Influence of organic amendments on ginger (*Zingiber officinale* rosc.) growth, yield and economics

ABSTRACT

The present investigation *i.e.*" Effect of organic amendments on growth yield and economics of ginger (*Zingiber officinale* Rosc.)" was conducted during the year 2020-22 at the Horticultural Research Station, Mondouri, BCKV, Nadia, West Bengal. The variety Gorubathan was selected for this study. The experiment was laid out in randomized block design. Raised beds of 3.0 m x 1.0 m and 15 cm in height were prepared. The main objective was to study the influence of organic amendments on growth, yield and economics of ginger. There were altogether five combinations of FYM and neem cake with six replications namely FYM@ 15t ha-1 + neem cake@ 1t ha-1(T1), FYM @15 t ha-1+ neem cake@ 2t ha-1 (T2), FYM@ 15 t ha-1 + neem cake@ 3 t ha-1(T3), FYM@ 23 (15+8) t ha-1 (T4) and (FYM @ 15t ha-1 (T5). Application of FYM @15t ha-1 + neem cake@ 3 t ha-1, (e.g. T3) recorded maximum plant height of 39.68 cm, 65.33cm and79.58cm at 90,150 and 180 days after planting. At harvest T3 recorded maximum weight of 191.91g per clump, 3.63 primary fingers 4.22, secondary fingers, and highest projected yield (24.49t ha-1) respectively. Highest B: C ratio of 2.35 along with maximum net return of Rs 687341 ha-1 was recorded in the combination of FYM @15t ha-1 + neem cake@ 3 t ha-1, (T3).

Considering all the parameters it may be concluded that FYM@15t ha-1+neem cake@ 3tha-1 (T3) was the most effective organic treatment combination for obtaining maximum profit from ginger and may be recommended.

Keywords: FYM, ginger, neem cake, growth, yield, B:C ratio

1. INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) belongs to the family Zingiberaceae, ~~The~~ the plant is indigenous to South Eastern Asia which has warm tropical climates with long growing periods. Ginger has been prized for its aroma, flavor, pungency and medicinal properties since ancient times. Commonly used as a spice for over 2000 years and contains characteristic odour and flavor such as the pungent taste. Rhizomes of ginger plants have been widely used as spices or condiments. Ginger is a perennial herb with tuberous or rhizomatous roots. The plant is widely cultivated all over India, Bangladesh, Taiwan, Jamaica and Nigeria. This perennial grows in warm climates [10].

Fresh ginger has 80.9 percent moisture, 2.3 percent protein, 0.9 percent fat, percent minerals, 2.4 percent fiber, and 12.3 percent carbohydrates, while powdered rhizome has 3-6 percent fatty oil, 9 percent protein, 60-70 percent carbohydrates, 3-8 percent crude fiber, about 8% ash, 9-12 percent water, 4-7.5 percent oleoresin and percent volatile oil. It also contains minerals such as iron, calcium, and phosphorus, as well as vitamins such as thiamine, riboflavin, niacin, and vitamin C, as well as pungent compounds such as gingerol, shogaol, zingerone, and paradol. The development of appropriate production technology to increase crop output is necessary, as the yield potential of a variety alone is insufficient [14].

Ginger is a long-term crop that requires a steady supply of nutrients over time to produce high-quality ginger rhizomes, which can be obtained from organic sources. Thus, rather than using chemical fertilizers that degrade soil quality, it is necessary to use locally accessible organic sources of plant nutrients such as organic manures, poultry manure, pig manure, goat manure, rural compost, and so on. Inadequate or imbalanced nutrient supply is one of the major constraints in augmenting fresh rhizome yields. Organic sources can supply balanced nutrients. Application of different organic sources such as farm yard manure, vermicompost and neem cake results in high yield and quality rhizomes of turmeric [9]. This will not only be helpful for sustainable agricultural development but will also avoid chemical-based farming. Furthermore, consistent and indiscriminate use of inorganic fertilizers has caused severe damage to the soil and ecology.

