E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 422-424
Received: 17-09-2025
Accepted: 19-10-2025

Parth Naval Hatiskar
M.Sc. (Hort) Plantation, Spices, Medicinal and Aromatic Crops College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

SB Thorat
Assistant Professor, College of Horticulture, Dapoli Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

PC Mali
Professor (CAS) and Head of Department of Fruit Science, College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

NA Meshram
Scientist, (Asst. Prof. of SSAC), AICRP on Agroforestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

YS Saitwal
Assistant Professor, College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Prafulla A Wakade
M. Sc. (Hort) Floriculture and landscaping

Mayuresh Ajit Palav
Ph. D. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops, Dr. B. S. K. K. V. Dapoli, Maharashtra, India

Vishal Jagdish Kelaskar
Ph. D. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops, Dr. B. S. K. K. V. Dapoli, Maharashtra, India

Shephali Satish Surve
Ph. D. (Hort.) Plantation, Spices, Medicinal and Aromatic Crops, Dr. B. S. K. K. V. Dapoli, Maharashtra, India

Corresponding Author:
Parth Naval Hatiskar
M. Sc. (Hort) Plantation, Spices, Medicinal and Aromatic Crops College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Response of Ginger (*Zingiber officinale* Rosc.) cv. IISR Mahima to varying fertilizer doses for growth and yield parameters

Parth Naval Hatiskar, SB Thorat, PC Mali, NA Meshram, YS Saitwal, Prafulla A Wakade, Mayuresh Ajit Palav, Vishal Jagdish Kelaskar and Shephali Satish Surve

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i11f.4203

Abstract
The application of 125:50:100 kg NPK/ha (T_9) resulted in the most superior growth and yield performance of ginger (*Zingiber officinale* Rosc.) cv. IISR Mahima. This treatment significantly enhanced vegetative traits such as plant height, number of leaves and tillers and plant spread, while also producing the highest rhizome yield with respect to number, length, girth, weight of primary and secondary rhizomes, and yield per plant. Therefore, (125:50:100 kg NPK/ha) T_9 was identified as the optimum fertilizer dose for maximizing both vegetative growth and productivity in ginger.

Keywords: Integrated Farming System, farm productivity, crop-livestock integration

Introduction
Ginger (*Zingiber officinale* Rosc.) is an important spice crop in India and belongs to the family Zingiberaceae. It is a herbaceous perennial native to tropical Asia and is widely cultivated in tropical and subtropical regions for its aromatic and pungent rhizome. The rhizome is nutritionally rich, containing proteins (2-3%), fats (0.9%), minerals (1.2%), carbohydrates (12.3%) and fibers (2.4%), and serves as a good source of calcium, phosphorus, iron and vitamins (Vadivel *et al*., 2006) [6]. The characteristic pungency of ginger is primarily attributed to gingerol (23-25%) and shogaol (18-19%), while α-zingiberene is the major constituent of its essential oil (Swaminathan, 1974) [4]. Owing to its nutritional, medicinal and industrial importance, ginger holds a significant place in the spice economy both in India and globally.
In Maharashtra, large-scale ginger cultivation is predominantly practiced in the districts of Satara, Sangli, Pune and Kolhapur, whereas in the Konkan region, particularly in Ratnagiri and Sindhudurg, it is grown mainly on a small scale for household consumption (Yadav, 2009) [9]. However, the favorable agro-climatic conditions of the Konkan region provide significant potential for expanding ginger cultivation. This expansion could support crop diversification and enhance farmers' income and regional agricultural sustainability.
Ginger is a nutrient demanding and economically important crop that requires adequate fertilization to achieve optimal productivity. An adequate supply of nitrogen (N) is essential for optimal plant growth, as it is a key component of nucleic acids, proteins, chlorophyll and amino acids, thereby promoting vigorous vegetative development. It also enhances the deep green colouration of foliage and improves the uptake and utilization of other essential nutrients such as phosphorus (P) and potassium (K) (Nayak *et al.*, 2020) [1]. Phosphorus is essential for energy release through carbohydrate metabolism, nucleoprotein synthesis, and cell division, while also promoting early and vigorous root development (Nayak *et al*., 2020) [1]. Potassium regulates stomatal function and osmotic balance, enhances resistance to abiotic and biotic stresses, improves nitrogen use efficiency and protein synthesis, thereby contributing to larger rhizome development, higher yield and increased oleoresin content in ginger (Nayak *et al*., 2020) [1].

