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Effect of plant spacing and nitrogen schedule on growth and quality of Asiatic lily (*Lilium* × *asiatica*) cv. Litouwen under naturally ventilated Polyhouse conditions of Prayagraj

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Abstract
The experiment entitled “Effect of plant spacing and nitrogen schedule on growth and quality of Asiatic lily (*Lilium* × *asiatica*) cv. Litouwen under naturally ventilated polyhouse conditions of Prayagraj”, was carried out under Prayagraj agro-climatic condition in the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the month of December 2020 to March 2021. The experiment was laid out in Factorial Randomized Block Design with three replications and twelve treatment combinations. Treatments comprised of three different spacing (15 cm x 20 cm, 20 cm x 20 cm and 25 cm x 20 cm) and recommended dose of CAN (Calcium ammonium nitrate) was applied as foliar spray in splits. The results revealed that the spacing S_1 (15 cm x 20 cm) resulted better in vegetative growth (Plant height and stalk length) and flowering parameter (bud diameter) whereas spacing S_3 (25 cm x 20 cm) resulted in better vegetative growth (Number of leaves, plant spread and total chlorophyll content) and floral parameters (Bud emergence, number of buds, flower diameter, stalk diameter, vase life and number of bulblets). Among nitrogen schedule, nitrogen schedule N_4 (Foliar application of CAN thrice a week) gave better result in vegetative growth (plant height, number of leaves, plant spread and chlorophyll content) and floral parameters (bud emergence, number of buds, bud diameter, flower diameter, stalk length, stalk diameter, vase life and number of bulblets). The best interaction among the different spacing and nitrogen schedule was found to be spacing S_3 (25 cm x 20 cm) and nitrogen schedule N_4 (Foliar application of CAN thrice a week) which gave maximum growth and qualitative characteristics of Asiatic lily.

Keywords: Asiatic lily, spacing, nitrogen schedule, foliar spray, growth, quality, polyhouse

Introduction

Lilium is one of the most fascinating ornamentals in appearance, beauty, different forms and hues of colours and it is a “low volume” high value crop. Lilium is one of the largest genera of flower bulbs produced world-wide. The genus lilium belongs to family Liliaceae and comprises of 100 species, including many beautiful ornamental species. Lilium has excellent keeping quality, fragrance and longer stem which fetches premium price in flower market. It has wide applicability in floral industry, mainly as flower and potted plants. Hence, it ranks fourth among the top ten bulbous cut flower of the world in Aalsmeer auction market after tulip, gladiolus and narcissus (Anonymous, 1996) [2]. They have been long admired for their aesthetic qualities and often depicted as the symbol of purity and regality.

Nutrients such as nitrogen play a major role in growth and development of plants (Scott, 2008) [14]. Nitrogen as an essential element that improves the chemical and biological properties of soil and thereby stimulates the production of higher yield in plants. Nitrogen plays an important role in the synthesis of protoplasm and primarily in the manufacture of amino acids to enhance the Auxin activities which leads to increased meristematic activities have an important role in maximum vegetative growth and yield (Tisdale and Nelson, 1975) [18]. Nutrient availability in the soil has become a limiting factor in the production of crops under the optimum conditions of all other resources, as the soil's capacity to supply the required nutrients has been challenged by many factors. Reduced nutrient loss, direct availability of nutrients, lower fertilizer requirements and a high B:C ratio are advantages of foliar application of nutrients over soil application. Calcium is an essential macronutrient that maintains the structure of the plant cell wall, acts as an intracellular messenger in the cytoplasm, assists in other nutrient uptake and mediates enzymatic processes

(Goud and Kumar, 2021) [5]. Hence, calcium nitrate is a good substitute for the application of both nutrients. The plant growth is mainly stimulated by N availability in the soil. Split application of N fertilizer may substantially improve N use efficiency. During early growth stages, considerable N may be lost due to denitrification and leaching (Hamid and Nasab, 2001) [6].

