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Impact of fertigation on growth, yield and economic returns in rose scented geranium (*Pelargonium graveolens* L.)

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Abstract

A field experiment was conducted to determine the optimal fertigation in rose scented geranium during Rabi season of 2023-24. Experiment comprised of 6 fertigation level (50, 75, 100, 125, 150% of RDF and conventional method of fertilizer application). Experiment had a RCBD design, with five replications. Fertigation at 100% of RDF (T_2) resulted in significantly higher fresh herbage yield (22.58 and 18.31 t/ha) and essential oil yield (27.09 and 20.14 kg/ha), net return (Rs 1,46,524.10 and Rs 1,17,333.00) and return per rupee of expenditure (2.32 and 2.58) at main crop and first ratoon crop, respectively than other treatment.

Keywords: Fertigation, fresh herbage yield, essential oil and net returns

Introduction

Pelargonium graveolens, an evergreen shrub with woody basal branches, is technically a perennial but often treated as an annual due to its high aromatic qualities. It typically grows to heights of approximately 4.9 feet (1.5 m) with a spread of about 3.3 feet (1 m). China and Egypt lead global production and export of rose scented geranium oil, with a combined output exceeding 641.38 US tons annually. In contrast, India produces only 20 tons per year, a fraction of the global demand estimated at over 600 tons. Currently, production occurs on a small scale across North Indian states such as Uttar Pradesh, Uttarakhand and Himachal Pradesh, as well as in South Indian states including Andhra Pradesh, Karnataka and Tamil Nadu (Kulkarni *et al.*, 1997) [10].

In the family of rose scented geranium varieties, while historical roots suggest hundreds of types, the essential oil market primarily recognizes two main types: "Egyptian" and "Bourbon." Each type offers distinct scents and therapeutic benefits. Notably, M/S SH Kelkar and Co. in Mumbai has introduced a new cultivar known as Kelkar/Egyptian, cultivated on a small scale.

In India, drip irrigation holds immense potential, estimated at 35,340 hectares (Annual report 2022-23, Department of Horticulture, KSDH). This method has proven superior to traditional irrigation techniques due to its ability to deliver water and nutrients directly to the plant root zone. Moreover, drip irrigation systems facilitate fertigation, the simultaneous application of fertilizers and irrigation water. Today, fertigation is gaining popularity worldwide with over 75% of the drip irrigated area being fertilized through this method.

Fertigation is the practice of delivering dissolved fertilizers directly through an irrigation system, offering considerable benefits for agricultural productivity. The productivity gains from fertigation can vary widely across different vegetable crops, typically ranging from 20% to 80%. These improvements are largely due to the precise application of nutrients to the plant root zone at critical growth stages, which contrasts with the more significant nutrient losses (40-45%) typically seen in traditional fertilization methods. In addition to boosting crop productivity, fertigation contributes to environmental sustainability by reducing fertilizer losses. This method enables a reduction in fertilizer use by 25-50% while maintaining or even increasing nutrient efficiency.

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This reduction not only lowers production costs but also minimizes the environmental impact, particularly by decreasing nutrient runoff into water bodies. In summary, the adoption of fertigation is a crucial step toward more efficient and sustainable agricultural practices, benefiting both farmers through cost savings and improved crop yields, as well as the environment by reducing pollution and resource waste. (Sathya *et al.*, 2017) [9]. Hence, present study is taken up with the objective to estimate the effect of fertigation on economics of herbage and oil yield.

Materials and Methods

The present experiment was conducted during Rabi season of 2023-23 at The Department of PSMA field research block in Kittur Rani Channamma College of Horticulture, Arabhavi (16° 15' North latitude and 94° 45' East longitude) in University of Horticultural Sciences, Bagalkot, Karnataka, India. Rose scented geranium variety i.e. Kelkar was selected for the experiment and cuttings were prepared in August. 30 days old rooted cuttings were planted at spacing 1.2 m x 0.6m in experiment plot. The experiment consists of 6 treatments with 5 replication was Randomized Complete Block Design (RCBD). Fertigation commenced in the second week after transplanting and continued for four months for the main crop in weekly interval. For the ratoon crop, it started in the first week after the main crop harvest and lasted three months, utilizing only nitrogen fertilizer. In the main crop, a full dose of phosphorus and potassium was applied as a basal dose. Water-soluble fertilizers, including Urea, 12:61:0 (MAP) and 0:0:50 (SOP), were used for fertigation, administered at weekly intervals. Additionally, farmyard manure (FYM) was applied at a rate of 10 tonnes per hectare, ensuring even distribution and thorough mixing across all plots. This integrated nutrient management approach optimized nutrient availability and enhanced overall plant growth. The treatments details were,

