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Comparative analysis of ginger cultivated soils under different nutrient management practices

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ABSTRACT

Ginger, an important commercial crop, is grown in the hilly zone of Karnataka. A survey-based study was carried out in the Shivamogga district to assess the effect of different nutrient management on ginger-grown soils. Sixty ginger-growing farmers were selected from 3 different clusters (20 each), and information on nutrient management practices and ginger yields was obtained. The ginger farmers were grouped based on nutrient applications into three categories, namely, Category 1 (High fertilizers with low Org. Manure), Category 2 (Moderately high fertilizers with high Org. Manure), and Category 3 (Very high fertilizers with low Org. Manure). Surface and subsurface soil samples were collected after ginger harvest from 0-15 and 15-30 cm, respectively. The quantity of organic manures ranged from 9.50 to 34.87 t ha^{-1}. The number of major nutrients added through inorganic fertilizers ranged from 84.57 to 315.45 kg N ha^{-1}, 58.69 to 342.65 kg P_2O_5 ha^{-1} and 52.12 to 303.09 kg K_2O ha^{-1}. The total nutrient additions varied significantly among three categories, with category 3 > category 2 > category 1. Analysis of soil samples revealed that the available-N, P2O5 and K2O varied significantly in order of category 3 > category 2 > category 1. However, the ginger yield was found to be significantly higher in category 2 (29.48 ± 3.34 t ha^{-1}) compared to the other two categories. Organic manures help to retain nutrients in the soil. Phosphorus and potassium buildup were noticed in plots with high nutrient applications. Yield reductions were observed with high fertilizer applications.

Keywords: Hilly zone, Karnataka, Integrated nutrient management, Organic manures, Excess fertilizer use

INTRODUCTION

Ginger (*Zingiber officinale*), a popular hot spice, is consumed as a rhizome and its products in daily diets (Singh *et al*., 2015). Globally, India is the largest producer, consumer and exporter of ginger. In India, Karnataka stands 2nd in terms of area (20.53 thousand hectares) and production (249.9 thousand tonnes). Ginger is a shallow-rooted and nutrient-exhaustive crop widely cultivated in medium-textured soils with low nutrient retention capacity (Kandiannan *et al.,* 1996) and demands a frequent supply of nutrients (Patra *et al*., 2022). Thus, providing adequate and balanced nutrients by combining organic manures and inorganic chemical fertilizers remains a viable option for ginger (Singh *et al*., 2015) and other crops (Shivakumar *et al*., 2010). Use of organic manures helps to reduce the overuse of chemical fertilizers and thereby safeguard the environmental quality (Divyashree *et al.,* 2022). At present, the nutrient recommendation for ginger in Malanad regions is 100:50:50 kg N, P_2O_5 and K_2O $ha^{-1,}$ along with 25 t ha^{-1} of organic manures. Most farmers apply less organic manures than recommended, while fertilizer nutrients are added at 1.5 to 3.0 times higher (Poornima, 2020). Thus, the use of manures and fertilizers in ginger differs substantially among farmers. Considering these issues, a survey-based field study was carried out to assess nutrient additions and their influence on ginger yields and the fertility status of ginger-cultivated soils.

MATERIALS AND METHOD

Study area

Based on the area under ginger cultivation data, three taluks, namely Sagara, Shikaripura and Shivamogga, were selected for this study. Ginger farmers were chosen (20 farmers from each taluk) and interviewed to get information on nutrient management practices and corresponding ginger yields. The data collected were used to obtain the amounts of nutrients added through fertilizers and organic manures.

Grouping of ginger farmers

Based on the quantity of organic manures and fertilizers added, the ginger farmers were grouped into three different categories, namely, Category 1 (High fertilizers with low Org. Manure), Category 2 (Moderately high fertilizers with high Org. Manure) and Category 3 (Very high fertilizers with low Org. Manure) by using K-clustering technique. The quantities of nutrients added through fertilizers were converted into unit weights of N, P_2O_5 and K_2O per hectare based on their nutrient contents and applied quantity. A nutrient content of 0.5:0.2:0.5 per cent of N, P_2O_5 and K_2O was multiplied by the amount of organic manures to get nutrient additions from organic manures. Finally, total nutrients added to each field were derived by adding nutrient values from organic manures and fertilizers applied by each farmer. The ginger rhizome yield obtained was recorded in terms of bags and then converted into tonnes per hectare.

