GROWTH AND FLOWERING OF LISIANTHUS (*Eustoma grandiflorum*) WITH NITROGEN DOSES AND PLANT SPACING

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"Blessed is he who has placed stars in the heaven and has set in it in the glowing sun (that produces light) and the glittering moon (that reflects light)"

(Surah Al-Furqaan-25:61)

DEDICATED TO-

MY HONORABLE PARENTS

They are the very first instructors of my life who taught me that 'good humanity is the greatest qualification'

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CERTIFICATE

*This is to certify that the thesis entitled **"GROWTH AND FLOWERING OF LISIANTHUS (Eustoma grandiflorum) WITH NITROGEN DOSES AND PLANT SPACING"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of authentic research work carried out by **MST. ASMAUL HUSNA,** Registration No. **18-09216** 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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GROWTH AND FLOWERING OF LISIANTHUS (*Eustoma grandiflorum*) WITH NITROGEN DOSES AND PLANT SPACING

ABSTRACT

A field experiment was accomplished at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2018 to April 2019 to study the effect of nitrogen doses and spacing on growth and flowering of Lisianthus (variety-SAU Blue Nandini). Nitrogen doses *viz*. N_1=225 kgha^{-1} (BARI recommended for marigold), N_2= 250 kgha^{-1}, N_3= 275 kgha^{-1} and Spacing *viz*. S_1 (30 cm x 15 cm), S_2 (30 cm x 20 cm), S_3 (30 cm x 25 cm) were used in this experiment arranged in a Randomized Complete Block Design with three replications. Data on different growth, flower yield and quality attributes parameters were taken in which all the treatment showed significant variations. Among nitrogen doses, maximum stem number per plant (5.8), peduncle length (13.4 cm), flower head diameter (6.2 cm), flower number per plant (42.6), petal number per flower (19.8) were found from N_3 whereas minimum in N_1. Among different spacing, maximum stem number per plant (6.5), stem length (58.4 cm), flower head diameter (6.0 cm), flower per plant (42.3) found in wider spacing S_3 whereas minimum found in S_1. Maximum flower number per plant (55.3) were found in N_3S_3 and minimum flower number per plant (14.6) were found in N_1S_1. The study showed that the higher nitrogen doses with wider spacing would be the potential for Lisianthus production.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-ecological Zone
Agric.	=	Agricultural
ANOVA	=	Analysis of Variance
BARI	=	Bangladesh Agricultural Research Institute
Biol.	=	Biology
CV	=	Coefficient of variance
DAP	=	Days after planting
et al.	=	And others
Ex.	=	Experiment
FAO	=	Food and Agriculture Organization
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
spp.	=	Species
Technol.	=	Technology
UNDP	=	United Nations Development Program
Viz.	=	Namely

CHAPTER I

INTRODUCTION

Lisianthus (*Eustoma grandiflorum*) belongs to the family Gentianaceae, which is originated from the eastern slope of Rocky Mountains, USA (Halevy and Kofranek, 1984) and is a perennial herbaceous ornamental species that is used as cut flower due to its big and attractive flowers, long stalks, and long duration in vases. Lisianthus is a newcomer in Bangladesh and popularly known as Nandini, which has the advantage of striking bloom with great appeal. Lisianthus has been ranked one of the lucrative and expensive cut flower in the world. It has a great cosmopolitan demand mainly for its large and attractive flowers, long and hard stem, wide range of colors specially have purple, blue, lavender and has a long vase life which are the common traits of an ideal and best quality cut flower. Day by day demand of this flower increasing to the people. Flower growers also are attracted towards its cultivation because of its habit of free flowering, earliness, broad range of attractive color, form, size, quality and more importantly, the high demand of cut-flower. Very often, Bangladesh has to import them from other countries like China, Japan, and India. The successful cultivation is influenced various agro-techniques.

However, in Bangladesh, there is no recommended technology for Lisianthus production. Specially, optimum fertilizers and planting density is still unknown for Lisianthus flower production to meet up the demand and it is imperative to provide more information to the growers for higher productivity and quality. For Sustainable flower production requires optimal fertilizer management and nutrients. Nutrients such as nitrogen play a major role in the growth and development of plants (Scott, 2008). Nitrogen is one of the very important major plant nutrients which directly affect the plant growth and flowering behavior. Nitrogen is an essential element that improves the chemical and biological properties of soil, and thereby stimulates the production of higher yield in plants. It should be emphasized, that to increase plant quality and productivity nutrients need to be available from the soil during a plant's growth period. Among different essential plant nutrient, nitrogen is considered to be the most crucial and nitrogen applied as fertilizer is considered as the key source for meeting the nitrogen requirements of plant growth (Konnerup and Brix, 2010) because it is a constituent of protein and nucleic acid which is helpful in plant growth (Haque, 2001). Nitrogen promotes vegetative growth and stimulates the flower opening cycle during the flowering season (Fan *et al.*, 2005). On the other side, excessive and improper use of nitrogen fertilization has a detrimental effect because high nitrogen application influences in dark green leaves and leads to delay flowering. Proper nitrogen application, at the correct rates and time, contributes to the optimal growth and, higher number of flower and seed yield of ornamentals (Swetha *et al*., 2018). Application of appropriate amount of nitrogen is important as its deficiency causes several abnormalities like over growth and less flowering. An optimum dose of application of nutrient elements will not only ensure better yield and quality but also lead to minimum wastage of the nutrients. There is a scope of increasing plant growth, yield of Lisianthus with the appropriate size of flower.

Furthermore, plant spacing is particularly important for the cultivation of flower to maximize the flower growth, yield, quality and quantity. Plant spacing can influences crop productivity and plant quality (Langton *et.al*., 1999). Spacing between plants is particularly important for the maximize flower production. In cut flower industry, the most important aspects are maximum production of better quality cut flowers in order to fetch more market prices. For obtaining better vegetative growth and thereby, increasing the yield of better quality flowers, plant spacing plays an important role. Very little research work has been carried out in Lisianthus regarding plant spacing and hence sufficient information on different agro- techniques followed in this crop as a cut flower is not available. In Bangladesh, no research work has been conducted to determine the optimum plant spacing so that flowers growers in our country still faced problem to produce large number and standard quality flower. Number of flowers and flowering attributes produced per plot was affected by plant spacing and the performance of cut flower crops is greatly influenced by spacing (Singh and Bijimol, 2000). Spacing has been found to influence growth, flowering and yield of daughter bulbs in gladiolus (Swetha *et al*., 2018). Plant population affects crop yield by imposing competition among plants for nutrients, moisture, sunlight and other growth sources. If plants are planted far apart, they will not have to compete at all for resources. They may produce higher yields per plant than more crowded plants, but if they are spaced too far apart the yield for the entire field of plants can still be low. The optimum spacing helps not only in obtaining good quality cut flowers but also in better utilization of land, providing good open position for sunlight, soil moisture conservation, weed control and availability of nutrients vital for successive crop production and quality (Sanjib *et al*., 2002).

Keeping this in view, the present research was conducted with the following objectives-

Objectives:

1. To determine the optimum nitrogen doses for growth and flowering of Lisianthus

2. To find out the optimum plant spacing on growth and flowering of Lisianthus

3. To study the effect of nitrogen doses and plant spacing on growth and flowering of Lisianthus

CHAPTER II

REVIEW OF LITERATURE

Lisianthus is one of the most highly ranked cut flowers in the international market due to its rose like flowers, excellent post-harvest life and diverse color. Furthermore, demand and popularity is increasing day by day in our country. Lack of knowledge of production technology is the crucial issue for Lisianthus production especially application of proper amount of nitrogenous fertilizer as well as plant spacing. Farmers usually apply vast amount of urea or sometimes a little amount which hampers vegetative growth as well as flower yield. In addition, plant spacing also not maintained properly so that influence flower production. Therefore, information available regarding nitrogen doses (urea) and spacing has been reviewed and presented in this section.

Acharya and Dashora (2004) conducted an experiment in Rajasthan to study the response of graded levels of nitrogen and phosphorus on vegetative growth and flowering in African marigold. Among different levels of nitrogen and phosphorus, application of 200kg/ha each of nitrogen and phosphorus produced maximum plant height, plant spread, diameter of flower and early flowering. Whereas, the maximum number of branches and flowers per plant with yield of flowers per plant and hectare basis were recorded with 150 kg N/ha and 200kg P/ha. The maximum weight of single flower was obtained with 150 kg N/ha and 100 kg P/ha in African marigold cv. Pusa Basanti Gainda.

A field experiment was carried out to study the effect of different doses of nitrogen on growth and flower yield of marigold under container gardening at Bharatpur-11, Bhojad, Chitwan, Nepal during autumn 2018. Five treatments including different doses of nitrogen, i.e. (T_1: Control (0:90:75) kg NPK ha^{-1}; T_2: (45:90:75) kg NPK ha^{-1}; T_3: (90:90:75) kg NPK ha^{-1}; T_4: (135:90:75) kg NPK ha^{-1}; and T_5 (180:90:75) kg NPK ha^{-1}) were evaluated in Randomized

Block Design with four replications. Results showed that plant height, plant spread, and number of branches were statistically significant. Marigold plant applied with 180 kg ha^{-1} nitrogen gave the maximum height (49.47 cm), spread (36.40 cm), and number of branches (24.75) in 45 DAT (days after transplanting) while the control plot showed the least. Similarly, nitrogen @ 180 kg ha^{-1} was found to be effective for early flowering initiation (32.50 DAT) and days (41.25 DAT) compared to control (39 and 48.75 DAT, respectively) and also resulted in maximum number of flower (34.73), flower diameter (7.03 cm) and yield (22.29 t ha^{-1}) compared to other treatments. Thus, the overall results suggest that the application of 180 kg N ha^{-1} in marigold produced the highest flower production (Adhikari *et al*., 2020).

Ayub *et al*. (2007) conducted a field experiment to evaluate the effect of 0, 50, 100 and 150 kg N ha-1 on pearl millet sown at seeding rate of 10, 15 and 20 kg ha-1 was conducted at Agronomic Research area, University of Agriculture, Faisalabad, Pakistan. Nitrogen application significantly increased the green fodder and dry matter yield due to increased plant height, stem diameter and number of leaves per plant. Crude protein and crude fibre contents were also increased due to an increase in nitrogen level. However, increase in nitrogen level decreased the ash percentage. Nitrogen application of 100 and 150 kg ha-1 produced statistically similar green fodder yield (79.37 and 79.74 t ha-1, respectively). Increase in seed rate significantly increased the plant density, plant height, green and dry matter yield and dry matter contents but decreased the stem diameter. The number of leaves per plant, crude fibre, and crude protein and ash contents were decreased with increased seed rate but not to a significant level. Pear millet sown at seed rate of 20 kg ha-1 and receiving 100 kg N ha-1 seems to be the best combination for getting higher green fodder yield of “BY-18” under Faisalabad conditions.

Baral (2012) carried out an experiment to access the influence of nitrogen level (100, 150, 200, 250, 300 kg/ha) on growth performance, cut flower characteristics and corm/cormel production of three varieties (American beauty, Interpret and Candyman) of gladiolus (Gladiolus hybrida L.) in the farmer's field at Gunjanagar VDC, Chanauli, Chitwan, during September, 2010 to April, 2011. The experiment consisted of 15 treatment combinations laid out in 2 factorial randomized complete block design (RCBD) with 4 replications. Nitrogen levels significantly influenced growth performance, cut flower characteristics and corm/cormel production of gladiolus. Increasing the level of nitrogen up to 200 kg/ha, increased the rate of sprouting (97.33%), number of sprout/corm (2.05), taller plant (106.7cm) with more number of leaves (9.85), longest spike(86.58cm) with more number of florets/spike (16.73) were produced. Moreover, largest spike (92.62 g weight) having thicker (1.14 cm girth) and longest rachis (54.5 cm) were produced by 300 kg/ha. Size of daughter corm (5.8 cm) was highest with 300 kg/ha while number of the cormels per plants (89.45) was highest at 200 kg/ha nitrogen.

A study was carried out during 2005 - 2006 at the Division of Floriculture to determine the effect of corm size (4.1-4.5, 4.6-5.0 and 5.1-5.5 cm) and spacing (10 x 20, 15 x 20 and 20 x 20 cm) on growth, flowering and corm production in gladiolus cv. White Prosperity. Larger sized corms (5.1-5.5 cm) with wider plant spacing (20 x 20 cm) gave the best performance. Number of days taken to spike emergence, plant height, number of leaves plant-1, spike length, number of florets spike-1 and diameter of floret were observed to be significantly better with larger-sized corms. Minimum days taken to slipping were also found to be due to larger size of the corms. Number of corms plant-1, corm weight, diameter of corm, number of cormel plant-1 and cormels weight plant-1, in terms of both quality and quantity, showed increasing trend with an increasing corm-size and spacing. Therefore, wider spacing and larger corm size may be recommended for realizing better quality and higher production in gladiolus cv. White Prosperity under Kashmir conditions (Bhat and Khan, 2007).

Bijimol and Singh (2000) conducted an experiment to assess the effect of spacing and nitrogen levels on flowering, flower quality and vase life of gladiolus cv. Red Beauty. Four spacing's (15x30, 20x30, 25x30 and 30x30 cm) and four nitrogen rates (0, 100, 200 and 00 kg/ha) were taken. Corms planted at 25x30 cm and 200 kg N/ha significantly increased the diameter of spike, number of florets per spike, number of spikes per plant and number of spikes per ha and early emergence of spike under field conditions (Nagaland, India). Application of 200 kg N/ha also resulted in maximum length of spike and diameter of floret. However, early opening of flower was recorded with lower N rate (100 kg/ha), while length of floret with 300 kg N/ha. Spacing and N levels had significant effect on postharvest life of cut gladioli. Spacing 25x30 cm had striking effect on percent opening of florets per spike, number of open florets with drooping of minimum florets. N at 200 kg/ha had significant effect on percent opening of florets per spike, number of open florets per spike and water uptake during vase life.

Boroujerdnia and Ansari (2007) conducted an experiment at Shahid Chamran University of Ahwaz, Iran during 2005-2006 to determine the effect of nitrogen fertilizer rates and cultivars on growth and critical yield of lettuce. The treatments included four nitrogen rates (0, 60, 120, and 180 kg N ha-1) as the main plot and two lettuce cultivars ('Pich Ahwazi' and 'Pich Varamini') as the sub-plot. The criteria measured were plant length, fresh and dry weights of leaves, leaf area, number of leaves, crop growth rate (CGR), leaf area index (LAI) and yield. Results indicated that different levels of nitrogen fertilizer on all growth characteristics were significant at $P<0.01$. Increased plant length, fresh and dry weights of leaves, leaf area, number of leaves, crop growth rate (CGR), leaf area index (LAI) and yield were shown up to 120 kg N ha-1. Nitrogen fertilizer caused head formation to accelerate and delayed the bolting date of lettuce. Cultivar had a significant effect on growth characteristics, on fresh and dry weights of leaves and on leaf number but not on plant length and leaf area. The highest yield was obtained with 120 kg ha-1 treatment by 'Pich

Ahwazi'. Also, it took 'Pich Varamini' longer to form a head and to flower than 'Pich Ahwazi'.

A study was carried out to standardize nitrogen application at different stages of tuberose (Polianthestuberosa L.) (cv. Double) for improving growth, flowering and vase life in a farmer's field at Gunjanagar VDC, Chitwan, Nepal, during May to September, 2012. The experiment was laid out in randomized complete block design with 10 treatments of nitrogen in split doses and replicating thrice. The cut flower and vase life characteristics of tuberose were studied and the economics of production was also analysed. Significant difference was found between treatments of split doses of nitrogen in flowering and post-harvest characteristics of this flower. Three equal split doses of nitrogen, 33% N basal + 33% N at 30 days after planting + 33% N at 50 days after planting resulted in the earliest spike initiation (60 days) and the first flower opening (95.17 days). The same treatments recorded longest vase life (16.47 days). The longest (91.69 cm), heaviest (87.97g) and thickest (0.89 cm) spikes with longest rachis (38.77 cm) were produced by three equal split doses of nitrogen, 33% N basal + 33% N at 50 days after planting + 33% N at 70 days after planting. The same treatments produced maximum net income (NRs. 214,250/-) and benefit-cost (B:C) ratio (1.29) per hectare. Thus, three equal split doses of nitrogen, 33% N basal + 33% N at 50 days after planting + 33% N at 70 days after planting are appropriate for commercial cultivation of tuberose in Nepal (Dahal *et al.*, 2014).

The experiment was carried out to study the effects of nitrogen (0, 20, 40, 60, 80 g/m2), phosphorous (0, 5, 10, 20 g/m2) and potassium (0, 15, 20, 25 g/m2) on growth, flowering and yield in gladiolus cv. Jester Gold in FRBD at IARI, New Delhi, during 2000-1 and 2001-2. Application of 60 g N/m2 resulted into maximum leaves/shoot (6.0), leaf area/plant (330.83 cm2), plant height (80.6 cm), diameter of first floret on third day of opening (9.7 cm), durability of first floret (3.8 days) and whole spike (12.4 days) floret /spike (15.7), spike length

(58.8 cm), rachis length (44.7 cm) and useful life of the spike (7.2 days). N at 20 g/m2 resulted in earliest 50% sprouting (7.9 days). Higher dose of nitrogen (80 g/m2) resulted into maximum corms/plant (1.8), corm size (5.3 cm), corm weight (44.8 g), cormel weight (5.0 g), cormels/plant (19.3) and propagation coefficient (315.2%) (Eajiv and Mishra, 2000).

Evans (1998) conducted an experiment to find out the efficacy of nitrogen and Photosynthesis in the Flag Leaf of Wheat. The amounts of chlorophyll, soluble protein, nitrogen, and phosphorus were determined for each flag leaf and found that chlorophyll content and RuP_2 carboxylase activity were approximately proportional to leaf nitrogen content.

