# MORPHOLOGICAL CHARACTERISATION OF LENTIL (*Lens culinaris* Medik.) GERMPLASMS

**BY**

**SYEDA NIHARICA BEGUM**

**REGISTRATION NO: 26250/00537**

A Thesis

Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

**MASTER OF SCIENCE**

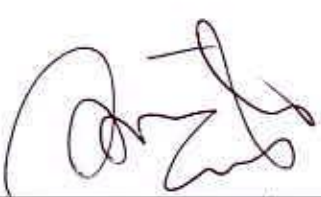
**IN**

**GENETICS AND PLANT BREEDING**

**SEMESTER: JULY-DECEMBER, 2007**

**Approved by:**

**(Dr. Md. Sarowar Hossain)**
Professor
Department of Genetics and Plant Breeding
Supervisor



**(Dr. Md. Shahidur Rashid Bhuiyan)**
Professor
Department of Genetics and Plant Breeding
Co-supervisor

**(Firoz Mahmud)**
Chairman
Examination Committee

**DEPARTMENT OF GENETICS AND PLANT BREEDING**
**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**
**SHER-E-BANGLA NAGAR, DHAKA-1207**
**BANGLADESH**

Ref: .....

Date : .....

# *CERTIFICATE*

*This is to certify that thesis entitled, 'MORPHOLOGICAL CHARACTERISATION of LENTIL(Lens culinaris Medik.) GERMPLASMS' submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE, GENETICS AND PLANT BREEDING, embodies the result of a piece of bonafide research work carried out by* ***SYEDA NIHARICA BEGUM*** *Registration Number 26250/00537 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

*Dated: desember, 2007*
*Place: Dhaka, Bangladesh*

*(Dr. Md. Sarowar Hossain)*
*Professor*
*Department of Genetics and Plant Breeding*
*Supervisor*

*Dedicated to*
*My*
*Parents who laid the foundation of my success*

## ACKNOWLEDGEMENT

*The author expressed her heartiest sense of gratitude to the almighty Allah who has blessed and enabled her to complete this thesis work and submit the thesis for MS degree.*

*The author would like to convey her heartfelt honor, sincere appreciation to her reverent teacher and research supervisor,* ***Dr. Md. Sarowar Hossain*** *Professor, Sher-e-Bangla Agricultural University, Dhaka for his dynamic and painstaking guidance, suggestions, inspiration, encouragement to the all phases of study and in conducting research work and writing of the manuscript.*

*The author expressed her sincere apperception, gratitude and indebtedness to her honorable teacher and research Co-supervisor* ***Prof. Dr. Md. Shahidur Rashid Bhuiyan.*** *Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka for his sincere help,*

*The author expresses her gratitude to* ***Firoz Mahmud,*** *Chairman, Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka for his constant co-operation during the preparation of the manuscript.*

*The author would like to convey her sincere apperception, gratitude and indebtedness to her honorable teachers, Prof. Abu Akbar Mia, Department of Genetics and Plant Breeding, Dr. Md. Ekramul Hoque, Chairman, Department of Biotechnology, Sher-e-Bangla Agricultural University, Dhaka for their constant co-operation during the preparation of the manuscript.*

*The author express her sincere respect to lecturer Md. Ashaduzzaman Siddikee and lecturer Md. Abdur Rahim., Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka for their valuable suggestions and advice in constructive criticisms and comments in preparing the manuscript.*

*Finally the author expressed her special appreciation regards and indebtedness to her parents, Syed Meshkature Rhaman and Most Jahanara Begum, for their sacrifice, inspiration, encouragement and continuous blessing paved the way to her higher education.*

*December, 2007*

*The Author*

Nibonica

# Some Commonly Used Abbreviation

| Full word | Abbreviation | Full word | Abbreviation |
|---|---|---|---|
| Agro-Ecological Zone | AEZ | International Center for Agricultural Research in Dry Areas | ICARDA |
| Agriculture | *Agril.* | *Journal* | *J* |
| Agriculture | *Agric* | Potassium | K |
| Bangladesh Agricultural Research Institute | BARI | Kilogram | kg |
| Bangladesh Bureau of Statistic | BBS | Square meter | $m^2$ |
| Bangladesh Institute of Nuclear Agriculture | BINA | Magnesium | Mg |
| Degree Celsius | °C | Ministry of Agriculture | MOA |
| Centimeter | cm | Number | No |
| Cation Exchange Capacity | CEC | Nitrogen | N |
| Cultiver(s) | Cv | Phosphorus | P |
| Etcetera | etc | Parts per million | ppm |
| And others (et all) | *et al* | Hydrogen ion conc. | pH |
| Food and Agricultural Organization | FAO | Randomized Complete Block Design | RCBD |
| Gram | g | Research | Res |
| Hectare | ha | Shere -e- Bangla Agricultural University. | SAU |
| Zinc | Zn | Ton | t |
| Percent | % | Tonns per hacter | t/ha |

# CONTENTS

## LIST OF TABLES

## LIST OF TABLES



## LIST OF PLATE

## LIST OF APPENDICES

# MORPHOLOGICAL CHARACTERISATION OF LENTIL (*Lens culinaris* Medik.) GERMPLASM

SYEDA NIHARICA BEGUM

## ABSTRACT

An experiment was conducted at the experimental plot of Sher-e-Bangla Agricultural University; Dhaka-1207 during the period from November 2006 to March 2007. It was observed that out of 31 genotypes, 15 genotypes had broad leaflet and rest 16 had narrow leaflet. G-1 (31 cm) and G-2 (38cm) exhibited maximum and minimum plant height. The highest days to 50% flowering was observed from G-27 (98 days) and the lowest in G-9 (63) days. Number of flower per peduncle ranged from 1.63 (G-9) to 2.75 (G-13). The highest pod per plant was observed in G-9 (118) and the lowest in G-11 (76). The number of seed per plant ranged from 199 (G-14) to 156 (G-10). The number of seed per plant ranged from 199(G-14) to 156 (G-10). The maximum, hundreds seed weight was observed in G-1, G-14, G-22 (1.47g) and minimum in G-5 (1.25g). The highest days to maturity was observed in G-4 (108 days) and the lowest in G-15 (94days). The seed yield per plant ranged from 6.0g (G-24) to 3.9g (G-29). G-1, G-9 and G-24 have high value for 100 seed weight; plant height, pod per plant, early 50% flowering and seed yield per plant. For this causes G-1, G-9 and G-24, might be considered as a prospective one for commercial cultivation as well as prospective parent in future breeding programmed.

On the basis of morphological marker, out of 31 genotypes, 22 genotypes showed leaf pubescence and 9 genotypes had no pubescence. Tendril formation was observed in 18 genotypes and 13 genotypes had no tendril. Both leaf pubescence and tendril formation was observed in 11 genotypes, only leaf pubescences were in 11 genotypes, only tendril were in 7 genotypes and, no leaf pubescence and tendril formation was observed in 2 genotypes. Eighteen genotypes showed leaf pigmentation and 13 had no leaf pigmentation. Stem pigmentation was observed in 22 genotypes and no pigmentation was observed in 9 genotypes. Pod pigmentation was observed in 9 genotypes and 22 genotypes had no pod pigmentation. On the basis of seed coat colour, all the genotypes

were classified into four colour groups. Among the genotypes, G-1 showed black and G-7 showed brownish seed coat colour. Six genotypes showed dark brown and rest 23 genotype were showed light brown seed coat colour. Maximum 17 genotypes were grouped into non-mottled and 14 genotypes were grouped into mottled testa pattern. On the basis of cotyledon colour, were genotypes classified into five different groups.

On the basis of genertic parameter high genotypic co-efficient of variation value was observed pod per plant, plant height, days to 50% flowering, days to maturity. High heritability with high genetic advance was obtained from pod per plant, days to maturity, days to 50% flowering. Correlation study reveled positive association of yield per plant with seed per plant, pod per plant, hundreds seed weight, days to maturity and plant height. Significant and positive correlation were observed in days to maturity, seed per plant. Path analysis indicated higher number of days to maturity, hundreds seed weight higher direct effect on grain yield. Days to 50% flowering, number of flower per peduncle, seed per plant had positive but indirect effect on grain yield

Considering pods per plant, seeds per plant, yield, hundreds seed weight, days to maturity, number of flower per peduncle, BARI ILL 6284 (G-9), BARI ILL 5105 (G-14), BARI 8406-129 (G-24), BARI ILX 87039 XL5 (G-15), BARI ILL 95052 (G-22), BINA mosure 1 (G-1) could be chosen for general cultivation or as parent in future breeding program. Considering high heritability with high genetic advance G-27, G-9, G-4, G-15, G-1 and G-2 and considering significant and positive correlation G-14 could be chosen for general cultivation or as parent in future breeding program. Identification of morphological marker could also help for selection of suitable one.

# CHAPTER I

# INTRODUCTION

Lentil (*Lens culinaris* Medik.) is one of the major legume crops in Bangladesh, which ranks third among the lentil growing country of Asia and the Pacific region (FAO, 2004). It is the second most important pulse crop in relation to area and production, but stand first in the consumer's preference in this country. In 2002-2003 it was grown on about 1,54,000 ha of land producing 116,000 tones of grain, with an average yield of 752 kg/ha and contributes about 33% to the total pulses production (BBS, 2002). It contains the highest protein content among grain legumes except soybean and also contains relatively more iron. It takes short cooking time and most easily digested. It can fix atmospheric nitrogen up to 107 kg/ha.

In Bangladesh, lentil cultivation is mostly concentrated in the gangetic flood plain of western part of the country. It is cultivated during winter season (rabi or post rainy season; November-March). Domestic pulse production satisfies less than half of the country's demands. The rest, some 140,000 tones, is imported from Australia, Nepal, and Turkey (MOA, 2002) at a cost of about US $ 32.2 million per annum. The resulting high prices have led to widespread protein malnutrition especially among vulnerable groups, such as rural children and the aged. In Bangladesh, all the indigenous and landraces and varieties are microsperma with red cotylede, whereas the exotic macrosperma varieties posses yellow cotylede.

In spite of so many advantages, lentil in Bangladesh is generally grown under minimum fertility and management practices. The development of high potential genotypes with good, stable yield and higher protein content is important to improve yield status of the crops. The existing varieties in Bangladesh are mostly low yielding. Several factors are responsible for low yield of lentil, such as, less attention on cultural practices, lack of pest control measures, post-harvest losses, the use of traditional varieties or landraces with low genetic potential.

The development of high yielding and high protein containing legume with other desirable characters is needed to improve the yield status of this crop. Considering yield and nutritive value, lentil is better than the traditional legume and other cereals. Moreover this crop fits well in the cropping pattern of Bangladesh and there is a scope of its improvement. The research work in this direction is limited and fragmentary in Bangladesh. More work is needed for making a tangible improvement of this crop.

Information on genetic divergence and morphological appearance among the plant materials is vital to a plant breeder for an efficient choice of parent for hybridization. It is an established fact that genetically diverse parents with favourable characters are likely to contribute desirable segregates and/or to produce high heterotic crosses. More diverse the parents, greater are the chance of obtaining high heterotics and broad spectrum of variability in segregating generations (Arunachalam, 1981). The parents identified on the basis of divergence analysis would be more promising in selecting genotypes with desirable character combination from the segregating generation obtained through hybridization. Thus in Bangladesh this study

would be very important in breeding varieties of this crop. Precise information on the morphological character and degree of genetic divergence of the parents is the pre-requisite of effective breeding programs.

Morphological marker of any agricultural crop is a valuable tool, which can utilize for crop improvement program. Identification of phenotypic marker is essential to sort out the segregating generation and subsequent selection. Screening of lentil genotypes on the basis of phenotypic marker will be helpful for lentil breeding to distinguish among the breeding material. In Bangladesh, information about the availability of genetic variation, morphological character and phenotypic marker identification in lentil germplasm is scanty. Therefore, the present investigation was undertaken with the following objectives:

a) To study the morphological and yield contributing character
b) Classification of germplasm on the basis of physical/morphological marker
c) To determine the character association and contribution of character toward grain yield in the genotypes

# CHAPTER II

# REVIEW OF LITERATURE

# 2. REVIEW OF LITERATURE

Lentil (*Lens culinaris* Medik.) is one of the major legume crops in Bangladesh, It is the second most important pulse crop in relation to area and production, but stand first in the consumer's preference in this country. Morphological marker of any agricultural crop is a valuable tool, which can utilize for crop improvement program. Identification of phenotypic marker is essential to sort out the segregating generation and subsequent selection. The relevant literatures to the recent study have been reviewed in this chapter.

