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Nutrient management and its effect on growth, yield and quality of ginger cultivars

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ABSTRACT

An experiment was conducted during 2010-11 at College of Horticulture, Mandsaur (M.P.) to study the effect of nitrogen, phosphorus and potassium on growth, yield and quality of ginger cultivars. The experiment was laid out in a factorial, randomized block design with 16 treatments, comprising of two cultivars Akya Local (V_1) and Suprabha (V_2), two levels each of nitrogen (100 and 125 kg ha^{-1}), phosphorus (40 and 60 kg ha^{-1}) and potassium (40 and 60 kg ha^{-1}). The cultivar Akya Local was found better than Suprabha in terms of growth, yield and quality attributes. The growth attributes (length, diameter and number of rhizome fingres and fresh and dried yield of rhizomes) and quality attributes (fresh ginger oil, oleoresin and crude fiber content) were found to increase significantly with the higher level of fertilizers. The highest fresh rhizome yield (142.25 q/ha), fresh ginger oil (1.52%) and oleoresin (6.2%) and a maximum net profit of Rs. 6,20,108 ha^{-1} with a B:C ratio of 4.87:1 was obtained with the application of 125 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1} to Akya Local.

Key words: Ginger, growth, nutrient management, yield.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is one of the oldest known spices esteemed for its aroma and pungency. India is the largest producer of ginger and during 2009-10, the production and productivity was about 385.33 thousand MT and 3.6 MT/ha, respectively from an area of 107.54 thousand ha contributing approximately 30 to 40 per cent of the world production (NHB, 11). In Madhya Pradesh, the ginger is mostly cultivated in Tikamgarh, Ratlam, Chhattarpur and Khandwa districts occupying an area of 6,456 ha, with a production and productivity of 0.07 lakh tonne and 1.16 t/ha, respectively (Anon, 1). It shows that productivity of ginger in Madhya Pradesh is very low as compared to the national productivity, which should be increased to make the crop more remunerative. Nutrient management particularly NPK plays major role in production of a crop. Nitrogen is one of the inevitable major nutrients and an indispensable constituent of protein and nucleic acid molecules. Troug (9) mentioned that N application increases the assimilating process through glycolysis and fatty acid synthesis. Phosphorus is the most important nutrient element in the production of tuber and rhizomatous crops (Venkatesh *et al*., 20). In general, crops with restricted root systems like ginger require fertilizer containing a high proportion of water soluble P_2O_5 for obtaining maximum yields (Sushama and Jose, 16). Potassium is often described as a quality improvement element in crop production. It indirectly improves utilization of nitrogen and protein formation, fruit size, weight, oil content, colour etc. It increases the yield, size of fingers in ginger (Haque *et al*., 6). Keeping in view the importance of the above nutrients in ginger crop, an experiment was undertaken.

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MATERIALS AND METHODS

The present investigation was carried out at the Research Farm, College of Horticulture (RVSKVV), Mandsaur, Madhya Pradesh during 2010-11. The soil of the experimental field was light black loamy in texture with pH 7.1 and 0.24 dS/m EC; having low level of available nitrogen (140.0 kg ha^{-1}), medium in available phosphorus (21.0 kg ha^{-1}) and low in available potassium (144.0 kg ha^{-1}). The experiment was laid out in factorial randomized block design. There were 16 treatment combinations with two varieties (V_1- Akya Local and V_2- Suprabha), two levels each of nitrogen (N_1-100 and N_2-125 kg ha^{-1}), phosphorus (P_1-40 and P_2-60 kg ha^{-1}) and potassium (K_1-40 and K_2-60 kg ha^{-1}), replicated thrice in 48 well ploughed and raised beds of 2.4 m × 1.8 m size with a planting distance of 30 cm × 30 cm. A basal dose of well rotten farm yard manure @ 20 tonnes ha^{-1} was incorporated in the soil before planting. The ginger seed rhizome weighing 25-30 g was planted on 1st July, 2010. First light irrigation was done just after sowing then subsequent irrigations were given at different intervals, as per the requirement

