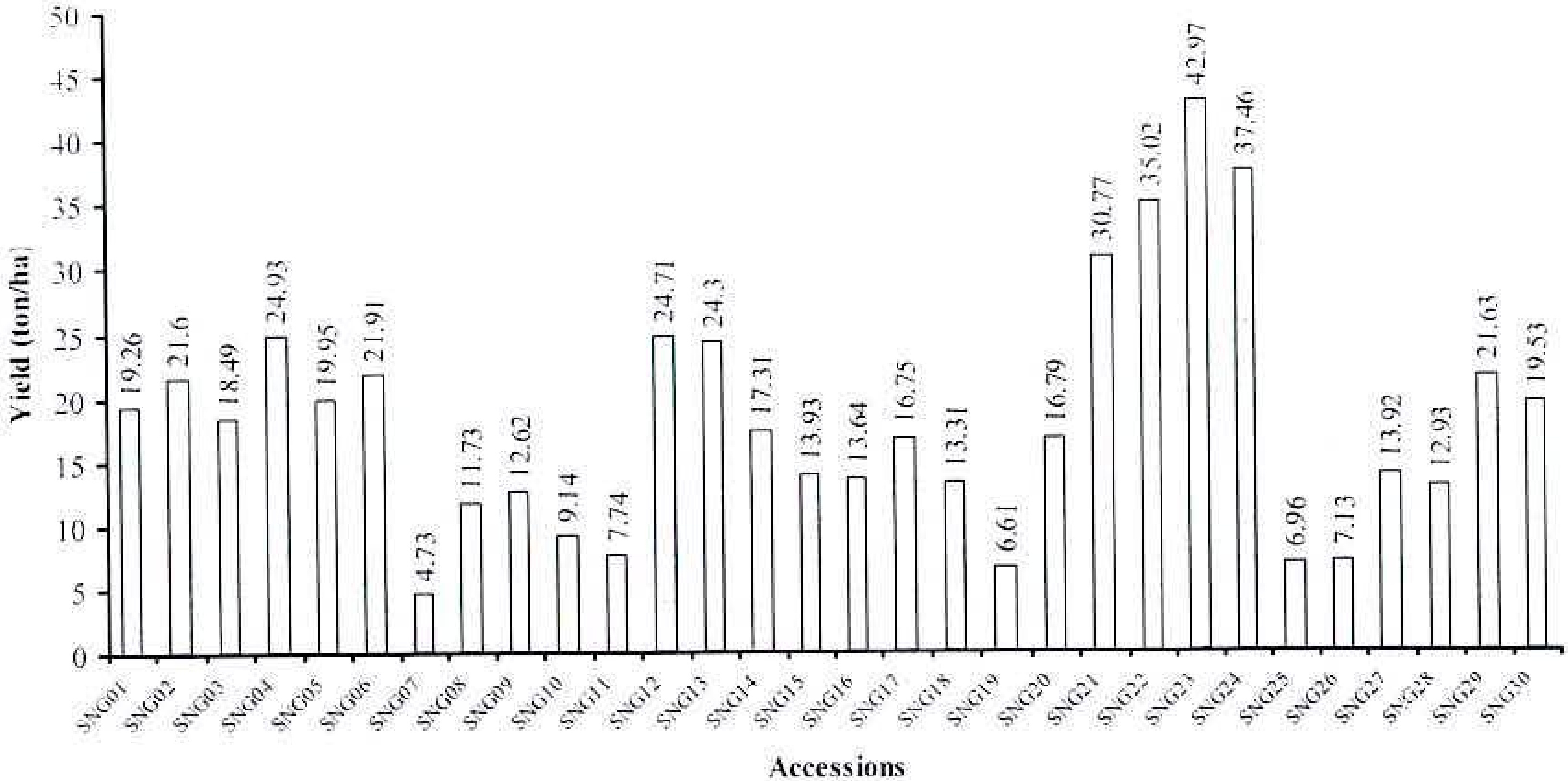
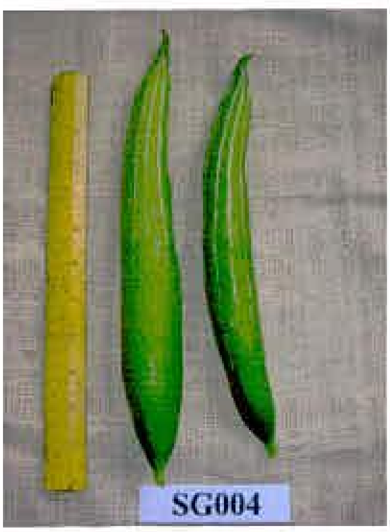


Fig.1. Yield of fruit in ton per hactare of 30 accessions of snake gourd. Vertical bar indicates LSD value at 0.01 level

SNG01

SNG02

SNG03



SNG04

SNG05

SNG06

SNG07

SNG08

SNG09

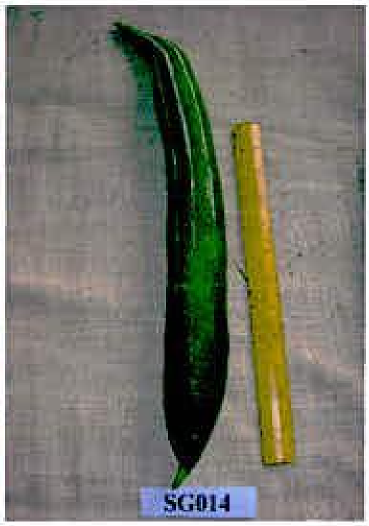
Plate2 Photographs showing the variability of fruits of the snake gourd accessions (SNG01-SNG09)

SNG10

SNG11

SNG12

SNG13



SNG14

SNG15

SNG16

SNG17

SNG18

Plate2 Contd. Photographs showing the variability of fruits of the snake gourd accessions (SNG10-SNG18)

SNG19

SNG20

SNG21

SNG22

SNG23

SNG24

SNG25

SNG26

SNG27

Plate2 Contd. Photographs showing the variability of fruits of the snake gourd accessions (SNG19-SNG27)

SNG 28

SNG 29

SNG 30

Plate2 Contd. Photographs showing the variability of fruits of the snake gourd accessions (SNG28-SNG30)

4.2 Correlation coefficient

Estimation of simple correlation coefficient of genotypic and phenotypic variance was made among eight important yield contributing characters with yield of 30 snake gourd accessions. The value of 'r' and the characters correlated are presented in Table 8 and Table 9.