Fan *et al*., (2005) examined the effects of non-flooded mulching cultivation and traditional flooding and four fertilizer N application rates (0, 75, 150 and 225 kg ha−1 for rice and 0, 60,120, and 180 kg N ha−1 for wheat) on grain yield, N uptake, residual soil N min and the net N balance in a rice–wheat rotation on Chengdu flood plain, southwest China. There were significant grain yield responses to N fertilizer. Nitrogen applications of >150 kg ha−1 for rice and >120 kg ha−1 for wheat gave no increase in crop yield but increased crop N uptake and N balance surplus in both water regimes. High N inputs led to a positive N balance (160–621 kg ha−1), but low N inputs resulted in a negative balance (−85 to −360 kg ha−1).

Gaire *et al*. (2020) studied the effect of spacing and nitrogen level on growth and yield of maize in Parbat from February to July, 2019. The experiment was laid out in two Factorial Randomized complete Block Design (RCBD) comprising of spacing: 60×15 cm and 60×25 cm and nitrogen: 30, 60, 90 and 120 kg/ha level as treatment with three replications. “Arun-2” variety of maize was planted on clay loam and acidic soil (pH 5.3) having medium in total nitrogen (0.15%), medium in soil available phosphorus (48.1 kg/ha), medium in soil available potassium (218.8 kg/ha) and medium in organic matter content

(2.92%). Result shows that yield was significantly increased with increment in N-level up to 90 kg N/ha. The grain yield (5.18 mt/ha) was significantly higher at 90 kg N/ha than at 30 and 60 kg N/ha but at par with 120 kg N/ha. Significant effect on grain yield due to spacing was observed. The grain yield (4.11 mt/ha) obtained at spacing 60×15 cm. Moreover, the highest grain yield showed that highest grain yield (4.33 mt/ha) was obtained under 90 kg N/ha plus 60×15 cm spacing. The result revealed that different spacing and nitrogen level significantly affect the plant height and leaf area index. The plant height and leaf area index were significantly high at close spacing (60×15 cm) and at 120 kg N/ha. Likewise, yield attributing characteristics like cob length, cob diameter, number of kernel/rows, number of kernel row, thousand gran weight were the highest at 90 kg/ha but as par with 120 kg/ha at close spacing (60×15 cm). This study suggested that maize production can be maximized by cultivating "Arun-2" maize fertilizing with 90 kg N/ha and maintaining 60×15 cm spacing.

Optimizing plant nitrogen (N) and phosphorus (P) nutrition is required in healthy propagation of strawberry nursery plants for fruit production. Strawberry (Fragaria x ananassa Duch.) nursery plant ability for N and P acquisition was examined in a northern Atlantic coastal soil for providing field-based information for optimizing strawberry nursery plant nutrition. The study was conducted in a Cornwallis loamy soil in Nova Scotia, Canada in 2008. The treatments consisted of seven strawberry cultivars: 'Darselect', 'Mesabi', 'V151', 'Seneca', 'Serenity', 'K93-20' and 'Jewel', all highly hardy cultivars. Nutrient NPK supply was respectively at the rates of 105, 145 and 165 kg/ha, based on soil testing and regional recommendation. Results showed that strawberry nursery plant propagation and productivity expressed using runner and daughter-plant variables were significantly different among the seven cultivars ($P < 0.05$). Total nitrogen uptake (mean±SD) varied between 2.96±0.91 g/plant and total P uptake was 0.29±0.06 g/plant among the seven cultivars. The cultivar 'Seneca' and 'Jewel' showed a significantly higher ability of N and P acquisition (P < 0.05). It was suggested that strawberry nursery plant propagation could be enhanced with nutrition accumulation ranges of 2.47-3.26 g N/plant and 0.25 0.34 g P/plant. Runner thinning would be an option for regulating strawberry plant N and P nutrition and nursery plant productivity (Hong *et al*., 2008).

Studies were undertaken to evaluate the response of autumn planted sunflower (*Helianthus annuus* L.) to different levels of N, P and K fertilizers at the Agronomic Research Farm, University of Agriculture, Faisalabad during, 2004 and 2005. Treatments comprised five N levels (0, 60. 90, 120 and 150 kg ha/sup -1/), five P levels (0, 30, 60, 90 and 120 kg ha/sup -1/), four K levels (0, 60, 90 and 120 kg ha/sup -1/) in different combinations and two hybrids viz. FH-314 (standard height) and FH-245 (semi dwarf). Hybrid FH-314 produced significantly higher achene yield (2725.41 kg ha/sup -1/) than that of FH-245. There was a progressive increase in achene yield and yield components With increasing levels of N, P and K. The highest achene yield (3023 kg ha/sup -1/) and highest net benefit (Rs.19743) was obtained when the crop was fertilized at the rate 120:90:60 kg NPK ha/sub -1 (Iqbal *et al*., 2008).

An experiment was conducted at the Horticultural Research Field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during September 2008 to May 2009 to determine the response of hippeastrum (cu. ‘Apple Blassom) to different combinations of nitrogen, phosphorus and potassium levels. There were 14 treatment combinations comprising four levels of nitrogen viz. 0, 100, 200, and 300 kg ha-1; five levels of phosphorus viz. 0, 200, 300, 400 and 500 kgha-1 and five levels of potassium viz. 0, 100, 200, 300 and 400 kgha-1. The experiment was laid out in a Randomized Complete Block Design with three replications. The growth and flowering parameter of hippeastrum were significantly influenced by combined application of N, P & K. The highest values in respect of leaves per plant (8.6), leaf breadth (5.4 cm), number of plants per bulb (3.07), flower scape per plant

(2.07), flowers per scape (4.2), length and diameter of flower (14 cm x 13.83 cm), flower scape (43.33 cm x 29.37 cm) and flowering duration (10.7 days) were observed with N200P400K300. The same treatment showed earliness in days to flower scape emergence (172.3 days), days to flower bud appearance (185.3 days) and days to first flower open (189.3 days) (Jamil *et al*., 2016).

A study was conducted in India during 1997-98 to determine the effect of spacing and nitrogen fertilizer application on C. coronarium Local White. Treatments comprised: three spacings (30x20, 30x30 and 30x40 cm) and four nitrogen rates (0, 50, 100 and 150 kg/ha). The number of branches, plant spread, main stem diameter, fresh weight of plant and dry weight of plant were significantly highest in the widest spacing (30x40 cm) and highest nitrogen rate (150 kg N/ha) (Karavadia and Dhaduk, 2002).

A field experiment was carried out by (Khalaj and Edrisi, 2012) as a factorial in a Randomized Complete Block Design (RCBD) format with 3 replications. Different levels of nitrogen (0, 50, 100, 150, 200, 250 Kg/ha), in the form of ammonium nitrate was the first factor and the second factor was the different plant spacing of (10 x 10, 15 x 15, 20 x 20, 25 x 25 cm). The spacing between plants of 25 x 25 cm had a significant effect on flower stalk height, flowering stem diameter, spike length, floret diameter, floret weight, vase life, bulb number and weight. Nitrogen levels affected stem diameter, stem and spike length. The results showed that an application of 200 Kg/ha N can improve growth and yield of tuberose in terms of flower stalk height, stem diameter and bulb weight. Data showed that the plant spacing of 25 x 25 cm with nitrogen application of 200 Kg/ha N obtained the maximum qualitative and quantitative characteristics of flowers.

The effects of inorganic nitrogen (N) source ($NH4+$, $NO3-$ or both) on growth, biomass allocation, photosynthesis; N uptake rate, nitrate reductase activity and mineral composition of Canna indica were studied in hydroponic culture. The relative growth rates (0.05–0.06 g g−1 d−1), biomass allocation and plant morphology of C. indica were indifferent to N nutrition. However, NH4+ fed plants had higher concentrations of N in the tissues, lower concentrations of mineral cations and higher contents of chlorophylls in the leaves compared to NO3− fed plants suggesting a slight advantage of NH4+ nutrition. The NO3− fed plants had lower light-saturated rates of photosynthesis (22.5 µmol m−2 s−1) than NH4+ and NH4+/NO3− fed plants (24.4–25.6 µmol m−2 s−1) when expressed per unit leaf area, but similar rates when expressed on a chlorophyll basis (Konnerup, D. and Brix, H. 2010).

A study was conducted to evaluate the effect of plant density on growth, flowering corm and cormel production of gladiolus (Gladiolus sp.) cv. American Beauty at the farm of the Department of Horticulture, C.C.R (P.G.) College, Muzaffarnagar (Uttar Pradesh). The experiment was laid out in randomized complete block design with four replications and three spacing's viz. S1 (40cm x 20cm), S2 (30cm x 40cm) and S3 (40cm x 40cm). The observations were recorded for various vegetative, floral and corm parameters. Maximum germination percentage (86.71%), plant height (105.66cm) and number of leaves per plant (8.01), number of days taken for initiation of spike (94.13 days), number of spikes per plant (0.96), length of spike (81.56cm), number of florets per spike (17.86) and duration of flowering (18.54 days) was found with 30cm x 40cm spacing (S2). However, number of corms per plant (1.31), number of cormels per plant (21.56), weight of corms per plant (57.68g), weight of cormels per plant (36.43g) was found maximum with 40cm x 40cm spacing (S_3) which was at par with S2, whereas, yield of corms and cormels per plot (3.18) was found maximum with 40cm x 20cm spacing (S_1). Hence, 30cm x 40cm spacing can be recommended for the commercial cultivation of gladiolus (Kuldip *et al*., 2016).

Kumar *et al*. (2001) worked in Mohanpur, India on Gladiolus grandiflorus cv. Tropic Sea to find out the effect of different levels of N (40, 50 and 60 g/m2) at

2 splits (3 and 6 leaf stages) as side dressing, P205 (10, 20 and 30 g/m2) and K20 at 20 g/m2. They found that the fertilizer combination of N at 50 g/m2, P at 10 g/m2 and K at 20 g/m2 resulted in the highest spike weight, numbers of flowers per spike, flower diameter, number of open flowers at a time.

Langton *et al.* (1999) reported that average total fresh weight per plant varied greatly between experiments, but empirical linear regression relationships showed that changes in space per plant gave near proportional changes in weight per plant over the whole range of densities sampled. This suggests that the density responses were essentially mediated by the available light per plant. Increasing density was associated with progressively slower flowering and this trend was most pronounced in 'Delta' and in the autumn and winter experiments. Stems were generally reduced in length at high density but this was not always the case. The development of a simple model to predict average stem weights and grade-outs for given spacings at particular times of year is discussed.

Lehri *et al*. (2011) conducted an experiment to determine the response of different doses of N and P_2O_5 on the growth and flower quality of gladiolus at farmer field district Quetta during the summer season 2008. Six treatments were included in the trial viz; T1 (125+100); T2 (125+200); T3 (150+100); T4 (150+200); T5 (175+100) and T6 (175+200) NP kg/ha were tested in four replicated randomized complete block design. The results reveal that fertilizer treatments had significant response on leaves length, leaves number, florets number per spike, corms number per plant, corm lets number per corm and spike length. The highest N and P_2O_5 dose 175+200 kg/ha produced significantly maximum length of leaves (44.4 cm), greater number of leaves (13.75), number of florets per spike (14.00), number of corms per plant (4.00), number of cormlets per corm (18.62) and longer spike length (99.75cm). It was concluded that for obtaining maximum number of florets per spike, number of corms per plant, number of corm lets per corm and longer spike length application of nitrogen and phosphorus at 175+200 kg/ha may be applied.

Field experiments were conducted at Junagadh during 2002-05 to study the response of spacing (45×45, 45×30, 45×15, 30×30 and 30×15 cm) and crop duration (first year crop, first ratoon and second ratoon) on growth, flowering, cut-flower yield and bulb production in tuberose cv. Double. The widest spacing (45 cm × 45 cm) registered the highest values for plant height (46.18 cm), number of leaves per clump (67.25), spike length (89.64 cm), spike diameter (0.95 cm), diameter of open flower (4.6 cm), rachis length (34.8 cm), number of spikes per clump (4.1), number of florets per spike (48.2), number of bulbs per clump (18.40) and number of bulblets per clump (31.60). It also induced early spike emergence and flowering. A planting distance of 30×30 cm realized the highest cut flower yield (2.72 lakh ha-1) and that of 30 cm × 15 cm recorded the highest bulb production (22 lakh ha-1). Ratoon crops showed higher plant height, number of leaves, bulbs, bulblets and spikes per clump and cut flower yield as well as bulb production over the first year crop. Early spike emergence and flowering was also noted in ratoon crops compared to the first year crop. However, spike and flower quality was inferior to that of first year crop with regard to spike length and diameter, number of florets per spike, diameter of open flower and rachis length (Malam *et al.*, 2010).

An experiment was laid out by Mane *et al.*, (2007) with three spacing (15, 20, 25 cm), two bulb sizes (2.5, 3 cm diameter) and three depths of planting (3,5,7 cm). In respect of spacing, flower yield and quality parameters except girth of the spike were significantly influenced in widest spacing (20 x 25 cm2). Longevity of spike (19.23 days) and keeping quality at room temperature (14.30 days) was highest in widest spacing. The large bulb size (B2) recorded significant increase in number of spikes per plant, the length and girth of spike, keeping quality of the spike at room temperature. Planting the bulbs at shallow depth (3 cm) resulted in the earliest spike emergence, but had no identical difference with medium depth (5 cm) of planting. The length of spike, number of spikes per plant and longevity of spike in field increased significantly at 7 cm depth, while the treatment D_2 (5 cm) recorded significantly superior results in case of diameter of spike, number of florets per spike and length of rachis. The bigger sized bulb (3 cm diameter) planted at widest spacing (20 x 25 cm2) and at 5 cm depth of planting was found best to get maximum commercial advantage for achieving higher flower yield and quality of tuberose.

Mishra (1998) conducted an experiment to study the effect of nitrogen levels and planting density on gaillardia flower. Four levels of nitrogen, i.e., 0, 10, 20 and 30g/m^2 and three spacings, i.e., 30 x 20, 30 x 30 and 40 x 30 cm along with all possible combinations were tried on gaillardia. Nitrogen @ 20 g/m2 significantly increased the number of flowers per unit area, stalk length and flower life as compared to other treatments. The height and spread of the plant, days to flower, size of flowers and flower weight were noted to be significantly higher at 30g followed by 20g N/m^2 over control. So far planting density is concerned, 30 x 30 cm spacing was found superior in increasing all parameters except size, stalk length and weight of the flowers which were recorded higher with 40 x 30 cm spacing followed by 30 x 30 cm. Interaction effect of nitrogen and plant population showed that number of flowers and flower yield per unit area were significantly higher with N_2S_2.

In order to study the effects of different levels of nitrogen fertilizer and plant density on grain yield and its components in sunflower, Mojiri and Arzani (2003) conducted an experiment using 'Record' cultivar at the Research Farm of College of Agriculture, Isfahan University of Technology in 1996. Four levels of nitrogen (0, 75, 150 and 225 kg/ha) and four plant densities (65000, 75000, 85000 and 95000 plants/ha) were used in a split plot arranged in a randomized complete block design with three replications. Developmental stages, plant height, stem diameter, head diameter, number of head per m^2, grain yield, biological yield, harvest index, 1000-grain weight, number of grains per head, grain oil percentage, oil yield and grain protein content were measured. The results indicated that N fertilizer caused an extension of the growth period and means of days to physiological maturity. It also increased plant height, stem diameter and head diameter. While increasing plant density had an incremental effect on plant height, it negatively affected stem diameter and head diameter. N fertilizer up to 150 kg/ha increased the grain yield and biological yield, whereas higher levels of N fertilizer decreased both. Plant density of 85000 plants per hectare was observed as a suitable plant density, whereas the higher plant density had a negative effect on grain yield. Nitrogen fertilizers increased the number of grains per head, and plant density via increasing the number of heads per unit.

A field experiment was conducted to determine the response of different doses of N, P and K on plant growth, flower quality and yield of Gerbera (Gerbera jamesonii L.) in the Department of Horticulture, SHUATS, Allahabad, U.P. during the Rabi season 2016-2017. Eleven treatments were included in the trial viz., T0 (10:15:20) RDN; T1 (11:16.5:22); T2 (12:18:24); T3 (13:19.5:26); T4 (14:21:28); T5 (15:22.5:30); T6 (16:24:32); T7 (17:25.5:34); T8 (18:27:36); T_9 (19:28.5:38); T_{10} (20:30:40) N.P.K g/m^2 were tested in three replication. The experiment of design was Randomized Block Design. The results revealed that fertilizer treatments had significant response on plant height, number of leaves per plant, plant spread, number of suckers per plant, number of flowers per plant, number of flowers per treatment, days to first flower bud appearance, flower diameter, stalk length, stalk diameter and vase life of flower. The maximum plant height (41.47 cm), number of leaves per plant (17.70), plant spread (56.57 cm), days to first flower bud appearance (50.13) were produced by the treatment (T7) of N:P:K in the ratio of 17:25.5:34 g NPK/m^2. Maximum number of suckers per plant (6.47) was found in treatment (T9) in the ratio of 19:28.5:38 g NPK/m^2 and the maximum number of flowers per plant (12.87), number of flowers per treatment (49.03), flower diameter (14.47 cm), stalk length (46.47 cm), stalk diameter (0.90 cm) and vase life of flower (14.87 days) were recorded by treatment (T10) in the ratio of 20:30:40 g NPK/m^2 (Nayak *et al*., 2005).

Pratibha *et al*. (2018) carried out in an experimental farm in the Department of Floriculture and Landscaping, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during March to December, 2010. The experiment was laid out in split plot design, comprising of eight different planting dates and two spacing, (viz., 30 × 20 cm and 30 × 30 cm) as sub-plot treatment at monthly intervals from, mid-March to October, 2010. Maximum flower size was recorded for April planting date crop, whereas, June planting date gave the best results for plant height and plant spread. However, maximum number of flowers and maximum yield per plant were recorded in March planted crop. Plant height, plant spread flower size and yield per plant were at maximum in a wider spacing S_2 (30 × 30 cm). Maximum number of flowers per plant as well as maximum yield per plant was recorded in March planting at closer spacing S_2 (30 × 20 cm).