of the crop. All the beds were mulched with dry leaves of *Palash* (*Butea monosperma*) after planting. The crop was harvested on 1st Feb. 2011. Growth observations on plant (height, number of leaves and number of tillers) were recorded at 60, 90, 120, 150 and 180 DAP. The yield attributes and yield (length, diameter and number of rhizome fingers, fresh and dried yield of rhizomes) were recorded at the time of harvest. Quality attributes such as fresh ginger oil, dry oleoresin, crude fibre content and alcoholic extract were also analysed after harvest. Fresh ginger oil was obtained by steam distillation using modified Clevenger's method (AOAC' 2). Oleoresin and crude fibre contents were determined as per the method suggested by Horwitz (7) and Thimmaiah (18), respectively. Alcoholic extract was estimated as per ASTA (3) analytical method. Nitrogen content of the rhizome tissues were determined by Kjeldahl's method as described by Black (4). Phosphorus was estimated by vando-molybdate yellow colour method (Jackson, 8) and potassium content was estimated by flame photometry as suggested by Chapman and Pratt (5). The results thus obtained were presented in terms of percentage on dry weight basis.

RESULTS AND DISCUSSION

Different plant growth attributes such as height, number of leaves per plant and number of tillers per plant gave significant changes in different cultivars at 60, 90, 120, 150 and 180 DAP (Table 1). The maximum plant height (cm), number of leaves per plant, and number of tillers were found to be significantly higher in Akya Local as compared to Suprabha (Table 1). This might be due to the difference in their genotypic potential and adaptability to soil and climate. The Akya Local variety gave significantly the highest length of rhizome fingers (6.09 cm), diameter of rhizome fingers (1.87 cm), number of rhizome fingers (16.63), fresh yield (92.26 g/plant), dried yield (17.68 g/plant), fresh yield (142.25 q/ha), dried yield (30.70 q/ha) as compared to Suprabha (Table 2). This might be due to the fact that rhizome yield per plant was positively and significantly correlated with yield.

The Akya Local showed superior quality with higher fresh ginger oil (1.52%), oleoresin (6.20%), alcoholic extract (6.04%) and low fibre content (3.89%) as compared to Suprabha. The N (1.81%), P (0.80%) and K (1.98%) content in the rhizomes were also found to be significantly higher in Akya Local over Suprabha (Table 3). Similar findings have been also reported by Sasikumar *et al.* (14), Singh (15) and Natrajan *et al.* (10). They indicated that different cultivars varied considerably with regard to oil and oleoresin contents.

Significantly higher plant height, number of leaves per plant and number of tillers per plant at 60, 90, 120, 150 and 180 DAP was recorded as a result of higher levels of nitrogen fertilizer (125 kg ha^{-1}). These growth attributes were highest with the application of 60 kg phosphorus ha^{-1} and 60 kg potassium ha^{-1} (Table 1). This may be attributed to better nutritional environment in the root zone as well as in the plant system. The increased uptake of nutrients seemed to have promoted vegetative growth.

The application of 125 kg N/ha recorded significantly highest length of rhizome fingers (5.79 cm), diameter of rhizome fingers (1.83 cm), number of rhizomes (15.55/plant), fresh yield (83.34 g/plant), dried yield (16.28 g/plant), fresh yield (129.42 q/ha), dried yield (28.27 q/ha) as compared to application of 100 kg N/ha. Similarly, the maximum length of rhizome fingers (5.67 cm), diameter of rhizome fingers (1.78 cm), No. of rhizomes (14.93/plant), fresh yield (77.39 g/plant), dried yield (15.48 g/plant), fresh yield 119.35 q/ha) and dried yield (26.88 q/ha) recorded with the application of 60 kg phosphorus/ha. The application of potassium 60 kg/ha gave significantly superior yield attributes such as length of rhizome fingers (5.54 cm), diameter of rhizome fingers (1.75 cm), No. of rhizome fingers (14.52 per plant), fresh yield (74.44 g/plant), dried yield (14.97 g/plant), fresh yield (114.88 q/ha) and dried yield (25.99 q/ha) as compared to 40 k/ha (Table 2).

Application of 125 kg N/ha indicated significant increase in the quality of ginger with respect of volatile oil (1.41%), oleoresin (5.66%), crude fibre content (4.07%), as well as content of N, P and K in rhizomes, *i.e.*, 1.85, 0.81 and 2.00% respectively. The quality parameters of ginger like volatile oil, oleoresin, crude fibre and content of N, P and K in the rhizomes were significantly influenced with the application of phosphorus @ 60 kg/ha as compared to 40 kg/ha. Similarly, the application of higher dose of K 60 kg/ha recorded the maximum volatile oil (1.38%), oleoresin (5.52%), crude fibre (3.97%) and N, P, K contents in rhizomes (1.75, 0.79 and 1.96%) as compared to 40 kg K/ha. Beside, these the alcoholic content of ginger was significantly decreased with higher level of N, P and K applications (Table 3). Rapid vegetative growth stimulated and increased the sink in terms of rhizome size and thus increasing the fresh and dried yield of rhizomes. There was a progressive increase in the volatile oil, oleoresin, crude fibre and N, P and K content in the rhizomes with the increasing levels of nutrient. A gradual decline in the alcoholic extract was noted with the increase in nutrient levels. The higher number of leaves and tillers along with plant height and larger size of leaves produce more carbohydrates

Table 1. Effect of nitrogen, phosphorus and potassium on growth attributes of ginger.

