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Effect of integrated nutrient management through vermicompost and inorganic fertilizers on growth, yield, nutrient uptake and oil quality of geranium (*Pelargonium graveolens* L' Her. ex Ait.) grown on alfisol

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Abstract

The effect of vermicompost and inorganic fertilizers (NPK) on growth, herbage, essential oil yield, oil quality and nutrient uptake pattern of geranium (*Pelargonium graveolens*) was studied at Bengaluru in a semi-arid climate. Among the five treatments compared, the combination of vermicompost @ 5 t ha^{-1} + 50% recommended NPK fertilizer (100 : 25 : 25 kg ha^{-1}) gave significantly better growth, high fresh herbage yield and oil yield which was on par with full dose of fertilizer NPK (200 : 50 : 50 kg ha^{-1}). A similar pattern was noticed in case of nitrogen, phosphorus and potassium uptake by plants. Oil content and oil quality were not influenced by vermicompost and inorganic fertilizers, alone or in combination.

Keywords: geranium, inorganic fertilizer, nutrient uptake, *Pelargonium graveolens*, vermicompost, yield.

Introduction

Integrated supply of nutrients to plants through organic and inorganic sources is becoming an increasingly important aspect of environmentally sound agriculture. Research work on the influence of vermicompost and combined application of organic and inorganic fertilizers on yield and oil quality of geranium (*Pelargonium graveolens* L' Her. ex Ait.) is meagre. Keeping this in view, the present experiment was conducted to study the effect of integrated nutrient management through vermicompost and inorganic fertilizers on growth, yield, nutrient uptake and oil quality of geranium grown on alfisol in a semi-arid climate.

Materials and methods

The field experiment was conducted for two years during 2004 to 2006 at Central Institute of Medicinal and Aromatic Plants, Research Centre, Bengaluru, India. The soil was red sandy loam (alfisol) in texture with pH 6.4, available nitrogen 195.0 kg ha^{-1}; phosphorus 10.5 kg ha^{-1}, potassium 145.7 kg ha^{-1} and organic carbon 0.3% in 0-15 cm soil profile which indicated low to medium fertility of the soil. Vermicompost was prepared at the research farm using distilled waste material of lemongrass. Vermicompost contained 1.95% N, 0.3% P and 0.7% K. The experiment was laid out in a randomized block design

with five treatment combinations replicated four times, namely, T_1 : Control (no fertilizer); T_2 : Vermicompost 10 t ha^{-1}; T_3 : Vermicompost 7.5 t ha^{-1} + 33% Recommended NPK (67 : 17 : 17 kg ha^{-1}) ; T_4 : Vermicompost 5 t ha^{-1} + 50% Recommended NPK (100 : 25 : 25 kg ha^{-1}) and T_5 : 100% Recommended NPK (200 : 50 : 50 kg ha^{-1}) (Table 1). Forty five day old rooted geranium cuttings (cv. Bourbon) were planted at inter and intra row spacing of 45 cm on 24 December 2004 and 18 December 2005, accommodating 45,000 plants ha^{-1}. The individual plot size was 12.96 m^2. Whole quantity of vermicompost and full dose of P_2O_5 and K_2O of inorganic fertilizers were applied before planting as basal dose. Nitrogen was applied in six equal splits at 60 days interval in the form of urea and P and K were applied in the form of single super phosphate and muriate of potash, respectively. The crop was irrigated by flood method of irrigation with 3 cm depth of water once in a week. The crop was harvested twice during first (June and October 2005) and second year (June and November 2006) by hand sickle leaving 20 cm above the ground level. Data on plant height, plant canopy and fresh herbage yield above the ground level were recorded at the time of harvest and moisture was determined by drying the samples at 80°C in an oven. Dry matter yields were calculated from fresh herbage yields and moisture content within. Dried samples were powdered for determination of N, P and K.

Table 1. Treatment combinations and applied nutrient levels under different treatments in geranium

Treatment	Fertilizer (kg ha^{-1})			Vermicompost (t ha^{-1})	Total applied nutrients (kg ha^{-1})		
	N	P	K		N	P	K
T_1 : Control	-	-	-	-	-	-	-
T_2 : Vermicompost	-	-	-	10	195.0	30.0	70.0
T_3 : Vermicompost + NPK	67	17	17	7.5	213.3	39.5	69.6
T_4 : Vermicompost + NPK	100	25	25	5.0	197.5	47.5	60.0
T_5 : NPK	200	50	50	-	200.0	50.0	50.0

Oil concentration (%) in fresh herbage was estimated by hydro distillation method using Clevenger's apparatus (Clevenger 1928). Moisture in oil samples were removed by adding sodium sulphate anhydrous 2%. The essential oil yield was computed by multiplying the oil concentration (%) with that of herbage yield and expressed in kg ha^{-1}.