Optimum plant density is another important factor for high plant growth and yield. Spacing between plants is particularly important for the cultivation of Asiatic lily to maximize flower quality and quantity characteristics. Therefore, inter and intra row spacing together with a balanced supply of nutrients such as nitrogen are important for obtaining optimum quality and quantity of Asiatic lily flowers.

Materials and Methods

Experimental site

The experiment was carried out in naturally ventilated polyhouse of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Science, Prayagraj, during December, 2020 to March, 2021. Allahabad is situated in the agroclimatic zone (sub-tropical belt) of Uttar Pradesh. The experimental site is situated at a latitude of 24°27' North and longitude of 81°51' East and altitude of 98 meters above mean sea level (MSL). The area of Allahabad district comes under agro climatic zone V (Upper Gangetic Plain region) and sub-zone of Central Plains. The climate ranges from dry sub-humid to semi-arid. The District experiences average maximum temperature range between 43ºC - 47ºC which may go as high as 48ºC during peak summers (May-June). The minimum average temperature is 2-4ºC, which may fall as low as 1ºC during peak winter months (December-January). The average rainfall of the district is 960 mm and the monsoon season is spread between July-September.

Experimental designs and treatment

The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and twelve treatment combinations. Treatments comprised of three different spacing S_1 (15 cm x 20 cm), S_2 (20 cm x 20 cm) and S_3 (25 cm x 20 cm) and recommended dose (2.5 g/L/week) of nitrogen (CAN) was applied as foliar spray in splits. The details of treatments are $T_1 = S_1N_1$ (15 cm x 20 cm + soil application once a week), $T_2 = S_1N_2$ (15 cm x 20 cm + foliar application once a week), $T_3 = S_1N_3$ (15 cm x 20 cm + foliar application twice a week), $T_4 = S_1N_4$ (15 cm x 20 cm + foliar application thrice a week), $T_5 = S_2N_1$ (20 cm x 20 cm + soil application once a week), $T_6 = S_2N_2$ (20 cm x 20 cm + foliar application once a week), $T_7 = S_2N_3$ (20 cm x 20 cm + foliar application twice a week), $T_8 = S_2N_4$ (20 cm x 20 cm + foliar application thrice a week), $T_9 = S_3N_1$ (25 cm x 20 cm + soil application once a week), $T_{10} = S_3N_2$ (25 cm x 20 cm + foliar application once a week), $T_{11} = S_3N_3$ (25 cm x 20 cm + foliar application twice a week) and $T_{12} = S_3N_4$ (25 cm x 20 cm + foliar application thrice a week).

Cultural practices

The land was brought to fine tilth by thorough tillage, flat beds of 60 cm width was prepared. Vermicompost @ 1kg/m^2 was thoroughly mixed at the time of bed preparation. Fertilizer was not applied at the time of bed preparation as soil of the experimental site was rich in nitrogen & potassium (210.50 & 200.08, respectively) as lilium needs minimum nutrition particularly during 1st three weeks. Nitrogen was applied in the form of CAN (Calcium ammonium nitrate) after 30 days of planting. CAN was given @2.5 g/L per week as soil application as well as foliar application as per the treatment combination. Foliar application of nitrogen was given in split doses once, twice and thrice a week.

Data collection and analysis

Data on growth and flowering components like plant height (cm), number of leaves, plant spread (cm^2), chlorophyll content (SPAD unit), 1st flower bud emergence (days), no. of flower buds, flower diameter (cm) and stalk length (cm) were recorded on three plants randomly selected. The data collected for all the characters studied were subjected to statistical analysis by adopting 'Analysis of Variance' (ANOVA) technique for factorial randomized block design as suggested by Panse and Sukhatme (1967) [13].

Results and Discussion

All the growth and flowering quality parameters *viz*., plant height, plant spread, no. of leaves, chlorophyll content, first flower bud emergence, No. of flower buds, flower diameter and stalk length of Asiatic lily were influenced by spacing and nitrogen schedule individually (Table 1).