Ram *et al*. (2012) conducted an experiment to assess the effect of spacing and salicylic acid levels on vegetative growth and flowering of gladiolus cv. White Properity at HRC, SVPUAT, Meerut. The three levels of spacing (20 x 10, 20 x 20, and 20 x 30 cm) and three levels of salicylic acid (0, 50 and 100 ppm) were used in randomized block design (RBD) with three replications. Out of these a optimum spacing 20 x 20 cm was found superior with 100 ppm salicylic acid con centration in respect of number of leaves, leaf length (cm), days to opening of 1st floret and visibility of first spike, spike length, and number of florets per spike.

Rincon *et al*. (2002) investigated the effect of N (25, 50, 100, 150 and 200 kg/ha), applied in fertigation, on the yield and nitrate content of iceberg lettuce (Lactuca sativa var. capitata) in Murcia, Spain. Crop yield increased with N levels of up to 100 kg/ha, obtaining green biomass of 53.4 t/ha and commercial lettuce heads of 33.1 t/ha. Biomass and yield index decreased with N at 150 and 200 kg/ha. The nitrate content in the soil solution increased with the 150 and 200 kg N/ha treatments, and decreased with the 25 and 50 kg N/ha treatments. Nitrate concentration remained uniform during the growth cycle when 100 kg N/ha was applied, and the availability of nitrate was balanced with the absorption by the plant. N absorption increased between the 25 and 50 kg N/ha treatments and those of the 100, 150 and 200 kg N/ha treatments. However, no significant differences were observed between the higher N treatments. The outer leaves of plants showed a nitrate concentration 3 times higher than that of the inner leaves. This concentration changed according to the quantity of N provided. At harvest, the nitrate concentration in the outer leaves ranged from 1635 to 4494 ppm, while that in the inner leaves ranged from 651 to 1508 ppm.

Roy chowdhury (1989) conducted the research for five years (1982-1987) under polythene tunnel with gladiolus cv. 'Psittacinus hybrid'. The corms (2.5-2.7 cm in diameter) were soaked (for 6 hours) in GA_3 (50 and 100 ppm), Ethrel (100 and 200 ppm) and Kinetin (25 and 50 ppm) before planting at 25 and 33 corms/m2 densities. Results show that higher plant density (33 corms/m2) increases the plant height, length of flower stalk and corm yield/unit area, while it decreases the number of florets/ spike, length and diameter of flower, irrespective of the treatments including control. Treatment with Ethrel inhibited plant growth but markedly increased the corm yield and the maximum corm yield of 132.5/plot (25 corms/m2) and 138.6/plot (33 corms/m2) were noted by soaking of corms with Ethrel at 100 and 200 ppm respectively, compared to 60.0 and 79.2 corms/plot in control. Soaking of corms with Kinetin however, showed an increase in the number of florets/spike and size of flowers.

Sanjib *et al*. (2002) conducted the experiment which was laid out in randomized complete block design with four replications and three spacing's viz. S_1 (40cm x 20cm), S_2 (30cm x 40cm) and S_3 (40cm x 40cm). The observations were recorded for various vegetative, floral and corm parameters. Maximum germination percentage (86.71%), plant height (105.66cm) and number of leaves per plant (8.01), number of days taken for initiation of spike (94.13 days), number of spikes per plant (0.96), length of spike (81.56cm), number of florets per spike (17.86) and duration of flowering (18.54 days) was found with 30cm x 40cm spacing (S_2).

A study was conducted to determine the effects of varying light intensity and nitrogen nutrition on photosynthetic physiology and biochemistry were examined in the sun plant Phaseolus vulgaris (common bean) and in the shade plant Alocasia macrorrhiza (Australian rainforest floor species). Thus, the RuBP Case/chlorophyll ratio was quite responsive to N availability and light intensity in both species (but for different reasons), ranging from 6 grams per gram for Phaseolus and 2 grams per gram for Alocasia at high leaf N and 1.5 gram per gram for Phaseolus and 0.5 gram per gram for Alocasia at low leaf N. These large changes in the proportions of components of the photosynthetic apparatus had marked effects on the sensitivity of these species to photoinhibition (Seemann *et al*., 1987).

This study was carried out to determine the effect of different application rates of nitrogen (N) on yield and quality of cotton (Gossypium hirsutum). N was applied to the soil at rates of 0, 100, 200 and 300 kg ha . Statistical results of study showed that N application significantly (P 0.05) increased boll number, boll 1 weight, seed cotton weight of boll, seed cotton yield and lint yield. Moreover, leaf blade N concentration was affected by N application rate and increased significantly. Results of study also showed that the highest seed cotton yield was obtained in case of 200 kg ha 1 N application rate and this application rate resulted in 19.6% increased seed cotton yield. Statistical results showed that effect of different application rates of N was not significant for all studied fiber properties (fiber length, fiber strength and fiber fineness). Generally, application of 200 kg ha N resulted in the highest boll number, boll weight, seed cotton yield and lint yield (Seilsepour and Rashidi, 2011).

Present experiment was conducted to study the effect of pinching and nitrogen on growth, flowering and seed yield of African of marigold cv. Pusa Narangi Gainda at Horticulture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 2015-2016. The experiment was planned out in Randomized Block Design with 12 treatments each replicated three times. The treatments include three levels of pinching i.e. no pinching, single pinching at 40 days after transplanting and double pinching at 40 and 60 days after transplanting with four levels of nitrogen i.e. 0%, 1%, 2% and 3%. Data on growth characters revealed that interaction of no pinching with 2% nitrogen recorded significantly maximum number of primary branches per plant (19.20), fresh weight of leaf (1.11 g), dry weight of leaf (0.25 g), leaf area (181.14 cm2), whereas maximum plant height (84.14 cm), leaf area index (13.42) was highest in interaction of no pinching with 3% nitrogen. Stem diameter was statistically non-significant and maximum stem diameter recorded in single pinching at 1% N (2.33 cm). Data on flowering characters showed that earliest days to bud initiation (51.67 days), days to flowering (63.67 days) and maximum duration of flowering (81.33 days) was recorded in interaction of no pinching with 0% foliar application of nitrogen, whereas interaction of no pinching with 3% nitrogen recorded maximum fresh weight of flower (4.86 g), dry weight of flower (1.01 g), flower diameter (5.12 cm), length of peduncle (5.38 cm). However number of flowers per plant (49.13) and flower yield per plant (193.52 g) recorded significantly maximum in combination of double pinching + 2% nitrogen (Singh and Kumar, 2009).

Steingrobe and Schenk (1994) reported that seeds of lettuce cv. 'Clarion' were sown in 4 × 4 cm peat blocks and seedlings were planted out 3 weeks later at a spacing of 30 x 30 cm. Seedlings received different amounts of N fertilizer before and after planting. They found that N application increased root growth in the first 3 weeks after planting out, but had no effect on yield.

An experiment was carried out by Sudhakar and Kumar (2012) to study the effect of corm size and spacing on growth and flowering of gladiolus Sp cv. white friendship under Tamilnadu condition was carried out thein Floriculture unit, Department Horticulture, Faculty of Agriculture, Annamalai University, Annamalai nagar, during 2010-2011 with objectives of studying individual and interaction effects of different corm size viz., 3.5– 4.5 cm, 4.6-5.5 cm and above 5.5 cm and spacing viz., 30x20 cm, 30x25 cm and 30x30 cm on growth and flowering parameters. All nine possible combinations of the corm size and spacing were laid in combination as treatment in factorial randomized block design (FRBD) with three replications. The growth and yield parameters of gladiolus were significantly influenced by corm size and spacing adopted. Corm size of above 5.5cm and spacing of 30x30cm were found excellent when compared to others. The interaction between corm size and spacing exhibited significant enhancement ingrowth and yield parameters. Combination of C_3 x S_3 with corm size of above 5.5cm and spacing of 30x30cm has exhibited the highest values in growth parameters viz., plant height (77.44 cm), number of leaves per plant (6.50), leaf length (45.47cm), leaf width (4.84 cm), and the yield parameters viz., days to spike emergence74.66 (days), number of floret per spike (10.52), length of spike (65.59cm), florets diameters (8.64cm), florets length(6.58cm), diameter of corm (5.06 cm) and number of cormels (19.12) when compared with other treatment combinations.

Swetha *et al*. (2018) conducted the experiment to evaluate the effect of spacing and nitrogen on vegetative growth and flower yield of Asiatic lily cv. Tressor at College of Horticulture, Venkataramannagudem, West Godavari district, Andhra Pradesh during the rabi season of 2016-17. Results showed that minimum number of days to bulb sprouting was observed with 30 cm x 15 cm and nitrogen at 200 kg ha-1. The vegetative parameters like plant height, number of leaves, leaf area per plant and total chlorophyll content was recorded highest with a spacing of 30 cm x 15 cm and nitrogen at 200 kg ha-1 both individually and in combination except to leaf area index. The spike yield per plot and spike yield per 1000 m2 was maximum with spacing of 30 cm x 15 cm, nitrogen dose of 200 kg ha-1 both individually and in combination.

The experiments were carried out as a factorial plot in a complete randomized block design with four replications. All the data was subjected to analysis of variance (ANOVA) using of SAS software and the means separated using the Duncan's Multiple Rang Test. In study of interaction of planting depth and bulb size, difference between treatments was not significant in parameters of days to emergence of spike, length of flower spike; total number of nodes per spike and length of inflorescence but differences in other characteristics were significant. Bulb size had any influence on time of emergence of flower spike, diameter and length of spike, as well as germination percentage of bulbs, but influenced on other characteristics. Results revealed that smaller bulbs, Due to failure in physiological maturity, produced any flowers. Larger bulbs had the better quality in flowering, as well as because of more active metabolically processes such as carbohydrates breakdown latter germinated but developed earlier (Tehranifar and Akbari, 2012).

The effect of nitrogen application levels (0.16 and 0.24 g N kg^{-1} soil) on seed proteins and their amino acid compositions of amaranth (Amaranthus spp.) and quinoa (Chenopodium quinoa Willd) were studied. Total proteins of amaranth and quinoa had high contents of lysine (6.3−8.2 g 100 g−1 proteins) but low contents of methionine (1.2−1.8 g 100 g^{-1} protein). Seed proteins were fractionated on the basis of different solubility in water, saline, and buffer as $albumin^{-1}$ (Albu-1), albumin-2 (Albu-2), globulin (Glob), and glutelin (Glu) and were identified by sodium dodecyl sulfate−polyacrylamide gel electrophoresis. Albu-1 was high in lysine (5.4−8.6 g 100 g−1 protein), while Albu-2, which is a part of storage proteins, had a high leucine content (7.2−8.9 g 100 g−1 protein) as an effect of different nitrogen application levels. Glu fractions were well-balanced in their essential amino acids with the exception of methionine. In conclusion, nitrogen application can be used for the nutritional improvement in human diet by increasing and maintaining protein and essential amino acid contents (Thanapornpoonpong *et al*., 2008).

Tittonell *et al*. (2001) reported that, higher relative growth rates and lower dry matter content in leaf tissues can be expected when the N availability in the soil is increased by fertilization. Also added that, high nitrate uptake leads to increased nitrate accumulation in lettuce leaves. Nitrate reduction may be limited by many factors such as light intensity and plant population. Nitrate content in leaf tissues at harvest affects commercial and nutritional quality. It is strongly related to phenolic metabolism during storage and its accumulation tends to increase polyphenol oxidase (PPO) activity, as well as concentrations of chlorogenic acid and phenolic compounds. Moreover, part of the nitrate ingested by human beings may be converted into nitrite, thereby causing methaemoglobinemia or even formation of carcinogenic nitrosamine. Since pre-harvest conditions such as N availability in the soil affect lettuce quality and postharvest behavior, we hypothesize that adjustments in the level of N application are required when the number of plants grown per area is increased.

CHAPTER III

MATERIALS AND METHODS

A field experiment was accomplished at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh, during the period from November 2018 to April 2019 to study the influence of Nitrogen doses and Spacing on growth and flowering of Lisianthus. This chapter contains brief description of location of the experimental site, climatic condition and soil, materials used for the experiment, treatment and design of the experiment, production methodology, intercultural operations, data collection procedure and statistical analysis etc. which are presented as following headings:

3.1 Experimental sites

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2018 to September 2019 to study the performance of growth and yield of Nandini (Lisianthus) to different application of nitrogen and planting spacing. The Location of the site is $23^{0}74'$ N latitude and $90^{0}35'$ E longitudes with an elevation of 8.2 meter from sea level (Anon., 1989) in Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climatic conditions

The experiment site was located in the subtropical monsoon climatic zone, set aparted by heavy rainfall during the months from April to September (Kharif season) and scantly of rainfall during the rest of the year (Rabi season).In addition, under the sub-tropical climatic, which is individualized by high temperature, high humidity, heavy precipitation with seasonal unexpected winds and relatively long in Kharif season (April- September) and sufficient sunlight with moderately low temperature, intensity humidity, and short day period of during Rabi season (October-March). The information of weather regarding the atmospheric temperature, relative humidity, rainfall, sunshine hours and soil temperature persuaded at the experimental site during the whole period of observation.

3.3 Characteristics of soil

The experimental soil belongs to the Modhupur Tract under AEZ No. 28 (UNDP-FAO, 1988). The land which selected was medium high and the soil series was Tejgaon. The soil characteristics of experimental plot were analyzed in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and the experiment field primarily had a pH of 6.5.

3.4 Planting materials

Seeds of Lisianthus variety (SAU Blue Nandini) were used in this experiment and seeds were collected from Takii Seed Co., Japan in August, 2018.

3.5 Treatments of the experiment

The experiment was conducted to find out the effects of nitrogen doses and plant spacing in Lisianthus. The experiment consisted of two factors and the treatments of the two factorial experiments were as follows:

Factor A: Nitrogen application.

- N_1 = 225 kg/ha urea (103.5 kg N)
- N_2 = 250 kg/ha urea (115.0 kg N)
- N_3 = 275 kg/ha urea (126.5 kg N)

In this experiment nitrogen doses applied as urea fertilizer application. As nitrogen is the essential plant nutrient and there are no recommended nitrogen doses for Lisianthus in Bangladesh.

So, N_1(control)- 225 kg urea per hectare was applied as BARI recommended fertilizer application for marigold production.

Factor B: Spacing

Spacing was maintained on this experiment are given below:

- S_1 = 30 cm x 15 cm
- S_2 = 30 cm x 20 cm
- S_3 = 30 cm x 25 cm

The treatment combinations were:

N_1S_1, N_1S_2, N_1S_3, N_2S_1, N_2S_2, N_2S_3, N_3S_1, N_3S_2, N_3S_3

3.6 Raising of seedling

The seeds were sown in 200 holes plug trays filled with growth medium and placed in Lisianthus growth chamber for germination and subsequent growth. Required care for proper development of seedlings was taken and 70 days old seedlings (with 2-3 pair true leaves) were taken for transplanting into the field.

3.7 Design and layout of the experiment

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 19.8 m × 6.5 m was divided into three equal blocks. Each block was divided into 9 plots where 9 treatment combinations were allotted at random. There were 27 unit plots and the size of the each unit plot was 1.5 m × 1.2 m The distance maintained between two blocks and two plots were 0.5 m and 0.25 m, respectively. The seedlings were planted with maintaining distance 30 cm × 15 cm, 30 cm × 20 cm and 30 cm × 25 cm as per spacing treatment. The layout of the experiment is shown in Figure 1.

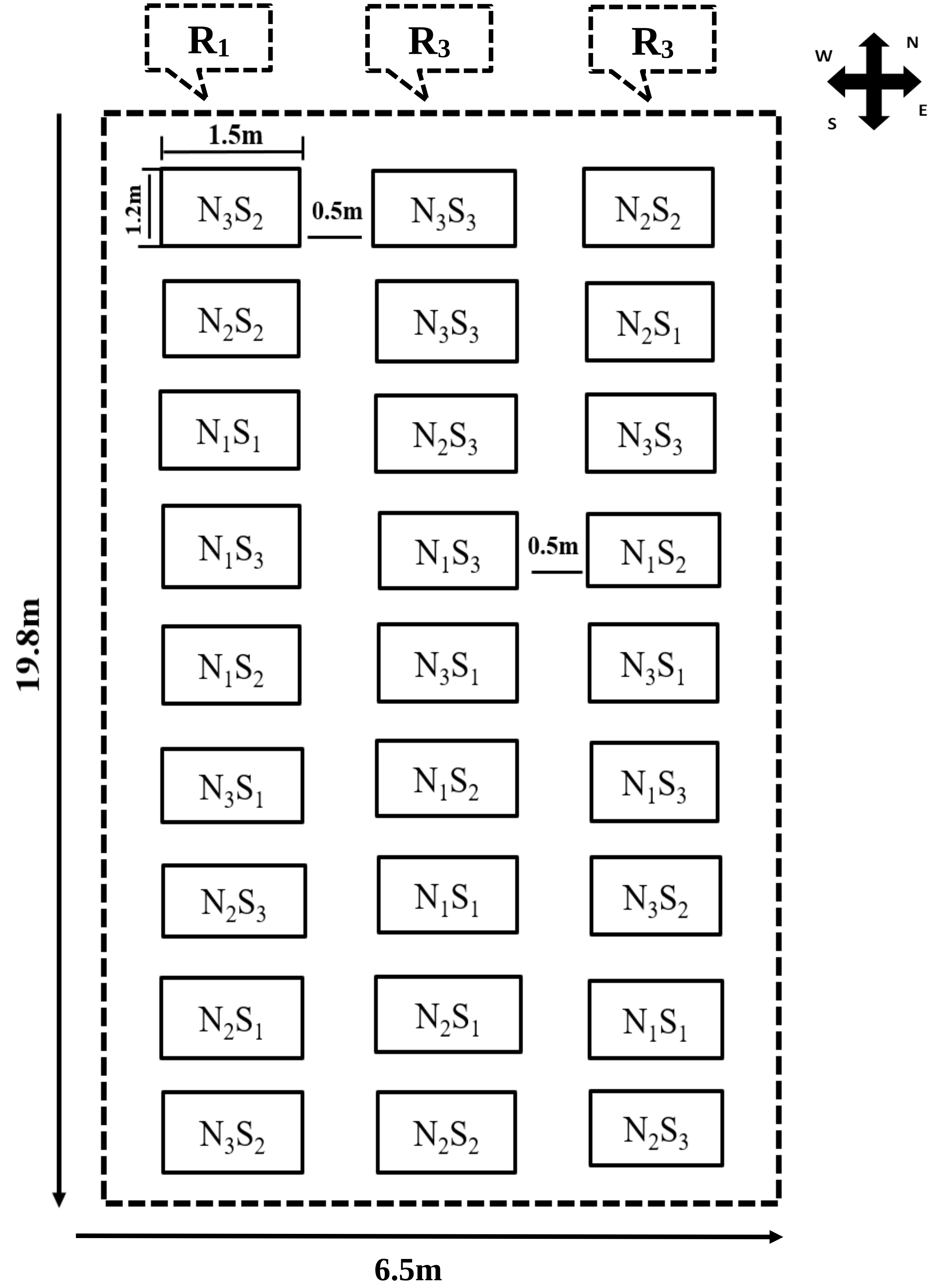


Figure 1. Layout of the experiment

3.8 Production methodology

3.8.1 Land preparation

The land was first open by ploughing with the help of power tiller and then it kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously, the clods were broken and the soil was made into good tilt.

