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Extricating the Impacts of Tactics of Nitrogen Source on the Growth & Development of Lilium Cultivars

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MAW and ITN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RA, SAM and AD helped in data collection. Author RAB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Lilium is one of the most important cut flower and ranks second among bulbous flowers in international market. 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 abroad, so there was need to rationalize the nutrition for optimum plant growth and bulb yield of lilies under Kashmir valley conditions. Consequently, an investigation was undertaken to evaluate the differential response of Asiatic lilies cultivars to different methods of application and nitrogen sources (urea and calcium nitrate) in terms of plant growth, bulb development and yield. Significant differences were observed in growth parameters and behaviour 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 (DAP). Bulb yield parameters (weight of mother bulb, weight of bulblets, number of bulbs plant^{-1}, propagation coefficient) varied significantly between the two cultivars.

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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. $Ca(NO_3)_2$ was more effective in ensuring the prompt availability of nitrogen to plants as compared to urea (NH_2CONH_2); also it was advantageous for improving the bulb growth because of presence of critically important micronutrient i.e. calcium. Split application of nitrogen was advantageous not only in improving the growth and yield attributes but also in preventing the significant losses of nitrogen caused by various processes such as leaching.

Keywords: Bulb; growth; lilium; nitrogen source; yield.

1. INTRODUCTION

Lilies rank among the premier bulbous cut flowers in the international market. Lilies are unmatched in the diversity of plant architecture, shape, colour, size and fragrance of flowers that can equally well be used as cut flowers, landscape plants and in pots (Fig. 1). Globally, lilium is the 2nd ranked cut flower in production [1]. 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 [2]. In 2009 wholesale value of lily cut flowers at Dutch auction was 141 million Euros [3]. 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. Limited research has been published on the essential nutrition requirements for bulb production of commercial lily species. Roberts and Blaney [4] reported that 140 kg ha^{-1} N, 122 kg ha^{-1} P, and 166 kg ha^{-1} K year^{-1} 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 [5] and Miller [6]. 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.

2. 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 levelled 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^{-1} in the form muriate of potash and phosphorous at the rate 150 kg ha^{-1} in the form of single super phosphate was applied at the time of land preparation as basal dose.

2.1 Plant Height (cm)

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

2.2 Number of Leaves Plant^{-1}

Recorded from the 4 randomly selected plants at 60, 75, 90, and 105 DAP (Fig. 1).

2.3 Stem Diameter (mm)

Stem diameter of four randomly selected plants at the ground level was recorded with the help of digital Vernier calliper at 90 DAP.

2.4 Leaf area (cm^2) and Leaf Area Index (LAI)

The leaf area (LA) plant^{-1} was taken at 50, 75, 90 and 105 DAP (Fig. 1) 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 the following equation:

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

2.5 Weight of Bulbs (g)

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

2.6 Bulb Circumference (cm)

The diameter of the main bulb was calculated with the help of digital calliper in centimetre. Later on, bulb circumference was empirically figured out from bulb circumference (Fig. 2).

