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Effect of Mulch and Nutrients on Yield and Physiological Parameters in Transplanted Ginger

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ABSTRACT

The conventional propagation method using ginger rhizome being slow, a suitable method of raising ginger seed material in portrays has been devised by Indian Institute of Spices Research. The advantages of this technology are production of healthy uniform planting materials and reduction in seed rhizome quantity which eventually reduced cost on rhizomes. The experiment was carried out in the Instructional Farm, College of Agriculture, Vellayani during April 2016 to January 2017. The ginger variety used was Karthika. Field experiment was laid out in split plot design with four levels of mulches in main plots and fertilizer levels in sub plots with four replications..Two nodded rhizome bits of ginger cultivar was raised in protrays were transplanted at 55 days in beds taken in the interspaces of coconut. Plants that received M_1 (30 t ha $^{-1}$) in main plot resulted in maximum plant height, number of tillers, number of leaves/plant and shoot weight, treatment T_2 (150:100:100 kg ha $^{-1}$) and their interaction (m_1t_2) also resulted in highest plant height, number of tillers, number of leaves/plant, shoot weight, Fresh yield and Dry yield on all periods of observation The results of the study indicated that ginger transplants intercropped in coconut garden, that mulching @ 30 t ha $^{-1}$(half at transplanting and half 2 MAT) along with 150:100:100 kg NPK ha^{-1} and basal application of 30 t ha^{-1} of farm yard manure could be recommended for higher yield and growth.

Introduction

Ginger (*Zingiber officinale* Rosc) is one of the earliest known oriental spices of the family Zingiberaceae is cultivated in India for underground modified stem called rhizomes which is used both as fresh vegetable and as a dried spice, since time immemorial. Ginger is mainly used as spice and flavoring agent in a wide variety of foods. India is the leading producer of ginger in the world producing 1025110 t (Spices Board, 2016). In conventional planting, the seed rhizome of 1500 to 2500 kg/ha is used depending on seed size and spacing. The conventional propagation methods of rhizomes being slow, a suitable method of raising ginger seed material in portrays has been devised by

Indian Institute of Spices Research. Apart from the conventional method, this technique has been found to be cost effective and on par in yield. The advantages of this technology are production of healthy uniform planting materials and reduction in seed rhizome quantity which eventually reduced cost on seeds. In the view of this, the present experiment was conducted to see the effect of mulch and fertilizer in transplanted ginger.

Materials and Methods

The experiment was carried out in the Instructional Farm, College of Agriculture, Vellayani during April 2016 to January 2017. The ginger variety used was Karthika. Field experiment was laid out in split plot design with four levels of mulches (M_1, M_2, M_3, M_4) in main plots and fertilizer levels in sub plots with four replications and plot size of 6m X 1m. The levels of mulches included organic mulches (mango leaves) @ 30, 15, and 7.5 t ha $^{-1}$ (M_1,M_2, M_3 respectively) and black coloured plastic mulch (M_4). For M_1 and M_2, half the quantity of organic mulch was applied at the time of transplanting (after 55 days) and the remaining at two months after transplanting (MAT). For M_3, full quantity of mulch was applied at the time of transplanting. The sub plot treatments were T_1 (75:50:50 kg of NPK ha^{-1}),T_2 (150: 100: 100 kg ha^{-1}),T_3 (T_1 + foliar application of 19:19:19 @ 0.5% applied at 1, 3, 4 MAT and T_4 (100:75:75 kg ha^{-1} + foliar application of 19:19:19 @ 0.5% applied at 1, 3, 4 MAT).Two nodded rhizome bits of ginger cultivar was raised in protrays filled with *Trichoderma* enriched coir pith compost and FYM in the ratio 2:1 for treatments and were transplanted at 55days in beds taken in the interspaces of coconut. FYM @ 30 t ha^{-1} was applied uniformly to all plots. The plants are planted at spacing of 25Cm X 25Cm.. The observations were taken at bimonthly intervals (4MAP) from each plot maintained for observation and the mean was worked out. The fresh rhizome yield of five plants uprooted from plots maintained for destructive sampling was recorded at biomonthly intervals from 4 MAP and expressed in kg ha^{-1}. Dry ginger yield was recorded from five ginger plants harvested from plants maintained for destructive sampling at bimonthly intervals from 4 MAP. The fresh rhizomes were washed and kept in hot air oven at $70^o \pm 5^o$ C till constant weight was obtained and at harvest dry ginger was measured from net plot and expressed in kg ha^{-1}. Observation on dry matter production, Crop growth rate, Leaf area index and Chlorophyll content were made from plants maintained for destructive sampling at 4, 6 and 8 MAP