Soil Sampling and Data analysis

The soil samples were collected during February - March 2022 from all 60 ginger fields representing the above farmers. Sampling was done separately at two depths (0-15 and 15-30 cm) after three to four weeks of crop harvest. The soil samples were dried in the shade and passed through a 2 mm sieve after powdering gently with a wooden pestle and mortar. The dried soil samples were stored in an airtight container for further chemical analysis. Soil pH and EC were measured for 1:2.5 soil: water suspensions (Jackson, 1973). Available N by alkaline permanganate method (Subbiah and Asija, 1956), available P_2O_5 by spectrophotometer method (Bray and Kurtz, 1945) and available K_2O by flame photometer method (Jackson, 1973) were followed for soil fertility analysis.

The data obtained were subjected to statistical analysis using Analysis of Variance (ANOVA) and compared 'F' test at 5 per cent significance (Gomez and Gomez 1984). The correlation coefficients (r) were worked out for nutrient additions and ginger yield to understand their interactions.

RESULT AND DISCUSSION

Nutrient additions

Applications of organic manures and fertilizers varied substantially among ginger farmers, which in turn influenced the crop yields. The information on the quantity of major nutrients added by both organic manures and fertilizers is depicted in Table 1.

The values of nitrogen and potassium are the same as their nutrient content in organic manures are same. The amounts of nitrogen and potassium added through organic manures were significantly higher (131.65 ± 26.70 kg N and K_2O ha^{-1}) in fields

Table 1. Application of different amounts of organic manure and fertilizer nutrients and their effect on ginger yields

Category of farmers	Organic manures applied (t ha^{-1})	Fertilizers applied (kg ha^{-1})			Yield (t ha^{-1})
		N	P_2O_5	K_2O	
Cat 1: High Fert. with low Org. Manure(n=22)	13.05 ± 2.72 ^{c}	102.40 ± 12.33 ^{c}	120.56 ± 31.29 ^{c}	70.20 ± 12.88 ^{c}	19.63 ± 2.51 ^{c}
Cat 2: Mod. high Fert. with high Org. Manure (n=23)	26.33 ± 5.34 ^{a}	159.13 ± 24.66 ^{b}	203.31 ± 19.69 ^{b}	161.33 ± 37.80 ^{b}	29.48 ± 3.34 ^{a}
Cat 3: Very high Fert. with low Org. Manure(n=15)	16.62 ± 2.39 ^{b}	264.00 ± 40.54 ^{a}	277.00 ± 29.44 ^{a}	269.27 ± 31.17 ^{a}	26.75 ± 1.67 ^{b}

applied with high organic manures and fertilizers (category 2), followed by category 3 (83.08 ± 11.96 kg N and K_2O ha^{-1}). Least nitrogen and potassium were added (65.27 ± 13.62 kg N and K_2O ha^{-1}) in category 1 ginger fields supplemented with low organic manures and high fertilizers. The amount of phosphorus added through organic manures among the three categories was less, but the trend was very similar to nitrogen and potassium. All the major nutrients through organic manures varied significantly in the order of Category 2 > Category 3 > Category 1.

The quantity of nitrogen applied through fertilizers was found to be significantly higher in category 3 (264.00 ± 40.54 kg N ha^{-1}), followed by category 2 (159.13 ± 24.66 kg N ha^{-1}) and least nitrogen additions (102.40 ± 12.33 kg N ha^{-1}) were recorded in category 1. Similarly, the amount of phosphorus added through inorganic fertilizers varied significantly in order of category 3 (277.00 ± 29.44 kg P_2O_5 ha^{-1}) > category 2 (203.31 ± 19.69 kg P_2O_5 ha^{-1}) > category 1 (120.56 ± 31.29 kg P_2O_5 ha^{-1}). The same trend was also recorded in potassium with respective values of 269.27 ± 31.17kg K_2O kg ha^{-1} (category 3) > 161.33 ± 37.80 kg K_2O kg ha^{-1} (category 2) > 70.20 ± 12.88 kg K_2O kg ha^{-1} (category 1). Thus, total nutrient additions through organic manures and fertilizers were found to be highest in category 3 and least in category 1. Among three categories of ginger farmers, total nutrient additions varied significantly in the order of category 3 > category 2 > category 1.

Nutrient additions through organic manures and fertilizers varied substantially among three categories of farmers (Fig. 1). Variations in nutrient additions from organic manures may be attributed to differential additions of organic manure itself. Different levels of organic manure applications might be due to its lesser availability and high cost (Poornima, 2020). The financial status of individual farmers and ownership of land are also important factors influencing organic manure applications (Shivakumar *et al.*, 2010). Excessive application of fertilizers by farmers may be due to the good response of ginger to higher nutrient additions (Nagarajan and Pillai, 1979). Nitrogen applications were 1.5 to 2 times higher than recommended level, while phosphorus and potassium applications were two to four times higher. Similar observations were reported earlier by Poornima (2020) for ginger grown in the north Kannada region.