2.7 Propagation Coefficient

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

Asiatic lilium cv. Serreda | **Asiatic lilium cv. Navona**

Plants of Asiatic lilium cv. Serreda | **Plants of Asiatic lilium cv. Navona**

Fig. 1. Asiatic lilium cultivars used in the study

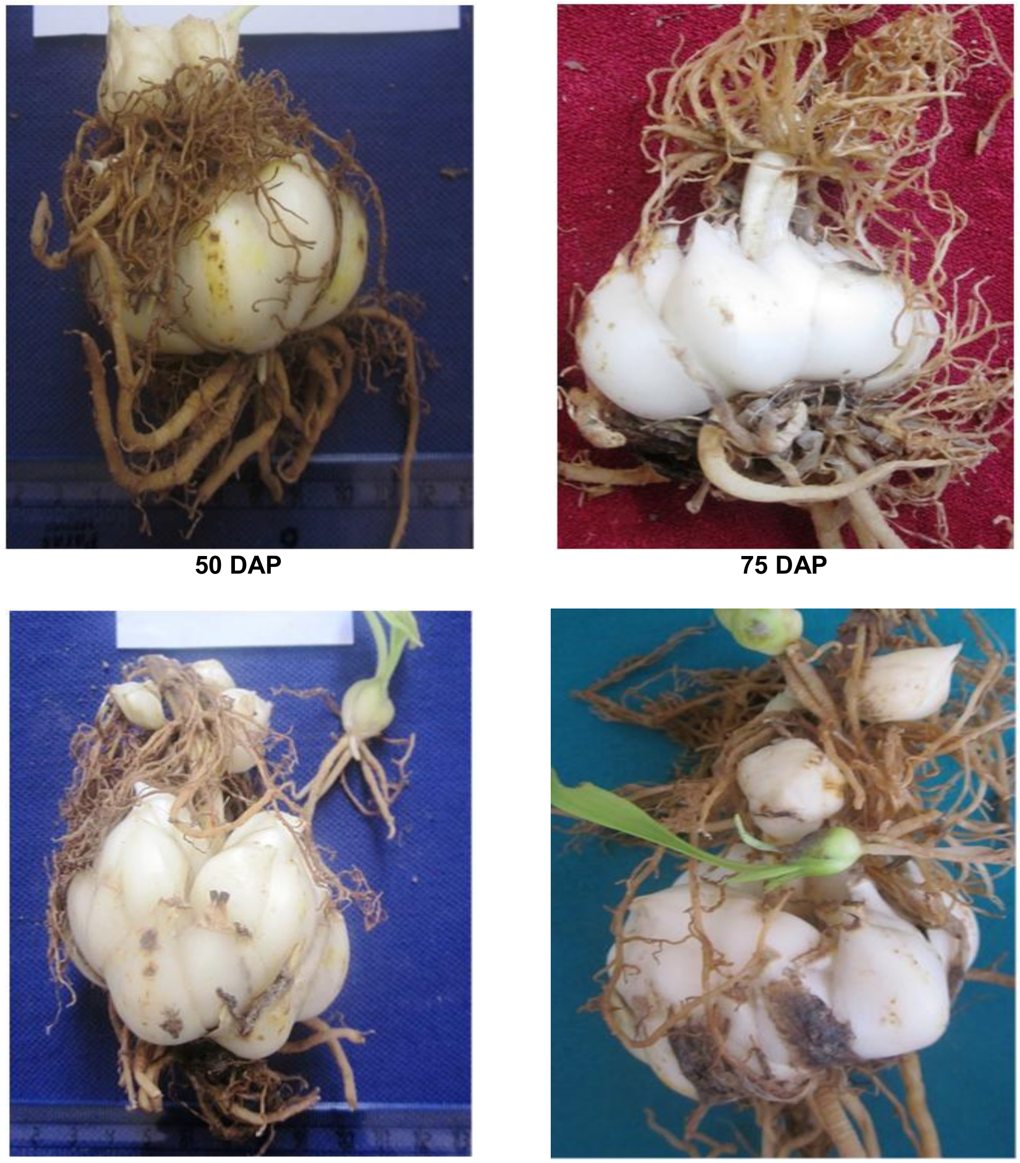

Fig. 2. Bulb development at 50, 75, 90 and 105 days after planting (DAP)

2.8 Statistical Analysis

The data collected on traits were analyzed statistically with the analysis of variance technique using statistical software SPSS. The results were tested at the 5% level of significance ($p \leq 0.05$).

3. RESULTS

3.1 Plant Height and Stem Diameter (cm)

Data pertaining to effect of source and split application of nitrogen on plant height at 60, 75, 90 and 105 days after planting (DAP) is presented in Table 1. Data reveal that the plant height of cv. Serreda was significantly more throughout the growth period. Plant height in cv. Navona ranged from 31.66 cm at 60 DAP to 46.35 cm at 105 DAP, which was significantly less than that recorded in cv. Serreda, which ranged from 50.55 cm at 60 DAP to 70.32 cm at 105 DAP.

Plants of cv. Serreda were significantly sturdier with an average plant diameter of 8.37 mm as against 8.05 mm recorded in cv. Novana.