Results and Discussion

Fresh yield

The main plot treatment using mulch M_1 @ 30 t ha^{-1} recorded the highest fresh yield on all periods of observation and resulted in 18093.53 kg ha^{-1} in 8th month (Table 1). This was followed by plots treated with plastic mulch (M_4) which recorded 17567.25 kg/ha. Fresh rhizome yield of ginger increased significantly as compared to no mulch in ginger (Chandra and Govind, 2001). Junior *et al.,* (2005) reported that in turmeric maximum yield plant^{-1} was recorded in paddy straw mulched plots which was significantly superior to control. Yield of turmeric was maximum with the paddy straw mulch gave maximum yield (169.33 q ha^{-1}) followed by mulching with dry grass (131.33 q/ha) (Verma and Sarnaik, 2006).

Mahey *et al.,* (1986) reported that application of paddy husk and wheat straw mulch increased the rhizome yield of turmeric by 59.5 and 218 % as compared to no-mulch plots, respectively, due to improved weed control and augmented soil moisture retention through reduced evaporation. Better performance of the ginger in the beds treated with 30 t ha^{-1} of organic mulch might be due to the optimized soil temperature, controlled evaporation losses, increased soil moisture conservation, suppression of weeds and higher uptake of major, secondary and minor nutrients

Treatment T_2 recorded the highest fresh yield on all periods and obtained 17855.03 kg ha^{-1} at harvest followed by T_4 (17455.58 kg/ha) T_3 and $T_{1.}$ Similar findings have been reported by Ajithkumar and Jayachandran (2001) that enhanced nitrogen application from 75 kg ha^{-1} to 150 kg ha^{-1} increased rhizome yield to 290 kg ha^{-1} and application of phosphorus significantly increased the rhizome yield and enhanced P application, from 50 kg ha^{-1} to 100 kg ha^{-1} increased rhizome yield to 202 kg $ha^{-1.}$ Satyareddi and Angadi (2014) showed higher fresh rhizomes yield per plot (34.45 kg plot $^{-1}$) and yield per ha (23.41 t ha $^{-1}$) with application of 270:135:180 kg $N:P_2O_5:K_2O$ ha^{-1} over other fertilizer levels in ginger.

The higher application of NPK (150:100:100 kg ha^{-1}) have resulted in higher uptake of NPK which might have contributed to higher rhizome yield compared to other nutrient levels.

Among interactions, combination of mulches @ 30 t ha^{-1} and double the recommended dose of fertilizer as per KAU package of practices (m_1t_2) gave the highest yield on all periods of observation and recorded 18.64 t ha^{-1} in 8^{th} month followed by m_4t_2(18135.30 kg ha^{-1}) which was on par with $m_1t_{4,}$ m_1t_3 and m_4t_4.

The increase in plant height, number of leaves $plant^{-1}$, number of tillers $plant^{-1}$, dry matter production, net assimilation rate due to higher uptake of NPK at increasing levels of mulches and fertilizer might have contributed to the increase in yield in m_1t_2

Dry yield

The treatment M_1 mulching with @ 30 t ha^{-1} recorded highest dry yield on different stages of observation and recorded 3828.15 kg ha^{-1} during harvest. The dry ginger yield in plastic mulch treatment was 3564.38t ha^{-1}(Table 2). The higher dry ginger yield m_1t_2 might be due to the higher nutrient (NPK) uptake as well as better soil conditions provided by highest quantity of mulch (30 t ha^{-1}). Babu and Jayachandran (1997) reported that dry ginger yield showed an increasing trend with increasing levels of mulch and a significant yield reduction was noticed in ginger cultivated under open condition when the quantity of mulch was reduced from 30 to 22.5 t/ha. Among the different mulching materials, dry leaves used as mulching material showed increased yield in ginger as reported by Sengupta *et al.,* (2008). The yield performance of ginger varieties under open and oil palm plantations in Nigeria revealed that mulching is required under both conditions for increased yield (Nwaogu *et al.,* 2011)

