



RESEARCH ARTICLE

Influence of different fertiliser regimes on production and yield of main and ratoon crop in statice (*Limonium sinuatum* [L.] Mill.)

Pooja R¹, Nomita Laishram^{1*}, Arvinder Singh¹, Sarabdeep Kour², Rakesh Sharma³ & BK Sinha⁴

¹Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Main Campus, Chatha 180 009, Jammu and Kashmir, India

²Division of Soil Science and Agriculture Chemistry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Main Campus, Chatha 180 009, Jammu and Kashmir, India

³Division of Agricultural Extension Education, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Main Campus, Chatha 1800 09, Jammu and Kashmir, India

⁴Division of Plant Physiology, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Main Campus, Chatha 180 009, Jammu and Kashmir, India

*Correspondence email - nomitalaishram@gmail.com

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Abstract

A field experiment was conducted to determine the effect of nutrition management in the main crop on the yield and quality of statice flower production under the ratoon cropping system. The experiment was laid out in a randomised block design (RBD) with 12 treatments and 3 replications. Different levels of nitrogen, phosphorus and potassium (NPK) applied during the main crop had a significant effect on the quality and yield of cut flowers in both the main crop and the ratoon crop. An increase in the dose of NPK fertiliser increases the yield and quality of the main as well as the ratoon crop. The increase was more prominent in main crops than ratoon crops. Application of 150 : 125 : 75 kg ha⁻¹ NPK was found superior, with more cut flower yield, better stem length, and fresh weight in the main crop. However, application of 150 : 50 : 25 kg ha⁻¹ NPK resulted in more flower longevity and vase life (VL). A different trend was observed for ratoon crop, where an application of 200 : 125 : 75 kg ha⁻¹ NPK was found to be optimum for ratoon crop regrowth and development. However, yield and quality parameters were observed with the application of 150 : 125 : 75 kg ha⁻¹ NPK and 150 : 75 : 50 kg ha⁻¹ NPK respectively. Ratoon crops could produce an average of 17.20 cut flower stems per plant with optimal nutrition. Results also indicate that 150 : 125 : 75 kg ha⁻¹ NPK applications could produce a considerably higher yield with longer durability in the main crop as well as the ratoon crop. It can also be concluded that statice ratooning could be a practical way to increase yields with minimal input. Proper nutrition management can further boost the productivity and sustainability of ratoon systems.

Keywords: : flowering; growth; NPK fertilisers; ratooning; statice cultivation

Introduction

Statice (*Limonium sinuatum* [L.] Mill.) is an important ornamental crop known for its hardiness and wide adaptability. It is grown for both fresh flowers and dried flowers. In recent years, the demand for statice has increased owing to its extended vase life (VL) and light stems, and ease of transportation (1). However, its cultivation in the country is very limited, ultimately leading to a shortfall in domestic supply. This limitation is due to farmers not being aware of the market value of their traditional flowers and continuing to cultivate them. This calls for product diversification to sustain the competitiveness of India's flower industry. Statice is a good option for diversification. The flowers are just as good as gypsophila for use as filler flowers in floral arrangements. The flower types of statice are categorised by flower colour (2). Ratooning is an age-old cultivation practice which enables two harvests in a single cropping season where the second crop is produced from the stubble of the first crop

after harvest (3). Normally, the duration of a ratoon crop is much shorter than that of a direct-seeded crop (4), resulting in higher resource-use efficiency per unit time and area, as operations such as land preparation and planting for the second crop are eliminated (5). This practice is commonly seen in agronomic crops like rice, wheat and sorghum, but very rare in ornamental crops. Annual statice is one such crop that responds well to ratooning. The quality and quantity of flower production in the ratoon system are largely dependent on the crop management practice, among which nutrition remains the primary factor. The yield and quality of the main crop are always superior to the ratoon crop due to the lack of nutrition left for the ratoon crop after the harvest of the main crop. The growth and development of the ratoon crop depends largely depend on the cultural practices followed in the main crop. By optimising fertiliser inputs, two high-quality harvests can be taken in a single cropping season.