Soil fertility status

The soil pH ranged from acidic to neutral, with a pH of 4.51 to 6.87 and 4.49 to 6.75 in surface and

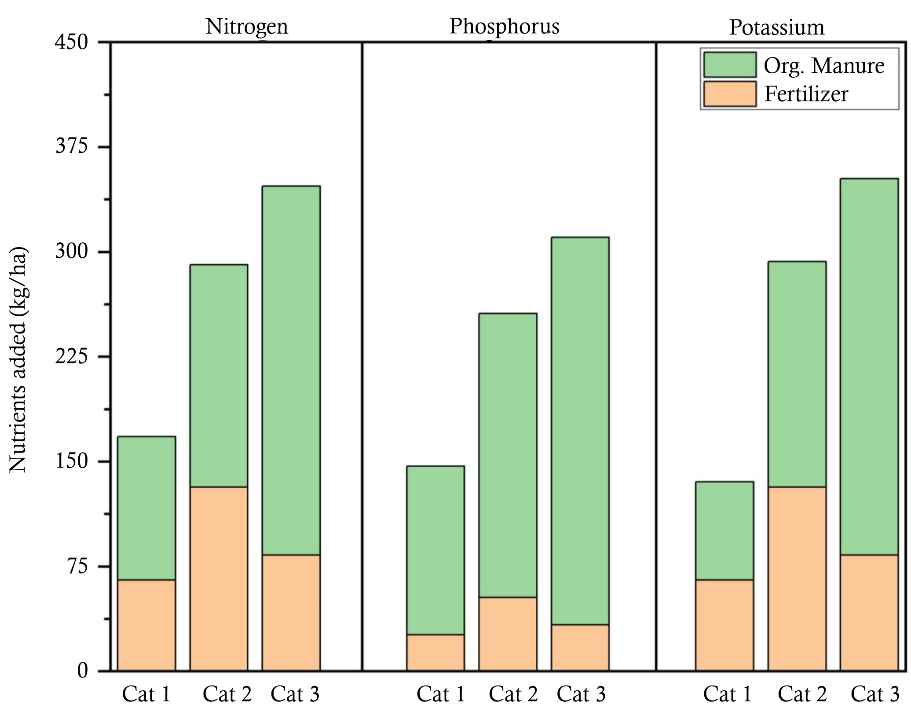

Fig. 1. Nutrient additions through organic manures and fertilizers

Table 2. Application of different amounts of fertilizers and organic manures on the availability of major nutrients in ginger cultivated soils (kg ha^{-1})

Category of farmers	Available N		Available P_2O_5		Available K_2O	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Cat 1: High Fertilizers with low Organic Manures (n=22)	242.75 ± 13.96[c]	226.20 ± 11.19[c]	59.34 ± 8.14[c]	52.43 ± 7.79[c]	232.89 ± 11.36[c]	200.39 ± 19.69[c]
Cat 2: Mod. High Fertilizers with high Organic Manures (n=23)	302.71 ± 21.15[b]	274.56 ± 16.26[b]	71.92 ± 9.14[b]	62.37 ± 9.06[b]	277.89 ± 19.59[b]	253.24 ± 20.63[b]
Cat 3: Very High Fertilizers with low Organic Manures (n=15)	317.56 ± 28.16[a]	284.83 ± 23.78[a]	88.81 ± 4.96[a]	79.09 ± 5.41[a]	306.66 ± 13.67[a]	272.95 ± 17.02[a]

subsurface soils, respectively. The electrical conductivity in these soils was low (0.08 to 0.30 and 0.09 to 0.31 dS m-1 in surface soils and subsurface soils, respectively), indicating non-salinity. However, the soil pH and EC did not vary significantly among the three categories of farmers.

The available nitrogen, phosphorus, and potassium varied significantly among the three categories of farmers. The nutrient availability status in surface and subsurface soils are given in Table 2. Available nitrogen was found to be significantly higher (317.56 ± 28.16 kg N ha^{-1}) in category 3 (very high fertilizers and low organic manures) and least (242.75 ± 13.96 kg N ha^{-1}) in category 1 (high fertilizers with low organic manures) group of farmers. Similar to nitrogen, the available P_2O_5 varied significantly among three categories of farmers. It was found to be significantly higher (88.81 ± 4.96 kg P_2O_5 ha^{-1}) in soils receiving higher dose of P fertilizers belonging to category 3 compared to category 1 (59.34 ± 8.14 kg P_2O_5 ha^{-1}) and category 2 (71.92 ± 9.14 kg P_2O_5 ha^{-1}) ginger farmers. The available potassium status at two depths in ginger-grown soils also varied significantly among three categories of farmers. The availability of potassium in surface soils was found to be significantly higher in category 2 (306.66 ± 13.67 kg K_2O ha^{-1}) followed by category 3 (277.88 ± 19.59 kg K_2O ha^{-1}), and the least was noticed in category 1 (232.89 ± 11.36 kg K_2O ha^{-1}). A similar trend was observed in subsurface soils. Availability of all the three major nutrients in soils increased with respective nutrient applications (Table 3). The correlation coefficient values for nitrogen, phosphorus and potassium were 0.937**, 0.870** and 0.935**, respectively.

