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Effect of Various Organic Amendments on Growth of Ginger (*Zingiber officinale* Rosc.) under Coconut Cropping System

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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

Ginger is one of the most important spices which has been utilised for centuries as a food flavouring agent as well as a key ingredient in pharmaceutical products. Since organic food is considered to be healthy by the consumers, the demand for organic products are increasing and organic farming is gaining popularity worldwide. As ginger is a shade loving crop, it can be grown well under coconut ecosystem. Therefore, a study was undertaken to evaluate the effect of organic amendments on the growth and yield of ginger (IISR Varada) under coconut based cropping system. The results revealed that the maximum plant height (72.08 cm) was recorded in T_8 - poultry manure + microbial consortium followed by T_9 - goat manure + microbial consortium (71.86 cm), the number of leaves per plant were maximum (86.57) in the combined application of poultry manure and microbial consortium (T_8) followed by T_6 - FYM + microbial consortium (83.03), the largest leaf

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length (26.75 cm) was observed in T_8 - poultry manure + microbial consortium followed by T_9 - goat manure + microbial consortium (25.83 cm) and similarly, the largest leaf width was observed in T_8 - poultry manure + microbial consortium (3.92 cm) followed by T_9 - goat manure + microbial consortium (3.87 cm). The application of T_8 - poultry manure + microbial consortium produced more number of tillers (9.48) followed by T_6 - FYM + microbial consortium (9.23). Thus, the combined application of poultry manure and microbial consortium is considered as the best and effective organic amendment for ginger under coconut based cropping system.

Keywords: Poultry manure; cropping system; Zingiberaceae; plant height.

1. INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) belongs to the family Zingiberaceae is a perennial herbaceous monocotyledon plant that is commercially cultivated as an annual crop for its rhizomes. It has been cultivated in the country since ancient times and is a significant commercial spice crop [1]. It is a high-value tropical rhizomatous spice crop grown in tropical and subtropical climates. Despite being grown in numerous countries, it thrives best in humid, tropical climates. Ginger has a long history that goes back more than 5000 years. It is a South East Asian native, but over the years, it has spread across several regions of the world, including Africa [2].

The countries like UK, the USA, and Saudi Arabia import the majority of the harvest. Nigeria is the greatest amount of ginger growing country (56.23% of the world's total area), followed by Bangladesh, India, China, and Indonesia, which have approximately 23.6, 4.7, and 3.4 per cent of the total area under ginger, respectively [1].

Ginger is used for various kinds of purposes in India, including pickles, food additives, confections, and traditional remedies for stomach aches. It is a powerful antioxidant and has been used to treat all kinds of nausea, including those brought on by motion sickness, pregnancy, surgery, and nausea following chemotherapy [3]. Traditional and modern medications both employ ginger as a common raw ingredient [4]. This is due to the volatile oleoresin and volatile oil found in ginger [5].

Regarding the rising global demand for organic products, ginger producers that cultivate organically should expect to receive significant profits on their investments. Organic has gained more attention due to enhanced quality, better market demand, and environmental protection [6]. The ginger rhizomes and leaves from organic sources have a much higher capacity for phytochemicals and antioxidants than those from non-organic sources [7]. PPFM bacteria have been shown to fix nitrogen and can also produce cytokinins, auxins, and inducible systemic resistance enzymes including pectinase and cellulase [8]. Prior research has shown that spraying soil and leaves simultaneously with PPFM bacteria could considerably improve ginger plant growth characteristics [9].

Ginger can be grown well in coconut's partial shade without harming the performance of the main crop. The ginger crop thrives in somewhat shaded conditions in the coconut garden, has reasonable market demand, is easy to process, and has a good shelf life [10]. Hence, this study was conducted to find out the effect of organic amendments on the growth and yield of ginger in the coconut ecosystem.

2. MATERIALS AND METHODS

A field experiment was conducted at a farmer's field, Kailasapatti near Periyakulam in Tamil Nadu. The field is located at an altitude of 356 m above MSL (mean sea level) at a geographical location of 10° 5' 50" N latitude and 77° 32' 2" E longitude. Composite soil samples were collected initially from 15 to 30 cm depth before sowing and analyzed for physical and chemical properties. The experiment was laid out in a randomized block design with three replications. The soil was brought to fine tilth by deep ploughing four times. Weeds, stubbles, roots etc. were removed. At the time of the last ploughing, 2t Neem cake/ha was applied. After levelling, the raised beds were formed to accommodate the treatments. Plots were divided at 5 m length to accommodate 10 treatments per replication.