4.2.1 Days required to first male flower anthesis

Genotypic and phenotypic co-efficient of variance for days to first male flower anthesis had positive association with days required to first female flower anthesis, node number for male flower anthesis, node number for female flower anthesis, number of fruits per plant, days of first harvest, days of last harvest, weight of fruit per plant, 100- seeds weight and yield of fruit (ton per hectare). On the other hand, days to first male flower anthesis had negative correlation with single fruit weight (Table 8 and Table 9). Singh *et al.* (1986) reported similar result in snake gourd.

4.2.2 Days required to first female flower anthesis

The genotypic and phenotypic co-efficient of variance for days to first female flower anthesis had positive association with node number for male flower anthesis, node number for female flower anthesis, number of fruits per plant, days of first harvest , days of last harvest, weight of fruit per plant, 100- seeds weight and yield of fruit ton per hectare. On the other hand, days to first female flower anthesis had negative correlation with single fruit weight (Table 8 Table 9). Singh *et al.* (1986) reported similar result in snake gourd.

4.2.3 Number of node at first male flower anthesis

Correlation coefficient revealed that the genotypic and phenotypic variance for number of node at first male flower anthesis had positive association with days of first harvest, days of last harvest, single fruit weight and 100- seeds weight. On the other hand, node for male flower anthesis had negative correlation with node number for female flower anthesis, number of fruits per plant, weight of fruit per plant and yield of fruit (ton per hectare) in Table 8 and Table 9. Similar findings were noticed by Sarkar *et al.* (1989) in snake gourd.

4.2.4 Number of node at first female flower anthesis

Correlation coefficient revealed that the genotypic and phenotypic variance for number of node at first female flower anthesis had positive association with number of fruits per plant, days to first harvest , days to last harvest, weight of fruit per plant and yield of fruit (ton per hectare). On the other hand, node at first female flower anthesis had negative correlation with single fruit weight and 100- seeds weight (Table 8 and Table 9). Similar findings were noticed by Sarkar *et al.* (1989) in snake gourd.

4.2.5 Number of fruits per plant

The genotypic and phenotypic variance for number of fruits per plant had positive correlation with days of first harvest, weight of fruit per plant, single fruit weight, 100- seeds weight and yield of fruit (ton per hectare). On the other hand, number of fruits per plant had negative correlation with days to last harvest (Table 8 and Table 9).

4.2.6 Days required to first harvest

Genotypic and phenotypic co-efficient of variance for days to first harvest had positive association with days to last harvest, weight of fruit per plant, 100- seeds weight and yield of fruit (ton per hectare). On the other hand, days to first harvest had negative correlation with single fruit weight (Table 8 and Table 9). Singh *et al.* (1986) reported similar result in snake gourd.

4.2.7 Days required to last harvest

Genotypic and phenotypic co-efficient of variance for the trait days to last harvest had positive association with weight of fruit per plant, 100- seeds weight and yield of fruit (ton per hectare). On the other hand, days to last harvest had negative correlation with single fruit weight (Table 8 and Table 9). Singh *et al.* (1986) reported similar result in snake gourd.

4.2.8 Weight of fruits per plant

The genotypic and phenotypic variance for weight of fruits per plant had positive significant correlation with single fruit weight. 100- seeds weight and yield of fruit (ton per hectare) which indicated that yield per plant would be increased with the increase number of fruits per plant (Table 8 and Table 9). Similar findings were noticed by Singh *et al.* (1986).

4.2.9 Single fruit weight

Correlation coefficient revealed that the genotypic and phenotypic variance for single fruit weight had positive significant correlation with yield of fruit (ton per hectare) (r = 0.21). On the other hand, single fruit weight had negative correlation with 100- seeds weight (Table 8 and table 9).

4.2.10 100- Seed weight

The genotypic and phenotypic variance for 100- seeds weight had positive correlation with fruit yield (t/ha) which indicated that yield per plant would be increased with the increase of 100- seeds weight (Table 8 and Table 9). Similar findings were noticed by Singh *et al.* (1986).

Table 8 Correlation co-efficient (genotypic) among eleven important yield contributing characters of 30 snake gourd accessions

Characters	Days anthesis of female flower	Node number for male flower anthesis	Node number for female flower anthesis	Fruit per plant	Days of first harvest	Days of last harvest	Weight of fruit per plant	Single fruit weight	100-seed weight	Yield t/ha
Days anthesis of male flower	0.89	0.55	0.03	0.15	0.78	0.79	0.17	-0.11	0.47	0.19
Days anthesis of female flower		0.50	0.07	0.16	0.92	0.93	0.18	-0.15	0.47	0.20
Node number for male flower anthesis			-0.36	-0.09	0.44	0.44	-0.06	0.17	0.32	-0.05
Node number for female flower anthesis				0.0 8	0.02	0.17	0.16	-0.01	-0.04	0.16
Fruit per plant					0.70	-0.05	0.87	0.02	0.06	0.87
Days of first harvest						0.95	0.06	-0.07	0.42	0.07
Days of last harvest							0.03	-0.07	0.41	0.04
Weight fruit per plant								0.22	0.01	0.99
Single fruit weight									-0.20	0.21
100 seed weight										0.02

