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Effect of split application of ammoniacal and nitrate sources of nitrogen on lilium growth and yield

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ABSTRACT

The aim of experiment was to evaluate the effect of split application of urea and calcium nitrate nitrogen sources on plant growth and yield in Asiatic lilies. Significant differences were observed in growth parameters and behavior of two cultivars *viz.,* Serreda and Navona. Calcium nitrate significantly improved plant height, leaf area (LA) and LA index (LAI) recorded at 50, 75, 90, and 105 days after planting. Bulb yield parameters varied significantly between two cultivars. Calcium nitrate significantly improved bulb weight, bulb circumference, the number of bulbs plant^{-1} and propagation coefficient. However, the effect of three and four split nitrogen application on plant height; LA and LAI was significant at 90-105 day interval.

KEY WORDS: Bulb, growth, lilium, nitrogen, split, yield

INTRODUCTION

Lilies rank among the premier bulbous cut flowers in the international market. Lilies are unmatched in the diversity of plant architecture, shape, color, size and fragrance of flowers that can equally well be used as cut flowers, landscape plants, in pots, etc. Globally, lilium is the 2nd ranked cut flower in production (Grassotti and Gimelli, 2011). Total area under lily bulb production in 2009 was 5500 ha out of which 4266 ha was contributed by The Netherlands. A total of 2.21 billion lilium bulbs out of which 0.41 billion for internal cut flower production were produced in The Netherlands in 2010 (Anonymous, 2010). In 2009 wholesale value of lily cut flowers at Dutch auction was 141 million Euros (PT/BKD, 2010). Comparable trade figures regarding India are lacking because of the unorganized nature of the floriculture sector in the country. The lilies are grown in some parts of valley normally the demand is during the marriage ceremonies, but the stems are exported to other markets in India like New Delhi, etc.

Limited research has been published on the essential nutrition requirements for bulb production of commercial lily species. Roberts and Blaney (1957) reported that 140 kg/ha N, 122 kg/ha P, and 166 kg/ha K/year were recommended fertilizer rates for Easter lily bulb production in northern California and Oregon. They indicated that a portion of the fertilizer should be applied at planting time in the fall and the remainder in split applications in the spring and early summer. This same recommendation was reiterated by Blaney and Roberts (1967) and Miller (1993).

The scope of the study lies in the fact that despite having the congenial climate of Kashmir for bulb production the cultivators are importing the bulbs from outside, so there is need to rationalize the nutrition for optimum plant growth and bulb yield of lilies under Kashmir valley conditions. Furthermore, there is an urgent need for efficient nutrient management for bulb production.

The objective of this study was to determine the influence of the different inorganic source of nitrogen on plant growth and yield of Asiatic lilium cultivars.

MATERIALS AND METHODS

The present investigation was carried out under 50% shade net. The experimental land was well prepared by ploughing, clod breaking and was brought to a fine tilth. The prepared land was divided into three blocks with adjacent blocks separated by a half meter path with a channel in the middle of each path. The blocks were leveled before planting, 4 kg fully decomposed compost was mixed in each plot prior to planting. The two varieties were planted at spacing 20 cm × 15 cm under two sources of nitrogen. The experiment was laid out in a randomized complete block design with 12 treatment combinations replicated three times. Whole compost was applied to the land one weak prior to planting and potassium at the rate of 80 kg/ha in the form muriate of potash and phosphorous at the rate 150 kg/ha in the form of single super phosphate was applied at the time of land preparation as basal dose.

Observations Recorded

The observations were recorded on the following parameters:

Plant height (cm)

Plant height was measured with the help of 1 m steel scale in centimeters from ground level to the tip of main shoot from 4 randomly selected plants at 60, 75, 90, and 105 days after planting (DAP).

Number of leaves plant^{-1}

Recorded from the 4 randomly selected plants at 60, 75, 90, and 105 DAP.

