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Divya Yadav
M.Sc. (Ag.), Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Yeman Kumar Dewangan
Principal Scientist, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), India

Deepak Chandrakar
Principal Scientist, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Aaradhana Lakra
Ph.D Scholar, Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Divya Yadav
M.Sc. (Ag.), Department of Agronomy, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Effect of integrated nutrient management practices on growth, oil yield and economics of sweet basil (*Ocimum basilicum* L.)

Divya Yadav, Yeman Kumar Dewangan, Deepak Chandrakar and Aaradhana Lakra

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Abstract
Sweet basil (*Ocimum basilicum* L.) is a popular culinary herb belongs to the family Lamiaceae. Leaf of basil has a pungent and strong taste some Asian basil have a clove like flavour. It is cultivated for religious and traditional medicine purposes, and also for its essential oil. The present investigation on "Effect of integrated nutrient management practices on growth, oil yield and economics of sweet basil (*Ocimum basilicum* L.)" was carried out at the instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) during the *kharif* season of 2023. The experiment was laid out in randomized block design with 3 replications and eight treatment. The experiments results showed that organic manure and inorganic fertilizer along with nano-urea have a significant effect on growth parameter, yield attributes and economics of sweet basil. The treatment application of N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1} + foliar spray of nano-urea @ 4 ml $liter^{-1}$ of water at 30 and 45 DAP was found superior over the other treatment for growth parameter i.e, plant height, number of branches $plant^{-1}$, number of leaves $plant^{-1}$ and number of inflorescences $plant^{-1}$, yield attributes i.e, oil yield (36.98 kg ha^{-1}) and dry herbage yield and economics.

Keywords: Sweet basil, organic manure, inorganic fertilizer, nano-urea, oil yield

Introduction
The aromatic plants belonging to genus *Ocimum* is popularly known as a Basil. The Basil was derived from Greek word "Basilica" which means royal plant. Among the *Ocimum* genus *Ocimum basilicum* is known as sweet basil, French basil occurs in nature as a tetraploid (2n=48). Tulsi is widely grown, sacred plant, it is found growing in environment having moist soil nearly all over the world which is original from its wild form (Vana Tulsi). Ocimum varieties have around 50 to 150 types of spices and bushes from the tropical native of Asia. In India, Basil is cultivated over an area of 25,000 ha and it accounts for annual production of about 250-300 tonnes of oil and the cultivation is mainly concentrated in Uttar Pradesh (Smitha *et al.* 2014) [7] Basil (*Ocimum basilicum* L.), belonging to the Lamiaceae family, is renowned as both an aromatic spice and a medicinal herb. The plant's valuable components include its leaves, oil, and seeds. Fresh and dried basil leaves are widely employed in the food and spice sectors. It is also considered as a source of aroma compounds and thus, possesses a range of biological properties such as insect repellent**,** nematocidal, antibacterial, antifungal agents and antioxidant properties. The Basil is useful in diseases of heart and blood, kapha and vata, leucoderma, etc. The cim saumya variety of tulsi is a local to subtropical Asia. It is a perennial sweet-smelling plant can grow between 30 to 130 cm tall and it is a short duration, dwarf, early flowering variety released from CIMAP, Lucknow in 2003, developed through half sib selection. The major constituents of variety is methyl chavicol 62.54%, linalool 24.61%. The crop was harvested at 90-95 days after planting in a stage when the plant was in full bloom stage and subsequent harvest can be done every 65-75 days. The integrated nutrient management system involves judicious combination of inorganic fertilizers and organic manures in building soil fertility and to improve the production potential of any crop.

Organic manure in comparison of the chemical fertilizers have lower nutrient content and are slow releasing but they are as effective as chemical fertilizers over longer periods of use. Nano-fertilizers are nutritional fertilizers made up of nanostructured particles that can be applied to plants, and these smart fertilizers have a high plant uptake efficiency (PUE), allowing for effective uptake or gradual release of active compounds. Nano structured materials have a single unit size that ranges from 1 to 100 nm, which is smaller than the size of bulk particles. Using nano-fertilizer significantly increased basil essential oil production. The rigorous management of fertilizer must try to ensure both an improved and safe guarded environment; so, a blanced fertilization strategy that combines the use of chemical, organic manure, inorganic fertilizer and nano- urea must be evaluated. In this context, the present study aimed to show the effect of integrated nutrient management practice on growth dynamics of tulsi (*Ocimum basilicum* L.)

