PHENOTYPIC SCREENING OF LISIANTHUS (*Eustoma grandiflorum*) LINES FOR PRODUCTION IN BANGLADESH

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PHENOTYPIC SCREENING OF LISIANTHUS (*Eustoma grandiflorum*) LINES FOR COMMERCIAL PRODUCTION IN BANGLADESH

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Most surely in the creation of the heavens and the earth and the alternation of the night and the day there are signs for men who understand.

(Surah Al Zumar 3:190)

DEDICATED TO-

MY BELOVED PARENTS

To whom I owe every fiber of my being

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CERTIFICATE

This is to certify that the thesis entitled ***"PHENOTYPIC SCREENING OF LISIANTHUS (Eustoma grandiflorum) LINES FOR COMMERCIAL PRODUCTION IN BANGLADESH"*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* ***HASIB AHMAD****, Registration No.* ***10-04065*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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- Author

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ABSTRACT

An experiment was accomplished in the Horticulture farm of Sher-e-Bangla Agricultural University during the period of April to October, 2016 to screen some lisianthus lines for production in Bangladesh. Fifteen lisianthus lines *viz*. L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee and L_{15}= Nandini Lavender was used in this experiment arranged in a Randomized Complete Block Design with three replications. Data on different growth and flowering parameters were taken to which all the lines showed significant variations. The flower color being the primary characteristics was given importance and their accurate determination was done using the Cartesian co-ordinates in CIELab color space. Based on the performances, the lines were ranked and L_9 was found to be the highest ranking although all the lines performed well as standard cut flowers which were classified into different groups based on their flower characteristics, behavior and their vase life. These findings may be a source of valuable information for further development of this promising cut flower in Bangladesh.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

ABBREVIATIONS AND ACCORONYMS

AEZ	=	Agro-ecological Zone
Agric.	=	Agricultural
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
Biol.	=	Biology
CV	=	Coefficient Variance
DAT	=	Days after Transplanting
EPB	=	Export Promotion Bureau
et al.	=	And others
GDP	=	Gross Domestic Product
Hort.	=	Horticulture
i.e.	=	That is
J.	=	Journal
LSD	=	Least Significance difference
mm	=	Millimeter
RCBD	=	Randomized Complete Blocked Design
Res.	=	Research
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
Technol.	=	Technology
UPOV	=	Union of Protection of Plant Varieties
Viz.	=	Namely

CHAPTER I

INTRODUCTION

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Lisianthus (*Eustoma grandiflorum* Grise, Bengali name- Nandini) belongs to the family Gentianaceae is an ornamental cut flower native to the southern parts of United States (Popa *et al*., 2004) particularly to the eastern slope of Rocky Mountains, USA where it is known as the prairies gentian ((Halevy and Kofranek, 1984). It is also known as Eustoma, Texas Blue bell, Tulip gentian etc. *Eustoma* is named after the two Greek words Eu (beautiful, good, well), and stoma (mouth). It is a moderately cold-tolerant annual or biennial plant (Roh and Lawson, 1988). It is a slow growing plant, requiring 5 to 6 months from sowing to flowering (Uddin *et al*., 2004).

The plant grows to 15 - 60 cm tall, with bluish green, slightly succulent leaves, mature rapidly, and produce beautiful funnel shaped flowers growing on long straight stems. Moreover, Lisianthus are long lasting flowers with four wide ruffled and delicate petals of oval shape. Modern cultivars offer a wide range of color including purple, rose, pink, white and a variety of bicolor. The petals of single flowers are large and rounded with only a fuse at the base. The petals are often yellow inside close to the mouth of the flower. Some varieties have double or semi double flowers that gives the impression of rose. Growth and quality of lisianthus are variety specific and they grow well at pH 6.3 to 6.7 (Harbaugh and Woltz, 1991). Ideal temperature range is 15^0 to 25^0C though it can withstand higher temperatures. Plants show rosetting if temperature goes too high during seedling up to 3 pairs of leaves (Harbaugh *et al.* 1992). Heavy watering maintains plant quality under high light intensity and temperature (Brian and Katz, 1997). Furthermore, the flowers have a good post-harvest life of generally 12-25 days (Uddin *et al.* 2013).

Floriculture has emerged as a lucrative agribusiness venture in the world particularly in the developing countries including Bangladesh which ensures higher potential income compared to other agricultural crops. Cut flower production has brought a dramatic increase in farmer’s income in Bangladesh particularly in the Jessor district. Flower trading worth of 50-60 million TK has been recorded at Godkhali flower market, Jhikargacha, Jessor simply on the occasion of spring festival and valentine day in recent years. So, it is a testimony of booming flower market in Bangladesh that is now contributing to our national GDP growth as well as employment generation in Bangladesh. At present flower cultivation has been adopted commercially in 20 districts out 64 of our country and a population of 2-3 lacs is directly or indirectly involved in this sector.

Flowers have an enormous international demand which creates huge opportunity for Bangladesh. The flower market in Bangladesh started to expand significantly from 2000 onward with rapid urbanization and cultural proliferation with new festivals like Valentine’s Day, 1st falgun etc. Bangladesh exported cut flowers and foliage worth of 4.71 million US dollar during the fiscal year 2015-16 (EPB report, 2015). The annual turnover in the wholesale market is more than Tk. 1 billion and in retail it is about Tk. 2 billion (Hussain & Anwar, 2011). Bangladesh has a favorable climatic condition for flower cultivation that has a good market prospect resulting vast area of agricultural land included in its production (Wittstock and Quinto, 2008). To target the export orientation of this sector, improvement as well as including new and high demand cut flowers is a must now. To achieve this target, lisianthus can play a major role with its commendatory position in the international demand scale.

Lisianthus is becoming one of the most highly ranked cut flowers in the international market due to its rose like flowers, excellent post-harvest life (Kunitake *et al.,* 1995) and diverse color. It is a prominent cut flower from Japan where it has been in cultivation since 1960 (Ohkawa and Sasaki, 1996). It gained importance on account of a variety of cultivars developed with respect to many traits like uniform flowering throughout the year, lack of rossetting, heat tolerance, flower colour, flower size (Hecht *et al.*, 1994) and form including double flower etc. (Toa, 2006). For this reason, Cut flower production of lisianthus has risen enormously all over the world and commercial varieties of Lisianthus have been intensively developed in Japan (Halevy and Kofranek, 1984). Within the last 10 years, lisianthus have been the fastest growing segment of new flower category worldwide.

Lisianthus is a newcomer in Bangladesh that has the advantage of striking bloom with great appeal. Due to its extended stem, long vase life and diverse flower color it should take a good demand in Bangladesh. In the commercial flower business, this flower is known as “Eustoma” that is only found in few flower shop in Bangladesh at a very high price. As a result, this flower is not available to the people of all levels. If production of lisianthus can be started in Bangladesh, it will be available in flower market for the consumers in our country as well as farmers can easily get economic benefit by local market production along with export in international market.

Considering the above circumstances, the study was undertaken with following characteristics:

i. to compare different lines of Lisianthus on the basis of growth and flowering characteristics;
ii. to screen out the suitable line(s) of Lisianthus for commercial production in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Floriculture is the most colorful sector of Horticulture which includes flowers, foliage, potted plants, ornamentals and greens. The present floriculture industry in Bangladesh is a new dimension. With urbanization and increase in disposable income level, the demand of floriculture products is increasing day by day in Bangladesh. Gebera, Rose, Tuberose, Orchid, Marigold, Lilium etc are among the most demandable flowers in Bangladesh. But the demand for new and more lucrative flower types and varieties are of present concern for sustainability and development of the flower industry that will lead to the export orientation approach. In that sense, Lisianthus can meet this demand through its wide range of colors and export potentiality. With this view in mind, the present research work was conducted to screen out suitable varieties of lisianthus through phenotypic characterization. Some important research works related to lisianthus that have been conducted so far have been presented here according to year in a descending order.

Uddin *et al.*, (2015a) conducted a study at roof top net house, Department of Horticulture, Sher-e Bangla Agricultural University, Dhaka, under 2a biotech lab, 2014 to October, 2014 to find out the growth, flowering and morphological attributes of Nandini (*Eustoma grandifolium*) varieties. Eight varieties of Nandini (*Eustoma grandiflorum*) namely, V_1, Mickey rose; V_2, Pink rose (single); V_3, Pink picotee; V_4, Blue rim; V_5, Chandra; V_6, Pink rose (double); V_7, Blue bell and V_8, Royal violet were used in this experiment. Maximum plant height (58.9 cm), number of stem (7.4), stem length (45.7 cm), number of leaves (22.0), days to first flower (113.0), flower head diameter (7.1 cm), number of petal (11.3), number of flower/stem (7.2) was found in V_6. Maximum stem diameter, number of bud and flower/plant (5.0 mm, 20.3 & 20.1 respectively) was observed in V_5. Minimum plant height, number of stem & stem length was observed in V_3 (40.1 cm, 2.9, & 24.3 cm respectively). Minimum stem diameter (1.7 mm), days to first flower (78.0), number of bud/plant (10) and flower/plant (7.3) was observed in V_7 whereas minimum number of leaves (4.7), flower length (3.4), flower head diameter (3.3) was observed in V_1, V_6, and V_5

respectively. So, growth and yield characters showed significant variation among different varieties.

An experiment was conducted to evaluate the growth and flowering performance of chrysanthemum cultivars. Thirty two chrysanthemum cultivars coded from V_1 to V_{32} were used in the experiment. Plant height, number of branch per plant, leaf area, number of leaf per branch, chlorophyll content, days to flower bud initiation, days to first petal spread, days to final bloom, number of flower bud per plant, number of flower per branch, number of flower per plant, bud diameter at initiation stage, bud diameter at mature stage, flower head diameter, stalk length and flower durability in plant (days to 50% flower senescence) for different cultivars varied significantly. Number of flowers per plant ranged from 4.3 to 194.6, flower head diameters varied from 2.8 to 17.6 cm and stalk lengths were from 4.4 to 20.1 cm. Amongst the chrysanthemum cultivars V_{15} (BARI chrysanthemum-1) was the maximum flower producing cultivar, while V_1 produced the largest flowers and flowers from the V_{21} had the longest shelf-life (Uddin *et al.* 2015b).

Shahrin *et al.* (2015) conducted an experiment to evaluate the performance of rose cultivars and their categorization based on color, fragrance and use. Field experiment included forty four rose cultivars coded from V_1 to V_{44}. It was found that all rose cultivars varied significantly for the studied characters. Considering the characteristics of the rose cultivars maximum number of shoot was found from V_{36} (42.0/plant) and minimum from V_1, V_{13}, V_{33}, V_{39}, V_{42} (4.0/plant). Maximum number of leaves was found from V_{12} (7.0/10 cm shoot) and minimum from V_2, V_7, V_{10}, V_{11}, V_{17}, V_{21}, V_{30}, V_{32}, V_{33}, V_{34}, V_{35}, V_{42} (3.0/ 10 cm shoot). Maximum number of thorns was found in V_{20} (47/10 cm shoot) and minimum from V_4, V_{14}, V_{15}, V_{29}, V_{30}, V_{37}, V_{41}, V_{43} (0.3/ 10 cm shoot). Maximum leaf area was found from V_{25} (69.5 cm^2) and minimum from V_{42} (23.5 cm^2). Maximum chlorophyll content was found in V_{35} (68.9%) and minimum from V_{15} (35.0%). Maximum number of flowers was found in V_{43} (68.0/plant) and minimum from V_3, V_9, V_{13}, V_{21}, V_{22}, V_{25}, V_{33}, V_{39}, V_{42} (1.0/plant). Maximum number of petals was found in V_{30} (83.0/flower) and minimum from V_{44} (15.7/flower). Maximum days were taken to flower bud initiation found in V_6 (40.0

days) and minimum from V_7 (18.0 days). Maximum stem diameter was found from T_7 (4.60 mm) and minimum from T_0 (1.0 mm. According to the found results, V_3 (Tajmahal), V_4 (Yellow star), V_{14} (Lavender gold), V_{16} (Compassion), V_{21} (SAU hero), V_{23} (Yellow gold), V_{25} (Sleepy moon), V_{26} (Sweet doll), V_{30} (Chrysanthemum rose) and V_{35} (Sweet sakata) cultivars were found as the cut flowers and rest were pot/bedding flower.

Kim *et al.* (2014) conducted an analysis of genetic relationship among Korean native *Chrysanthemum* species through the morphological study of 15 taxa of *Chrysanthemum* species Principal component analysis (PCA) and cluster analysis were conducted for the grouping based on the morphological data. Fifteen taxa of *Chrysanthemum* species were classified into three groups through PCA and cluster analysis based on the general plant growth and flowering characteristics. Groups I and II included non-bushy type and big size flower plants, while Group III included bushy type and small size flower plants. Group I had nine *C. zawadskii* subspecies: *acutilobum*, *acutilobum* var. *tenuisectum*, *acutilobum* var. *alpinum*, *lucidum*, *coreanum*, *naktongense*, *yezoense*, *latilobum* and *latilobum* var. *leiophyllum*. Group I was found to be desirable species as garden plants because of the white or pink flowers with a relatively large size (flower head diameter of 43.5–67.6 mm), good plant height (19.3–64.6 cm), and long flowering period (24–39 d). *C. lineare* was the only species included in Group II with unique cone head shaped seeds and no petiole. Group III included five *C. indicum* species and related species: *C. indicum*, *C. indicum* var. *albescens*, *C. indicum* var. *acuta*, *C. boreale*, and *C. makinoi*. Group III had great potentials as edible medicinal resources e.g. chrysanthemum flower tea, which is abundant in number and has small sized flowers with white or yellow petals.

Tarannum and Naik (2014) conducted an experiment to evaluate the performance of eight different genotypes of carnation namely Dona, White Dona, Harish, Big Mama, Soto, Liber, Golem and Big Net. Among these genotypes, maximum plant height was found in Soto (111.13 cm) and minimum in Liber (56.96 cm). Maximum numbers of shoots/plant were found in Soto (6.80) and minimum in Big Net (4.60). Numbers of leaves/plant were found Soto (149.73) and minimum in Big Net (79.07). Maximum days were taken to flower bud initiation found in Big Mama (135.34) and minimum in Soto (95.16). Maximum flower diameter was found in Soto (5.86 cm) and minimum in Liber (4.70 cm).

An experiment was carried out to evaluate seven genotypes of chrysanthemum for flower quality traits at IIHR, Bengaluru from 2010-11 to 2012-13. Significantly wide variation was recorded in all floral traits. Results revealed that maximum number of flowers/plant (81.51) and flowering duration (43.14 days) were recorded in Anmol. Maximum plant height (47.25 cm) and flower diameter (5.03 cm) were recorded in Garden Beauty. However, maximum average weight of flower (2.59 g) and flower yield/plant (131.43 g) were recorded in Autumn Joy. The genotype Winter Queen recorded maximum number of sprays/plant (6.89). On the basis of three years observations, genotypes Winter Queen, Garden Beauty and Autumn Joy found promising for garden display (Kumar, 2014).

Wazir (2014) conducted an experiment to evaluate eustoma/lisianthus cultivars for assessing their suitability as prominent new cut flower crop under mid hill conditions of Himachal Pradesh. Four hybrid colour variants of cv. Echo double (Yellow, Lavender, Champagne and White), Flamenco Blue and Roshita Pink form Sakata Seeds, Japan and ten hybrid cultivars namely, Art Marine, Bolero Blue Picottee, Bolero White, Luna Rose, Gavotte Yellow, Nightingale, Papillon Pink Flash, Purple Flamingo, Shallot Green and Minuet Apricot Rose from Miyoshi seeds, Japan were evaluated for growth, flowering and vase life characters. The experiment revealed that cultivar Flamenco Blue having single flowers produced the maximum plant height (94.5 cm) followed by the cv. Purple Flamingo (88.5 cm). Minimum days to visible flower bud and flowering were reported in cv. Echo Double Lavender (142.5 days) and (170.4 days) whereas the cultivar Art Marine took maximum time to form visible flower buds (159.4 days) and also were the latest to flower (187.6 days). Maximum number of flower buds per plant were obtained in cvs Luna Rose (18.6) and Shallot Green (18.5). Cultivars Gavotte Yellow and Bolero White resulted in maximum flower size (9.2 and 9.0 cm respectively) owing to their double character whereas cv

Flamenco Blue had the smallest flower size (5.7 cm) because of its single petals. In case of single flowering cultivars, Flamenco Blue produced the tallest stems (85.5 cm) where as in case of double cultivars, tallest stems were produced by Purple Flamingo and Gavotte Yellow (75.5 and 74.5 cm respectively). Maximum vase life of 18.5 and 18.2 days was recorded with cvs Art Marine and Bolero white respectively.

Ranchana *et al*. (2014) conducted an experiment on ten varieties of roses such as Aloynica, Biyanka, Golden Gate, Grand Gala, Konfity, Noblesse, Passion, Polo, Skyline and Tropical Amazon. Maximum days were taken for sprouting found in Noblesse (46.17) and minimum in Passion (32.83). Maximum days were taken for flowering found in Noblesse (46.65) and minimum in Passion (36.35). Maximum numbers of petals/plant were found in Passsion (49.48) and minimum in Tropical Amazon (35.39). Maximum plant height was found in Passion (115.59 cm) and minimum in variety Aloynica (65.66 cm). Maximum stem length was found in Passion (85.59 cm) and minimum in Aloynica (52.63 cm). Maximum neck length was found in Passion (11.56 cm) and minimum in Konfity (5.31 cm). Maximum flower diameter was found in the Passion (6.66 cm) and minimum both in Biyanka and Tropical Amazon (4.32 cm).

Ramzan *et al.*, (2014) conducted a study at Department of Floriculture and Land Scape, NARC, Islamabad, Pakistan during May to July 2011. The objective of the study was to assess the performance of exotic cultivars of hybrid tea roses under agroclimatic conditions of Islamabad. Nineteen hybrid *viz.* Bara Bara, Abby De Culnry, Mamorial Day, Rough Royal, Saran Bepti, Pink Peace, Julias Rose, Signature, Cendrila, M. Murad, Double Delight, Elizabeth Harkness, Allice, Red, Barkroloe Baragla Marandi, Head Liner, Honey Perfume, Decent Peace, American Beauty and Jagua rose cultivars were studied and data was collected on number of branches per plant, plant height (cm), stalk length (cm), number of flowers per plant and flowering percentage per plot. The highest stalk length (24.6, 24 cm) was recorded in cultivars Double Delight and Signature. Maximum plant height (100 cm) was recorded in Jagua followed by Pink Peace and Honey Perfume (97 cm). While minimum plant height (67.33 cm) was noted in Abby De Culnry. Maximum number of flowers (52) was produced by cultivar Honey Perfume followed by Pink Peace (50) and Allice Red (34). Supreme flowering percentage (65%) was observed in cultivar Abby De Culnry followed by Julias Rose (60%) and Cendrila (52%). Results of the study suggest that Double Delight, Signature, Honey Perfume and Pink Peace performed better during hot months of May to July and these are best suited cultivars for further research work.