Stem diameter (mm)

Stem diameter of four randomly selected plants at the ground level was recorded at 90 DAP.

Leaf area (cm^2)

The leaf area (LA) plant^{-1} was taken at 50, 75, 90 and 105 DAP with the help of non-portable LA meter (L.A 211, Systronics). The leaves were removed from the stem at the pre-designated time. The LA meter was calibrated before use and was set between the ranges of 0 and 100. The leaves were carefully placed on the stage and were covered with the glass plate, and the recordings were noted down. The sum of LA of all the leaves was taken to get the total LA plant^{-1}. LA index (LAI) was calculated with following equation

$$LAI = LA \div \text{Ground area}$$

Weight of bulbs (g)

Calculated with the help of digital balance (S.F 400, Capacity 750 g × 0.1 g).

Bulb circumference (cm)

The diameter of the main bulb was calculated with the help of digital caliper in centimeter. Later on bulb circumference was empirically figured out from bulb circumference.

Propagation coefficient

Propagation coefficient was calculated as a ratio of number of bulbs harvested to bulbs planted per unit area.

Statistical Analysis

The data collected on traits was analyzed statistically using analysis of variance technique using mini tap. The results were tested at the level of significance.

RESULTS AND DISCUSSION

Effect of source and split application of nitrogen on plant height and stem diameter of Asiatic lilium cultivars.

A significant difference in plant height [Table 1] among the two cultivars recorded at 60, 75 and 90 DAP. Cultivar "Serreda" is a robust variety with a longer internodal distance and a sturdier architecture which is reflected in the significant difference in the plant height measured at various intervals. The results were mainly due to calcium and split doses of nitrogen.

Use of calcium nitrate as a source of nitrogen resulted in significant improvement in plant height recorded at 60-, 75-, and 90-day interval. Calcium nitrate contains nitrogen in readily available NO_3^- form which translates into quicker spurts in growth when applied in split doses. In comparison nitrogen in urea which contains N in ammoniacal form undergo nitrification before it becomes available to the plants. Moreover, the presence of calcium in calcium nitrate also improves the overall growth of the plants [Table 1]. Calcium is essential for the physiological activity of meristematic zones of roots and shoots and particularly when cell division is occurring. The presence of calcium may also have contributed to the overall significant periodical increments in plant height

Table 1: Effect of source and split application of nitrogen on plant height (cm) and stem diameter of Asiatic lilium cultivars

Treatments	DAP				Stem diameter (mm)*
	60	75	90	105	
Cultivar					
Navona (C_1)	31.66	45.45	45.59	46.35	8.05
Serreda (C_2)	50.55	68.79	69.93	70.32	8.37
CD ($p \leq 0.05$)	0.90	1.52	1.06	1.39	0.30
Source of nitrogen					
Urea (N_1)	38.88	56.11	56.39	57.27	8.05
Calcium nitrate (N_2)	43.33	58.13	59.13	59.40	8.37
CD ($p \leq 0.05$)	0.90	1.52	1.06	1.39	0.30
Split application					
30, 60 DAP (S_1)	40.83	56.49	57.31	56.64	7.86
30, 60, 75 DAP (S_2)	41.37	57.29	57.77	58.76	8.30
30, 60, 75, 90 DAP (S_3)	41.11	57.58	58.19	59.60	8.48
CD ($p \leq 0.05$)	NS	NS	NS	1.71	0.37

*Data recorded at 90 DAP, DAP: Days after planting under calcium nitrate than under urea. In lilium Seeley (1950) and Miles (1952) reported poor growth in low calcium or when calcium was omitted altogether. Salazar *et al*. (2011) reported optimum plant height and stem diameter in plants fed with higher calcium concentration.

There was no significant effect of split application of nitrogen on plant height at 60, 75, and 90 DAP. However, height in plants receiving nitrogen in three and four splits (58.76 and 59.60 cm respectively) was significantly superior in comparison to those under two split application (56.64 cm). Split application of nitrogen spread over most of the growth cycle confers an advantage in terms of better growth that is evident in the foregoing results. Lin *et al*. (2011) also reported improved plant architecture with the rational use of nitrogen.

