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Influence of Organic Amendments on Ginger (*Zingiber officinale* rosc.) Growth and Yield

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation 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-

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1(T3), FYM@ 23 (15+8) t ha-1 (T4) and FYM @ 15t ha-1 (Control). 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. In view of the world demand for organic food, the improvement of soil health, productivity and the availability of local resources, cultivation under organic farming can be encouraged.

Keywords: FYM; ginger; organic; neem cake; growth; yield; B:C ratio.

1. INTRODUCTION

Ginger is botanically known as Zingiber officinale Rosc., belongs to the family Zingiberaceae, the plant is indigenous to South Eastern Asia. The plant is widely cultivated all over India, Bangladesh, Taiwan, Jamaica and Nigeria and this perennial herb grows in warm climates [1].

Ginger is one among the five important major spices of India, which play on important role in national economy. Ginger is widely spread out in tropical and subtropical countries. It grows up to 3-4 feet in height with thick spreading tuberous rhizomes. It is valued as a commercial crop, which is grown for its aromatic rhizomes and primarily being used as a spice and medicine [2]. Ginger has been used as a spice and as natural additive for more than 2000 years [3].

Fresh ginger contains 80.9% moisture, 2.3% protein, 0.9% fat, 1.2% minerals, 2.4% fibre and 12.3% carbohydrates and powdered rhizome contains 3-6% fatty oil, 9% protein, 60-70% carbohydrates, 3-8% crude fibre, about 8% ash, 9-12% water, 4-7.5% oleoresin and 2-3% volatile oil. It also contains minerals like iron, calcium and phosphorous and vitamins like thiamine, riboflavin, niacin and vitamin C and pungent substances, namely gingerol, shogaol, zingerone and paradol [4]. The chief constituent of ginger oil from dried ginger is zingiberine (38.6%), a sesquiterpene hydrocarbon. In traditional Chinese and Indian medicine, ginger is used to treat a wide range of ailments, including stomachaches, diarrhea, nausea, asthma and respiratory disorders [5]. The development of appropriate production technology to increase crop output is necessary, as the yield potential of a variety alone is insufficient [6].

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 [7]. 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 [8]. 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 [9-11].

Combined application of different organic sources such as the farmyard manure, vermicompost and neem cake results in to high yield and quality rhizomes of turmeric [7]. It 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.

Keeping the importance in view and the lack of consorted work under West Bengal conditions the present study was undertaken to investigate the effect of organic manures, on growth and yield by ginger crop.

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 Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, West Bengal 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 research station is located approximately at 23.5°N latitude, 89°E longitude having an average altitude of 9.75 m from the sea level.

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 done 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) 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.

sThere 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 Control (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. 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. As per treatment neem cake @ 1, 2 and 3 t $ha^{-1}$was applied in two split doses at 30 and 60 days intervals. 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 [12].

2.1 Economics

The cost of inputs such as FYM, seed rhizome. Neem cake, and output (rhizomes) were estimated as per prevailing market price. The gross return, net return and return invested in different treatments were assessed by computing the cost of the inputs and price of the produce (output) to study the economics of organic ginger production. 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 data collected were subjected to statistical analysis of variance. Fisher's method of the analysis of variance as given by Panse and Sukhatme (1967) was applied for analysis and interpretation of data. The level of significance used in the 'F' was at P = 0.05 and critical difference (CD) values were worked out whenever the 'F' test was significant.

Plate 1. General view of experimental plots

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant height

The mean data on height of the plants 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 $^{-1}$(Control) resulted in lower number of tillers at 90,120,150 and 180 DAP, respectively.

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 (Control). 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 Control. 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 in Table 2.

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
Control	**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**
LSD(0.05)	**1.06**	**1.13**	**1.28**	**1.54**	**0.39**	**0.15**	**0.4**	**0.94**

(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 control -@15tha -1fym)

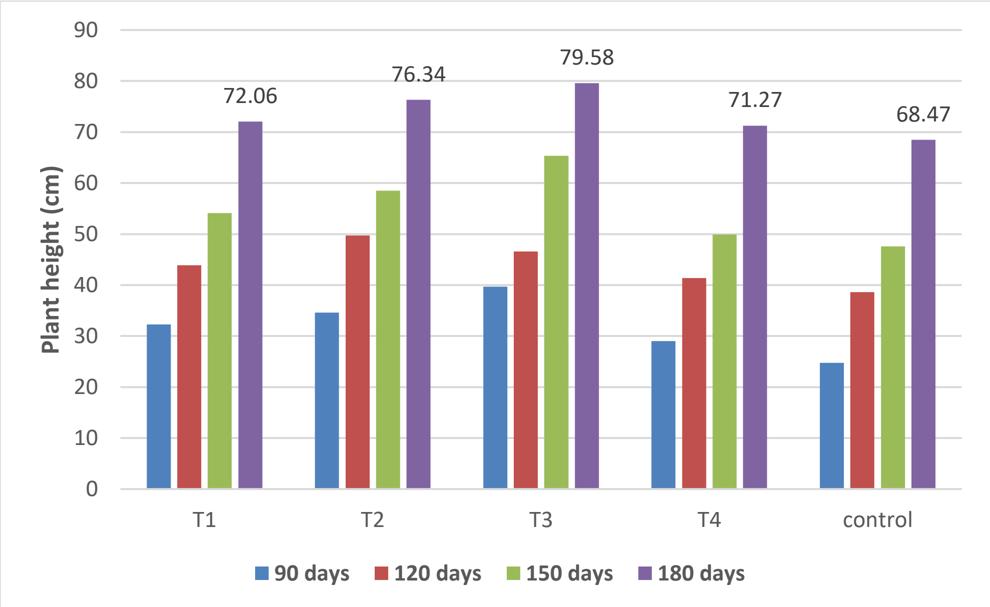

Fig. 1. Effect of organic amendments on plant height of ginger at different stages of growth

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
Control	**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**

(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 control -@15tha -1fym)

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).