A pot experiment was conducted for the first time in Bangladesh, at the Horticulture Farm of Sher-e- Bangla Agricultural University, Dhaka during November, 2010 to July, 2011 to assess the adaptability of seven lisianthus (*Eustoma grandiflorum*) cultivars namely Micky Rose, Pink Rose, Azuma No Yosooi, Purple Edge Glass, Piccolo Blue, Mellow Purple and Royal Violet for commercial cultivation in Bangladesh. The experiment was conducted in a Randomized Complete Block Design with nine replications. Significant differences among cultivars were noted for all the attributes evaluated. The highest number of flowers (16.0/plant) was produced by Piccolo Blue and the lowest from Pink Rose (7.0/plant). All the cultivars in this study showed very good shelf life (12.0-25.0days) in normal condition. All the seven lisianthus cultivars performed satisfactorily as ideal cut flowers (Uddin *et al.* 2013).

Mahmood *et al.* (2013) conducted an experiment on ten gerbera cultivars ('Labinel', 'Lilla', 'Alp', 'Alberino', 'Bonnie', 'Avemaria', 'Mammut', 'Lexus', ''Terramixa ' & 'Sarolta') to evaluated their growth, yield and quality characteristics under protected conditions. Among the cultivars studied, there were highly significant variations observed for growth, yield and quality parameters. Longest stalk length (60.3 cm) was exhibited by the cultivar 'Alberino' followed by 'Lexus' (59.0) and 'Mammut' (54.0 cm). The same cultivar also produced flowers with maximum diameter. With respect to vegetative parameters like number of leaves per plant and plant spread were also more in the same cultivar. Maximum number of flowers 135 per square meters was recorded in cv. 'Avemaria' (135) followed by 'Alberino' (125). Maximum vase life was recorded in cultivars 'Alberino' and 'Lexus' (6.6) followed by 'Mammut' (5.6) and ''Sarolta'' (5.6). Excellent quality flowers were observed in cultivar 'Alberino'

(4.8) followed by ‘Lexus’ (4.4). Cultivar ‘Alberino’ and ‘Lexus’ were found superior with respect to growth, yield and vase-life characteristics under protected conditions.

Shruti and Gajbhiye (2013) evaluated thirteen varieties of gerbera namely Charmander, Dalma, Diablo, Francella, Goldengate, Goldflor, Magnum, Ornella, Rosalin, Sangria, Savannah, Sunanda and Vino. As per the results obtained it was observed that the the growth parameters with respect to plant height, maximum plant height recorded by variety Charmander (45 cm) and Savannah (44.23 cm) were considered as the superior varieties. In respect of number of leaves, Savannah (31.2 leaves), Chamander (30.1 leaves) were considered better varieties. Savannah was considered superior variety as far as leaf area (264.43 cm^2) is concerned. In respect of days required for first bud initiation, Dalma (41.6 days), Goldflor (41.73 days), Charmander (42.4 days), Goldengate (42.6 days), Vino (44.6 days), Savannah (44.7 days), Diablo (44.8 days) were considered as the early varieties. Savanna (16.7 days), Diablo (16.83 days), Vino (16.86 days), Magnum (16.96 days) were considered as superior varieties in respect of days required for the development of flower. Charmander (16.6 days), Savannah (16.09 days) were considered as the superior than other varieties in respect of life span of flowers on plant.

An experiment was conducted on ten varieties of China aster *viz.* Kamini, Shashank, Poornima, Violet Cushion, Phule Ganesh Pink, Phule Ganesh Purple, Phule Ganesh White, Phule Ganesh Violet, Ostrich Plume Mixed and Mixed Variety Local to evaluate suitable varieties on growth and flower yield. According to the results tallest plant was found in Phule Ganesh Violet (74.56 cm) and shortest in Violet Cushion (51.95 cm). Maximum numbers of primary branches/plant were found in Phule Ganesh Violet (35.28) and minimum in Mixed Variety Local (20.70). Maximum numbers of secondary branches/ plant were found in Phule Ganesh Purple (36.18) and minimum in Phule Ganesh Pink (23.25). Maximum numbers of flowers/ plant were found in Phule Ganesh Violet (55.43) and minimum in Shashank (40.92) (Munikrishnappa *et al*. 2013).

Singh *et al.* (2013) conducted an experiment on eight carnation varieties namely Diana, Aurturo, White Dona, Pink Dona, Soto, Red King, Tuareg and Dona and found that among these varieties, highest numbers of shoots/plant were found in Red King (8.00) and lowest was in Diana (3.66). Maximum stem length was found in Red King (75.00 cm) and minimum was in Pink Dona (53.40 cm). Highest numbers of flowers/ plant were found in Red King (35.60) and lowest was found in Tuareg (22.00). Flower diameter was highest in Red King (7.80 cm) and minimum was found in Tuareg (5.70 cm).

Maitra and Roychowdhury (2013) conducted an experiment to evaluate the suitability to ten standard carnation cultivars (Dark Red, Yellow with Red, Bright Red, Pink, C. Rimo, Decio, Orange Isac, Lilac Tarres, Tashman Pink and Orange Triumph) in the plains of West Bengal was studied in this experiment. Results revealed that the longest plant producing cultivar was Dark Red (78.36 cm) and the shortest plant producing cultivar was Decio (51.96 cm). Highest leaf producing cultivar was Bright Red (28.96 leaves shoot-1). CV. Pink produced lowest number of leaves shoot^{-1} (20.59). CV. Yellow with Red was identified the longest leaf producer (12.31 cm) and cv. Orange Triumph was identified the shortest (9.18 cm). Widest leaves (0.79 cm) produced by Orange Isac and narrowest leaves were the character of cv. Pink. (0.50 cm). Decio produced the highest number of side-shoots (2.61) and Pink and Orange Isac produced the lowest number of side-shoots (1.08) plant-1. Earliest Flower Bud Initiation (FBI) was recorded with Lilac Tarres (69.66 days) and Orange Isac reached the FBI stage last of all (104.68 days). Bright Red recorded the lowest time period for flower bud development (18.94 days) and Orange Isac recorded the highest time period (24.98 days). In-situ longevity of flowers was found highest with Bright Red (11.78 days) and lowest with Orange Triumph (9.17 days). Bud length and bud diameter though non-significant was found highest with Tashman Pink (3.81 cm) and Lilac Tarres (1.88 cm) respectively. Longest stalks recorded with Dark Red (71.62 cm) and shortest with C. Rimo (49.70 cm). Bright Red was found to produce flowers of highest diameter (7.21 cm) and Tashman Pink was found the lowest flower diameter producing variety (5.85 cm). Variety Dark Red produced highest number of flowers plant-1 (4.54) and Bright Red produced lowest number of flowers plant-1

(2.65). The post-harvest longevity of cut flowers was found maximum with Dark Red (6.27 days) and minimum with Orange Triumph (4.97 days).

Zosiamliana *et al*. (2012) experimented on seven cultivars of china aster *viz.* Violet Cushion, Kamini, Phule Ganesh Purple, Phule Ganesh White, Phule Ganesh Violet, Phule Ganesh Pink and Local. The result of the experiment showed that tallest plant was found in Phule Ganesh Violet (66.50cm) and minimum in local (43.13 cm). Maximum numbers of primary branches/ plant were found in Phule Ganesh Violet (21.40) and minimum in local (15.93). Maximum number of secondary branches/ plant was found in Phule Ganesh Violet (32.80) and minimum in Phule Ganesh Pink (16.80). Maximum numbers of branches/ plant were found in Phule Ganesh Violet (192.73) and minimum in local (146.67). Maximum days were taken to lower bud initiation were found in found Local (65.93) and minimum in Phule Ganesh Pink (57.20) . Maximum flower diameter was found in Phule Ganesh White (7.37 cm) and minimum in local (4.79cm). Maximum days were taken for flowering found in Kamini (71.02).

Nadeem *et al.* 2011, conducted a study with nine *Rosa hybrida* cultivars including Autumn Sunset, Ice Berg, Paradise, Angel Face, Louise Odier, Casino, Grand Margina, Handel and Gruss an-Teplitz were evaluated for growth and yield attributed under the climatic conditions of Faisalabad. Maximum number of flowers per bush (40) were produced by the cultivar Ice Berg flowed by cultivar Angel Face (31). Minimum number of flowers (9) was produced by the cultivar Autumn Sunset. Maximum mean flower diameter was exhibited by the cultivar Grand Margina (5.75 cm) followed by the cultivar Louise Odier (5.37 cm). Minimum flower diameter (4.33 cm) was observed in the cultivar Autumn Sunset. Maximum mean height (1.7261 m) was observed in the cultivar Handel followed by Gruss-an-Teplitz (1.51 m) and Ice Berg (0.89 m). Minimum bush height (0.5917 m) was yielded in cultivar Louise Odier. Maximum numbers of primary branches (18) were yielded in the cultivar Gruss-an-Teplitz followed by Ice Berg. Minimum primary branches (9) were yielded by the cultivar Casino. Maximum number of petals (61) was exhibited by the cultivar "Casino" followed by "Gruss-an- Teplitz" (57). Minimum number of petals per flower was recorded in the cultivar “Autumn Sunset” and “Angel Face” (16). Maximum flower persistence life (17 days) was recorded in the “Handel” followed by the cultivar “Angel face” (16 days). Minimum flower persistence life (11 days) in the field was exhibited by the cultivar “Ice Berg”. Maximum pinnate length (15.1 cm) was yielded in the cultivar Grand Margina (14.7 cm) followed by the cultivar Paradise. Minimum pinnate length (10.5 cm) was recorded in Louise Odier. Comparison of means revealed that excellent bush shape was exhibited in the cultivar “Ice Berg” with compact, regular and dense growing habit getting 1.75 scores followed by Cultivar “Autumn Sunset” (2.25). Performance of cultivar “Handel” with respect to Bush shape was not satisfactory as it got 4.75 scores leading to irregular, scattering and creeping growth habit. However maximum prickles (scoring 3.5) were present in the cultivar Grand Margina. All other cultivars behaved in a similar fashion with respect to amount of prickles scoring between 2 and 2.5. Better performance on overall basis was shown by the cultivar Autumn Sunset and Gruss-an-Teplitz (2.5). Poor performance was exhibited by the cultivar Louise Odier (3.75)

Raghuvanshi *et al.* (2011) experimented on varietal evaluation of french marigold (*Tagetes patula linn.*) under mid-hill zone of Himachal Pradesh. Analysis of variance showed highly significant variation among cultivars for all the traits studied. Cultivar ‘Safari Queen’ recorded maximum plant height (35.80 cm), flower yield per square meter (8.27 kg), seed yield per plant (0.54g), and seed yield per square meter (9.06g). Plant spread (30.37 cm) was recorded maximum in cv. ‘Harmony Boy’ The cultivar ‘Bonanza Bolero’ recorded maximum values for three traits viz. leaf area (34.58 cm2).flower diameter (5.26 cm) and 1000-seed weight (2.60g). Maximum duration of flowering was recorded in cv. ‘Safari Tangerine’ (39.67 days) which was at par picking (131.11 g) was observed in cv. ‘Honey Comb’. Cultivar ‘Cupid on Varied Orange’ resulted highest 100- loose flower weight. Maximum carotene content of 3747.50 µg/g was obtained in cv. ‘Honey Comb’ which was at par with cv. ‘Hero Harmony’ (3745.83µg/g). Maximum storage duration of 8.67 days and 4.00 days was obtained in cv.’Cupid on Varie Orange’ under could store and ambient conditions, respectively.

Ahmad *et al*., (2011) conducted an experiment on five hybrid rose cultivars *viz.* Amalia, Anjlique, Kardinal, Whisky Mac and Rosy Cheeks. Tallest plant was found in Rosy Cheeks (83.0 cm) and shortest was in Kardinal (46.7 cm). Maximum numbers of leaves/plant were found in Rosy Cheeks (10.8) and minimum in Kardinal (8.8). Maximum leaf area was found in Whisky Mac (104.86 cm^2) and minimum in Anjlique (65.20 cm^2). Highest leaf chlorophyll content was found in Whisky Mac (58.12mg g^{-1}) and lowest was in Rosy cheeks (49.80 mg g^{-1}). Maximum bud diameter was found both in Amalia and Whisky Mac (3.1 cm) and minimum in Rosy Cheeks (2.6 cm). Maximum flower diameter was found in Amalia (5.8 cm) and minimum in Anjlique (4.8 cm).

Gharge *et al*. (2011) conducted an experiment to evaluate ten cultivars of carnation (*Dianthus caryophyllus*) namely Gaudina, Viking, Buemonde, Yellow Firatc, Firato, Diana, Pink Shiva, Aicardi, Alibaba, Dali. Tallest plant was found in Yellow Firato (134.0cm) and shortest in Viking (99.14 cm). Highest number of shoots/plant was found in Yellow Firato (7.64) and lowest in Viking (5.33). Maximum length of shoot was found in Yellow Firato (107.4 cm) and minimum in Alibaba (81.34 cm). Maximum numbers of leaves/plant were found in Yellow Firato (214.4) and minimum in Alibaba (172.8). Maximum numbers of flowers/plant were found in Yellow Firato (7.64) and minimum in Viking (5.33).

Punetha *et al.* (2011) evaluated fifteen chrysanthemum (Chrysanthemum morifolium Ramat.) genotypes to assess their performance under mid hill conditions of Garhwal Himalaya during 2009-10. Genotype Saifali recorded maximum (149.71 cm) plant height, followed by Terry (132.92 cm) but plant spread was maximum in genotype Paris White (45.04 cm), followed by Suneel (44.50 cm), however it was minimum in Saifali (25.96 cm). Genotype Paris White produced maximum number of primary (15.16) and secondary branches (19.16)/plant while minimum, i e 4.41 and 8.16 was recorded in genotype Saifali, respectively. Earliest bud burst (9.33 days) was observed in genotype Red Queen, whereas genotype Charming was late (30.00 days). The highest number of flowers/branch (10.43) was produced by genotype White Anemone followed by Gauri (9.08) and Appu (7.66), but number of flowers/plant was higher

(301.00) in Paris White and minimum (66.33) was recorded with genotype Suneel. Extended period of vase life was recorded in Gauri (24.66 days), followed by Shanti (22.00 days), while it was low with Red Queen (5.33 days).

Khattak *et al*. (2011) investigated the effect of summer pruning on the quality and performance of rose cultivars at the Ornamental Horticulture Nursery Farm, NWFP Agricultural University, Peshawar, Pakistan by observing ten rose cultivars for their performance with and without summer pruning. The experiment was laid-out in Randomized Complete Block Design (RCBD) with split plot arrangement having 2 factors. There were two treatments i.e. pruning in summer and no pruning in summer. Among the cultivars that received summer pruning, cv. Lintern was the earliest to sprout (in 6.50 days). Maximum number of petals per flower (31.36) and number of flowers (20.05) were recorded in unpruned plants, while the summer pruned plants produced minimum results for all the mentioned parameters. Among the cultivars, maximum number of petals (47.59), number of flowers (26.64) and plant height (125.00 cm) were recorded in cv. Baby Bray. CV. Lintern produced flowers with maximum persistence (11.06 days) and cv. Sharif Asma produced the biggest flowers (7.08 cm in diameter). Minimum flowers (5.55), with smallest size (5.15 cm in diameter) were observed in cv. Lintern, whereas cv. Bright Smile produced minimum petals (10.31 per flower) with minimum flower persistence (5.03 days) during the summer seasons.

Datta *et al.* (2011) conducted an experiment on five mustard cultivars *viz.* V_1-WBBN-1, V_2 –NC-1, V_3-YST-151, V_4-Ragini, V_5-B9. The result of the experiment expressed that among these varieties, maximum chlorophyll content was found in V_4 (1.550 mg g^{-1}) and minimum in V_1 (1.311 mg g^{-1}).

Paramagoudar (2010) conducted an experiment on ten cultivars of rose *viz.* Red Burlin, First Red, Passion, Tropical Amazon, Naranga, Grand Gala, Upper Class, African Dawn, Shakira, Gold Strike. Experiment result showed that highest number of shoots/plant was found in Naranga (3.46) and lowest in African Dawn (2.05). Highest number of leaves/plant was found in Gold Strike (5.80) and lowest was in African

Dawn (3.33). Maximum leaf area was found in Grand Gala (25.48 cm^2) and minimum in African Dawn (12.75 cm^2). Maximum days required for flower bud initiation was found in African Dawn (24.53 days) and minimum in Grand Gala (16.40 days). Maximum flower/plant was found in Naranga (14.13) and minimum was found in African Dawn (8.47). Maximum number of petals/flower was found in Naranga (36.67) and minimum in Upper Class (20.07).

Kumari *et al.* (2010) conducted an experiment to evaluate of five cultivars of gerbera (*Gerbera jamisonii* Bolus ex hooker F.) at the Horticulture Research Farm, A.A.U., Anand, Gujarat. The cultivars *viz.*, Dhoni, Zingaro, Roselin, Dune and Balance were evaluated under fan and pad cooled greenhouse conditions at Gujarat during August 2008-09. The analysed data indicated that Balance cultivar showed best performance with respect to tallest plant (41.05 cm), number of leaves per plant (25.91 leaves), leaf area (5895.00 cm^2), leaf area index (5.24), number of flowers per plant (10.59), number of flowers per sq. m. (94.04), number of suckers per plant (4.88) as well as maximum shelf life of flowers (10.11 days and 15.30 days) at ambient temperature (25.12°C) and 18°C temperature, respectively, as compared to all other cultivars under studied.