Plant diameter recorded at 90 DAP was significantly superior in cultivar Serreda. Calcium nitrate application also resulted in sturdier plants which is evident from the plant diameter of 8.37 mm in comparison to 8.05 recorded under urea application. The results are in conformity to those of Seyedi *et al.* (2013) who reported improved plant height and stem diameter in Asiatic lilium cultivars Tresor with adequate availability of calcium. Furthermore, Karimi *et al.* (2012) in lilium cultivars Navona demonstrated improved plant growth with the application of calcium nitrate.

Effect of Source and Split Application of Nitrogen on Number of Leaves Plant^{-1}

Although cultivars Serreda is sturdier than cultivars Navona, the number of leaves per plant was significantly more in cultivars Navona at all stages of the growth. Calcium nitrate application resulted in significantly more leaf number than urea application. These results could be attributed to the ready availability of nitrogen in the form of nitrate than ammoniacal form [Table 2]. Moreover, the calcium in the calcium nitrate might also have contributed to the higher leaf number. Since in monocotyledons with the determinate type of growth no new leaves are added in the later stages of growth no significant effect of split application of nitrogen on leaf number was recorded. The number of leaves declined in the later stages of growth, which could be attributed to the dropping off of the lower older leaves. Cultivars interacted positively with the application of calcium nitrate. Significantly higher number of leaves at all stages in both the cultivars was recorded with calcium nitrate than with the urea application. The results are in conformity with those of Salazar *et al*. (2011) who reported improved growth parameters with calcium nitrate. Also Neerja *et al*. (2005) reported the response of cultivars towards the different levels of nitrogen in increasing the number of leaves plant^{-1}. Nitrogen at 20 g/m^2 was reported to increase the number of leaves in lilium cultivars "Elite." Mohanty *et al.* (2002) also reported an increase in the number of leaves with the split application of nitrogen in tuberose.

Table 2: Effect of source and split application of nitrogen on number of leaves plant^{-1} of Asiatic lilium cultivars

Treatments	DAP			
	60	75	90	105
Cultivar				
Navona (C_1)	73.72	80.83	86.22	82.44
Serreda (C_2)	62.16	68.00	70.88	74.66
CD ($p \leq 0.05$)	NS	4.27	3.57	3.60
Source of nitrogen				
Urea (N_1)	66.05	70.55	75.83	76.16
Calcium nitrate (N_2)	69.83	78.27	81.27	80.94
CD ($p \leq 0.05$)	4.02	4.27	3.57	3.60
Split application				
30, 60 DAP* (S_1)	66.66	74.91	77.50	76.66
30, 60, 75 DAP (S_2)	66.83	73.00	78.66	78.41
30, 60, 75, 90 DAP (S_3)	70.33	75.33	79.50	80.58
CD ($p \leq 0.05$)	NS	NS	NS	NS

DAP: Days after planting

Effect of Source and Split Application of Nitrogen on LA and LAI

There was a significant difference in LA build up between the two cultivars Serreda and Navona. Serreda being robust of the two varieties with larger leaves had LA ranging from 436.75 cm^2 at 50 dap which increased to 638.92 cm^2 at 90 dap before dropping to 627.86 cm^2 at 105 dap. This was in comparison to 259.83, 396.12, and 385.62 cm^2 recorded for the same points in time in cultivars Navon, this difference is also manifest in the differences in LA to the ground area ratio of the two cultivars recorded in terms of LAI recorded at 50, 75, 90 and 105 dap. Pandey *et al.* (2008; 2010) also reported the differential varietal response of lilium as a result of varying the genetic makeup of Asiatic lilium cultivars.