Fourteen lentil genotype were evaluated by Gupta *et al.*, (2006) for genotype x environment interaction and phenotypic stability under 8 diverse environments and 11 different growth and yield characters (Days to 50% flowering, days to maturity, primary branch per plant, secondary branch per plant, pod numbers/ plant, hundred seed weight, plant height, seed number/plant harvest index and seed yield/plant). They reported that high yielding and stable genotypes were JLS-1, PL 639, PL 81-64, E 153, PL 3685, Sehore 74-3, PL 81-49, PL 81-67, L4605, L263, PL 4 and P 22127. These genotypes may be used to develop new ones with wider adaptability and no single genotype was stable for all the character.

Mershell and Abbas (2006) reported that some morphological traits were not enough to differentiate between lentil genotypes, such as seedling stem pigmentation, where it was present in all the genotypes.

Neha *et al.*, (2005) conducted an experiment to study variability and association studies in lentil, reported that seed yield, pod per plant and 100 seed weight showed high PCV and GCV. Days to 50% flowering, Days to maturity, seed yield and pods per plant showed high heritability. Seed yield, pods per plant, and seed weight had high genetic advanced. Pods per plant and seed per pod showed positive, whereas days to flowering, days to maturity and hundred seed weight showed negative correlation with seed yield. Pods per plant had the highest direct effect on seed yield, followed by plant height and seeds per pod.

Chauhan *et al.*, (2005) conducted a study to evaluate the genetic diversity among 160 genotypes of lentil (*Lens culinaris*) for 6 characters (days to 50% flowering, days to maturity, pods per plant, seed per-pod, hundred grain weight and seed yield) described that the non-hierarchical euclidean cluster analysis grouped the 160 genotypes into 6 cluster indicating existence of considerable genetic diversity in the germplasm collection. The 6 clusters contained genotypes of heterogeneous origin. They are by indicating no parallels between genetic and geographic diversity. Therefore, crosses between the members of clusters separated by high inter cluster distances, such as cluster VI, with III, V, II and I are likely to yield desirable segregates.

Ezzat *et al.*, (2005) conducted an experiment on evaluation of some lentil genotypes for earliness, yield components and seed quality. They detected significant and positive associations between seed weight per plant and each of plant height, number of branches, pods and seeds per plant and weight of 100 seeds. Factor analysis grouped 7 yield-contributing characters into 2

main factors accounting for 74.13% of the total variability in the dependence. Structure factor 1 was responsible for 42.66% of the total variation and contained plant height, number of branches, pods and seed per plant. Factor 2 included number of days to 50% flowering and maturity and weight of hundred seeds and contributed 31.47% of the total variability.

Ezzat *et al.*, (2005) study the effect of plant density on the performance of four new released lentil verities, namely, Sinai 1, Giza 4 and Giza 51, and local c.v. Giza 9 observed that the combined analysis of variance highly significant among seasons, locations, cultivars and plant densities for all studied characters (Plant height, number of branches per plant, number of seed per plant, hundred seed weight, seed weight per plant and seed yield, except days to flowering and maturity for season, number of pod per plant per location and hundred seed weight for plant density).

Ghahramanzadeh *et al.*, (2005) reported that based on morphological traits, two genotypic groups were distinguished 90% similarly level, and diversity index of morphological traits ranged from 0.36 for the number of two-seeded pods to 0.83 for the number of seed per plant. Genetic variation index 80% indicates high genetic variation among the accessions.

Tayyaba *et al.*, (2005) conducted an experiment to study genetic divergence in lentil germplasm for botanical description in relation with geographic origin, they characterized 317 accessions of lentil for stem colour, pedicle colour, growth habit, tendrils, hairiness, leaf pubescence, leaflet size, pod pigmentation, seed coat colour, seed coat pattern and cotyledon colour. Reported that high variability was observed for growth habit, leaf

pubescence, leaflet size, seed coat colour, testa pattern and cotyledon colour. Low level of association between genetic diversity and geographical distribution is expected due to less representation of accession from particular area that is needed to study uniformly.

Selection for high yielding lentil genotypes should be based on primary and secondary branches per plant, pods per plant, biological yield and plant height. Tejbir and Gupta (2005) study the character association analysis in lentil (*Lens culinaris* Medik.) and reported that number of primary and secondary branches per plant, pod per plant, plant height and biological yield showed positive and significant correlation with seed yield under both early and late sown conditions. Path analysis revealed that biological yield had the maximum direct effect on seed yield. All the characters (days to 50% flowering. Days to maturity, seed per pod, and biological yield) contributed indirectly to seed yield via biological yield. Thus selection for high yielding lentil genotypes should be based on pods per plant and plant height.

Gangele and Rao (2005) conducted an experiment to observe the heritability and genetic advance for yield and its component in lentil, reported that high genetic variation was observed for pods per plant, number of seeds per pod and hundred seed weight. Low genetic variation was observed for days to 50% flowering, days to maturity and plant height. Heritability was high for the entire trait. Seeds per plant, pods per plant showed high heritability with moderate genetic advance while hundred seed weight, seeds per plant, plant height and days to 50% flowering showed high heritability with moderate genetic advance. Result indicated that indirect selection for pods per plant and seeds per plant contributed to the genetic improvement of lentil.

Bicer *et al.*, (2004) reported that highest genetic variations were recorded for biological yield; grain yield and seed yield per plant. He observed highest genetic variation for grain yield and seed yield per plant. The highest heritability was recorded number of 50 days to flowering. Kishore and Gupta (2002) and Stoilova and Pereira (1999) reported similar result.

Haddad *et al.*, (2004) reported that high variability was observed for grain yield and yield related attributes, and co-efficient of variation (c.v.) ranged from 0.9% for days to maturity to 58% for seed yield. c.v. value above 40% was recorded for the number of seeds per plant, number of pods per plant and harvest index. The phenotypic diversity index for the studied character was 0.827+ or -0.134 where plant height had the maximum diversity.

Singh *et al.*, (2004) reported that the dominant variance was high for harvest index, number of primary branches per plant, number of secondary branches per plant and number of seeds per pod, while the same estimates attained a negative value for hundred seed weight. The additive genetic variance was also high for all the characters except number of seeds per pod and number of primary branches per plant. Narrow-sense heritability was high for all the character except days to 50% flowering and harvests index.

Hamdi *et al.*, (2003) reported that seed yield is positively and significantly correlated with pod and seed numbers, plant height and number of branches per plant, and negatively with flowering duration. Days to 50% flowering significantly correlated with days to 100% flowering, 50% and 100% podding and days to maturity. The result indicates that selection for early flowering is sufficient to identify the earliness in podding and maturity and

need to measure other early traits to save time and cost. Path analysis revealed that number of seeds per plant had the highest direct and indirect effect on seed yield followed by pods per plant.

Hoque *et al.*, (2002) observed that plant Pubescence which segregated in $F_2$ plant in the ratio of 3 (Pubescent): 1(non-pubescent) and in $F_3$ plant in the ratio of 1(Pubescent): 2 (Segregating): 1 (Non-pubescent).

Kishore and Gupta (2002) conducted an experiment on early selection in macrosperma-microsperma selection derived gene pool of lentil and reported that heritability was high for days to maturity whereas moderate for seed yield per plant. Seed yield per plant showed significant positive correlation with seeds per pod, hundred seed weight and days to 50% flowering.

Yadav *et al.*, (2002) conducted an experiment on the impact of different environments on genetic variation in lentil and used 11 traits (days to 50% flowering, days to maturity, plant height, pod per plant, number of seed per pod, seed yield per plant and hundred seed weight. Reported that the phenotypic coefficients of variation (PCV) were higher than the genotypic coefficient of variation (GCV). Higher (GCV) and (PCV) estimates for seed yield per plant and number of seed per pod indicated the better influence of the environment and the reliability of selection based on phenotypic performance. Heritability estimate were higher number of days to 50% flowering, hundred seed weight and plant height. High heritability estimate with high genetic advance was recorded for hundred seed weight and number of pod per plant, indicating the improvement of these traits through



simple selection. High estimates of heritability and low genetic advance, coupled with lower GCV and PCV estimates were recorded for number of days to 50% flowering and plant height, indicating the presence of dominance and epistatic effect.

Lazaro *et al.*, (2001) reported that characters related to seed and productivity correlated with climate of the origin site. While phenology and plant height did not show significant correlations. The climate variable related with extreme, temperature, which is more effective than average temperature or rainfall due to geographical location. They were evaluated 16 morphological characters with climate zone. The result indicates that a great part of landrace come form temperate areas with dry Mediterranean moisture regime. Most of the variety had plant pigmentation, slight leaf pubescence white flower with blue or violet veins green testa without pattern and yellow cotyledons.

Tullu *et al.*, (2001) reported that plant height and plant growth habit have a significant association with total biomass, seed yield and residue amounts. Lines with higher biomass produces higher seed yield.

Singh and Singh (1989) studied the genetic diversity and stability in chickpea entries. They suggested crossing among the 14 selected genotype on the basis of intra/ inter cluster distances to recombinent the genes for stability and high yield.

Swarp and Lal (1987) evaluated 28 high yielding and bold seeded (22.5g/100 seed) for time of 50% flowering, time of maturity, plant height, and 100 seed weight at India. They observed that the time of 50% flowering

ranged from 55-59 days, time of maturity ranged from 113 to 134 days after sowing in SL-904 and SL-397 respectively. Plant height varied from 28.7 cm (SL 945) to 33.9 cm (SL 598) and 100 seed weight from 2.90g (SL 666) to 4.30g (SL 143).

Mia *et al.*, (1986) found very low co-efficient of variation for time of maturity (3.94%) with a mean value 122 days, time of flowering (9.65%) with a mean value 74.7 days, and plant height (109%) with a mean value 55.5 cm, but high for seed yield per plant (43.9%) and 1000 seed weight (29.02%) with mean value of 0.96g and 22.8g respectively.

Shahi *et al.*, (1986) reported that wide range of variability for seed size with the range 1.4-3.4g/100 seed (mean 2.4), seed permeability 5.0-55.8 (mean 26.4%) as well as for germination, 44.2-89.46 (mean 72.9%). Shanmugam and Rangasamy (1982) observed that the characters yield per plant and pod cluster per plant contributed considerably towards diversity in blackgram. Again the same other in 1982 assigned 45 genotypes of blackgram to ten clusters by analyzing data on yield and nine yield components using Mahalanobis's $D^2$ statistic and stated that geographical diversity was not the only factor for determining genetic diversity. The clustering pattern more or less confirmed the canonical analysis. Furthermore, Sindu *et al.*, (1989), investigated diversity in 20 strains of blackgrame from different Agro-ecological zone of India using Mahalanobis's $D^2$ statistic. They observed no parallel relation between geographical and genetic diversity.

Genetic divergences were studies by Malik *et al.*, (1985) in mungbean. They observed days to flowering, seed yield and plant height-contributed

maximum towards divergence. However, genetic diversity in blackgrame was studies by Das and Gupta (1984). They observed 100-grain weight and branches per plant were the main component of diversity. Sagar *et al.*, studied the same experiment in 1976 through Mahalanobis's $D^2$ in blackgram and found days to flowering, plant height, hundred seed weight and length contributed maximum towards variability.

Malik *et al.*, (1984) in an evalution 55 lentil accessions collected from Sindu and Panjab province of Pakistan, found that the time to flowering varied from 117-150 days with mean value of 124 days, time to maturity varied from 130-165 cm with a mean of 151 days. Plant height ranged from 29.0cm - 45.5cm and the mean was 35.6 cm. Pod/ plant and yield/plant ranged between 22-154.8 and 0.48-3.95gm with the co-efficient of variation 47.3% and 45.2%, respectively. Tiwari and Singh (1980) also reported variability for these traits in lentil germplasm.

Sinha and Chowdhary (1984) at Bihar, India evaluated two hundred and seventy lentil lines for different morphological and quantitative characteristics. Lines varied little from each other in growth habit, flower colour and seed colour. Enough variability was found providing scope for selection in quantitative characters such as plant height (cm), time to flowering (days). Hundred seed weight (g) and seed yield (g) per meter row within the range of 20-25, 51-80, 1.02-2.66 and 7.2-7.15 respectively. Nandan and Pandey (1980) observed that hundred seed weight ranged from 1.52-3.62g.

Adhikari and Pandey (1983) by using $D^2$ analysis in chickpea reported that in native type seed per pod, pod per plant in kabuli types primary branches per plant and hundred seed weight contributed maximum towards diversity. Through multivariate analysis in cowpea reported that the character 100 seed weight and pod length contributed maximum to the genetic diversity. Natarajan and Palanisamy (1990) carried out an investigation for the divergence in eight genotypes of mungbean and their 15 hybrids. They utilized generalized distance and canonical analysis confirmed analysis and found five clusters. The canonical analysis confirmed to a large extent and the clustering pattern obtained by multivariate analysis.