Table 9 Correlation co-efficient (phenotypic) among eleven important yield contributing characters of 30 snake gourd accessions

Characters	Days anthesis of female flower	Node number for male flower anthesis	Node number for female flower anthesis	Fruit per plant	Days of first harvest	Days of last harvest	Weight fruit per plant	Single fruit weight	100 seed weight	Yield ton/ha
Days anthesis of male flower	0.89	0.55	0.03	0.14	0.77	0.77	0.17	-0.11	0.47	0.19
Days anthesis of female flower		0.48	0.07	0.16	0.90	0.85	0.17	-0.15	0.47	0.20
Node number for male flower anthesis			-0.36	-0.08	0.44	0.42	-0.06	0.17	0.31	-0.05
Node number for female flower anthesis				0.09	0.04	0.18	0.17	-0.02	-0.05	0.16
Fruit per plant					0.70	-0.06	0.87	0.03	0.05	0.87
Days of first harvest						0.90	0.06	-0.08	0.43	0.08
Days of last harvest							0.02	-0.07	0.39	0.05
Weight fruit per plant								0.22	0.01	0.99
Single fruit weight									-0.20	0.21
100 seed weight										0.02

4.3 Path coefficient analysis

Characters of association determined by correlation may not provide an exact picture of the relative significance of direct and indirect influence of each of the yield components towards yield. In true sense, in order to find a clear picture of the interrelationships among the fruit yield and yield contributing characteristics, direct and indirect effects were worked out using path analysis. This analysis at both the genotypic and phenotypic levels was done with the help of genotypic and phenotypic correlation coefficients, respectively. Genotypic and phenotypic path analysis is explained in the following headings (Table 10 and Table 11).

4.3.1 Days required to first male flower anthesis

Days to first male flower anthesis for genotypic co-efficient of variance showed highly positive direct effect (0.016) on yield ton per hectare. It also showed positive indirect effect on weight of fruits per plant through days required to first harvest, weight of fruit per plant and single fruit weight. On the other hand, it showed negative indirect effect on yield via days required to first female flower anthesis, number of node at male flower anthesis, number of node at female flower anthesis, number of fruits per plant and 100- seed weight (Table 10).

Phenotypic co-efficient of variance for the character days to first male flower anthesis showed highly negative direct effect (-0.024) on yield ton per hectare. It also showed negative indirect effect on yield ton per hectare through number of node at male flower anthesis, number of node at female flower anthesis, number of fruits per plant and 100- seed weight. On the other hand, it showed positive indirect effect on yield via days required to female flower anthesis, days required to first harvest, weight of fruit per plant and single fruit weight (Table 11).

4.3.2 Days required to first female flower anthesis

Days to first female flower anthesis in case of genotypic co-efficient of variance showed negative direct effect (-0.008) on yield ton per hectare. It also showed negative indirect effect on yield through number of node at male flower anthesis, number of node at female flower anthesis, number of fruits per plant and 100- seeds weight. On the other hand, it showed positive indirect effect on yield via days required to first harvest, weight of fruit per plant and single fruit weight (Table 10).

In respect of phenotypic co-efficient of variance for the character days to first female flower anthesis showed positive direct effect (0.047) on yield ton per hectare. It also showed positive indirect effect on yield through days required to first harvest, weight of fruit per plant and single fruit weight. On the other hand, it showed negative indirect effect on yield via number of node at male flower anthesis, number of node at female flower anthesis, number of fruits per plant and 100- seeds weight. (Table 11).

4.3.3 Number of node at first male flower anthesis

Genotypic co-efficient of variance for the character node number at first male flower anthesis showed negative direct effect (-0.002) on yield ton per hectare. It also showed negative indirect effect on yield through weight of fruit per plant, single fruit weight and 100- seed weight. On the other hand, it showed positive indirect effect on yield via node number for male flower anthesis, number of fruit per plant and days require to first harvest (Table 10).

Number of node at first male flower anthesis for phenotypic co-efficient of variance showed highly negative direct effect (-0.012) on yield ton per hectare. It also found negative indirect effect on yield per plant through weight of fruit per plant, single fruit weight and 100- seeds weight. On the other hand, it showed positive indirect effect on yield via number of node at female flower anthesis, number of fruits per plant and days required for first harvest (Table11).

4.3.4 Number of node at first female flower anthesis

Genotypic co-efficient of variance for the character node number at first female flower anthesis showed negative direct effect (-0.001) on yield ton per hectare. It also showed negative indirect effect on yield ton per hectare through number of fruit per plant. On the other hand, it showed positive indirect effect on yield via days required for first harvest, weight of fruit per plant, single fruit weight and 100- seeds weight. (Table 10).

Number of node at first female flower anthesis for phenotypic co-efficient of variance showed highly negative direct effect (-0.017) on yield ton per hectare. It also found negative indirect effect on yield through number of fruits per plant. On the other hand, it showed positive indirect effect on yield via days required for first harvest, weight of fruit per plant, single fruit weight and 100- seeds weight (Table11).

4.3.5 Number of fruit per plant

Genotypic co-efficient of variance for the character number of fruit per plant showed negative direct effect (-0.017) on yield ton per hectare. It also showed negative indirect effect on yield per plant via single fruit weight and 100- seeds weight. On the other hand, it showed positive indirect effect on yield via days required for first harvest and weight of fruit per plant. (Table 10).

Number of fruit per plant for phenotypic co-efficient of variance showed negative direct effect (-0.019) on yield ton per hectare. It also had negative indirect effect on yield per plant through single fruit weight and 100- seeds weight. On the other hand, it showed positive indirect effect on yield via days required for first harvest and weight of fruit per plant (Table11).

4.3.6 Days required for first harvest

In respect of genotypic co-efficient of variance for the character days required for first harvest showed positive direct effect (0.017) on yield ton per hectare. It also showed positive indirect effect on yield through weight of fruit per plant and single fruit weight. On the other hand, it showed negative indirect effect on yield via 100- seeds weight (Table 10).