Plant height (cm)

Significantly taller plants (32.8 cm) were recorded in spacing S_1 (15 cm x 20 cm) which was at par with S_2 (20 cm x 20 cm, 30.1 cm) while shorter plants (27.1 cm) were recorded in S_3 (25 cm x 20 cm). Among the different nitrogen schedule, significantly N_4 (Nitrogen applied thrice a week) recorded taller plants (33.7 cm) which was at par with N_3 (Nitrogen applied twice a week, 30.5 cm) while shorter plants (27.4 cm) were recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on plant height.

Increased plant height at closer spacing might be due to the fact that optimum use of resources such as light, moisture, space and aeration for proper growth and development of plants and also harness solar energy. This resulted in elongation of main stem, increase in stem length may be due to elongation of cells and number of cells due to cell division. Similar observations are also made by Vedavathi *et al*., (2014) [19]. Foliar application thrice a week increases fertilizer use efficiency of applied nitrogen, thus, increased nutrient contents might have accelerated the rates of various physiological and metabolic processes in the plant system that ultimately resulted in better plant growth. Similar findings were found by Pahare *et al*., (2020) [12] in Asiatic lily.

No. of leaves per plant

Significantly more number of leaves per plant (45.7) were recorded in spacing S_3 (25 cm x 20 cm), which was at par with S_2 (20 cm x 20 cm, 43.1) while fewer number of leaves (39.4) were recorded in S_1 (15 cm x 20 cm). Among the different nitrogen schedule, significantly more no. of leaves (46.9) were recorded in N_4 (Nitrogen applied thrice a week) which was at par with N_3 (Nitrogen applied twice a week, 44.9) while fewer no. of leaves (37.7) were recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on number of leaves.

The wider spacing recorded maximum more no. of leaves. This is due to better uptake of moisture, nutrients and better utilization of sunlight at wider spacing. A similar observation was observed by Vedavathi *et al*., (2015) [20] in Asiatic lily in terms of growth. Mohanty *et al*., (2002) [11] also reported an increase in the number of leaves with the split application of nitrogen in tuberose. Pahare *et al*., (2020) [12] found that foliar application thrice a week recorded more no. of leaves.

Plant spread (cm^2)

Significantly extreme plant spread (15.7 cm^2) was recorded in spacing S_3 (25 cm x 20 cm) which was at par with S_2 (20 cm x 20 cm, 14.9 cm^2) while least plant spread was recorded in S_1 (15 cm x 20 cm, 14.2 cm^2). Among the different nitrogen schedule, significantly extreme plant spread (16.2 cm^2) was recorded in N_4 (Nitrogen applied thrice a week) which was at par with N_3 (Nitrogen applied twice a week, 15.1 cm^2) while least plant spread (13.9 cm^2) was recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on plant spread.

The wider spacing recorded maximum vegetative growth. This is due to better uptake of moisture, nutrients and better utilization of sunlight at wider spacing. Similar observation was made by Sympli *et al*., (2019) [17]. Pahare *et al*., (2020) [12] found that foliar application thrice a week recorded extreme plant spread.

Table 1: Effect of plant spacing and nitrogen schedule and its interaction on growth and flowering quality of Asiatic lily at monthly intervals