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 Control (Fig. 2).

3.2.11 Projected yield/ha

Data presented in Table 3 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 Control 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.

Table 3. Effect of organic amendments on yield and economics in ginger (Mean of two years)

Treatment	Yield plot^{-1} (kg $3m^{-2}$)	Projected Yield (t ha^{-1})	Gross returns Rsha^{-1}	Expenditure Rsha^{-1}	Net returns Rsha^{-1}	Benefit :Cost ratio
T_1	7.6	19.08	763240	238819	524421	2.20
T_2	8.6	21.49	859520	262259	597261	2.28
T_3	9.8	24.49	979600	292259	687341	2.35
T_4	6.6	16.54	661560	210259	451301	2.15
Control	4.5	11.34	453600	202259	251341	1.24
S. Em(±)	0.01	0.01	-	-	-	-
LSD(0.05)	0.03	0.02	-	-	-	-

(Cost of Inputs: FYM @ Rs 1000 t^{-1},Trichoderma@ Rs 200 kg^{-1} , Man days @ Rs 328 day $^{-1}$ Neem cake @ Rs 30000 t^{-1} , Seed rhizome @ Rs 100 kg^{-1}, Diesel @ Rs 89.8 l^{-1} and Selling price ofginger @ Rs 40 kg^{-1})

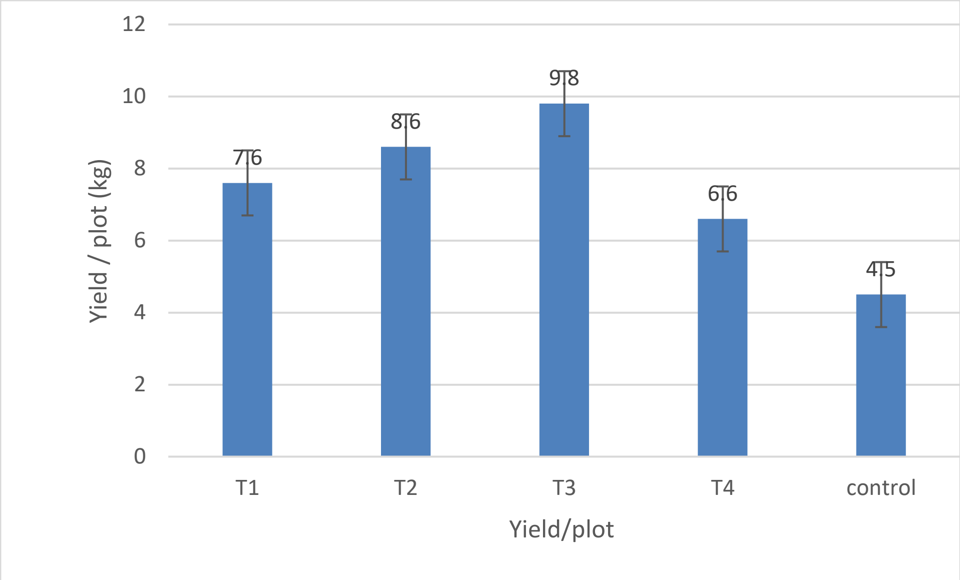

Fig. 2. Effect of organic amendments on the seed yield/plot in ginger

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).

3.3 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 (T3) recorded highest plant height of 39.68cm 65.33cm, 79.58cm, at 90,150 and 180 DAP, respectively while T2 recorded highest plant height at 120 DAP (49.71). Earlier studies by Singh et al. (2009) and Sarma et al. [13] had also reported that the organic manures increased the growth attributes of ginger, cabbage and other crops. 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 with narrow C: N ratio may produce humic acid and humic substances in the form of chelates with phosphorus. This will increase the number of tillers per plant and the same trend was studied by Sarma et al. [7] in turmeric and Singh et al. (2009) in ginger. 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, [14] 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, [15] 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 T3 (9.8 kg 3m^{-2}), followed by T2 (8.6 kg 3m^{-2}) and T1 (7.6 kg 3m^{-2}) and minimum (4.5 kg 3m^{-2}) was recorded in Control. The results are in accordance with the findings of Jadhav et al., [16] 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. Previous studies reported that organic fertilizer improved soil productivity and fertility, which improved yield and quality of such long duration crop as ginger [17,18]. Sadanandan and Iyer, [19,20] observed a reduction in rhizome rot and an increase in the yield of ginger when neem cake was applied @ 2 t ha^{-1} [21,22]. It also added organic carbon and potash to the soil [23,24].

4. CONCLUSION

It may be concluded that the growth, yield of ginger can be enhanced by application of FYM @ 15 t ha^{-1}+neem cake @ 3 tha^{-1}. Results of the study showed the efficiency of organic manures in ginger production in all aspects of growth and yield parameters evaluated. However, its uses will somehow minimize total reliance on mineral fertilizers. Based on the results obtained from the present study, it is evident that there is a wide scope for future research for increasing organic production of ginger.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

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.

Appendix– 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.

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

Month	Temperature (^{0}C)		Total Rainfall	Relative humidity (%)		Sun shine hours
	Max.	Min.	(mm)	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)

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