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

Treatments	DAP				(mm)*
	60	75	90	105	Stem diameter
Cultivar					
Navona (C1)	31.66	45.45	45.59	46.35	8.05
Serreda (C2)	50.55	68.79	69.93	70.32	8.37
CD (p≤0.05)	0.90	1.52	1.06	1.39	0.30
Source of nitrogen					
Urea (N1)	38.88	56.11	56.39	57.27	8.05
Calcium nitrate (N2)	43.33	58.13	59.13	59.4	8.37
CD (p≤0.05)	0.90	1.52	1.06	1.39	0.30
Split application					
30, 60 DAP (S1)	40.83	56.49	57.31	56.64	7.86
30, 60, 75 DAP (S2)	41.37	57.29	57.77	58.76	8.3
30, 60, 75, 90 DAP (S3)	41.11	57.58	58.19	59.6	8.48
CD (p≤0.05)	NS	NS	NS	1.71	0.37

**Data recorded at 90 DAP, DAP: Days after planting*

Calcium nitrate resulted in a significant increase in mean plant height recorded at 60, 75, 90 and 105 DAP. The value ranged from 43.33 cm at 60 DAP to 59.40 cm at 105 DAP as against a mean plant height of 38.88 cm to 57.27 cm at 60 and 105 DAP respectively recorded under urea application.

Average diameter in plants receiving nitrogen in the form of calcium nitrate was significantly more than that recorded in plants receiving nitrogen in the form urea.

No significant effects of two, three and four split application of nitrogen on average plant height were recorded up to 90 DAP. However average plant height at 105 DAP under 4 split application of nitrogen (59.60 cm) was significantly superior to plants under two split nitrogen application (56.64 cm). Further results recorded under 3 and 4 split application of nitrogen in terms of effect on plant height was statistically at par.

Three split application of nitrogen resulted in a significant increase in plant diameter (8.30 mm) as against (7.86 mm) recorded under two split application. Further increase in plant diameter under 4 split application of nitrogen was statistically marginal.

3.2 Number of Leaves Plant^{-1}

Data regarding Number of leaves plant^{-1} recorded at 60, 75, 90 and 105 DAP is presented in Table 2. Throughout the duration of experiment it was observed that the cultivar Navona though dwarfer of the two cultivars had significantly more number of leaves plant^{-1} than cv. Serreda. Number of leaves plant^{-1} in Navona ranged from 73.72 to 82.44 at 60 DAP and 105 DAP as against 62.16 and 74.66 at the same time for cv. Serreda.

Calcium nitrate application resulted in significantly more number of leaves per plant throughout the crop cycle ranging from 69.83 at 60 DAP to 80.94 at 105 DAP. This was in comparison to 66.05 and 76.16 number of leaves plant^{-1} recorded under urea regime at the same time.

There was no significant effect of split application of nitrogen on number of leaves plant^{-1} during growth season.

3.3 Leaf Area (cm^2)

Data pertaining to leaf area (cm^2) recorded at 50, 75, 90 and 105 DAP is presented in Table 3.

Leaf area in cv. Serreda was significantly higher than that recorded in cv. Navona throughout the crop cycle. Leaf area in cv. Serreda ranged from 436.75 to 638.92 cm^2 recorded at 50 DAP and 90 DAP and dropped to 627. 86 cm^2 at 105 DAP. This was in comparison to 259. 83 cm^2 and 396.12 cm^2 recorded at 50 and 90 DAP in cv. Navona which dropped to 385.62 cm^2 at 105 DAP.

Calcium nitrate application resulted in a significant increase in leaf area plant^{-1} throughout the crop cycle (50-105 days) with the highest recorded at 90 DAP (530.99 cm^2) which later dropped to 516.65 cm^2 at 105 DAP.