Organic manure application has several benefits, including improving soil physical properties, water holding capacity and organic carbon content, in addition to providing high-quality nutrients [12]. Because of the global demand for organic foods, the improvement of soil health and productivity and the availability of local resources, organic farming can be encouraged. A few reports on the use of organic manures and inorganic fertilizers in ginger have also been documented. [5,13,7].

2. MATERIALS AND METHODS

The field work was carried out during 1st fortnight of March to1st fortnight of December in two consecutive years (2020-2022) at HRS, Mondouri, BCKV, Nadia, WB and the laboratory work was carried out in the Departmental lab of Plantation, Spices, Medicinal and Aromatic Crops, Faculty of Horticulture, BCKV as per schedule. The soil of the experimental plot was well drained clay loam texture, with good water holding capacity, having pH of 6.5 with moderate soil fertility status. To prepare raised beds (15 cm) repeated ploughing at a depth of 30 cm was given to make the soil friable and pulverized. Properly sprouted well-developed healthy and disease free ginger rhizomes were selected as planting material. For seed treatment, the seed rhizomes were dipped in *Trichoderma* solution (@4g l^{-1}) for six hours. Treated seed rhizomes were then planted in the raised beds on 1st fortnight of March (2020 and 2021) ~~in~~ at a depth of 3-4 cm with a spacing of 25 x 20 cm. Soil drenching was done immediately after planting with *Trichoderma viride* solution @4g l^{-1}. Routine soil drenching was continued up to harvest at monthly intervals to check any soil borne pathogen attack as ginger is mostly susceptible to rhizome rot disease.

There were altogether five treatment combinations in randomized block design with six replications namely T_1 (FYM@15 t ha^{-1} + neem cake@1t ha^{-1}), T_2 (FYM @15 t ha^{-1}+ neem cake@2 t ha^{-1}), T_3 (FYM@15 t ha^{-1} + neem cake@3 t ha^{-1}), T_4 (FYM@23 (15+8) t ha^{-1}) and T_5 (FYM@15tha^{-1}). In general FYM @ 15 t ha^{-1} was applied in all plots in three splits *i.e*. half as a basal dose during final land preparation and the rest in two equal splits at 30 and 60 DAP. As per treatment neem cake @ 1, 2 and 3 t ha^{-1} was applied in two split doses at 30 and 60 days intervals. An additional quantity of FYM @ 8 t ha^{-1} was also added in two halves as T_4 and mixed up thoroughly in the soil. The crop was mulched immediately after sowing with paddy straw to enhance the uniform germination of the seed rhizomes and to check weed growth. Earthing up was done immediately after application of 1st split dose of manure in order to cover the exposed young rhizomes. Later on, mulching of each bed was done with green manuring dhaincha plants at 45 and 90 DAP. The crop was first irrigated 3-5 days after planting. Based on the soil moisture conditions, and rainfall further irrigation was given as per the requirement of the crop. Hand weeding was done twice at the initial stage after sowing at an interval of 30 days. Matured rhizomes were harvested during first fortnight of December, cleaned after removing the adhering soil, roots and other foreign matters. Five plants from each plot were randomly selected, tagged and growth parameters like plant height (cm) and number of tillers $clump^{-1}$ were recorded at 90, 120, 150 and 180 DAP and the mean data was calculated. Yield parameters like mean weight of clump (g), length and breadth of the clump (cm), primary and secondary number of fingers, length and breadth of primary and secondary fingers (cm) were recorded from randomly selected five clumps.

Total quantities of rhizomes from the replicated plots were weighed to obtain yield plot^{-1}. The projected yield per hectare was calculated based on yield per plot, considering 80% area occupied by ginger [1].

The prices of the inputs that were prevailing at the time of their use were considered to work out the cost of cultivation. Gross income was calculated by multiplying the rhizome yield by the prevailing market price of the rhizome. Net income per hectare was calculated by subtracting the cost of cultivation from gross income. The Benefit: Cost ratio was worked out by using the following formula. The data collected were subjected to statistical analysis of variance. Fisher and Snedecor's 'F' test at probability level of 0.05 was used to verify the significance of different sources of variation. For the determination of critical difference (C.D.) at 5% level of significance, [3] tables were consulted.

