



Effect of organic nutrient sources on productivity, profitability and quality of ginger (*Zingiber officinale*) in acid soils of Eastern Himalayas

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ABSTRACT

Ginger cultivated with limited organic manures will produce low yields and would require different nutrient combinations for increased nutrition availability for higher productivity. The combination of organic nutrient sources was expected to increase and improve the growth and yield of ginger rhizome. Research experiments were conducted at Krishi Vigyan Kendra, Ranipool, East Sikkim, India to study the effect of different organic nutrient sources on yield and quality of ginger for three consecutive summer seasons (2013-15) under field conditions aimed to assess the effect of different combinations of organic sources on growth, yield, quality and profitability of ginger rhizome. The study revealed that a single organic soil nutrient source does not significantly influence the growth and yield of ginger rhizomes. The combination of two nutrient sources significantly influenced all parameters of the growth and yield of ginger rhizome. The combination of 50% pig manure + 50% poultry manure gave the best response to all the vegetative growth parameters, viz. plant height (109.0 cm), tillers per plant (16.3 nos.), number of leaves per tiller (17.9 nos.), size of leaves (30.9 cm²) but combination of 50% FYM + 50% rural compost showed the significant effect on finger length (39.3 cm), finger width (29.9 cm), finger weight (563.5 g), fresh yield (16.0 t/ha), cured rhizome yield (3.3 t/ha), net return (₹ 324.30 × 10³ ha) and benefit:cost ratio (3.0), oleoresin content (5.26%), essential oil (3.96%) and crude fibre (4.95%) in rhizome over the other treatment combinations.

Key words: Crude fibre, Essential oil, Ginger, Oleoresin, Soil amendments

Ginger (*Zingiber officinale* Rosc.) is a tropical rhizomatous high value spice crop adopted for cultivation in tropical and subtropical climate. It is being produced in many countries but it does best in moist, tropical climatic conditions. The total production of ginger in the world is 1.683 million tons with the total acreage of 0.3104 million ha. China, India, Nepal and Thailand are the major producers of ginger, having production of 0.3966 million tonnes, 0.3853 million tonnes, 0.2108 million tonnes and 0.1726 million tonnes, respectively. India and Indonesia have the largest area under cultivation (FAO 2010). But the production of ginger in India remains low due to constraints like diseases and poor crop management. In Indian scenario, there was only marginal increase in acreage from 0.1086 million ha in 2008-09 to 0.1491 million ha in 2010-11 but the production however increased from 0.3801 million tonnes in 2008-09 to 0.702 million tonnes in 2010-11 (Indian Horticulture Database 2011). The region with the subtropical climate, where ginger production is the main cash crop,

has tremendous potential for increasing its production. The North East region of India accounts for 37% of area under ginger and contributes to 48.5% of the total production in the country (Kalyan Das 2016). One possible reason for its low yield in North Eastern region could be the inadequate nutrient management practices. Considering the increasing demand for organic products all over the world, the ginger farmers can receive higher returns from their produce if grown organically. Farmers of this region apply only locally available animal origin manures (e.g. cow dung manure, pig manure, poultry manure and rabbit manure) for ginger production. Ginger is a long duration crop and needs balanced supply of nutrients for longer period for better quality and higher production of ginger rhizome that can be supplied through organic sources. Thus, there is need to utilize locally available organic sources of plant nutrients like-organic manures, poultry manure, pig manure, goat manure, rural compost etc. as they constitute dependable sources of plant nutrients rather than chemical fertilizers that deteriorate the soil quality. Therefore, this study was conducted to find out the effect of organic nutrient sources on productivity, profitability and quality traits of ginger.