Days required for first harvest in case of phenotypic co-efficient of variance showed positive direct effect (0.017) on yield ton per hectare. It also showed positive indirect effect on yield through weight of fruit per plant and single fruit weight. On the other hand, it showed negative indirect effect on yield via 100- seeds weight (Table 11).

4.3.7 Weight of fruits per plant

Genotypic co-efficient of variance for the character weight of fruit per plant showed positive direct effect (1.004) on yield ton per hectare. On the other hand, it showed negative indirect effect on yield via single fruit weight and 100- seeds weight (Table 10).

Weight of fruit per plant for phenotypic co-efficient of variance showed positive direct effect (1.004) on yield ton per hectare. On the other hand, it showed negative indirect effect on yield ton per hectare through single fruit weight and 100- seeds weight (Table11).

4.3.8 Single fruit weight

In respect of genotypic co-efficient of variance for single fruit weight showed negative direct effect (-0.008) on yield ton per hectare. On the other hand, it showed positive indirect effect on yield via 100- seeds weight (Table 10).

Single fruit weight in case of phenotypic co-efficient of variance showed negative direct effect (-0.004) on yield ton per hectare. On the other hand, it showed positive indirect effect on yield via 100- seeds weight (Table 11).

4.3.9 100- Seeds weight

Genotypic co-efficient of variance for the character 100- seeds weight showed negative indirect effect (-0.001) on yield ton per hectare (Table 10).

100 seeds weight for phenotypic co-efficient of variance showed negative indirect effect (-0.005) on yield ton per hectare (Table11).

Table 10 Path analysis (genotypic) showing direct and indirect effects of yield components towards yield in snake gourd

Characters	Days anthesis of male flower	Days anthesis of female flower	Node number for male flower anthesis	Node number for female flower anthesis	Fruit per plant	Days of first harvest	Weight fruit per plant	Single fruit weight	100 seed weight	Yield ton/ha
Days anthesis of male flower	**0.016**	-0.007	-0.001	-0.000	-0.002	0.0136	0.1707	0.0009	-0.0005	0.19
Days anthesis of female flower	0.0014	**-0.008**	-0.0010	-0.0003	-0.0002	0.0016	0.1807	0.0013	-0.0005	0.20
Node number for male flower anthesis	0.0090	-0.0042	**-0.002**	0.0001	0.0015	0.0076	-0.060	-0.0014	-0.0004	-0.05
Node number for female flower anthesis	0.0005	-0.0006	0.0007	**-0.001**	-0.0013	0.0003	0.1607	0.00009	0.00004	0.16
Fruit per plant	0.0024	-0.0013	0.00018	-0.00003	**-0.017**	0.0122	0.8738	-0.00017	-0.00007	0.87
Days of first harvest	0.0128	-0.0078	-0.0009	-0.000009	-0.0119	**0.017**	0.0602	0.0006	-0.0005	0.07
Weight fruit per plant	0.0028	-0.0015	0.00012	-0.00007	-0.0148	0.00104	**1.004**	-0.0019	-0.00001	0.99
Single fruit weight	-0.0018	0.0012	-0.0003	0.000004	-0.0003	-0.0012	0.2209	**-0.008**	0.00024	0.21
100 seed weight	0.0077	-0.0039	-0.00066	0.000019	-0.00102	0.0073	0.01004	0.00175	**-0.001**	0.02

Residual effect: 0.0196

Note: Direct (bold) and indirect effects of yield contributing characters on yield in 30 snake gourd accessions

Table 11 Path analysis (phenotypic) showing direct and indirect effects of yield components towards yield in snake gourd

Characters	Days anthesis of male flower	Days anthesis of female flower	Node number for male flower anthesis	Node number for female flower anthesis	Fruit per plant	Days of first harvest	Weight fruit per plant	Single fruit weight	100 seed weight	Yield ton/ha
Days anthesis of male flower	**-0.024**	0.0423	-0.0065	-0.0005	-0.0026	0.0128	0.1707	0.0004	-0.0024	0.190
Days anthesis of female flower	-0.0215	**0.047**	-0.0057	-0.0011	-0.0030	0.0149	0.1707	0.0006	-0.0024	0.200
Node number for male flower anthesis	-0.0133	0.0228	**-0.012**	0.0061	0.0015	0.0073	-0.0602	-0.0007	-0.0016	-0.050
Node number for female flower anthesis	-0.0007	0.0033	0.0043	**-0.017**	-0.0017	0.0007	0.1707	0.0001	0.0002	0.160
Fruit per plant	-0.0034	0.0076	0.0009	-0.0015	**-0.019**	0.0117	0.8740	-0.0001	-0.0003	0.870
Days of first harvest	-0.0187	0.0428	-0.0052	-0.0007	-0.0132	**0.017**	0.0602	0.0003	-0.0022	0.080
Weight fruit per plant	-0.0041	0.0081	0.0007	-0.0029	-0.0164	0.0009	**1.004**	-0.008	-0.0001	0.990
Single fruit weight	0.0027	-0.0071	-0.0020	0.0003	-0.0006	-0.0013	0.2210	**-0.004**	0.0010	0.210
100 seed weight	-0.0113	0.0223	-0.0037	0.0008	-0.0009	0.0071	0.0100	0.0008	**-0.005**	0.020

Residual effect: 0.0187

Note: Direct (bold) and indirect effects of yield contributing characters on yield in 30 snake gourd accession

4.4 Studies on genetic divergence:

Genetic divergence between the accessions of snake gourd was studied through Mahalanobis D^2 analysis. The D^2 statistics quantify the distance between accessions considering a group of characters. In the present study D^2 analysis characters were included (i) Days to anthesis of first male flower, (ii) Days to anthesis of first female flower, (iii) Node number of first female flower anthesis, (iv)Days to first harvest, (V) Single fruit weight, (vi) Number of fruits per plant, (vii) weight of fruits per plant, (viii)100- seed weight and (ix) yield.