Dixit (1980) in the investigation in the lentil observed those primary branches per plant and yield per plant contributed a large to the total genetic diversity. In the same crop Sharma and Luthra (1987) reported that pods per plant and yield per plant contributed maximum towards diversity.

Muchlbauer (1974) conducted an experiment to find out the variability and association of characters in 45 lentil cultivers and found the greater variability in three characters *viz* yield (kg/ha), seeds/plant and pods/plant with the standard high variation (31.37%). Todorov (1980) found in his study that plant height, number of pods/plant, seeds/plant, seed weight/plant and pod length has got greater variation among the 35 lines and 18 initial populations.

Singh and Singh (1969), in a study comprising 20 indigenous and 20 exotic lines of lentil and found that pod number, branch numbers and days to flowering had high variability. They also observed that the characters, which

had high phenotypic variability, also exist high genotypic variability and wide ranges. Number of branch and number of pod had varied wide ranges and also had varied high phenotypic variability. Practically exotic line had varied small number of branch and a pod per plant whereas the indigenous line had varied high number of bunches and pods, and these wide differences accounted for larger phenotypic variability.

Thinking about magnitude of genetic variability for yield and its contributing characters has been of considerable interest to the plant breeders for planning and execution of genetic improvement program. A large number of such investigations have been carried out in different crops including lentils. (Malhotra *et al.* 1974), groundnut (Reddy *et al.*, 1987), soybean (Singh and Ram, 1985, Mishra *et al.* 1987, Broich and palmer,1980) blackgram (Singh *et al.*, 1973; Das 1978; Shing and Mishr 1983), Munhbean (Gupta and Singh, 1969; Yohe Poehman 1972; Malik *et al.*, 1983, Chickpea (Chauhan, 1968; Dumber and Deshmukh 1983) Pigeon pea (Heeramath and Talwar 1971; Dumber and Deshmukh 1983) and (Singh *et al.*, 1973; Singh *et al.*, 1985) All these studies were on the basis of simple analysis of variance, which enabled to computed genetic variance for different characters. But total genetic variability among different natural population of these crops could not be obtained which is imported from evolutionary and breeding point of view.

# CHAPTER III

# MATERIALS AND METHODS

### 3.1. Site of experiment

The experiment was conducted at the experimental farm, Shere-e-Bangla Agricultural University, Dhaka during the period from November 2006 to March 2007. The experimental site was at $90^0$ 22" E longitude and $23^0$ 41" N latitude at an altitude of 8.6 meters above sea level. The physical and chemical characteristics of soil have been presented in Appendix I.

### 3.2. Materials

A total of 31 genotypes of lentil (Table 1), originated from different place of Bangladesh were used in this experiment. The materials were collected from Bangladesh Institute of Nuclear Agriculture (BINA) and pulse research center Bangladesh Agricultural Research Institute (BARI), Gazipur.

### 3.3. Soil and climate

The land belong to agro-ecological region of Madhupur Tract' (AEZ 28) of Nodda soil series. The soil was sandy loam in texture having pH 5.47-5.63. The mean temperature of growing period was 24.36° C with average maximum and minimum being 30.00° C and 18.67° C, respectively. The monthly total rainfall, average sunshine hour, temperature during the study period are shown in Appendix II.

**Table 1. Name, sources and origin of the 31-lentil germplasm**

| SL No. | Genotype No | Accession no / Varity | Source | Origin |
|---|---|---|---|---|
| 1 | G-1 | BINA mosure 1 | BINA | Bangladesh |
| 2 | G-2 | BINA mosure 2 | BINA | Bangladesh |
| 3 | G-3 | BINA mosure 3 | BINA | Bangladesh |
| 4 | G-4 | BARI mosure 1 | BARI | Bangladesh |
| 5 | G-5 | BARI mosure 2 | BARI | Bangladesh |
| 6 | G-6 | BARI mosure 3 | BARI | Bangladesh |
| 7 | G-7 | BARI mosure 4 | BARI | Bangladesh |
| 8 | G-8 | BARI ILL 5094 | BARI | Bangladesh |
| 9 | G-9 | BARI ILL 6284 | BARI | Bangladesh |
| 10 | G-10 | BARI BLX 980081 | BARI | Bangladesh |
| 11 | G-11 | BARI 107 41X87015 | BARI | Bangladesh |
| 12 | G-12 | BARI ILL 4706 | BARI | Bangladesh |
| 13 | G-13 | BARI ILL 46081 | BARI | Bangladesh |
| 14 | G-14 | BARI ILL 5105 | BARI | Bangladesh |
| 15 | G-15 | BARI ILX 87039XL 5 | BARI | Bangladesh |
| 16 | G-16 | BARI 77 X 87015 | BARI | Bangladesh |
| 17 | G-17 | BARI 8406147 | BARI | Bangladesh |
| 18 | G-18 | BARI ILL 5143 | BARI | Bangladesh |
| 19 | G-19 | BARI ILX 87015 | BARI | Bangladesh |
| 20 | G-20 | BARI L 5X 87272 | BARI | Bangladesh |
| 21 | G-21 | BARI BLX 980051 | BARI | Bangladesh |
| 22 | G-22 | BARI ILL 95052 | BARI | Bangladesh |
| 23 | G-23 | BARI BLX 980063 | BARI | Bangladesh |
| 24 | G-24 | BARI 8406129 | BARI | Bangladesh |
| 25 | G-25 | BARI ILL 86058 | BARI | Bangladesh |
| 26 | G-26 | BARI BLX 980023 | BARI | Bangladesh |
| 27 | G-27 | BARI BLX 980031 | BARI | Bangladesh |
| 28 | G-28 | BARI ILL 5081 | BARI | Bangladesh |
| 29 | G-29 | BARI ILX 87040 | BARI | Bangladesh |
| 30 | G-30 | BARI 8046130 | BARI | Bangladesh |
| 31 | G-31 | BARI 8406122 | BARI | Bangladesh |

### 3.4. Experimental design and layout

The studey was laid out in Randomized Complete Block Design (RCBD) with three (3) replications. The plant-to-plant distance was 10 cm and line-to-line distance was 30cm. The total land size was length 352 square meter (length 32m and width 11m). The experimental plot was 2.5 meters width and 30 meters length. The plot-to-plot distance was 1m. The genotype was randomly distributed to two rows within the line.

### 3.5. Land preparation

The experimental plot was prepared by ploughing with tractor followed by harrowing and laddering by cows. Weed and stables were removed. Manure and fertilizer were applied as per the recommended dose before the final land preparation. Irrigation channels were made around each plot. The final land preparation was done on nine November 2006.

### 3.6. Manure and fertilizer

Due to its ability of nitrogen fixation from the atmosphere lentil require less nitrogen application. But for initial establishment of plant up to the stage of nodule formation a starter dose of 20-40-20kg NPK, respectively, was applied.

In this stud, fertilizer was applied as per recommendation of Bangladesh Agricultural Research Institute (BARI). The following dose of fertilizer and manure were applied to the plot for lentil cultivation.

| Fertilizers/ Manures | Doses (kg) Applied in the plot |
|---|---|
| Urea | 5 kg |
| TSP | 12 kg |
| MP | 5 kg |
| Cowdung | 8kg |
| Gypsum | 3kg |

Urea, TSP, MP, and Gypsum were applied at the time of final land preparation. Cowdung was applied two weeks before sowing during land preparation.

### 3.7. Sowing of seed and intercultural operation

The seed of 31 genotypes were sown in the field on 12th November 2006. Intercultural operation was done uniformly for all the genotypes. Thinning was done 25 days after sowing and weeding was done twice the first during thinning and the second one after about two month of sowing.

### 3.8. Harvesting

Different genotypes matured at different times. The harvesting was completed by 15th March 2007. Ten plants from each plot were randomly selected to collect data and were harvested by uprooting. Border plant was discarded to avoid border effect.

### 3.9. Recording of data

Data on the following characters were recorded on individual plant basis from randomly selected plants per genotypes in each replication. Out of 16 characters, days to 50% flowering, days to maturity, plant pigmentation, leaf, stem and pod pigmentation, tendril formation and plant pubescence were recorded in the field condition and the data on the other characters were recorded in the field laboratory after harvest.

**3.9.1 Plant height**: The height of plant (cm) from the ground level of the stem of the tip of the plant was measured in centimeter (cm) as plant height.

**3.9.2 Plant growth habit**: High number branch make prostate, minimum number of branch make erect.

**3.9.3 Stem, leaf and pod pigmentation**: The data were recorded on the basis of visible appearance of pigmentation in stem, leaf and pod.

**3.9.4 Leaf size:** The data were recorded on the basis of physical appearance of the leaf.

**3.9.5 Leaf pubescence:** Small spiny structure present on the surface of the leaf is considered as pubescence leaf.

**3.9.6 Tendril formation**: The data were recorded on the basis of development of long tendril like structure from the apex of the leaf.

**3.9.7 Days to 50% flowering**: Data on days to 50% flowering was recorded from the date of sowing to date when 50% of plant within a line had flowered.

**3.9.8 Flower per peduncle**: The data were recorded on the basis of number of flower present in peduncle.

**3.9.9 Pod per plant:** The total number of pod in individual plants was recorded.

**3.9.10 Days to maturity**: Data on days to maturity were recorded from date of sowing to date of harvesting.

**3.9.11 Seed per plant:** The total number of seed in individual plant was recorded.

**3.9.12 Hundred seed weight:** One hundred clean sundried seeds were randomly taken from each line and weighted in gram (g).

**3.9.13 Seed coat colour**: The data were recorded on the basis of visible appearance of colour in seed coat.

**3.9.14 Testa pattern**: The data were recorded on the basis of presence or absence of scatter black spot on upper surface of the seed.

**3.9.15 Cotyledon colour**: The data were recorded on the basis of visible appearance of colour in cotyledon.

**3.9.16 Yield per plant**: Weight of the total number of pod of each individual plant was taken in gram (g).

### 3.10 Statistical analysis

All the collected data of the present study were statistically analyzed. For each character, analysis of variance was done individually by F test (Panse and Shukhatme, 1978) and mean values were separated by DMRT (Steel and Torrie, 1980).

Table 2. The structure of Analysis of Variance (ANOVA)

| Source of variation | Df | MSS | Expected MSS | F-value |
|---|---|---|---|---|
| Replication | (r-1) | $M_r$ | $\sigma^2e + g\sigma^2r$ | $M_g / M_e$ |
| Treatment/genotypes/hybrids/ Parent/checks | (g-1) | $M_g$ | $\sigma^2e + r\sigma^2g$ | |
| Error | (r-1) (g-1) | $M_e$ | $\sigma^2e$ | |
| Total | (rg-1) | | | |

Where,
r = Number of Replication,
G = Number of genotypes (treatments),

$M_r$, $M_g$ and $M_e$ = Mean sum of squares due to replications, genotypes and error respectively

$\sigma^2e$ = Error variance = $M_e$
$\sigma^2g$ = Genotypic variance = $(M_g - M_e)/r$ and
$\sigma^2p$ = Phenotypic variance = $\sigma^2e + \sigma^2g$
MSS due to genotype were tested against the error variance using F test at p = 0.05 or p = 0.01 with degree of freedom for higher and lower value of variance.

The mean square (MS) at error and phenotypic variance were estimated as per Johnson *et al.* (1955). The error MS was considered as error variance ($\sigma^2$e). Genotypic variance ($\sigma^2$g) was obtained by subtracting error MS from the genotype MS and dividing by number of replication as shown below:

$$\sigma^2_g = \frac{GMS - EMS}{r}$$

Where
GMS= genotypic mean square
EMS= error mean square
r = number of replication.

The phenotypic variance ($\sigma^2$p) were derived by adding genotypic variance ($\sigma^2$g) with error variance ($\sigma^2$e) as given by the following formula

Phenotypic variance = Genotypic variance + error variance

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

### 3. 10. 1. Estimation of genotypic and phenotypic coefficient of variation:

Genotypic and Phenotypic Coefficient of variation was calculated according to Burtin (1952).