MATERIALS AND METHODS

This study was conducted at Krishi Vigyan Kendra-East Sikkim, Ranipool during three consecutive years of 2013 to

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2016. The study site was located at 27.3084°N, 88.6724°E and at an altitude of 950 m amsl. The temperature, relative humidity and rainfall recorded during study years are given in Fig 1. The soil was slightly acidic having pH 5.6, with higher soil organic carbon (1.42%), low available nitrogen (246.2 kg/ha), phosphorous (32.6 kg/ha) and potassium (198.5 kg/ha). Healthy rhizome of ginger bits of 50 g size were planted in the 1st week of April in three respective years at spacing of 30 cm × 45 cm. Experiment was laid out in randomized block design with 3 replications. The treatment consisted of FYM @ 10 t/ha (T_1) (0.5%N - 0.2%P - 0.5%K), rural compost @ 3 t/ha (T_2) (1.8%N - 0.5%P - 1.5%K), pig manure @ 4t/ha (T_3) (1.3%N - 0.3%P - 1.2%K), goat manure 2 t/ha (T_4) (3%N - 1%P - 2%K), poultry manure @ 2 t/ha (T_5) (3.03%N - 2.63%P - 1.4%K), 50% FYM + 50% rural compost (T_6), 50% FYM + 50% pig manure (T_7), 50% FYM + 50% goat manure (T_8), 50% FYM + 50% poultry manure (T_9), 50% rural compost + 50% pig manure (T_{10}), 50% rural compost + 50% goat manure (T_{11}), 50% rural compost + 50% poultry manure (T_{12}), 50% pig manure + 50% goat manure (T_{13}), 50% pig manure + 50% poultry manure (T_{14}), 50% goat manure + 50% poultry manure (T_{15}) and without manure i.e. control (T_{16}). All the organic sources of the nutrient were applied as basal as per the treatment 10 days prior to planting. The rhizome bits were treated with *Trichoderma viride* @ 5 g/kg prior to planting. Ginger cv. Bhaise bits weighing about 50 g were planted on raised bund of 15 cm height and 60 cm width. Rhizomes were planted at a spacing of 45 cm × 45 cm row to row and 25 cm × 25 cm plant to plant distance in two rows system in 9.6 m² plot size. The bio-mulching was done with green leaves of *Schima wallichii* and *Alnus nepalensis* and shrubs *Artemisia vulgaris* and *Eupatorium odoratum* @ 10 t/ha at the time of planting. It was repeated @ 5 t/ha at 40th and 90th day after planting immediately after weeding. Five sprays of each COC @ 0.5% and neem based formulation @ 0.7% were applied at weekly intervals for crop protection as per the organic package of practices recommended for the state. Response of treatments were evaluated in terms of plant

height, nos. of leaves/plant, nos. of tillers/clump, leaf size at maximum growth stage (150 days after planting) and yield parameters, viz. finger size, finger weight, fresh yield and cured yield. Estimation of essential oil (%), oleoresin (%) content and crude fibre (%) were estimated by standard soxhlet extraction method. Fisher's method of analysis of variance was applied for data analysis as given by Panse & Sukhatme (1967). The level of significance used in 'F' and 'T' test was at P=0.05. The economic analysis of different organic manures was worked out based on corresponding cost of inputs and prevailing market prices.

RESULTS AND DISCUSSION

Effect on physio-morphological characters: The results under present investigation revealed significant difference for all the traits over control (Table 1). The plant height significantly increased with the application of organic manures as compared to control. The combination of two sources 50% pig manure + 50% poultry manure registered significantly maximum plant height (109.0 cm) followed by 50% FYM + 50% goat manure (108.0 cm), 50% rural compost + 50% poultry manure (106.3 cm). The lowest plant height (47.0 cm) was recorded with control condition. Since, the plant height is an important yield attribute in ginger, any practice to alter the plant height would influence the rhizome yield (Vincent 1980). Similar results are also reported by Singh *et al.* (2009) in ginger and Balkrishnamurthy *et al.* (2009) in turmeric. This may be due to increased uptake of nitrogen which being the constituent of protein and protoplasm, vigorously induces the vegetative development of the plant. The increased water holding capacity, reduction of bulk density, improved particle density, pore space, texture and soil available nutrient status favorably influenced the root growth and development, thereby indirectly influencing the increased plant height.