Material and Methods

The field experiment was carried out at instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *kharif* 2023.The experiment was laid out in randomized block design with three replications and eight treatment i.e, T_1: Control, T_2: N, P_2O_5, K_2O @ 100: 40: 40 kg ha^{-1}, T_3: FYM @ 15 ton ha^{-1}, T_4: N, P_2O_5, K_2O @ 75:30:30 kg ha^{-1}+ FYM @ 3.75 ton ha^{-1}, T_5: N, P_2O_5, K_2O @ 50: 20: 20 kg ha^{-1}+ FYM @ 7.5 ton ha^{-1}, T_6: N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1}, T_7: T_5+ foliar spray of nano urea @ 2 ml liter^{-1} of water of water at 30 and 45 DAP, T_8: T_6+ foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP. The uniform and healthy seedlings of tulsi plants were selected and taken from nursery in last week of July for transplanting in different plots the transplanting of crop was started from 24th August 2023 onwards. The spacing of plant to plant was kept 30 cm x 30 cm. The 1st cutting of tulsi crop was done on 24th November 2023 for the oil extraction of tulsi and 2nd cutting was done on 31st January 2024 for the herbage yield of tulsi. Under growth parameters, plant height (cm), number of leaves plant $^{-1}$, were recorded at 20, 40, 60, 80, 90, and 145 DAP. Yield attributing characters viz. herbage yield, oil yield and economics were determined. The data were statistically analyzed for various characters as described by Gomez and Gomez (1984) [4].

Result and Discussion

Plant height (cm)

The data pertaining to the plant height of sweet basil as influenced by different treatment at 20, 40, 60, 80 DAP, 1st harvesting and 2nd harvesting stage of tulsi were presented in Table 4.1. The plant height was differed significantly with various treatment and increased with advancement of crop stages. The highest plant height was observed in treatment T8 (N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1} foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP) followed by T_7 (N, P_2O_5,K_2O @ 50: 20: 20 ha^{-1} + FYM 11.25 ton ha^{-1}+ foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP), and lowest plant height was obtained in T_1 (control). The increased plant height may be due to the increased beneficiary effect of FYM, along with inorganic fertilizers might have increased the absorption of nutrients which in turn resulted in significant increment in plant height. The elongation and improving of plant height may be due to the role of organic fertilizers by enhancing the cell division rate and cell enlargement. Additionally, the positive effect of combination nano urea on plant height can be derived from providing equilibrium plant nutrients and imposed a direct effect on number of nodes and inter nodal length that finally lead to increasing plant height. The results are in accordance with Al-Mansour *et al.* (2017) [2], Roghaye *et al.* (2012) [8] in basil crop.

Number of leaves plant^{-1}

The data presented in Table 1. revealed that the mean number of leaves plant^{-1} was found to be significantly with the treatment. At 20 DAP, highest number of leaves plant $^{-1}$ was observed in the application of N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1} foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP (T_8) which was at par with T_7 (N, P_2O_5, K_2O @ 50: 20: 20 kg ha^{-1}+ FYM @ 7.5 ton ha-1+ foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP) and T_2 (NP_2O_5, K_2O @ 100: 40: 40 kg ha^{-1}) and found significantly superior over rest of the treatment. Similarly, except at 145 DAP is not at par with T_7 and T_8 and at 40, 60,80 DAP, 1st and 2nd cutting stage of tulsi, application of N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1} foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP, which was at par with T_7 (N, P_2O_5, K_2O @ 50: 20: 20 kg ha^{-1}+ FYM @ 7.5 ton ha-1+ foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP) and T_2 (N, P_2O_5, K_2O @ 100: 40: 40 kg ha^{-1}) and significantly superior over rest of the treatments. These findings confirmed with the findings of Alhasan (2020) [1] and Rahman *et al.* (2014) [5].

Yield attributes

Dry herbage yield (q ha^{-1})

It is evident from the observations recorded on dry herbage yield (q ha^{-1}) of sweet basil have been presented in Table 2. The analysis revealed a notable disparity among the treatments concerning the dry herb yield (q ha^{-1}). Treatment T_8, consisting of N, P_2O_5, K_2O at 25:10:10 kg ha^{-1} + FYM at 11.25 ton ha^{-1} + foliar spray of nano urea at 4 ml liter-1 of water at 30 and 45 DAP, achieved the highest dry herbage yield at (28.65 q ha^{-1}). This was closely followed by T_7, which attained a yield of 24.98 q ha^{-1}. Both treatments significantly performed the remaining treatments. In contrast, the lowest dry herb yield of (10.29 q ha^{-1}) was observed in T_1 (Control), which did not receive any manures or fertilizers. This may be due to the increased dosage of beneficiary effect, FYM and nano-urea along with inorganic fertilizers increased the absorption of nutrients. Similar results were reported by Singh *et al*., (2014) [6], Al-Mansour *et al.*, (2017) [2].

Oil yield (kg ha^{-1})

The detailed scrutiny of Table 2. revealed that the oil yield kg ha^{-1} was significantly influenced due to different integrated nutrient management. The maximum oil yield 36.98 kg ha^{-1} was recorded in the treatment T_8 (N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1} foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP, which was statistically at par with T_7 (N, P_2O_5, K_2O @ 50: 20: 20 kg ha^{-1}+ FYM @ 7.5 ton ha^{-1} + foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP) and T_2 (N, P_2O_5, K_2O @ 100: 40: 40 kg ha^{-1}) is not at par, it is inferior to T_8 and T_7, while the minimum oil yield (17.51 kg ha^{-1}) was recorded in T_1 (control) Similar result supports. It is demonstrated that using vermicompost and compost increase the relative content of linalool and methyl chavicol in basil (*Ocimum basilium* L.) (Anwar *et al*., 2012) [3].