Genotypic co-efficient of variation $(GCV) = \frac{\sigma_g}{x} \times 100$

Where
$\sigma$g = genotypic standard deviation,
x = population mean,

Similarly, the phenotypic co-efficient of variation was calculated from the following formula:

$$\text{Phenotypic co-efficient of variation } (PCV) = \frac{\sigma_p}{x} \times 100$$

Where
σp = phenotypic standard deviation
x = population mean

### 3. 10. 2. Estimation of heritability:

Heritability in broad sense was estimated using the given formula suggested by Hanson *et al. (1956).*

$$H_b = \frac{\sigma^2_g}{\sigma^2_p} \times 100$$

Where
$H_b$ = Heritability in broad sense
$\sigma^2 g$ = Genotypic variance
$\sigma^2 p$ = Phenotypic variance

### 3. 10. 3. Estimation of genetic advance:

The expected genetic advance under selection was estimated using the formula suggested by Lush (1949) and Johnson *et al.* (1955).

$$\text{Genetic advance } (GA) = h^2_b . k . \sigma_p$$

Where
$h^2 b$= Heritability in broad sense
k = Selection intensity, the value of which is 2.06 at the 5% selection intensity.
σp = phenotypic standard deviation

### 3. 10. 4. Estimation of Correlation of coefficient:

Penotypic correlation co-efficient was calculated suggested by Miller *et al.* (1955), Johnson *et al.* (1955) and Hanson *et al.* (1956)

$$\text{Phenotypic correlation } (r_{pxy}) = \frac{\sigma^2_{pxy}}{\sqrt{(\sigma^2_{px} \times \sigma^2_{py})}}$$

Where
$\sigma^2_{pxy}$ = Phenotypic covariance between the trait x and y
$\sigma^2_{px}$ = Phenotypic variance of the trait x
$\sigma^2_{py}$ = Phenotypic variance of y.

### 3. 10. 5. Path Analysis:

Correlation co-efficient was further partitioned into component of direct and indirect effect by Path co-efficient analysis originally developed by Right (1921) and later described by Dewey and Lu (1959).

# CHAPTER IV

# RESULTS AND DISCUSSION

# 4. RESULTS AND DISCUSSION

The experimental results obtained from the present investigation are presented here under the following heads:

- Study of the morphological and yield contributing characters in lentil genotypes
- Classification of germplasm on the basis of physical/ morphological markers
- To determine the character association and contribution of character toward grain yield in the genotypes

A total of 31 genotypes were collected from different places of Bangladesh were used in this experiment for morphological characterization. The results of mean performance for various morphological and yield contributing characters are presented under the following heads:

## 4. 1 Analysis of variance

Analysis of variance was carried out and the mean sums of square for various characters are presented in Table 3. 'F' test revealed significant variation among all the genotypes for all the character studied except seed per plant and yield per plant.

## 4. 2 Morphological characteristics

Mean performance of lentil genotypes has been presented character wise in Table 4.

### 4. 2. 1. Leaf shape

Leaf shape is important character of lentil. In the present study, two types leaf shape were observed (Table 4). Out of 31 genotypes, 15 genotypes were broad type leaf shape and 16 were narrow type. A comparative depiction of leaf shape is presented in Plate 1.

**Table 3. Analysis of variance (ANOVA) for yield and its related character in lentil**

| SL No | Character | Mean sum of square (MSS) | | |
|---|---|---|---|---|
| | | Replication | Treatment | Error |
| | df | 2 | 30 | 60 |
| 1 | Plant height | 30.54 | 11.54** | 2.29 |
| 2 | Days to 50% flowering | 37.79 | 29.47** | 2.30 |
| 3 | Flower per peduncle | 0.78 | 0.34* | 0.17 |
| 4 | Pod per plant | 54.71 | 286.30** | 8.30 |
| 5 | Seed per plant | 288.25ns | 314.40ns | 313.06 |
| 6 | 100 seed weight | 0.064 | 0.024ns | 0.018 |
| 7 | Days to maturity | 62.92 | 62.58** | 2.23 |
| 8 | Yield per plant | 0.44ns | 0.53ns | 0.41 |

** Significant at 1% level

* Significant at 5% level

ns Not significant

## Table 4. Morphological appearance and mean performance for yield related characters in 31 lentil genotypes

| Genotypes | Leaf shape | Plant height (cm) | Growth habit | Days to 50% Flowering | No. of flower per peduncle | Pods per plant | Seeds Per plant | 100 seed wt. Per plant (g) | Days to maturity | Seed yield Per plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| G-1 | B | 31 | P | 64 | 1.70 | 95 | 170.53 | 1.47 | 101 | 4.93 |
| G-2 | B | 38 | E | 68 | 1.70 | 113 | 170.63 | 1.41 | 106 | 5.07 |
| G-3 | B | 33 | E | 65 | 1.71 | 103 | 180.70 | 1.44 | 104 | 4.83 |
| G-4 | B | 33 | P | 66 | 1.79 | 103 | 194.09 | 1.34 | 108 | 4.79 |
| G-5 | N | 33 | P | 66 | 2.04 | 94 | 192.20 | 1.25 | 107 | 4.88 |
| G-6 | B | 32 | P | 64 | 1.69 | 85 | 187.17 | 1.36 | 103 | 4.72 |
| G-7 | B | 33 | P | 68 | 1.91 | 108 | 181.27 | 1.45 | 94 | 5.40 |
| G-8 | N | 34 | P | 64 | 2.0 | 107 | 168.58 | 1.42 | 94 | 5.53 |
| G-9 | N | 33 | E | 63 | 2.32 | 118 | 156.66 | 1.28 | 94 | 5.63 |
| G-10 | N | 36 | E | 63 | 2.08 | 104 | 155.75 | 1.35 | 96 | 4.22 |
| G-11 | B | 37 | E | 68 | 1.85 | 76 | 175.80 | 1.38 | 94 | 4.73 |
| G-12 | B | 37 | P | 65 | 2.30 | 99 | 169.77 | 1.31 | 97 | 5.07 |
| G-13 | B | 36 | E | 64 | 2.75 | 99 | 189.87 | 1.42 | 96 | 5.17 |
| G-14 | N | 36 | E | 74 | 1.68 | 96 | 198.97 | 1.47 | 99 | 5.60 |
| G-15 | N | 37 | P | 65 | 2.06 | 95 | 195.60 | 1.41 | 94 | 4.97 |
| G-16 | N | 35 | P | 65 | 1.97 | 94 | 180.77 | 1.42 | 97 | 3.73 |
| G-17 | N | 34 | P | 68 | 1.75 | 95 | 182.47 | 1.30 | 95 | 5.17 |
| G-18 | N | 36 | E | 69 | 1.84 | 111 | 185.77 | 1.29 | 98 | 4.78 |
| G-19 | B | 37 | P | 76 | 1.63 | 95 | 191.63 | 1.32 | 99 | 5.66 |
| G-20 | B | 37 | E | 73 | 2.72 | 99 | 177.67 | 1.37 | 99 | 5.39 |
| G-21 | B | 37 | E | 67 | 1.70 | 87 | 177.17 | 1.31 | 97 | 5.37 |
| G-22 | N | 38 | E | 65 | 2.09 | 111 | 185.45 | 1.47 | 97 | 4.55 |
| G-23 | N | 36 | P | 68 | 1.85 | 82 | 184.25 | 1.44 | 96 | 5.41 |
| G-24 | N | 34 | E | 64 | 1.77 | 94 | 188.30 | 1.41 | 99 | 5.93 |
| G-25 | N | 35 | E | 96 | 1.83 | 100 | 173.97 | 1.44 | 96 | 5.30 |
| G-26 | N | 37 | E | 96 | 1.83 | 99 | 172.03 | 1.40 | 96 | 5.78 |
| G-27 | B | 36 | P | 98 | 2.10 | 88 | 176.63 | 1.29 | 98 | 5.73 |
| G-28 | B | 35 | P | 97 | 1.85 | 85 | 173.47 | 1.42 | 97 | 3.80 |
| G-29 | N | 34 | P | 94 | 2.43 | 109 | 177.73 | 1.35 | 94 | 3.09 |
| G-30 | N | 37 | E | 96 | 1.70 | 86 | 176.77 | 1.38 | 96 | 5.40 |
| G-31 | B | 34 | E | 95 | 2.10 | 102 | 177.03 | 1.41 | 95 | 5.27 |
| **Mean** | | **35.19**** | | **73.35**** | **2.004*** | **98**** | **180** | **1.38** | **98**** | **5.18** |
| **C.V (%)** | | **4.30** | | **2.30** | **20.78** | **2.95** | **9.85** | **4.95** | **1.52** | **12.38** |
| **Range** | | **31-38** | | **63 - 98** | **1. 63-2.75** | **76 - 118** | **156-199** | **1.25-1.47** | **94 -108** | **3-6** |

**B=Broad N=Narrow P=Prostrate E=Erect**

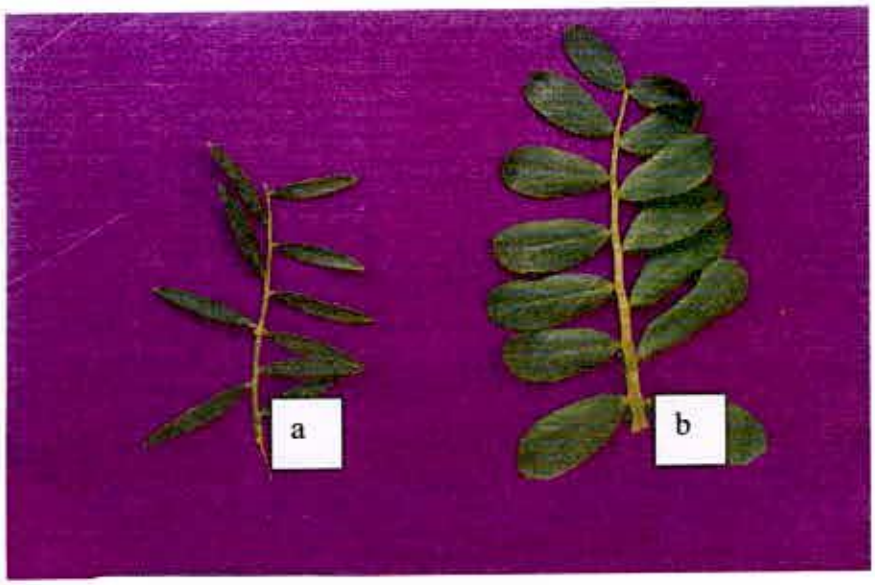



**Plate 1. (a). Narrow leaf and (b). Broad leaf of lentil**

**Plate 2. Flower number per peduncle of lentil**

### 4. 2. 2. Days to 50% flowering

The number of days recorded for 50% flowering ranged from 63 to 98 days in case of G-9 50% flowering observed in 63 days in G-27 50% flowering observed in 98 days among the 31 genotypes, with a mean being 66 days. Swarp and Lal (1987) evaluated 28-lentil germplasm and reported that the time of 50% flowering ranged from 55 to 59 days. Sinha and Chowdhary (1984) evaluated 270 lentil lines for different morphological characters and reported that 50% flowering time ranged from 51 days to 80 days. Hamdi *et al.*, (2003) reported that 50% flowering time significantly correlated with 100% podding and days to maturity. The result indicated that selection for early flowering was sufficient to identify the earliness in poding and maturity and need to measure other early traits to show time and cost.

### 4. 2. 3. Number of flower per peduncle

Number of flower per peduncle was varied from 1.63 to 2.75 with a mean of 2.084. The highest number of flowers per peduncle was observed in the genotype G-13 and lowest value was observed in genotype G-19. A comparative view of number of flower per peduncle has been presented in Plate 2.

### 4. 2. 4. Plant growth habit

Both prostrate and erect type growth habits were observed in tested lentil germplasm. Out of 31 genotypes, 15 genotypes showed prostrate type growth habit and the rest 16 genotypes were erect type. Tayyaba *et al.*, (2005) observed high variability for growth habit during study of genetic divergence in lentil germplasm. Which is defer from the present study.

### 4. 2. 5. Plant height

Plant height of lentil genotypes ranged from 31 cm (G-1) to 38 cm (G-2) with a mean of 35.19 cm. Tejbir *et al.*, (2005) reported that number of primary and secondary branches per plant, plant height and biological yield showed positive and significant correlation with seed yield under both early and late sown conditions. Tullu *et al.*, (2001) also reported that plant height and plant growth habit have a significant association with total biomass, seed yield and residue amounts. Malik *et al.*, (1984) evaluated 55 lentil accessions and found that plant height ranged from 29.0 cm to 45.5 cm with a mean of 35.60 cm.

### 4. 2. 6. Pods per plant

Pods per plant ranged from 76 to 118, with a mean of 98. Maximum number of pods per plant was observed in genotype G-9 and minimum was in genotype G-11. Though pods per plant related with seed yield and productivity, but it had also correlation with climate. Favorable climate increase pods per plant. Lazaro *et al.*, (2000) and Malik *et al.*, (1984) observed that pods per plant ranged between 22 to 154.8. More number of effective pods per plant can contribute to the genetic improvement of lentil.

### 4. 2. 7. Seeds per plant

Number of seed per plant ranged from 156 to 199, with a mean of 180. The highest number of seeds per plant was observed in the genotype G-14 and the lowest was observed in the genotype G-10. Yadav *et al.*, (2002) reported that number of seeds per plant influenced by the environment, i.e unfavorable environment reduced the number of seeds per plant of high yielding variety.