Treatment	Plant height (cm)					No. of leaves/ plant					No. of tillers/ plant				
	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Variety															
Akya Local (V_1)	28.69	41.23	44.32	45.80	45.86	21.32	63.36	112.26	174.11	174.22	3.73	8.95	16.00	18.40	18.55
Suprabha (V_2)	25.41	33.45	34.78	36.27	36.43	13.98	39.10	62.11	97.98	98.04	2.33	5.83	10.20	12.04	12.25
CD (P = 0.05)	0.51	0.36	0.36	0.34	0.23	0.48	0.70	1.18	2.26	1.50	0.16	0.19	0.37	0.64	0.59
Nitrogen (kg ha^{-1})															
100 (N_1)	24.38	33.96	36.53	38.16	38.23	15.19	44.68	73.17	116.03	116.09	2.56	6.49	11.58	13.38	13.58
125 (N_2)	29.73	40.71	42.56	43.90	44.07	20.11	57.78	101.20	156.06	156.17	3.50	8.28	14.63	17.07	17.22
CD (P = 0.05)	0.51	0.36	0.36	0.34	0.23	0.48	0.70	1.18	2.26	1.50	0.16	0.19	0.37	0.64	0.59
Phosphorus (kg ha^{-1})															
40 (P_1)	25.49	35.94	38.11	39.53	39.60	16.42	47.60	79.68	124.36	124.43	2.78	6.87	12.37	14.23	14.38
60 (P_2)	28.61	38.74	40.98	42.53	42.70	18.88	54.86	94.68	147.73	147.83	3.29	7.90	13.84	16.21	16.41
CD (P = 0.05)	0.51	0.36	0.36	0.34	0.23	0.48	0.70	1.18	2.26	1.50	0.16	0.19	0.37	0.64	0.59
Potassium (kg ha^{-1})															
40 (K_1)	25.94	36.33	38.51	40.34	40.41	17.08	49.58	83.78	130.63	130.69	2.92	7.20	12.63	14.60	14.79
60 (K_2)	28.16	38.34	40.58	41.72	41.89	18.23	52.88	90.58	141.46	141.57	3.14	7.57	13.58	15.84	16.00
CD (P = 0.05)	0.51	0.36	0.36	0.34	0.23	0.48	0.70	1.18	2.26	1.50	0.16	0.19	0.37	0.64	0.59

Table 2. Effect of nitrogen, phosphorus and potassium on yield attributes and yield of ginger.

Treatment	Length of rhizome fingers (cm)	Diameter of rhizome fingers (cm)	No. of rhizome fingers	Fresh yield (g/plant)	Dried yield (g/plant)	Fresh yield (q/ha)	Dried yield (q/ha)
Variety							
Akya Local (V_1)	6.09	1.87	16.63	92.26	17.68	142.25	30.70
Suprabha (V_2)	4.77	1.56	11.23	50.68	10.97	77.48	19.04
CD (P = 0.05)	0.23	0.30	0.21	0.72	0.18	1.28	0.35
Nitrogen (kg ha^{-1})							
100 (N_1)	5.07	1.61	12.32	58.60	12.37	90.31	21.47
125 (N_2)	5.79	1.83	15.55	84.34	16.28	129.42	28.27
CD (P = 0.05)	0.23	0.30	0.21	0.72	0.18	1.28	0.35
Phosphorus (kg ha^{-1})							
40 (P_1)	5.18	1.66	12.94	65.55	13.17	100.39	22.87
60 (P_2)	5.67	1.78	14.93	77.39	15.48	119.35	26.88
CD (P = 0.05)	0.23	0.30	0.21	0.72	0.18	1.28	0.35
Potassium (kg ha^{-1})							
40 (K_1)	5.31	1.69	13.35	68.50	13.68	104.85	23.75
60 (K_2)	5.54	1.75	14.52	74.44	14.97	114.88	25.99
CD (P = 0.05)	0.23	0.30	0.21	0.72	0.18	1.28	0.35

Table 3. Effect of nitrogen, phosphorus and potassium on quality attributes and content of N, P and K in the rhizomes of ginger.