3.8.2 Application of manure and fertilizers

The sources of N, P_2O_5 and K_2O were urea, TSP and MP, applied respectively. The entire amounts of TSP, MP and half urea were applied during the final land preparation. Rest half urea was applied in two equal installments at 20 and 45 days after seedling transplanting as per treatments. Well-rotten cow-dung at 25 t/ha also applied during final land preparation. The following amount of manures and fertilizers were used which shown in table-1 (BARI, 2005).

Table 1. Manures and fertilizer with BARI recommended doses along with plot wise application dose

Manures/ fertilizers	Recommended Dose
Cowdung	7 ton/ha
Urea	As per treatment
TSP	200 kg/ha
MoP	150 kg/ha

3.8.3 Transplanting of seedling

Healthy, uniform and rosette free seedlings were transplanted in the main field as per spacing treatment. The seedlings were uprooted carefully from the seed tray to avoid any damage to the root system. A considerable number of seedlings were also planted in the border of the experimental plots for gap filling.

3.9 Intercultural operations

When the seedlings transplanted in the main field it was always kept under careful observation. Various intercultural operations viz. weeding, irrigation and drainage, gap filling, disease and pest control, staking were accomplished for better growth and development of Lisianthus flower production.

3.9.1 Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully from the field. Later black polythene was also used as a mulch for controlling weeds.

3.9.2 Irrigation and Drainage

During seedling development, irrigation was provided using a hand sprayer to keep the growth medium moist. After transplanting of the seedlings, overhead irrigation or spray irrigation was provided through a pipe as and when necessary during experimental period. However, during bud or flower initiation only soil surface irrigation provided as per plant requirement.

3.9.3 Rogueing and gap filling

At field stages rosette forming plant and damaged plant through disease were removed from the field and new seedlings were transplanted to fill the gap as per requirement.

3.9.4 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 growth stage, Furadan 5G @ 3g/L was also applied to protect from soil nematode.

3.9.5 Staking

Staking was provided to the plants using bamboo sticks and plants were tied with rope.

3.9.6 Harvesting

Lisianthus flowers were harvested blooming flowers along with non-blooming flower or bud. In this regard, flower stem was cutting sharply with holding blooming flower and non-blooming bud.

3.10 Parameters of the experiment

Data were collected in respect of following parameters:

1. **Growth related parameters**
    a. Plant height (cm)
    b. Number of leaves per plant
    c. Leaf length (cm)
    d. SPAD value
    e. Number of stem per plant
    f. Stem length (cm)
    g. Stem diameter (mm)
2. **Yield attributing parameters**
    a. Number of flower bud per stem
    b. Number of flower per stem
    c. Number of flower per plant
    d. Number of flower per plot
3. **Quality attributing parameters**
    a. Peduncle length (cm)
    b. Receptacle diameter (mm)
    c. Flower head diameter (cm)
    d. Number of petal per flower
    e. Variation of color percentages

3.11 Data collection

Three plants were randomly selected from each unit of plot for the collection of data. However, the yield of all plants was considered per plot yield. Data have been collected on the basis of three attributed like- growth related parameters, yield attributing parameters and quality attributes parameters.

3.11.1 Plant height (cm)

Plant height of each sample plant was measured in centimeter from the ground level to the tip of the longest leaf and mean value was calculated and expressed in cm. It was recorded during different days at 30, 45, 60, 75 and 90 days after transplanting.

3.11.2 Number of leaves per plant

The number of leaves per plant was counted from the selected plants and their average mean was taken as the number of leaves per plant. It was recorded during different days at 30, 45, 60, 75 and 90 days after transplanting.

3.11.3 Leaf length (cm)

Leaf length was measured using measuring scale and mean value was calculated and expressed in cm.

3.11.4 SPAD value

Chlorophyll content of leaves was measured at 40, 60 and 80 days after transplanting. Mature leaf (fourth leaves from top) were measured all time. Three mature plant of each pot were measured by using portable Chlorophyll Meter (SPAD-502, Minolta, Japan) and then calculated an average SPAD value for each pot at each sampling time. (SPAD-502) is a simple and portable diagnostic tool that measures the greenness or the relative chlorophyll concentration of leaves.

3.11.5 Number of stem per plant

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

3.11.6 Stem length (cm)

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).

3.11.7 Stem Diameter (mm)

Stem diameter was measured using Digital caliper -515 (DC-515) in millimeter (mm) and mean was calculated.

3.11.8 Number of bud per stem

Number of bud per stem was counted up to initiation of buds on branch and the mean value was calculated.

3.11.9 Number of flower per stem

Number of flower per stem was counted just before harvesting the stem and mean value was calculated.

3.11.10 Number of flower per plant

Number of flower per plant was counted at the end of the experiment just before harvesting and the mean value was calculated.

3.11.11 Yield of flower per plot

Flower yield per plot was recorded from the mean number of flower observed from the total plants of each plot.

3.11.12 Peduncle length (cm)

Randomly selected flower peduncle length was measured using a measuring scale from each of the following ones and mean value was calculated and expressed in cm.

3.11.13 Receptacle diameter (mm)

Receptacle diameter was measured using Digital caliper -515 (DC-515) in millimeter (mm) and mean was calculated.

3.11.14 Flower head diameter (cm)

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

3.11.15 Petal number per flower

Number of petal per flower was counted from the second bloomed flower and mean value was derived from them. The second flower was chosen because petal number and the size of the flower often vary on the first flower to open but it’s generally consistent on all secondary flowers.

3.11.16 Petal color measurement

Colorimetric measurement of the experiment of the lisianthus flower was doing using IWAVE and 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” and standard illumination D65. Beams effective axes were at 45+-2’ from the normal of the specimen surface in illuminated petals. Metric chroma, c* and hue angel, h_{ab} were calculated as c*= (a=b) 0.5 and h_{ab} = tang-1 (b*/a*). The individual petals were separated and were placed under the measurement port for colour measurement.

3.12 Statistical Analysis

The data recorded for different parameters were statistically analyzed using Statistix-10 scientific analysis software to find out the significance of variation among the treatments and treatment means were compared by LSD test at 5% level of probability.

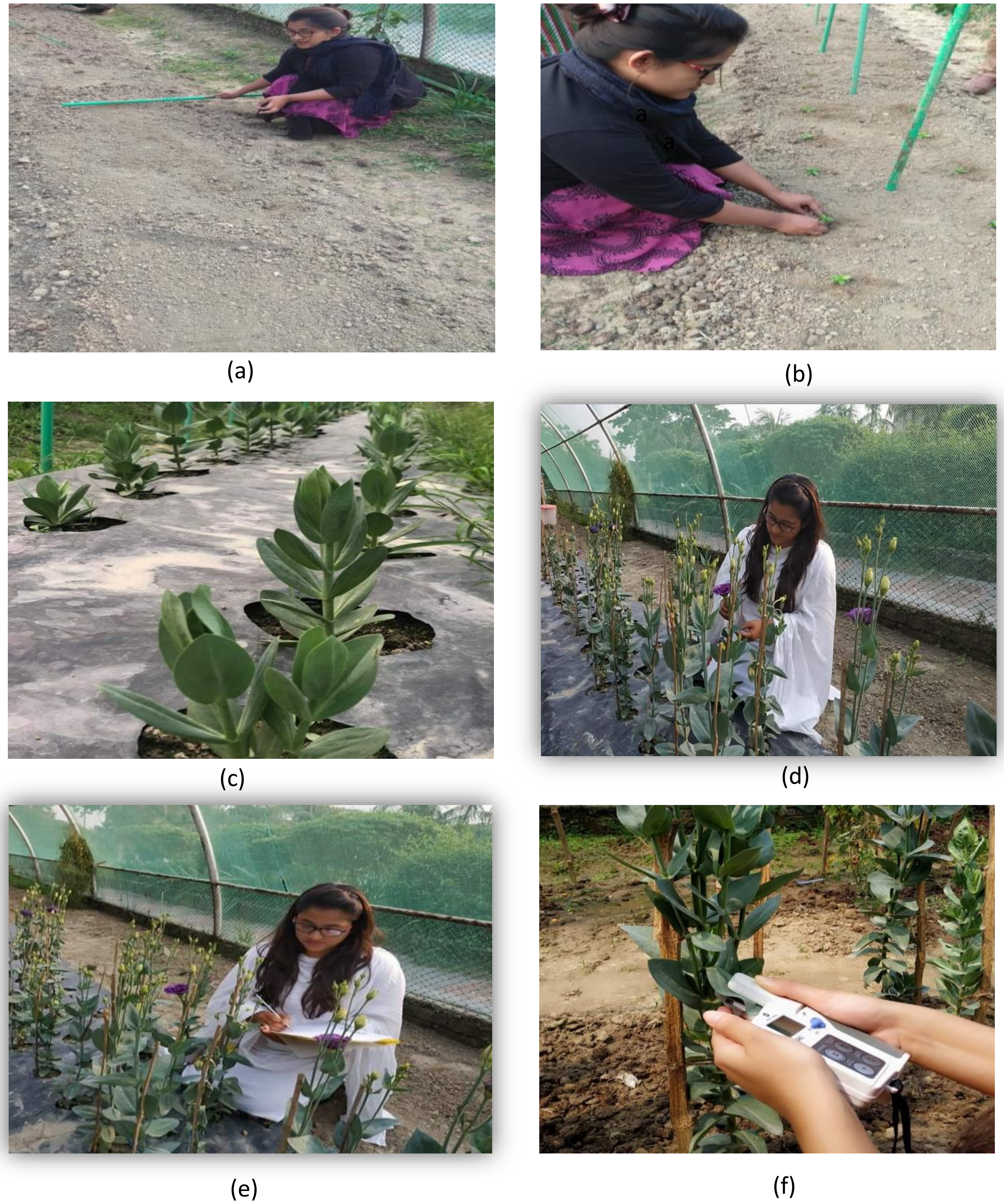


Plate 1. Photographs showing, (**a).** Land preparation, (**b).** Seedling transplanting, (**c).** Mulching, **(d)**. Measurement of plant height using measuring scale**, (e).** Leaf and stem number count., **(f)**. Chlorophyll (%) measurement using SPAD-502 chlorophyll meter.

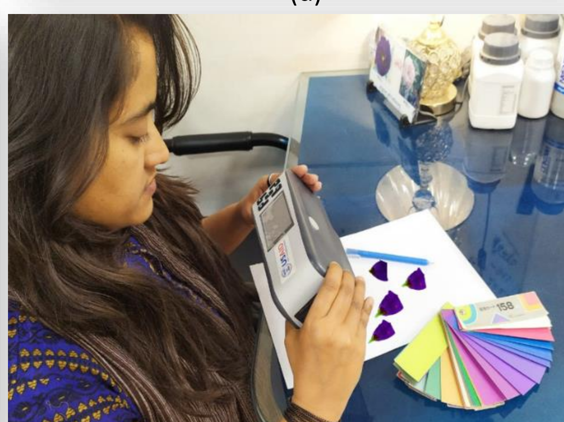
(a)

(b)

(c)

(d)

(e)



(f)

Plate 2. Photograph showing, **(a)**. Final data collection after harvesting, **(b)**. Measurement of peduncle diameter by using slide caliper, **(c)**. Measurement of receptacle diameter using slide caliper, **(d).** Measurement of flower head diameter using Digital Caliper-515, (**e**). Counting No. of petals in single flower, (**f**). CIELab color co-ordinate measurement of flower petals using IWAVE WF32 precision colorimeter (Shenzhen wave)

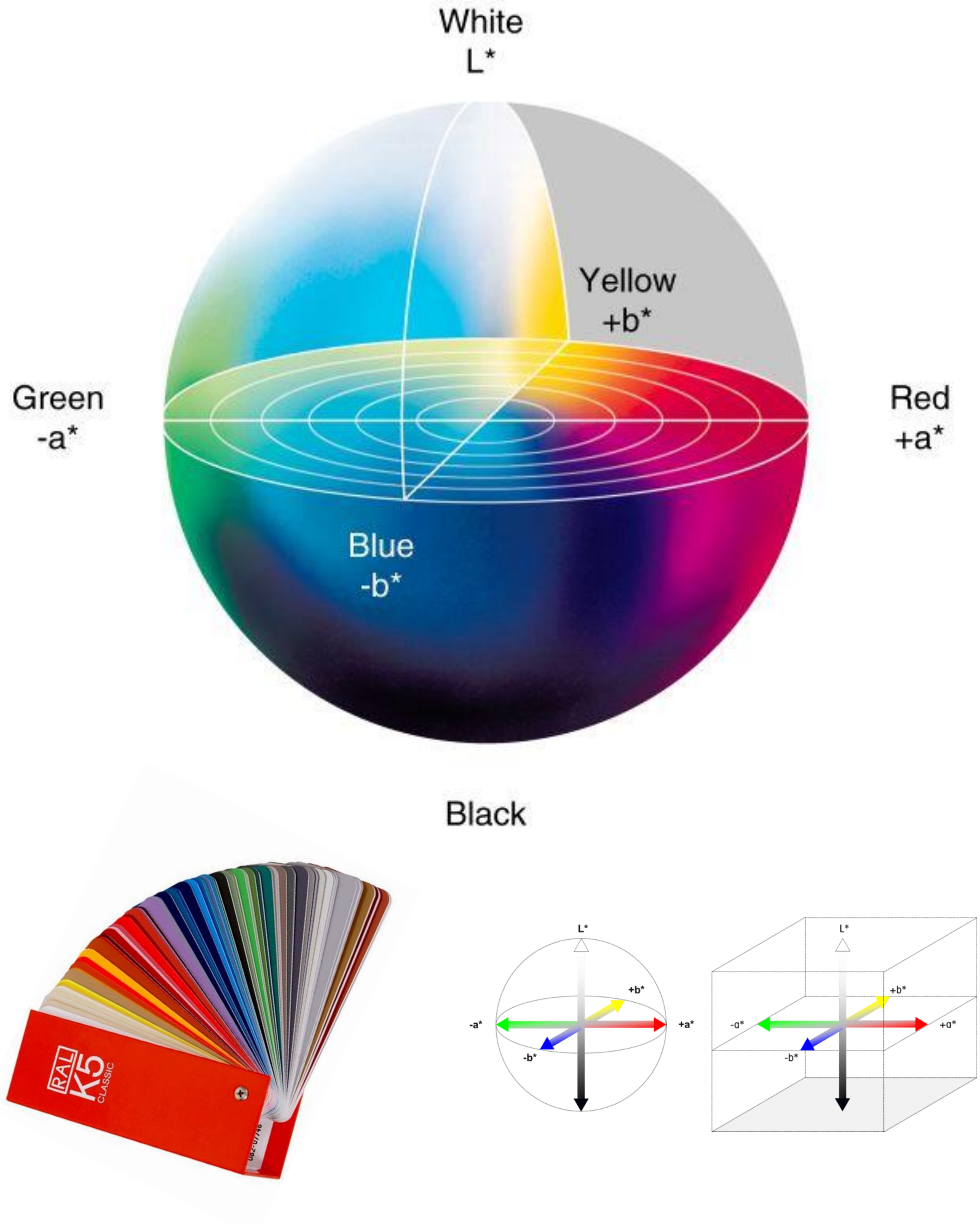


Plate 3: CIELab color scale

CHAPTER IV

RESULT AND DISCUSSION

The research work on "Growth and Flowering of Lisianthus with Nitrogen doses and Plant Spacing" was undertaken in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The experimental findings on growth and yield parameters obtained during the entire period of study, and variation was observed in the studied parameters. This contrasting attributes were presented and discussed in this chapter either in tables or 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. Growth related parameters

4.1.1 Plant height (cm)

Significant variation was found in the effect of different nitrogen doses in terms of plant height (Appendix II). The shortest plant height ranged from 15.1 cm to 80.4 cm at 30, 45, 60, 75 and 90 DAT. The tallest plant (26.7 cm, 42.1 cm, 55.7 cm, 69.0 cm and 80.4 cm at 30, 45, 60, 75 and 90 DAT respectively) was found from N_3 where the shortest plant (15.1 cm, 30.6 cm, 45.2 cm, 57.5 cm and 66.6 cm at 30, 45, 60, 75 and 90 DAT respectively) was observed from N_1 (Figure 2). The present finding also agreed to the results of Baral *et al*. (2012). Plant height as well as growth of plant significantly increased with the application of nitrogen fertilizers reported by Dahal *et al*. (2014). Hong *et al*. (2008) reported that optimizing nitrogen (N) nutrition is required for healthy and vigorous plants. Nitrogen was absorbed by the plants and thereby stimulated plant growth and induced the plant protoplasm resulting in increased plant height (Jamil *et al.*, 2016).