### 4. 2. 8. Hundreds seed weight (g)

The highest 100 seed weight was observed in G-1, G-14 and G-22 (each 1.47 g) and the lowest in G-5 (1.25 g), with a mean of 1.38 g. Generally the bold seeded showed higher testa weight than small seeded. Nandan and Pandey (1980) observed that 100 seed weight ranged from 1.52 g to 3.62 g.

### 4. 2. 9. Days to maturity

Days to maturity, ranged from 94 to 108 days, with a mean of 98 days. Maximum days to maturity were recorded in the genotype G-4 (108 days) and the minimum was with genotype G-15 (94 days). Swarp and Lal (1987) reported that maturity period, ranged from 113 to 134 days lentil lines SL 945 and SL 598 respectively. Mia *et al.*, (1986) found vary low co-efficient of variation for time of maturity (3.94%) with a mean of 122.3 days. Malik *et al.*, (1984) evaluated 55 lentil accessions and reported that time of maturity varied 117-150 days with a mean of 124.3 days.

### 4. 2. 10. Seed yield per plant (g)

Seed yield per plant ranged from 3.09g to 5.93g, with mean of 5.184 g, Maximum average yield/plant was observed in genotype G-24 and minimum average yield/plant in genotype G-29. Malik *et al.*, (1984) evaluated 55 lentil and reported that yield per plant ranged from o.43 g to 3.95 g.

## 4. 3 Classification of germplasm on the basis of physical/morphological markers

Morphological or physical marker of any agricultural crop is a valuable tool, which can utilize for crop improvement. Marker can directly help the Breeder to select desirable plant from the large number of population.

Identification of phenotypic marker is essential to sort out the segregating generation and subsequent selection. Many kind of morphological markers are present in lentil genotypes. In the present study, all the 31 genotypes are classified on the basis of present morphological marker which are described under the following heads:

**4. 3. 1. Leaf pubescence and tendril formation**

Out of 31 genotypes, 22 genotypes showed leaf pubescence and did not show in 9 genotypes (Table 5). Tendril formations were observed in 18 genotypes and were absent in 13 genotypes.

Hoque *et al.*, (2002) reported that plant pubescence is a genetically controlled character which segregated in $F_2$ plant in the ratio of 3 (pubescent): 1(non- pubescent) and in $F_3$ plant in the ratio of 1(pubescent): 2(segregating): 1(non- pubescent). A comparative depiction of non - tendril and tendril leaf of lentil are presented in Plate 3. Tendril formation was observed in 18 genotypes while 13 genotypes had no tendril.

No definite fashion was observed in case of leaf pubescnce and tendril formation. All the 31 lentil genotypes were classified in to 4 groups on the basis of presence and abscence of leaf pubescence and tendril formation which are presented in table 6. Both leaf pubescence and tendril were present in 11 genotypes (G-1, G-3, G-4, G-5, G-9, G-14, G-16, G-21, G-25, G-29 and G-31), only leaf pubescence were present but tendril absent in 11 genotypes (G-6, G-7, G-11, G-12, G-13, G-18, G-19, G-23, G-24, G-27 and G-30), only tendril present but leaf pubescence absent were 7 genotypes (G-2, G-8, G-10, G-15, G-20, G-22 and G-26). No leaf pubescence and no tendril formation was observed in case of two genotypes (G-17 and G-28).

**Table 5. Leaf pubescence and tendril formation in lentil genotype**

| Genotypes | Leaf pubescence | | Tendril formation | |
|---|---|---|---|---|
| | Present | Absent | Present | Absent |
| G-1 | Present | - | Present | - |
| G-2 | - | Absent | Present | - |
| G-3 | Present | - | Present | - |
| G-4 | Present | - | Present | - |
| G-5 | Present | - | Present | - |
| G-6 | Present | - | - | Absent |
| G-7 | Present | - | - | Absent |
| G-8 | - | Absent | Present | - |
| G-9 | Present | - | Present | - |
| G-10 | - | Absent | Present | - |
| G-11 | Present | - | - | Absent |
| G-12 | Present | - | - | Absent |
| G-13 | Present | - | - | Absent |
| G-14 | Present | - | Present | - |
| G-15 | - | Absent | Present | - |
| G-16 | Present | - | Present | - |
| G-17 | - | Absent | - | Absent |
| G-18 | Present | - | - | Absent |
| G-19 | Present | - | - | Absent |
| G-20 | - | Absent | Present | - |
| G-21 | Present | - | Present | - |
| G-22 | - | Absent | Present | - |
| G-23 | Present | - | - | Absent |
| G-24 | Present | - | - | Absent |
| G-25 | Present | - | Present | - |
| G-26 | - | Absent | Present | - |
| G-27 | Present | - | - | Absent |
| G-28 | - | Absent | - | Absent |
| G-29 | Present | - | Present | - |
| G-30 | Present | - | - | Absent |
| G-31 | Present | - | Present | - |
| **Total** | **22** | **9** | **18** | **13** |


**Plate 3. (a). Non- tendrilled leaf and (b). Tendrilled leaf of lentil**

**Table 6. Classification of lentil genotypes based on the presence and absence of leaf pubescence and tendril**

| Character | Genotypes | Total No |
|---|---|---|
| Both leaf pubescence & tendril present | G-1, G-3, G-4, G-5, G-9, G-14, G-16, G-21, G-25, G-29, G-31 | 11 |
| Leaf pubescence present & tendril absent | G-6, G-7, G-11, G-12, G-13, G-18, G-19, G-23, G-24, G-27, G-30 | 11 |
| Leaf pubescence absent & tendril present | G-2, G-8, G-10, G-15, G-20, G-22, G-26 | 7 |
| Both leaf pubescence & tendril absent | G-17, G-28 | 2 |

### 4. 3. 2. Pigmentation behaviour of leaf, stem and pod

Out of 31 lentil genotypes, 18 genotypes showed leaf pigmentation and 13 did not; (Table 7). In case of stem, pigmentation was observed in 22 genotypes and no pigmentation was observed in 9 genotypes. Pod pigmentation was observed in 9 genotypes while the character was absent in 22 genotypes. Maximum number of genotypes (22) showed stem pigmentation and fewer number genotypes (9) showed pod pigmentation. Moderate number of genotypes showed leaf pigmentation (18). Marshell *et al.,* (2006) reported that some morphological traits were not enough to differentiate between lentil genotypes, such as seedling stem pigmentation, where it was present in all the genotypes. A comparative depiction of leaf pigmentation and stem pigmentation are presented in Plate 4 and Plate 5.

No correlation was observed in case of leaf, stem and pod pigmentation of lentil genotypes. On the basis of presence and absence of pigmentation on leaf, stem and pod all the genotypes were classified into 7 groups that presented in Table 8. Out of 31 genotypes, 7 genotypes showed leaf, stem and pod pigmentation (G-1, G-3, G-6, G-11, G-14, G-22, and G-27). Only leaf pigmentation was present in one genotype named G-30 and only stem pigmentation was present in 9 genotypes (G-9, G-12, G-13, G-15, G-16, G-19, G-23, G-29 and G-31). Maximum 13 genotypes (G-1, G-3, G-6, G-7, G-11, G-14, G-17, G-18, G-21, G-22 G-25, G-26 and G-27) showed both leaf and stem pigmentation. Leaf and pod pigmentation were present in 9 genotypes like G-1, G-3, G-5, G-6, G-8, G-11, G-14 G-22 and G-27; and stem and pod pigmentation were present in 7 genotypes (G-1, G-3, G-6, G-11, G-14, G-22, and G-27). No pigmentation was found in 4 genotypes viz., G-4, G-10, G-20 and G-24.

Table 7. Pigmentation behaviour of leaves, stem and pod in lentil genotypes

| Genotypes | Leaf Pigmentation | | Stem Pigmentation | | Pod Pigmentation | |
|---|---|---|---|---|---|---|
| | Pigmented | Non pigmented | Pigmented | Non pigmented | Pigmented | Non pigmented |
| G-1 | + | | + | | + | |
| G-2 | + | | | - | | - |
| G-3 | + | | + | | + | |
| G-4 | | - | | - | | - |
| G-5 | + | | | - | + | |
| G-6 | + | | + | | + | |
| G-7 | + | | + | | | - |
| G-8 | + | | | - | + | |
| G-9 | | - | + | | | - |
| G-10 | | - | | - | | - |
| G-11 | + | | + | | + | |
| G-12 | | - | + | | | - |
| G-13 | | - | + | | | - |
| G-14 | + | | + | | + | |
| G-15 | | - | + | | | - |
| G-16 | | - | + | | | - |
| G-17 | + | | + | | | - |
| G-18 | + | | + | | | - |
| G-19 | | - | + | | | - |
| G-20 | | - | | - | | - |
| G-21 | + | | + | | | |
| G-22 | + | | + | | + | |
| G-23 | | - | + | | | - |
| G-24 | | - | | - | | - |
| G-25 | + | | + | | | - |
| G-26 | + | | + | | | - |
| G-27 | + | | + | | + | |
| G-28 | + | | | - | | - |
| G-29 | | - | + | | | - |
| G-30 | + | | | - | | - |
| G-31 | | - | + | | | - |
| **Total** | **18** | **13** | **22** | **9** | **9** | **22** |

+ = Pigmented, - = Non pigmented,

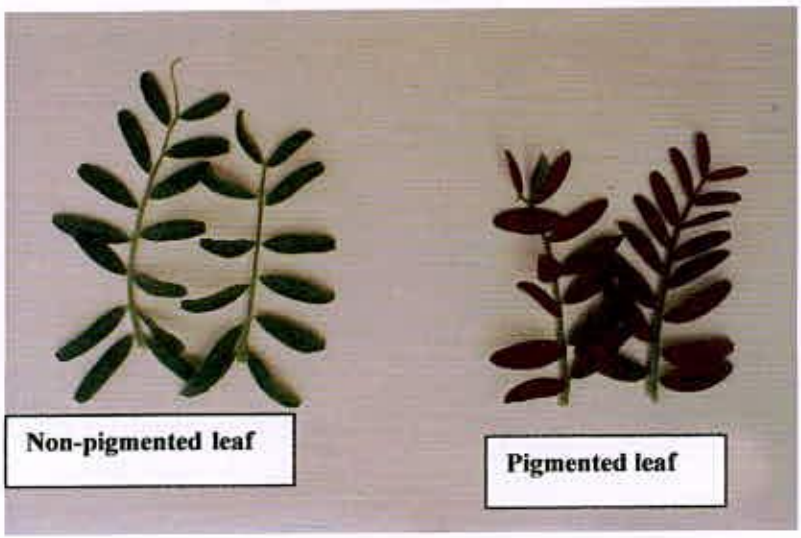



**Plate 4. Non-pigmented leaf and pigmented leaf of lentil**

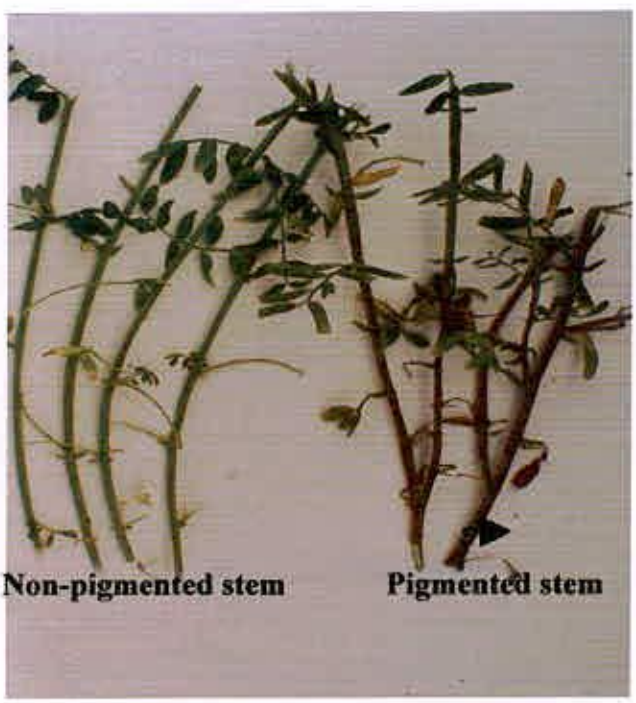





**Plate 5. Non-pigmented stem and pigmented stem of lentil**

### 4. 3. 3 Seed coat colour

Lentil seed showed different seed coat colour. On the basis of seed coat colour all the 31 genotypes were classified into 4 groups (Table 9). The genotypes G-1 showed black seed coat colour where as genotype G-7 showed brownish seed coat colour. Six genotypes (G-6, G-9, G-10, G-14, G-21 and G-30) showed dark brown seed coat colour. Rest 23 genotypes showed light brown seed coat colour.