Ratooning utilises resources very efficiently and enhances productivity with minimum investment in inputs (6). It has been reported that surplus nutrients applied to the main crop remain in the soil after meeting its demand (7). The quality and yield of static flowers in single cropping are reported to be predominantly influenced by the variety, growing conditions and management practices (8). A study reported an average yield of 15–30 flower stems per plant under single cropping (9). Among the management practices, plant nutrition plays an important role in increasing the quality and quantity of bloom to a large extent (10). Therefore, the main objective of the present experiment was to assess the relationship between optimisation of nutrition in the main crop and ratooning regeneration ability, and to examine the effect of fertilisation management for optimisation of crop yield under the ratoon cropping system.

Materials and Methods

Experimental site

The experimental site is situated at an altitude of 296 m AMSL, at a latitude of 33°55' North and a longitude of 74°58' East. The climate is generally subtropical, with hot summers reaching 45–46 °C, cold winters dropping to 3–4 °C, and annual rainfall ranging from 1000 to 1200 mm. A physico-chemical analysis of the experimental field soil was conducted before initiation of the experiment through standard procedures and revealed sandy loam texture with electrical conductivity (EC) of 0.32 dS m⁻¹, 0.36 % organic carbon (OC), 230.84 kg ha⁻¹ available nitrogen (N), 26.70 kg ha⁻¹ available phosphate (P₂O₅) and 220.70 kg ha⁻¹ available potash (K₂O). Available N was determined by alkaline potassium permanganate (KMnO₄) method (11), phosphorus (P) by Olsen method (12), potassium (K) by neutral ammonium acetate (NH₄OAc) method (13) and OC was determined by chromic acid (H₂CrO₄) titration method (14).

Plant material

The seeds of static (*L. sinuatum*) cv. QIS White from Pan American Seeds were obtained from the germplasm maintained in the Division of Floriculture and Landscaping. Seeds were sown in nursery beds in October. Seedlings at the 4 leaf expanded stage were transplanted in the experimental plots at a spacing of 30 cm × 30 cm, with a total of 20 seedlings per bed of 1.50 m × 1.20 m. Replacement of mortality was done until 10 days after transplanting. No disease or pest was observed during the crop period.

Experimental setup

The experiment was laid out in a randomised block design (RBD) with 3 replications. The treatments comprised of 100 : 100 : 100 kg ha⁻¹ nitrogen, phosphorus and potassium (NPK) (T₁); 100 : 75 : 50 kg ha⁻¹ NPK (T₂); 100 : 50 : 25 kg ha⁻¹ NPK (T₃); 150 : 125 : 75 kg ha⁻¹ NPK (T₄); 150 : 75 : 50 kg ha⁻¹ NPK (T₅); 150 : 50 : 25 kg ha⁻¹ NPK (T₆); 200 : 125 : 75 kg ha⁻¹ NPK (T₇); 200 : 75 : 50 kg ha⁻¹ NPK (T₈); 200 : 50 : 25 kg ha⁻¹ NPK (T₉); 250 : 125 : 75 kg ha⁻¹ NPK (T₁₀); 250 : 75 : 50 kg ha⁻¹ NPK (T₁₁); 250 : 50 : 25 kg ha⁻¹ NPK (T₁₂).

Full dose of P, K and half dose of N were given as basal application. The remaining half dose of N was applied 45 days after transplanting. Urea, single super phosphate (SSP), and muriate of potash (MOP) were used to supply the elements of N, P and K respectively. After harvesting the main crop, no fertiliser was applied to the ratoon crop. For the ratoon crop, plants were irrigated as

needed.

Evaluations of growth and flowering parameters

Growth, flowering and yield parameters were observed from 5 randomly tagged plants from each treatment and each replication. Plant height (PH) and plant spread were measured at the peak flowering stage. The duration for which the flower remained presentable in the field after it fully blooms was recorded as field flower longevity. Flower harvesting was done when the inflorescences were fully opened. Immediately after harvesting, the flowers were placed in containers filled with clean water and VL was determined at room temperature.