An experiment was conducted to evaluated the performance of thirty gerbera cultivars *viz.* Entourage, Baston, Softcell, California, Monthblance, Danelli, Frisbel, Fiction, Carambole, Scope, Picobella, Onedine, Loveliness, W.Grizzly, Lombogine, Dina, Esperenza, Gucci, Grizzly, Solem, Verginia, Tecla, Devil, Banesa, Martinque, Skyline, Viviane, Opium, Women, Sonata. Result of the experiment expressed that maximum numbers of leaves/plant were found in Sonata (48.33) and minimum in Bastion (30.77). Maximum leaf area was found in Grizzly (274.93 cm^2) and minimum in Softcell (143.89cm^2). Maximum flower diameter was found in Martinque (13.33cm) and minimum in Sonata (4.48 cm). Highest stalk length was found in Danelli (70.71cm) and shortest was in Onedine (52.40 cm). Maximum number of flowers/ plant was recorded in Sonata (62.87) and minimum in Onedine (42.27) (Chobe *et al*. 2010).

Pralhad (2009) conducted an experiment on ten cultivars of carnation *viz.* Aicardi, Buemonde, Diana, Firato, Gaudina, Pink Shiva, Alibaba, Dali Yellow Firato and Viking,. Result showed that, highest number of shoots/plant was found in Yellow Firato (7.64) and lowest in Viking (5.33). Maximum numbers of leaves/plant were found in Yellow Firato (214.4) and minimum in Alibaba (172.8). Maximum days required for bud initiation was taken by Gaudina (91.47days) and minimum was required by Diana (67.58 days). Maximum number of petals/flower was found in Gaudina (74.18) and minimum in Yellow Firato (46.36).

An experiment was conducted on ten gerbera cultivars *viz.* Lamborghini, White Grizziy, Grizziy, Virginia, Onedin, Dino, Baron, Solemio, Hope and Mademoiselle. Highest numbers of leaves/plant were found in Dino (27.5 and 32.30 respectively in rainy and winter seasons) and lowest in Baron (20.4 and 26.0 respectively in rainy and winter seasons). Maximum leaf area was found in White Grizziy (212.6 cm^2 and 235.6 cm^2 respectively in rainy and winter seasons). Maximum days required for flower bud initiation was found in Mademoiselle (17.9 and 16.3 days respectively in rainy and winter seasons) and minimum was required in Dino (12.6 and 11.0 days respectively in rainy and winter seasons) (Pattanashetti, 2009).

Manjula (2005) conducted an experiment on ten cultivars of rose namely Grand Gala, Samurai, First Red, Konfittee, Skyline, Tineke, Lambada, Ravel, Eternal, Versilia. Among these cultivars, maximum number of shoot/plant found in Tineke (3.46) and minimum in Versilia (2.05). Highest number of leaves/plant was found in Konfittee (6.39) and lowest in Versilia (2.91). Widest leaf was found in Grand Gala (152.63 cm^2) and narrowest in Lambada (98.43 cm^2). Maximum days were taken for flower bud initiation found in Versilia (24.53) and minimum in Grand Gala (16.40). Maximum numbers of petals/flower were found in Tineke (40.98) and minimum found in Lambada (17.48).

An experiment was carried out under naturally ventilated poly house at the College of Agriculture, Bijapur during 2002-03 to study the effect of single bending (T_1), double bending (T_2) and pruning (T_3) on six exotic rose varieties viz. Miracle (V_1), Polo (V_2), Passion (V_3), Sweetness (V_4), Sky line (V_5) and First red (V_6). Single bending and double bending treatments recorded significantly higher number of flowers, stem length, and flower diameter compared to pruning, irrespective of varieties. Among the varieties, significantly higher number of flowers was recorded in the variety Sweetness (114.50/m^2) followed by Passion (105.98/m^2) which was on par with Polo (103.47/m^2). With respect to flower stem length Polo (64.18 cm) was significantly superior followed by First red (59.63 cm) and Sky line(55.95 cm), while the flower diameter was significantly higher in First red (2.62 cm) followed by Polo (2.52 cm) and Passion (2.45 cm) (Mantur *et al.*, 2005).

A two-year trial of open-cycle soilless cultivation of four varieties of rose was conducted in Bagheria (Sicily, Italy), in an unheated greenhouse with metal structure and polyethylene cover, with the aim of evaluating the influence of two growing media on quantitative and qualitative parameters of cut flower production. Plants of the CV. Anastasia, Fenice, New Fashion and Gold Strike were grown in plastic bags filled with perlite, pure or mixed with coconut coir dust (1:1, v/v). Growing media affected yield and quality: perlite/coir dust caused the highest amount of flowers (17.7 stems/plant) and the longest stems (65 cm). Significant differences were also recorded among varieties: CV. Anastasia produced the highest number of stems (18.7 per plant) and the longest buds (5.8 cm); CV. Fenice provided flowers with the maximum average length (70 cm); CV. New Fashion gave the highest amount of leaves/stem (55.8) (Fascella and Zizzo, 2005).

Sarker and Ghimray (2004) conducted an investigation to evaluate the performance of nine gerbera cultivars of gerbera (*Gerbera jamesonii* bolus ex hook f.) under protected condition in the hilly region of West Bengal. All the characters studied in the experiment showed significant variation among the cultivars. Cv. Red explosion showed earlier flowering whereas delayed flowering was observed in cv. Kalimpong Red. The cv. Vital showed maximum plant height (47.38 cm) followed by cv. Sunway (42.56 cm) and the minimum plant height (33.88 cm) was observed in cv. Kalimpong Red.

Sankar *et al.* (2003) conducted a study at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara to evaluate the performance of five gerbera varieties, viz., Essandre, Juvena, Lindessa, Tamara and Yanara and to compare ground planting with pot culture under low cost green house. The varieties differed significantly with respect to vegetative and floral characters. Variety Essandre was found to have maximum plant height (21.43 cm), number of leaves (16.87), leaf area (1276.28 cm2) and number of flowers (17.69/ plant) whereas, the cv. Tamara was very poor in flower production (8.0/plant). Flower diameter (9.59 cm) and stalk length (56.77 cm) was maximum in cv. Yanara.

Mahanta *et al.* (2003) evaluated five black centered gerbera cultivars under naturally ventilated polyhouse and his experiment showed that highest number of flowers/plant (5.66) and per meter square (51.00) was found in cv. Ellymay followed by cv. Aquilla (5.00 and 45.00/m2) respectively. Maximum flower diameter (9.92 cm) was observed in cv. Aquilla. The longest blooming period (19.55 days) with maximum vase life (12.22 days) was observed in cv. Golden Gate.

Reddy *et al.* (2003) observed the performance of eleven gerbera cultivars under naturally ventilated greenhouse and reported that among the cultivars, Sangria, Kabana, Marisol and Tamra were superior for their growth, yield and quality as compared to the other genotypes. With maximum plant height (48.31 cm), number of leaves (47.31), number of suckers per plant (7.54), number of flowers per plant (57.54), stalk length (69.46 cm), thickness (0.73 cm) and diameter of the flower (12.16 cm) the cv. Sangria was found to be best.

Jeevajothi *et al.* (2003) studied the influence of three growing environments *viz.* glasshouse, shade house and open field on ten cultivars of gerbera. The flowers produced in glasshouse had maximum flower stalk length (46.16 cm) and flower diameter (8.11 cm), followed by shade house with stalk length (40.89 cm) and flower diameter (7.32 cm) while flowers grown in open field had the lowest stalk length (33.87 cm) and flower diameter (6.73 cm).

Singh and Mandhar (2002) studied the performance of nine exotic cultivars of gerbera under fan and pad cooling system greenhouse environment. The greatest plant height (48.83 cm), and number of suckers (5.16) and leaves (46.27) per plant were obtained with Tiramisu, Lyonella and Ornella, respectively, while the lowest values of the aforementioned parameters were recorded for Whitsun (47.88 cm), Sunset (3.82) and Tiramisu (26.74), respectively. Flowering was earliest (47.88 and 57.47 days for 50 and 100% flowering, respectively) in Whitsun and latest (83.10 and 88.30 days) in Tiramisu. The greatest diameter of flower (10.70 cm) and length of flower stalk (58.27 cm) were recorded for Tiramisu and Lyonella, respectively. The thickest (0.70 cm diameter) and heaviest (22.20 g) flower stalks were observed in Twiggy, whereas the thinnest (0.60 cm diameter) and lightest (13.94) stalks were observed in Whitsun.

Tabassum *et al*. (2002) evaluated ten rose cultivars namely Alexendra, Double Delight, Day Dream , Englique, Freesia, Golden Time , Paradise, Regret Berg , Red Sex and Yankee Doodle. Tallest plant was found in Englique (139.83cm) and shortest in Double Delight (87.17cm). Maximum days required for bud sprouting was found in Englique (46.17) and minimum was in Golden Time (34.67). Maximum days required for flowering was found in Day Dream and Englique (54.67 days) and minimum was in Red Sex (41.83 days). Maximum numbers of shoot/plant were found in Paradise (12.50) and minimum in Freesia (4.17). Highest numbers of flowers/plant were found in Day Dream (41.00) and lowest in Double Delight (5.33). Maximum flower diameter was found both in Alexandra and Paradise (7.93) and minimum in Regret Berg (5.17). Maximum numbers of petals/flower were found in Yankee Doodle (59.20) and minimum in Regret Berg (18.97). Longest flower persistency was found in Golden Time (17.17) and shortest in Regret Berg (5.67). Maximum vase life was in Freesia (8.00 days) and minimum in Regret Berg (5.00 days).

Singh and Ramachandran (2002) conducted an experiment to study the vegetative characteristics of nine gerbera cultivars at the age of one year of crop growth under naturally ventilated greenhouse. The cultivar “Lyonella” expressed the highest plant height (47.10 cm), plant spread (70.19 cm) and number of suckers/plant (4.85 cm) whereas the cultivar “Orenella” recorded highest number of leaves/plant (46.10) and cultivar white sun produced dwarf plant (35.40 cm) with plant spread of 59.34 cm. The cultivar “Tara” showed minimum number of suckers (3.66) and leaves/plant (31.66).

An experiment was conducted to measure the effects of pulse treatments of BA, sucrose, and BA before, after, or with sucrose, on the vase life of cut Eustoma flowers. A BA pulse at 50 mg/l before 4% sucrose promoted the longevity of cut Eustoma flowers better than other treatments. Simultaneously, sucrose, glucose, and mannose concentrations in flowers during vase periods were maintained at higher levels in double pulse treatments than in the single pulses. Ethylene production in flowers 2 days after vase treatment was highest in the BA-treated flowers; intermediate in flowers pulsed with BA before, after, or with sucrose; and lowest in sucrose-treated flowers. Although a BA pulse increased ethylene production over that of controls, it inhibited senescence in cut Eustoma flowers. Respiration in flowers pulse-treated with sucrose or with BA before, after, or with sucrose, was significantly higher than that in controls. Results suggest that the vase life of cut Eustoma flowers is improved by either BA or sucrose in vase solution and especially when BA was pulsed before the sucrose pulse (Kuang-Liang Huang, 2002).

Ichimura *et al.* (2002) investigated the variations in the way of flower opening and vase life of cut rose (Rosa hybrid L.) flowers among 25 cultivars. The way of flower opening varied among 25 cultivars; the cut flowers of some cultivars did not open completely. To elucidate the factors that affect the variation in the vase life of cut roses with the cultivar, 10 major cultivars in Japan, were used. There was no correlation between vase life and petal thickness or transpiration rate of the cut flowers. To investigate whether vascular occlusion or sugar content is involved in the variation of the vase life, we continuously treated the cut flowers with 200 mg liter^{-1} 8 hydroxyquinoline sulfate (HQS) on 20g·liter^{-1} sucrose with both of them. Treatment with HQS, sucrose and sucrose plus HQS significantly extended the vase life of two, two and four cultivars, respectively. However, none of the chemicals extended the vase life of ‘Delilah’, ‘Calibra’, ‘Konfetti’, ‘Pareo[90] and ‘Rote Rose’. The vase life of these cultivars except for ‘Rote Rose’ was longer than 8 days. These results also suggest that a short vase life in some cultivars is attributed to vascular occlusion and/or shortage of sugars.

Shimizu and Ichimura (2002) investigated the effects of the ease of self-pollination on the vase life in cut Eustoma flowers by using 13 cultivars. The vase life of Eustoma florets was reduced by self-pollination in 10 out of 13 cultivars. The distance from the stigma to anther and the rate of natural self-pollination varied among the cultivars, such that the rate of pollinated flowers was negatively correlated with the distance from the stigma to anther (r=-0.86). This indicates that flowers are more apt to be pollinated if the distance is short. Hence, we conclude that the vase life of cut Eustoma florets is affected by the relative ease at which natural self-pollination occurs, which in turn, is a function of the distance between the stigma and the anthers.

Kumar and Kumar (2001) conducted an study on the effect of different modified environment *viz.*, 50 percent summer shading, winter plastic covering, 50 percent shading followed by winter covering and natural sunlight on five gerbera cultivars. Vegetative growth, flower quality and yield showed significant inequality among these treatments. The best performance among these different shading treatments was observed in plants grown under 50 percent shading followed by winter covering with highest plant height (42.34 cm), leaf number (32.86), leaf area (100.62 cm^2), early bud appearance (162.42 days), anthesis (17.17 days), yield/plant (4.64), yield/unit area (29.12), flower diameter (9.20 cm) and stalk length (43.01 cm).

Harbaugh *et al.* (2000) conducted an experiment to evaluated 47 cultivars of lisianthus representing series (cultivar groups) that were marketed in the United States in 1998. Evaluations were made for rosetting, plug performance, cutflower characteristics (vegetative and flowering attributes) as well as postharvest longevity of cut flowers. ‘Heidi Wine Red’ had the highest percentage rosetted plants (35%) followed by ‘Flamenco Wine Red’ and ‘Mariachi Pink’ (29%) and ‘Avila Purple’ (0%), ‘Alice Pink’ (1%) and ‘Avila Rose’ (3%) the lowest. Seedling width varied from 4.6 cm (1.81 inch) for ‘Bridal Ocean’ to 9.3 cm (0.76 inch) for ‘Malibu Purple’. Root vigor ratings ranged from 1.8 for ‘Bridal Ocean’ to 4.7 for ‘Heidi Cherry

Blossom 'Heidi Cherry Blossom', 'Ventura Purple', 'Flamenco Pink Rim', and 'Echo Lilac Rose' had earliest harvest dates of 138 to 143 d from sowing while 'Bridal Ocean', 'Mariachi White', and 'Mariachi Lime Green' were the last cultivars to be harvested at 162 d from sowing. Plant height ranged from 94 cm (37.0 inch) for 'Heidi Pastel Blue Imp.' and 'Ventura Purple' to 129 cm (50.8 inch) for 'Bridal Ocean'. For double-flowering stems, 'Mariachi Misty Blue' had the greatest weight at 87 g (3.07 oz) and 'Echo Lilac Rose' the least at 43 g (1.52 oz). For single-flowering stems, 'Royal Rose Lavender' had the greatest weight at 77 g (2.72 oz) and 'Tyrol White' the least at 45 g (1.59 oz). 'Royal Rose Lavendar' had the thickest stem [7.8 mm (0.31 inches)], while 'Balboa Blue Blush' had the thinnest [5.4 mm (0.21 inches)]. Flower and bud number per stem ranged from 8 for 'Balboa Blue Blush' to 18 for 'Balboa Blue'. Flower diameter was smallest with 'Alice Purple' (7.4 cm, 2.91 inch) and largest for 'Malibu Purple' (11.8 cm, 4.65 inch). For lisianthus with double flowers, petal number varied from 9 per flower for 'Catalina Blue Blush' and 'Echo Lilac Rose' to 28 for 'Avila Rose'. Vase life was as short as 10 d for 'Catalina Yellow' and as long as 31 d for 'Alice White'. On the basis of the findings, Cultivars selected as best in class were 'Malibu Purple', 'Malibu Blue Blush', 'Alice Purple', 'Balboa Blue', 'Avila Blue Rim', 'Mellow Pink', 'Flamenco Wine Red', 'Flamenco Rose Rim', 'Alice Pink', 'Avila Rose' and 'Echo Pink', 'Alice White', and 'Mariachi White'.

Anuradha and Gowda (2000) studied the association of cut flower yield with growth and floral characters in gerbera. In studies on 25 gerbera genotypes at Bangalore, cut flower yield exhibited a high level of positive and significant correlation with number of leaves per plant, weight of ray florets and days taken to flower opening. Path analysis revealed that number of leaves per plant had the greatest positive direct effect on flower yield.

Ichimura and Korenaga (1998) investigated the flower senescence of *Eustoma grandiflorum* in relation to ethylene production and sensitivity to ethylene. Ethylene production of flowers increased with flower senescence. Ethylene was mainly produced in the pistil, in particular in the style, and production in the petal increased with flower senescence. Flowers were not sensitive to ethylene at anthesis, but became more sensitive with increasing senescence. Treatment with silver thiosulphate (STS), an ethylene action inhibitor, extended flower longevity. Continuous application of 20g/l sucrose with 200mg/l HQS markedly promoted floret opening and extended the vase life of all the cultivars tested. This treatment also increased anthocyanin concentrations. STS inhibited ethylene production from the whole flower, particularly that from the petal. Thus, ethylene is considered to be involved in the flower senescence of *Eustoma*.

Schoellhorn *et al.* (1996) conducted an experiment on the branching of chrysanthemum cultivars in relation to season, temperature and photosynthetic photon flux using 12 commercial cultivars *viz.* Boaldi, Bright Golden Anne, Davis, Limelight, Royal Trophy, Tara, Theme,Yellow Ovaro, Yellow Torch, Improved Mefo, Fuji Mefo and Nimba. Number of lateral branch count varied among the cultivars from 0-12 per pinched plant and by as much as 60% between seasons. With air at 20C, lateral branch counts (3 weeks after pinch) declined by 50% with the medium at 15C relative to 25C. At 25C, lateral branch count was lower with medium at 30^0 C than at 20^0 C. Cultivars differed in their response to the treatments. Comparing the interactions among temperature, PPF, and cultivar on lateral branch count revealed that dpending on cultivar, the count was increased in the PPF between 400 and 1400 $mmolm^{-2}s^{-1}$. Air temperature had no effect on lateral branch count. PPF had a stronger effect on lateral branch count than air temperature, and cultivars differed in their response.