The numbers of tillers per plant significantly increased with the application of 50% pig manure + 50% poultry manure over rest of the application sources and control. The application of 50% pig manure + 50% poultry manure gave

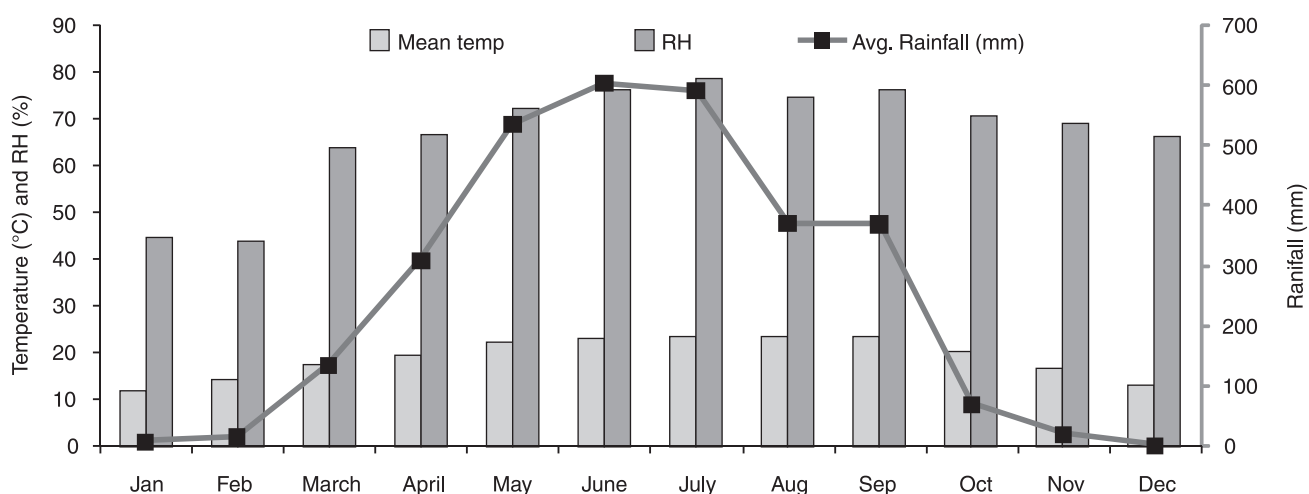


Fig 1. Average mean weather data of three consecutive years

Table 1 Effect of organic nutrient sources on physio-morphological characters of ginger

Treatment	Plant height (cm)	Tillers/ clump	Leaves/ tiller	Leaf size (cm ²)	Finger length (cm)	Finger width (cm)	Finger weight (g)	Fresh yield (t/ha)	Cured yield (t/ha)
FYM @ 10 t/ha	91.3	12.6	15.6	26.4	36.1	25.5	467.0	12.6	1.9
Rural compost @ 3 t/ha	92.0	12.0	15.3	25.5	32.2	24.0	434.5	12.2	1.9
Pig manure @ 4 t/ha	94.6	14.3	16.0	24.5	26.9	21.0	384.4	11.4	1.7
Goat manure @ 2 t/ha	89.3	14.0	15.3	22.4	25.3	19.0	357.4	10.8	1.7
Poultry manure @ 2 t/ha	96.6	15.3	17.3	24.8	25.0	20.8	340.5	10.3	1.6
50% FYM + 50% Rural compost	104.0	15.3	17.6	25.7	39.3	29.9	563.5	16.0	3.3
50% FYM + 50% Pig manure	101.0	13.3	16.0	30.1	34.4	25.5	498.4	13.2	2.4
50% FYM + 50% Goat manure	108.0	15.0	17.3	30.6	37.1	28.7	546.8	15.5	3.0
50% FYM + 50% Poultry manure	104.6	14.3	17.0	29.7	35.4	27.3	520.4	15.0	2.9
50% Rural compost + 50% Pig manure	101.6	14.0	17.0	29.3	33.2	25.8	521.7	14.4	2.6
50% Rural compost + 50% Goat manure	99.0	13.6	16.0	27.8	31.0	24.1	515.1	13.7	2.3
50% Rural compost + 50% Poultry manure	106.3	14.6	17.3	30.2	36.4	28.2	524.3	15.5	2.9
50% Pig manure + 50% Goat manure	104.3	14.3	16.6	26.8	28.5	22.6	498.0	12.7	1.9
50% Pig manure + 50% Poultry manure	109.0	16.3	17.9	30.9	27.3	25.4	439.8	11.6	1.8
50% Goat manure + 50% Poultry manure	100.6	15.0	16.0	25.2	28.9	21.7	471.2	12.8	1.9
Control	47.0	8.6	10.0	15.9	17.1	13.2	187.0	3.6	0.5
CD (P= 0.05)	2.29	0.94	1.09	1.50	1.58	1.25	13.9	0.39	0.23