The quality of the essential oil was determined by GC on a Perkin Elmer 8500 Gas Chromatograph fitted with Flame Ionization Detector (FID) and an electronic integration, using a 25 m x 0.25 mm BP-1 fused silicon column. The column was heated in an oven from 120°C to 230°C at 5°C min^{-1}. Injector and detector were kept at 250°C and 300°C, respectively. The peaks of different chemical constituents were identified by their retention times as previously determined with pure chemicals as standards.

Nitrogen in above ground plant samples was determined by indophenol-blue method (Novozamsky *et al.* 1974). Phosphorus was determined as described by John (1970) and potassium by flame photometric method described by Jackson (1958). Uptake values were calculated from the dry matter yields above ground and concentration of nutrients in them. After carrying out Bartlett's test of homogeneity of variance, data of two years was pooled. Statistical analysis of data was performed by following the procedure depicted in Panse & Sukhatme (1978).

Results and discussion

Plant growth, herbage and oil yield

Application of NPK fertilizer and

vermicompost separately and in combination significantly increased plant height, plant canopy, herbage (fresh weight), and essential oil yield over control (no vermicompost or fertilizer). Application of vermicompost 5 t ha^{-1} + 50% recommended NPK (100 : 25 : 25 kg ha^{-1}) significantly increased plant height compared with other treatments in first and second harvests. Plant height increased in first harvest by 10.6%, 12.6% and 23.0% over control (no fertilizer) in T_2, T_3 and T_4, respectively. Similarly, plant height increased in second harvest also (13.7%, 15.8% and 27.0%) and plant canopy (spread of plant) significantly increased in T_4 compared with T_1 (14.5%, 14.5% and 32.1%) beyond that there was no effect of fertilizer application. A similar pattern was noticed in second harvest also (6.7%, 48.5% and 74.8% increase over control T_1) (Table 2).

Fresh herbage yield increased significantly in T_5 (full dose of NPK - 200 : 50 : 50 kg ha^{-1}) compared with T_2 and T_1 in first harvest and T_4 gave significantly higher yield than T_3, T_2 and T_1 (control) in second harvest but there was no difference between T_4 and T_5. A similar trend was noticed in total herbage yield of geranium. In addition, mean fresh herbage yield with full NPK was significantly higher than full dose of vermicompost. However, combined application of vermicompost + 50% recommended NPK resulted in significantly higher herb yield than the organic source applied alone. Similar results were reported by Patra *et al.* (2000) and Chand *et al.* (2001) in menthol mint (*Mentha arvensis* L.). A similar trend was observed with respect to essential oil yield (Table 2). Treatment T_4 (vermicompost 5 t ha^{-1} + 50% recommended NPK-(100 : 25 : 250 kg ha^{-1}) gave significantly higher oil yield than T_3, T_2 and T_1 and was on par with T_5. The highest increase in essential oil yield was observed with application of full fertilizer NPK dose (146.1%) followed by vermicompost 5 t ha^{-1} + 50% recommended NPK (114.3%) which did not differ significantly (Table 2).

Oil content and quality

Content and quality of oil were not influenced by vermicompost and inorganic fertilizers. However, geranium oil had 21.3% to 24.3% citronellol, 22.8% to 29.5% geraniol, 6.5% to 7.0% isomenthone, 3.7% to 4.2% citronellyl formate, 6.3% to 7.0% linalool and 4.4% to 5.7% 10-epi-γ-eudesmol in various treatments which is accepted in international trade (Tables 2 & 3).

Nutrient uptake

Uptake of major nutrients by the plant was

Table 2. Effect of vermicompost and inorganic fertilizers (NPK) on growth, fresh herbage, oil content and essential oil yield of geranium (pooled data of 2 years)

Treatment	Plant height (cm)		Plant canopy (m^2 $plant^{-1}$)		Fresh herbage yield (t ha^{-1})			Essential oil yield (kg ha^{-1})			Oil content (%)	
	Harvest		Harvest		Harvest			Harvest			Harvest	
	First	Second	First	Second	First	Second	Total	First	Second	Total	First	Second
T_1	43.5	42.3	0.165	0.163	5.27	2.88	8.15	12.71	7.34	20.05	0.24	0.26
T_2	48.1	48.1	0.189	0.174	6.36	3.49	9.85	15.85	9.37	25.22	0.25	0.27
T_3	49.0	49.0	0.189	0.242	8.59	4.87	13.46	18.09	13.12	31.21	0.22	0.27
T_4	53.5	53.7	0.218	0.285	8.53	7.57	16.10	20.70	22.23	42.93	0.24	0.28
T_5	51.4	51.6	0.223	0.282	10.22	8.66	18.88	23.36	25.98	49.34	0.23	0.29
CD (P=0.05)	3.2	3.1	0.019	0.018	3.48	1.37	3.86	8.85	4.80	11.45	NS	NS

