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Integrated nutrient management for growth and yield in Glory Lily (*Gloriosa superba* L.)

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***Gloriosa superba* L. is an important medicinal plant species found in tropical and subtropical regions of India. Seeds and tubers contain colchicine which is used for treating gout, rheumatism and for producing polyploides. Due to diverse use, the species has been largely exploited from natural habitat leading to its threatened status. A field experiment was conducted to study the influence of organic and inorganic fertilizers on its growth and seed yield. Eight treatments including Control (T_1), NPK at 120:50:75 kg/ha (recommended dose) (T_2), FYM at 20 t/ha (T_3), Vermicompost(VC) at 6 t/ha (T_4), FYM at 10 t/ha + ½ T_2 (T_5), VC at 3 t/ha + ½ T_2 (T_6), FYM at 13.3 t/ha + ⅓T_2 (T_7), VC at 4 t/ha + ⅓T_2 (T_8) were followed to find their effect on growth and yield. The treatments were significantly different from each other and higher values were recorded for plant height (144.96 cm), number of leaves plant^{-1} (172.03), number of branches plant^{-1} (4.35), number of flowers plant^{-1} (30.50), number of fruits plant^{-1} (10.10), seed yield plant^{-1} (4.47 g) and estimated seed yield hectare^{-1} (197.50 kg) in the treatment VC at 4 t/ha + ⅓T_2. Available major nutrients (NPK) in soil also recorded higher after harvesting the crop in the treatment VC at 4 t/ha + ⅓T_2.**

Key words: Glory lily, inorganic fertilizers, organic manures, *Gloriosa,* seed yield

INTRODUCTION

Resurgence of interest in herbal medicines world over resulted in many fold increase in demand of medicinal plants. Due to this, many species were over-exploited from their natural habitat leading to their endangered/threatened/extinct status. Cultivation of such species is the only alternative to meet the growing demand in a sustainable way. Integrated nutrient management (combination of chemical fertilizers with organic sources) plays vital role in supply of all essential nutrients for agriculture production which simultaneously ensure efficiency of fertilizer use and promote synergistic interactions. This will not only discontinue the alarming degradation of soil health but assure the purity of produce. Integrated nutrient management is equally important in case of medicinal plants also, as they are used directly or indirectly to treat various human ailments in traditional system of medicine.

Gloriosa superba L, (Glory lily, Flame lily, Kalihari, Agnishikha, Langli, Family- Liliaceae) is one such plant which is widely used in traditional and modern system of medicines in India. Due to its widespread use, the species was largely exploited from its natural habitat. The species is indigenous to India and is found in tropical and sub-tropical climate up to an altitude of 2100 m above mean sea level (Farooqi et al., 1993). Colchicine ($C_{22}H_{26}O_6H$), present in its tubers and seeds is used for treating gout, cancer control and for inducing polyploidy in plants (Satyavati et al., 1976). The species is also

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reported to have anticoagulant properties and found effective for controlling the larvae of various livestock parasites including *Rhipicephalus microplus, Paramphistomum cervi, Anopheles subpictus* and *Culex tritaeniorhynchus* (Kee et al., 2008; Zahir et al., 2009). The flowers due to their colour and shape are used as cut flowers (Dey, 1998).

Earlier, the colchicine was thought to be present in tubers only and these were ruthlessly extracted without any concerted attempt to regrow these plants. Lately, it was found that the seed also possess the colchicine (Bhakuni and Jain, 1995), but the seed yield in nature is quite low and variable. At present this species has become threatened due to unchecked extraction of tubers coupled with low seed yield in nature. Use of seed for colchicine extraction is better than tuber as it contains more content (Gupta et al., 2005) and does not involve destructive harvesting as in the case of tubers.

Keeping this in view, the present investigation was conducted to study the effect of application of fertilizers and manures on growth and yield of Glory lily.

MATERIALS AND METHODS

Study area

The present study was carried out in Sher-e-Kashmir University of Agricultural Sciences and Technology, Division of Agroforestry, Chatha, Jammu**,** India.

Experimental details

Randomized block design with eight treatments and three replications were used to conduct the study. Raised beds of size 1.8 × 1.2 m^2 were prepared and tubers were planted at a spacing of 60 cm x 40 cm, thereby accommodating nine plants per plot. The farm yard manure (FYM) and vermicompost (VC) were applied at the time of planting. Nitrogen (N) applied in the form of urea, whereas, phosphorus (P) and potassium (K) were applied in the form of diammonium phosphate (DAP) and muriate of potash (MOP), respectively. One third of N and full doses of P and K were applied as basal, while the remaining two third dose of N was top dressed after 56 days of planting. The eight treatments applied were Control (T_1), NPK at 120:50:75 kg/ha (recommended dose) (T_2), FYM at 20 t/ha (T_3), Vermicompost (VC) at 6 t/ha(T_4), FYM at 10 t/ha + ½ T_2 (T_5), VC at 3 t/ha + ½ T_2 (T_6), FYM at 13.3 t/ha + ⅓T_2 (T_7), VC at 4 t/ha + ⅓T_2(T_8).