Van Doorn and Schroder (1995) studied the petal abscission in twelve hybrid tea rose (*Rosa hybrida* L.) cultivars. At about 20 °C the time to petal abscission in uncut stems in greenhouses was the same as in cut stems placed in water in the greenhouse or in a climate-controlled room. The time between petal unfolding and abscission depended on the cultivar, and varied between 12 and 35 d. The time to petal abscission of the cultivars was inversely correlated with their flower diameter at full bloom (linear regression, r^2= 0·82). In the cultivars with a relatively large flower diameter (10-18

cm) the petals fell without visible desiccation symptoms, whereas in the group with a small diameter the petals were partially or fully desiccated when shed.
Fertilization occurred in some flowers of a few cultivars studied. In cultivars with a relatively large flower diameter (Papa Meilland, Cocktail, Dr. Verhage, Tineke) it had no effect on the time to abscission in Motrea, Europa, and Carolien roses, which bear small flowers, the petals fell after fertilization, whereas in unfertilized flowers of the latter group of cultivars an abscission zone just above the uppermost node became active and all parts above this node (pedicel and flower) turned brown and desiccated, though remained attached for more than a month.
It is concluded that in the cultivars investigated: (*a*) the time to petal abscission was inversely related to their flower diameter, (*b*) abscised petals were more desiccated in cultivars in which the time to abscission was longer, (*c*) fertilization had little effect on the time to abscission in most cultivars, whereas the absence of fertilization prevented petal abscission in a number of the small-diameter cultivars where it was replaced by flower abscission, and (*d*) cutting and placement in water at 20 °C did not affect the time to abscission.

Kannan and Ramadas (1990) conducted an experiment where they studied the variability of 48 accessions of gerbera for vegetative parameters where the maximum and minimum number of leaves was expressed by Accession-14 (74.53) and Accession-17 (23.95), respectively. Highest number of suckers/plant was recorded from Accession-22 (29.43) which was followed by Accession-23 (29.01). Lowest number of suckers was recorded from Accession-9 (5.08).

Hybrid Eustoma grandiflorum was evaluated as a cut flower and a flowering pot plant. Lisianthus is a day neutral summer blooming plant flowering earlier at high (18/26 degrees C night/day) than at low temperatures. It is a slow growing plant requiring about 5 to 6 months from sowing to flowering. The forcing period is about 2 months. Three colour variants are available: blue, pink and white. Only the blue and white are suitable as cut flowers (Halevy and Kofranek, 1984).

Xu and Miao (1983) experimented on the relationship between the leaf morphological and anatomical features of three cultivars of soybean and photo-synthetic rate. Results showed that the photosynthetic rate of soybean leaves in field-grown plants depends on the leaf thickness and the number of palisade cells. Har 78-9140 and 78-2, the leaves of these two cultivars have nearly the same number of palisade cells per unit area but different leaf thickness, Har 79-9440, with the greater leaf thickness have the greater photosynthetic rate. On the other hand, 78-2 and Heinong 8, with the same leaf thickness, the photosynthetic rate will be determined by the number of palisade cells.The changes of photosynthetic rate in growing period related to the varieties of morphological and anatomical features. The palisade tissue such as the thickness of the palisade tissue, the number of palisade cells and the number of palisade cell layers was found to make the main contribution in the leaf photosynthesis.

Buttery *et al.* (1981), conducted a field experiments with young spaced plants of 48 soybean (*Glycine max* L. Merr.) cultivars where derived lines tended to have higher rates of apparent photosynthesis (P_A) than their parent lines over 3 year of tests using the $^{14}CO_2$ method. For 2 year in which chlorophyll and specific leaf weight (SLW) were also measured, a significant number of derived lines had higher P_A, chlorophyll and SLW than their parent lines. With 12 cultivars of similar maturity, grown as row-crop tests for 4 yr, P_A and leaf percent N were correlated with each other during August (pod-filling period) but not during July (flowering period). August P_A and leaf percent N were correlated with bean yield, but July values were not. Chlorophyll and SLW were correlated with each other in July and in August; each was correlated with P_A in July but not in August. Although July measurements of leaf characters were not correlated with bean yield, July and August values were correlated for $P_A$and for chlorophyll. The correlations observed among the characters in different sampling periods are discussed in relation to possibilities for selection.

Wilfret *et al*. (1973) conducted an experiment with forty-two chrysanthemum cultivars *viz.* BGA Cheers, BGA Commander, BGA Mercury, BGA Neptune, Oregon, BGA Puritan, CFPC White Daisy Pot, CFPC White Pot, BGA Cunnarib, Delaware, BGA Festival, BGA Red Baron, BGA Vermillion, BGA Warhawk, BGA Wildfire, BGA Always Pink, BGA Bravo, Bridesmaid, Bright Rosamund, Conquest, BGA Illini Hot Pink, BGA In the Pink, BGA Malabar, BGA Discovery, Bright Golden Anne, BGA Goldenrod, BGA Mt. Sun, BGA Sunnyside Up, BGA Treasure Chest, CFPC Yellow Daisy Pot to evaluate their potential use as a mass market product. Rooted cuttings were planted on February 18, 1972, pinched on February 23, and treated with B-9 (0.5%) on March 3. Plants were grown in the greenhouse under prevailing day lengths and light intensities. Data recorded at flowering were on plant height and width, number of shoots, flower size and number, general foliage and stem characteristics. Height of the plants above the rim of the pot ranged from 7.9 to 23.2 in, represented by 'Delaware* and 'CFPC Marguerita', respectively. Plant width ranged from 8.3 to 14.2 in, rep resented by 'BGA Mt. Sun' and 'CFPC Margue rita', respectively. Flower diameter ranged from 1.9 to 15.4 in, represented by 'BGA Frolic' and 'White Spider Pot', respectively. Number of laterals per plant ranged from 3.4 to 8.6, represented by 'Bright Rosamund' and 'BGA Bravo', respectively. Number of potential flowers, obtained by counting the number of floral buds per lateral, ranged from 4.8 to 17.8, represented by 'BGA Sunnyside Up' and 'CFPC White Pot', respectively. Cultivars which were adapted to cultivation for mass-market included 'BGA Always Pink', 'Discovery', 'Wildfire', and 'Distinctive'.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from April 2016 to October 2016 to compare different lisianthus lines for adoption in Bangladesh. The materials and methods used for the experiment were as follows:

3.1 Experimental site

The study was conducted in Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study growth and floral characteristics of some lisianthus varieties to screen out suitable varieties for adoption in Bangladesh. The location of the experimental site is 23074^{0}N latitude and 90035^{0}E longitude and at an elevation of 8.2m from sea level (Anon. 1989).

3.2 Climatic condition

Experimental site was located in the subtropical monsoon climatic zone, set aparted by heavy rainfall during the months from April to September (Kharif season) and scant of rainfall during the rest of the year (Rabi season). Plenty of sunshine and moderately low temperature prevails during October to March (Rabi season), which is generally preferred for flower production in Bangladesh. But Lisianthus is a non-photosensitive crop hence the experiment was done in the khrarif season.

3.3 Planting materials

Lisianthus seeds were collected from Sakata Seed Co., Yokohama and Dai-ichi Seed, Japan. In April, 2016, the seeds were sown in 200 hole plug trays filled with growth medium and placed in Nandini growth chamber for germination and subsequent growth. Required care for proper development of seedlings were taken and 70 days old seedlings (with 4 pair true leaves) were taken for transplanting in the field.

3.4 Land preparation

The experimental area was brought to fine tilth with cross plowing using power tiller. Then the area was divided to plots of 3m X 1m according to the layout of the experiment (Fig. 1). The following fertilization rate/hectare was followed -

- Cowdung- 10 ton
- Urea- 350 Kg
- TSP- 250 Kg
- MoP- 300 Kg

All these were applied to the plot soil during final land preparation. Cocodust was mixed with soil to make it more friable for easier root penetration.

3.5 Treatments and layout of the experiment

The experiment was conducted to compare growth, flowering characteristics and petal coloration of some lisianthus lines in SAU horticultural farm. The single factorial experiment was laid out in Randomized Complete Blocked Design (RCBD) with three replications (Fig. 1). 30 cm distance from row to row and 20 cm distance from plant to plant was maintained in each replications.

The treatments of the single factorial experiment were as follows:

Factor: Lisianthus lines

Name	SAU code name		Denoted as
SAU line 1	Nandini Moonlight	=	L_1
SAU line 2	Nandini Suvro	=	L_2
SAU line 3	Nandini Chandra	=	L_3
SAU line 4	Nandini Light pink	=	L_4
SAU line 5	Nandini Lemon double	=	L_5
SAU line 6	Nandini Lemon Single	=	L_6
SAU line 7	Nandini Pink cup	=	L_7
SAU line 8	Nandini Rose	=	L_8
SAU line 9	Nandini Royal Violet	=	L_9
SAU line 10	Nandini Violet Single	=	L_{10}
SAU line 11	Nandini Blue vase	=	L_{11}
SAU line 12	Nandini Ocean Violet	=	L_{12}
SAU line 13	Nandini Purple Vase	=	L_{13}
SAU line 14	Nandini Purple Picotee	=	L_{14}
SAU line 15	Nandini Lavender	=	L_{15}

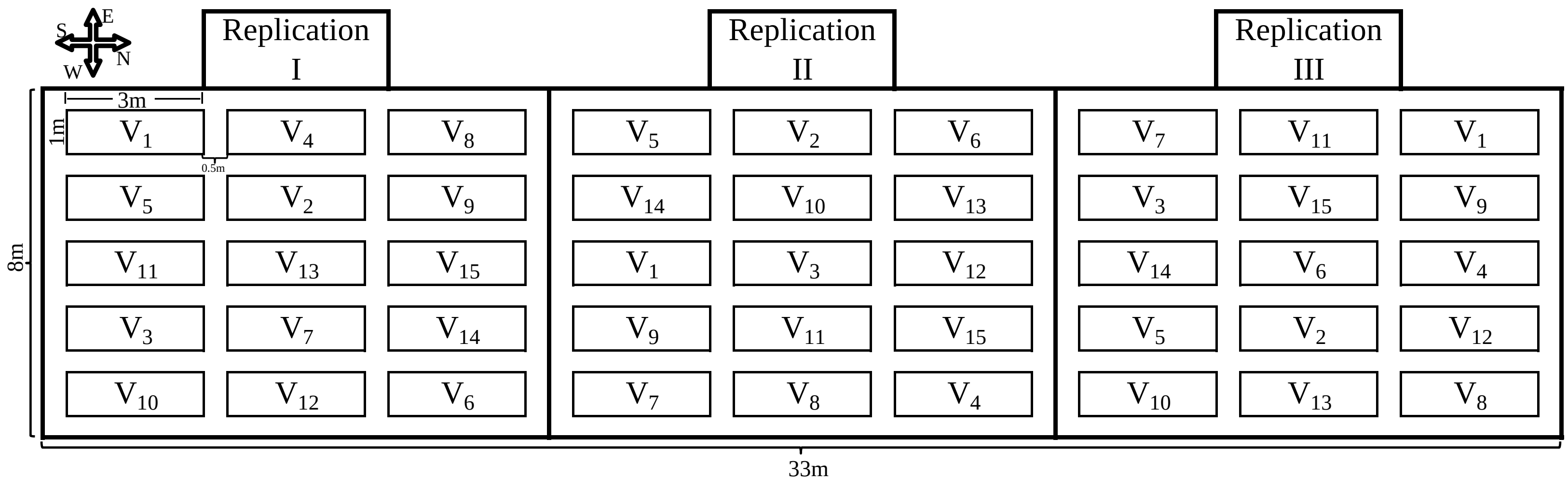

Fig. 1: Layout of the experiment

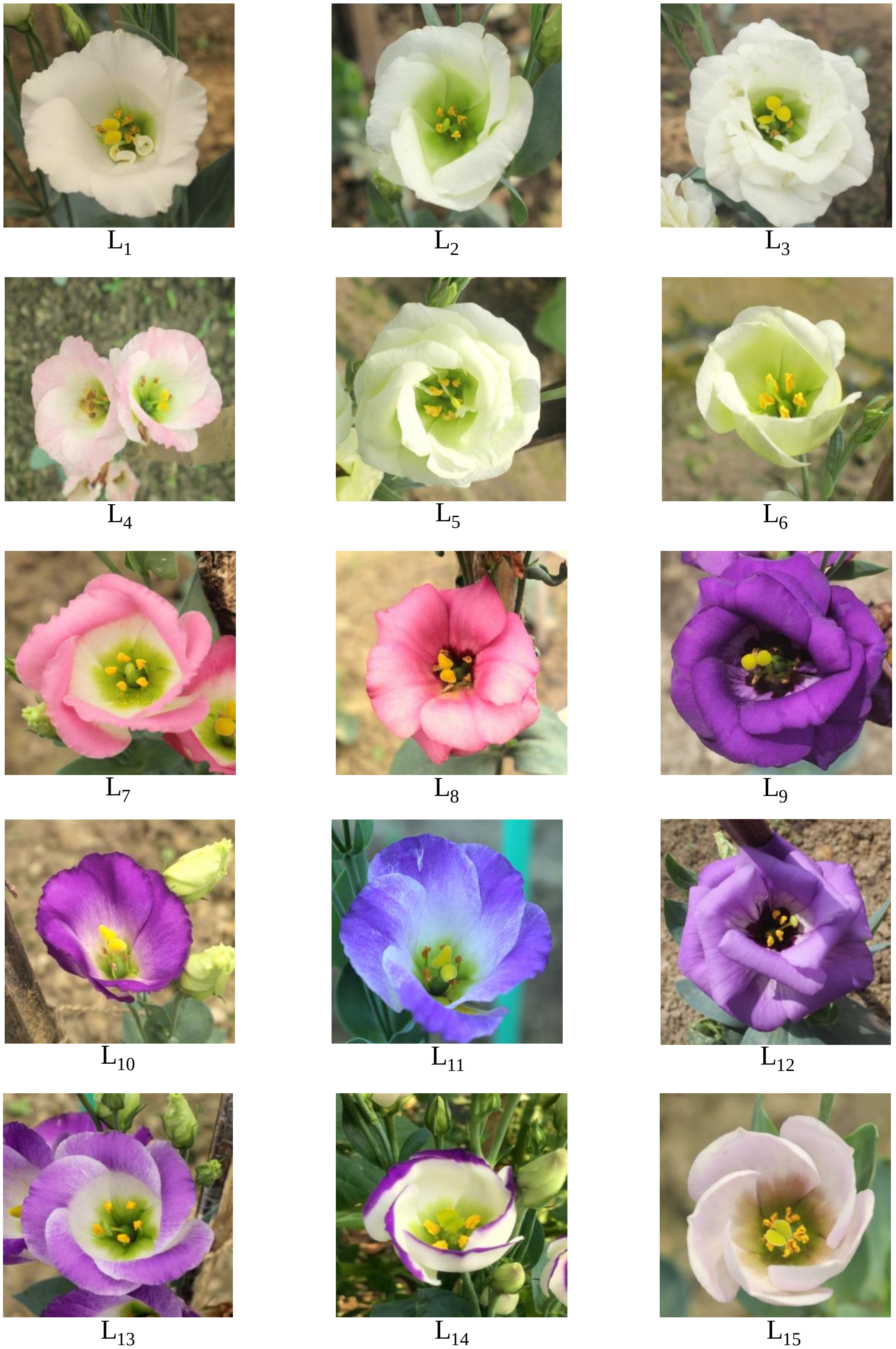

Plate 1. Pictorial view of lisianthus lines used in the experiment

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

3.6 Intercultural operations

3.6.1 Irrigation

During seedling development, mist irrigation was provided using a hand sprayer to keep the growth medium moist. After transplanting of the seedlings, over-head irrigation was provided through a pipe as and when necessary during the experimental period.

3.6.2 Weeding

Weeding was done as and when necessary.

3.6.3 Disease and pest control

To prevent fungal infection, Dithane M-45 was sprayed 3 times at 15 days interval along with Pyrithrum @ 1.5ml/L to prevent insect attack. In vegetative stage, Furadan 5G @ 3 g/l was also applied to protect from soil nematode.

3.6.4 Staking

Staking was provided to the plants using bamboo sticks.

3.7 Parameters studied

- ❖ Rosette %
- ❖ Plant height (cm)
- ❖ No. of leaves
- ❖ No. of stem
- ❖ Chlorophyll percentage (%)
- ❖ Days to flower bud initiation
- ❖ Days to full bloom

- ❖ No. of flower bud/stem
- ❖ No. of flower/stem
- ❖ No. of flower/plant
- ❖ No of petal/flower
- ❖ Flower head diameter (cm)
- ❖ Stem diameter (mm)
- ❖ Stem length (cm)
- ❖ Vase life (days)

3.8 Data collection for the experiment

3.8.1 Rosette%

The percentage of seedlings that did not bolt within 45 days after sowing were considered as rosette. Seedlings which had not rosetted had at least two elongated internodes on the bolted stem within that time (Harbaugh *et al.* 2000).

3.8.2 Plant height

Plant height was measured using a graduated measuring scale at mature stage of the plant (75 DAT) (Plate 2a.)

3.8.3 Number of leaves

Total no. of leaves was determined by counting all the leaves from the base to the tip of the plant at maturity.

3.8.4 Number of stem

No. of flowering stem was measured by counting the stems containing flowers and flower buds.

3.8.5 Chlorophyll %

Chlorophyll percentage was measured using a portable chlorophyll meter (SPAD-502, Minolta, Japan). The procedure of this measurement was non-destructive. Data were collected from five randomly selected leaves taking three data from each leaves and the mean was derived from them (Plate 2b.)

3.8.6 Days to flower bud initiation

Days to flower bud initiation was determined by counting from the days of transplanting to the appearance of the first flower bud.

3.8.7 Days to full bloom

Days to full bloom was determined by counting from the day of appearance of the bud to the complete opening of the flower.

3.8.8 Number of flower buds/stem

No. of flower buds/stem was counted up to blooming of the first flower and the mean value was calculated.

3.8.9 Number of flower/stem

No. of flower/stem was counted just before harvesting the stem and mean value was calculated.

3.8.10 Number of flower/plant

No. of flower/plant was counted at the end of the experiment just before harvesting and the mean value was calculated.

3.8.11 Number of petal/flower

No. of petal/ flower was counted from the second bloomed flower and mean value was derived from them (Plate 2d.). The second flower was chosen because petal number and the size of the flower often vary on the first flower to open but is generally consistent on all secondary flowers (Harbaugh *et al.*, 2000).

3.8.12 Flower head diameter

Flower head diameter was measured using Digital caliper-515 (DC-515) in millimeter (mm). The data was then converted to centimeter (Plate 2c.)

3.8.13 Stem diameter

Stem diameter was measured using Digital caliper-515 (DC-515) in millimeter (mm). Mean value was derived from the collected data.