T₁: RDF (210:35:35 kg/ha) was given through conventional method of fertilizer application

T₂: 100% RDF (210:35:35 kg/ha) through fertigation

T₃: 50% RDF (105:17.5:17.5 kg/ha) through fertigation

T₄: 75% RDF (157.5:26.5:26.5 kg/ha) through fertigation

T₅: 125% RDF (262.5:43.75:43.75 kg/ha) through fertigation

T₆: 150% RDF (315:52.5:52.5 kg/ha) through fertigation

Cultural practices

After transplanting the crop was watered immediately. Daily irrigation was provided for a month post-transplantation. Subsequently, irrigation frequency reduced to once a week, contingent upon soil moisture levels. Drip irrigation was

employed for watering. Gaps between seedlings of identical age were filled 15 days post-transplanting. Hand weeding was undertaken to maintain weed-free plots at 30, 60 and 90 days post-transplantation for main crops and immediately after and 60 days later for ratoon crops.

Harvesting of crop

Harvesting was carried out manually during the morning hours on sunny days, typically 4 to 5 months after transplanting, depending on the growth of the foliage. The ideal time for harvest was marked by the appearance of sparse flowering, the yellowing of the basal leaves and a noticeable change in aroma from a lemon-like scent to a more rose-like fragrance. When the leaves were gently pressed between the fingers, they released a delicate rosy aroma. To harvest, the portion of the plant about 15 to 20 cm above the ground was carefully cut, including both the young, tender branches and leaves, using secateurs or a sharp sickle.

Distillation of herb

To reduce the moisture content, fresh geranium herbage samples were partially dried under shaded conditions. The herbs were left to wilt or partially dry overnight in the shade. The essential oil was then extracted using the steam distillation method. Any remaining trace amounts of water in the oil were removed by adding anhydrous sodium sulphate. The percentage of essential oil was calculated using a specific formula.

$$\text{Essential oil content (\%)} = \frac{\text{Final weight of essential oil in bottle (g)} - \text{Initial empty bottle weight (g)}}{\text{Weight of wilted herbage (g)}} \times 100$$

Results and Discussion

Growth

In this experiment maximum plant height was recorded in T₂:100% of RDF at main crop and first ratoon harvest (82.25 and 80.23 cm), number of leaves per plant (1564.00 and 1110.23), number of branches per plant (51.50 and 35.26) as presented in table 1. This is due to fertigation releasing the nutrients at active root zone of the plant which increases maximum nutrient uptake. Taller plants typically exhibit more leaves, branches and an expanded plant spread which is crucial for maximizing photosynthesis. This is due to fertigation releasing the nutrients at active root zone of the plant which increases maximum nutrient uptake. Similar results were mentioned by Akash *et al.* (2023) [7] in fennel, Zehra *et al.* (2014) [8] in Gerbera and Behera *et al.* (2014) [1] in mint.