Observations

The observations were recorded for number of days taken to sprouting, number of days taken to initiation of flowering, plant height (cm), number of leaves per plant, number of branches per plant, number of flowers per plant, number of fruits per plant, fruit size (length and diameter in cm), number of seed per fruit, 100-seed weight (g), seed yield per fruit (g) and seed yield per plant (g). The nutrient status of plants and soil was determined after harvesting the crop (Olsen et al., 1954; Subbiah and Asija, 1956; Jackson, 1967). The statistical analysis for each character was carried out on mean values.

RESULTS AND DISCUSSION

Growth and yield attributes

Organic and inorganic fertilizer application significantly influenced the growth and yield characters in *Gloriosa superba* (Tables 1 and 2). The results indicated that manuring was necessary to achieve good growth and yield. Chemical fertilizers though showed improvement over control, proved inadequate compared with integrated nutrient management, that is, organic manures (vermicompost or FYM) in conjunction with inorganic fertilizers. Integrated nutrient management resulted in higher values of growth and yield parameters compared to manures or inorganic fertilizers alone. In general, addition of organic manures (FYM and vermicompost) has reduced the number of days taken to sprouting and initiation of flowering. The number of days taken to sprouting (36.66) and initiation of flowering (61.67) were minimum in the T_8 (vermicompost at 4t/ha along with ⅓ of recommended dose of NPK), whereas maximum number of days taken to sprouting (47.20) and initiation of flowering (81.33) were observed in control (T_1). The growth parameters including plant height, number of leaves per plant and number of branches per plant were also significantly influenced by the application of inorganic fertilizers, organic manures (FYM and vermicompost) and under integrated nutrient management. Although, FYM alone and under integrated nutrient management, increased the growth parameters significantly compared to control but they were not significantly different from inorganic fertilizers. This might be due to the lack of sufficient moisture in soil required for decomposition of FYM besides slow release and uptake of nutrients by the crop (Naik and Babu, 2007). Among the different combinations of fertilizers and manures, application of vermicompost at 4t/ha along with ⅓ of recommended dose of NPK (T_8) has significantly increased the growth parameters and resulted in maximum plant height (144.96 cm), number of leaves per plant (172.03) and number of branches per plant (4.35). However, growth parameters observed under T_6 (vermicompost at 3 t/ha along with ½ of recommended dose of NPK) were almost statistically at par with T_8. The reason for higher growth under integrated nutrient management may be due to sustainable/continuous availability of nutrients especially nitrogen throughout the growth period coupled with lesser leaching losses of nutrients (Ayanaba and Okigbo, 1974).

Fertilizer applications not only influenced the growth but also the yield and its attributing characters in *Gloriosa superba* (Table 2). Inorganic fertilizers have significantly increased the yield and its contributing factors than control. This observation is in concurrence with finding of Kumaraswamy et al. (1994), where higher values of yield contributing parameters and seed yield were obtained with the application of inorganic fertilizers in glory lily.

Table 1. Effect of integrated nutrient management on growth parameters in *Gloriosa superba*.

Treatments	Days taken to sprouting	Days taken to initiation of flowering	Plant height (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}
Control (T_1)	47.20	81.33	94.75	97.56	1.61
NPK at 120:50:75 (T_2)	45.91	74.19	120.18	123.30	2.16
FYM at 20 t ha^{-1} (T_3)	43.11	72.59	118.75	138.28	2.12
VC at 6t ha^{-1} (T_4)	38.20	71.52	130.36	154.37	2.20
FYM at 10 t ha^{-1} + ½ T_2 (T_5)	39.26	70.06	126.25	128.70	2.25
VC at 3t ha^{-1} + ½ T_2 (T_6)	42.83	64.70	136.25	164.39	2.33
FYM at 13.33 t ha^{-1} + ⅓ T_2 (T_7)	39.16	68.25	123.58	166.40	3.41
VC at 4t ha^{-1} + ⅓T_2 (T_8)	36.66	61.67	144.96	172.03	4.35
$CD_{0.05}$	5.482	8.180	9.574	10.476	0.379