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant height

The mean data on height of the plants were recorded at different growth stages of the crop (90, 120, 150 and 180 DAP) showed significant variation among the treatments. Plots treated with FYM @15t ha $^{-1}$+neem cake @3 t ha $^{-1}$(T3) recorded highest plant height of 39.68 cm, 65.33cm and 79.58cm at 90,150 and 180 DAP respectively, whereas at 120 DAP T2(FYM @ 15t ha^{-1}+neem cake @ 2t ha^{-1}) showed maximum plant height of 49.71cm, while control (FYM @15t ha $^{-1}$) recorded lowest at all crop growth stages as shown in Table 1.

3.1.2 Number of tillers plant^{-1}

The data presented in Table 1 showed that the mean number of tillers per plant was significantly influenced by different treatments. At 180 DAP, FYM @15t ha^{-1} +neem cake @ 3 t ha $^{-1}$(T3) recorded highest 14.49 number of tillers per plant which was on par with all other treatments except in T5 (4.81numbers). The data also indicated that at all stages, application of FYM @ 15t ha $^{-1}$+ neem cake @3 t ha $^{-1}$ recorded higher number of tillers per plants. The application of FYM @ 15t ha $^{-1}$(T_5) resulted in lower number of tillers at 90,120,150 and 180 DAP, respectively.

Table 1: Effect of organic amendments on plant height and number of tillers per

clump in ginger (Mean of two year)

Treatments	Plant height (cm)				Number of tillers clump^{-1}			
	Days after planting				Days after planting			
	90	120	150	180	90	120	150	180
T1	32.28	43.89	54.09	72.06	6.28	8.43	10.35	12.72
T2	34.58	49.71	58.48	76.34	7.85	8.68	10.99	13.99
T3	39.68	46.6	65.33	79.58	7.91	9.02	11.07	14.49
T4	28.99	41.39	49.91	71.27	5.19	8.35	9.88	12.43
T5	24.75	38.63	47.58	68.47	4.81	8.24	8.96	11.74
S.Em (±)	0.36	0.38	0.43	0.52	0.13	0.05	0.13	0.32
(P=0.05)	1.06	1.13	1.28	1.54	0.39	0.15	0.4	0.94

(t1-@15t ha -1fym + 1t ha -1neem cake, t2- @15t ha -1fym + 2 t ha-1neem cake, t3-@15t ha –1 fym+ 3tha-1neemcake, t4 (@15+8=23tha-1fym and t5-@15tha -1fym)

3.2 Yield parameters

3.2.1 Clump weight

Data presented in Table 2 revealed that the mean weight of the clump was significantly influenced by the treatments. At harvest FYM @15t ha $^{-1}$+ neem cake @3 t ha^{-1}(T3) recorded the highest clump weight of 191.91g, which was on par with all other treatments except the application of farm yard manure (T$_5$). The application of FYM@15t ha^{-1} resulted lowest clump weight of 100.20 g only.

3.2.2 Length of the clump

With respect to the mean length of clump, the results were significant at all stages of plant growth (Table 2). However, the highest clump length of 16.89 cm was registered in T3 and the lowest of 12.01cm was noted in T5. The results indicated that the clump weight was significantly influenced by FYM and a higher dose of neem cake.

3.2.3 Breadth of the clump

The data on the influence of treatments on mean breadth of clump presented in Table 2 shows significant differences among the treatments. The application of FYM @15tha^{-1}produced lowest breadth of clump (7.89 cm). On the other hand, maximum 12.76 cm clump breadth was recorded in treatment T_3 involving FYM @ 15t ha $^{-1}$+ neem cake @3t ha^{-1}. The result indicated the superiority of higher quantity of neem cake in combination with FYM on the increased breadth of the clumps.

3.2.4 Number of primary fingers

The mean maximum 3.63 number of primary fingers was recorded in the combination of FYM @ 15t ha $^{-1}$ + neem cake @ 3t ha^{-1} (T3) and minimum of 2.33 numbers were registered by the control plot which was on par with the other treatment as shown inTable 2.