4.4.1 Clustering

In this study 30 snake gourd accessions were grouped into four different clusters (Table 12). Clusters IV contained the highest number of accessions (12) followed by cluster II (10) and cluster III (6) respectively. The lowest number of accessions (2) was found in the clusters I. The clustering pattern of the accessions under this study revealed that the accessions collected from the same location were grouped into different clusters. The accessions collected from different location were distributed in different clusters. As for example, the accessions of cluster I were collected from Dinajpur. In cluster IV, four out of twelve in spite of being collected from the same region. Masud *et al.* (1995) reported similar results in sweet gourd, Mannan *et al.* (1993) in pani kachu, Singh and Singh (1979) in okra as well as Ram (2001) and Khan (2006) in pointed gourd.

4.4.2 Canonical vector analysis (CVA)

Canonical vector analysis was done to compute the inter-cluster distance (Mahalanobis D^2 value). The intra and inter cluster distance (D^2) are presented in Table 13. Statistical distances represent the index of genetic diversity among the clusters. The inter cluster distances were larger than the intra cluster distances suggesting wider genetic diversity among the genotypes of different groups (Table 13). Uddin and Chowdhury (1994) and Khan (2006) obtained higher inter cluster distances than the intra cluster distances in multivariate analysis in sesame and pointed gourd. The intracluster distance, obtained by using the values of inter accessions distance under each cluster as suggested by Singh and Chaudhuary (1985). and intracluster distance obtained from CVA are presented in table 13.

Table 12 Distribution of 30 snake gourd accessions in 4 clusters including source of collection

Cluster no.	Total no. of accessions in cluster	Accessions included in different clusters	Origin
I	2	SNG023 and SNG024	Dinajpur
II	10	SNG01, SNG02, SNG03, SNG04, SNG05 and SNG06	Rangpur
		SNG09, SNG017, SNG020 and SNG030	Pabna
III	6	SNG012, SNG013and SNG014	Bogra
		SNG021, SNG022 and SNG029	Kushtia
IV	12	SNG07, SNG08, SNG010, SNG011, SNG015 and SNG016	Rajshahi
		SNG018 and SNG019	Bogra
		SNG025, SNG026 SNG027 and SNG028	Dinajpur

Table 13 Average inter and intra-cluster distance (D^2) for 30 snake gourd accessions

Cluster	I	II	III	IV
I	**2.56**	1.69	2.34	2.64
II		**3.29**	1.93	3.01
III			**4.11**	1.55
IV				**3.78**

The intra cluster distance was computed by using the values of inter accession distance from distance matrix according to Singh and Chaudhuary, (1985). The highest intra cluster distance was computed for cluster III (4.11) composed of six accessions followed by cluster IV (3.78) and cluster II (3.29). The minimum intra cluster distance was found in cluster I (2.56). The clusters II and IV were more diverse as indicated by maximum inter cluster distances between them (3.01) followed by the distance among clusters I and IV (2.64), I and III (2.34), II and III (1.93) and between I and II (1.69). However the maximum inter cluster distance was recorded between II and IV cluster, accessions from these two clusters if involved in hybridization may produce a wide range segregating population, as genetic variation is very distinct among these groups. On the other hand, the maximum values of inter cluster distance indicated that the accessions belonging to cluster II were far away from those of cluster IV. The minimum inter cluster divergence was observed between cluster III and IV (1.55) indicating that the genotype of these cluster were genetically closed. The lowest inter cluster distance was also found by Prasad (1995) in bush bean. Similar results were found by Khan (2006) in pointed gourd between clusters V and X. Higher inter and intra- cluster distance indicates higher genetic variability among accessions between and within clusters, respectively. The minimum inter and intra-cluster distance indicates closeness among the accessions of two clusters and within the cluster also.

Accessions among the clusters separated by high D^2 values could be used in hybridization program for obtaining wide spectrum of variations among the segregates (Bhatt, 1970 and Seetharaman *et al.* (1988). It is revealed that crosses should be made between accessions belonging to the distant clusters for high heterotic response. In the present study, the intercluster distances between clusters ranged from 1.55 to 3.01 suggesting crossing genotypes of cluster III with desirable genotypes of others clusters would express heterosis. Mian and Bhal (1989) reported that parental clusters separated by medium D^2 values had significant positive heterosis. Thus, heterosis could also be exploited by crossing between accessions belonging to clusters with moderate diversity like between accessions of cluster I and III and cluster I and IV.

Table 14 Cluster mean values for yield and yield contributing characters of snake gourd

Characters	I	II	III	IV
Days to anthesis of 1st female Flower (day)	19	21	18	19
Days to anthesis of 1st male flower (day)	27	30	26	28
Node number at 1st female flower anthesis	26	27	22	24
Days to 1st Harvest (day)	35	36	34	35
Single fruit weight (g)	241	179	161	155
Number of fruits per plant	16	28	26	11
Weight of fruits per plant (kg)	2.91	6.0	4.26	1.61
100-seed weight (g)	24.8	24.0	28.1	26.1
Yield (t/ha)	16.86	39.99	28.49	10.20

4.4.3 Cluster mean values for yield and yield contributing characters of snake gourd

The cluster means of nine characters of 30 accessions of snake gourd are presented in Table 14. Cluster I was composed of two accessions were highest mean value was found in single fruit weight (241g) and 100 seed weight (24.8g). Cluster II were composed of ten accessions and highest mean value was found in number of fruits per plant (28), weight of fruit per plant (6.0 kg) and yield (39.99 t/ha). As well as in cluster II highest mean value was found in days to anthesis of frist female flower (21 day), days to anthesis of frist male flower (30 day), node number at which frist female flower anthesis (27) and days to frist harvest (36) also found which indicated that the member of cluster II is a late maturity type. Prasad *et al.* (1993) also reported similar findings in cucumber. Cluster III comprising six accessions had the second highest mean value for number of fruits per plant (26), weight of fruit per plant (4.26kg) and yield (28.1t/ha) as well as lowest mean value were also found in days to anthesis of frist female flower (18 day), days to anthesis of frist male flower (26 day), node number at which frist female flower anthesis (22) and days to frist harvest (34) which indicated that the accessions of the cluster III is earlier. Cluster IV was composed of twelve accessions and the lowest mean value was found in single fruit weight (155g), number of fruits per plant (11), weight of fruit per plant (1.61kg) and yield (10.20t/ha) which indicated that performances of the accessions belongs to their cluster are not good.