Statistical analysis

The data were analysed using analysis of variance (ANOVA) to test the significance of the data recorded. The means were compared using Tukey's test at the 5 % probability level, with ANOVA indicating significant differences. The analysis was conducted using the SPSS analytical package (IBM SPSS Statistics 27.0.1).

Results and Discussion

Yield and productivity of a crop may be compromised if the plant's optimum nutrient requirements are not met. Successful cultivation depends on a balanced use of all the major elements. Indiscriminate use of these nutrients increases production costs, which eventually lowers net returns. Also, this situation may pose harmful effects on the environment. Like any other crop, the growth of static and flowering are influenced by balanced nutrition. Under optimum nutrient supply, the plant exhibits full expression of its genetic potential, yield and quality for a long period. Furthermore, the application of an optimum dose of nutrients led to an improvement in the quality of flower production in the ratoon crop, resulting in additional income over and above that obtained from the main crop.

Vegetative characters

Different NPK levels did not significantly influence the PH of static in both the main and ratoon crops (Table 1 and 2). However, plant spread was significantly affected by fertilisation treatments in this study. The results suggest that increasing N from 100 kg to 150 kg significantly increased the plant spread, indicating increased plant vigour. This is because N plays a key role in the plant's vegetative growth and thus should remain available throughout its growth stages. The involvement of N in amino acid synthesis might have played a crucial role in enhancing meristematic activity and, subsequently, vegetative development, which may have contributed to the plant's increased vegetative growth (9). A large amount of N also accelerates cell division and growth. On the other hand, root growth and early crop maturity have been linked to P availability. The findings presented here are consistent with the results of previous studies (15,16).

Flowering characters

Nitrogen, P and K are primary nutrients required by plants for proper growth and development. Growth and development are negatively affected by deficiencies of any of these nutrients during the life cycle. The effect of nutrient management on the yield and quality of static cut flowers in the ratoon cropping system is presented in Table 3 and 4. The flower yield and quality traits of the main crop were higher than those of the ratoon crop. Under suitable environmental conditions and appropriate cultivation practices, the yield potential

Table 1. Effect of NPK doses on plant height and plant spread in the main and ratoon crops of statice

Treatments (Kg/ha NPK)	Plant height (cm)		Plant spread (cm ²)	
	Main crop	Ratoon crop	Main crop	Ratoon crop
T ₁ = 100 : 100 : 100	83.00 ± 7.87	62.36 ± 6.02	3183.47 ± 192.78	2154.82 ± 133.49
T ₂ = 100 : 75 : 50	80.13 ± 8.53	58.41 ± 6.94	2813.13 ± 50.71	1849.00 ± 68.18
T ₃ = 100 : 50 : 25	80.60 ± 1.91	57.82 ± 6.30	3576.67 ± 84.99	2420.64 ± 287.62
T ₄ = 150 : 125 : 75	95.40 ± 5.08	61.79 ± 7.09	3341.00 ± 268.30	2246.76 ± 174.90
T ₅ = 150 : 75 : 50	82.40 ± 1.48	60.66 ± 6.26	4528.07 ± 211.50	3266.12 ± 128.47
T ₆ = 150 : 50 : 25	87.33 ± 2.79	60.54 ± 1.09	3863.33 ± 253.26	2724.84 ± 98.24
T ₇ = 200 : 125 : 75	91.40 ± 3.97	60.89 ± 5.69	3504.93 ± 80.42	2412.77 ± 57.34
T ₈ = 200 : 75 : 50	91.27 ± 2.69	59.76 ± 2.40	3608.40 ± 62.09	2512.01 ± 195.55
T ₉ = 200 : 50 : 25	84.60 ± 8.04	59.58 ± 7.13	3064.40 ± 288.78	2052.09 ± 89.12
T ₁₀ = 250 : 125 : 75	86.80 ± 5.19	58.07 ± 2.57	3455.93 ± 150.09	2375.59 ± 134.32
T ₁₁ = 250 : 75 : 50	85.20 ± 6.14	56.38 ± 6.00	2667.20 ± 251.35	1705.69 ± 146.76
T ₁₂ = 250 : 50 : 25	83.27 ± 6.82	55.81 ± 1.55	3476.93 ± 324.80	2383.39 ± 201.16
Significance	ns	ns	**	**

ns: non-significant; **: significant at the 0.05 % probability.