3.2.5 Length of primary fingers

It was evident from the data presented in Table 2 that in T_3 *i.e.* FYM and neem cake had a significant variation on the mean length of primary finger. However, in the sole effect of 15 t ha^{-1} FYM, the minimum (3.31 cm) length of primary finger was noticed.

3.2.6 Breadth of primary fingers

The treatments showed significant influence with respect to the mean breadth of the primary fingers at all stages of growth (Table 2). Maximum breadth of 2.54 cm of the primary fingers was recorded with 15t ha^{-1} FYM+3t ha^{-1} neem cake while the lower values (2.08 cm) were recorded by the plots receiving only 15t ha^{-1} of FYM (control) which was on par with the other treatments.

3.2.7 Number of secondary fingers

The data on mean number of secondary fingers were recorded after harvesting showed significant variations among the treatments (Table 2). TreatmentT_3 (e.g. 15t ha^{-1}FYM + 3t ha $^{-1}$ neem cake) recorded the highest number of secondary fingers (4.22), while only 15t ha $^{-1}$ FYM recorded lowest numbers of 2.84 only.

3.2.8 Length of secondary fingers

Significant variations in mean length of secondary fingers were observed in case of all the treatments. However, in T_3 a maximum of 8.70 cm was recorded at the time of harvesting whereas, minimum of 6.94 cm length of secondary finger was found in control plots (Table 2).

3.2.9 Breadth of secondary fingers

The treatment showed significant influence with respect to mean breadth of the secondary fingers at all stages of growth (Table 2). The mean maximum breadth of the secondary fingers was recorded in T_3 (5.80cm) followed by T_2 (5.59cm) and T_1 (5.23cm) while the lower values was recorded by the plots receiving 15t ha^{-1} FYM (4.90cm).

Table 2: Effect of organic amendments on clump, primary and secondary fingers characters in ginger (Mean of two years)

Treatments	Clump			Primary fingers			Secondary fingers		
	Weight (g)	Length (cm)	Breadth (cm)	Number	Length (cm)	Breadth (cm)	Number	Length (cm)	Breadth (cm)
T1	128.04	13.84	9.97	2.91	4.12	2.26	3.44	7.61	5.23
T2	169.32	15.16	11.93	3.53	4.76	2.45	4.08	8.33	5.59
T3	191.91	16.89	12.76	3.63	5.15	2.54	4.22	8.7	5.8
T4	107.28	13.04	8.2	2.68	3.91	2.19	3.15	7.35	5.15
T5	100.2	12.01	7.89	2.33	3.31	2.08	2.84	6.94	4.9
S.Em(±)	3.88	0.11	0.24	0.08	0.15	0.04	0.08	0.14	0.05
LSD(0.05)	11.17	0.33	0.72	0.25	0.43	0.11	0.23	0.4	0.14

(t1-@15t ha -1fym + 1t ha -1neem cake, t2- @15t ha -1fym + 2 t ha-1neem cake, t3-@15t ha –1 fym+ 3tha-1neemcake, t4(@15+8=23tha-1fym and t5-@15tha -1fym)