In subplot, treatments showed significant difference throughout the periods of observation and treatment T_2 recorded highest dry yield on all periods and obtained 3.91 t ha^{-1} at harvest. The dry ginger yield of T_4 was 3.58 t ha^{-1} while that for T_3 and T_1 were 3406.73 and 3319.73 kg ha^{-1} respectively. Govind *et al.,* (1995) reported that more secondary rhizomes per plant, and higher dry yields of rhizome in cv. Nadia with 90 kg of P_2O_5 ha^{-1}.

Interaction effects were significant throughout the periods of observation and among interaction combination of mulches @ 30 t ha^{-1} and double the recommended dose of fertilizer as per KAU package of practice (m_1t_2) obtained highest dry yield on all periods of observation and recorded 4316.10 kg ha^{-1} at harvest followed by m_4t_2 (3881.80 kg ha^{-1}) which was on par with m_1t_4 (3842.10 kg ha^{-1}).

Dry matter production

Dry matter production was significant on main plot treatment of mulches, subplot treatment with different levels of fertilizers and their interaction (Table 3)

Treatment M_1 with mulches @ 30 t ha^{-1} recorded highest dry matter production on all periods and obtained 76.95 g $plant^{-1}$ in 8^{th} month. Singh *et al.,* (2014) reported that mulching with oak leaves in ginger resulted in maximum average soil moisture conservation (54.5%) and with less average soil temperature (20.4^{o} C) and thus favoured yield.

In the present study also higher mulch the mulch (30 t ha^{-1}) might have helped in retaining more soil moisture as well as reducing soil temperature thus favouring good growth resulting in higher dry matter production.

Double the dose of recommended fertilizers recorded the highest dry matter production on all periods and obtained 75.67 g $plant^{-1}$ on 8^{th} month. This was similar to the results obtained by Mridula (1997) in mango-ginger that higher dose of N produced higher DMP. This shows that the supply of nutrients might have activated many metabolic processes leading to production of complex substances which in turn influenced the growth and yield of mango ginger.

Interaction effects were significant throughout the periods and among interaction combination of mulches @ 30 t ha^{-1} and double the recommended dose of fertilizer as per package of practices of KAU obtained the highest dry matter production on all periods of observation and recorded 83.70 g $plant^{-1}$ at 8^{th} month. The congenial conditions provided by mulch together with the higher nutrient combination (m_1t_2) might have resulted in higher dry matter production.

Crop growth rate

Significant effects on crop growth rate (CGR) was observed at different periods of observation due to mulching, fertilizers and their combination.

Main plot treatment of mulching was significant only in period of 6^{th} to 8^{th} month and produced highest CGR in mulching @ 30 t ha^{-1} and plastic mulch (0.029 g $m^{-2}day^{-2}$). Babu (1993) reported an increasing trend in CGR with increasing levels of mulch and also observed that under open condition mulching @ 22.5 t ha^{-1} and was on par with mulches @ 30 t $ha^{-1.}$

In sub plot, fertilizer treatment were significant only in 4^{th} to 6^{th} months of observation and highest was recorded by NPK dose of 150:100:100 kg ha $^{-1}$ and 100:75:75 kg ha $^{-1}$ and foliar application of 19:19:19 @ 0.5% (T_4).Maximum CGR and increased response to nutrients in terms of CGR under 25 and 50 per cent shade levels were observed by Joseph (1992) and Babu (1993) in ginger. Ajithkumar (1999) reported that a significant increase in CGR at higher levels of potassium (100 kg K_2O) at the later stages.

Interaction was significant during the periods of 4^{th} to 6^{th} months of observation and treatment combination of mulches @ 30 t ha^{-1} and fertilizer dose of 150:100:100 kg ha^{-1} noted the highest CGR on 4^{th} to 6^{th} months of observation

A significant difference was observed between the treatments and the control on all periods of growth. The comparison of C_1 and C_2 also showed a significant difference between them in 4^{th} to 6^{th} months.