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 (C1)	73.72	80.83	86.22	82.44
Serreda (C2)	62.16	68.00	70.88	74.66
CD (p≤0.05)	NS	4.27	3.57	3.60
Source of nitrogen Urea (N1)	66.05	70.55	75.83	76.16
Calcium nitrate (N2)	69.83	78.27	81.27	80.94
CD (p≤0.05)	4.02	4.27	3.57	3.60
Split application 30, 60 DAP* (S1)	66.66	74.91	77.50	76.66
30, 60, 75 DAP (S2)	66.83	73.00	78.66	78.41
30, 60, 75, 90 DAP (S3)	70.33	75.33	79.50	80.58
CD (p≤0.05)	NS	NS	NS	NS

DAP: Days after planting

Corresponding values for cv. Navona for the same points were 504.05 cm^2 and 496.82 cm^2 respectively.

There was no significant effect of split application on leaf area plant^{-1} upto 75 DAP. However, at 90 & 105 DAP three and four split application of nitrogen resulted in a significant enhancement in average leaf area over two split application. Moreover, effect of three and four split application on leaf area at 90 and 105 DAP was statistically at par. Highest leaf area of 519.90 and 519.52 cm^2 was recorded under 3 and 4 split application of nitrogen at 90 days after planting.

3.4 Leaf Area Index (LAI)

Data pertaining to leaf area index (LAI), recorded at 50, 75, 90 and 105 DAP are presented in Table 3.

Data reveal that the LAI of cv. Serreda was significantly higher than cv. Navona during all growth intervals. LAI in Serreda ranged from 1.53 at 50 DAP to 2.20 at 105 DAP. Highest leaf area index in cv. Serreda as well as in cv. Navona (1.39 and 2.24 respectively) was recorded at 90 DAP after which the crop experienced a slight decrease in leaf cover.

Results indicated a significantly increased LAI under calcium nitrate regime and ranged from 1.25 at 50 DAP to 1.86 at 90 DAP. This was in comparison to 1.19 and 1.76 LAI recorded for the same days after planting under urea application. After 90-105 DAP the LAI tended to decrease under both forms of nitrogen application (1.74 and 1.81 under urea and calcium nitrate respectively).

There was no significant effect of split application of nitrogen on LAI to 75 DAP. However, at 90 and 105 DAP three and four split applications (1.82 & 1.81 each) resulted in a significant increase over two split application (1.81.70).

3.5 Yield Parameters

Data pertaining to effect of source and split application of nitrogen on yield parameters is presented in Table 4. Number of bulbs plant^{-1} in cv. Serreda was significantly higher (4.94) than that recorded in cv. Navona (2.00). An average number of bulbs plant^{-1} (3.80) under calcium nitrate application was significantly more in comparison to that recorded under urea application (3.13). Three and four split application of nitrogen resulted in significant improvement over two split application in terms of number of bulbs plant^{-1} i.e. the average of 3.48 and 4.13 bulbs plant^{-1} under S_2 and S_3 respectively in comparison to 2.81 bulbs plant^{-1} under S_1. Two way and three-way interaction effects of cultivar, source of nitrogen and split application of nitrogen on bulb number plant^{-1} was not significant.

Average bulb circumference of cv. Serreda (23.43 cm) was significantly higher than that recorded in cv. Navona (19.07 cm). Nitrogen in the form of calcium nitrate resulted in a higher mean bulb circumference (22.12 cm) than 20.38 cm recorded under urea application. Difference in mean bulb circumference under two, three and four split application (19.27, 21.32

and 23.17 cm respectively) was significant. Two way and three-way interaction effects of cultivar, source of nitrogen and split application of nitrogen on bulb circumference were not significant.

Significant differences were observed in main and small bulb weights between the two cultivars that were reflected in significant differences in total bulb weight. Average total bulb weight in cv. Serreda was 162.76 g in comparison to 57.74 g recorded in cv. Navona. Calcium nitrate application significantly improved the main and small bulb weight. Average total bulb weight under calcium nitrate was 116.65 g in comparison to 103.85 under urea application (Fig. 2).

Three and four split application of nitrogen gave comparable results in terms of main and small bulb weight that was also reflected in total bulb weight.

However, both three and four split application significantly improved the bulb weight in comparison to two split application. Average total bulb yield under three and four split application was 111.22 and 115.88 g in comparison to 103.66 g recorded with two split application of nitrogen.