### 4. 3. 4. Testa pattern

On the basis of testa pattern, all the 31 genotypes were classified into mottled and non-mottled groups (Table 10). Maximum 17 genotypes were grouped into non-mottled and 14 genotypes were grouped into mottled groups.

**Table 8. Classification of lentil genotypes on the basis of leaf, stem and pod pigmentation behaviur**

| Characters | Genotypes | Total No |
|---|---|---|
| Both leaf, stem and pod pigmentation present | G-1, G-3, G-6, G-11, G-14, G-22, G-27 | 7 |
| Only leaf pigmentation present | G-30 | 1 |
| Only stem pigmentation present | G-9, G-12, G-13, G-15, G-16, G-19, G-23, G-29, G-31 | 9 |
| Leaf and stem pigmentation present | G-1, G-3, G-6, G-7, G-11, G-14, G-17, G-18, G-21, G-22, G-25, G-26, G-27 | 13 |
| Leaf and pod pigmentation present | G-1, G-3, G-5, G-6, G-8, G-11, G-14, G-22, G-27, | 9 |
| Stem and pod pigmentation present | G-1, G-3, G-6, G-11, G-14, G-22, G-27, | 7 |
| No pigmentation | G-4, G-10, G-20, G-24 | 4 |

**Table 9.Classification of lentil genotypes on the basis of seed coat colour**

| Colour of seed coat | Genotypes | Total No. |
|---|---|---|
| Black | G-1 | 1 |
| Brownish | G-7 | 1 |
| Dark Brown | G-6, G-9, G-10, G-14, G-21, G-30 | 6 |
| Light Brown | G-2, G-3, G-4, G-5, G-8, G-11, G-12, G-13, G-15, G-16, G-17, G-18 G-19, G-20 G-22, G-23, G-24, G-25, G-26, G-27, G-28, G-29, G-31 | 23 |

**Table 10. Classification of lentil on the basis of testa pattern**

| Testa pattern | Genotypes | Total No. |
|---|---|---|
| Mottled | G-3, G-6, G-10, G-11, G- 12,G-14, G-15, G-16, G-17, G-18, G-20, G-24, G-30, G-31 | 14 |
| Non – mottled | G-1, G-2, G-4, G-5, G-7, G-8, G-9, G-13, G-19, G-21, G-22, G-23, G-25, G-26, G-27, G-28, G-29 | 17 |

### 4. 3. 5. Cotyledon colour

A vast variation was observed incase of cotyledone colour of lentil seed. On the basis of cotyledone colour, all the genotypes were classified into 5 different groups (Table 11). Maximum 11 genotypes (G-5, G-6, G-8, G-9, G-12, G-15, G-16, G-17, G-25, G-27 and G-28) showed yellow cotyledone colour and minimum one genotype (G-24) showed red cotyledone colour. Seven genotypes (G-2, G-4, G-7, G-10, G-14, G-18 and G-21) showed brown cotyledone colour. Similarlly another seven genotypes (G-1, G-13, G-G-20, G-22, G-26, G-29 and G-31) showed orange cotyledon colour. Rest five genotypes (G-3, G-11, G-19, G-23 and G-30) showed green cotyledone colour.

**Table 11. Classification of lentil genotypes based on the cotyledon colour**

| Colour of cotyledon | Genotypes | Total No |
|---|---|---|
| Brown | G-2, G-4, G-7, G-10, G-14, G-18, G-21 | 7 |
| Green | G-3, G-11, G-19, G-23, G-30 | 5 |
| Yellow | G-5, G-6, G-8, G-9, G-12, G-15, G-16, G-17, G-25, G-27, G-28 | 11 |
| Orange | G-1, G-13, G-20, G-22, G-26, G-29, G-31 | 7 |
| Red | G -24 | 1 |

## 4. 4. To determine the character association and contribution of character toward grain yield in the genotypes

### 4. 4. 1. Correlation co-efficient

Correlation co-efficient among yield contributing character are presented in Table 12. Plant height showed positive correlation with days to 50% flowering, and positive association highly significant with number of flower per peduncle, seed per plant and yield per plant, while negative correlation with pod per plant and 100 seed weight. Days to 50% flowering showed highly positive correlation with days to maturity (0.602), while negative with yield per plant. Days to maturity were positively correlated with most traits except 100 seed weight. Number of flower per peduncle showed significant negative correlation with 100 seed weight, and negative association with other character. There was positive association of pod per plant with seed per plant and yield per plant except 100 seed weight. Seed per plant was positively significant associated with yield per plant. 100 seed weight showed positive correlation with yield per plant. Hamdi *et al.* (2003) Observed that seed yield was positively and significantly correlated with pod and seed number, plant height and negatively with flowering duration. Days to 50% flowering were significantly correlated with days to 100% flowering, 50 and 100% podding and days to maturity. Neha *et al.* (2005) revealed that pods per plant and seed per pod showed positive, whereas days to flowering, days to maturity, 100 seed weight showed negative correlation with seed yield. Tejbir and Gupta (2005) observed that pod per plant, plant height showed positive significant correlation with seed yield.

**Table 12. Correlation co-efficient among the yield contributing character of lentil**

| Character | DF | DM | NFPP | PP | SPP | 100SW | YPP |
|---|---|---|---|---|---|---|---|
| **PH** | 0.271 | 0.526** | 0.349 | -0.112 | 0.115 | -0.101 | 0.155 |
| **DF** | | 0.602** | 0.090 | 0.0070 | 0.061 | 0.035 | -0.068 |
| **DM** | | | 0.247 | 0.190 | 0.143 | -0.156 | 0.050 |
| **NFPP** | | | | -0.015 | -0.052 | -0.482** | -0.038 |
| **PP** | | | | | 0.048 | -0.097 | 0.170 |
| **SPP** | | | | | | 0.331 | 0.455* |
| **100SW** | | | | | | | 0.227 |
| **YPP** | | | | | | | |

NB
** 1% level of significant
* 5% level of significant
PH = Plant Height, DF = Days to 50% flowering, DM = Days to maturity, NFPP = Number of flower per peduncle, PP = Pod per plant, SPP = Seed per plant, 100SW = Hundred seed weight.

### 4. 4. 2. Path Analysis

Path coefficient analysis used to find out clear picture of the inter-relationship between yield and yield contributing characters. By using path analysis the interrelation between yield and other morph- physiological components, are presented in Table 13. Here grain yield was considered as effect (dependent) variable and plant height, days to 50% flowering, days to maturity, number of flower per peduncle, pod per plant, seed per plant and hundred seed weight were treated as causes or independent variables.

#### 4. 4. 2. 1. Plant height

Plant height had positive direct effect (0.2113) on grain yield and had positive correlation (0.155) with grain yield. Plant height had positive indirect effect on yield through number of flower per peduncle, and seed per plant.

#### 4. 4. 2. 2. Days to 50% flowering

Days to 50% flowering had small negative direct effect (-0.1361) on grain yield and also had negative correlation with grain yield (-0.068). Days to 50% flowering had positive but indirect effect on grain yield through plant height, number of flower per peduncle, pod per plant, seed per plant and 100 seed weight. The direct and indirect effect of days to50% flowering were relatively unimportant. Negative direct effect of days to 50% flowering on grain yield may be nullified by positive indirect effect of days to 50% flowering via 100 seed weight, seed per plant, pod per plant, number of flower per peduncle and plant height. So selection should be done not only

based on days to 50% flowering but other associated characters must also be considered.

**Table 13. Path analysis shows direct and indirect effect of some yield contributing characters of lentil germplasm**

| Character | PH | DF | DM | NFPP | PP | SPP | 100SW | Correlation with yield |
|---|---|---|---|---|---|---|---|---|
| PH | **0.2113** | -0.0369 | -0.0285 | 0.0011 | -0.0233 | 0.0450 | -0.0138 | 0.155 |
| DF | 0.0573 | **-0.1361** | -0.0326 | 0.0002 | 0.0146 | 0.0239 | 0.0048 | -0.068 |
| DM | 0.111 | -0.0820 | **-5.4175** | 0.0008 | 0.0395 | 0.0560 | -0.0213 | 0.050 |
| NFPP | 0.0738 | -0.0122 | -0.0133 | **3.3062** | -0.0031 | -0.0204 | -0.0660 | -0.038 |
| PP | -0.0237 | -0.0095 | -0.0103 | -0000 | **0.2080** | 0.0188 | -0.1327. | 0.170 |
| SPP | 0.0430 | -0.0083 | -0.0077 | -0.0001 | 0.009 | **0.3916** | 0.0453 | 0.455* |
| 100SW | -0.0213 | -0.0048 | 0.0085 | -0.0016 | -0.0201 | 0.1296 | **0.1367** | 0.227 |

Residual effect, R = 0.5463, ** = 1% level of significant, * = 5% level of significant
PH = Plant Height, DF = Days to 50% flowering, DM = Days to maturity, NFPP = Number of flower per peduncle, PP = Pod per plant, SPP = Seed per plant, 100SW = Hundred seed weight.

### 4. 4. 2. 3.Days to maturity

Days to maturity had high negative direct effect (-5.4175) through it had positive correlation (0.050) with grain yield. Days to maturity contributed indirectly on grain yield through plant height, number of flower per peduncle, pod per plant and seed per plant.

### 4. 4. 2. 4. Number of flower per peduncle

Number of flower per peduncle exhibited negative association (-0.038) with grain yield through. Path analysis revealed a considerable positive direct effect (3.3062).

### 4. 4. 2. 5. Pod per plant

Pod per plant had positive direct effect (0.2080) on grain yield per plant and also had positive association (0.175) with grain yield. The positive indirect effect of on grain yield was observed by seed per plant. Neha *et al.* (2005) observed that pods per plant had highest direct effect on seed yield, followed by plant height and seeds per plant

### 4. 4. 2. 6. Seed per plant

Positive direct effect (0.3916) on grain yield through seed per plant and its correlation with grain yield also significant. Positive direct effect of seed per plant on grain yield of lentil indicated that higher seed per plant is the character for producing higher yield of lentil. Higher positive indirect effect on grain yield was observed by pod per plant and 100 seed weight through seed per plant might be due to significant positive correlation of seed per plant with corresponding growth parameters. The result suggested that seed

per plant should be a selection criterion for improving yield. Tejbir and Gupta (2005). Path analysis revealed that biological yield had the maximum direct effect on seed yield. Hamdi *et al.* (2003) revealed that number of seeds per plant had the highest direct and indirect effect on seed yield followed by pods per plant

### 4. 4. 2. 7. Hundreds seed weight

Hundreds seed weight had positive direct effect (0.1367) on grain yield and also had positive correlation (0.227) with grain yield. The positive grain yield was observed in case of seed per plant and days to maturity.

## 4. 5. Estimation of genetical parameter

Genetical parameter among yield contributing character are presented in Table 14.

### 4.5. 1. Plant height

The mean value of plant height showed significant difference among the genotypes. The maximum plant height was observed in G- 2(38) and minimum plant height in G-1 (31). The phenotypic co-efficient of variation and genotypic co-efficient of variation was more or less similar. The moderate heritability and genetic advance indicated that this character might be under taken into plant height consideration while selection a suitable line or genotypes. Gangele and Rao (2005) showed high heritability with moderate genetic advance in case of plant height.

### 4. 5. 2. Days to 50% flowering

The mean value of days to 50% flowering showed significant difference among the genotypes. The maximum were observed in G-7(98) and minimum days to 50% flowering in G-9 (63). The phenotypic and genotypic coefficient of variation was more or less similar. The high heritability and genetic advance indicate that selection might be judicious for this trait. Bicer and Sakar (2005) detected higher heritability for number of days to 50% flowering.

### 4. 5. 3. Days to maturity

The maximum value was observed in G-4 (108) and minimum days to maturity in G-15 (94). The difference between PCV and GCV was considerably high indicating prominent influence of environment on the trait. The high heritability with genetic advance provided opportunity for selecting high valued genotypes for breeding programs. Kishore and Gupta (2002) observed that heritability was high for days to maturity

### 4. 5. 4. Number of flower per peduncle

Significant difference was observed among the genotypes for this character ranging from 1.63 to 2.75. The GCV and PCV value close to each other. The low heritability with low genetic advance in percent of mean indicate this character might be under taken into consideration while selection a suitable line.