3.8.14 Stem length

Stem length was measured using a measuring scale from each of the flowering ones. The measurement was done from the first internode from the soil and recorded in centimeter (cm) (Harbaugh *et al.*, 2000)

3.8.15 Vase life

Three stems were selected at random from each line, cut to 25 cm, and placed in a 500 ml conical flask containing tap water. Stems that had one flower about to bloom and one or two unopened flower-bud were selected. Stem ends were cut and tap water was changed in every alternate days. The number of days till the wilting of flowers and buds were recorded to determine the vase life.

3.9 Petal color measurement

Colorimetric measurement of the different lisianthus lines was done using IWAVE WF32 precision colorimeter (Shenzhen Wave) following L* (lightness), a* and b* (two Cartesian coordinates) including C* and h_{ab} (Chroma & hue angle) based on

CIELab scale with standard observer 10^0 and standard illumination D65 (CIE, 1986; McGuire, 1992) (Plate 2e.). Beams effective axes were at 45 ± 2^0 from the normal of the specimen surface in illuminated petals. Metric chroma, C* and hue angel, h_{ab} were calculated as $C^* = (a^{*2}+b^{*2})^{0.5}$ and $h_{ab} = \text{tang}^{-1}$ (b*/a*) (Gonnet, 1998). The individual petals were separated and were placed under the measurement port for color measurement. In case of bi-color lines the distinguishing color portion of the petals were arranged under the measuring port of the colorimeter and test was conducted.

3.10 Classification of lisianthus lines

The studied lisianthus lines were classified in to different classes using the findings of the parameters as well as visual observation which is based on the Union of Protection of Plant Varieties (UPOV) guidelines.

3.11 Statistical analysis

Collected data were organized and analysis of variance was conducted by “F” (Variance ratio) test using MSTAT-C computer package program in relation to the objectives of the experiment. Differences between treatments were estimated by the Least Significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984). Cluster analysis between the lisianthus lines i.e. dendrogram was made using SPSS computer program (SPSS 19.0.1).

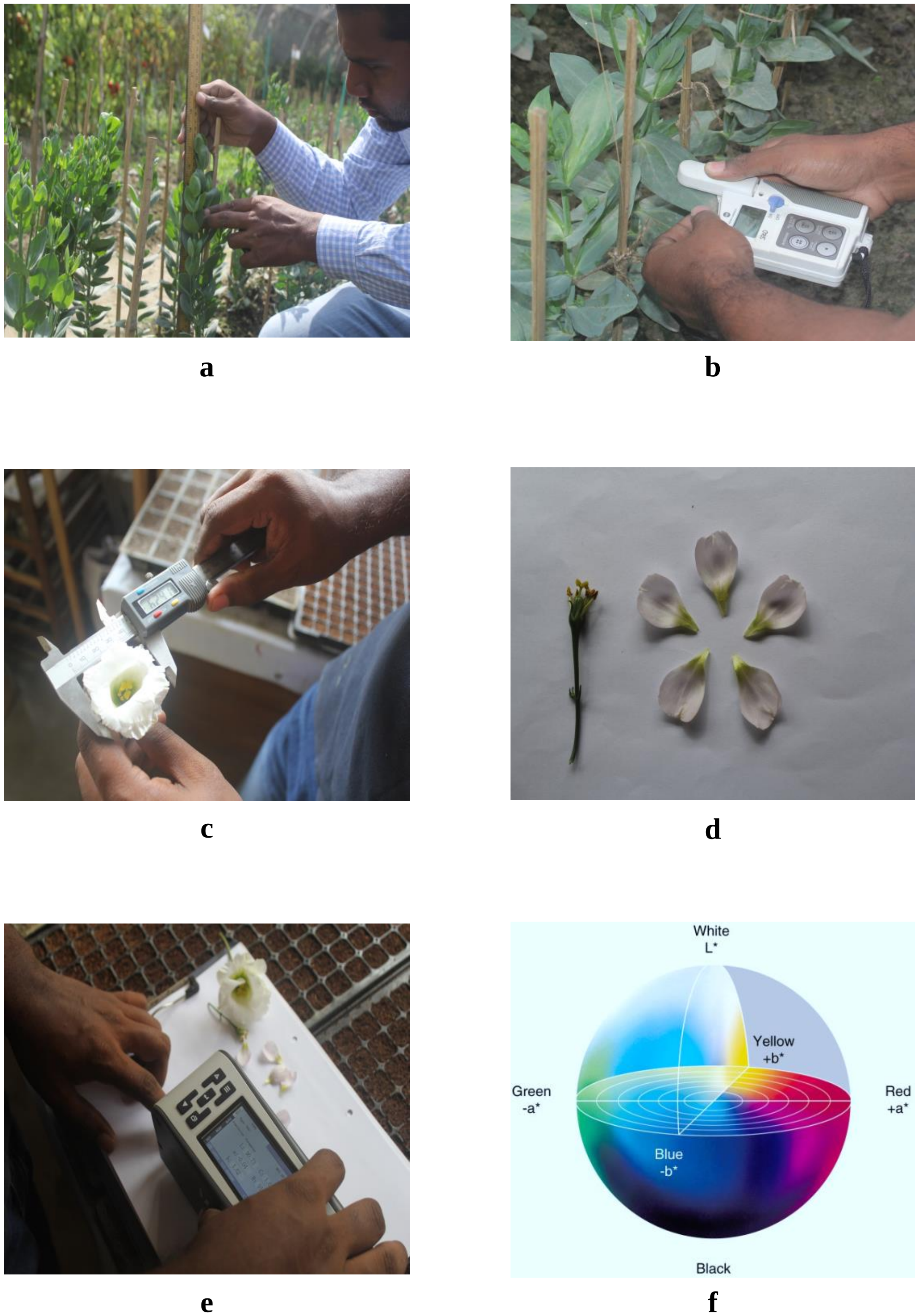

Plate 2. Photographs showing, **a.** Measurement of plant height using measuring scale, **b.** Chlorophyll % measurement using SPAD-502 chlorophyll meter, **c.** Measurement of flower head diameter using Digital Caliper-515, **d.** Counting no. of petals in a single flower, **e.** CIELab color co-ordinate measurement of flower petals using IWAVE WF32 precision colorimeter (Shenzhen Wave), **f.** CIELab color scale

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

The aim of this research works is to screen out suitable Lisianthus lines for commercial production in Bangladesh by studying their growth, floral behavior and petal coloration. Variation in the studied parameters was observed among the lines due to their different genetic makeup. This contrasting attributes were presented and discussed in this chapter. Some of the characters were presented in tables and some presented in figure for easier comprehension of the findings. A summary of analysis of variances in respect of all parameters was presented in the appendices. Results have been presented, discussed and possible interpretation was presented under the following heads:

4.1 Parameters

4.1.1 Rosette %

Seedlings grown in the growth chamber under controlled environment showed considerable variation in case of resetting among different lines (Appendix I). The highest percentage (17.7) was observed in L_{12} and the minimum percentage was found in L_8 (4.7) (Figure 2). Harbaugh *et al.* (2000) also observed similar variations in rosetting among different cultivars with highest observed in Heidi Wine Red' (35%) followed by 'Flamenco Wine Red' and 'Mariachi Pink' (29%) and 'Avila Purple' (0%), 'Alice Pink' (1%) and 'Avila Rose' (3%) the lowest.

4.1.2 Plant height

Significant variation was observed among the different lines of Lisianthus in case of plant height at maturity (Appendix I). The tallest plant was observed in L_9 (68.8cm) followed by L_8 (65.9cm) and the shortest plant was observed in L_{15} (40.3 cm) (Table 1). Genotype and environmental factors plays an important role to regulate plant height along with it's over all performances. Similar results were also observed by Uddin *et al.* (2013) in evaluation of seven Japanese Lisianthus lines grown in Bangladesh and stated that plant height of lisianthus is genetically controlled.

Variation in plant height among different lines was also observed in chrysanthemum (Kumar, 2014 and Kim *et al.*, 2014), in marigold (Raghuvanshi *et al.*, 2011) and in rose (Hussain and Khan, 2004, Ramzan *et al.,* 2014).

4.1.3 Number of leaves

Number of leaves showed significant variation in the lisinathus lines under study (Appendix I). Maximum number of leaves was observed in L_9 (51.7) which was followed by L_8 (49.7) and the minimum was observed in L_{15} (30.3) (Table 1). Lisianthus shows variations in number of leaves among lines as observed by Uddin *et al.* (2015a) during the evaluation of eight lisianthus lines for growth, flowering and seed production. Variation in number of leaves among lines was also observed in rose (Manjula, 2005,; Ahmad *et al*, 2011 and Paramagoudar, 2010), in chrysanthemum (Wilfret *et al.*, 1973 and Uddin *et al*. 2015b) in carnation (Pralhad, 2009; Gharge *et al.* 2011 and Tarannum and Naik, 2014), in gerbera (Kannan and Ramdas, 1990: Kumar and Kumar, 2001; Singh and Ramachandran, 2002; Singh and Mandhar 2002; Pattanashetti, 2009; Kumari *et al*., 2010; Mahmood *et al*. 2013 and Shruti *et al.* 2013). There is a relatively positive co-relation between the number of leaves and plant height (Sankar *et al.,* 2003) as observed in gerbera. The prime function of the leaves is the production of food for plant through the process of photosynthesis. The more photosynthates are produced the more the plant can divert these energies to its yield. Higher number of leaves adds into the overall photosynthesis process resulting in higher food production and ultimately profuse flowering.

4.1.4 Number of stems

Number of stems showed significant inequality in different lines of lisianthus under study (Appendix II). Maximum number of stems was observed in L_{10} (6.7) which was followed by L_{13}, L_{14} and L_2 (6.7, 6.3, 6.0 and 6.0 respectively) and the lowest was observed by L_8 (4.0) (Table 1). Similar variation was also observed by Uddin *et al.* (2015a) in his study on growth, flowering and seed production of eight lisianthus lines. Variation in stem number was also found in rose (Tabassum *et al*., 2002; Manjula. 2005; Paramagoudar, 2010; Ramzan *et al*., 2014 and Shahrin *et al*., 2015), in chrysanthemum (Schoellhorn *et al.* (1996) and Uddin *et al*., 2015b), in china aster (Zosiamliana *et al*., 2012 and Munikrishnappa *et al*., 2013) in carnation (Pralhad, 2009; Gharge *et al*., 2011; Singh *et al*., 2013 and Tarannum and Naik, 2014). Number of stems plays an important role towards the total productivity of plants particularly in the case of cut flowers. Higher number equals to higher number of harvestable flowering stem.

4.1.5 Chlorophyll percentage (%)

Chlorophyll percentage varied significantly among the different lisianthus lines under study (Appendix V). The highest percentage of chlorophyll observed in SPAD was expressed by L_5 (60.5%) followed by L_9 (58.3%) and L_8 (54.8%) whereas the lowest was observed in L_{15} (33.3%) (Table 1). Uddin *et al.* (2015a) also observed similar variation in chlorophyll percentage in his study on eight lisianthus lines. Variation in chlorophyll percentage was also observed in rose (Ahmad *et al.,* 2011, Shahrin *et al.,* 2015), in chrysanthemum (Uddin *et al.* 2015b), in orchid (Thomas and Lekharani, 2008), in Mustard (Datta *et al.* 2011). The difference in chlorophyll level among the lines might be attributed to genetic variations. Chlorophyll content in leaf enhanced photosynthetic activity, which produce carbohydrates. Carbohydrates serve as energy source for growing bud, flower opening and longevity. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower (Tarannum and Naik, 2014).

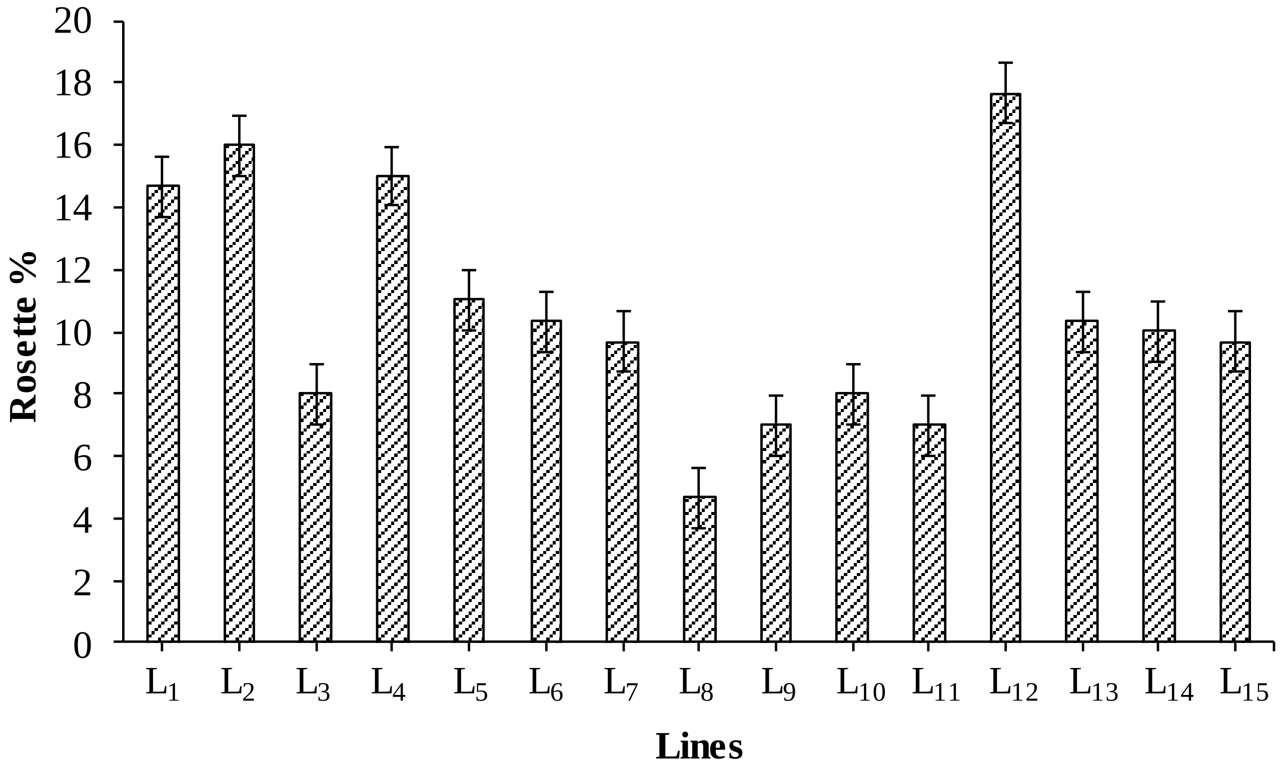

Figure 2. Variation in rosette % among different lisianthus lines

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 1. Performance of lisianthus lines to plant height (cm), number of leaves, number of stem and chlorophyll% **

Lines*	Plant height (cm)	Number of leaves	Number of stem	Chlorophyll %
L_1	55.8 ef	42.0 ef	4.7 efg	44.9 g
L_2	55.7 ef	41.7 ef	6.0 abc	48.6 e
L_3	63.0 bc	47.3 bc	4.3 fg	51.7 d
L_4	45.7 hij	34.3 ij	5.3 cde	36.6 j
L_5	58.1 de	43.7 de	4.7 efg	60.5 a
L_6	48.5 gh	36.3 hi	5.3 cde	46.4 fg
L_7	46.5 hi	34.7 ij	5.7 bcd	39.9 i
L_8	65.9 ab	49.7 ab	4.0 g	54.8 c
L_9	68.8 a	51.7 a	5.0 def	58.3 b
L_{10}	52.7 fg	39.7 fg	6.7 a	47.3 ef
L_{11}	44.1 ijk	33.0 jk	5.7 bcd	43.0 h
L_{12}	60.9 cd	45.7 cd	4.7 efg	51.7 d
L_{13}	50.8 g	38.0 gh	6.3 ab	41.7 hi
L_{14}	42.1 jk	31.7 jk	6.0 abc	35.3 j
L_{15}	40.3 k	30.3 k	5.3 cde	33.3 k
CV%	4.5	4.5	8.2	2.3
LSD (0.05)	4.0	3.0	0.7	1.8

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

** In a column, means having similar letter (s)are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.6 Number of flower bud/stem

Significant variation was found in case of number of flower bud/ branch among different lines of Lisianthus under study (Appendix II). Highest number of flower bud/branch was observed in L_4 (9.0) and the minimum was observed in L_{15} (5.7) (Table 2). Number flower bud varied significantly among the different lines of Lisianthus as stated by Wazir (2014) and Uddin *et al.* (2013). Variation in number of flower bud was also observed in Chrysanthemum (Uddin *et al.*, 2015b). Number of flower bud contributes to the final flower production of a plant. Higher number of flower buds ensures a good number of full bloomed flowers that is one of most important character of lisianthus to be considered as quality cut flowers.

4.1.7 Number of flower/stem

Lisianthus lines displayed significant non-uniformity in case of number of flower/branch (Appendix II). L_{13} showed the highest number of flowers/stem (7.7) and the lowest was observed in L_{10} (4.3) (Table 2). Number of flower/stem in lisianthus ranged from 8 (in 'Balboa Blue Blush' to 18 (in 'Balboa Blue') in the study conducted by Harbaugh *et al.* (2000). Similar variation in number of flowers was observed by Uddin *et al*. (2015a). Variation in flower number is controlled by genotype. Presence of higher number of flowers is not the only criteria for selection of cut flower. Petal compactness along with a suitable and standard stem length also contributes to that selection.

4.1.8 Number of flower/plant

Variation in number of flower/plant was observed among the different lines of lisianthus (Appendix III). Higher number of flowers/plant was observed in L_{13} (47.0) and the lowest was observed in L_8 (18.7) (Table 2). Similar variation was also observed by Wazir (2014); Uddin *et al*. (2013) and Uddin *et al.* (2015a) in their evaluation of different lines of lisianthus. Number of flower buds and flower per stem greatly contributes to the total production of a plant. Lines with higher number of marketable flowers are of importance in screening of any potential cut flower. Variation in number of flowers was also observed in Chrysanthemum (Wilfret *et al.*, 1973 and Punetha *et al.*, 2011), in gerbera (Mahanta *et al.*, 2003; Reddy *et al.*, 2003; Chobe *et al.*, 2010 and Mahmood *et al.*, 2013), in china aster (Munikrishnappa *et al.*, 2013), in carnation (Reddy *et al.*, 2003; Gharge *et al.*2011; Maitra and Roychowdhury., 2013 and Singh *et al.* 2013), in rose (Tabassum *et al.*, 2002; Paramagoudar, 2010; Nadeem *et* al., 2011; Ramzan *et al.*, 2014 and Shahrin *et al.* 2015).