Treatment	Plant height	No. of leaves	Plant spread	Chlorophyll content	1st bud emergence	No. of flower buds	Flower diameter	Stalk length
S = Spacing (cm)								
S_1= 15 x 20 cm	32.84	39.47	14.25	61.92	31.05	2.08	16.18	31.65
S_2= 20 x 20 cm	30.12	43.10	14.90	67.20	28.69	2.25	16.75	28.93
S_3= 25 x 20 cm	27.15	45.78	15.73	68.05	25.25	2.67	17.35	27.67
CD (P=0.05)	3.13	4.67	1.15	2.30	0.98	0.44	0.71	2.69
N = Nitrogen schedule								
N_1 - Soil application once a week	27.40	37.74	13.97	62.98	29.3	1.86	15.96	26.75
N_2 - CAN applied once a week	28.48	41.53	14.47	65.25	28.86	2.14	16.71	28.93
N_3 - CAN applied twice a week	30.50	44.90	15.13	66.26	27.81	2.37	17.01	30.11
N_4 - CAN applied thrice a week	33.78	46.97	16.26	68.40	27.34	2.96	17.36	31.88
CD (P=0.05)	3.61	5.73	1.33	2.66	1.13	0.51	0.82	3.11
Interaction (S x N)								
S1N1	28.91	36.20	13.13	56.53	30.86	1.60	15.36	28.43
S1N2	31.03	38.53	13.96	59.93	31.26	2.10	16.06	31.86
S1N3	34.36	40.70	14.90	65.58	31.10	1.96	16.42	32.66
S1N4	37.06	42.46	15.0	65.64	30.96	2.66	16.90	33.66
S2N1	29.25	35.06	14.13	65.40	30.20	1.86	16.03	26.30
S2N2	28.23	41.83	14.40	68.26	29.50	2.03	16.60	28.73
S2N3	29.53	46.70	14.90	65.60	28	2.40	16.93	29.36
S2N4	33.46	48.83	16.20	69.55	27.06	2.73	17.43	31.33
S3N1	24.03	41.96	14.66	67.03	26.83	2.13	16.50	25.53
S3N2	26.16	44.23	15.06	67.56	25.83	2.29	17.46	26.20
S3N3	27.60	47.30	15.60	67.60	24.33	2.76	17.70	28.30
S3N4	30.83	49.63	17.60	70.03	24	3.5	17.76	30.65
$CD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS

Total chlorophyll content (SPAD unit)

Significantly higher chlorophyll content (68.0) was recorded in spacing S_3 (25 cm x 20 cm), which was at par with S_2 (20 cm x 20 cm, 67.2) while lower chlorophyll content (61.9) was recorded in S_1 (15 cm x 20 cm). Among the different nitrogen schedule, significantly higher chlorophyll content (68.4) was recorded in N_4 (Nitrogen applied thrice a week) which was at par with N_3 (Nitrogen applied twice a week, 66.2) while lower chlorophyll content (62.9) was recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on chlorophyll content.

Maximum chlorophyll content was recorded in wider spacing by Swetha *et al*., (2018) [16] in Asiatic lily. Similar observation was made by Ahirwar *et al*., (2012) [1] in African marigold. Nitrogen in the form of calcium nitrate as 3 and 4 split applications significantly improved chlorophyll content, thus helping export of photosynthates to bulbs as well as chlorophyll retention. Nitrate was significantly superior in improving plant growth and net chlorophyll content Wani *et al*., (2016) [21] in Asiatic lilies.

1st flower bud emergence (days)

Among different spacing, Significantly took lesser number of days to flower bud emergence (25.2 days) were recorded in spacing S_3 (25 cm x 20 cm), which was followed by S_2 (20 cm x 20 cm, 28.6 days) while more no. of days taken to flower bud emergence (31.0 days) were recorded in spacing S_1 (15 cm x 20 cm). Among the different nitrogen schedule, significantly took lesser no. of days taken to flower bud emergence (27.3 days) were recorded in N_4 (Nitrogen applied thrice a week) which was at par with N_3 (Nitrogen applied twice a week, 27.8 days) while more no. of days taken to bud emergence (29.3 days) were recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on no. of days taken to bud emergence.

Planting at a wider spacing records lesser no. of days taken to flower bud emergence, observations made by Fatmi and Singh (2020) [4] in tuberose. Time taken to flower bud formation, was found to be influenced by split application of nitrogen. Lesser no. of days taken to flower bud formation were recorded with increased split dose of water soluble fertilizers applied through fertigation as well as through foliar application. This might be due to the reason that with the increasing split dose of N, nitrogen uptake efficiency of the plants also gets increased due to which the bud formation were accomplished in advance as compared to the recommended practices and other treatments where lesser split doses of N were applied by Singh *et al*., (2013) [15].