Statistically significant variation on plant height of Lisianthus was shown due to different plant spacing at 30, 45, 65, 75 and 90 DAT (Figure 3, Appendix II).

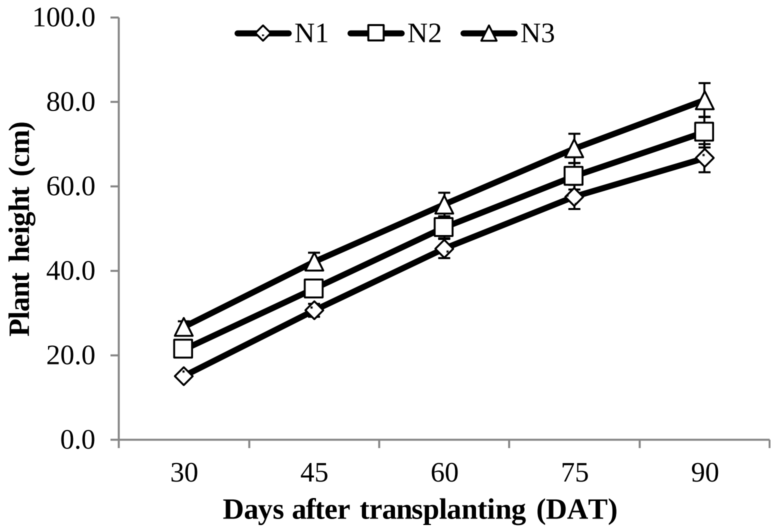


Figure 2. Effect of nitrogen doses on plant height (cm) at different days after transplanting (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

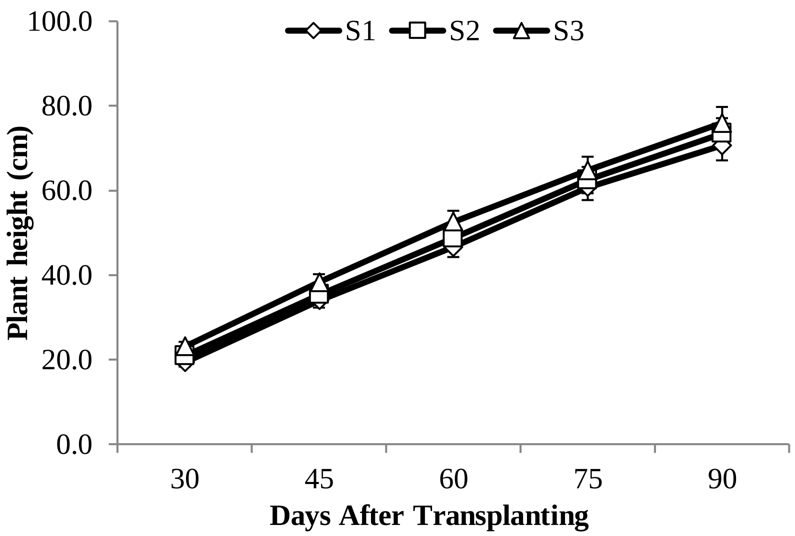


Figure 3. Effect of different spacing on plant height (cm) at different days after transplanting (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

At different days after transplanting (DAT) the tallest plant (23.0 cm, 38.2 cm, 52.5 cm, 64.7 cm and 75.9 cm at 30, 45, 65, 75 and 90 DAT respectively) was recorded from S_3 (30 cm × 25 cm). On the other hand, the shortest plant (19.3 cm, 33.9 cm, 46.5 cm, 60.7 cm and 70.6 cm at 30, 45, 65, 75 and 90 DAT respectively) was found from S_1 (30 cm × 15 cm).

The obtained results could be due to elongation of cells and the number of cells from cell division. Similar observation has been reported in other research in Gairi et al. (2020), in chrysanthemum (Karavadia and Dhaduk 2002) and in tuberose (Mane *et al.*, 2006). It may be due to intra plant competition for light, moisture, space, nutrients and aeration where the more plant spacing have less competition and influence plant height.

Table 2. Interaction Effect of nitrogen doses and spacing on plant height of Lisianthus at different days after transplanting**

	Plant height				
Treatment*	35 DAT	50 DAT	65 DAT	80 DAT	90 DAT
N_1S_1	13.3 h	27.4 f	41.9 f	54.2 g	65.6 g
N_1S_2	14.9 g	28.0 f	43.6 ef	55.9 f	66.9 fg
N_1S_3	16.9 f	30.5 e	44.3 e	56.4 f	67.5 f
N_2S_1	19.2 e	33.6 d	47.2 d	60.8 e	71.3 e
N_2S_2	21.2 d	35.9 c	49.9 c	62.5 d	73.2 de
N_2S_3	23.6 c	37.5 c	50.6 c	63.8 d	74.1 d
N_3S_1	25.3 b	40.9 b	54.8 b	67.2 c	78.0 c
N_3S_2	26.3 b	41.8 ab	55.6 ab	68.9 b	80.1 b
N_3S_3	28.5 a	43.8 a	56.7 a	70.9 a	83.1 a
LSD	1.2	2.0	1.7	1.4	1.9
CV	3.3	3.4	2.0	1.3	1.5

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha. and S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

**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

Significant variation was observed due to interaction effect of nitrogen and plant spacing in terms of plant height of Lisianthus at 30, 45, 65, 75 and 90 DAT (Table 2 and Appendix II). The tallest plant (28.5 cm, 43.8 cm, 56.7 cm, 70.9 cm and 83.1 cm at 30, 45, 65, 75 and 90 DAT, respectively) was recorded from N_3S_3. The shortest plant (13.3 cm, 27.4 cm, 41.9 cm, 54.2 cm and 65.6 cm cm at 30, 45, 65, 75 and 90 DAT, respectively) was found from N_1S_1.

Bijimol and Singh (2000) reported that plant height of gladiolus flower had positive impact with the combination of nitrogen fertilizer and plant spacing. The results revealed that optimum doses of nitrogen and plant spacing ensured maximum plant height with plant growth.

4.1.2 Number of leaves per plant

Significant variation was recorded for number of leaves per plant of Lisianthus with application of different levels of nitrogen at 30, 45, 65, 75 and 90 DAT (Figure 4 and Appendix III). At 30, 45, 65, 75 and 90 DAT the maximum number of leaves per plant was 23.7, 37.0, 50.0, 62.7 and 74.1 respectively which was obtained from N_3 (275 kg urea/ha) and the minimum number of leaves per plant (12.6, 21.2, 35.2, 47.4 and 57.2 at 30, 45, 65, 75 and 90 DAT respectively) was found from N_1 (225 kg urea/ha). It was revealed number of leaves per plant varied with the variation of nitrogen doses where higher doses of nitrogen level showed higher number of leaves per plant at all growth stages. Maximum number of leaves per plant was recorded for highest level of nitrogen because nitrogenous fertilizer ensures favorable condition for the growth of Lisianthus. Similar findings were observed by Tittonell *et al.* (2003), Rincon *et al.* (1998) and Boroujerdnia and Ansari (2007).

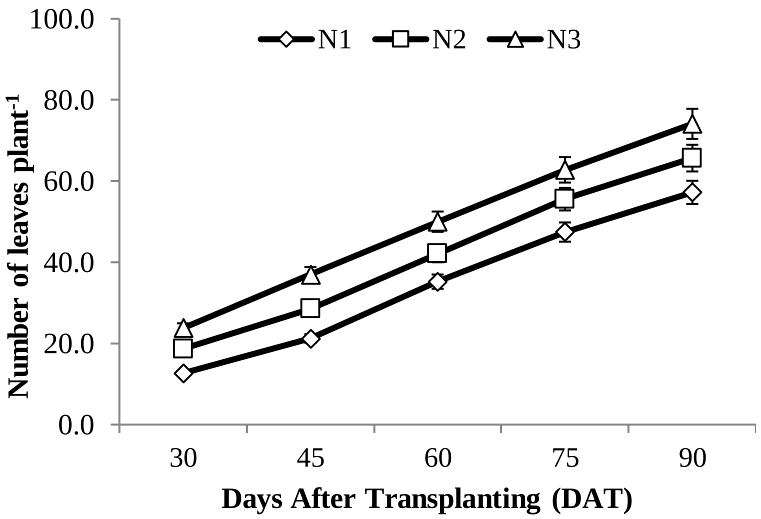


Figure 4. Effect of nitrogen doses on number of leaves per plant at different days after transplanting (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

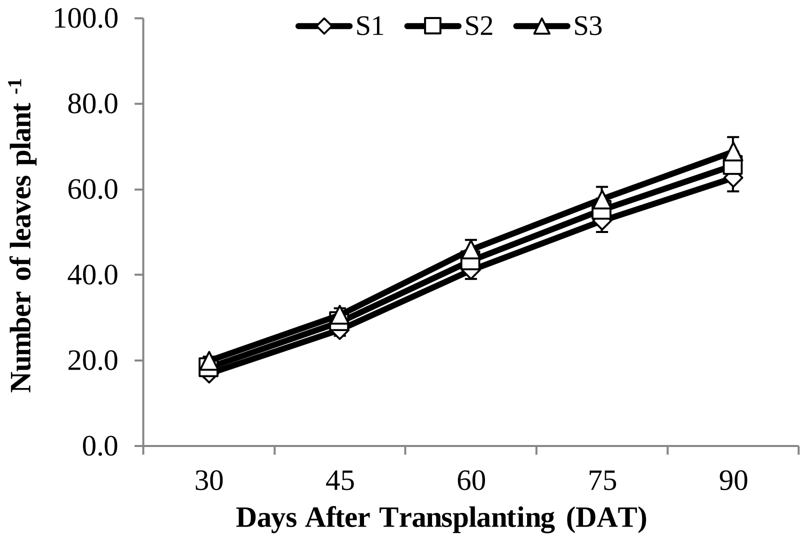


Figure 5. Effect of different spacing on number of leaves per plant of Lisianthus at different days after transplanting (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

Effect of plant spacing showed significant difference among the treatment in terms of number of leaves per plant of Lisianthus at different days after transplanting (Figure 5 and Appendix III). The maximum number of leaves per plant (19.8, 30.6, 45.8, 57.7, 68.7 at 30, 45, 65, 75 and 90 DAT respectively) was obtained from S_3 (30 cm × 25 cm). At the same condition, the minimum number of leaves per plant (16.8, 27.1, 41.1, 52.6 and 62.6 at 30, 45, 65, 75 and 90 DAT respectively) was recorded from S_1 (30 cm × 15 cm), It was revealed that with the increases of spacing, number of leaves per plant also increased. Enough space for vertical and horizontal expansion in the optimum spacing that leads for production of maximum number of leaves per plant than the closer spacing. Steingrobe and Schenk (1994) also reported similar results earlier.

Table 3. Interaction Effect of nitrogen doses and spacing on number of leaves per plant at different days after transplanting**

	Number of leaves plant^{-1}				
Treatment	35 DAT	50 DAT	65 DAT	80 DAT	95 DAT
N_1S_1	11.6 h	19.3 f	33.3 h	46.3 e	56.3 e
N_1S_2	12.6 gh	21.6 e	35.3 g	47.3 e	56.6 e
N_1S_3	13.6 g	22.6 e	37.0 f	48.6 e	58.6 e
N_2S_1	16.6 f	26.6 d	41.6 e	53.6 d	63.3 d
N_2S_2	18.6 e	28.3 d	44.3 d	55.3 cd	65.6 cd
N_2S_3	20.6 d	30.6 c	46.3 c	57.6 c	68.0 c
N_3S_1	22.3 c	35.3 b	48.3 b	61.0 b	71.3 b
N_3S_2	23.6 b	37.0 ab	50.3 a	62.6 ab	74.3 a
N_3S_3	25.3 a	38.6 a	51.3 a	64.6 a	76.6 a
LSD	1.0	1.7	1.1	2.3	2.5
CV	3.6	3.4	1.5	2.4	2.2

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha. and S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

Interaction effect of nitrogen and plant spacing had significant variations among the treatments in terms of number of leaves per plant of lettuce at 30, 45, 65, 75 and 90 (Table 3 and Appendix III). The maximum number of leaves/plant (25.3, 38.6, 51.3, 64.6 and 76.6 at 30, 45, 65, 75 and 90 DAT, respectively) was found from N_3S_3, and at 90 DAT statistically similar result was observed in N_3S_2 (74.3). Again, the minimum number of leaves/plant (11.6, 19.3, 33.3, 46.3 and 56.3 at 30, 45, 65, 75 and 90 DAT respectively) was attained from N_1S_1, statistically similar result was found at 80 DAT, N_1S_2 (47.3) and N_1S_3 (48.6), and N_1S_2 (56.6) and N_1S_3 (58.6) at 90 DAT. It was revealed that optimum level of nitrogen and plant spacing ensured maximum number of leaves per plant.

4.1.3 Leaf length (cm)

Application of different levels of nitrogen showed statistically significant variation for leaf length of Lisianthus (Figure 6 and Appendix VI). The highest leaf length was 6.7 cm which was achieved from N_3 (275 kg urea/ha). Again, the lowest leaf length 4.5 cm was found from N_1 (225 kg urea/ha). Results showed that higher doses of nitrogen cause higher leaf length. Optimum vegetative growth was occurred due to higher amount of nitrogen fertilizer that leads for the growth of Lisianthus and the ultimate results was the longest leaf. Application of nitrogen helps in synthesis of protein which is the main constituent in the plants. Thus, the higher supply of nitrogen through fertilizer in the experiment had increased the synthesis of amino acids in plants, thereby; it increased vegetative growth of the plant. Mishra (1998) also reported that growth characters in gaillardia plant were significantly increased with higher doses of nitrogen application.

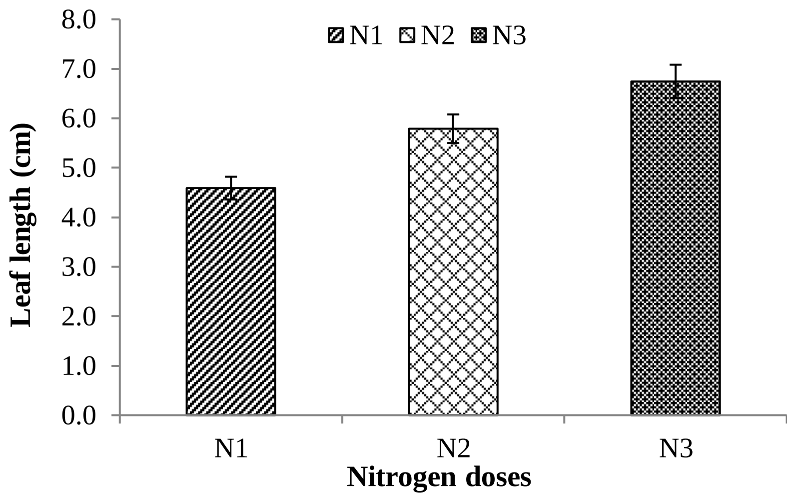


Figure 6. Effect of nitrogen doses on leaf length of Lisianthus (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

Leaf length of Lisianthus was significantly varied among different spacing treatment (Figure 7 and Appendix VI). The highest leaf length (6.0 cm) was observed from S_3 (30 cm × 25 cm) and the lowest leaf length (5.4 cm) was recorded from S_1 (30 cm × 15 cm). It was revealed that with the increases of spacing leaf length showed increasing trend. In case of closer spacing plant compete for light and with the time being leaf length decreases. Kumar *et al*. (2001) observed that growth of Lisianthus plant varied with different spacing.

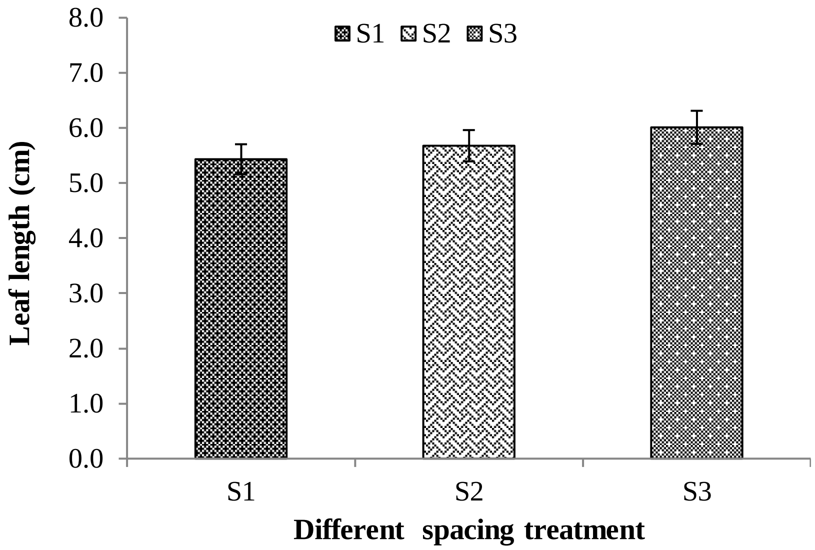


Figure 7. Effect of different spacing on on leaf length of Lisianthus (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

In case of interaction effect of nitrogen doses and plant spacing, leaf length of Lisianthus showed statistically significant variation (Table 5 and Appendix VI). The highest leaf length (7.0 cm) was found from N_3S_3. The lowest leaf length (4.3 cm) was obtained from N_1S_1 which was statistically similar with N_1S_1 (4.5 cm). Data revealed that optimum level of nitrogen and plant spacing ensured the highest leaf length with maximum vegetative growth.