Table 2. Effect of NPK doses on days taken to spike emergence in the main and ratoon crop of statice

Treatments (Kg/ha NPK)	Days taken from transplanting to spike emergence (main crop)	Days taken from the main crop harvest to spike emergence (ratoon crop)
T ₁ = 100 : 100 : 100	86.20 ± 8.22	35.76 ± 0.71
T ₂ = 100 : 75 : 50	86.47 ± 3.61	37.42 ± 2.45
T ₃ = 100 : 50 : 25	81.53 ± 3.40	38.26 ± 1.22
T ₄ = 150 : 125 : 75	87.60 ± 5.24	38.74 ± 0.92
T ₅ = 150 : 75 : 50	85.07 ± 2.86	37.89 ± 2.33
T ₆ = 150 : 50 : 25	88.33 ± 3.76	39.56 ± 2.79
T ₇ = 200 : 125 : 75	84.73 ± 2.15	36.92 ± 1.21
T ₈ = 200 : 75 : 50	86.07 ± 1.48	37.45 ± 2.15
T ₉ = 200 : 50 : 25	89.87 ± 3.61	39.24 ± 1.99
T ₁₀ = 250 : 125 : 75	91.40 ± 8.91	40.82 ± 1.14
T ₁₁ = 250 : 75 : 50	90.53 ± 7.79	41.58 ± 2.32
T ₁₂ = 250 : 50 : 25	95.20 ± 5.46	45.47 ± 4.54
Significance	ns	**

ns: non-significant; **: significant at 0.05 % probability.

Table 3. Effect of fertilisation on cut flower yield and quality parameters in main and ratoon crops of statice

Treatments (Kg/ha NPK)	No. of cut flower stems per plant		Spike length (cm)		Fresh weight of flower spike (g)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
T ₁ = 100 : 100 : 100	18.20 ± 1.43	13.73 ± 1.05	72.47 ± 6.83	73.54 ± 4.68	33.60 ± 0.98	30.56 ± 2.10
T ₂ = 100 : 75 : 50	16.33 ± 0.82	11.67 ± 0.39	72.73 ± 5.18	69.32 ± 3.29	29.07 ± 1.79	27.46 ± 1.21
T ₃ = 100 : 50 : 25	17.13 ± 0.76	11.50 ± 0.69	70.60 ± 3.00	68.84 ± 8.18	26.93 ± 2.00	22.70 ± 1.84
T ₄ = 150 : 125 : 75	20.13 ± 2.18	17.20 ± 0.59	83.53 ± 7.39	72.19 ± 6.21	52.33 ± 3.56	34.36 ± 3.18
T ₅ = 150 : 75 : 50	15.13 ± 1.31	14.97 ± 0.50	74.07 ± 4.37	74.66 ± 3.85	28.93 ± 3.10	26.70 ± 1.53
T ₆ = 150 : 50 : 25	17.33 ± 1.93	12.87 ± 0.83	77.33 ± 7.54	70.54 ± 7.34	24.00 ± 1.59	22.54 ± 0.85
T ₇ = 200 : 125 : 75	19.93 ± 2.22	13.57 ± 1.30	80.93 ± 5.50	69.66 ± 5.88	45.73 ± 5.28	38.33 ± 4.05
T ₈ = 200 : 75 : 50	17.87 ± 0.32	13.13 ± 1.43	75.73 ± 1.73	70.19 ± 7.25	36.80 ± 2.83	29.07 ± 0.62
T ₉ = 200 : 50 : 25	17.87 ± 0.66	13.50 ± 1.56	77.67 ± 5.09	69.84 ± 2.17	32.73 ± 0.59	26.60 ± 0.63
T ₁₀ = 250 : 125 : 75	19.87 ± 0.47	13.73 ± 0.66	76.40 ± 7.01	68.06 ± 7.03	37.13 ± 4.50	30.91 ± 0.61
T ₁₁ = 250 : 75 : 50	18.60 ± 0.64	12.90 ± 1.22	73.87 ± 5.51	66.47 ± 2.40	33.13 ± 3.90	28.26 ± 2.01
T ₁₂ = 250 : 50 : 25	18.93 ± 0.95	13.07 ± 1.58	74.27 ± 9.01	67.22 ± 5.29	36.27 ± 1.84	24.13 ± 0.89
Significance	**	**	ns	ns	**	**

ns: non-significant; **: significant at 0.05 % probability.