Number of flower buds per plant

Among different spacing, significantly more number of buds per plant (2.6) were recorded in spacing S_3 (25 cm x 20 cm), which was followed by S_2 (20 cm x 20 cm, 2.25) while lesser number of buds per plant (2.08) were recorded in S_1 (15 cm x 20 cm). Among the different nitrogen schedule, significantly more number of buds per plant were recorded in N_4 (Nitrogen applied thrice a week, 2.9) which was followed by N_3 (Nitrogen applied twice a week, 2.3) while lesser no. of buds per plant (1.8) were recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on number of buds.

More number of buds were recorded in wider spacing in Chrysanthemum, observations made by Kour (2009) [8]. 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. These results are in line with those reported by Kumar and Singh (1998). Foliar application of nitrogen thrice a week recorded more no. of flower buds indicated by Pahare *et al.*, (2020) [12].

Flower diameter (cm)

Among different spacing, significantly higher flower size (17.3 cm) was recorded in spacing S_3 (25 cm x 20 cm) which was at par with S_2 (20 cm x 20 cm, 16.7 cm) while lower flower size (16.1 cm) was recorded in S_1 (15 cm x 20 cm). Among the different nitrogen schedule, significantly N_4 (Nitrogen applied thrice a week) was recorded higher in flower size (17.3 cm) which was at par with N_3 (Nitrogen applied twice a week, 17.0 cm) while lower flower size (15.9 cm) was recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on flower size.

Wider spacing gave bigger flower diameter in carnation. The result was recorded by Kazaz *et al*., (2011) [7]. The results were in agreement with Bunt (1978) [3], who reported that flower diameter got smaller with increasing planting density i.e., closer spacing in carnations. Foliar application of N must have resulted in higher translocation of carbohydrates from vegetative parts to the reproductive parts which quality may have resulted in better development of flower size. Pahare *et al*., (2020) [12]. The increase in flower size may be attributed to enhanced utilization and translocation of metabolites and more chances for absorption of nitrogen required for growth with increase in split doses of nitrogen. Singh *et al*. (2013) [15].

Stalk length (cm)

Among different spacing, significantly longer stalk length (31.6 cm) was recorded in spacing S_1 (15 cm x 20 cm), which was followed by S_2 (20 cm x 20 cm, 28.9 cm) while shorter stalk length (27.6 cm) was recorded in S_3 (25 cm x 20 cm). Among the different nitrogen schedule, significantly N_4 (Nitrogen applied thrice a week) was recorded longer in stalk length (31.8 cm) which was at par with N_3 (Nitrogen applied twice a week, 30.1 cm) while shorter stalk length (26.7 cm) was recorded in N_1 (Nitrogen applied as soil application). There was no significant interaction between spacing and nitrogen schedule on stalk length.

Length of flower stalk was longer in case of closer spacing than in wider spacing. This might be due to high competition for light and aeration in closer spacing. The result was given by Malik *et al*., (2019) [10] in snapdragon. There was significant effect on spike length due to the role of foliar application of split doses of nitrogen in more chances of absorption of nutrients resulting in increased nucleic acid and protein synthesis. The result shown by Pahare *et al*., (2020) [12]. The stem length was recorded by more no. of split doses of nitrogen indicated by Singh *et al*., (2013) [15] in carnation.

Conclusion

It is concluded from the present investigation that best interaction among the different spacing and nitrogen schedule was found to be spacing S_3 (25 cm x 20 cm) and nitrogen schedule N_4 (Foliar application of CAN thrice a week). The investigation fully exponents that foliar split application of nitrogen (CAN) is advantageous not only in improving the growth and flowering attributes but prevents the significant loss of nitrogen occurring due to various processes like leaching, volatilization etc.

Future scope

The cut flower trade of Asiatic lily is lagging behind in the local regions of UP, owing to the non-availability of quality planting material at larger scale. The adoption of the technique and scientific knowledge can give farmers higher. Therefore, keeping in view the economic importance of the crop and with the increasing demand of Asiatic lily for various purposes, there is a good scope of increasing the production of better quality stalks and bulbs.

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Conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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