4.4.4 Contribution of different characters towards divergence

The characters which contributed maximum to the divergence are given greater emphasis for deciding on the cluster for the purpose of further selection and the choice of patterns for hybridization (Jagadev *et al.*, 1991). The results of CVA revealed that in vector I (Z1), the important characters responsible for genetic divergence in the major axis of differentiation were days to anthesis of frist female flower, days to frist harvest, number of fruits per plant, and 100-seed weight (Table 15). In vector II (Z2), days to anthesis of frist male flower and 100-seed weight played a major role in the second axis of differentiation. The role of 100-seed weight in both the vectors indicated the important component of genetic divergence among the 30 snake gourd accessions. Negative values in both the vectors for node number at frist female flower anthesis, single fruit weight, weight of fruits per plant and yield indicated the lowest contribution to the total divergence. Hence, considerable emphasis should be given on these characters to increase fruit yield in snake gourd. Mathew *et al.* (1986) reported that fruit weight per plant was the major contributor towards divergence in *Cucumis melo*. Masud *et al.* (1995) found that fruit weight was one of the important contributors to genetic divergence in sweet gourd. Khan (2006) observed that fruit weight, number of fruits per plant and weight of fruits per plant were the higher contributors to the divergence in pointed gourd. Anitha and Dorairaj (1990) concluded that days to flower was the important contributor to the genetic divergence.

Table 15 Relative contribution of different characters towards divergence

Characters	Vector I	Vector II
Days to anthesis of frist Female Flower	0.0165	-0.1132
Days to anthesis of frist male flower	-0.1632	0.0983
Node number at frist Female flower anthesis	-0.4761	-0.5531
Days to frist Harvest	0.0685	-0.0723
Single fruit weight	-0.3018	-0.0286
Number of fruits per plant	0.1624	-0.3215
Weight of fruits per plant	-0.3018	-0.0286
100-seed weight	0.0132	0.0067
Yield of ton per hectare	-0.0513	-0.03312

4.4.5 Selection of accessions for future improvement

The crosses involving parents belonging to the maximum divergent clusters were expected to manifest maximum heterosis and also wide variability in genetic architecture. Ramanujam *et al.* (1974) in mungbean, Mian and Bhal (1989) in chickpea reported that parental clusters separated by medium D^2 values exhibited significant and positive heterosis for seed yield and some of its components in mungbean. Similar findings were observed by Masud *et al.* (1995) in sweet gourd and Khan (2006) in pointed gourd. Thus cross between the genotypes of cluster I and III and cluster I and IV would exhibit heterosis and is likely to produce new recombinants with desired characters in snake gourd.

Considering the magnitude of genetic distance, contribution of different characters towards the total divergence and magnitude of cluster means for different characters performance, the following genotypes were considered to perform better if used in hybridization program.

The accessions of cluster I could be selected for fruit weight. The accessions of the cluster II could be selected for number of fruits per plant, higher fruit weight per plant and yield. The accessions of the cluster III could be selected for earliness.

As evident from correlation studies the single fruit weight, number of fruits per plant and weight of fruits per plant were important for snake gourd yield, which showed moderate and positive relationship with yield, selection could be effective for breeding for further improvement of snake gourd. Similar result was found in Colocasia (Mannan *et al.*,1993).

Chapter V

SUMMARY AND CONCLUSION

The present experiment was undertaken to study the variability, correlation, path analysis, and genetic divergence of 30 snake gourd accessions. The experiment was conducted at the Horticulture Division of Regional Agricultural Research Station (RARS) Bangladesh Agricultural Research Institute (BARI) Ishurdi, Pabna during the period from April 2007 to September 2007. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on yield contributing characters and yield of fruit were recorded. The statistical analysis of variance indicated the existence of wide variability for different characters.

In case of variability study, the range of variation was observed high in case of days to anthesis of first male flower (9-29), days to anthesis of first female flower (21-36) node number of first male flower anthesis (7-16), node number of first female flower anthesis(20-34), number of fruits per plant(3-28), days to first harvest(28-45), days to last harvest(46-63), weight of fruits per plant(0.681-6.420kg), average fruit weight(102.00-262.67g), 100 seed weight(20.77-32.73) and yield (4.73-42.97t/ha) suggesting to give priority on these characters for selection. In all the characters it was found that phenotypic coefficient of variation was higher than genotypic coefficient of variation. The highest genotypic and phenotypic coefficient of variation was observed in weight of fruits/plant and single fruit weight.

In case of days to anthesis of first male flower, SNG17 took the lowest day (9 days) to first male flower and the highest days to anthesis of first male flower (29 days) was taken by SNG25. Days to anthesis of first male flower was positive association with node number of first male flower anthesis, node number of first female flower anthesis, number of fruits per plant, days to first harvest, days to last harvest, weight of fruits per plant, 100 seed weight and yield. On the other hand, days to anthesis of first male flower had negative correlation with single fruit weight.