Integrated nutrient management, where FYM and vermicompost were used separately with inorganic fertilizers proved better compared to organics or inorganic fertilizers alone. Higher values of flowers per plant (30.50), number of fruits per plant (10.10), fruit length (4.63 cm), fruit diameter (1.60 cm), number of seed per fruit (16.12), seed yield per fruit (0.48 g), seed yield per plant (4.47 g) and estimated seed yield (197.50 kg/ha) were recorded, when vermicompost at 4 t/ha along with ⅓ of recommended dose of NPK (T_8) was used instead of other fertilizer combinations. Except estimated seed yield per hectare, seed yield per plant and its attributing parameters follow the same trend as of growth parameters, where T_6 (vermicompost at 3 t/ha along with ½ of recommended dose of NPK) was statistically alike to T_8. The better vegetative growth due to vermicompost along with inorganic fertilizers might have reflected in increased production of flowers, more number of fruits per plant, better fruit size, more seed per fruit and subsequently higher seed yield per plant. More fruits per plant due to vermicompost under integrated nutrient management could be attributed to the presence of B group vitamins, plant hormones (cytokinin and auxin) and chemicals exudates released during biological activity promoted by the vermicompost in the soil (Kale and Krishnamoorthi, 1981). The other probable reason could be the presence of micro and macro-nutrients in sufficient quantity and increased supply of readily available plant nutrients through mineralization process, physical effect of vermicompost on porosity, aeration of soil and higher rate of metabolic functions.

Increase in the growth and yield characteristics with conjunctive use of organic and inorganic rather than their sole application reported in the present investigation is in consonance with earlier reports of Bhaskar and Sreenivasmurthy (2005) in *Coleus forskohlii*, Joy et al. (2005) in black musli (*Curculigo orchioides*), Kothari et al. (2005) in *Spilanthus acmella*, Rajendran and Gnanavel (2008) in *Aloe vera* and Velmurugan et al. (2008) in *Curcuma longa*.

Nutrient concentration in plant and soil after harvest of the crop

The different treatments of manure and fertilizers (Table 3) increased the N, P and K concentrations (%) in *Gloriosa superba* over the control. Though the treatments are not significantly different, T_6 (vermicompost at 3 t/ha along with ½ of recommended dose of NPK) and T_7 (FYM at 13.33 t/ha along with ⅓ of recommended dose of NPK) decreased the value of P concentration in plant. The increase in NPK concentrations (%) might be due to the efficient supply of macro and micro nutrients under integrated nutrient management with regard to organic manures act as a source of plant nutrient and humus, which improves the soil physical condition by increasing its capacity to absorb and store water, improving aeration and favoring microbial activity, thereby making conditions favorable for nutrient uptake (Joy et al., 2005).

After the harvest of the crop, no significant variation is observed in soil pH and EC with the application of different fertilizers and manures (Table 4), however, their range in different treatments varies from 0.15-0.20 ds/m and 7.49-8.16 ds/m, respectively. It is evident from Table 4 that incorporation of manures and fertilizers significantly increased the available nutrients of the soil over control. T_2 (recommended dose of NPK), T_7 (FYM at 13.33t/ha along with ⅓ of recommended dose of NPK) and T_8 (vermicompost at 4t/ha along with ⅓ of recommended dose of NPK) not only increased the available N in the soil over the control, but also over its initial status. Phosphorus content of soil is also increased over its initial value by incorporating vermicompost at 4t/ha along with ⅓ of recommended dose of NPK (T_8), whereas T_5, T_6, T_7 and T_8 resulted in increased K content of soil over initial. The lower nutrient status under control plot than the initial value could be due to non-application of either manures or fertilizers and the existing status was nothing but the native status left over after the uptake by the plant. In case of organic fertilizers, N content was slightly higher but P and K contents were lower than initial status

Table 2. Effect of integrated nutrient management on yield and yield attributing traits in *Gloriosa superba*.

Treatments	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Number of seed fruit^{-1}	100-seed weight (g)	Seed yield fruit^{-1} (g)	Seed yield plant^{-1} (g)	Estimated seed yield (kg/ha)
Control (T_1)	13.83	6.63	3.60	1.29	11.30	3.10	0.34	2.21	92.29
NPK at 120:50:75 (T_2)	16.88	7.50	4.02	1.42	12.15	3.26	0.37	2.81	117.08
FYM at 20 t ha^{-1} (T_3)	19.60	7.75	4.07	1.41	13.20	3.13	0.39	2.91	121.26
VC at 6t ha^{-1} (T_4)	22.22	9.10	4.41	1.52	14.40	3.00	0.42	3.85	160.45
FYM at 10 t ha^{-1} + ½ T_2 (T_5)	20.50	7.90	4.42	1.56	13.40	3.10	0.41	3.21	134.04
VC at 3t ha^{-1} + ½ T_2 (T_6)	28.50	9.50	4.50	1.53	15.70	3.10	0.47	4.43	184.58
FYM at 13.33 t ha^{-1} + ⅓ T_2 (T_7)	24.20	8.30	4.13	1.58	14.30	3.01	0.41	3.43	142.39
VC at 4t ha^{-1} + ⅓T_2 (T_8)	30.50	10.10	4.63	1.60	16.12	3.10	0.48	4.47	197.50
$CD_{0.05}$	4.864	0.837	0.501	0.045	0.473	NS	0.022	0.358	9.343