4.1.4 SPAD Value

Chlorophyll enhances the growth of a plant which is correlated with the plant growth. Chlorophyll (%) on leaves (SPAD reading) showed significant variation with the application of different nitrogen doses at different days after transplanting (Appendix IV). The highest SPAD value (53.5, 60.9 and 55.8) was measured at 40, 60 and 80 DAT from N_3 whereas the lowest (37.3, 45.1

and 41.2) was observed at 40, 60 and 80 DAT from N_1 (Figure 8). Chlorophyll content of leaves is frequently correlated with photosynthetic capacity, with leaf N status, and RuBP carboxylase activity (Evans, 1998; Seemann *et al.*, 1987).

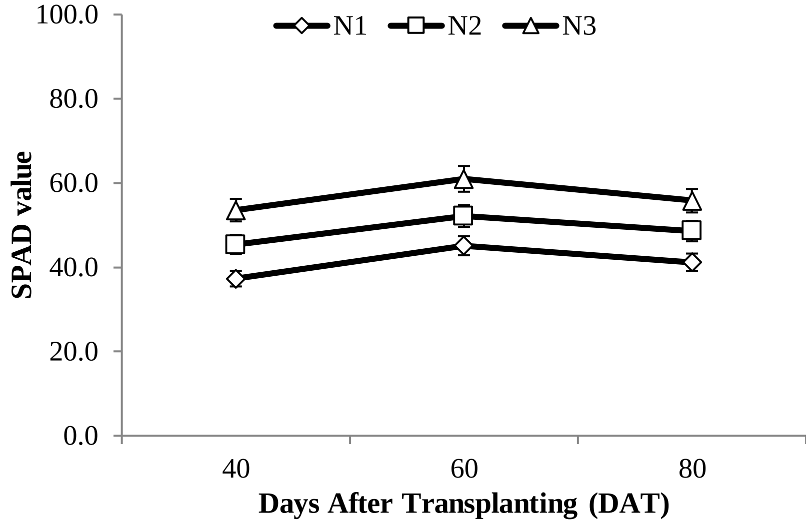


Figure 8. Effect of nitrogen doses on SPAD value of leaves at different days after transplanting (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

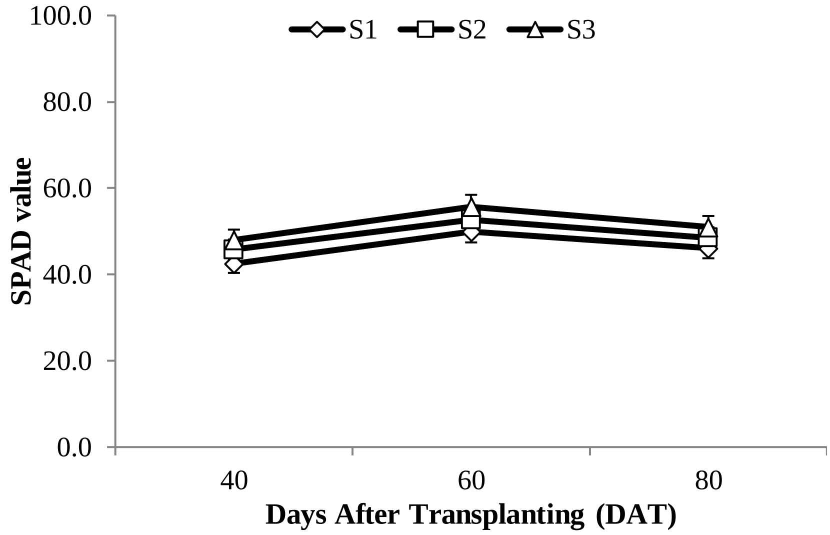


Figure 9. Effect of different spacing on SPAD value of leaves at different days after transplanting (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

In different spacing treatment SPAD value of leaves showed significant variation (Appendix IV). Maximum SPAD value (47.9, 55.6 and 51.0) was found at 40, 60 and 80 DAT from treatment (S_3) and minimum (42.4, 49.9 and 46.0) was observed 40, 60 and 80 DAT in (S_1) (Figure 9). Effective photochemical quantum yield of photosystem, coefficient of photochemical fluorescence quenching varied with the variation of row and plant spacing, so spacing is conducive to improving the photosynthetic performance of crop population (Prathibha et al., 2018). This is because plant density affects the nutritional state of plants, light interception and distribution of crop canopy.

Table 4. Interaction Effect of nitrogen doses and spacing on SPAD value of leaves at different days after transplanting**

	SPAD Value		
Treatment	40 DAT	60 DAT	80 DAT
N_1S_1	34.2 h	41.9 g	38.1 g
N_1S_2	37.5 g	45.5 fg	41.0 f
N_1S_3	40.1 f	47.8 f	44.4 e
N_2S_1	42.7 e	49.0 ef	46.6 de
N_2S_2	45.9 d	51.9 de	48.7 cd
N_2S_3	47.4 d	55.4 cd	50.4 c
N_3S_1	50.4 c	58.7 bc	53.4 b
N_3S_2	53.8 b	60.4 ab	55.7 ab
N_3S_3	56.4 a	63.7 a	58.1 a
LSD	2.4	3.7	2.4
CV	3.1	4.0	2.9

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha. and S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

Combination of nitrogen doses and spacing treatment had significant variation on SPAD value of leaves (Appendix IV). The utmost SPAD value of leaves (56.4, 63.7 and 58.1) was found in (N_3S_3) and minimum (34.2, 41.9 and 38.1) was found from treatment (N_1S_1) at 40, 60 and 80 DAT respectively (Table 4). This may be due to nitrogen application that enhances growth metabolism, and spacing influence nutritional states of plants as well as light interpretation.

4.1.5 Number of stem per plant

Significant difference was revealed on number of stem per plant with different doses of nitrogen application (Appendix V). Among them, the maximum stem per plant (7.2) observed in N_3 while minimum stem number (4.7) found in N_1 (Figure 10). Acharya and Dashora (2004) reported that nitrogen produced the maximum vegetative growth in marigold plants. This might be due to an increased uptake of the nutrient. Being, nitrogen is a constituent of protein, component of protoplasm and chlorophyll, all the factors contributed to cell multiplication, cell enlargement and cell differentiation resulting in increased photosynthesis and translocation.

Number of stem per plant of Lisianthus showed statistically significant variation due to different plant spacing (Figure 11 and Appendix V). The wider spacing of 30 cm x 25 cm had recorded significantly maximum stem number (6.5) and minimum number of stem (5.5) was observed with the closer spacing of 30 cm x 15 cm. This might be due to sufficient amount of nutrients available for widely spaced plants for producing vigorous growth of plant with maximum number of stem. Similar result was reported by Kumar and Singh (2011).

The significant variation was recorded due to combined effect of nitrogen and spacing in terms of stem number of plant (Appendix V). The maximum number of stem per plant (7.6) was found from N_3S_3 treatment and the minimum (4.3) from N_1S_1 treatment (Table 5). This is because effect of spacing and external application of fertilizer specially nitrogen influence plant growth.

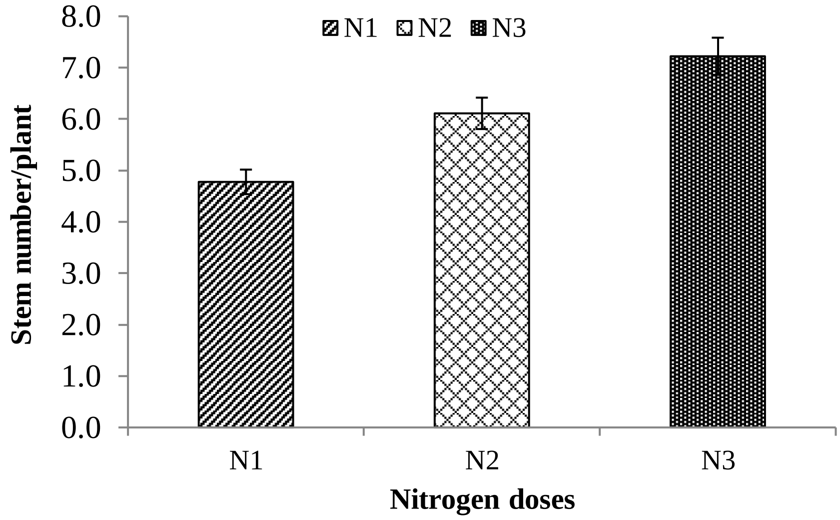


Figure 10. Effect of nitrogen doses on number of stem per plant (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

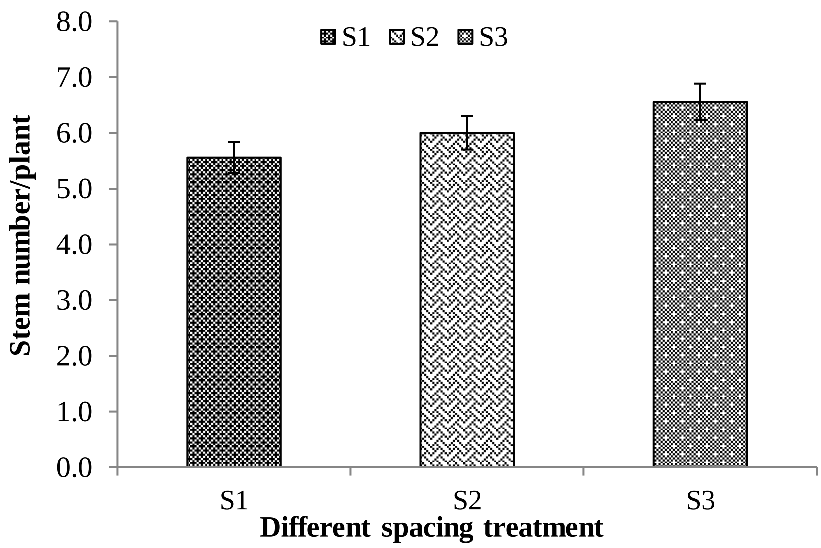


Figure 11. Effect of different spacing on number of stem per plant of Lisianthus (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

4.1.6 Stem length (cm)

Stem length at harvest showed statistically significant difference due to the effect of different nitrogen doses (Appendix V). The highest stem length (63.1 cm) was recorded in N_3 (Figure 12). On the other hand, lowest length (49.9 cm) was recorded in N_1 treatment. Iqbal *et al*. (2008) observed that various levels of nitrogen significantly affect physiological parameters of plant.

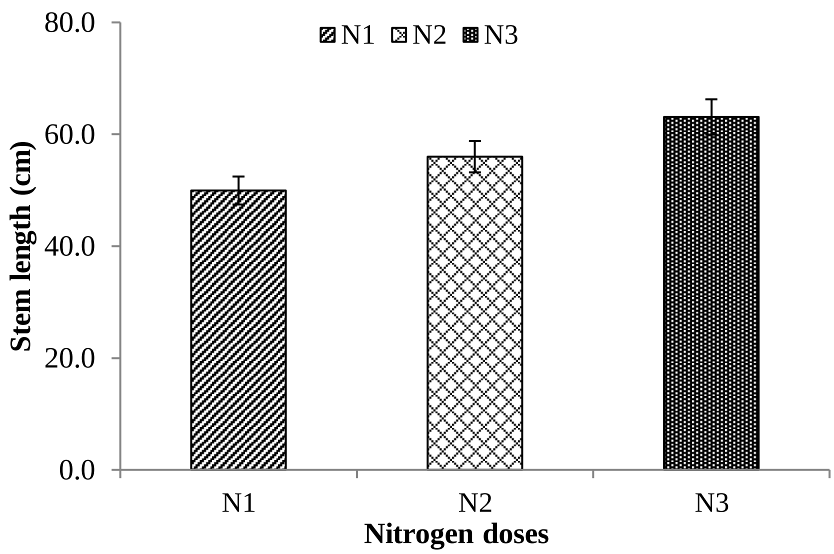


Figure 12. Effect of nitrogen doses on stem length (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

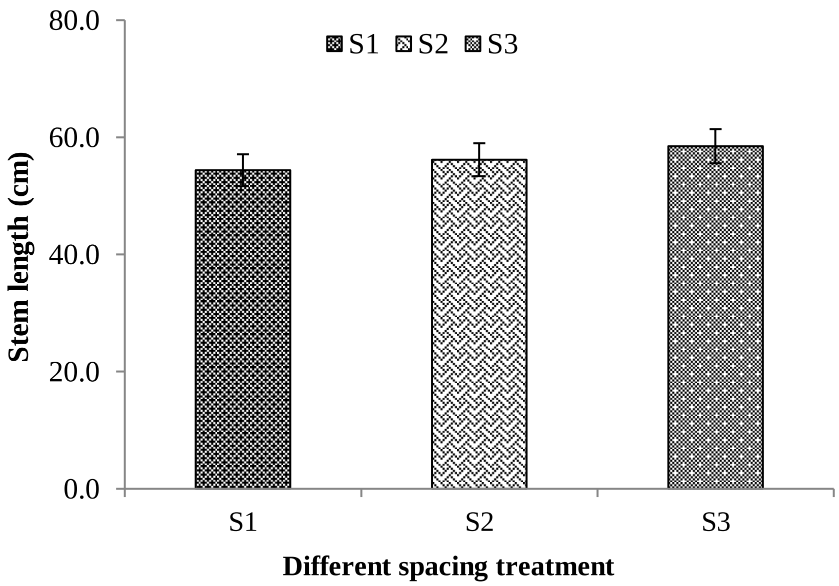


Figure 13. Effect of different spacing on stem length (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

The stem length increased probably due to the presence of higher nutrient content which resulted in better vegetative and reproductive growth of the plant.

In case of different spacing treatment stem length of Lisianthus showed significant variation (Figure 13 and Appendix V). The highest stem length (58.4 cm) was observed from S_3 (30 cm × 25 cm) and the lowest stem length (54.3 cm) was recorded from S_1 (30 cm × 15 cm). The increase in plant stem with wider levels of spacing might be due to less competition for nutrients, optimum plant population per unit area and all the plants received proper amount of sun light, aeration and nutrition for maximum vegetative growth (Sudhakar and Kumar, 2012).

Interaction effect of nitrogen doses and plant spacing, stem length of Lisianthus showed statistically significant variation (Table 4 and Appendix V). The highest stem length (65.2 cm) was found from N_3S_3. The lowest stem length (48.0 cm) was obtained from N_1S_1, which was statistically similar with N_1S_2 (49.4 cm). Data revealed that different level of nitrogen application and plant spacing influenced the highest stem length with maximum vegetative growth.

4.1.7 Stem diameter (mm)

The difference in nitrogen doses for stem diameter (mm) was found significant (Appendix V). The maximum diameter of stem (5.8 mm) was observed in N_3 while the lowest stem diameter (4.2 mm) found in N_1 (Figure 14). The increase in growth characters and yield components from increased nitrogen level might be due to the role of nitrogen in stimulating vegetative growth. The hypothesis is that nitrogen is a constituent of protein, nucleic acids and nucleotides that are essential to the metabolic function of plants. Parallel findings to this experiment have been cited in other research (Ayub et al., 2007).

Breadth of stem of Lisianthus showed statistically significant variation due to different plant spacings (Figure 15 and Appendix V).

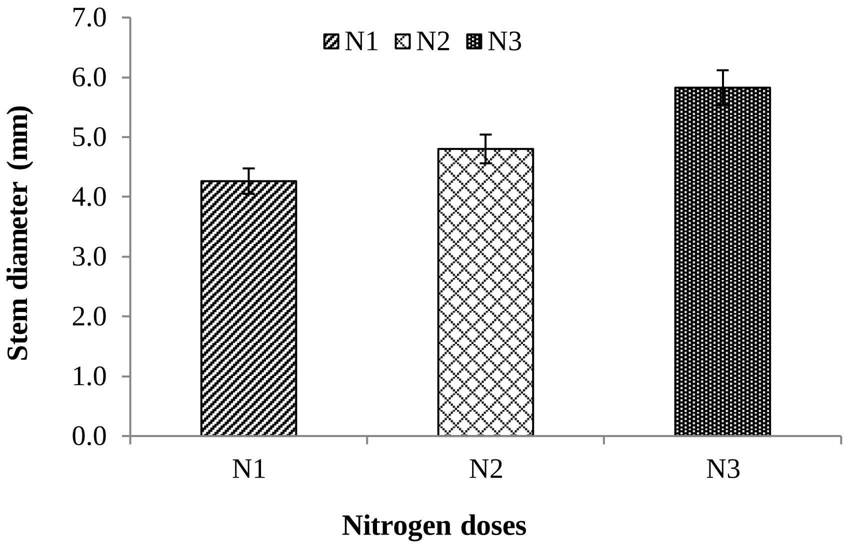


Figure 14. Effect of nitrogen doses on stem diameter (Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha. and N_3: 275 kg urea/ha.)