In case of days to anthesis of first female flower, SNG03 took the lowest day (21 days) to first female flower and the highest days to anthesis of first female flower (36 days) was taken by SNG25. Days to first female flower anthesis had positive association with node number for male flower anthesis, node number for female flower anthesis, number of fruits per plant, days of first harvest , days of last harvest, weight of fruit per plant, 100- seeds weight and yield of fruit ton per hectare. On the other hand, days to first female flower anthesis had negative correlation with single fruit weight.

The maximum number of node at first male flower anthesis was recorded (16) in the plant of accession SNG25 and the minimum (7) in SNG03. Number of node at first male flower anthesis had positive association with days of first harvest, days of last harvest, single fruit weight and 100- seeds weight. On the other hand, days to first female flower anthesis had negative correlation with node number for female flower anthesis, number of fruits per plant, weight of fruit per plant and yield of fruit ton per hectare.

The plant of accession SNG29 had maximum number of node at first female flower anthesis (34) and minimum number of node at first female flower anthesis was found in the plant of accession SNG19 (20). Number of node at first female flower anthesis had positive association with number of fruits per plant, days to first harvest , days to last harvest, weight of fruit per plant and yield of fruit ton per hectare. On the other hand, days to first female flower anthesis had negative correlation with single fruit weight and 100- seeds weight.

The accession of the plant SNG03 required the minimum days to first harvest (28 day) while SNG10 took the maximum days to first harvest (45 day). Days to first harvest had positive association with days to last harvest, weight of fruit per plant, 100- seeds weight and yield of fruit (ton per hectare). On the other hand, days to first harvest had negative correlation with single fruit weight.

In respect of days to last harvest, accession SNG10 and SNG 01 was highest (63) and accession SNG08 was lowest (46).

In respect of single fruit weight, the highest weight was observed in the accession SNG14 (262.67g) and lowest weight was found in SNG10 (102.00g). Single fruit weight had positive significant correlation with yield of fruit (ton per hectare). On the other hand, single fruit weight had negative correlation with 100- seeds weight.

In respect of number of fruits per plant, SNG07 had the lowest (3) number and SNG24 had the highest (28) number of fruits per plant and number of fruits per plant had positive correlation with days of first harvest, weight of fruit per plant, single fruit weight, 100- seeds weight and yield of fruit ton per hectare. On the other hand, number of fruits per plant had negative correlation with days to last harvest.

In case of weight of fruit per plant, SNG07 had the lowest (0.681kg) and the highest weight of fruit (6.420 kg) was in SNG23. Weight of fruits per plant had positive significant correlation with single fruit weight, 100- seeds weight and yield of fruit ton per hectare.

It was observed that plant of accession SNG13 produced the highest 100 seed weight (32.73) and the lowest (20.77) 100 seed weight was found in SNG12.

From path coefficient analysis it was observed that number of fruits per plant had maximum direct and positive effects on yield of fruit. The correlation of number of fruits per plant, fruit weight per plant was also found high and such high correlation of fruit yield was mainly due to the high positive direct effect on number of fruits per plant and considerable indirect effect via single fruit weight. Single fruit weight was also highly positive and the direct effect on yield per plant. This character contributes indirectly to yield per plant via node number of first female flower anthesis, 100 seed weight.

As per D^2 and cluster analysis, the 9 morphological characters, 30 accessions of snake gourd were grouped into four different clusters. The clusters IV contained the highest number of accessions (12) followed by cluster II (10), cluster III (6) and cluster I having 2 accessions, respectively. The clustering pattern of the accessions revealed that the accessions collected from the same location were grouped into different clusters.

The maximum inter cluster distance was recorded between II and IV cluster, accessions from these two clusters if involved in hybridization may produce a wide range segregating population, as genetic variation is very distinct among these groups. On the other hand, the maximum values of inter cluster distance indicated that the accessions belonging to cluster II were far away from those of cluster IV. The minimum inter cluster divergence was observed between cluster III and IV (1.55) indicating that the genotype of these cluster were genetically closed. The highest intra cluster distance was computed for cluster III (4.11) composed of six accessions followed by cluster IV (3.78) and cluster II (3.29). The minimum intra cluster distance was found in cluster I (2.56). The clusters II and IV were more diverse as indicated by maximum inter cluster distances between them (3.01) followed by the distance among clusters I and IV (2.64), I and III (2.34), II and III (1.93) and between I and II (1.69). Geographic diversity was not associated with genetic diversity.

The result of the present experiment revealed that a wide variability existed among the collected snake gourd accessions. Also there was correlation of different yield contributing characters with the yield of snake gourd. Cluster analysis revealed that there is no relation between geographic distributions with genetic diversity. From the results of the experiment the following conclusion can be made

(i) Wide variability existed among the snake gourd accessions used in this experiment. That variability's could be used for future breeding programme to develop a high yielding snake gourd variety in our country.

(ii) To develop a high yielding variety of snake gourd selection should be done on the basis of desired characters such as average fruit weight, number of fruits per plant and weight of fruits per plant etc.

The following recommendations may be drawn from the finding of present trial-

(i) Collection of snake gourd germplasm should be continued for getting more variability and desired traits.

(ii) Molecular techniques such as RAPD, RFLP should be used for proper identification of the germplasm at molecular level.