Table 1: Effect of different doses of fertigation on plant height, number of leaves and number of branches at harvest in rose scented geranium (*Pelargonium graveolens*)

Treatment	Plant Height (Cm)		Number of Leaves Per Plant		Number of Branches Per Plant	
	Main crop harvest	First ratoon harvest	Main crop harvest	First ratoon harvest	Main crop harvest	First ratoon harvest
T ₁ (RDF-(210:35:35 kg/ha) Conventional method)	75.34	65.21	1050.10	675.23	31.44	25.36
T ₂ (100% of RDF (210:35:35 kg/ha))	82.25	80.23	1564.00	1110.23	51.50	35.26
T ₃ (50% of RDF (105:17.5:17.5 kg/ha))	69.32	55.23	1010.24	875.23	41.12	28.56
T ₄ (75% of RDF (157.5:26.5:26.5 kg/ha))	80.12	80.10	1390.00	1012.23	48.48	34.25
T ₅ (125% of RDF(262.5:43.7:43.7kg/ha))	74.25	68.23	950.46	745.26	43.90	30.25
T ₆ (150% of RDF (315:52.5:52.5 kg/ha))	75.60	64.23	936.00	735.36	43.54	30.01
Mean	76.09	68.86	1150.24	860.14	44.99	30.37
S.E.M±	0.92	0.23	5.24	2.14	0.82	0.27
C.D. @ 5%	2.72	0.69	1.54	6.15	2.43	0.82

Table 2: Effect of different doses of fertigation on yield parameters at main and first ratoon harvest of rose scented geranium (*Pelargonium graveolens*)

Treatment	Yield Per Hectare (T)		Essential Oil Content (%)		Essential Oil Yield (Kg/Ha)	
	Main crop	First ratoon crop	Main crop	First ratoon crop	Main crop	First ratoon crop
T ₁ (RDF-(210:35:35 kg/ha) Conventional method)	19.65	15.32	0.08	0.08	15.72	12.25
T ₂ (100% of RDF (210:35:35 kg/ha))	22.58	18.31	0.12	0.11	27.09	20.14
T ₃ (50% of RDF (105:17.5:17.5 kg/ha))	14.84	12.21	0.09	0.08	13.35	9.76
T ₄ (75% of RDF (157.5:26.5:26.5 kg/ha))	20.16	15.64	0.11	0.11	22.17	17.20
T ₅ (125% of RDF (262.5:43.7:43.7kg/ha))	16.91	12.35	0.09	0.09	15.21	11.11
T ₆ (150% of RDF (315:52.5:52.5 kg/ha))	16.81	11.98	0.09	0.09	15.12	10.78
Mean	18.47	14.30	0.10	0.10	18.11	13.54
S.E.M ±	0.09	0.07	0.01	0.01	0.07	0.05
C.D. @ 5%	0.29	0.22	0.03	0.03	0.21	0.17

Likewise, due to the effect of different fertigation doses significantly maximum fresh herbage yield per hectare (22.58 and 18.31) at main and first ratoon crop were recorded in T₂: 100% of RDF as presented in Table 2. Yield increased due to better water utilization and uptake of nutrients and an excellent soil-water air relationship with higher oxygen concentration in root zone. Another reason might also be due to the optimum moisture conditions in the entire root zone. A higher yield per hectare may result from increasing the fresh weight of individual plants particularly in crops produced for their above ground

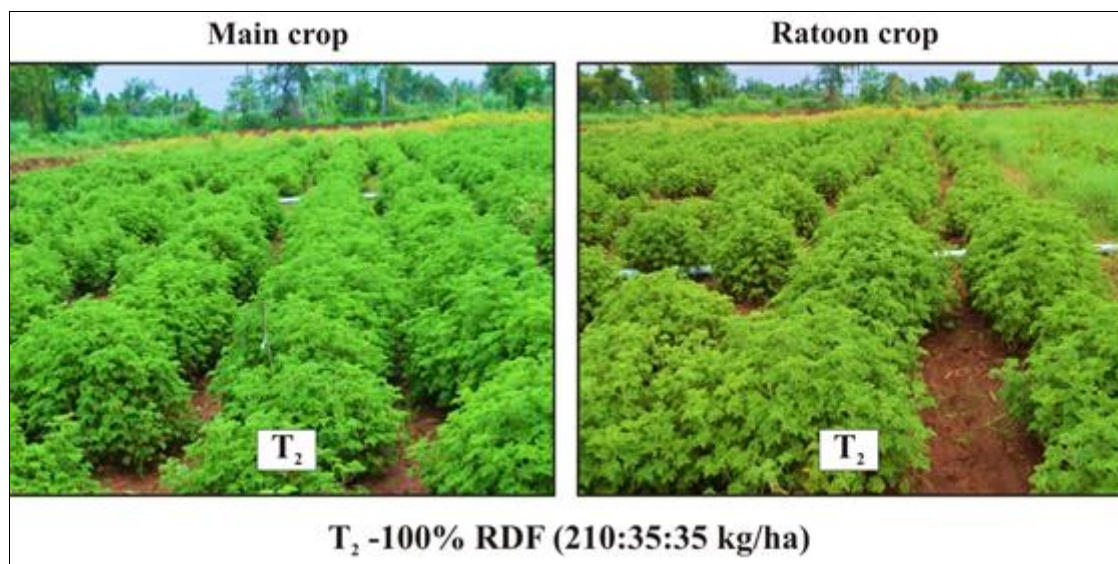
biomass i.e. economic part of rose scented geranium is above ground portion. Moti *et al.* (2020) [6] and Bairwa and Bhunia (2023) [5] both supported these findings.