Table 3. Effect of nitrogen on LA (cm^2) and LAI of Asiatic lilium cultivars

Treatments	DAP							
	50		75		90		105	
	LA	LAI	LA	LAI	LA	LAI	LA	LAI
Cultivar								
Navona (C1)	259.83	0.91	380.53	1.33	396.12	1.39	385.62	1.35
Serreda (C2)	436.75	1.53	632.02	2.21	638.92	2.24	627.86	2.2
C.D (p≤0.05)	6.21	0.02	8.44	0.03	4.08	0.01	3.09	0.01
Source of Nitrogen								
Urea (N1)	339.71	1.19	489.57	1.71	504.05	1.76	496.82	1.74
Calcium nitrate (N2)	356.87	1.25	522.97	1.83	530.99	1.86	516.65	1.81
C.D (p≤0.05)	6.21	0.02	8.44	0.03	4.08	0.01	3.09	0.01
Split application								
30, 60 DAP* (S1)	346.56	1.21	506.23	1.77	513.14	1.8	485.59	1.7
30, 60, 75 DAP (S2)	347.38	1.22	506.37	1.77	519.9	1.82	516.72	1.81
30, 60, 75, 90 DAP (S3)	350.92	1.23	506.21	1.77	519.52	1.82	517.9	1.81
C.D (p≤0.05)	NS	NS	NS	NS	5.00	0.02	3.78	0.01

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

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	No. 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
C.D (p≤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
C.D (p≤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
C.D (p≤0.05)	0.80	2.01	3.82	2.03	5.32	0.80

C_1 = (Navona); C_2 (Serreda); N_1 (Urea); N_2 (Calcium nitrate); S_1 (30, 60 DAP); S_2 (30, 60,75 DAP); S_3 (30, 60, 75, 90DAP)

4. DISCUSSION

4.1 Effect 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, 90 and 100 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 under calcium nitrate than under urea. In lilium Seeley [7] and Miles [8] reported poor growth in low calcium or when calcium was omitted altogether. Salazar et al. [9] 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. [10] 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. [11] who reported improved plant height and stem diameter in Asiatic lilium cultivars Tresor with adequate availability of calcium. Furthermore, Karimi et al. [12] in lilium cultivars Navona demonstrated improved plant growth with the application of calcium nitrate.

4.2 Effect 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. [9] who reported improved growth parameters with calcium nitrate. Also, Neerja et al. [13] reported the response of cultivars towards the different levels of nitrogen in increasing the number of leaves plant^{-1}. Nitrogen at 20 gm^{-2} was reported to increase the number of leaves in lilium cultivars "Elite." Mohanty et al. [14] also reported an increase in the number of leaves with the split application of nitrogen in tuberose.

4.3 Effect 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 Navona, 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. [15,16] 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. [9] also reported improved LA under calcium nitrate regime in lilium 'Rio negro'.

Effect of three and four split application of nitrogen is evident only in later stages of plant growth i.e., from 90 days 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 a 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. [17] 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 cultivars.

4.4 Effect on Yield Attributes

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 bulbs 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. [10] who observed increased yield of the bulb with N application. Also, Nehl and Benkenstein [18] observed that the bulb size and circumference increased with increased levels of nitrogen. Slangen et al. [19] 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. [20] who recorded an 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 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 [21] that the bulb size increased with the split application of nitrogen as ammonium nitrate. Furthermore, Neerja et al. [13] recorded increase in the number of bulbs and bulblets with the split application of nitrogen.

5. CONCLUSION

The results of the present study showed that Cultivar Serreda exhibited studier growth than the cultivar Navona in terms of plant growth and bulb yield. Nitrogen in the form of Calcium nitrate source was significantly superior in improving plant growth and bulb yield. $Ca(NO_3)_2$ resulted in prompt availability of nitrogen source to plants whereas $(NH_2)_2CO$ delayed the availability of nitrogen to plants and resulted in significant losses. The investigation fully exponents that split application of nitrogen is advantageous not only in improving the growth and yield attributes but prevents the significant loss of nitrogen occurring due to various processes like leaching, volatilization etc.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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