4.1.9 Number of petal/flower

Number of petal/flower varied significantly among the studied lisianthus lines (Appendix III). The highest number of petal observed in L_3 (14.0) followed by L_5 and L_9 (12.0 each) and the lowest was observed in L_1, L_{10}, L_{11}, L_{13}, L_{14} and L_{15} (5.0) (Table 2). Lisianthus lines are classified in to single and double according to the number of petals in flower. Single flowers generally consists 5-6 petals and 9 or more petals are present in doubles. Harbaugh *et al.* (2000) found large variation in the number of petals of lisianthus lines with doubles having a range of 9 (in 'Catalina Blue Blush') to 28 (in 'Avila Rose'). A varietal study of eight lisianthus lines was conducted by Uddin *et al.* (2015a), who stated that petal number varied significantly among lisianthus lines. Number of petals and their arrangement is an essential point in assessing the consumer's attitude towards selecting the flower. A good number of petals give a flower a compact appearance that contributes towards its marketability. Depending on the number of petals lisianthus is divided in to single and double flowers and each division has a different consumer preference. But slow and uniform opening along with good petal arrangement gives a flower better consumer acceptance. Petal number variation among lines was also observed in rose (Tabassum *et al.*, 2002; Manjula, 2005; Paramgouder, 2010; Khattak *et al.* 2011; Ranchana *et al.*, 2014 and Shahrin *et al.*, 2015) and carnation (Pralhad, 2009).

4.1.10 Days to flower bud initiation

Significant inequality was observed in case of days required for flower bud initiation among different lines of lisianthus (Appendix III). The minimum days required for flower bud initiation was observed in L_1 (44.3) and L_4 took maximum days (64.7) to do the same (Table- 2). Wazir (2014) also observed similar variation in days to visible flower bud and stated that these variations were primarily controlled by genotype. Genetic buildup of a line plays a major role in the exhibition of floral characters of a flowering plant. Uddin *et al.* (2015a) also found similar variations that confirms to the findings of this study. Variations in days to flower bud initiation was also observed in flowers like rose (Manjula, 2005 and Paramagoudar, 2010), in chrysanthemum (Uddin *et al.*, 2015b), in gerbera (Pattanashetti, 2009), in carnation (Pralhad, 2009; Maitra and Roychowdhury, 2013 and Tarannum and Naik, 2014). Lines that produce early flowering bud can be sorted as early lines and the others as late.

4.1.11 Days to full bloom

Significant variation was exposed in case of days required for complete blooming of the flowers produced by the different lisianthus lines (Appendix IV). Maximum days required from bud initiation to full bloom was observed in L_6 (23.3) whereas the minimum days (14.0) was required by L_{11} (Table 2). Variation in days required for complete blooming was also observed by Wazir (2014) and he expressed that lisianthus lines generally require 25-35 days from visible bud stage to complete bloom. The findings of Uddin *et al.* (2013) in case of days to full bloom of flower in his study of seven Japanese lisianthus lines grown in Bangladesh also agreed with the result of this study. He stated that flowering times in lisianthus are affected by varietal characters, habitat and species type. Variation in completion of bloom from bud initiation stage was also observed in chrysanthemum (Kim *et al.*, 2014 and Uddin *et al.*, 2015b). Even though single lines had fewer petals than the double ones, some of the single lines took longer time to unfurl their petals compared to the doubles. This suggests that days required for bud initiation and from there to complete bloom is primarily controlled by the genetic buildup of different lines.

Table 2. Performance of lisianthus lines to number of flower bud/stem, number of flower/stem, number of flower/plant, number of petal/flower, days to flower bud initiation and days to full bloom **

Lines*	No. of flower bud/ stem	Number of flower/ stem	Number of flower/ plant	Number of petal/ flower	Days to flower bud initiation	Days to full bloom
L_1	8.7 ab	6.7 bcd	28.3 f	5.0 e	44.3 j	18.3 cde
L_2	8.0 bc	7.0 abc	40.3 b	6.0 c	48.0 i	20.3 abc
L_3	6.0 fg	5.0 fg	20.3 h	14.0 a	51.7 g	21.3 ab
L_4	9.0 a	7.0 abc	35.7 c	5.3 de	64.7 a	17.0 def
L_5	7.0 de	5.7 ef	19.7 h	12.0 b	62.0 bc	21.7 ab
L_6	7.7 cd	5.7 ef	28.3 f	5.7 cd	49.0 hi	23.3 a
L_7	8.7 ab	7.3 ab	38.7 b	5.3 de	51.0 gh	19.0 bcd
L_8	6.7 ef	4.7 g	18.7 h	12.0 b	54.0 f	22.0 a
L_9	7.7 cd	6.3 cde	29.3 ef	12.0 b	52.7 fg	16.0 efg
L_{10}	6.7 ef	4.3 g	25.3 g	5.0 e	60.0 cd	21.0 abc
L_{11}	7.7 cd	5.7 ef	31.3 de	5.0 e	60.7 bcd	14.0 g
L_{12}	8.0 bc	6.0 de	24.7 g	12.0 b	57.3 e	21.0 abc
L_{13}	8.7 ab	7.7 a	47.0 a	5.0 e	59.0 de	15.3 fg
L_{14}	7.7 cd	5.7 ef	33.0 d	5.0 e	62.3 b	22.7 a
L_{15}	5.7 g	5.0 fg	23.7 g	5.0 e	61.3 bc	23.0 a
CV%	6.7	7.2	5.2	3.2	2.2	7.9
LSD (0.05)	0.8	0.8	2.6	0.4	2.0	2.6

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

** In a column, means having similar letter (s)are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.12 Flower head diameter

Variation in flower head diameter was observed during the study of different lisianthus lines after full bloom (Appendix IV). The maximum flower head diameter was observed in L_9 (7.3 cm) followed by L_8 and L_3 (6.9 cm and 6.6 cm respectively) and L_{15} showed the minimum (3.2 cm) (Table 3). Similar variation in flower head diameter was also observed by Harbaugh *et al.* (2000), Wazir (2014) and Uddin *et al.* (2015a). Wazir (2014) found Cultivars "Gavotte Yellow" and "Bolero White" resulted in maximum flower size (9.2 and 9.0 cm respectively) owing to their double character whereas cv "Flamenco Blue" exhibited the smallest flower size (5.7 cm) because of its single petals. Uddin *et al.* (2015a) found maximum head diameter (7.1 cm) from line "White-pink", and minimum (3.6 cm) from "Pink". Harbaugh (2000) stated that breeders have introduced some lisianthus with small flowers as a new category. Within that class, smaller flowers are desirable. For others, larger are considered best in ranking.

4.1.13 Stem diameter

Documented stem diameter showed significant statistical variation among different lines of lisianthus under study (Appendix IV). The thickest flower stem was expressed by L_9 (5.4 mm) to which L3 showed statistical similarity (5.2 mm) followed by L_{12} and L_5 (4.8 mm and 4.5 mm respectively) and the minimum was observed in L_6 (2.7 mm) (Table 3). This variation in stem diameter was also documented by Harbaugh (2000) and Uddin *et al.* (2015a) who stated that stem thickness or diameter varies from line to line. Stem diameter is an important character of an ideal cut flower. A good diameter ensures the strength of the stem that will hold the blooming flowers. Also higher diameter will ensure a good surface area for absorption of water when cut for the vase extending the vase life. Stalk diameter and number of leaves had the greatest positive direct effect on cut flower yield (Anuradha and Narayanagowda, 2002).

4.1.14 Stem length

Stem length of different lisianthus lines under study exposed significant variations (Appendix V). The longest stem was shown by L_9 (53.5 cm) and the shortest stem was observed in L_4 (24.3 cm) (Table 3). Uddin *et al.* (2015a) found stem length variation ranging from 45.7 cm to 25.0 cm in his study on eight lisianthus lines which confirms the findings of this experiment. Wazir (2014) also found variations among the different lisianthus lines during his evaluation of lisianthus. This difference in stalk length could be attributed to a genetic factor which is expected to vary among cultivars. Stem length is the single most important factor in ensuring quality of a cut flower. A longer stem ensures strength and flexibility for arrangement in a bouquet as well as in vase. Variation in stem length was also observed in rose (Mantur *et al.,* 2005; Fascella and Zizzo, 2005; and Ramzan *et al*., 2014), in chrysanthemum (Uddin *et al.,* 2015b), in gerbera (Jeevajothi *et al.,* 2003; Sharkar and Gimaray, 2004).

4.1.15 Vase life

Vase life showed significant variation in respect to different lisianthus lines under study (Appendix V). Maximum vase life was obtained from L_9 (20.7) followed by L_8 and L_5 (20.3 and 20.0 respectively) and the minimum was obtained from L_{15} (12.0) (Figure 3). Wazir (2014) also observed a vase life range of 12.5 to 18.5 days among different lines of lisianthus that confirms the observed variation in the present study. Similar variation was also observed by Harbaugh (2000), Kuang-Liang Huang (2002) and Uddin *et al.,* (2015a). According to Uddin *et al.,* (2015a) the vase life of lisianthus was 12-25 days which is more than those of rose, tuberose, gladiolus etc. (7-15 days) which is an indication of ideal cut flower. The longevity of cut lisainthus in vase was also reported by Halevy and Kofranek (1984), Ichimura *et al.,* (1998), Ichimura and Korenaga, 1998 and Shimamura and Okabayashi, (1997).The length of vase life is one of the most important factors for quality of cut flowers (Ichimura *et al.,* 2002). Depending on the species flower longevity is varied and the functional life of petals is ended by flower closure, wilting or abscission or changing color of petals prior to wilting or abscission (Van Doorn and Schroder, 1995). Variation in the vase life among the different lisianthus may be due to the different level of self-pollination caused by the varied distance from the stigma to anther (Shimizu and Ichimura, 2002).

Table 3. Performance of lisianthus lines to flower head diameter (cm), stem diameter (mm) and stem length (cm)**

Lines*	Flower head diameter (cm)	Stem diameter (mm)	Stem length (cm)
L_1	5.3 e	3.9 e	39.4 de
L_2	4.6 g	4.1 de	39.3 de
L_3	6.6 c	5.2 a	46.7 bc
L_4	3.6 i	3.1 h	24.3 i
L_5	6.0 d	4.5 bc	41.8 cd
L_6	4.0 h	2.7 i	32.2 fgh
L_7	3.6 i	4.1 de	29.9 ghi
L_8	6.9 b	4.8 bc	49.3 ab
L_9	7.3 a	5.4 a	53.5 a
L_{10}	4.9 f	4.4 cd	36.7 def
L_{11}	4.0 h	3.7 ef	28.1 hi
L_{12}	6.1 d	4.8 b	44.9 bc
L_{13}	5.0 f	3.5 fg	34.8 efg
L_{14}	3.9 h	4.6 bc	26.1 i
L_{15}	3.2 j	3.2 gh	29.4 ghi
CV%	2.6	5.0	8.2
LSD (0.05)	0.2	0.3	5.1

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

** In a column, means having similar letter (s)are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

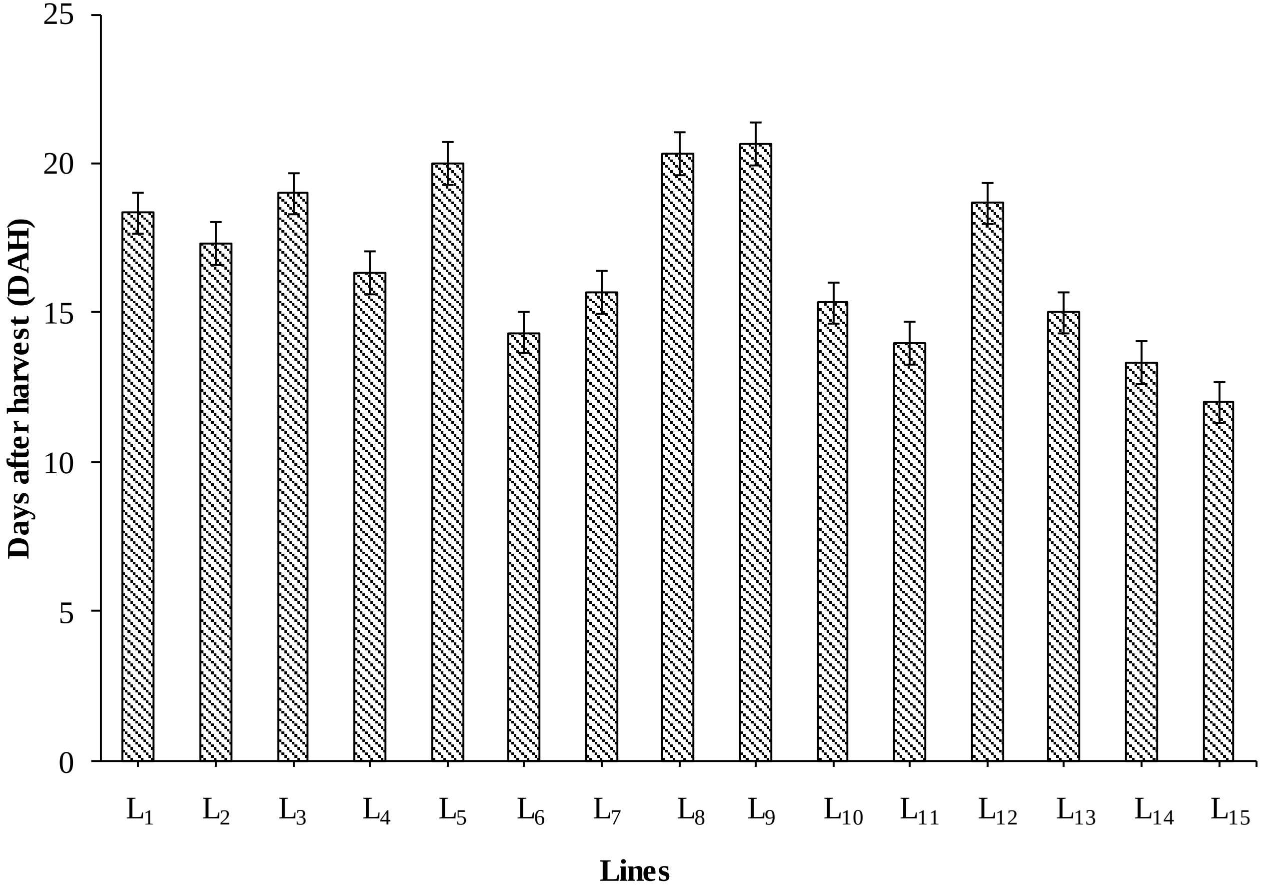

Figure 3. Vase life variation of different lisianthus lines after harvest (in fresh water)

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

4.2 Colorimetric measurement of lisianthus lines under study using CIELab

The colorimetric measurement of the fifteen lisianthus lines under study were conducted using a precision colorimeter IWAVE WF32 (Shenzhen Wave) and L* (lightness), a* and b* (two Cartesian coordinates) including C* and h_{ab} (Chroma & Hue angle) based on CIELab scale with standard observer 10^0 and standard illumination D65 (CIE, 1986; McGuire, 1992). The respective data for each of the lines were presented in Table 4.

Table 4. Variations in petal color attributes in different lisianthus lines

Lines*	L*	a*	b*	c*	h_{ab}	Illustration
L_1	99.556	0.005	-0.010	0.011	296.565	
L_2	97.730	0.920	-3.370	1.759	19.146	
L_3	98.644	-0.690	1.897	2.019	109.988	
L_4	90.453	15.233	-2.572	15.449	350.416	
L_5	99.157	-4.158	1.236	4.338	163.445	
L_6	98.482	-2.112	-1.289	2.474	211.397	
L_7	77.727	37.465	-4.165	37.696	353.656	
L_8	72.632	44.737	2.686	44.818	3.436	
L_9	36.200	5.590	-13.180	14.320	292.990	
L_{10}	45.430	17.390	-37.120	41.000	295.100	
L_{11}	44.390	6.160	-38.190	38.680	279.170	
L_{12}	58.300	12.030	-32.700	34.850	290.200	
L_{13}	44.840	24.060	-38.810	45.670	301.800	
L_{14}	35.320	24.450	-21.700	32.690	318.420	
L_{15}	96.068	5.893	-0.604	5.924	354.148	

*Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

4.3 Ranking lisianthus lines

The fifteen lisianthus lines under study were scored on the basis of some critical parameters primarily focused on standard cut flower characteristics like flower head diameter (cm), stem length (cm) and vase life (days). The grade is ranged from 1 to 5 and with 5 being the highest grade meaning any line attaining the desirable quality was given the grade 5. After grading all the parameters, all the scores were summed for each line to find the total score obtained by the respective line. This total score was used as the basis for ranking the lines.

On the basis of the total score the lisianthus line L_9 was found to be the best obtaining a score of 15 (highest total) followed by L_8, L_3, L_5 and L_{12} (14, 13, 12 and 12 respectively) (Table 4 and 5). On the other hand, line L_{15} was found to have obtained the lowest score (6) for the parameters (Table 4 and 5). This identification will act as basic information for conducting experiment by the breeders as well as help farmers choosing the line for commercial production.

Table 5. Scoring of different lisainthus lines according to their performance

Line*	Flower head diameter (cm)	Stem length (cm)	Vase life (days)	Total score	Ranking
L_1	3	3	4	10	3
L_2	3	3	4	10	3
L_3	5	4	4	13	2
L_4	2	2	4	8	4
L_5	4	4	4	12	2
L_6	2	3	3	8	4
L_7	2	2	4	8	4
L_8	5	4	5	14	2
L_9	5	5	5	15	1
L_{10}	3	3	4	10	3
L_{11}	2	2	3	7	4
L_{12}	4	4	4	12	2
L_{13}	3	3	3	9	3
L_{14}	2	2	3	7	4
L_{15}	1	2	3	6	5

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Flower head diameter (cm): > 6.5= 5, 5.6-6.5= 4, 4.6-5.5= 3, 3.6-4.5= 2, 2.6-3.5= 1, <2.6= 0

Stem length (cm): > 50= 5, 41-50= 4, 31-40= 3, 21-30= 2, 11-20= 1, <10= 0

Vase life (days): > 20= 5, 15-20= 4, 10-14= 3, 5-9= 2, 4-5= 1, < 4= 0

Table 6. Ranking of 15 lisianthus lines

Lisianthus lines*	Ranking
L_9	1
L_3, L_5, L_8, L_{12}	2
L_1, L_2, L_{10}, L_{13}	3
L_4, L_6, L_7, L_{11}, L_{14}	4
L_{15}	5

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

4.4 Cluster analysis:

Dendrogram is a branching diagram that graphically represents the relationships of similarity among a group of entities. Each branch is called clad and each terminal portion is called leaf. Clades can have just one leaf (these are called *simplicifolious*, a term from botany that means "single-leafed") or they can have more than one. Two-leaved clades are *bifolious*, three-leaved are *trifolious*, and so on. There is no limit to the number of leaves in a clade. The arrangement of the clades tells us which leaves are most similar to each other. The length of the branch points indicates how similar or different they are from each other: the greater the height, the greater the difference.