Materials and Methods

A field trial was undertaken in the Kharif season at Nursery No. 4, College of Horticulture, Dapoli to investigate the response of ginger (*Zingiber officinale* Rosc.) cv. Mahima to varying fertilizer levels. The experiment was conducted using a Randomized Block Design (RBD) with ten treatments, each replicated three times. Treatment specifications are provided in Table 1. The fertilizer doses specified in the treatment schedule, along with all other recommended agronomic practices for ginger cultivation, were applied uniformly to all experimental plots, including the control.

Table 1: Treatment details

S. No.	Treatment
1	T_1: 75:50:50 NPK kg/ha
2	T_2: 75:50:75 NPK kg/ha
3	T_3: 75:50:100 NPK kg/ha
4	T_4: 100:50:50 NPK kg/ha
5	T_5: 100:50:75 NPK kg/ha
6	T_6: 100:50:100 NPK kg/ha
7	T_7: 125:50:50 NPK kg/ha
8	T_8: 125:50:75 NPK kg/ha
9	T_9: 125:50:100 NPK kg/ha
10	T_{10}: Absolute control (No fertilizers)

Results and Discussion

Fertilizer levels play a pivotal role in determining the growth and yield of ginger by supplying essential nutrients required for key physiological and biochemical functions. Proper nutrient supply enhances growth parameters, including plant height, leaf count number of tillers and plant spread which collectively influence yield. Balanced fertilizer application facilitates efficient nutrient uptake, vigorous vegetative growth and enhanced rhizome formation, making it crucial for sustainable ginger cultivation.

1) Plant Height (cm)

Plant height in ginger was significantly influenced by fertilizer levels, with the maximum height (83.65 cm) in T_9 (125:50:100 kg NPK/ha) and the minimum (55.18 cm) in the control, which might be due to the positive effect of balanced NPK nutrition. Nitrogen promotes vegetative growth and deep green foliage development, phosphorus supports energy metabolism and root development and potassium enhances nutrient use efficiency and stress tolerance, collectively might contributed to increased plant height. The findings of this study are in agreement with Verma *et al*. (2009) [7] and Seyie (2011) [3] who reported that varying levels of inorganic fertilizers enhanced plant height in ginger.

2) Number of leaves per plant

Fertilizer levels significantly affected number of leaves in ginger, with the highest no. of leaves (132.36) in T_9 (125:50:100 kg NPK/ha) and the lowest (57.51) in the control, attributed to the combined effect of N, P and K. Nitrogen stimulates vegetative growth initiation and expansion, phosphorus supports cell division and energy supply for leaf development and potassium improves nutrient use efficiency and stress tolerance, which might collectively contributed for enhancing the number of leaves per plant. Similar findings were reported by Seyie (2011) [3] in ginger, where fertilizer application significantly increased the number of leaves per plant.

3) Number of tillers per plant

The number of tillers per plant was significantly affected by fertilizer application, with T_9 (125:50:100 kg NPK/ha) produced the highest tiller count (11.02) and the control (T_{10}) recorded the lowest (6.33). The enhanced tillering under T_9 may be due to the balanced supply of N, P and K, where nitrogen promotes vegetative growth and shoot initiation, phosphorus supports cell division and root establishment and potassium enhances nutrient translocation and stress tolerance, which might collectively contribute to an increased number of tillers per plant. The results of the present study are consistent with the findings of Seyie (2011) [3] in ginger.

4) Plant Spread (cm)

The maximum plant spread (E-W: 48.94 cm) and (N-S: 56.88 cm) was recorded in treatment T_9, whereas the minimum plant spread (E-W: 34.52 cm) and (N-S: 40.35 cm) was observed in the control (T_{10}), which might be due to the beneficial effect of balanced NPK nutrition. Nitrogen promotes vigorous vegetative growth through its role in protein and chlorophyll synthesis, phosphorus supports energy transfer and root development enabling better canopy expansion, while potassium regulates osmotic balance and stomatal function, enhancing turgidity. Saraswati *et al*. (2025) [2] reported similar findings in turmeric, supporting the present results on the positive effects of fertilizer application.

5) Weight of primary rhizomes (g)

The maximum primary rhizome weight (319.94 g) was recorded in treatment T_9 (125:50:100 kg NPK ha^{-1}), which was significantly superior to all other treatments, while the lowest weight (66.25 g) was observed in the absolute control (T_{10}). The increase in primary rhizome weight per plant might attributed to balanced NPK nutrition, with nitrogen supporting chlorophyll synthesis and cell division, phosphorus promoting root development and energy transfer and potassium regulating assimilate movement. Tiwari *et al*. (2014) [5] reported similar results in turmeric fertilizer application.