The organic manures were applied at nitrogen equivalent doses such as FYM @ 30 kg/plot, Vermicompost @ 15 kg/plot, Poultry manure @ 5 kg/plot, Goat manure @ 5 kg/plot. 50% of the phosphorous were applied as basal. 150 g P were applied in control plot. Healthy and disease-free rhizomes weighing about 15-20 grams each were selected and treated with *Pseudomonas fluorescens* for 20 minutes, shade dried for 30 minutes and used for sowing on 03.02.2023. The seed rhizome bits with one or two well-sprouted buds were planted at a distance of 30 x 30 cm in raised beds. The seed rhizomes were planted by dibbling method. Manual weeding was done at 30, 60, 90,120 and 150 days after planting. Microbial consortium was sprayed @ 1% conc. at monthly intervals to the respective treatments.

The performance of treatments was assessed based on growth characters like plant height, number of leaves per plant, leaf length, leaf width, number of tillers per clump and leaf area index at monthly intervals.

Leaf Area Index was calculated using the following formula.

$$\mathrm{LAI} = \frac{\text{Total leaf area of the plant (cm}^2)}{\text{Ground area occupied by the plant (cm}^2)}$$

Treatment details:

T_1 -FYM (30t/ha)

T_2 -Vermicompost (5t/ha)

T_3 -Poultry manure (3t/ha)

T_4 -Goat manure (2t/ha)

T_5 - Microbial consortium (1%)

T_6 -T_1 + Microbial consortium (1%)

T_7 -T_2+ Microbial consortium (1%)

T_8 -T_3 + Microbial consortium (1%)

T_9 -T_4 + Microbial consortium (1%)

T_{10} -Control (Recommended Dose of fertilizers-75:50:25 kg/ha)

3. RESULTS AND DISCUSSION

3.1 Soil Properties

The physical and chemical properties of soil are given in Table 1.

3.2 Effect of Organic Amendments on Growth Characters of Ginger

3.2.1 Plant height

Poultry manure combined with foliar spraying of microbial consortium (T_8) recorded the highest plant height (72.08 cm) followed by T_9 - goat manure + microbial consortium (71.86 cm). However, the lowest values of plant height were recorded for control (Table 2). Any method used to modify plant height would have an impact on the rhizome because plant height is a key yield parameter for ginger yield. Similar outcomes are also reported by [11], [12] in ginger and [13] in mango ginger [14] in strawberry. This might be attributed to microbial consortium which enhances plant growth by a variety of mechanisms, including the production of plant growth regulators like cytokinin and auxins [15], which regulate plant development a number of physiological processes [16], and the generation and production of enzymes like urease or 1aminocyclopropane-1-carboxylate deaminase (ACCD), which modulates plant growth [17]. This may also occured as a result of poultry manure that increases nitrogen uptake, which as a component of protein and protoplasm, strongly encourages the vegetative growth of the plant. By favourably influencing the root growth and development, the improved particle density, reduced bulk density, expanded pore space, texture, and soil availability of nutrients were able to contribute indirectly to the increased plant height [12].

3.2.2 Number of leaves

The highest number of leaves were recorded for T_8 - poultry manure + microbial consortium (86.57) followed by T_6 - FYM + microbial consortium (83.03) and the lowest number of leaves were recorded for T_{10} - control (Table 3). Egbuchua et al. [11] in ginger and Anupam Pariari et al. [13] in mango ginger also reported that application of poultry manure produced the highest number of leaves. Vadivukkarasi and Bhai [9] also revealed that spraying microbial consortium can increase the number of leaves. This may be happened due to the methyl bacteria producing phytohormones like auxin, which stimulates plant elongation and cell division and poultry manure contains easily accessible nutrients and hormonal activity. More leaves are produced and as a result, increasing the available space for the photosynthetic process. The effectiveness of nutrient absorption by plants is correlated with an increase in the number of leaves on a ginger plant. The more leaves there are, the more effectively the leaves absorb light, resulting in better growth [18].