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APPENDICES

Appendix 1. Physical and chemical properties of soils at RARS, Ishurdi, Pabna

Land category	Textural class	pH	OC* (%)	Total N (%)	P (ppm)	K (mg / 100 g)	S (ppm)	Zn (ppm)
High	clay loam	8.5	0.58	0.06	12.20	0.25	25	0.70

*Organic carbon

Appendix 2. Analysis of variance of data on yield and yield contributing characters of snake gourd

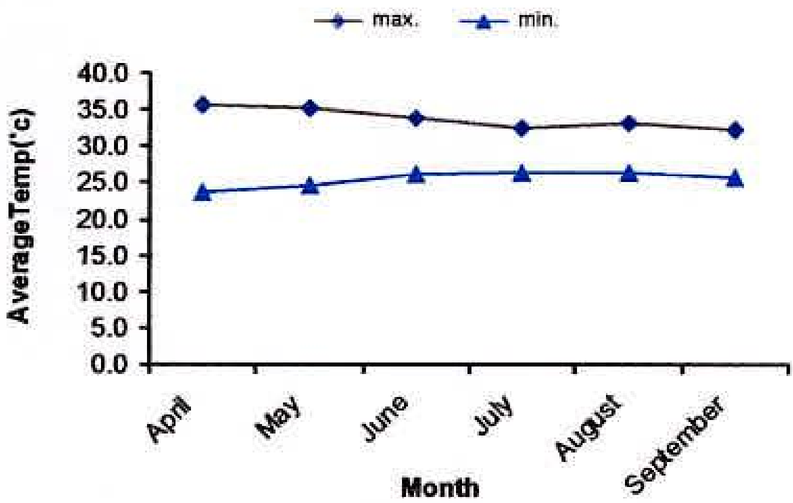
Source of variation	Degree of freedom	Mean sum of square				
		Days to anthesis of first male flower	Days to anthesis of first female flower	Node number of first male flower anthesis	Node number of first female flower anthesis	Number of fruits per plant
Replication	2	126.300	92.211	20.933	100.878	159.100
Treatment	29	68.910*	52.504*	14.638*	38.108*	143.732*
Error	58	0.541	3.073	1.002	3.096	2.146

*Significance at 1%.

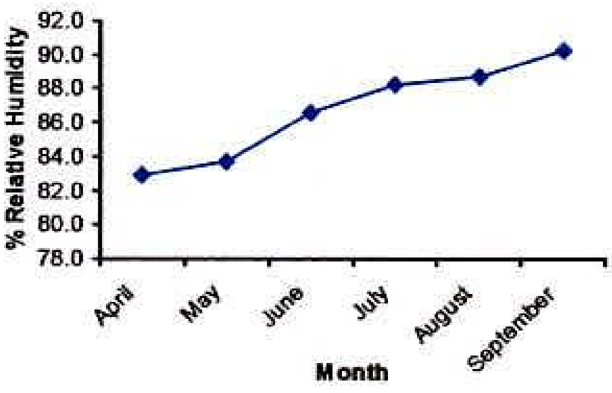
Appendix 3. Analysis of variance of data on yield and yield contributing characters of snake gourd.

Source of variation	Degree of freedom	Mean sum of square					
		Days to first harvest	Days to last harvest	Weight of fruits per plant	Average fruit weight	100 seed weight	Yield (t/ha)
Replication	2	48.633	10.544	55891.678	536.011	4.170	1.499
Treatment	29	51.498*	46.964*	5840601.275*	7431.327*	36.173*	262.396*
Error	58	5.231	13.326	13253.184	28.184	0.899	0.365

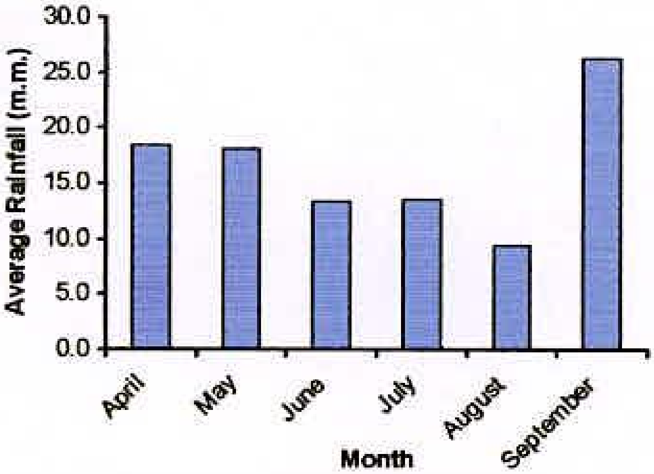
*Significance at 1%.



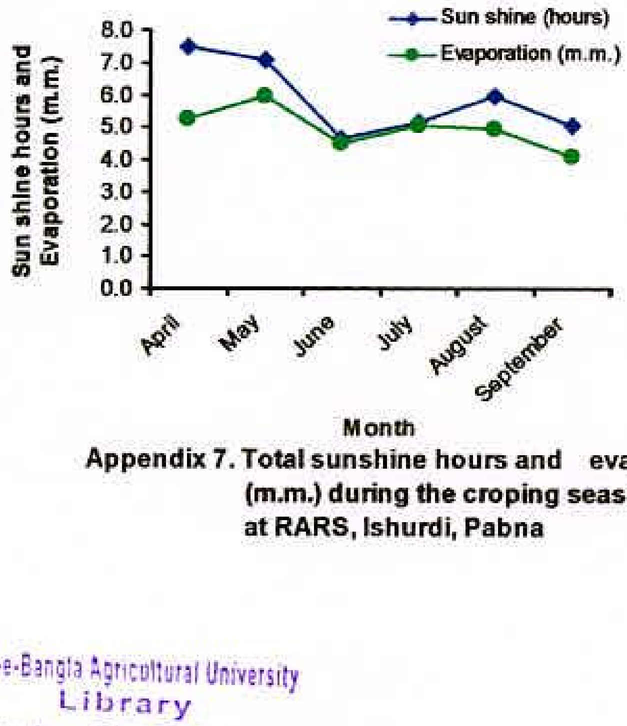
Appendix 4. Average temperature ('c) during the croping season in 2007 at RARS, Ishurdi, Pabna



Appendix 5. Percent relative humidity during the croping season in 2007 at RARS, Ishurdi, Pabna



Appendix 6. Average rainfall (m.m.) during the croping season in 2007 at RARS, Ishurdi, Pabna



Appendix 7. Total sunshine hours and evaporation (m.m.) during the croping season in 2007 at RARS, Ishurdi, Pabna