The result of cluster analysis of the fifteen lisianthus lines under study based on some important morphological characteristics of a cut flower is expressed graphically by dendrogram in Figure 4.

The studied lines were arranged randomly into different groups based on some important traits (number of flower/plant, number of petal/flower, stem length, vase life) of ideal cut flower. Based on these, the lines were primarily divided to two major group *viz.* A & B. Each of this group is further divided to two clusters *viz*. I & II and III & IV. Each line also acted as its own cluster. Cluster I included one line (L_9) making it the smallest cluster and Cluster II contained four lines (L_3, L_5, L_8, and L_{12}). Within cluster II the four lines showed closeness in all the considered parameters in 1 point average linkage distance thus forming the group. At average linkage distance of 3, cluster II links with cluster one on the basis of similarity in number of petal thus forming the group A.

The lines L_4 and L_7 showed relative closeness in the considered parameters thus linked together at 1 point average linkage distance. L_2 and L_{13} linked at average linkage distance point 2 showing closeness in stem length parameter. Both this sub-cluster linked together at 3 point average linkage distance with L_1 on the basis of vase life parameter forming the cluster III.

Cluster IV contained five lines (L_6, L_{10}, L_{11}, L_{14} and L_{15}). L_6 and L_{10} showed closeness linking at point 1. Similarly, L_{11} and L_{14} also linked at average linkage distance of 1. On the basis of vase life parameter, this two sub-cluster links together along with L_{15} at point 2.

Cluster III and IV links together at average linkage distance of 6 on the basis on number petal/flower thus forms the group B.

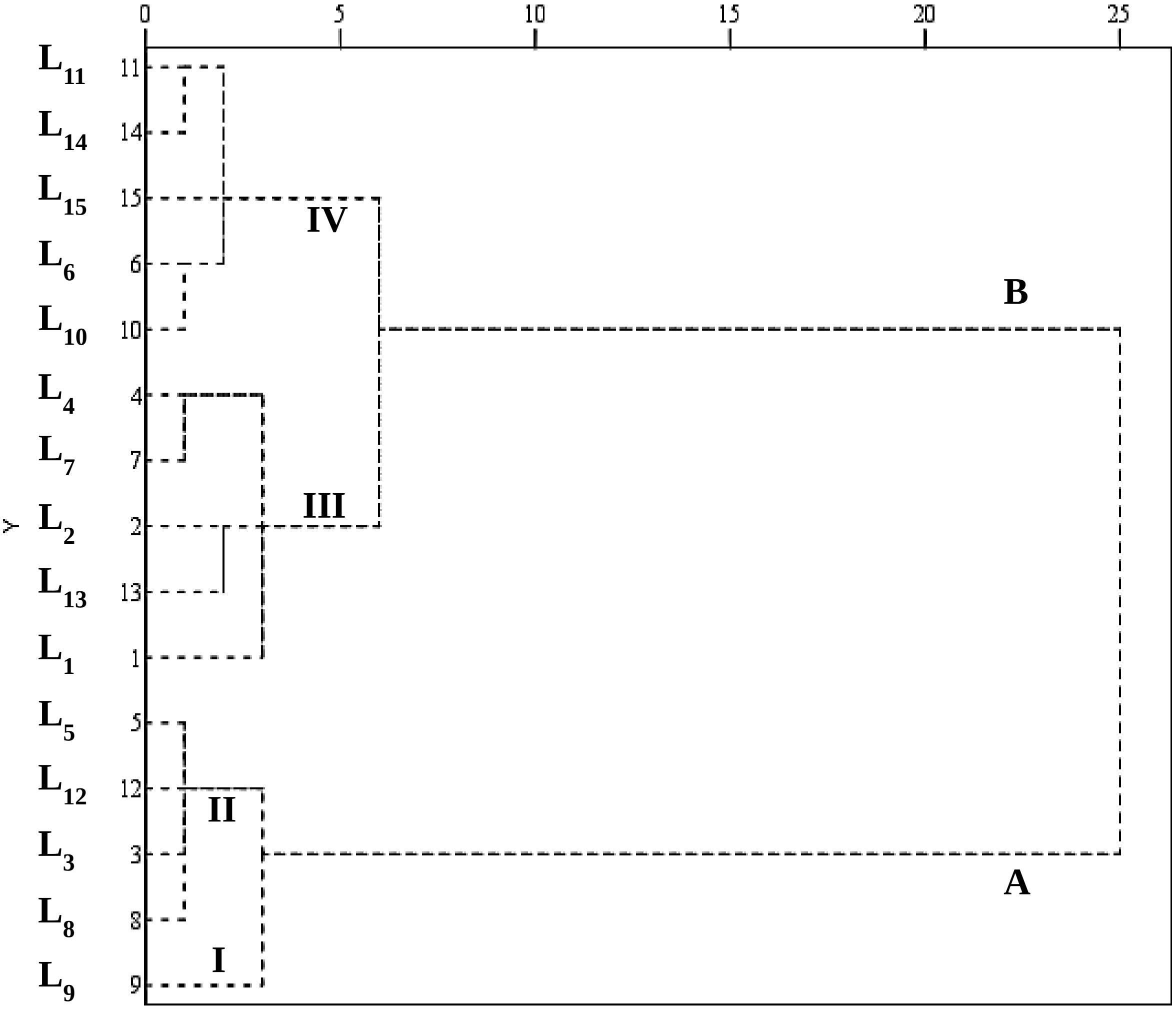

Figure 4. Dendogram of fifteen lisianthus lines using Ward's Method with rescaled distance cluster combine on the basis of average linkage between groups. Two major groups were found (A & B) at linkage distance of 25. Both group further subdivided to two cluster (I & II) and (III & IV) at average linkage distance of 3 and 6 respectively.

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

4.5 Classification of lisianthus lines

4.5.1 Classification of lisianthus lines according to color

On the basis of number of color present in petals, the studied lisianthus lines were classified in to two groups following UPOV standard (Appendix VI).

i) **One color:** Ten lines of lisianthus among the fifteen under study showed one color throughout the petal. L_1, L_2, L_3, L_5, L_6, L_8, L_9, L_{12} and L_{15} lines belong to this category (Table 7), (Plate 3A).

ii) **Bi-color:** Five lines among the fifteen lisianthus lines under study showed bi-color. Primary color was present upper portion of the petal or closer to the tip whereas the secondary color was present between the base and primary color. L_4, L_7, L_{10}, L_{11}, L_{13} and L_{14} lines belong to this category (Table 7), (Plate 3B).

The studied lisianthus lines were further classified in to six groups according to their visual color. For visual distinction color was measured by observation. In case of bi-color lines, the distinctive color of the upper portion of the petal was considered.

i) **White to whitish:** Five among the fifteen lines of lisianthus studied in this experiment belongs to this category. L_1, L_2, L_3, L_5 and L_6 were found to have white color with the last two with light lemonish vibe (Table 8), (Plate 4A).

ii) **Pink:** Three lines among the fifteen were found to belong to this color range. L_4, L_7 and L_8 were pink in color (Table 8), (Plate 4B).

iii) **Violet:** Among the fifteen lines of lisianthus studied in this experiment, four lines were found to have violet color. L_9, L_{10} and L_{12} expressed violet color with the last line showing little lightness compared to other three (Table 8), (Plate 5A).

iv) **Blue:** One line among the fifteen belonged to this color range. L_{11} expressed the blue color (Table 8), (Plate 4C).

v) **Purple:** Two lines of lisianthus among the fifteen under study showed purple color. L_{13} and L_{14} belong to this category (Table 8), (Plate 5B).

vi) **Lavender:** One line of lisianthus among the fifteen under observation showed lavender color. The line L_{15} belongs to this category (Table 8), (Plate 5C).

According to color of the petal base the studied lines were divided into three categories following UPOV standard (Appendix VI).

i) **Green:** Eleven out of the fifteen lisinthus lines under study showed green petal base. L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_{10}, L_{11}, L_{13} and L_{14} lines belongs to this category (Table 9), (Plate 6A).

ii) **Violet:** Three out of the fifteen lisianthus lines under study showed violet petal base. L_8, L_9 and L_{12} lines belong to this category (Table 9), (Plate 6B).

iii) **Brown:** One out of fifteen lisianthus lines under study showed brown petal base. L_{15} line belongs to this category (Table 9), (Plate 6C).

4.5.2. Classification of lisianthus lines according to number of petals

According to number of petals, the studied lisianthus lines were divided in to two classes.

i) **Single:** Lisianthus lines exhibiting flowers with 5-6 petals were considered to belong to this category. The lines L_1, L_2, L_4, L_6, L_7, L_{10}, L_{11}, L_{13}, L_{14} and L_{15} belongs to this class having a petal number range from 5 to 6 (Table 10), (Plate 7A).

ii) **Double:** Lines showing 10 or more petals were considered to belong to this category. L_3, L_5, L_8, L_9 and L_{12} lines belong to this class with petals number ranging from 10 to 14 (Table 10), (Plate 7B).

4.5.3 Classification of lisianthus lines according to the shape of leaves

The lisianthus lines under study were divided in to four classes according to the shape of the leaves following the UPOV standard (Appendix VII).

i) **Lanceolate:** Two lines among the fifteen under study showed this type of leaf shape. L_1 and L_3 line belong to this class (Table 11), (Plate 8A).

ii) **Ovate:** Eight lines of lisianthus among the fifteen under study showed ovate shaped leaves. L_2, L_4, L_6, L_7, L_9, L_{10}, L_{11} and L_{12} belong to this class (Table 11), (Plate 8B).

iii) **Broad ovate:** Among the studied lisianthus lines five showed broad ovate shaped leaves. L_5, L_8, L_{13}, L_{14} and L_{15} lines belong to this class (Table 11), (Plate 8C).

4.5.4 Classification of lisianthus lines according to days required to flowering

The studied lisianthus lines were classified in to three groups according to total days required for flowering from transplanting.

i) **Early (≤70 days):** Lisianthus lines that took 70 days or less than that time for flowering from transplanting were placed in this group. L_1, L_2, L_7 and L_9 lines belong to this group (Table 12).

ii) **Mid (71-80 days):** Lines that flowered between 70 to 80 days after transplanting belongs to this group. Lines L_3, L_6, L_8, L_{11}, L_{12} and L_{13} belong to this group (Table 12).

iii) **Late (> 80 days):** Lines that took more than 80 days to flower after transplanting belong to this group. Lines L_4, L_5, L_{10}, L_{14} and L_{15} belong to this group (Table 12).

4.5.5 Classification of lisianthus lines according to vase life

According to the longevity of cut stems in the vase, the lisianthus lines under study were classified in to two classes.

i) **Class one (> 2 weeks):** Lisianthus lines with vase life more than 14 days were placed in this class. The lines L_1, L_2, L_3, L_4, L_5, L_7, L_8, L_9, L_{10}, L_{12} and L_{13} belong to this class (Table 13).

ii) **Class two (≤ 2 weeks):** Lines with vase life less or up to 14 days were placed in this class. L_6, L_{11}, L_{14} and L_{15} lines belongs to this class (Table 13).

Table 7. Classification of lisianthus lines according to "Number of color present in petals"

Sl. No.	Color	Lines*
1	One color	L_1, L_2, L_3, L_5, L_6, L_8, L_9, L_{12}, L_{15}
2	Bi-color	L_4, L_7, L_{10}, L_{11}, L_{13}, L_{14}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 8. Classification of lisianthus lines according to "Primary petal color"

Sl. No.	Color	Lines*
1	White to whitish	L_1, L_2, L_3, L_5, L_6
2	Pink	L_4, L_7, L_8
3	Violet	L_9, L_{10}, L_{12}
4	Blue	L_{11}
5	Purple	L_{13}, L_{14}
6	Lavender	L_{15}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 9. Classification of lisianthus lines according to "Petal base color"

Sl. No.	Color	Lines
1	Green	L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_{10}, L_{11}, $L_{13,}$ L_{14}
2	Violet	L_8, L_9, L_{12}
3	Brown	L_{15}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 10. Classification of lisianthus lines according to "Number of petals"

Sl. No.	Type	Lines
1	Single	L_1, L_2, L_4, L_6, L_7, L_{10}, L_{11}, L_{13}, L_{14}, L_{15}
2	Double	L_3, L_5, L_8, L_9, L_{12}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 11. Classification of lisianthus lines according to "Leaf shape"

Sl. No.	Shape	Lines
1	Lanceolate	L_1, L_3
2	Ovate	L_2, L_4, L_6, L_7, L_9, L_{10}, L_{11}, L_{12}
3	Broad ovate	L_5, L_8, L_{13}, L_{14}, L_{15}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 12. Classification of lisianthus lines according to "Days required to flowering"

Sl. No.	Duration	Lines
1	Early	L_1, L_2, L_7, L_9
2	Mid	L_3, L_6, L_8, L_{11}, L_{12}, L_{13}
3	Late	L_4, L_5, L_{10}, L_{14}, L_{15}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Table 13. Classification of lisianthus lines according to "Vase life"

Sl. No.	Duration	Lines
1	Excellent (> 2weeks)	L_1, L_2, L_3, L_4, L_5, L_7, L_8, L_9, L_{10}, L_{12}, L_{13}
2	Standard (≤ 2 weeks)	L_6, L_{11}, L_{14}, L_{15}

* Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

Plate 3. Classification of lisianthus lines according to number of colors present in petal. (A) One color lisianthus, (B) Bi-color lisianthus

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

(A)

L_1

L_2

L_3

L_5

L_6

(B)

L_4

L_7

L_8

(C)

L_{11}

Plate 4.Classification of lisianthus lines according their visual color. (A) White to whitish lines, (B) Pink lines, (C) Blue line

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_{11}= Nandini Blue Vase

(A)

L_9

L_{10}

L_{12}

(B)

L_{13}

L_{14}

(C)

L_{15}

Plate 5.Classification of lisianthus lines according their visual color. (A) Violet lines, (B) Purple lines, (C) Lavender line

Here, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

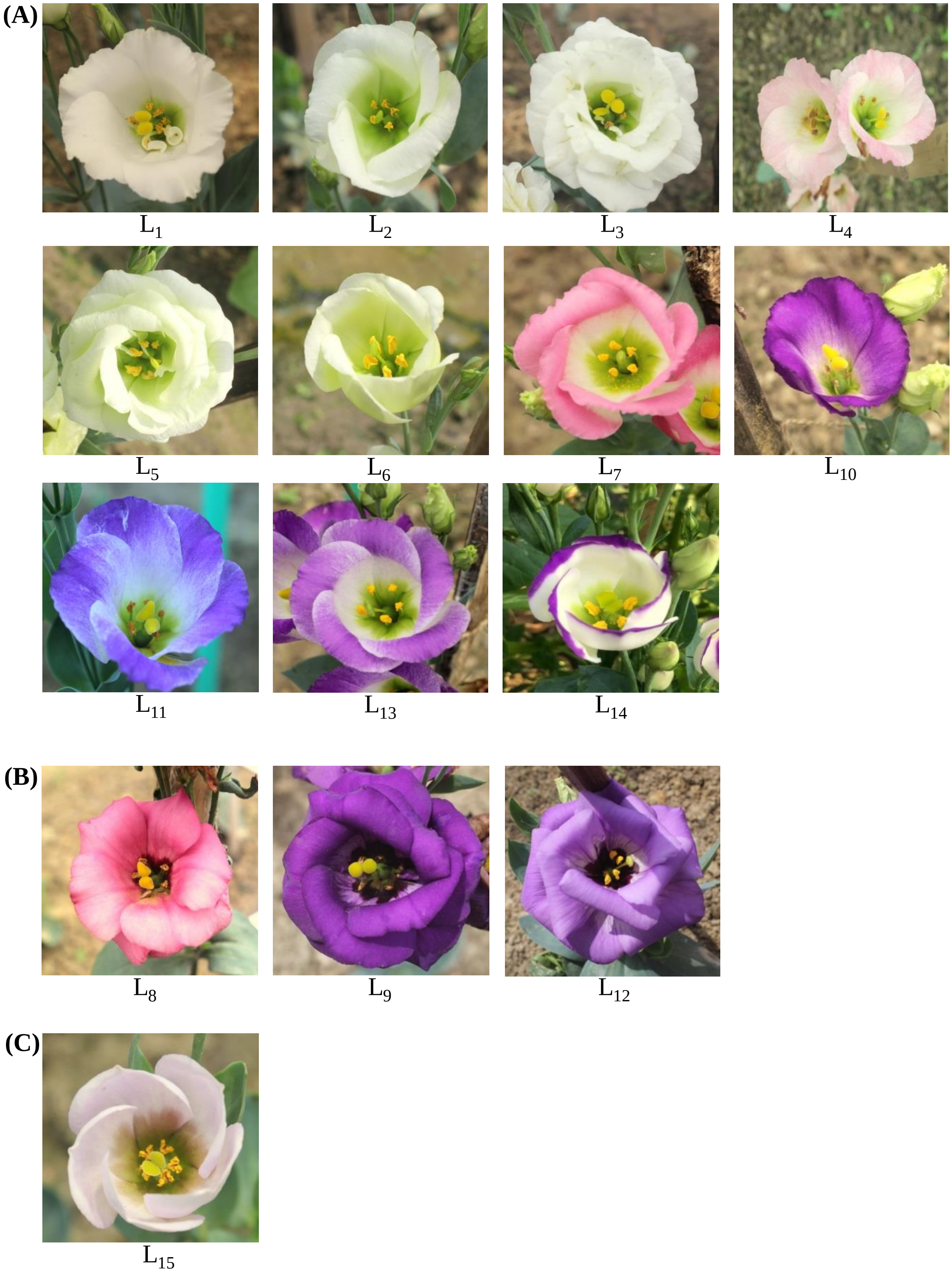

Plate 6. Classification of lisianthus lines according to petal base color. (A) Green petal base, (B) Violet petal base, (C) Brown petal base