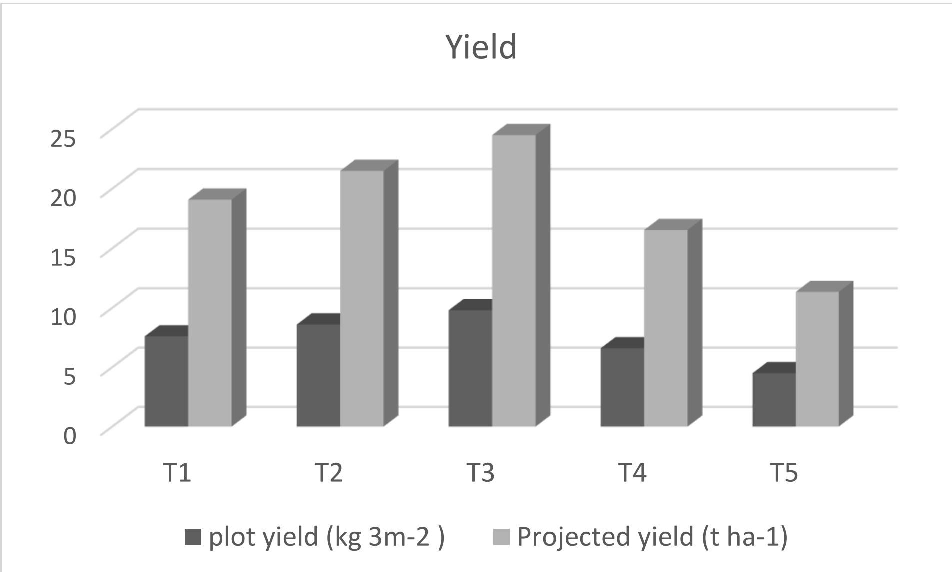
3.2.10 Yield per plot

An increasing trend in yield $plot^{-1}$was observed with increasing the quantity of neem cake along with farm yard manure. Maximum mean plot yield of 9.8 kg $3m^{-2}$ was observed in the treatment T3 followed by T2 (8.6kg$3m^{-2}$), T1 (7.6kg$3m^{-2}$) and T4 (6.6kg$3m^{-2}$). However, minimum yield (4.5kg$3m^{-2}$) was recorded in T5 (Fig 1).

3.2.11 Projected yield/ha

Data presented in Fig 1 on the effect of organic amendments on projected yield per hectare clearly indicated that the rhizome yield has differed significantly among the treatments. T_3 recorded the highest projected rhizome yield of 24.49tha^{-1} followed by T_2 (21.49 t ha^{-1}) while T_5 recorded a minimum yield of 11.34 t ha^{-1}. It is important to point out here that during the whole period of study no rhizome rot infection was observed in the field which may be due to the application of *Trichoderma viride* solution @4g l^{-1}through seed treatment and soil drenching on regular basis.

Fig 1: Effect of organic amendments on yield in ginger (Mean of two years)



3.2.12 Economics

The economic assessment of the different treatment combinations were done on the basis of the cost of inputs, gross return, net return, and prevailing market price of the ginger rhizomes during the period of experimentation. From Table 3 it is clear that the highest B: C ratio of 2.35 was recorded under the treatment T3 along with maximum net returns of Rs.687341 ha^{-1} followed by T2 (2.28 and Rs.597261ha^{-1} respectively).

Table 3: Effect of organic amendments on economics in ginger (Mean of two years)

Treatments	Grossreturns Rsha^{-1}	Expenditure Rsha^{-1}	Netreturns Rsha^{-1}	Benefit:Cost ratio
T1	763240	238819	524421	2.2
T2	859520	262259	597261	2.28
T3	979600	292259	687341	2.35
T4	661560	210259	451301	2.15
T5	453600	202259	251341	1.24

(t_1-@15t ha -1fym + 1t ha -1neem cake, t_2- @15t ha -1fym + 2 t ha-1neem cake, t_3-@15t ha –1 fym+ 3tha-1neemcake, t4–(@15+8=23tha-1fym and t5-@15tha - 1fym)

(Cost of Inputs: FYM@ Rs1000 t^{-1},*Trichoderma* @ Rs 200 kg^{-1} , Man days @ Rs 328 day^{-1} Neem cake @ Rs 30000 t^{-1} , Seed rhizome @ Rs100 kg^{-1}, Diesel @ Rs 89.8 l^{-1} and Selling price of ginger @ Rs40kg^{-1})