the maximum number of tillers per plant (16.3) which was significantly higher to all sources. The lowest number of tillers (8.6) was recorded with control. Since, the number of tillers is also an important yield contributing character in ginger, it influences the yield and mother rhizome as reported by Balkrishnamurthy *et al.* (2009) in turmeric, Singh *et al.* (2009) in ginger and Singh (2013) in turmeric. The number of leaves per tiller was significantly different with all the organic nutrient sources as compared to control. Combination of 50% pig manure + 50% poultry manure recorded maximum number of leaves per tiller (17.9) which was at par with 50% FYM + 50% rural compost (17.6), poultry manure @ 2 t/ha (17.3), 50% FYM + 50% goat manure (17.3), 50% and rural compost + 50% poultry manure (17.3). The lowest number of leaves (10.0) was noticed under the control condition.

The combination of organic nutrient sources 50% pig manure + 50% poultry manure produced the largest size of leaves (30.9 cm²) followed by 50% FYM + 50% goat manure (30.6 cm²), 50% rural compost + 50% poultry manure (30.2 cm²), 50% FYM + 50% pig manure (30.1 cm²), 50% FYM + 50% poultry manure (29.7 cm²) and 50% rural compost + 50% pig manure (29.3 cm²). This might be due to the adequate release and supply of nutrients from the manures which ultimately resulted in triggering the production of plant growth hormones, viz. Indole-3-

acetic acid and other hormones. The present findings are in consonance with the previous observation of Cosenova *et al.* (1999), Singh *et al.* (2009) in ginger, Sanker *et al.* (2009) and Singh (2013) in turmeric.

Effect on yield and yield attributing characters: The results under present investigation revealed significant differences in ginger finger length, finger width, finger weight, fresh yield and cured yield. The maximum ginger finger length (39.3 cm), finger width (29.9 cm), finger weight (563.5 g), fresh yield (16.0 t/ha) and cured yield (3.3 t/ha) were recorded with application of 50% FYM + 50% rural compost. On the other hand, among the different sources, the lowest ginger finger length (17.1 cm), finger width (13.2 cm), finger weight (187.0 g), fresh yield (3.6 t/ha) and cured yield (0.5 t/ha) were recorded with poultry manure @ 2 t/ha but it was significantly higher with control (Table 1). Farmyard manure improves the structure of the soil by more aggregation, water holding capacity and air permeability. These comprehensive changes in soil might have improved the rhizome development. All these comprehensive changes paved the way for greater fresh and average weight of rhizomes. Further, the reduced loss of nitrogen by ammonia volatilization and narrow C:N ratio might have also contributed to the better performance of crop supplied with farm yard manure (Kirchmann and Witter 1992). Another possible reason for pronounced

Table 2 Effect of organic nutrient sources on qualitative traits of ginger

Treatment	Oleoresin (%)	Essential oil (%)	Crude fiber (%)
FYM @ 10 t/ha	5.06	3.79	4.75
Rural compost @ 3 t/ha	4.90	3.30	4.17
Pig manure @ 4 t/ha	4.86	3.38	4.12
Goat manure @ 2 t/ha	4.86	3.53	4.64
Poultry manure @ 2 t/ha	5.03	3.83	4.81
50% FYM + 50% Rural compost	5.22	3.81	4.84
50% FYM + 50% Pig manure,	4.91	3.53	4.24
50% FYM + 50% Goat manure,	5.18	3.79	4.75
50% FYM + 50% Poultry manure,	5.24	3.90	4.94
50% Rural compost + 50% Pig manure,	5.19	3.85	4.78
50% Rural compost + 50% Goat manure,	5.05	3.60	4.61
50% Rural compost + 50% Poultry manure,	5.26	3.96	4.95
50% Pig manure + 50% Goat manure,	5.20	3.83	4.88
50% Pig manure + 50% Poultry manure	4.64	3.17	4.54
50% Goat manure + 50% Poultry manure	5.05	3.73	4.84
Control	4.50	3.09	4.03
CD. (P=0.05)	0.25	0.15	0.07