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

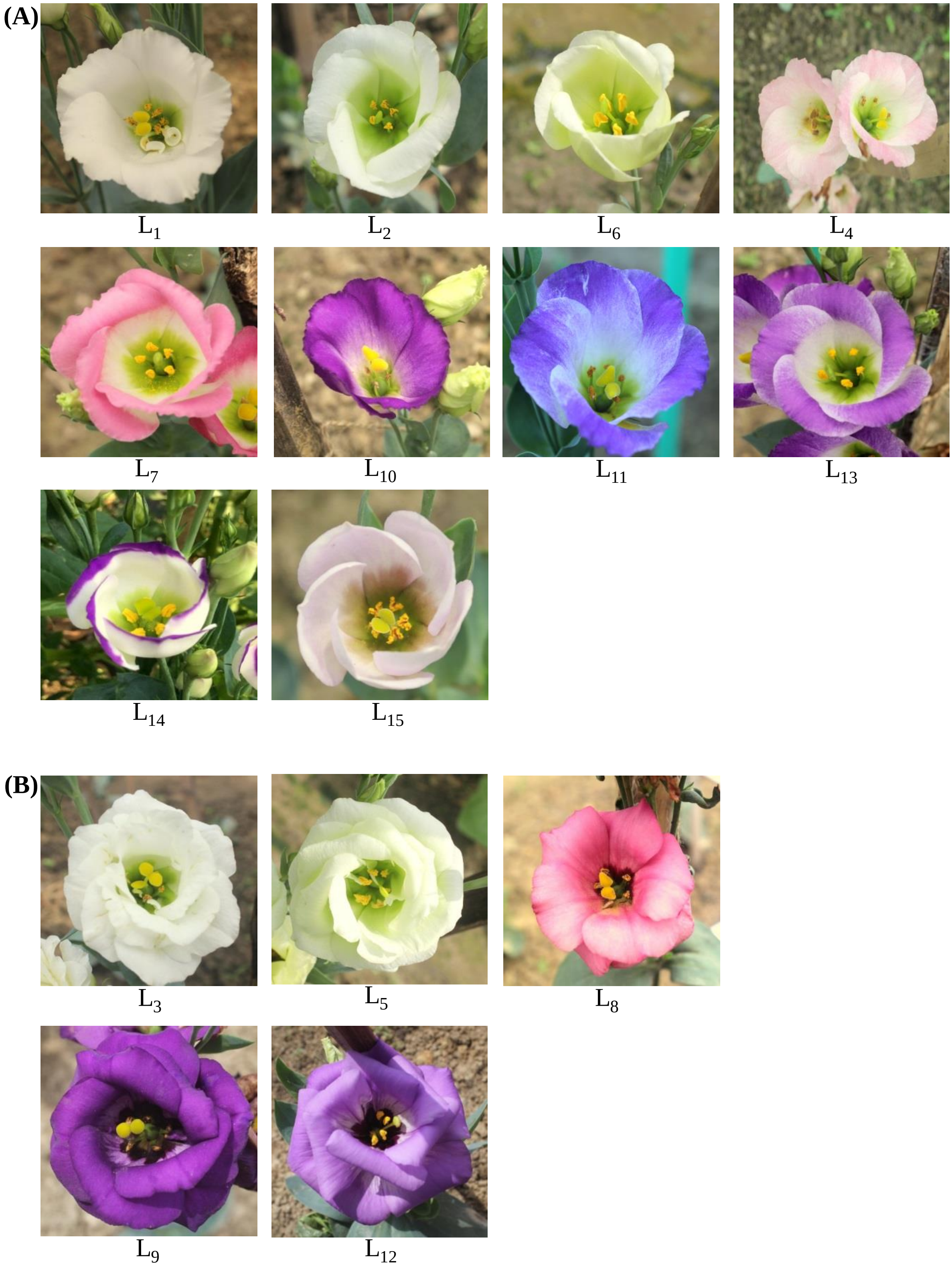

Plate 7. Classification of lisianthus lines according to number of petals. (A) Single, (B) Double

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

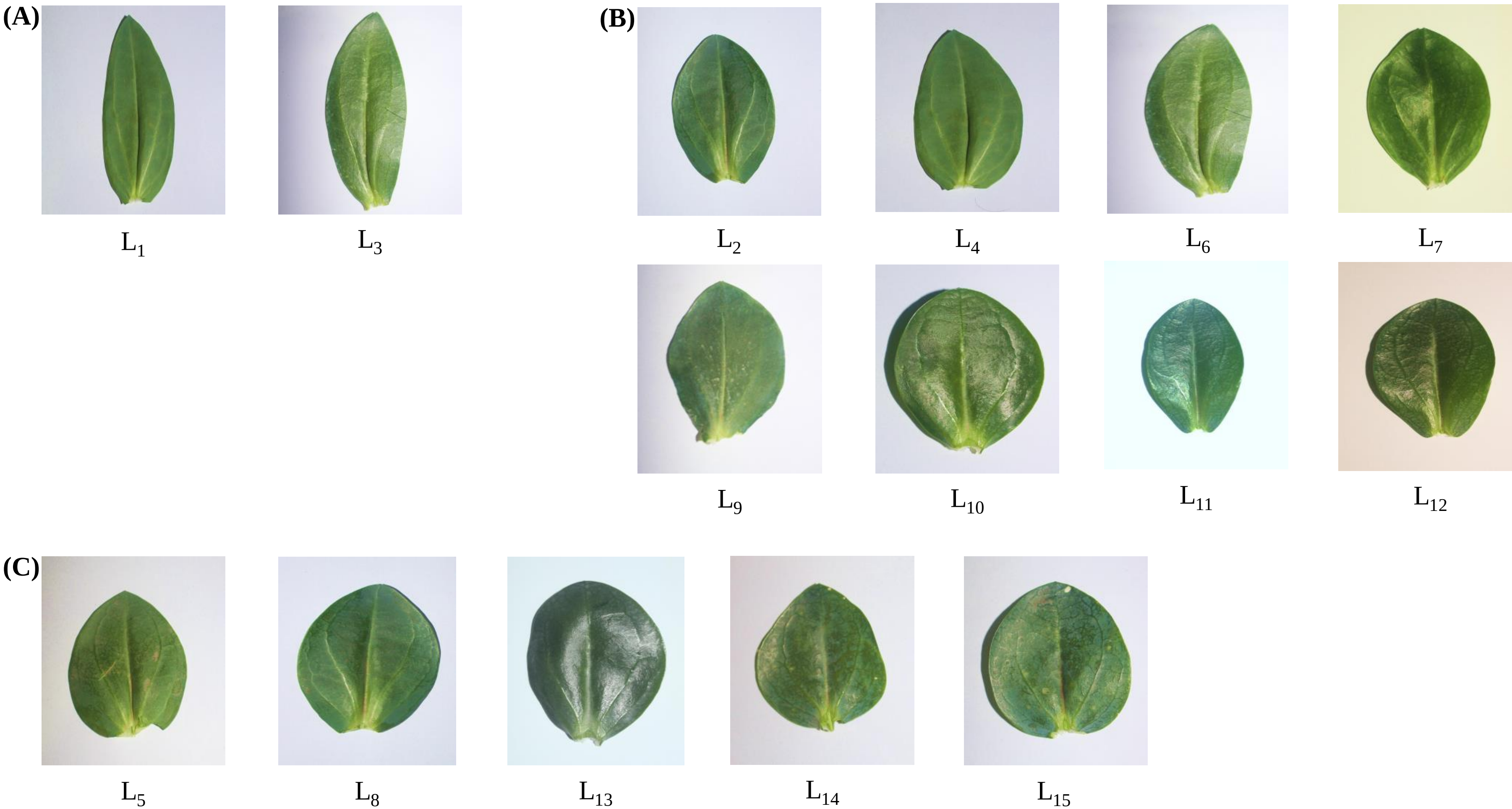

Plate 8. Classification of Lisianthus lines according leaf shape. (A) Lanceolate, (B) Ovate, (C) Broad ovate

Here, L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee, L_{15}= Nandini Lavender

CHAPTER V

SUMMARY AND CONCLUSION

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5.1 Summary

Lisianthus (*Eustoma grandiflorum* Raf. Shinn) originated from North America and is widely grown as an ornamental flower in temperate areas. It is also known as known as Prairie gentian, Texas bluebell, Tulip gentian, bluebells, or lira de san Pedro, is a herbaceous annual, interesting as a new species for the cut flower market. It grows from 15 to 60 cm in height, has bluish green, slightly succulent leaves, and large funnel shaped flowers growing on long straight stems. Lisianthus is particularly popular and has a number of cultivars that are grown for the cut flower market. Lisianthus (*Eustoma grandiflorum*) is becoming one of the most highly ranked cut flower in international markets, due to its rose-like flower shapes and various colors. The vase life of lisianthus flowers is known to be relatively long, but there are cultivar variations. Due to its wide color variation and long vase life, export potentiality of this flower is very high. Bangladesh has a climate that is particularly favorable for production of lisianthus which can enable us to exploit its high demand and boost our flower industry that has recently started its expansion.

For screening out suitable lines for adoption in production, a research was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University to evaluate growth and flowering behavior of different lisianthus lines along with their classification during the period of April, 2016 to October, 2016. Fifteen lisianthus lines *viz.* L_1= Nandini Moonlight, L_2= Nandini Suvro, L_3= Nandini Chandra, L_4= Nandini Pink light, L_5= Nandini Lemon Double, L_6= Nandini Lemon Single, L_7= Nandini Pink Cup, L_8= Nandini Rose, L_9= Nandini Royal Violet, L_{10}= Nandini Violet Single, L_{11}= Nandini Blue Vase, L_{12}= Nandini Ocean violet, L_{13}= Nandini Purple bell, L_{14}= Nandini Purple picotee and L_{15}= Nandini Lavender were used in this experiment and it was arranged in a Randomized Complete Blocked Design (RCBD) with three replications.

All the collected data to the relevant parameters were arranged accordingly and analyzed to evaluate the performance of different lisianthus lines for adoption in Bangladesh. The findings of the experiment are summarized in this segment.

In case of the morphological traits studied, significant variations were observed among the different lines of lisianthus lines under study.

The highest percentage of rosetting was observed from the line L_{12} (17.7) whereas the lowest was observed in L_8 (4.7).

Tallest plant was observed from L_9 (68.8 cm) followed by L_8 (65.9 cm) and the shortest was found from L_{15} (40.3 cm).

Maximum no. of leaves were found in line L_9 (51.7) and the minimum was observed in line L_{15} (30.3).

Highest no. of stems was observed in L_{10} (6.7) followed by L_{13}, L_{14} and L_2 whereas the minimum was observed from L_8 (4.0).

In case of chlorophyll percentage, the highest amount was observed in line L_5 (60.5%) whereas the lowest was found in line L_{15} (33.3%).

L_4 showed the maximum no. of flower bud/stem (9.0) followed by L_1, L_7 and L_7. On the other hand, L_{15} showed the minimum (5.7).

Highest no. of flower/stem was expressed by L_{13} (7.7) followed by L_7 and L_4 and the lowest number was expressed by L_{10} (4.3).

Maximum no. of flower/plant was observed in L_{13} (47.0) and minimum was observed in L_8 (18.7).

L_3 line showed the highest number of petals in a single flower (14.0) and lowest (5.0) was observed in L_1, L_{10}, L_{11}, L_{13}, L_{14} and L_{15}.

Minimum days required for flower bud initiation and blooming was observed in L_1 (44.3) and L_{11} (14.0) respectively and maximum was found in L_4 (64.7) and L_6 (23.3) respectively.

Maximum flower head diameter was found in L_9 (7.3) and minimum diameter was observed in L_{15} (3.2).

Stem diameter and length were found maximum in L_9 (5.4 mm and 53.5 cm respectively) whereas minimum in L_6 (2.7 mm) and L_4 (24.3 cm).

Vase life was found highest in line L_9 (20.7 days) and lowest from line L_{15} (12.0 days).

All the lisianthus lines under study were scored from 1 to 5 (5= best) based on some important characteristics (flower head diameter, stem length and vase life) for standard cut flower. According to the total score, the lines were ranked and L_9 was found to be the best line obtaining a total of 15.

A cluster analysis was conducted on the basis of some important morphological cut flower characteristics (no. of flower/plant, no. of petal/flower, stem length, vase life) and the result was expressed through a dendogram. The studied lines formed two major group i.e. A & B. Group A was further divided in to two clusters i.e. I and II. Cluster I included one lines (L_9) and Cluster II included four lines (L_3, L_5, L_8, and L_{12}). Group B was also divided in to two clusters i.e. III and IV. Cluster III included five lines (L_1, L2, L_4, L_7 and L_{13}) and Cluster IV also included five lines (L_6, L_{10}, L_{11}, L_{14} and L_{15}).

Lisianthus lines were classified in to different group on the basis of their morphological characteristics. On the basis of number of colors present in petals the lines were divided in to two group *viz.* Mono-color (single color throughout the petal) containing lines L_1, L_2, L_3, L_5, L_6, L_8, L_9, L_{12}, and L_{15} and Bi-color (two colors present in a petal) containing lines L_4, L_7, L_{10}, L_{11}, L_{13} and L_{14}.

On the basis of the primary petal color the lines were further classified into six groups. These are White to whitish (L_1, L_2, L_3, L_5 and L_6), Pink (L_4, L_7 and L_8), Violet (L_9, L_{10} and L_{12}), Blue (L_{11}), Purple (L_{13} and L_{14}) and Lavender (L_{15}).

According to the petal base color differentiation, the lisianthus lines were divided into three groups. These are Green (L_1, L_2, L_3, L_4, L_5, L_6, L_7, L_{10}, L_{11}, L_{13}, and L_{14}), Violet (L_8, L_9, and L_{12}) and Brown (L_{15}).

On the basis of number of petals, the studied lines were classified into two groups. They are Single (5 to 6 petals; containing lines L_1, L_2, L_4, L_6, L_7, L_{10}, L_{11}, L_{13}, L_{14} and L_{15}) and Double (10 or more petals; including lines L_3, L_5, L_8, L_9 and L_{12}).

Lisianthus lines under study were classified in to three groups according to their leaf shapes. These are Lanceolate (L_1 and L_3), Ovate (L_2, L_4, L_6, L_7, $L_{9,}$ L_{10}, L_{11} and L_{12}) and Broad ovate (L_5, L_8, L_{13}, L_{14} and L_{15}).

Based on days required to flowering the fifteen lisianthus lines were divided in to three groups *viz.* Early (≤70 days includes L_1, L_2, L_7 and L_9), Mid (71-80 days includes L_3, L_6, L_8, L_{11}, L_{12} and L_{13}) and Late (>80 days includes L_4, L_5, L_{10}, L_{14} and L_{15}).

The fifteen lisianthus lines under study were classified in to two classes according to their longevity in vase. These are Excellent (> 2 weeks; includes L_1, L_2, L_3, $L_{4,}$ L_5, L_7, L_8, L_9, L_{10}, L_{12}, L_{13}) and Standard (≤ 2 weeks; includes L_6, L_{11}, L_{14}, L_{15}).

5.2 Conclusion

From the result and discussion it can be concluded that the lisianthus lines under study showed significant variation in the studied characteristics under Bangladesh condition. All the lines showed promise as a commercial cut flower. According to the total score, L_9 appeared to be the best line among the 15 lisianthus lines under study. Due to its potential of versatile colors including interesting color combinations and long vase life lisianthus has the promise to acquire a core position in the commercial cut flower market in a very short time. Through the present study, the studied lisianthus lines were categorized based on the different morphological parameters and performance as a base line for the researchers and breeders.

Suggestions

i) Further experiment regarding its suitability in different regions could be done.

ii) New color variant development through conventional and molecular method could be done.

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APPENDICES

Appendix I. Analysis of variance of the data on Rosette %, Plant height and No. of leaves of lisianthus lines

Source of Variation	Degrees of freedom	Mean Square of		
		Rosette %	Plant height (cm)	No. of leaves
Factor A (Lisianthus lines)	14	41.152*	3297.339*	1876.978*
Error	28	2.033	158.341	0.203

***: Significant at 0.05 level of probability**

Appendix II. Analysis of variance of the data on No. of stem, No. of flower bud/stem and No. of flower/stem of lisianthus lines

Source of Variation	Degrees of freedom	Mean Square of		
		No. of stem	No. of flower bud/stem	No. of flower/ stem
Factor A (Lisianthus lines)	14	1.737*	3.022*	3.022*
Error	28	0.189	0.256	89.822

***: Significant at 0.05 level of probability**

Appendix III. Analysis of variance of the data on No. of flower/plant, No. of petal/flower and Days to flowe bud initiation of lisianthus lines

Source of Variation	Degrees of freedom	Mean Square of		
		No. of flower/ plant	No. of petal/ flower	Days to flower bud initiation
Factor A (Lisianthus lines)	14	200.708*	28.260*	114.848*
Error	28	2.356	0.260	1.486

***: Significant at 0.05 level of probability**

Appendix IV. Analysis of variance of the data on Days to full bloom, Flower head diameter (cm) and Stem diameter (cm) of lisianthus lines

Source of Variation	Degrees of freedom	Mean Square of		
		Days to full bloom	Flower head diameter (cm)	Stem diameter (cm)
Factor A (Lisianthus lines)	14	26.438*	5.306*	1.107*
Error	28	2.419	0.017	0.047

***: Significant at 0.05 level of probability**

Appendix V. Analysis of variance of the data on Stem length (cm), Vase life (days) and Chlorophyll % of lisianthus lines

Source of Variation	Degrees of freedom	Mean Square of		
		Stem length (cm)	Vase life (days)	Chlorophyll %
Factor A (Lisianthus lines)	14	237.566*	22.356*	201.593*
Error	28	9.272	1.241	1.132

***: Significant at 0.05 level of probability**

Appendix VI. UPOV standard for petal color characteristics

Charecteristics	UPOV class
No. of color	One colored
	Bi-colored
Petal base color	Green
	Violet
	Brown

Appendix VII. UPOV standard for leaf shape

Characteristics	UPOV class	Illustration
Leaf shape	Lanceolate	
	Ovate	
	Broad ovate