The variations in the availability of nutrients may be attributed to their strong relationships with added organic manures and fertilizers; and their behaviour in soils (Dudhat *et al.*, 1997). The higher availability of nitrogen in ginger-grown soils may be due to better retention by soil organic matter (Nagaraja, 1997) though it is highly prone to leaching. Low nitrogen content in subsurface soils further strengthens the above observations. High applications of phosphorus and potassium and their low nutrient use efficiency might have contributed to phosphorus buildup (Guptha *et al.*, 1998; Shanthy *et al.,* 1999; Shivakumar *et al.*, 2010). It is immobility and direct application on surface soils might be the reasons for higher phosphorous content in surface soils. Similar reports of phosphorus buildup in surface soils of grape and pomegranate systems are well documented (Kondi *et al.,* 2018). Positive correlations were observed among all three available nutrients with respect to their nutrient additions (Malo *et al.*, 2005).

Rhizome yields

The rhizome yield was significantly higher in category 2 (29.48 ± 3.34 t ha^{-1}), while least rhizome yield was noticed in category 1 (19.63 ± 2.51 t ha^{-1}). The fields belonging to category 2 receiving high organic manures and moderately high fertilizers recorded ginger yields of 26.78 ± 1.67 t ha^{-1}. Thus, rhizome yield varied significantly in the order of Category 2 > Category 3 > Category 1 (Table 1). The supplementation of nitrogen, phosphorus and potassium increased ginger yields significantly with respective correlation coefficient values of 0.898**, 0.825** and 0.877** (Table 3). However, the increase in yield was observed only up to a certain level of nutrients but decreased with excess applications (Fig. 2).

Table 3. Correlation coefficients among organic manure, total nutrient additions, available nutrient status and ginger yields

	Org. Manure	Total N added	Total P added	Total K added	Ginger Yield	Ava-N	Ava-P_2O_5	Ava-K_2O
Org. Manure	1.00							
Total N added	0.577**	1.00						
Total P added	0.501**	0.877**	1.00					
Total K added	0.587**	0.916**	0.915**	1.00				
Ginger Yield	0.853**	0.898**	0.825**	0.877**	1.00			
Ava-N	0.614**	0.937**	0.813**.	0.888**	0.760**	1.00		
Ava-P_2O_5	0.298*	0.781**	0.870**	0.800**	0.610**	0.666**	1.00	
Ava-K_2O	0.440**	0.835**	0.867**	0.935**	0.668**	0.792**	0.783**	1.00