Table.1 Effect of mulches and nutrients on Fresh Yield (kg ha^{-1})

Treatments	4^{th} month	6^{th} month	Harvest
(Mulches) M_1	5435.78	10574.03	18093.53
M_2	4675.43	10011.45	17241.15
M_3	4053.15	9197.775	16385.18
M_4	5234.23	9958.80	17567.25
CD	154.027	153.580	175.023
(Fertilizers) T_1	4501.65	9512.55	16746.15
T_2	5241.23	10195.88	17855.03
T_3	4660.95	9907.05	17230.35
T_4	5082.75	10026.58	17455.58
CD	156.37	167.364	121.861
(Interaction) m_1t_1	4902.00	10181.10	17545.80
m_1t_2	6120.90	10537.20	18644.40
m_1t_3	5187.60	10118.20	18045.30
m_1t_4	5532.60	10159.60	18138.60
m_2t_1	4473.60	9606.60	16756.80
m_2t_2	4969.80	10193.00	17717.10
m_2t_3	4537.50	9923.40	17196.90
m_2t_4	4720.80	10162.80	17293.80
m_3t_1	3728.70	8687.40	15931.80
m_3t_2	4246.20	9685.50	16923.30
m_3t_3	3906.00	9127.50	16208.70
m_3t_4	4331.70	9290.70	16476.90
m_4t_1	4902.30	9575.10	16750.20
m_4t_2	5628.00	10201.80	18135.30
m_4t_3	5012.70	9959.10	17377.20
m_4t_4	5793.90	10093.20	18006.30
CD	312.729	334.729	257.722

Table.2 Effect of mulches and nutrients on Dry yield (kg ha^{-1})

Treatments	4^{th} month	6^{th} month	Harvest
(Mulches) M_1	1024.58	2172.60	3828.15
M_2	821.78	1910.93	3504.75
M_3	729.45	1757.93	3328.05
M_4	961.88	1867.50	3564.38
CD	27.525	35.941	44.317
(Fertilizers) T_1	765.68	1746.15	3319.73
T_2	1013.25	2120.78	3911.10
T_3	815.03	1879.95	3406.73
T_4	943.73	1962.08	3587.78
CD	24.736	25.169	35.806
(Interaction) m_1t_1	863.10	1990.20	3640.50
m_1t_2	1286.40	2489.40	4316.10
m_1t_3	919.80	1995.90	3513.90
m_1t_4	1029.00	2214.90	3842.10
m_2t_1	733.50	1722.60	3257.40
m_2t_2	971.10	2180.40	3811.10
m_2t_3	750.90	1800.30	3299.10
m_2t_4	831.60	1940.40	3581.40
m_3t_1	614.40	1517.40	3096.00
m_3t_2	830.10	2002.80	3635.40
m_3t_3	672.30	1707.30	3164.70
m_3t_4	801.00	1804.20	3416.10
m_4t_1	851.70	1754.40	3285.00
m_4t_2	965.40	1810.50	3881.80
m_4t_3	917.10	2016.30	3649.20
m_4t_4	1113.30	1888.80	3511.50
CD	49.473	50.329	71.612

Table.3 Effect of mulches and nutrients on Dry matter production (g plant $^{-1}$)

Treatments	4th month	6th month	8th month
(Mulches) M_1	31.80	48.79	76.95
M_2	30.20	44.67	71.07
M_3	26.54	42.88	67.72
M_4	31.05	46.28	73.58
CD	0.646	0.963	0.536
(Fertilizers) T_1	26.79	42.86	68.27
T_2	33.03	47.61	75.67
T_3	29.45	46.09	71.69
T_4	31.81	46.06	73.70
CD	0.530	0.979	0.424
(Interaction) m_1t_1	28.70	46.01	74.47
m_1t_2	35.47	51.32	83.70
m_1t_3	30.32	48.41	74.16
m_1t_4	32.73	49.31	75.50
m_2t_1	25.34	43.08	67.27
m_2t_2	33.77	46.17	75.50
m_2t_3	29.74	42.88	68.85
m_2t_4	31.96	46.55	72.70
m_3t_1	23.67	39.67	62.91
m_3t_2	28.92	44.57	69.50
m_3t_3	25.83	42.33	67.58
m_3t_4	27.75	44.96	70.92
m_4t_1	29.48	42.70	68.43
m_4t_2	33.97	42.19	74.02
m_4t_3	31.95	49.13	76.19
m_4t_4	34.23	49.32	75.69
CD	1.071	1.948	0.858