**Table 14. Estimation of statistical and genetical parameter of yield contributing character of lentil**

| Parameter | PH | DF | DM | NFPP | PP | SPP | 100 Seed Weight | Yield per plant |
|---|---|---|---|---|---|---|---|---|
| **Mean** | 35.19 | 65.99 | 98.35 | 2.00 | 97.76 | 179 | 2.69 | 5.18 |
| **Range** | 31-38 | 63-98 | 94-108 | 1.63-2.75 | 76-118 | 155.75 - 198.97 | 1.25-1.47 | 3.09-5.93 |
| **MS** | 11.54** | 29.47** | 62.58 | 0.34** | 28.63** | 31.43 | 0.024 | 0.53 |
| $\delta^2p$ | 5.37 | 11.36 | 22.35 | 0.22 | 10.9 | 31.35 | 0.02 | 0.45 |
| $\delta^2g$ | 3.08 | 3.37 | 20.12 | 0.05 | 9.26 | 0.44 | 0.002 | .04 |
| $\delta^2c$ | 2.29 | 2.30 | 2.23 | 0.179 | 8.3 | 3.13 | 0.18 | 0.412 |
| **Heritability** | 57.36 | 79.75 | 90.02 | 22.73 | 91.78 | 0.14 | 10 | 8.89 |
| **GA** | 2.74 | 5.53 | 8.77 | 22 | 1.9 | 5.10 | 0.412 | 12.93 |
| **GCV** | 4.97 | 4.56 | 4.57 | 11.5 | 9.86 | 0.37 | 1.49 | 3.86 |
| **PCV** | 6.59 | 5.11 | 4.81 | 23.5 | 10.28 | 9.89 | 0.74 | 12.93 |
| **ECV** | 4.26 | 2.27 | 1.53 | 21 | 2.95 | 0.95 | 1.83 | 12.36 |

NB
** 1% level of significant, * 5% level of significant
MS = Mean Square, $\delta^2p$ = Phenotypic Variance, $\delta^2g$ = Genotypic Variance, $\delta^2c$ =Environmental Variance, GCV = Genotypic co- efficient of variation, PCV = Phenotypic co efficient of variation, ECV = Environmental co- efficient of variation, GA= Genetic advance

### 4. 5. 5. Pod per plant

Significant difference among the genotypes was observed for pod per plant. The GCV and PCV value differ to each other. The high heritability with low genetic advance indicates this character might be under taken into consideration while selection a suitable line.

### 4. 5. 6. Seed per plant

The highest mean value of seed per plant was observed G-14 (199) and lowest in G -10(156). The GCV and PCV value differ to each other. The low heritability indicates this character might be under taken into consideration while selection a suitable line.

### 4. 5. 7. Hundreds seed weight

The highest mean value of hundreds seed weight was observed G-1, G-14, G-22 (1.47) and lowest in G-5 (1.25). Least difference was observed between PCV and GCV value. The low heritability with low genetic advance indicates this character might be under taken into consideration while selection a suitable line.

### 4. 5. 8. Yield per plant

The highest mean value of yield per plant was observed G-29 (3g) and lowest in G -24(6g). Least difference was observed between PCV and GCV value. The low heritability indicates this character might be under taken into consideration while selection a suitable line.

Considering pods per plant, seeds per plant, Seed yield, 100 seed weight, days to maturity and number of flower per peduncle, 6 genotypes vis., BARI

ILL 6284 (G-9), BARI ILL 5105 (G-14), BARI 8406-129 (G-24), BARI ILX 87039 XL5 (G-15), BARI ILL 95052 (G-22), BINA mosure 1 (G-1) could also help for easy selection of suitable ones.

Significant variation was observed among the genotypes tested. Considering genertic parameter high genotypic co- efficient of variation value was observed pod per plant, plant height, days to 50% flowering, days to maturity. High heritability with high genetic advance was obtained from pod per plant, days to maturity, days to 50% flowering. Correlation study reveled positive association of yield per plant with all the character except 100 seed weight, seed per plant, and pod per plant. Significant and positive correlation were observed in days to maturity, seed per plant. Path analysis indicated higher number of days to maturity, 100 seed weight higher direct effect on grain yield. Days to 50% flowering, number of flower per peduncle, seed per plant had positive but indirect effect on grain yield.

Considering high heritability with high genetic advance G-27, G-9, G-4, G-15, G-1and C-2 and considering significant and positive correlation G-14 could be chosen for general cultivation or as parent in future breeding program.

# CHAPTER V

# SUMMARY AND CONCLUSION

# 5.SUMMARY AND CONCLUSION

Lentil is the second most important pulse crop in area and production, in Bangladesh but stand first in the consumer preference in this country. It is an established fact that genetically diverse parents with favurable characters are likes to contribute desirable segregates and/ or to produce high heterotic crosses. Morphological marker of lentil can utilize for improvement of this crop. In Bangladesh, information about the availability of genetic variation, morphological characters and phenotypic marker identification in lentil germplasm is scanty. Therefore, the germplasm of lentil have been critically analyzed with the following objectives

- Study of morphological and yield contributing characters
- Classification of germplasm on the basis of physical/ morphological markers.
- To determine the character association and contribution of character toward grain yield in the genotypes

Field experiment was conducted at the central research farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2006 to March 2007. A total of 31 genotypes of lentil collected from Bangladesh Agricultural Research Institute (BARI), pulse research center and Bangladesh Institute of Nuclear Agriculture (BINA) were used for this experiment. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The out come of the investigation is summarized as under:

**Study of morphological and yield contributing characters**

Analysis of variance revealed highly significant variation present among the lentil genotypes. Existing of significant level of variation present in the germplasm indicated that the possibility of improving genetic yield of these material. Out of 31 genotypes, 15 genotypes were broad leaflet and rest 16 had narrow leaflet. Fifteen genotypes showed prostrate type growth habit and sixteen genotypes showed erect type.

G-1 (31 cm) and G-2 (38cm) exhibited maximum and minimum plant height. The heighest days to 50% flowering was observed from G-27 (98 days) and the lowest in G-9 (63) days. Number of flower per peduncle ranged from 1.63 (G-9) to 2.75 (G-13). The heighest pod per plant was observed in G-9 (118) and the lowest in G-11 (76). The number of seed per plant ranged from 199 (G-14) to 156 (G-10). The number of seed per plant ranged from 199(G-14) to 156 (G-10). The maximum, 100 seed weight was observed in G-1, G-14, G-22 (1.47g) and minimum in G-5 (1.25g). The heighest days to maturity was observed in G-4 (108 days) and the lowest in G-15 (94days). The seed yield per plant ranged from 6.0g (G-24) to 3.9g (G-29). G-1, G-9 and G-24 have high value for 100 seed weight; plant height, pod per plant, early 50% flowering and seed yield per plant. For this causes G-1, G-9 and G-24, might be considered as a prospective one for commercial cultivation as well as prospective parent in future breeding programmed.

Considering pods per plant, seeds per plant, seed yield, 100 seed weight, days to maturity and number of flower per peduncle, BARI ILL 6284 (G-9), BARI ILL 5105 (G-14), BARI 8406-129 (G-24), BARI ILX 87039 XL5 (G-15), BARI ILL 95052 (G-22), BINA mosure 1 (G-1) could be chosen for general cultivation or as parent in future breeding program

**Classification of germplasm on the basis of physical /morphological markers**

Out of 31 genotypes, 22 genotypes had showed leaf pubescence and 9 genotypes had no pubescence. Tendril formation was observed in 18 genotypes and 13 genotypes had no tendril. Both leaf pubescence and tendril formation was observed in 11 genotypes, only leaf pubescences were in 11 genotypes, only tendril was in 7 genotypes and no leaf pubescence and tendril formation was observed in two genotypes. Eighteen genotypes showed leaf pigmentation and 13 had no leaf pigmentation. Stem pigmentation was observed in 22 genotypes and no pigmentation was observed in 9 genotypes. Pod pigmentation was observed in 9 genotypes and 22 genotypes had no pod pigmentation. No correlation was observed in case of leaf, stem and pod pigmentation. On the basis of seed coat colour, all the genotypes were classified into four colour groups. Among this genotype G-1 showed black and G-7 showed brownish seed coat colour. Six genotypes showed dark brown and rest 23 showed light brown seed coat colour. Maximum 17 genotypes were grouped into non-mottled and 14 were grouped into mottled testa pattern. On the basis of cotyledone colour, all the genotypes were classified into five different groups. Maximum 11 genotypes showed yellow cotyledone colour and minimum one genotype (G-24) showed red cotyledone colour. Seven genotypes showed brown and similarly another seven genotyps showed orange cotyledone colour. Rest five genotypes showed green cotyledone colour.

**To determine the character association and contribution of character toward grain yield in the genotypes**

Significant variation was observed among the genotypes tested. Considering genertic parameter high genotypic co- efficient of variation value was observed pod per plant, plant height, days to 50% flowering, days to maturity. High heritability with high genetic advance was obtained from pod per plant, days to maturity, days to 50% flowering. Correlation study reveled positive association of yield per plant with all the character except 100 seed weight, seed per plant, and pod per plant. Significant and positive correlation were observed in days to maturity, seed per plant. Path analysis indicated higher number of days to maturity, 100 seed weight higher direct effect on grain yield. Days to 50% flowering, number of flower per peduncle, seed per plant had positive but indirect effect on grain yield.

Considering high heritability with high genetic advance G-27, G-9, G-4, G-15, G-1and C-2 and considering significant and positive correlation G-14 could be chosen for general cultivation or as parent in future breeding program.

Both phenotypic and genotypic variance was high in case of plant height, number of flower per peduncle and pod per plant. Least difference between genotypic and phenotypic coefficient of variation was observed in days to maturity, pod per plant, 100 seed weight, indicating that there were less environmental influence, which might be due to their genetic control. Relatively high genotypic coefficient of variation was observed in number of flower per peduncle; seed per plant and seed yield per plant. High heritability was observed in pod per plant (91.78%) days to maturity (90.02%) days to 50% flowering (79.75%) and plant height (57.36%).

Although high heritability estimates were found to be helpful in making selection of superior genotypes on the basis of phenotypic performance, Heritability estimates along with genetic advance would be useful in predicting the best individual. High heritability with high genetic advance was observed in days to 50% flowering, days to maturity, moderate heritability with moderate genetic advance was observed in plant height, indicating the effect of additive gene action for the experession of the above character. Improvement of such type traits might be fruitful in future programme.

The high heritability estimates with low genetic advance indicated that non-additive type of gene action and genotype X environment interaction played a significant role in the experation of the traits as observed in pod per plant. The low heritability estimates with low genetic advance was observed in number of flower per peduncle, hundred seed weight, seed per plant, seed yield per plant.

Grain yield significantly and positively correlated with the days to maturity, days to 50% flowering. So selection on the basis of these characters should get preference for selection of parental line for further breeding programe. The result of path coefficient analysis in yield contributing traits that hundreds seed weight (0.333) was the highest direct effect on grain yield followed by days to 50% flowering (0.271), number of flower per peduncle (0.247), seeds per plant (0.227), on the other hand pod per plant showed negative direct effect on grain yield.

# REFERENCES

## 6. REFERENCES


Adhikari, G. and Pandey, M. P. (1983). Genetic divergence in chickpea. *Indian.J Genet*. 43(2): 188-192.

Anderson, E. (1957). A semi graphical method for the analysis of complex problems. *Proc. Nat. Acad. Sci.* 43: 923-927.

Arunachalam, V. (1981). Heterosis for character governed by two genes in relation genetic divergence and specific combining ability in groundnut (*Arachis hypogaea* L.). *Euphytica*. 33: 33-39.

BBS (Bangladesh Bureau of Statistic). (2002). Year book of Agricultural Statistic Bangladesh. Statistic Division, Ministry of Planning, Government of Bangladesh.

Bicer, B. T. and Sarkar, D. (2004). Genetic variability for grain yield and other characters in lentil. *J. of Biological Sci.* 4(2): 216-218.

Broich, S. L. and Palmer, R. G. (1980). A cluster analysis of wild and domestic soybean phenotypes. *Euphytica.* 29: 23-32.

Chauhan, M. P., Ram, N. and Srivastava, R. K. (2005). Classification on genetic diversity in Indian lentil germplasm. *Legume Res*. 28(2): 125-127.

Chauhan, S. (1968). Variability in gram. *Indian J. Genet.* 28(2): 205-210.

Das, P. K. and Gupta, T. D. (1984). Multivariate analysis in blackgram. *Indian J. Genet.* 44 (2): 243-247.

Das, P. K. (1978). Genetic estimates, correlation, path coefficients and the implication of discriminant function on selection in blackgram *(Phaseolus vulgaris* L.*) Indian Agric.* 22(4): 227-236.

Dixit, R. K. (1980). Genetic divergence for yield and its components in lentil. *Indian Agric. Sci.* 50(3): 22-224

Dumber, A. D. and Deshmukh, R. B. (1983). Analysis of genetic variability in cowpea. *J. Maharashtra Agric.* 8(1): 85.