3.2.3 Leaf size

Table 4 shows that the combination of organic nutrient sources T_8 - poultry manure + microbial consortium produced the largest leaf length (26.75 cm) followed by T_9 - goat manure + microbial consortium (25.83 cm) which was at par with T_6 - FYM + microbial consortium (25.22cm). The lowest leaf length was observed in control condition T_{10} (22.24 cm). The largest leaf width was observed in T_8 - poultry manure + microbial consortium (3.92 cm) followed by T_9 - goat manure + microbial consortium (3.87 cm). The lowest leaf width was recorded in control (Fig 1). Lepcha *et al,* [12] in ginger and Anupam Pariari et al. [13] in mango ginger also recorded the largest leaf size with the application of poultry manure. Similar findings were reported by Vadivukkarasi and Bhai in [9] that spraying microbial consortium can increase the leaf length and leaf width in ginger. 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 [12] or due to generation of phytohormones, nodulation, nitrogen fixation, and nutrient acquisition from PPFM which helps to encourage plant growth [19].

3.2.4 Number of tillers

The numbers of tillers per plant significantly increased with the application of T_8 - poultry manure + microbial consortium (9.48) followed by T_6 - FYM + microbial consortium (9.23) and T_9 - goat manure + microbial consortium (9.04). There was no significant difference among those three treatments. The lowest number of tillers were recorded in control condition (Fig 2). This may be attributed to the action of auxin which aids in the establishment of a massive root system, consequently, cytokinins signal the shoot system to create more tillers [20]. As revealed by Lepcha et al. [12], Egbuchua et al. [11] and Singh et al. [21] in ginger, Balkrishnamurty et al. [22] and Singh [23] in turmeric, the number of tillers, which is also a significant yield-contributing trait in ginger, affects the yield and mother rhizome. Similar findings were revealed by Aswathy et al. [24] in rice as application of microbial consortium increases the number of tillers.

3.3 Physiological Characters

The leaf area of the plant increased with the number of leaves, which likewise increased sunlight absorption. A plant's capacity to tolerate shade is essentially shown by the increase in leaf area. The way leaves get light has an impact on how quickly a plant grows. The energy required to carry out photosynthesis and raise the amount of photosynthate increases as more light reaches the leaves [18]. Fig 3 shows that the leaf area index was higher in the combination of poultry manure and microbial consortium (8.09) followed by goat manure + microbial consortium (7.34). The lowest leaf area was calculated in control. Shadia et al. [14] in strawberry and Aswathy et al. [24] in rice reported that microbial consortium can increase the leaf area index. Egbuchua et al. (2013) in ginger and Anupam Pariari et al. [13] in mango ginger also recorded the largest leaf area with the application of poultry manure.

Table 1. Properties of experimental soil

Sl. No.	Properties	Content
1.	Textural class	Sandy clay loam
2.	Soil pH	8.21
3.	EC (dSm^{-1})	0.31
4.	Available nitrogen (kg//ha)	163.09
5.	Available phosphorus (kg/ha)	27.18
6.	Available potassium (kg/ha)	289.11
7.	Organic carbon (%)	0.24

Table 2. Effect of various organic amendments on plant height (cm) of ginger at different growth stages

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
T_1	26.82	29.71	60.14	61.28	64.89
T_2	26.01	28.99	59.52	60.41	62.6
T_3	27.95	30.34	60.88	61.87	65.49
T_4	24.54	29.16	58.23	59.62	61.16
T_5	23.36	27.98	55.27	58.45	59.23
T_6	25.42	31.23	61.63	66.34	69.54
T_7	25.76	30.64	61.08	64.79	68.77
T_8	27.64	33.97	64.36	69.52	72.08
T_9	26.52	31.72	62.47	67.95	71.86
T_{10}	24.63	29.82	52.25	54.18	56.41
Mean	25.86	30.35	59.58	62.44	65.20
SE(d)	0.67	0.78	1.54	1.61	1.67
CD (0.05)	1.41	1.64	3.24	3.38	3.52