T_1=Control (no fertilizer); T_2=Vermicompost 10 t ha^{-1}; T_3=Vermicompost 7.5 t ha^{-1} + 33% Recommended NPK (67 : 17 : 17 kg ha^{-1}); T_4=Vermicompost 5 t ha^{-1} + 50% Recommended NPK (100 : 25 : 25 kg ha-1); T_5=100% Recommended NPK (200 : 50 : 50 kg ha^{-1})

significantly influenced by various treatments (Table 4). Highest N uptake was recorded with T_5 (93.83 kg ha^{-1}) followed by T_4 (75.55 kg ha^{-1}) which were 214.3% and 153.1% higher than control (T_1), respectively. Increase in N uptake with T_2 and T_3 were 32.0% and 89.3%, respectively over control (T_1). A similar trend was observed with respect to P uptake by the plants. Increase in P uptake with vermicompost 10 t ha^{-1} (T_2) and vermicompost 5 t ha^{-1} + 50% recommended NPK (T_4) were 31.5% and 115.2%, respectively over control. The order of K uptake was $T_5 > T_4 > T_3 > T_2 > T_1$. The highest uptake of NPK under different combinations was due to combined influence of higher nutrient concentration and yield under those treatments.

The study indicated that combined application of vermicompost 5 t ha^{-1} + 50% recommended NPK (100 : 25 : 25 kg ha^{-1}) in geranium produced optimum fresh herbage and essential oil yield (16.10 t ha^{-1} and 42.93 kg ha^{-1}, respectively) compared with control which was on par with full dose of NPK fertilizer 200 : 50 : 50 kg ha^{-1} under semi-arid tropical condition of Bengaluru which indicated that 50% inorganic fertilizers can be replaced with organic fertilizer (vermicompost) without affecting the yield and oil quality of geranium.

Table 3. Influence of vermicompost and inorganic fertilizers (NPK) on oil quality of geranium (pooled data of 2 years)

Treatment	Oil composition (%)						
	Geraniol (%)	Citronellol (%)	Isomenthone (%)	Linalool (%)	10-epi-γ-eudesmol (%)	Geranyl formate (%)	Citronellol formate (%)
T_1	23.2	22.9	6.7	6.3	4.4	4.0	4.0
T_2	25.9	21.7	6.5	6.3	5.7	4.1	4.1
T_3	26.2	21.8	6.8	6.3	5.4	4.2	4.1
T_4	22.8	23.1	6.9	6.6	5.2	4.1	4.1
T_5	25.3	21.3	7.0	6.9	5.4	4.0	4.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

T_1=Control (no fertilizer); T_2=Vermicompost 10 t ha^{-1}; T_3=Vermicompost 7.5 t ha^{-1} + 33% Recommended NPK (67 : 17 : 17 kg ha^{-1}); T_4=Vermicompost 5 t ha^{-1} + 50% Recommended NPK (100 : 25 : 25 kg ha-1); T_5=100% Recommended NPK (200 : 50 : 50 kg ha^{-1})

Table 4. Effect of vermicompost and inorganic fertilizers (NPK) on nitrogen, phosphorus and potassium content and total uptake in geranium (pooled data of 2 years)

Treatment	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)	Total nitrogen uptake (kg ha^{-1})	Total phosphorus uptake (kg ha^{-1})	Total potassium uptake (kg ha^{-1})
T_1	1.85	0.11	0.63	29.85	1.78	10.17
T_2	2.02	0.12	0.61	39.40	2.34	11.90
T_3	2.12	0.15	0.65	56.50	4.00	17.32
T_4	2.37	0.12	0.61	75.55	3.83	19.45
T_5	2.51	0.15	0.66	93.83	5.61	24.67
CD (P=0.05)	0.24	NS	NS	8.72	1.15	4.63

T_1=Control (no fertilizer); T_2=Vermicompost 10 t ha^{-1}; T_3=Vermicompost 7.5 t ha^{-1} + 33% Recommended NPK (67 : 17 : 17 kg ha^{-1}); T_4=Vermicompost 5 t ha^{-1} + 50% Recommended NPK (100 : 25 : 25 kg ha-1); T_5=100% Recommended NPK (200 : 50 : 50 kg ha^{-1})

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