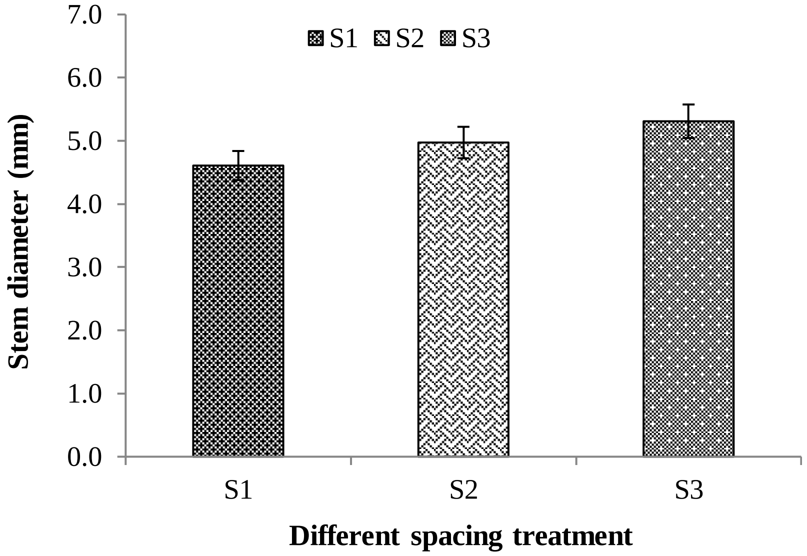


Figure 15. Effect of different spacing on stem diameter (Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm)

The wider spacing of 30 cm x 25 cm had recorded significantly maximum stem diameter (5.3 mm) and minimum stem diameter (4.6 mm) was observed with the closer spacing of 30 cm x 15 cm. Similar types of responses have also been observed in Sunflower with wider spacing (Khalaj and Edrisi, 2012). This is because the wider spaced plants have less competition for nutrients, water and light that induces better quality flower production.

Interaction effect of nitrogen doses and plant spacing, stem diameter of Lisianthus showed statistically significant variation (Table 5 and Appendix V). The maximum stem diameter (6.2 mm) was found from N_3S_3. The lowest stem diameter (3.9 mm) was obtained from N_1S_1. Data revealed that different level of nitrogen application and plant spacing influenced the highest stem diameter with maximum vegetative growth.

Table 5. Interaction Effect of nitrogen doses and spacing on leaf length, stem number per plant, stem length and stem diameter of Lisianthus**

Treatment	Leaf length (cm)	Stem Number per plant	Stem Length (cm)	Stem dia. (mm)
N_1S_1	4.3 f	4.3 f	48.0 f	3.9 h
N_1S_2	4.5 f	4.6 ef	49.4 f	4.3 g
N_1S_3	4.9 e	5.3 de	52.3 e	4.5 f
N_2S_1	5.5 d	5.6 d	54.3 de	4.4 fg
N_2S_2	5.8 cd	6.0 cd	55.7 cd	4.8 e
N_2S_3	6.0 c	6.6 bc	57.8 c	5.1 d
N_3S_1	6.4 b	6.6 bc	60.7 b	5.4 c
N_3S_2	6.7 b	7.3 ab	63.3 ab	5.7 b
N_3S_3	7.0 a	7.6 a	65.2 a	6.2 a
LSD	0.3	0.9	2.6	0.1
CV	3.5	9.5	2.6	1.5

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha. and S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

4.2 Yield attributes

4.2.1 Number of flower bud per stem

Significant variation was found in case of number of flower bud/ stem among different levels of nitrogen application (Appendix VI). The highest number of flower bud/stem was observed in N_3 (9.8) and the minimum was observed in N_1 (7.5) (Table 6). This finding is in agreement with that of Mojiri and Arzani (2003). It may be due to application of nitrogen fertilizer (urea) and with the higher doses of urea induced flower.

Number of flower bud per stem was significantly varied among different spacing treatment (Table 7 and Appendix VI). The highest number of flower bud (10.4) was observed from S_3 (30 cm × 25 cm) and the minimum (6.7) was recorded from S1 (30 cm × 15 cm). It was revealed that with the increases of spacing leaf length showed increasing trend. The production of flower bud may probably be due to less competition between plants for water, mineral nutrients and light. Similar results have been recorded elsewhere (Roychowdhary, 1989).

Considering combination of nitrogen doses and plant spacing treatment, flower bud number per stem showed statistically significant variation (Table 8 and Appendix VI). The maximum flower bud (12.3) was found from N_3S_3 and the lowest (6.3) was obtained from N_1S_1.

4.2.2 Number of flower per stem

Number of flower per stem of Lisianthus showed prominent effect among different doses of nitrogen levels (Appendix VI). The results revealed that higher the rate of nitrogen fertilizer application induced maximum flower. The maximum number of flower (5.8) observed in N_3 treatment, while the minimum number (4.44) found in N_1 treatment (Table 6). Similar results were found in Adhikari *et al*. (2020). Flower number increased due to quick vegetative growth and thereafter, enhancing reproductive development of flower under optimum nitrogen treatment. Higher content of nitrogen might have also accelerated protein synthesis which promotes earlier floral primordial development.

In case of different spacing treatment, flower per plant showed positive effect (Appendix VI). The maximum number of flower per stem (6.4) was produced at the wider spacing of 30 cm x 25 cm, compared to the minimum flower number per stem at the narrower spacing of 30 cm x 15 cm, which produced 3.8 (Table 7). The decrease in flower number might be due to higher plant population pressure leading to increase in competition for nutrients among the plants, whereas, increase in flower number might be due to lesser availability of space and solar radiation in closely spaced calendula plants. Similar findings reported by Mane et al. (2007).

Considering nitrogen doses and spacing treatment, flower number per stem showed statistically significant variation (Table 8 and Appendix VI). The maximum number of flower per stem (7.3) was found from N_3S_3 and the lowest (3.3) was obtained from N_1S_1.

4.2.3 Number of flower per plant

Significant variation was found in case of number of flower per plant among different levels of nitrogen application (Appendix VII). The results revealed that higher the rate of nitrogen fertilizer application induced maximum flower. The maximum number of flower (42.6) observed in N_3 treatment, while the minimum number (21.5) found in N_1 treatment (Table 6). These findings are similar to those of Rajiv and Misra (2000). Higher rate of nitrogen might have quick vegetative growth that promotes floral development and increased Flower number. In different spacing treatment flower number per plant showed significant variation Appendix VII.

Table 6. Effect of nitrogen doses on number of flower bud per stem, number of flower per stem, number of flower per plant and number of flower yield per plot of Lisianthus**

Treatment	Flower bud per stem	Flower per stem	Flower per plant	Flower yield per plot
N_1	7.5 c	4.4 c	21.5 c	605.0 c
N_2	8.4 b	5.3 b	32.5 b	923.3 b
N_3	9.8 a	5.8 a	42.6 a	1219.3 a
LSD	0.7	0.4	1.5	8.6
CV	9.0	8.4	4.8	0.9

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha.

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

Table 7. Effect of different spacing on number of flower bud per stem, number of flower per stem, number of flower per plant and number of flower yield per plot of Lisianthus**

Treatment	Flower bud per stem	Flower per stem	Flower per plant	Flower yield per plot
S_1	6.7 c	3.8 c	22.1 c	783.8 c
S_2	8.6 b	5.3 b	32.3 b	950.0 b
S_3	10.4 a	6.4 a	42.3 a	1013.9 a
LSD	0.7	0.4	1.5	8.6
CV	9.0	8.4	4.8	0.9

*Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

The wider spacing of 30 cm x 25 cm had recorded significantly maximum flower number (42.3) and minimum number of flower (22.1) was observed with the closer spacing of 30 cm x 15 cm (Table 7). This might be due to availability of more area per plant for absorption of nutrients and moisture, no shading effect which ultimately increased the rate of net photosynthesis and translocation of assimilates to the storage organs which promotes more flower in plant compare to the less space per plant. Similar result was found in Kumar and Singh (2011).

Interaction effect of nitrogen doses and plant spacing, flower number per plant showed statistically significant variation (Table 8 and Appendix VII). The maximum number of flower (55.3) was found from N_3S_3 and the lowest number of flower (14.6) was obtained from N_1S_1. Data revealed that different level of nitrogen application and plant spacing influenced optimum growth of plant with inducing large number of flower.

4.2.4 Number of flower per plot

Significant variation was observed in number of flower per plant among different levels of nitrogen application (Appendix VII). The results revealed that higher the rate of nitrogen fertilizer application induced maximum flower. The maximum number of flower (1219.3) observed in N_3 treatment, while the minimum number (605.0) found in N_1 treatment (Table 6). A similar result was found in marigold plant (Singh and Saha, 2009). This might have due to high doses of nitrogen enhanced vegetative growth that promotes the number of flower.

In case of different spacing treatment, flower per plot showed significant variation (Appendix VII). The maximum number of flower per plot 1013.9 was produced at the wider spacing of 30 cm x 25 cm, compared to the minimum flower number per plot at the lesser spacing of 30 cm x 15 cm, which produced 783.8 (Table 7). It could be due to availability of more space facilitating improved aeration and better penetration of light which in turn might have increased photosynthetic activity and translocation of assimilates to growing parts resulting in better availability of nutrients (Ram et al., 2012).

Combination effect of nitrogen doses and plant spacing, flower number per plot showed statistically significant variation (Table 8 and Appendix VII). The maximum number of flower (1328.3) was found from N_3S_3 and the lowest number of flower (510.0) was obtained from N_1S_1. Data revealed that different level of nitrogen application and plant spacing influenced optimum growth of plant with inducing large number of flower.

Table 8. Interaction effect of nitrogen doses and spacing on flower bud per stem, number of flower per stem, number of flower per plant and number of flower yield per plot of Lisianthus**

Treatment	Flower bud per stem	Flower per stem	Flower per plant	Flower yield per plot
N_1S_1	6.3 d	3.3 f	14.6 f	510.0 h
N_1S_2	7.3 cd	4.6 de	21.6 e	633.3 g
N_1S_3	9.0 b	5.3 cd	28.3 d	671.7 f
N_2S_1	6.6 d	4.0 ef	22.6 e	796.7 e
N_2S_2	8.6 bc	5.3 cd	31.6 c	931.7 d
N_2S_3	10.0 b	6.6 ab	43.3 b	1041.7 c
N_3S_1	7.3 cd	4.3 e	29.0 cd	1044.7 c
N_3S_2	10.0 b	6.0 bc	43.67 b	1285.0 b
N_3S_3	12.3 a	7.3 a	55. a	1328.3 a
LSD	1.3	0.7	2.6	14.9
CV	9.0	8.4	4.8	0.9

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha. and S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

4.3 Traits of flower quality

4.3.1 Peduncle length (cm)

Significant variation was observed in peduncle length of flower among different levels of nitrogen application (Appendix VIII). The highest peduncle length (13.4 cm) was recorded in N_3 (Table 9) On the other hand, lowest length (10.6 cm) was recorded in N_1 treatment. This might have important role in metabolic activities of the plant resulting in the synthesis of chlorophyll and cytochromes, which are essential for photosynthesis and respiration process in the plants (Thanapornpoonpong *et al*., 2008) that increased growth.

Considering different spacing treatment peduncle length of Lisianthus flower showed significant variation Appendix VIII. The longest peduncle (12.6 cm) was observed in S_3 treatment and the lowest peduncle length (11.4 cm) in S_1 treatment (Table 10). At wider spacing peduncle length increased, which may be due to more nutrients uptake from soil through root hairs and more available space and consequent more photosynthetic production (Tehranifar and Akbari, 2012).

In case of interaction effect of nitrogen doses and plant spacing, peduncle length of flower positively influenced (Table 11 and Appendix VIII). The highest peduncle length of flower (14.1 cm) was found from N_3S_3 and the lowest (10.1 cm) was obtained from N_1S_1. Data revealed that different level of nitrogen application and plant spacing influenced optimum growth of plant with inducing large number of flower.

4.3.2 Receptacle diameter (mm)

This study showed that application of nitrogen levels significantly influenced flower receptacle diameter of Lisianthus compared to the control and receptacle diameter increased when the nitrogen rate increased (Appendix VIII). The maximum peduncle diameter (8.4 mm) was recorded in N_3 (Table 9). On the other hand, lowest result (7.5 mm) was recorded in N_1 treatment. This might be due to greater uptake of nutrients into the plants system which involved in cell division, cell elongation as well as protein synthesis which ultimately enhanced the plant parts. Similar results were found by Lehri *et al*. (2011).

Different plant spacing positively influenced the receptacle diameter of Lisianthus flower. The highest receptacle diameter of flower (8.1 mm) was found from S_3 and the lowest (7.6 mm) was obtained from S_1 (Table 10). The availability of more light for synthesis of photosynthesis and more area for better root growth and nutrient absorption in widest spacing may have enhanced the flower quality. Similar result was found in Bhat and Khan (2007).

Considering the interaction effect of nitrogen doses and plant spacing, receptacle diameter of flower influenced significantly (Table 11 and Appendix VIII). The highest peduncle diameter of flower (8.6) was found from N_3S_3 and the lowest (7.1) was obtained from N_1S_1. Data revealed that different level of nitrogen application and plant spacing influenced optimum growth of plant with inducing large number of flower.

4.3.3 Flower head diameter (cm)

Flower head diameter greatly varied with the application of different doses of nitrogen fertilizer (Appendix VIII). The maximum flower head diameter (6.2 cm) was observed in N_3 while the lowest diameter (5.1 cm) found in N_1 (Table 9). This might to be a facilitative response of nitrogen to extend the plant growth stages was due to its involvement in structural support of cell membrane as well as in non-structural components of enzymes, nucleic acids, amino acids and chlorophyll pigments (Seilsepour and Rashidi, 2011).

Different plant spacing showed significant variation in respect to flower head diameter (Appendix VIII). The maximum flower head diameter (6.0 cm) was observed in wider spacing (S_3) while the minimum diameter (5.4 cm) found in closer spacing (S_1) (Table 10). Wider spacings resulted in early opening of flowers, with higher diameter of open flower. Better leaf growth under wider spacing may have accelerated photosynthesis during the vegetative period and its translocation of photosynthesis to various metabolic sinks during the reproductive period could be responsible for improvement in floral attributes. Similar result was observed in Malam *et al*. (2010).

In case of combined effect of nitrogen doses and spacing treatment, significant variation was found in flower head diameter (Appendix VIII). Maximum head diameter (6.7 cm) was obtained from N_3S_3 whereas minimum (4.8 cm) was obtained from with control (N_1S_1) (Table 11).

4.3.4 Petal number per flower

Significant variation was observed in number of petal per flower among different levels of nitrogen application (Appendix VII). The results revealed that higher the rate of nitrogen fertilizer application induced maximum number of petal per flower. The maximum number of flower (19.89) observed in N_3 treatment, while the minimum number (15.2 found in N_1 treatment (Table 9). Fertilizer application with appropriate dose of nitrogen seemed to have increased the number of flowers per plant in gerbera. Similar result was obtained by Nayak *et al.*, (2005).

Considering different spacing treatment petal number per flower of Lisianthus flower showed significant variation (Appendix VII). The highest number of petal (18.6) was observed in S_3 treatment and the lowest number (17.0) in S_1 treatment (Table 10). Medium and wider spacing recorded highest number of florets per spike. This might be due to less competition between plants for water, minerals, nutrients and light. Similar result was found in Kuldip *et al.*, (2016).

Table 9. Effect of nitrogen doses on peduncle length, receptacle diameter, flower head diameter and number of petal per flower of Lisianthus**

Treatment	Peduncle length (cm)	Receptacle dia. (mm)	Flower head dia. (cm)	No. of petal/flower
N_1	10.6 c	7.5 c	5.1 c	15.2 c
N_2	12.1 b	7.8 b	5.7 b	18.3 b
N_3	13.4 a	8.4 a	6.2 a	19.8 a
LSD	0.7	0.1	0.1	0.5
CV	6.2	1.6	2.7	3.0

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha

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

Table 10. Effect of different spacing on peduncle length, receptacle diameter, flower head diameter and number of petal per flower of Lisianthus**

Treatment	Peduncle length (cm)	Receptacle dia. (mm)	Flower head dia. (cm)	No. of petal/flower
S_1	11.4 b	7.68 c	5.40 c	17.00 c
S_2	12.1 ab	7.91 b	5.67 b	17.78 b
S_3	12.6 a	8.16 a	6.07 a	18.67 a
LSD	0.7	0.13	0.16	0.54
CV	6.2	1.63	2.75	3.01

Here, S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

In case of combined effect of nitrogen doses and spacing treatment, significant variation was found in number of petal per flower while counting (Appendix VII). The highest number of petal (20.6) was revealed from N_3S_3 whereas minimum (14.6) was obtained from with control (N_1S_1) (Table 11).

Table11. Interaction Effect of nitrogen doses and spacing on of peduncle length, receptacle diameter, flower head diameter and number of petal per flower of Lisianthus**

Treatment	Peduncle length (cm)	Receptacle dia. (mm)	Flower head dia. (cm)	No. of petal/flower
N_1S_1	10.1 e	7.1 e	4.8 f	14.6 f
N_1S_2	10.5 de	7.6 d	5.1 e	15.3 ef
N_1S_3	11.3 c-e	7.7 d	5.5 d	15.6 e
N_2S_1	11.5 cd	7.6 d	5.5 d	17.0 d
N_2S_2	12.2 c	7.7 d	5.7 cd	18.3 c
N_2S_3	12.6 bc	8.1 c	5.9 c	19.6 b
N_3S_1	12.5 bc	8.2 bc	5.8 c	19.3 b
N_3S_2	13.6 ab	8.4 ab	6.1 b	19.6 b
N_3S_3	14.1 a	8.6 a	6.7 a	20.6 a
LSD	1.3	0.2	0.2	0.9
CV	6.2	1.6	2.7	3.0

*Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha, and; S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

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

4.3.5 Colorimetric measurement of Lisianthus under study using CIELab

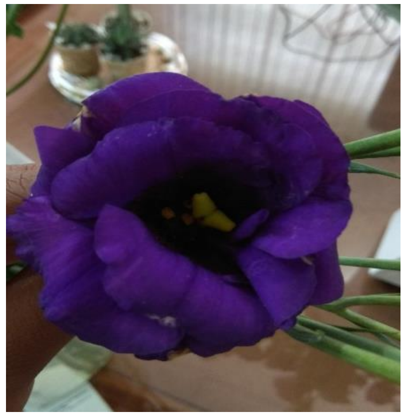
The colorimetric measurement of Lisianthus flower under study were conducted using a precision colorimeter IWAVE WF32 (Shenzhen Wave) and L* (lightness), a* and b* (two Cartesian coordinates) including c* and h_{ab} (Chroma & Hue angle) based on CIELab scale with standard observer 100 and standard illumination D65 (CIE, 1986; McGuire, 1992). The respective data for each of the lines were presented in Table 12.