Calcium nitrate application [Table 3] significantly improved both LA and LAI in comparison to urea. the difference is significant at 50 dap even though lilium plants for the first 5-6 weeks draw nutrition from the bulbs as feeding roots are yet to develop fully. Readily available NO_3^- in calcium nitrate is the probable cause of enhanced LA, and hence improved LAI even at early stages of plant development. This early advantage in improved photosynthetic interface under calcium nitrate application is carried forward throughout the growth cycle as is indicated by enhanced mean LA and LAI values sampled at 75, 90 and 105 dap.

Salazar *et al.* (2011) also reported improved LA under calcium nitrate regime in lilium cultivars "rio negro."

Effect of three and four split application of nitrogen is evident only in latter stages of plant growth i.e., from 90 day onward. Data show no significant difference in three and four split application of nitrogen at 90 and 105 DAP. However, both are significantly superior to two split application in enhancing the LA. Continued availability of nitrogen is known to stimulate vegetative growth in apical bud meristem. In monocots leaf number of a plant is an entity that is determined at the time of vegetative bud formation. In case of lillium, this number is determined in storage or quiescent bud while bulbs pass the adverse period underground. In spite of this there is a scope for increasing the leaf cover by way of improved leaf expansion and hence ground cover/reduced leaf drop if the plants continue to receive nutrition through critical periods of growth. Enhanced LA and LAI recorded at 90 days under 3 and 4 split application can be attributed to the availability of nitrogen as a result of late application at 75 DAP. Data also throw up an interesting result in that the drop in LA post 90 DAP in plants under two split application is appreciable (513.14-485.59 cm^2). LA loss for the corresponding period in three and four split application is only marginal, i.e., 519.90-516.72 cm^2 in the case of three split application and from 519.52-517.90 cm^2. LAI also follows the same trend as the LA post 90 DAP period. Zhu *et al.* (2012) also reported a positive correlation between nitrogen availability and LA.

Results show that the two cultivars interact differentially to calcium nitrate and urea application throughout the growth period. Significantly higher LA was recorded under calcium nitrate in both the cultivars throughout the growth period. Split application and cultivar interaction appeared to operate at 105 DAP with three and four split doses significantly improving the LA in both cultivar.

Data reveal significant differences in cultivars Navona and Serreda in terms of various bulb yield parameters. Serreda was more prolific with an average yield of 3.94 bulb planted as against 1.00 bulb harvested per bulb planted in cultivars Navona. Bulb circumference main and small bulb weight and total weight was also significantly higher in cultivars Serreda. The results are also supported by superior dry matter accumulating capacity calculated in terms of relative growth rate and net assimilation rate in cultivar Serreda and Navona [Table 4]. Our results are in harmony with those of Lin *et al*. (2011) who observed increased yield of the bulb

Table 3: Effect of source and split application of nitrogen on LA (cm^2) of Asiatic lilium cultivars

Treatments	DAP							
	50		75		90		105	
	LA	LAI	LA	LAI	LA	LAI	LA	LAI
Cultivar								
Navona (C_1)	259.83	0.91	380.53	1.33	396.12	1.39	385.62	1.35
Serreda (C_2)	436.75	1.53	632.02	2.21	638.92	2.24	627.86	2.20
CD ($p\leq0.05$)	6.21	0.02	8.44	0.03	4.08	0.01	3.09	0.01
Source of nitrogen								
Urea (N_1)	339.71	1.19	489.57	1.71	504.05	1.76	496.82	1.74
Calcium nitrate (N_2)	356.87	1.25	522.97	1.83	530.99	1.86	516.65	1.81
CD ($p\leq0.05$)	6.21	0.02	8.44	0.03	4.08	0.01	3.09	0.01
Split application								
30, 60 DAP* (S_1)	346.56	1.21	506.23	1.77	513.14	1.80	485.59	1.70
30, 60, 75 DAP (S_2)	347.38	1.22	506.37	1.77	519.90	1.82	516.72	1.81
30, 60, 75, 90 DAP (S_3)	350.92	1.23	506.21	1.77	519.52	1.82	517.90	1.81
CD ($p\leq0.05$)	NS	NS	NS	NS	5.00	0.02	3.78	0.01

DAF: Days after planting, LA: Leaf area, LAI: Leaf area index

with N application. Also Nehl and Benkenstein (1978) observed that the bulb size and circumference increased with increased levels of nitrogen. Slangen *et al*. (1989) reported that the application of nitrogen in split doses greatly influenced bulb yield.