Discussion

From the present study, it was observed that organic amendments had a consistent effect on all the growth and yield parameters of ginger. Results presented in Table 1 indicated that the application of FYM @15t ha^{-1}+3t ha^{-1}neem cake (T_3) recorded highest plant height of 39.68cm, 65.33cm, 79.58cm, at 90,150 and 180 DAP, respectively while T_2 recorded highest plant height at 120 DAP (49.71). The mean number of tillers per plant (7.91, 9.02, 11.07, 14.49 at 90, 120, 150 and 180 DAP, respectively) as shown in the (Table 1). FYM which is regarded as a balanced source of macro and micro nutrients and neem cake with 5.2% N, 1.0% P and 1.4% K might have contributed to the increased growth of plants. Similar results were reported by Sharu [11] that the growth attributes like plant height and number of tillers in ginger as a result of neem cake application was found to be on par with plants received manuring as per the package of practices recommendation of KAU. While studies done by Mishra [6] reported that farm yard manure applied @5t ha^{-1} produced highest germination percentage including maximum plant height and number of fingers in ginger. In case of yield, the maximum yield was recorded in the plots which were applied with the highest quantity of neem cake along with FYM in T_3 (9.8 kg 3m^{-2}), followed by T_2 (8.6 kg 3m^{-2}) and T_1 (7.6 kg 3m^{-2}) and minimum (4.5 kg 3m^{-2}) was recorded in T_5. The results are in accordance with the findings of Jadhav *et al* [4] where they reported that there was an increase in the yield of rice due to an increase in the number of productive tillers per hill, number of grains per panicle with an application of 75 kg N per ha with 33 kg neem cake. Sadanandan and Iyer [8] observed a reduction in rhizome rot and an increase in the yield of ginger when neem cake was applied @ 2 t ha^{-1}. It also added organic carbon and potash to the soil.

4. Conclusion

Considering the growth and yield of Ginger it was found that FYM @ 15 t ha^{-1}+neem cake @ 3 tha^{-1} was the most effective treatment combination for getting maximum profit and may be recommended.

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Appendices

Details of soil at the experiment site

The soil of the experiment at the field was Gangetic Alluvial sandy clay loam texture, well-drained, good water holding capacity with moderate soil fertility status.

Appendices – 1 Physico-chemical properties of the soil at the experiment site.

Properties	Particulars	Value	Methods used
Physical Properties	Sand	54.25%	International pipette (Piper, 1996)
	Silt	30.20%	
	Clay	14.30%	
	pH	5.74	pH meter, (Jackson, 1996)
	Organic carbon (%)	0.85	(Walkey and Black, 1967)
Chemical Properties	N (kg/ha) (A)	207	Modified Kjeldhal's (Jackson, 1973)
	P_2O_5(kg/ha) (A)	380.1	Modified Olsen (Jackson, 1973)
	K_2O (kg/ha) (A)	526.6	Flame photometer (Jackson, 1973)
	S (mg/ha) (A)	60.18	
	Zn (mg/ha) (A)	1.66	
	Ca (mg/ha) (A)	949.55	
	B (mg/ha) (A)	0.44	

CLIMATIC CONDITION

The climatic condition of the experimental site is sub-tropical sub humid. The details of metrological parameters during the experimental period of (march,2021- march, 2022) have been presented below.

Appendices – 2 Meteorological parameters during the cropping period of experimentation March 2021 to March 2022

Month	Temperature (^{0}C)		Total rainfall (mm)	Relative humidity (%)		Sun shine hours
	Max.	Min.		Max.	Min.	
Mar-21	35.98	20.78	0.00	86.54	33.14	6.92
Apr -21	37.01	24.63	0.86	84.23	41.16	8.26
May -21	34.24	24.73	11.37	89.57	66.04	6.61
Jun -21	32.67	25.85	11.94	93.53	77.69	3.77
Jul -21	32.60	26.28	8.18	94.48	79.42	3.63
Aug -21	32.88	26.39	7.36	94.93	77.35	3.94
Sep -21	31.76	25.61	8.51	93.90	77.68	4.34

Oct -21	31.29	23.32	5.66	93.24	69.40	6.03
Nov -21	28.40	17.61	20.7	90.06	57.03	6.67
Dec -21	24.48	14.11	14.0	91.79	62.6	4.92
Jan -22	23.65	12.39	25.8	92.26	60.38	5.15
Feb -22	26.70	13.10	0.98	90.76	49.95	7.44
Mar-22	34.30	20.98	0.00	90.54	45.29	8.21

(Source: AICRP, Agrometeorology, BCKV Mohanpur)