Treatment	Quality attributes				Nutrient content		
	Fresh ginger oil (%)	Dry oleoresin (%)	Crude fibre content (%)	Alcoholic extract (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Variety							
Akya Local (V_1)	1.52	6.20	3.89	6.04	1.81	0.80	1.98
Suprabha (V_2)	1.19	4.73	4.00	5.13	1.63	0.78	1.90
CD (P = 0.05)	0.03	0.04	0.04	0.23	0.04	0.007	0.04
Nitrogen (kg ha^{-1})							
100 (N_1)	1.30	5.27	3.83	6.25	1.58	0.77	1.87
125 (N_2)	1.41	5.66	4.07	4.92	1.85	0.81	2.00
CD (P = 0.05)	0.03	0.04	0.04	0.23	0.04	0.007	0.04
Phosphorus (kg ha^{-1})							
40 (P_1)	1.33	5.34	3.89	5.96	1.64	0.78	1.90
60 (P_2)	1.39	5.59	4.00	5.21	1.79	0.80	1.98
CD (P = 0.05)	0.03	0.04	0.04	0.23	0.04	0.007	0.04
Potassium (kg ha^{-1})							
40 (K_1)	1.34	5.41	3.92	5.71	1.68	0.78	1.9
60 (K_2)	1.38	5.52	3.97	5.46	1.75	0.79	1.96
CD (P = 0.05)	0.03	0.04	0.04	0.23	0.04	0.007	0.04

Table 4. Benefit : cost ratio of different treatment combinations in ginger.

Treatment combination	Yield (q ha^{-1})	Cost of cultivation in Rs. ha^{-1} (including the cost of treatments)	Gross return ha^{-1} @ Rs. 4,000 q^{-1}	Net profit (Rs. ha^{-1})	Benefit : cost ratio
$V_1N_1P_1K_1$	104.04	1,26,840	4,16,160	2,89,320	2.28 :1
$V_1N_1P_1K_2$	117.81	1,26,980	4,71,248	3,44,268	2.71 :1
$V_1N_1P_2K_1$	123.24	1,27,240	4,92,960	3,65,720	2.87 :1
$V_1N_1P_2K_2$	130.21	1,27,380	5,20,840	3,93,460	3.09 :1
$V_1N_2P_1K_1$	143.36	1,26,912	5,73,440	4,46,528	3.52 :1
$V_1N_2P_1K_2$	159.84	1,27,052	6,39,360	5,12,308	4.03:1
$V_1N_2P_2K_1$	172.62	1,27,312	6,90,480	5,63,168	4.42 :1
$V_1N_2P_2K_2$	186.89	1,27,452	7,47,560	6,20,108	4.87 :1
$V_2N_1P_1K_1$	45.56	1,42,840	1,82,240	39,400	0.28 :1
$V_2N_1P_1K_2$	53.39	1,42,980	2,13,560	70,580	0.49 :1
$V_2N_1P_2K_1$	70.22	1,43,240	2,80,880	1,37,640	0.96 :1
$V_2N_1P_2K_2$	78.00	1,43,380	3,12,000	1,68,620	1.18 :1
$V_2N_2P_1K_1$	84.46	1,42,912	3,37,840	1,94,928	1.36 :1
$V_2N_2P_1K_2$	94.62	1,43,052	3,78,480	2,35,428	1.64 :1
$V_2N_2P_2K_1$	95.30	1,43,312	3,81,200	2,37,888	1.65 :1
$V_2N_2P_2K_2$	98.28	1,43,452	3,93,120	2,49,668	1.74 :1
$CD_{(P=0.05)}$	3.63				

on account of accelerated photosynthesis, which are responsible for better storage in terms of quality (Purseglove *et al*.,13). However, the alcoholic extract showed a decreasing trend with the increase in the fertilizer levels, which is similar to the findings of Pariari and Bhattacharya (12).

Benefit : cost ratio of different treatment combinations presented in Table 4 clearly reveals that application of 125 kg N + 60 kg P_2O_5 + 60 kg K_2O ha^{-1} to Akya Local resulted in maximum net profit of Rs. 6,20,108 ha^{-1} with a B : C ratio of 4.87 : 1. Similarly, Lujiu *et al*. (9) and Swain *et al*. (17) also reported higher economic benefits with higher doses of NPK in ginger and turmeric, respectively.

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