Table 12. Combination effect of nitrogen doses and spacing on variations in petal color attributes in different lisianthus

Treatments	**L***	**a***	**b***	**c***	**h_{ab}**	**Illustration**
N_1S_1	43.567	6.005	-38.013	39.011	292.565	
N_1S_2	44.734	5.921	-38.371	38.759	292.146	
N_1S_3	45.342	5.599	-36.342	39.453	289.988	
N_2S_1	45.344	5.452	-34.345	40.134	291.416	
N_2S_2	44.453	6.233	-33.527	39.338	288.445	
N_2S_3	43.157	5.187	-34.236	40.166	295.397	
N_3S_1	44.227	5.455	-37.122	37.696	289.656	
N_3S_2	44.393	6.166	-38.193	38.688	279.174	
N_3S_3	43.398	5.566	-35.189	34.326	292.591	

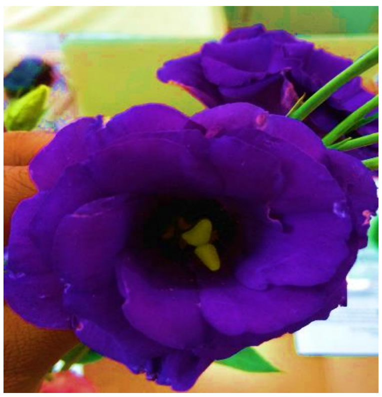
Here, N_1: 225 kg Urea/ha.; N_2: 250 kg urea/ha.; N_3: 275 kg urea/ha, and; S_1: 30 cm × 15 cm; S_2: 30 cm × 20 cm and S_3: 30 cm × 25 cm

N_1S_1



N_1S_2

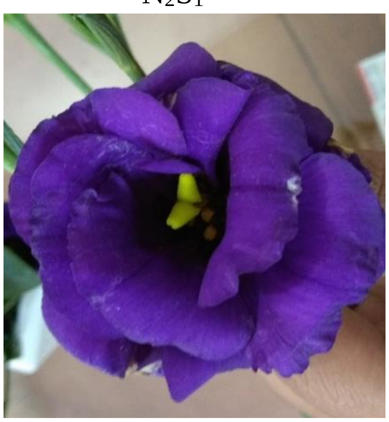
N_1S_3



N_2S_1

N_2S_2

N_2S_3



N_3S_1

N_3S_2

N_3S_3

Plate 4. Pictorial view of single Lisianthus flower (SAU Blue Nandini) according to treatment combinations

Plate 5. Pictorial view of growth and quality parameters, **(a)**. Plant height (cm), **(b)**. Stem length (cm), **(c)**. Number of bud per stem, **(d).** Flower peduncle length (cm), (**e**). Flower per stem, (**f**). Flower per plant

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

Lisianthus (*Eustoma grandiflorum*) is one of the top ten ranked cut flower, belongs to the family Gentianaceae. Lisianthus is newcomer and very popular cut flower in Bangladesh due to its vase life and widely variation with color combination as known as Nandini. However, these flowers have to import from china to meet up the demand because of proper technology. Lisianthus is new flower in Bangladesh and there is no technology for Lisianthus production. Specially, there are no recommended fertilizer doses (nitrogen) and planting spacing. So farmers in our country apply nitrogen fertilizers either vastly which affects environment and more amount of nitrogenous fertilizers make toxicity reduced production or less amount of fertilizer reduced the yield. Furthermore, without optimum planting spacing hampered crop production.

In order to study the effect of doses of nitrogen fertilizer (urea) and plant spacing, a research was conducted to inspect the growth and flowering response of Lisianthus to nitrogen and spacing at Horticultural farm, Sher-e-Bangla Agricultural University, Dhaka during period from November, 2018 to April, 2019. Two factorial experiment included doses of nitrogen: N_1 (103.5 kg N), N_2 (115.0 kg N), N_3 (126.5 kg N) and spacing: S_1 (30 x 15 cm), S_2 (30 x 20 cm), S_3 (30 x 25 cm) was outlined in Completely Randomized Block Design (RCBD) with three replications.

Collected data were statistically analyzed for the evaluation of treatments for the determination of the appropriate doses of nitrogen and the optimum plant spacing. The findings and conclusion have been described in this segment.

Significant variations were observed in case of application of nitrogen doses and plant spacing as well as their combination on all parameters like as following –

The tallest plant was found from N_3 (26.7 cm, 42.1 cm, 55.7 cm, 69.0 cm, 80.4 cm) and from S_3 (23.0 cm, 38.2 cm, 52.5 cm, 64.7 cm, 75.9 cm) at 30, 45, 60, 75, 90 DAT respectively. On the other hand, the shortest plant height was found from N_1 (15.1 cm, 30.6 cm, 45.2 cm, 57.5 cm, 66.6 cm) and from S_1 (19.3 cm, 33.9 cm, 46.5 cm, 60.7 cm, 70.6 cm) at 30, 45, 60, 75 and 90 DAT respectively. In case of treatment combination, the tallest plant (28.5 cm, 43.8 cm, 56.7 cm, 70.9 cm, 83.1 cm) was observed from N_3S_3 while the lowest plant height (13.3 cm, 27.4 cm, 41.9 cm, 54.2 cm and 65.6 cm) was measured from N_1S_1 at 30, 45, 60, 75 and 90 DAT accordingly.

The maximum number of leaves per plant was 23.7, 37.0, 50.0, 62.7 and 74.1 respectively which was obtained from N_3 (275 kg urea/ha) and the minimum number of leaves per plant (12.6, 21.2, 35.2, 47.4 and 57.2) was found from N_1 (225 kg urea/ha) at 30, 45, 65, 75 and 90 DAT respectively. Regarding plant spacing, the maximum number of leaves per plant (19.8, 30.6, 45., 57.7 68.7) was found from S_3 (30 cm × 25 cm) and the minimum number of leaves (16.8, 27.1, 41.1, 52.6, 62.6) was observed from S_1 at 30, 45, 65, 75 and 90 DAT respectively. In case of their interaction effect, the highest number of leaves (25.3, 38.6, 51.3, 64.6 and 76.6) was recorded from N_3S_3 and the lowest number (11.6, 19.3, 33.3, 46.3 and 56.3) was from N_1S_1 at 30, 45, 65, 75 and 90 days after transplanting.

Regarding the leaf length, maximum leaf length (6.7 cm) was found in N_3 and minimum (4.5 cm) in N_1. In case of spacing, maximum leaf length (6.0 cm) was found in S_3 and minimum (5.4 cm) in S_1. Combined effect of nitrogen doses and plant spacing, maximum leaf length (7.0 cm) was found in N_3S_3 and minimum (4.3 cm) in N_1S_1.

Considering nitrogen doses, maximum SPAD value (53.5, 60.9 and 55.8) was found in N_3 and minimum (37.3, 45.1 and 41.2) in N_1 at 40, 60 and 80 DAT. In case of spacing, the SPAD value (47.9, 55.6 and 51.0) was found in S_3 and minimum (42.4, 49.9 and 46.0) in S_1 at 40, 60 and 80 DAT. Combined effect of nitrogen doses and spacing, maximum SPAD value ((56.4, 63.7 and 58.1) was found in N_3S_3 and minimum (34.2, 41.9 and 38.1) in N_1S_1 at 40, 60 and 80 days after transplanting.

In terms of stem number of plant, maximum stem number (7.2) was found in N_3 and minimum (4.7) in N_1. In case of spacing, maximum stem number (6.5) was found in S_3 and minimum (5.5) in S_1. Combined effect of nitrogen doses and plant spacing, maximum stem number (7.6) was found in N_3S_3 and minimum (4.3) in N_1S_1.

In case of the stem length, maximum leaf length (63.1 cm) was found in N_3 and minimum (49.9 cm) in N_1. In case of spacing, maximum stem length (58.4 cm) was found in S_3 and minimum (54.3 cm) in S_1. Combined effect of nitrogen doses and plant spacing, the highest stem length (65.2 cm) was found in N_3S_3 and minimum (48.0 cm) in N_1S_1.

In terms of the stem diameter, maximum diameter (5.8 mm) was found in N_3 and minimum (4.2 mm) in N_1. In case of spacing, maximum stem diameter (5.3 mm) was found in S_3 and minimum (4.6 mm) in S_1. Combined effect of nitrogen doses and plant spacing, the highest stem diameter (6.2 mm) was found in N_3S_3 and minimum (3.9 mm) in N_1S_1.

The highest number of flower bud per stem was observed in N_3 (9.8) and the minimum (7.5) was observed in N_1. Regarding plant spacing, highest number of flower bud (10.4) was observed from S_3 (30 cm × 25 cm) and the minimum (6.7) was recorded from S_1 (30 cm × 15 cm). In case of their combination, the maximum flower bud (12.3) was found from N_3S_3 and the lowest (6.3) was obtained from N_1S_1.

Considering number of flower per stem, the maximum number of flower (5.8) observed in N_3 treatment, while the minimum number (4.4) found in N_1 treatment. Regarding plant spacing, highest number of flower per stem (6.4) was observed from S_3 (30 cm × 25 cm) and the minimum (3.8) was recorded from S_1 (30 cm × 15 cm). In case of their combination, the maximum flower per stem (7.3) was found from N_3S_3 and the lowest (3.3) was obtained from N_1S_1.

In case of number of flower per plant, the maximum number of flower (42.6) observed in N_3 treatment, while the minimum number (21.5) found in N_1 treatment. Regarding plant spacing, highest number of flower per plant (42.3) was observed from S_3 (30 cm × 25 cm) and the minimum (22.1) was recorded from S_1 (30 cm × 15 cm). In case of their combination, the maximum flower per plant (55.3) was found from N_3S_3 and the lowest (14.6) was obtained from N_1S_1.

Flower yield per plot varied significantly, maximum flower yield per plot (1219.3) observed in N_3 treatment, while the minimum number (605.0) found in N_1 treatment. In case of plant spacing, maximum number of flower per plot (1013.9) was produced at S_3 while the minimum number (783.8) found in S_1 treatment. Considering their interaction effect, maximum number of flower (1328.3) was found from N_3S_3 and the lowest number of flower (510.0) was obtained from N_1S_1.

The highest peduncle length (13.4 cm) was found in N_3 and minimum (10.6 cm) in N_1. In case of spacing, the longest peduncle length (12.6 cm) was found in S_3 and shortest (11.4 cm) in S_1. Combined effect of nitrogen doses and plant spacing, the highest peduncle length (14.1 cm) was found in N_3S_3 and the lowest (10.1 cm) in N_1S_1.

In case of nitrogen doses, the maximum receptacle diameter (8.4 mm) was found in N_3 and minimum (7.5 mm) in N_1. In terms of spacing, the longest receptacle diameter (8.1 mm) was found in S_3 and shortest (7.6 mm) in S_1. Combined effect of nitrogen doses and plant spacing, the highest receptacle diameter (8.6 mm) was found in N_3S_3 and the lowest (7.1 mm) in N_1S_1.

Flower head diameter greatly varied with the application of different doses of nitrogen and plant spacing. The maximum flower head diameter (6.2 cm) was recorded from N_3 while minimum diameter (5.1 cm) from N_1. In case of spacing treatment, the highest flower head diameter (6.0 cm) measured in S_3 while shortest head diameter (5.4 cm) observed in S_1. Regarding their, combination, the highest flower head diameter (6.7 cm) was found in N_3S_3 and the lowest (4.8 cm) in N_1S_1.

In case of number of flower petal per flower, the maximum number of petal (19.8) observed in N_3 treatment, while the minimum number (15.2) found in N_1 treatment. Regarding plant spacing, highest petal number per flower (18.6) was observed from S_3 (30 cm × 25 cm) and the minimum (17.0) was recorded from S_1 (30 cm × 15 cm). In terms of their combination, the maximum result (20.6) was found from N_3S_3 and the lowest (14.6) was obtained from N_1S_1.

5.2 Conclusion

In respect as the above results it can be articulated that different doses of nitrogen and spacing showed significant variation to Lisianthus growth and flowering. According to result, nitrogen doses N_3 (126.5 kg N) showed tallest plant height, maximum stem number, SPAD value, flower head diameter, peduncle length, receptacle diameter and ultimately the highest yield and even, recorded maximum petal number per flower. On the other hand, wider spacing (S_3) showed excellent among the different spacing used in terms of all parameters. Besides the combination, nitrogen doses N_3 treated with spacing S_3 performed as the best combination (N_3S_3). To sum up, it can be concluded that

that N_3 (126.5 kg N) as a source of (275 kg/ha urea) was the most suitable doses and wider spacing (S_3) and combination treatment (N_3S_3) was the best for growth, yield and quality attributes of Lisianthus production.

5.3 Recommendation

Based on the findings of the research, recommendations are:

1. As there is no recommended doses of nitrogen for Lisianthus production. So, N_3 (126.5 kg N/ha.) as a source of urea (275 kg/ha.) would be the potential for commercial Lisianthus production.
2. Furthermore, Lisianthus flower plants have no suitable plant spacing in Bangladesh. This study finding (30 cm × 25 cm) could be the best for field trial for commercial Lisianthus production.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November, 2018 to April, 2019

Month	*Air temperature (^{o}C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
November, 2018	24.9	18.6	90	34.4
December, 2018	25.8	13.8	96	12.8
January, 2019	26.0	12.3	87	7.7
February, 2019	28.9	15.1	69	28.9
March, 2019	33.3	20.4	63	65.8
April, 2019	34.1	23.5	64	66.7

*Monthly average,

*Source: Bangladesh Meteorological Department (Climate & weather division) Agargaon, Dhaka-1207

Appendix II. Analysis of variance on plant height at different days after transplanting of Lisianthus

Source of Variation	Degrees of freedom	Mean Square for plant height (cm)				
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
Factor A (Nitrogen doses)	2	304.693	412.321	412.321	410.103	427.204
Factor B (Spacing)	2	31.792	24.717	24.717	20.071	24.721
Interaction (A×B)	4	0.359	0.558	0.558	0.491	2.302
Error	16	0.503	1.464	1.464	0.722	1.236

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

Appendix III. Analysis of variance on the number of leaves per plant at different days after transplanting of Lisianthus						
Source of Variation	**Degrees of freedom**	**Mean Square for Number of leaves**				
		30 DAT	**45 DAT**	**60 DAT**	**75 DAT**	**90 DAT**
Factor A (Nitrogen doses)	2	28.481	561.037	498.111	529.593	641.778
Factor B (Spacing)	2	278.370	28.481	32.444	25.148	38.111
Interaction (A×B)	4	20.259	0.370	0.556	0.593	2.222
Error	16	0.759	1.009	0.417	1.829	2.194
***: Significant at 0.05 level of probability**						

Appendix IV. Analysis of variance on the data of SPAD value at different days after transplanting of Lisianthus				
Source of Variation	**Degrees of freedom**	**Mean Square of**		
		40 DAT	**60 DAT**	**80 DAT**
Factor A (Nitrogen doses)	2	594.554	570.339	479.634
Factor B (Spacing)	2	69.301	74.296	55.007
Interaction (A×B)	4	0.412	0.966	1.294
Error	16	2.003	4.641	1.983
***: Significant at 0.05 level of probability**				

Appendix V. Analysis of variance on the data of stem number per plant, stem length and stem diameter of Lisianthus				
Source of Variation	**Degrees of freedom**	**Mean Square of**		
		Number of stem /plant	**Stem length (cm)**	**Stem diameter (mm)**
Factor A (Nitrogen doses)	2	13.4815	390.258	5.67585
Factor B (Spacing)	2	2.2593	38.010	1.10658
Interaction (A×B)	4	0.0370	0.499	0.02823
Error	16	0.3287	2.268	0.00580
***: Significant at 0.05 level of probability**				

Appendix VI. Analysis of variance on the data of leaf leangth number of bud/stem, number of flower/stem of Lisianthus				
Source of Variation	**Degrees of freedom**	**Mean Square of**		
		Leaf length (cm)	**Number of bud/stem**	**Number of flower/stem**
Factor A (Nitrogen doses)	2	10.4993	12.4815	4.7778
Factor B (Spacing)	2	0.7570	30.2593	14.7778
Interaction (A×B)	4	0.0115	1.2037	0.2222
Error	16	0.0413	0.6065	0.1944
***: Significant at 0.05 level of probability**				

Appendix VII. Analysis of variance on the data of number of petal per flower, number of flower per plant and flower yield per plot of Lisianthus				
Source of Variation	**Degrees of freedom**	**Mean Square of**		
		Number of petal/flower	**Number of flower/plant**	**Flower yield/plot**
Factor A (Nitrogen doses)	2	50.8148	1003.37	849536
Factor B (Spacing)	2	6.2593	920.15	126994
Interaction (A×B)	4	0.6481	32.20	4821
Error	16	0.2870	2.41	74
***: Significant at 0.05 level of probability**				

Appendix VIII. Analysis of variance on the data of peduncle length, receptacle diameter, flower head diameter of Lisianthus				
Source of Variation	**Degrees of freedom**	**Mean Square of**		
		Peduncle length (cm)	**Receptacle diameter (mm)**	**Flower head diameter (cm)**
Factor A (Nitrogen doses)	2	17.3704	1.91259	2.74473
Factor B (Spacing)	2	3.6337	0.51370	1.02584
Interaction (A×B)	4	0.1159	0.04704	0.05159
Error	16	0.5711	0.01662	0.02475
***: Significant at 0.05 level of probability**				