yield improvement in organic treatment might be due to sustained availability of nitrogen throughout the growing phase and also due to enhanced carbohydrate synthesis and effective translocation of these photosynthates to the sink i.e. rhizome, while at lower fertility levels plants remained stunted resulting in decreased yield.

Effect on quality: Different organic soil amendments exerted favourable effect on quality of ginger rhizome. All the organic nutrient sources showed the positive impact on the improvement of all the quality traits on ginger rhizome (Table 2). Combination of 50% rural compost + 50% poultry manure showed very significant effect and contained the highest oleoresin content (5.26%), essential oil (3.96%) and crude fibre (4.95%) in rhizome and thereby improved its quality over control (4.5%) oleoresin content, (3.09%) essential oil and (4.03%) crude fibre. The application of 50% FYM + 50% poultry manure recorded oleoresin content (5.24%), essential oil (3.90%) and crude fibre (4.94%). The essential oil content and crude fibre content in rhizome, however, did not vary much among the different treatments during the investigation. Similar findings are also reported by Jyotsna *et al.* 2013 in ginger.

Effect on economics: The effect of organic nutrient

Table 3 Economics of different organic nutrient sources on ginger cv. Bhaise ginger production under different organic nutrient management

Treatment	Gross cost (10 ³ ₹/ha)	Net Return (10 ³ ₹/ha)	B:C Ratio
FYM @ 10 t/ha	160.00	219.80	2.4
Rural compost @ 3 t/ha	155.00	212.80	2.4
Pig manure @ 4 t/ha	160.00	182.90	2.1
Goat manure @ 2 t/ha	157.50	167.40	2.1
Poultry manure @ 2 t/ha	170.00	139.90	1.8
50% FYM + 50% Rural compost	157.50	324.30	3.0
50% FYM + 50% Pig manure,	160.00	236.90	2.5
50% FYM + 50% Goat manure,	165.00	300.90	2.8
50% FYM + 50% Poultry manure,	167.50	283.40	2.7
50% Rural compost + 50% Pig manure,	157.50	274.50	2.7
50% Rural compost + 50% Goat manure,	162.50	249.40	2.5
50% Rural compost + 50% Poultry manure,	165.00	300.00	2.8
50% Pig manure + 50% Goat manure,	165.00	216.99	2.3
50% Pig manure + 50% Poultry manure	167.50	181.40	2.1
50% Goat manure + 50% Poultry manure	172.50	212.49	2.2
Control	125.90	110.80	1.8

treatments on gross return, net return and B:C ratio had very modest effect on cost of cultivation of ginger (Table 3). The study revealed that the combined use of FYM + 50% rural compost showed significant effect on net return (₹ 324.30 × 10³/ha) and benefit: cost ratio (3.0) as compared to control plots (₹ 110.8 × 10³/ha and 1.8, respectively). Application of 50% rural compost + 50% poultry manure resulted in reasonably good net return (₹ 300.0 × 10³/ha) and B:C ratio of 2.8. These treatment combinations were found to exert the maximum additive and synergistic microbial effects on enhancing growth, productivity and economic return of rainfed organic ginger in the north-eastern region of India.

The results of this study concluded that the combination of two organic nutrient sources greatly affected the parameters of growth and yield of ginger rhizome cv. Bhaise. Among different treatments, 50% farmyard manure + 50% rural compost gave the best response to all yield attributes, yield, economic returns and B:C ratio. Similarly, combination of 50% rural compost + 50% poultry manure showed very significant effect and had the highest oleoresin content, essential oil and crude fibre in rhizome and thereby, improved its quality. Hence, these two treatment combinations may

be recommended for high yield, economic returns and improved quality traits in the ginger growing areas of North Eastern Himalayas.

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