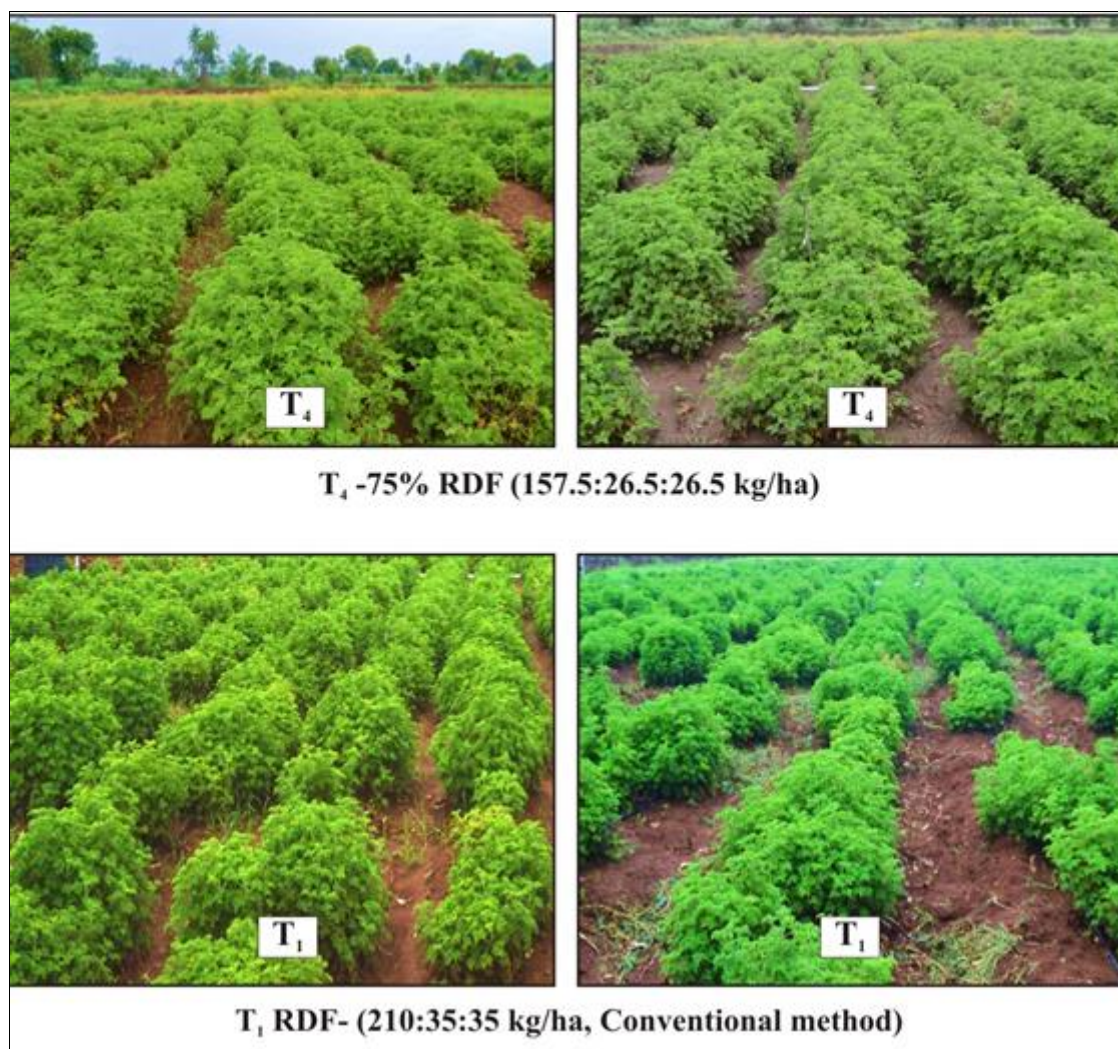
The yield obtained under different fertigation treatments are presented in table 2. From this, it is clear that maximum essential oil yield was obtained in T₂: 100% of RDF (27.09 and 20.14 kg/ha) which was followed by T₄: 75% of RDF (22.17 and 17.20 kg/ha) at main crop and first ratoon harvest. Average essential oil yield under conventional method of fertilizer application (T₁) was 15.72 and 12.25 kg per ha, respectively.