6) Weight of secondary rhizomes (g)

The application of 125:50:100 kg NPK/ ha (T_9) resulted in the maximum secondary rhizome weight (67.75 g), whereas the minimum weight (31.96 g) was observed in T_{10} (Absolute control). The balanced application of NPK significantly enhanced secondary rhizome weight, with nitrogen promoting cell division and chlorophyll synthesis, phosphorus supporting energy transfer and root development and potassium regulating assimilate translocation. Tiwari *et al*. (2014) [5] observed comparable effects of fertilizer application on turmeric.

7) Yield per ha (t)

The highest fresh rhizome yield per hectare (26.54 t) was recorded in treatment T_9 (125:50:100 kg NPK/ha), which was significantly superior to all other treatments, while the lowest yield (7.66 t) was observed in the absolute control (T_{10}). The highest ginger yield per hectare in T_9 (125:50:100 kg NPK/ha) might be due to the balanced supply of nitrogen, phosphorus and potassium, which together enhanced vegetative growth, increased plant spread and promoted the development of rhizomes, while improving nutrient uptake and translocation, ultimately resulting in maximum fresh rhizome yield. These results agree with the observations of Seyie (2011) [3] in ginger and Priyanka (2018) [8] in mango ginger.

Table 2: Effect of varying fertilizer doses on growth parameters of Ginger

Treatment details	Growth parameters				
	Plant height (cm)	Number of leaves per plant	Number of tillers per plant	Plant Spread (cm)	
				(E-W)	(N-S)
T_1: 75:50:50 kg NPK/ha	73.28	100.30	7.12	37.73	44.15
T_2: 75:50:75 kg NPK/ha	73.16	102.49	7.84	39.17	45.60
T_3: 75:50:100 kg NPK/ha	73.49	103.13	7.98	40.02	46.12
T_4: 100:50:50 kg NPK/ha	75.96	107.46	8.15	41.95	48.21
T_5: 100:50:75 kg NPK/ha	77.01	109.74	8.47	44.77	52.03
T_6: 100:50:100 kg NPK/ha	79.89	112.54	8.55	45.79	53.21
T_7: 125:50:50 kg NPK/ha	76.75	108.37	8.38	44.01	51.65
T_8: 125:50:75 kg NPK/ha	82.47	126.75	9.61	46.53	55.31
T_9: 125:50:100 kg NPK/ha	83.65	132.36	11.02	48.94	56.88
T_{10}: Absolute control	55.18	57.51	6.33	34.52	40.35
Mean	75.08	106.07	8.34	42.34	49.35
Range	55.18 - 83.65	57.51 - 132.36	06.33 - 11.02	34.52 - 48.94	40.35 - 59.80
S.E.m (±)	0.47	0.78	0.03	0.01	1.41
C. D. @ 5%	1.41	2.33	0.09	0.05	4.18
F test	SIG	SIG	SIG	SIG	SIG

Table 3: Effect of varying fertilizer doses on yield parameters of Ginger

Treatment details	Yield parameters		
	Weight of primary rhizomes (g)	Weight of secondary rhizomes (g)	Yield per ha (t)
T_1: 75:50:50 kg NPK/ha	147.41	48.89	14.75
T_2: 75:50:75 kg NPK/ha	164.08	53.44	16.98
T_3: 75:50:100 kg NPK/ha	169.34	56.46	18.88
T_4: 100:50:50 kg NPK/ha	175.04	58.20	20.08
T_5: 100:50:75 kg NPK/ha	187.86	60.72	23.57
T_6: 100:50:100 kg NPK/ha	243.25	64.06	24.42
T_7: 125:50:50 kg NPK/ha	182.65	58.52	21.54
T_8: 125:50:75 kg NPK/ha	269.18	64.48	25.77
T_9: 125:50:100 kg NPK/ha	319.94	67.75	26.54
T_{10}: Absolute control	66.25	31.96	7.66
Mean	192.50	31.96 - 67.75	7.66 - 26.54
Range	66.25 - 319.94	56.45	20.02
S.E.m (±)	9.51	0.27	0.19
C. D. @ 5%	28.27	0.81	0.57
F test	SIG	SIG	SIG

Conclusion

The study concluded that treatment T_9 (125:50:100 kg NPK/ha) significantly improved vegetative growth and yield of ginger Cv. IISR Mahima, recorded the maximum growth parameters and the highest yield.

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