*NS: Non-significant

Table 3. Effect of manures and fertilizers application on NPK concentrations (%) in *Gloriosa superb.*

Treatments	N (%)	P (%)	K (%)
Control (T_1)	1.28(1.51)	0.29(1.13)	2.21(1.78)
NPK at 120:50:75 (T_2)	1.35(1.52)	0.30(1.14)	2.29(1.81)
FYM at 20 t ha^{-1} (T_3)	1.39(1.54)	0.29(1.13)	2.34(2.08)
VC at 6t ha^{-1} (T_4)	1.41(1.55)	0.31(1.14)	2.35(1.82)
FYM at 10 t ha^{-1} + ½ T_2 (T_5)	1.43(1.56)	0.29(1.14)	2.36(2.09)
VC at 3t ha^{-1} + ½ T_2 (T_6)	1.47(1.56)	0.28(1.13)	2.50(1.87)
FYM at 13.33 t ha^{-1} + ⅓ T_2 (T_7)	1.45(1.56)	0.27(1.13)	2.41(1.84)
VC at 4t ha^{-1} + ⅓T_2 (T_8)	1.54(1.59)	0.32(1.15)	2.55(1.88)
$CD_{0.05}$	NS	NS	NS

*Figures in parentheses indicate transformed (square root) values; **NS: Non-significant.

of soil. This is not due to the plant uptake alone, but may be due to leaching of N and K. The higher contents of NPK in soil were observed in manures alone and under integrated nutrient management. Maximum contents of available N (257.40 kg/ha), P (17.56 kg/ha) and K (168.10 kg/ha) in soil after harvest of crop are observed in T_8 (vermicompost at 4 t/ha along with ⅓ of recommended dose of NPK) followed by T_6 (vermicompost at 3 t/ha along with ½ of recommended dose of NPK). The increase in available N may be ascribed to mineralization of partially or fully immobilized N by vermicompost in soil besides application of inorganic fertilizers. Substantial increase in N content could also be due to inability of micro-organisms to decompose the organic manures applied and make it available for the plant. The noticed increase in available P

Table 4. Post harvest soil fertility status under application of different fertilizers and manures.

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)	EC (dS/m)	pH
Control (T_1)	191.30	11.42	154.00	0.17	7.94
NPK at 120:50:75 (T_2)	255.30	12.87	157.00	0.15	8.16
FYM at 20 t ha^{-1} (T_3)	245.39	14.87	159.00	0.16	7.96
VC at 6t ha^{-1} (T_4)	231.09	13.88	160.40	0.18	8.03
FYM at 10 t ha^{-1} + ½ T_2 (T_5)	247.72	13.89	163.50	0.17	8.03
VC at 3t ha^{-1} + ½ T_2 (T_6)	249.50	14.06	166.50	0.19	8.01
FYM at 13.33 t ha^{-1} + ⅓ T_2 (T_7)	253.60	13.70	163.70	0.20	8.05
VC at 4t ha^{-1} + ⅓T_2 (T_8)	257.40	17.56	168.10	0.17	8.03
$CD_{0.05}$	5.321	1.159	1.611	NS	NS
Initial status of soil	251.30	16.10	162.70	0.15	7.90

*NS: Non-significant

of soil may be due to greater mobilization of native soil P, contribution through added manure and fertilizers, mineralization of organic P and production of organic acids making soil P more available. On the other hand, increase in available K of soil may be due to K applied through fertilizer and organic residues, the solubilizing action of certain organic acids produced during decomposition of organic residues and greater capacity of organic manures to hold K in the available form. These results are in close conformity with the earlier reports of Bhandari et al. (1992); Katyal et al. (1998) in rice-wheat cropping system; Dudhat et al. (1997) in wheat; Joy et al. (2005) in *Curculigo orchioides*; Naik and Babu in *Psidium guajava* (2007).

CONCLUSION

Combination of organic and inorganic fertilizers is superior over application of manures or fertilizers alone for achieving higher growth and yield in glory lily. Application of vermicompost at 4 t ha^{-1} along with 40 kg N, 16.67 kg P and 25 kg K ha^{-1} is beneficial not only to increase the seed yield (4.47 g per plant) but in augmenting the fertility status of soil.

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