Ezzat, Z. M., Shaboan, M., and Hamid, A. (2005). Effect of plant density on the performance of four new released lentil varieties. *Egyption. J. of Agric. Res.* 83(1): 167-176.

Ezzat, Z. M., Ashmawy, B. F. and Marsy, S. M. (2005). Evalution of some lentil genotypes for earliness, yield components and seed quality. *Egyption J. of Agric. Res*. 83(1): 167-176.

FAO. Yearbook of production. (2004). 6(1): 14

Gangele, N. K. and Rao, S. K. (2005). Heritability and genetic advance for yield and its components in lentil. *JNKVV Res. J.* 39(1): 43-46.

Ghahramanzadeh, R., Bagheri, A. and Nezami, A. (2005). Evaluation of genetic variation and phylogenic relationships among lentil accession using morphological trait and RAPD analysis. *Agri. Sci and Tech.* 19(2): 207-216.

Griffin, B. and Lindstorm, E. W. (1994). A study of combining abilities of corn inbreeds having varying proportions of corn belt and non-corn belt germplasm. *Agron. J.* 46: 545-552.

Gupta, K. K., Tejbir, S. and Tomar, R. S. (2006). Genotype x environment interaction for yield and yield contributing characters in lentil (*Lens culinaris* Medik). *Advances in Plant Sci.* 19(1): 57-262.

Gupat, M. P. and Singh, R. B. (1969). Variability and correlation studies in green gram, *Phaseolus aureus Roxb. Indian J. Agric. Sci.* 39 (6): 482-493.

Haddad, M. I. (2004). Evaluation of variation for morphological and agronomic traits in lentil (*Lens culinaris* Medik). *Dirasat Agric. Sci.* 31(3): 363-371.

Hamdi, A., Shafey, S. A. and Ibrahim, M. A. M. (2003). Direct and indirect relationships among lentil characters. *Egyptian J. of Agric. Res.* 81(1): 139-150.

Heeramath, K. G. and Talwar, S. N. (1971). A study of genetic variability in pigeon pea. *Audhra Agric. J.* 18(3-4): 144-148.

Hoque, M. E., Mishra, S. K., Yogesh, K., Rajesh. K., Tomar, S. M. S. and Sharma, B. (2002). Inheritance and linkage of leaf colour and plant pubescence in lentil (*Lens culinaris* Medik.). *Indian J. of Gen. and Plant Breeding.* 62(2): 140-142.

ICARDA. (2004). Research for the poor: a successful partnership with NARS in Bangladesh. ICARDA annual report 2003. ICARDA, *Aleppo syria.* pp : 28-30.

Joshi, A. H. and Dhnawan, M. V. (1966). Genetic improvment of yield with special reference to self-fertilizing crop. *Indian J. Argil. Set* 2(A): 101-113.

Kishore, N. and Gupta, V. P. (2002). Early generation selection in microsperma-macrosperma derived gene pool of lentil. *Indian J. of Genetics and Plant-Breeding.* 62(1): 34-37.

Lazaro, A., Rosa, L. D. L. and Martin. (2001). Relationship between agro/morphological characters and climate parameters in Spanish landraces of lentil *(Lens culinaris* Medik.). *Genetic Res. and Crop Evaluation.* 48(3): 239-249.

Malhotra, V. V., Singh, R. S. and Singh, K. B. (1974). Releation between geographic diversity and genetic divergence and the relative role of each character toward maximizing divergence in green gram. *Indian J. Agric. Sci.* 44(12): 811-815.

Malik, B. A., Hossain, S. A., Haqqani, A. M. and Chowdhary, A. H. (1983). Genetic variability in mungbean (*Vigna radiata*). *Pakistan J. Agric. Res.* 4(3): 171-173.

Malik, B. A., Hossain S. A., Haqqani, A. M. and Chowdhary, A. H. (1984). Genetic variability in mungbean *(Vigna radiata). Pakistan. J. Agric. Res.* 4(3): 171-173.

Malik, B. A., Tahir, M. and Zubair, M. (1985). Genetic divergence for morphological characters in *Vigna radiata L. Wilczek. Pakistan J. Sci Res.* 28(2): 123-125.

Mershell, I. F. and Abbas, E. E. (2006). Morphological and technological studies on some lentil (*Lens culinaris* Medik.) genotypes. *Analysis of Agric. Sci.* 44(1): 101-110.

Mia, M. W., Mian, M. A. K. and Rahman, M. M. (1986 ). Perfermance of exotic lentil germplasm in Bangladesh. *Lens Newsletter*. 13 (2): 12-13.

Mishra, R. M., Kouth, G. K. and Bilaiya, S. K. (1987). $D^2$ and metroglyph analysis in soyabean. *J. Oilseeds Res.* 4(1): 103-107.

Muchlbauer, E. J. (1974). Seed yield component in lentils. *Crop Sci.* 14 (May-June): 403-405.

MOA (Ministry of Agriculture). 2002. Agricultural statistic of Bangladesh. Sector Monitoring Unit. Dhaka, Bangladesh.

Nandan, R. and Pandey, B. P. (1980). Correlation, path coefficient and selection indices in lentil. *Indian J. Genet.* 40(2): 399-404.

Natrajan, M. and Palanisamy, S. (1990). Genetic divergence released heterosis based on dry matter components in mungbean. *Indian J. Genet.* 50(3): 248-252.

Neha, J., Sarvjeet, S. and Inderjit, S. (2005). Variability and association studies in lentil. *Indian J. of Pulse Res.* 18(2): 144-146.

Nevo, E., Golenbarg, E., Beilies, A., Brown, A. H. D., and Zohary, D. (1982). Genetic diversity and environmental associations of wild wheat in Israel. *Theor. Appl. Genet.* 62: 241-254.

Rao, C. R. (1952). Advance statistical methods in biometrical research. John Wiley and Sons. *Inc Newyork*

Reddy, V. R. G., Singh, B. N. and and Rai, B. (1987). Analysis of genetic divergence in spreading varieties of groundnut. *Crop Improvement.* 14(2): 149-152.

Sagar, P., Chandra, S. and Arora, N. D. (1976). Analysis of diversity in some urdbean (*Phaseolus mungo* L.) cultivars. *Indian J. Agric. Res.* 10(2): 73-78.

Shahi, J. P., Singh, J., Indu, A. and Lal, M. S. (1986). Studied on variability for seed size, permeability of seed to water and germination in lentil. *Lens Newsletter.* 13(2): 14-15.

Shanmugam, A. S. and Rangasamy, S. R. S. (1982). Multivariate Analysis of genetic divergence in blackgram [*Vigna mungo* (L) Hepper]. *Madras Agric. J.* 69(11): 701-706.

Sharma, P. C. and Luthra, S. K. (1987). Genetic divergence in lentil (*Lens culinaris* Medik.). *Genet. Agric.* 41(4): 349-359.

Sindu, J. S., Ahmed, S., Singh, M. B. and Singh, K. P. (1989). Multivariate analysis in blackgram (*Vigna mungo* L). Legume Research. 12(1): 35-37.

Singh, A. K. and Mishra, M. K. (1983). Genetic variability and quantitative traits of rabi urd (*Vigna mungo*). *Agric. Sci. Digest.* 3(3-4): 187-189.

Singh, G., Singh, I. S. and Rajendra, K. (2004). Genetic variability for seed yield and its component characters in a macrosperama x microsperama cross of lentil (lens culinaris Medik.). *Crop Improvement.* 31(2): 206-209.

Singh, H. N., Srivastava, J. P. and Sing S. P. (1973). Genetic variability and heritability in table pea (*Pisum sativum* L.). *Progressive Horticulture.* 4(3-4): 79-86.

Singh, K. and Ram, H. H. (1985). Genetic divergence in new breeding lines of soyabean. *Indian j. Genet.* 45(3): 531-538.

Singh, K. B. and Singh, S. (1969). Genetic variability and interrelationship studies on yield and other quantitative characters in Lentil (*Lens culinaris* Medik.). *Indian J. Agric. Sci.* 39(7): 737-741.

Singh, V. and Singh F. (1989). Genetic diversity and stability in chickpea. *Indian j. Genet.* 49(3): 349-353.

Sinha, R. P. and Chowdhary, S. K. (1984). Variability in lentil germplasm. *Lens Newsletter* (ICARDA). 11(1): 13-15.

Swarp, I. and Lal, M. S. (1987). Performance of bold seeded lentil in Madhya Pradesh. *Lens Newsletter* (ICARDA). 14(1): 10-11.

Stoilova, T. and Pereira, M. G. (1999). Morphological characterization of 120 lentil (*Lens culinaris* Medik.) accessions. *Lens newsletter.* 26(1/2): 7-9.

Tayyaba, S., Ghafoor, A. and Asraf, M. (2005). Genetic divergence in lentil germplasm for botanical description in relation with geographic origin. *Pakistan J. of Botany.* 37(1): 61-69.

Tejbir, S. and Gupta, K. K. (2005). Character association analysis in lentil (*Lens culinaris* Medik.). *Plant Archives.* 5(1): 261-264.

Tiwari, A. S. and Singh, B. P. (1980). Evaluation of lentil germplasm, *Lens culinaris* Medik. 7: 20-22.

Todorov, Y. (1980). Variability and correlation of some characters in lentil. *Gentika Selecktsiya.* 13(1): 37-49.

Tomooka, N. (1991). Genetic diversity and landrace differentiation of mungbean, *vigna radiata*(L) Wilczek, and evalution of its wild relatives (The subgenus Ceratotropics) as breeding matrials. Tech. Bull. Trop. Res, Center, Japan. No 28 Ministry of Agri, Forestry and Fisheries, Japan. p. 1.

Tullu, A., Kusmenoglu, I., Mcphee, K. E. and Muehlbauer, F. J. (2001). Characterization of core collection of lentile germplasm for phenology, morphology, seed and straw yields. Genetic Resources and Crop Evalyation. 48(2): 143-152.

Venora, G., Grillo, O., Shahin, M. A. and Symons, S. J. (2007). Identification of sicilian landraces and andean cultivars of lentil using an image analysis system. *Food Res International.* 0(1): 161-166.

Yohe, J. M., Pochlman. (1972).Genetic variability in the mungbean, *Vigna radiata* (L). *Wilczek. Crop Sci.* 12: 236-332.

Yadav, S. S., Phogat, D. S., Solanki, I. S., Malik, B. P. S., (2002). Impact of different environments on genetic variation in lentil. *Indian Journal of Pulse Res.* 15(2): 181-182.

# APPENDICES

# APPENDICES

**Appendix I. Morphological physical and chemical characteristics of initial soil (0 –15cm depth).**

**I. A. Physical composition of the soil**

| Soil separate | % | Methods employed |
|---|---|---|
| Sand | 36.90 | Hydrometer method (Days, 1915) |
| Silt | 26.40 | Do |
| Clay | 36.66 | Do |
| Texture class | clay loam | Do |

**I. B. Chemical composition of the soil**

| Sl. No. | Soil Characteristics | Analytical Data | Methods employed |
|---|---|---|---|
| 1 | Organic Carbone (%) | 0.82 | Walkey and Black, 1947 |
| 2 | Total N (kg/ha) | 1790.00 | Bremner and Mulvaney, 1965 |
| 3 | Total S (ppm) | 225.00 | Bardsley and Lanester, 1965 |
| 4 | Total P (ppm) | 840.00 | Olsen and Sommers, 1982 |
| 5 | Available P (kg/ha) | 54.00 | Bremner,1965 |
| 6 | Available K (kg/ha) | 69.00 | Olsen and Dean, 1965 |
| 7 | Exchangable K (kg/ha) | 89.00 | Pratt, 1965 |
| 8 | Available S (ppm) | 16.00 | Hunter, 1984 |
| 9 | ph (1: 2.5 soil to water) | 5.55 | Jacson, 1958 |
| 10 | CEC | 11.23 | Champan,1965 |

**Appendix II. Monthly average temperature, relative humidity, total rainfall and sunshine hours of the experiment site during the period from October 2005 to February 2006**

| Year | Month | Air temperature | | | Relative humidity (%) | Rainfall (mm) | Sunshine (hr) |
|---|---|---|---|---|---|---|---|
| | | Max | Min | Mean | | | |
| 2005 | October | 30.6 | 24.6 | 27.60 | 77 | 326 | 142.20 |
| | November | 29.1 | 19.8 | 24.45 | 70 | 03 | 197.63 |
| | December | 27.1 | 15.7 | 21.4 | 64 | Trace | 217.03 |
| 2006 | January | 25.3 | 18.2 | 21.75 | 68 | 0 | 165.10 |
| | February | 31.3 | 19.4 | 25.35 | 61 | 0 | 171.01 |

Source: Bangladesh Metrological Department (climate division), Agargaon. Dhaka-1207.