Table 3. Effect of organic amendments on number of leaves per plant of ginger at different growth stages

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
T_1	4.82	18.74	47.84	66.65	70.85
T_2	4.57	17.65	45.61	61.59	65.72
T_3	5.96	19.52	48.42	67.94	74.92
T_4	6.08	19.24	47.12	64.12	68.32
T_5	4.31	15.87	44.68	58.24	62.76
T_6	5.68	20.07	51.58	72.53	83.03
T_7	3.99	18.98	48.91	71.15	78.69
T_8	6.24	20.43	52.72	74.39	86.57
T_9	5.13	19.86	50.63	71.76	81.26
T_{10}	3.32	13.92	41.87	55.98	60.84
Mean	5.01	18.42	47.938	66.43	73.29
SE(d)	0.13	0.47	1.23	1.70	1.87
CD (0.05)	0.27	1.00	2.59	3.58	3.93

Table 4. Effect of organic amendments on leaf length (cm) of ginger at different growth stages

Treatments	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP
T_1	9.54	13.85	18.92	22.15	23.46
T_2	9.02	13.31	16.71	20.42	23.25
T_3	10.46	14.29	19.22	22.98	24.37
T_4	10.28	14.01	18.41	21.68	23.91
T_5	8.72	12.64	15.75	20.03	22.89
T_6	10.09	15.47	20.15	23.86	25.22
T_7	9.39	14.78	19.63	22.74	24.64
T_8	10.63	16.46	20.89	24.37	26.75
T_9	9.81	15.96	20.57	23.39	25.83
T_{10}	8.34	11.55	15.19	19.84	22.24
Mean	9.628	14.232	18.544	22.146	24.25
SE(d)	0.24	0.36	0.47	0.56	0.62
CD (0.05)	0.52	0.76	0.99	1.19	1.31

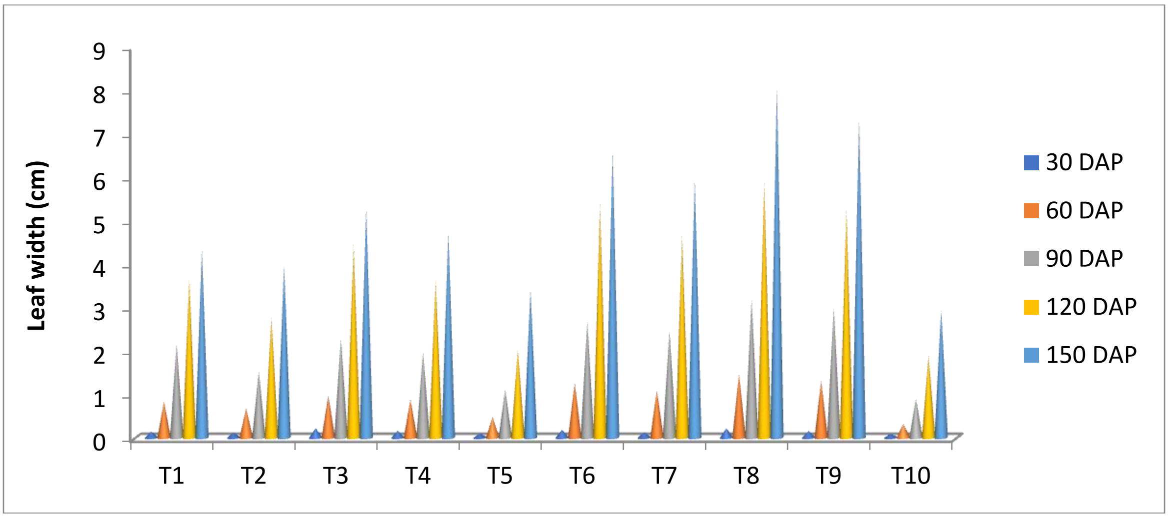

Fig. 1. Effect of organic amendments on leaf width of ginger at different growth stages