Table 3: Effect of different doses of fertigation on economics of rose scented geranium (*Pelargonium graveolens*)

Treatment	Total Cost of Cultivation (Rs /ha)		Gross Return (Rs /ha)		Net return (Rs /ha)		Return per rupee of expenditure	
	Main crop	First ratoon crop	Main crop	First ratoon crop	Main crop	First ratoon crop	Main crop	First ratoon crop
T ₁ (RDF-(210:35:35 kg/ha) Conventional method)	94287.96	72998.10	149340.00	116375.00	55052.03	43376.9	1.58	1.59
T ₂ (100% of RDF (210:35:35 kg/ha))	110830.90	73997.00	257355.00	191330.00	146524.10	117333.00	2.32	2.58
T ₃ (50% of RDF (105:17.5:17.5 kg/ha))	83972.67	66476.42	126825.00	92720.00	42852.33	26243.58	1.51	1.39
T ₄ (75% of RDF (157.5:26.5:26.5 kg/ha))	102402.36	70673.71	210615.00	163400.00	108212.64	92726.29	2.05	2.31
T ₅ (125% of RDF (262.5:43.7:43.7kg/ha))	109956.04	67394.71	144495.00	105545.00	34538.97	38149.22	1.31	1.56
T ₆ (150% of RDF (315:52.5:52.5 kg/ha))	115486.6	67223.07	143640.00	102410.00	28153.38	35186.93	1.24	1.52

Note—cost of essential oil (2023-2024)-Rs 9500 per kg





The gross returns were computed by multiplying average market rate of rose scented geranium oil during the crop harvesting period with the essential oil yield obtained and for different treatments. Higher gross return was obtained in treatment T₂ (Rs. 2,57,355.00 and Rs. 1,91,330.00) during main crop and first ratoon crop. Maximum net return (Rs. 146524.10 and Rs. 117333.00) and returns per rupee of expenditure (2.32 and 2.58) also obtained in treatment T₂ which was followed by T₄ (2.05 and 2.31) as presented in Table 3. By optimizing nutrient management, fertigation proves to be a viable strategy for rose scented geranium growers, offering higher yields, superior quality of essential oil and increased profitability. It leads to the higher returns per rupee by boosting crop production and net income. Behera *et al.* (2014)^[1] in mint, Shigvan *et al.* (2023)^[4], Vaidehi *et al.* (2017)^[2] and Sanjit and Patra (2015)^[3] observed similar outcomes.

Conclusion

Based on the experiment, it can be concluded that T₂: 100% of RDF (210:35:35 kg/ha) recorded maximum fresh herbage yield (22.58 and 18.31 t/ha) and returns per rupee of expenditure of 2.32 and 2.58, respectively for main and ratoon crop which was performed better over the treatment T₁ (Conventional method of fertilizer application) and helps to increase yield and economic level. Hence, T₂ 100% of RDF will be the best treatment in turn it will be recommended to get higher yield and returns

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