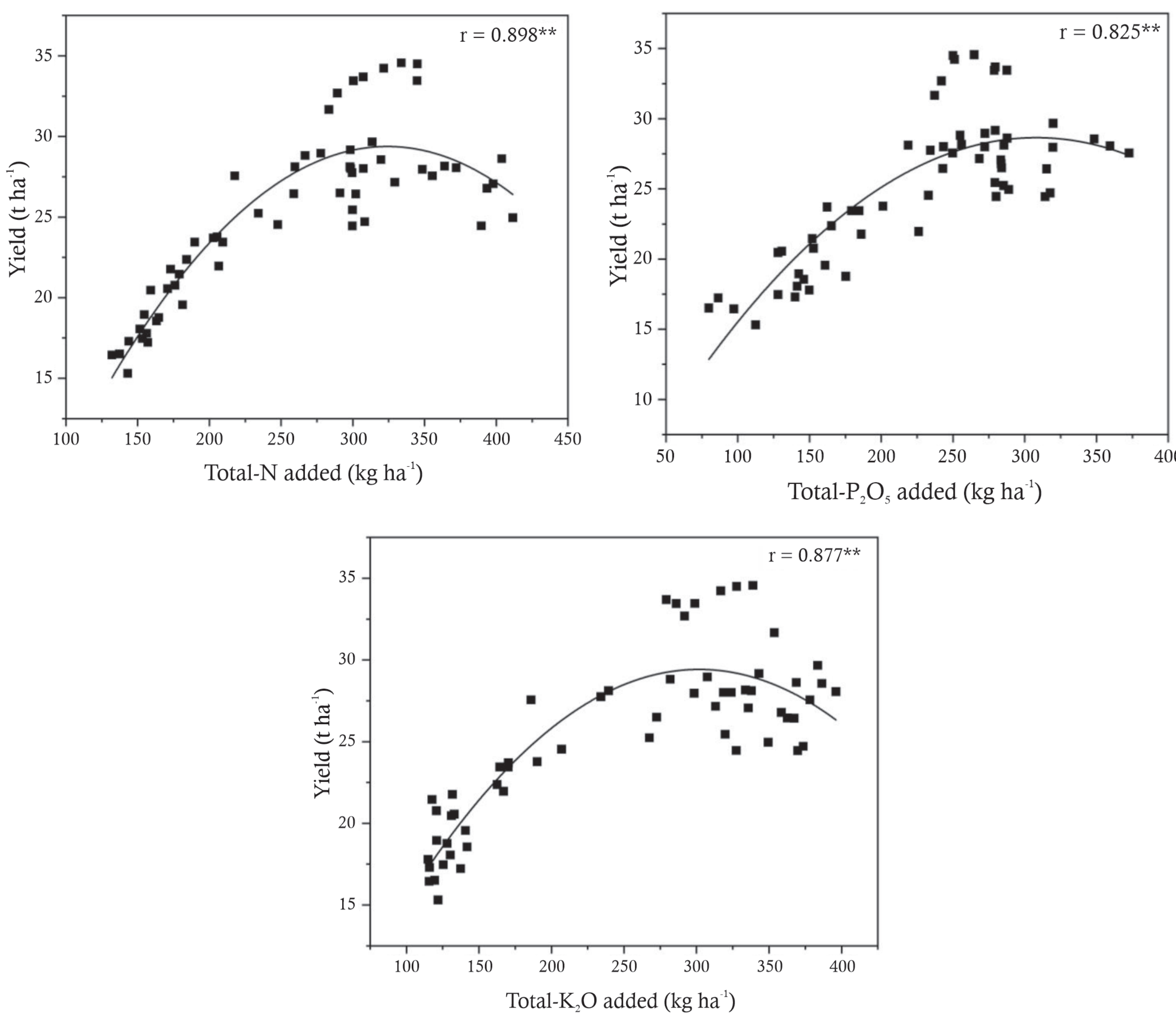

Fig. 2. Effect of nitrogen, phosphorus and potassium additions on ginger rhizome yields

The differences in yields could be attributed to variations in soil nutrient availability as influenced by their applications (Jayachandran *et al.,* 1991). Similar reports on nutrient applications and yield relations in chilli (Shivakumar *et al*., 2010) and tomato (Punith Raj *et al*., 2013) are reported. It was very evident that nutrient management through organic manures and fertilizers plays a key role in determining ginger yields (Muralidharan and Raman Kutty, 1977). The applied organic manures might have helped ginger by better nutrient retention and higher use efficiency. Organic manure additions also benefited indirectly by supplementing secondary and micronutrients (Patil and Biradar, 2001). The productivity increased with an increase in nutrient additions through fertilizers and organic manures. However, higher nutrient additions did not result in terms of crop yields (Fig. 2). It was evident in all three nutrients significantly. Nutrient supplementation enhances the crop yields initially, tends to get optimized up to a level and then declines with further additions (Kondi *et al*., 2018). Higher doses of nutrients are ineffective, and they can even decrease crop yield. Higher N content in plants may disturb N and carbohydrate compounds balance in plants and causes a high incidence of pests and diseases (Palakatti and Sulieri, 2000). Antagonistic interactions of phosphorus with Ca and Zn and potassium with calcium might have reduced the yields (Shivakumar *et al*., 2010; Punith Raj *et al*., 2013).

CONCLUSION

The study on nutrient management practices for ginger cultivation in Shivamogga district indicated that the farmers obtained higher yields and applied more than recommended levels of nutrients. The levels of organic manures and fertilizer applications largely determined the soil fertility status in terms of available nutrients. The farmers applying high organic manures and moderately high fertilizers (Category 2) recorded higher rhizome yields compared to the other two categories. Yield reductions were observed with very high levels of fertilizer applications. A mere high dose of fertilizer nutrients (category 3) did not help to achieve higher yields. Though, the soil fertility was better than ginger fields of category 1 and category 2. This study also suggests that the present nutrient recommendations and practices for ginger cultivation must be revalidated, as none of the farmers are practising the current nutrient recommendations.

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