Calcium nitrate as a source of nitrogen significantly improved all the bulb yield parameters. The results regarding dry matter accumulation point to the early advantage conferred on calcium nitrate receiving plants in terms of RGR and NAR, which seems to have been carried forward into bulb development phase. Readily available NO_3^- along with calcium, which is also reported to improve N uptake by plants may also have had a positive influence on bulb yield. Higher propagation coefficient under calcium nitrate may be result of the positive influence of calcium on meristem development and hence more bulbs harvested per bulb planted. These results corroborated with those of Haadi-e-Vincheh *et al*. (2013) who recorded increase in bulb diameter with the application of ammonium nitrate.

Three and four split application also had a significant positive impact on bulb yield. Whereas there was a significant increase in the number of bulbs and propagation coefficient from two to three split application further increase in bulb number, and propagation coefficient under four split applications was only marginal. Similarly, increment in main bulb circumference and weight and total bulb weight as a result of additional fourth nitrogen dose was only marginal. The usefulness of fourth nitrogen dose

Table 4: Effect of source of nitrogen on number of bulbs plant^{-1}, bulb circumference (cm), bulb weight plant^{-1} (g) and propagation coefficient of Asiatic lilium cultivars

Treatments	Number of bulbs plant^{-1}	Bulb circumference	Bulb weight plant^{-1}			Propagation coefficient
			Main bulb	Small bulbs	Total weight	
Cultivar						
Navona (C_1)	2.00	19.07	54.66	3.08	57.74	1.00
Serreda (C_2)	4.94	23.43	138.15	24.61	162.76	3.94
CD ($p \leq 0.05$)	0.65	1.64	3.12	1.66	4.34	0.65
Source of nitrogen						
Urea (N_1)	3.13	20.38	92.07	11.78	103.85	2.14
Calcium nitrate (N_2)	3.80	22.12	100.74	15.91	116.65	2.81
CD ($p \leq 0.05$)	0.65	1.64	3.12	1.66	4.34	0.65
Split application						
30, 60 DAP* (S_1)	2.81	19.27	91.06	12.59	103.66	1.81
30, 60, 75 DAP (S_2)	3.48	21.32	97.88	13.33	111.22	2.48
30, 60, 75, 90 DAP (S_3)	4.13	23.17	100.27	15.61	115.88	3.13
CD ($p \leq 0.05$)	0.80	2.01	3.82	2.03	5.32	0.80

CD: Critical difference

is evident only in the improvement recorded in small bulb weight. This shows that availability of nitrogen late into the crop production cycle is advantageous in improving the weight of accessory bulbs that are instrumental in improving the quality of propagules in the further multiplication of bulbs. Our results are in harmony with those obtained by Anonymous (1989/90) that the bulb size increased with the split application of nitrogen as ammonium nitrate. Furthermore, Neerja *et al*. (2005) recorded increase in the number of bulbs and bulblets with the split application of nitrogen.

CONCLUSIONS

The results of present study showed that Cultivar Serreda exhibited studier growth than the cultivars Navona in terms of plant height, LA, LAI, and bulb yield. Nitrogen in the form of Calcium nitrate was significantly superior in improving plant growth and bulb yield.

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AUTHOR'S CONTRIBUTION

M.A.W collected the literature, formulated the theme, designed the experiments and contributed in writing. I.T.N., carry out statistical analysis and improvement of the article. A.D was monitoring the field and recorded the observations at various intervals.

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