Table 4. Effect of fertilisation on cut flower vase life and flower longevity in main and ratoon crops of static

Treatments (Kg/ha NPK)	Vase life (days)		Flower longevity in the field (days)	
	Main crop	Ratoon crop	Main crop	Ratoon crop
T ₁ = 100 : 100 : 100	9.73 ± 0.20	7.45 ± 0.30	45.80 ± 5.23	26.25 ± 2.82
T ₂ = 100 : 75 : 50	10.73 ± 0.94	8.53 ± 0.30	44.13 ± 1.88	24.43 ± 2.54
T ₃ = 100 : 50 : 25	11.87 ± 1.04	8.76 ± 0.42	41.47 ± 3.40	21.75 ± 1.62
T ₄ = 150 : 125 : 75	11.93 ± 0.76	9.21 ± 0.78	47.27 ± 0.85	27.47 ± 0.83
T ₅ = 150 : 75 : 50	12.47 ± 1.40	9.67 ± 1.13	51.10 ± 3.94	29.26 ± 3.19
T ₆ = 150 : 50 : 25	9.40 ± 0.78	7.12 ± 0.70	49.93 ± 2.90	29.21 ± 3.35
T ₇ = 200 : 125 : 75	8.27 ± 0.58	6.81 ± 0.43	47.27 ± 3.53	27.35 ± 2.78
T ₈ = 200 : 75 : 50	7.53 ± 0.85	6.02 ± 0.57	48.13 ± 4.10	27.42 ± 2.88
T ₉ = 200 : 50 : 25	8.80 ± 0.43	6.95 ± 0.83	48.27 ± 3.64	26.45 ± 2.14
T ₁₀ = 250 : 125 : 75	7.40 ± 0.28	6.01 ± 0.28	40.00 ± 4.46	20.76 ± 0.92
T ₁₁ = 250 : 75 : 50	7.60 ± 0.74	6.22 ± 0.75	45.93 ± 1.39	25.65 ± 2.46
T ₁₂ = 250 : 50 : 25	8.53 ± 0.73	7.43 ± 0.23	46.53 ± 4.73	26.23 ± 2.86
Significance	**	**	**	**

ns: non-significant; **: significant at 0.05 % probability.

of the ratoon crop could be fully exploited (4). It was further suggested that a higher level of N application was needed to prevent production differences between main and ratoon crops of sorghum (17). In the present study, with proper fertiliser application, the yield gap between main and ratoon crops narrowed.

Results also indicate that 100 : 100 : 100 kg ha⁻¹ NPK applied at the main crop was almost adequate for the ratoon crop regrowth, development and production. However, the yield and flower quality of the ratoon crop increased with an increase in fertiliser dose to a certain extent, along with assured irrigation. Excessive fertiliser application might have reduced nutrient use efficiency. Earlier, it was also suggested that a good main-crop stand is essential for producing a good ratoon crop (18). Nitrogen fertiliser applied immediately after main crop harvest had a more evident and positive influence on ratoon crop yield than N applied before harvest (19). There are also reports of a significant correlation between main-crop yield and ratoon-crop yield (20).

Maximum number of cut flower stems per plant in the main crop as well as ratoon crop (20.13 and 17.20 respectively) was obtained with the application of 150 : 125 : 75 Kg ha⁻¹ NPK. Increasing P from 50 to 125 kg ha⁻¹ increased static flower yield parameters, possibly due to increased cell division, root growth, and flowering. Phosphorus is found in plant parts with high metabolic activity and rapid cell division; therefore, it plays a role in the storage and transfer of energy released during photosynthesis, and its deficiency delays maturity (21). In the present investigation, it was observed that a further increase in N dose from 150 kg ha⁻¹ to 200 kg ha⁻¹ reduced the number of cut-flower stems in the main crop. Earlier studies also reported that once the optimal requirement is met, further increases in N may not benefit the plant (22).