Table 1: Plant height (cm) and number of leaves plant^{-1} of tulsi as influenced by various integrated nutrient management practices at various stage of crop

Treatments	Plant height (cm)						Number of leaves plant^{-1}					
	20 DAP	40 DAP	60 DAP	80 DAP	90 DAP	145 DAP	20 DAP	40 DAP	60 DAP	80 DAP	90 DAP	145 DAP
T_1: Control	17.82	27.15	35.30	51.73	69.41	79.75	19.13	50.55	178.73	323.90	441.93	625.27
T_2: N, P_2O_5, K_2O @ 100: 40:40 kg ha^{-1}	25.67	35.97	49.02	65.44	79.02	88.17	35.72	71.95	273.02	520.17	662.43	872.75
T_3: FYM @ 15 ton ha^{-1}	20.45	30.97	43.39	56.11	73.95	80.75	24.01	53.61	192.73	370.53	473.02	673.02
T_4: N, P_2O_5, K_2O @ 75:30:30 kg ha^{-1}+ FYM @ 3.75 ton ha^{-1}	23.79	33.36	46.72	62.56	77.85	84.24	31.17	65.93	257.33	423.60	634.40	834.40
T_5 : N, P_2O_5, K_2O @ 50: 20: 20 kg ha^{-1}+ FYM @ 7.5 ton ha^{-1}	22.76	32.97	45.54	58.48	76.44	83.69	27.67	56.53	225.67	420.80	526.20	776.20
T_6: N, P_2O_5, K_2O @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1}	21.29	31.55	44.10	57.49	75.44	82.71	26.05	54.00	198.03	419.61	519.61	722.61
T_7: T_5+ foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP.	26.13	36.56	50.49	66.27	81.64	92.31	36.52	74.33	274.81	533.45	677.53	898.87
T_8: T_6+ foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP	27.26	37.58	51.90	68.79	83.31	93.49	37.21	75.53	277.47	549.50	693.67	911.27
SEm±	0.62	0.64	0.98	1.31	1.68	1.89	0.51	1.24	1.51	9.77	10.93	11.78
CD(P= 0.05)	1.87	1.94	2.97	3.43	5.09	5.74	1.55	3.75	4.59	29.62	33.14	35.78

Table 2: Herbage yield (q ha^{-1}), oil yield (kg ha^{-1}) and economics of tulsi as influenced by various integrated nutrient management practices at various stage of crop.

Treatment	Herbage yield (q ha^{-1})	Oil yield (kgha^{-1})	Net returns (Rs ha^{-1})	Benefit cost ratio (B:C)
T_1: Control	10.29	17.52	33374	1.85
T_2: N, P_2O_5, K_2O @ 100:40:40 kg ha^{-1}	21.05	31.3	87604	2.92
T_3: FYM @ 15 ton ha^{-1}	18.09	23.98	53844	1.87
T_4: N, P_2O_5, K_2O @ 75:30:30 kg ha^{-1}+ FYM @ 3.75 ton ha^{-1}	20.52	26.11	79654	2.61
T_5: N, P_2O_5, K_2O @ 50: 20:20 kg ha^{-1}+ FYM @ 7.5 ton ha^{-1}	19.88	25.06	71046	2.32
T_6: N, P_2O_5, K2 @ 25:10:10 kg ha^{-1} + FYM @ 11.25 ton ha^{-1}	18.50	24.88	59721	2.01
T_7: T5+ foliar spray of nano urea @ 2 ml liter^{-1} of water at 30 and 45 DAP.	24.98	32.51	104421	2.93
T_8: T6+ foliar spray of nano urea @ 4 ml liter^{-1} of water at 30 and 45 DAP.	28.65	36.98	121432	3.03
SEm±	0.46	1.62		
CD(P= 0.05)	1.41	4.92		

Economics

Net return (Rs ha^{-1})

The data on Net return (Rs ha^{-1}) were given in table 2. The treatment T_8 (T_6+ foliar spray of nano urea @ 4 ml liter^{-1} at 30 and 45 DAP) had given the maximum net return Rs. 121432 ha^{-1}, followed by T_7 (T_5+ foliar spray of nano urea @ 2 ml liter^{-1} at 30 and 45 DAP) i.e. Rs. 104421 ha^{-1}.

B:C ratio

The data on benefit cost ratio were given in table 2. The B: C ratio showed the best value with the treatment T_8 (T_6 + foliar spray of nano urea @ 4ml^{-1} at 30 and 45 DAP) which is (3.03), and minimum B:C ratio (1.85) obtain in T_1 (control). Adoption of a balanced fertilization is the way of enhancing productivity and economic profitability of basil.

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