* Significant at 5% level

Table.4 Effect of mulch and nutrients on crop growth rate (g $m^{-2}day^{-1}$)

Treatments	4^{th} to 6^{th} month	6^{th} to 8^{th} month
(Mulches) M_1	0.018	0.029
M_2	0.015	0.018
M_3	0.016	0.016
M_4	0.014	0.029
CD	NS	0.009
(Fertilizers) T_1	0.013	0.027
T_2	0.017	0.031
T_3	0.016	0.027
T_4	0.017	0.027
CD	0.001	NS
(Interaction) m_1t_1	0.018	0.027
m_1t_2	0.019	0.035
m_1t_3	0.015	0.027
m_1t_4	0.015	0.022
m_2t_1	0.015	0.022
m_2t_2	0.017	0.035
m_2t_3	0.017	0.027
m_2t_4	0.015	0.022
m_3t_1	0.017	0.022
m_3t_2	0.015	0.026
m_3t_3	0.017	0.022
m_3t_4	0.012	0.027
m_4t_1	0.017	0.027
m_4t_2	0.005	0.032
m_4t_3	0.017	0.025
m_4t_4	0.015	0.022
CD	0.002	NS

** Significant at 1% level

Table.5 Effect of mulch and nutrients on leaf area index

Treatments	4^{th} month	6^{th} month	8^{th} month
(Mulches) M_1	7.33	8.38	8.64
M_2	6.31	7.33	7.70
M_3	5.23	5.80	6.22
M_4	6.63	6.96	7.42
CD	0.205	0.132	0.061
(Fertilizers) T_1	5.68	6.42	6.77
T_2	7.04	7.72	8.11
T_3	6.19	6.92	7.30
T_4	6.58	7.41	7.80
CD	0.170	0.111	0.063
(Interaction) m_1t_1	6.42	7.68	8.00
m_1t_2	8.31	8.92	9.20
m_1t_3	7.02	8.32	8.56
m_1t_4	7.56	8.60	8.80
m_2t_1	5.30	6.39	6.72
m_2t_2	7.31	8.00	8.32
m_2t_3	6.23	7.01	7.52
m_2t_4	6.39	7.93	8.24
m_3t_1	4.91	5.33	5.81
m_3t_2	5.66	6.47	6.90
m_3t_3	5.01	5.60	5.92
m_3t_4	5.35	5.82	6.24
m_4t_1	6.07	6.28	6.56
m_4t_2	6.89	7.48	8.01
m_4t_3	6.51	6.78	7.20
m_4t_4	7.03	7.31	7.90
CD	0.350	0.223	0.137

* Significant at 5% level

Table.6 Effect of mulch and nutrients on chlorophyll content (mg g $^{-1}$)

Treatments	4^{th} month	6^{th} month	8^{th} month
(Mulches) M_1	0.52	0.86	1.33
M_2	0.51	0.81	1.18
M_3	0.43	0.82	1.16
M_4	0.49	0.83	1.20
CD	0.016	0.006	0.016
(Fertilizers) T_1	0.47	0.79	1.18
T_2	0.51	0.85	1.24
T_3	0.49	0.83	1.22
T_4	0.49	0.82	1.24
CD	0.013	0.003	0.008
(Interaction) m_1t_1	0.50	0.835	1.22
m_1t_2	0.54	0.91	1.39
m_1t_3	0.53	0.86	1.33
m_1t_4	0.52	0.87	1.37
m_2t_1	0.51	0.77	1.18
m_2t_2	0.52	0.81	1.21
m_2t_3	0.50	0.84	1.19
m_2t_4	0.51	0.86	1.15
m_3t_1	0.42	0.79	1.10
m_3t_2	0.48	0.83	1.16
m_3t_3	0.43	0.82	1.17
m_3t_4	0.44	0.84	1.19
m_4t_1	0.46	0.79	1.18
m_4t_2	0.52	0.86	1.21
m_4t_3	0.49	0.85	1.22
m_4t_4	0.52	0.83	1.23
CD	0.026	0.017	0.017

** Significant at 1% level

The CGR also increased with the advancement of growth from 4^{th} to 6^{th} month and 6^{th} to 8^{th} month. For all the subplot treatment and interaction the CGR increased with the advancement in growth, but for the main plot treatment M_2, CGR remained the same during 4^{th} to 6^{th} and 6^{th} to 8^{th} months. Thus mulching @ 30 t ha^{-1} and use of plastic mulch had shown a rapid growth during the period for 6^{th} to 8^{th} month, while other main plot treatments had shown a slow steady growth rate. The lower CGR during the early phase in M_3 and M_2 favoured more of weed growth and development ultimately affecting the growth and yield of the crop.