The findings also revealed that fertiliser application did not significantly affect the number of days to spike emergence in the main crop. However, fertiliser application of 100 : 100 : 100 kg ha⁻¹ NPK resulted in the earliest flower spike emergence (35.76 days) in the ratoon crop (Table 4). Results of another study indicated that delayed flowering with higher N fertiliser application may result from the role of N in the buildup of energy stores in plant tissues (23). It was further suggested that the days to blossom appearance changed inversely with increasing N and potash dosages (24). Similar results were also obtained from studies on *Gerbera* (25). It

has also been reported that K accelerates photosynthesis and mobilises sucrose to shoots, both of which favour the onset of flowering (26).

Increased doses of NPK were directly linked with a continuous supply of essential nutrients throughout the growth period, which resulted in better flower quality. Similar results were also reported in another study (27). It was further reported that low N fertilisation resulted in satisfactory cut-flower output, demonstrating that N is not a limiting factor in static plants (28). Another study recorded maximum flower numbers when 150 : 100 : 100 kg ha⁻¹ NPK was applied as fertiliser (29). A separate investigation, however, recommended an integrated nutrient management approach to enhance static flower yield (30). Application of P between 30 and 46 mg L⁻¹ was reported to produce the maximum number of stems and total weight of flowers in static (31). The application of 150 : 125 : 75 kg ha⁻¹ NPK recorded the highest significant spike fresh weight in main crop as well as ratoon crop (52.33 g and 34.36 g respectively).

Vase life

With the application of 150 : 75 : 50 kg ha⁻¹ NPK, flower longevity in the field (51.10 days) and VL (12.47 days) at ambient temperature were recorded as the highest in the main crop. However, maximum flower longevity of 29.26 days and VL of 9.67 days were observed with the same treatment in the ratoon crop as well. These results showed that increasing N application decreased flower longevity and VL in static. Vase life is negatively affected by high N levels, with the shortest VL observed when plants were treated with 250 kg ha⁻¹ N. The negative impact of high N levels on VL may be due to excessive N promoting rapid, lush vegetative growth, resulting in softer tissues and higher water content. These tissues tend to have thinner cell walls, lower structural strength, higher respiration rates and greater susceptibility to microbial infection. As a result, cut flowers from high-N plants often wilt faster, lose firmness more quickly, and are more prone to stem blockage due to microbial growth in the vase solution. Increased respiration also accelerates carbohydrate depletion, shortening postharvest longevity.

Another reason for increased VL with the 150 : 75 : 50 kg ha⁻¹ NPK treatment may be the better overall nutritional status of the flower under these treatments. The findings are consistent with a previous study (32). A separate study found that flower longevity in

the field (60.97 days) was maximum with the application of N at 20 g m⁻² (9). Similar results were also reported in another study (33).

Several workers have reported that high N levels adversely affect the quality of flowers. When it comes to the differentiation of floral buds, P is crucial. This may explain why higher P application caused early flowering. Plant growth was also significantly influenced by P application. The increase in vegetative growth might also be the reason for an increasing number of flowers, weight of the flower stalk, length of the flower stalk, the number of flower bunches per stalk, and per bunch. An essential component of P triggers flowering and enhances flower quality. These outcomes seem typical of improvements in flowering characteristics. Whereas K application will improve water uptake, flower opening, longevity, and pest and disease resistance in cut flowers.

Conclusion

The present study showed encouraging results concerning higher economic return for static cultivation. Proper fertiliser management improved the quality and yield of static flowers in both the main and ratoon crops. It can be concluded from the present investigation that NPK fertilisation could improve soil nutrient status, thus improving crop productivity. Application of 150 : 125 : 75 kg ha⁻¹ NPK was found to be the most effective for static cut flower production under Jammu conditions.

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Authors' contributions

NL, AS and PR conceptualised and conducted the experiment, prepared the original draft and contributed to its review and editing, while BKS, SK and RS assisted in the study design and performed the statistical analysis. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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