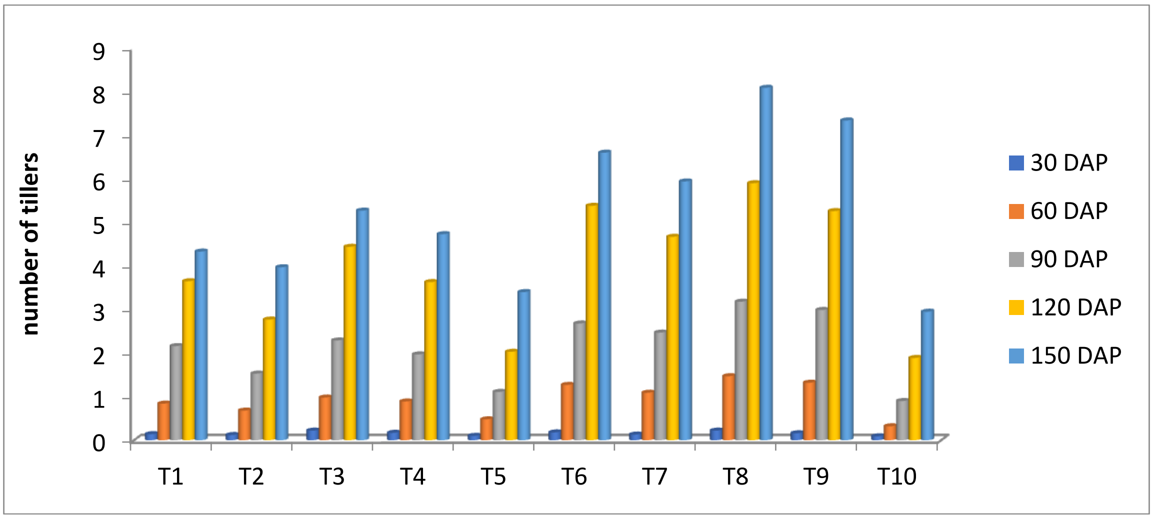

Fig. 2. Effect of organic amendments on number of tillers of ginger at different growth stages

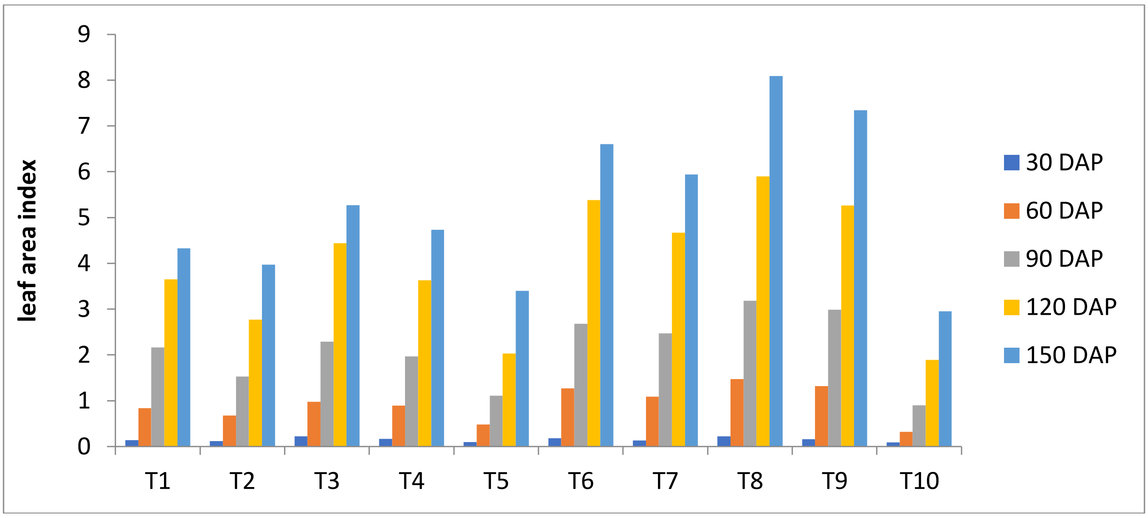

Fig. 3. Effect of organic amendments on leaf area index of ginger at different growth stages

4. CONCLUSION

According to the findings of the study, it is concluded that the growth and yield characteristics of ginger rhizome were increased with the combined application of two organic nutrient sources such as poultry manure and microbial consortium. Among the various treatment combinations, T_8 gave the best response to all the growth characters and yield attributes of ginger under coconut based cropping system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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