Leaf area index

Treatment with mulch treatment, fertilizer and their interaction had significant influence in the leaf area index (LAI) at all periods of growth and interaction effect is presented in

Application of 30 t ha^{-1} of mulch (M_1) retained significantly higher LAI in all periods of growth and recorded 8.64 at 8^{th} month. Under open and shade levels the application of higher quantities of mulch enhanced total leaf area (Babu, 1993). Ajithkumar (1999) reported no significant effect of mulch on leaf area.

In sub plot treatment double the recommended dose of fertilizer, T_2 (150:100:100 kg ha^{-1}) recorded the highest of 8.11 in 8^{th} month. Potassium is important in the photosynthetic process and it increases leaf area and carbon dioxide assimilation (Russell, 1973). Joseph (1992) observed an increase in LAI with increase in fertilizer level in ginger. Ajithkumar (1999) reported that higher LAI was observed with increase in fertilizer levels.

Interaction effect resulted in significant difference in all periods of growth and the highest LAI was recorded from the combination of mulches @ 30 t ha^{-1} and fertilizer dose of 150:100:100 kg ha^{-1} (m_1t_2) in all periods of observation and in 8^{th} month LAI of 9.20 was recorded.

LAI of treatments varied significantly from the control on all periods of growth. The comparison of C_1 as well as C_2 with the treatments also indicated significant difference in the number of leaves in all periods of growth. A significant difference was noticed in LAI between the control C_1 and C_2. Mridula (1997) in mango ginger reported positive and significant correlation of LAI with yield. LAI is an important agronomic parameter which reflects crop growth and predicts crop yield (Fageria *et al.,* 2006).Differences in leaf area can affect plant spatial distribution and the microenvironment within population (Giunta *et al.*, 2008) which plays a decisive role in the photosynthetic efficiency and light energy distribution of crops (Boedhran *et al.,* 2001; Elings, 2000). Higher LAI noticed is M_1, T_2 and m_1t_2 might have helped in harvesting more light which together with more uptake of nutrients producing more photosynthates and translocated to rhizomes.

Chlorophyll content

Significant differences in chlorophyll content among mulch treatments was observed throughout the crop growth period. (Table 6)

Plants that received 30 t ha^{-1} of mulch (M_1) resulted in maximum chlorophyll content in all growth periods. At 8 months chlorophyll content of 1.33 mg g^{-1} was recorded from M_1. The positive influence of mulch on chlorophyll content may be due to enhanced soil physical condition caused by the mulch treatment.

Sub plot treatment of 150:100:100 kg ha^{-1} (T_2) recorded the highest chlorophyll content on 4^{th} and 6^{th} months of observation. while in 8 months chlorophyll content of 1.24 mg g^{-1} was recorded for 150:100:100 kg ha^{-1} (T_2) and 100:75:75 kg ha^{-1} + foliar application of 19:19:19 @ 0.5% (T_4). Nitrogen is an integral part of chlorophyll molecule, thus its supply at higher amount would have favoured the production of chlorophyll which in turn increased photosynthetic efficiency of plant and thus yield. Higher nutrient levels were adequate for the production of good amount of chlorophyll.

The interaction between mulching and fertilizers, was significant throughout the periods of observation and combination of mulches @ 30 t ha^{-1} and fertilizer dose of 150:100:100 kg ha^{-1} resulted in maximum chlorophyll content. The results of the study indicated that ginger transplants intercropped in coconut garden at 50-55 days mulched with

@ 30 t ha $^{-1}$ half of which applied at transplanting and half 2 MAT along with 150:100:100 kg NPK ha^{-1} and basal application of 30 t ha^{-1} of farm yard manure produced ginger plants with higher yield and physiological parameters.

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