Effect of mulch and nutrients on growth and yield 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 portraits has been devised by Indian Institute of Spices Research and Kerala Agricultural University. 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 portraits were transplanted at 55 days in beds taken in the interspaces of coconut. Plants that received M₁ (30 t ha⁻¹) in main plot resulted in maximum plant height, number of tillers, number of leaves/plant shoot weight, fresh yield and dry yield treatment T₁ (150:100:100 kg ha⁻¹) and their interaction (m₁t₁) 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 plants 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.

Key words: Fertilizer, Ginger, Mulch, Rhizome bits, Transplanted.

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 portraits has been devised by Indian Institute of Spices Research and Kerala Agricultural University. 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 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 (M₁, M₂, M₃, M₄) in main plots and fertilizer levels in sub plots with four replications and plot size of 6m × 1m. The levels of mulches included Organic mulches (mango leaves) @ 30, 15, and 7.5 t ha⁻¹ (M₁, M₂, M₃ respectively) and black coloured plastic mulch (M₄). For M₁, M₂ half the quantity of organic mulch was applied at the time of transplanting the sub plot treatments were T₁ (75:50:50 kg of NPK ha⁻¹), T₂ (150:100:100 kg ha⁻¹) T₃ (T₁ + foliar application of 19:19:19 @ 0.5% applied at 1, 3, 4 MAT), T₄ (T₁ +basal application of 30 t ha⁻¹ of farm yard manure) and full quantity of mulch was applied at the time of transplanting the sub plot treatments were T₅ (75:50:50 kg of NPK ha⁻¹) T₆ (T₂ + foliar application of 19:19:19 @ 0.5% applied at 1, 3, 4 MAT). Two nodded rhizome bits of ginger cultivar was raised in portraits 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 × 25Cm. Growth parameters such as plant height(cm), number of leaves/plant, number of tillers and shoot weight (g plant⁻¹). 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 bimonthly intervals from 4 MAP and expressed in kg

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RESULTS AND DISCUSSION

Plant height: The plant height was significantly higher for the mulch treatment, M, (30 t ha$^{-1}$) (Table 1) throughout the observed crop growth period. The height increased from 37.48 cm to 44.84 cm from 4th to 8th month of observation in plots treated with 30 t ha$^{-1}$ of mulch and it was the least in M$_1$ (7.5 t ha$^{-1}$) varied from 28.84 to 35.76 cm. Babu (1993) reported that under shade levels (0, 25, 50, 75) there was an increasing trend in plant height in ginger with increasing mulch levels. Among the different mulching materials, dry leaves used as mulching material showed maximum height, in ginger (Sengupta et al., 2008). The increase in plant height might be due to the beneficial effect due to increased levels of organic mulch. The fertilizer level T$_2$ (150:100:100 kg ha$^{-1}$) resulted in the highest plant height on all periods of observation and a plant height of 43.33 cm was recorded at 8th month in T$_2$. Muralidharan et al. (1974) reported a progressive increase in plant height with an increase in the amount of N applied up to 90 kg ha$^{-1}$. Ajithkumar (1999) reported the effect of N and K in enhancing plant height and observed maximum plant height at the highest levels of N and K. Akinwumi et al. (2013) reported that in turmeric N applied alone or in combination with P, K or PK alone resulted in significantly higher plant height. Ginger is a soil exhaustive crop and shows good response to added to nutrients (Babu, 1993). In this study also application of double the fertilizer dose of recommendation of KAU have resulted in highest plant height in all growth periods compared to other fertilizer levels. Interaction between mulch and fertilizer, was significant throughout the periods of observation and highest level of mulch and double the recommended dose of fertilizer recorded the highest plant height on all periods.

Number of leaves / plant: Significantly the higher number of leaves was produced due to higher level of mulch of 30 t ha$^{-1}$ (230.78 in 8th month) (Table 2) and Islam et al., (2015) reported that maximum number of leaves (129.28) were recorded from rice straw while the minimum number of leaves (70.55) was recorded from control treatment. Leaves per clump increased significantly as compared to no mulch in ginger (Chandra and Govind, 2001). Fertilizer treatment, T$_2$ (150:100:100 kg ha$^{-1}$) recorded the highest number of leaves at 8th month (210.24) and the least number was in 75:50:50 kg ha$^{-1}$. Similar studies conducted by Ajithkumar (1999) reported that with increasing rate of N up to 150 kg ha$^{-1}$ and P$_2$O$_5$ up to 100 kg ha$^{-1}$ significantly increased number of leaves plant$^{-1}$ was noticed but the increasing rate of K$_2$O

Table 1: Effect of mulches and nutrients on the plant height (cm).

| Treatments | 4th month | 6th month | 8th month |
|------------|-----------|-----------|-----------|
| (Mulches)  |           |           |           |
| M          | 37.48     | 41.51     | 44.84     |
| M$^1$      | 36.10     | 40.21     | 42.74     |
| M$^2$      | 28.84     | 33.85     | 35.76     |
| M$^3$      | 33.64     | 38.99     | 41.50     |
| CD         | 0.607     | 0.668     | 0.417     |
| (Fertilizers) |         |           |           |
| T          | 30.36     | 36.68     | 38.45     |
| T$^1$      | 36.8      | 41.01     | 43.33     |
| T$^2$      | 34.9      | 37.17     | 40.25     |
| T$^3$      | 34.9      | 40.24     | 42.81     |
| CD         | 0.669     | 0.294     | 0.357     |
| (Interaction) |         |           |           |
| m t        | 35.20     | 39.15     | 43.08     |
| m t$^1$    | 39.60     | 44.10     | 48.00     |
| m t$^2$    | 38.01     | 40.90     | 43.80     |
| m t$^3$    | 36.55     | 41.90     | 44.48     |
| m t$^4$    | 33.95     | 39.20     | 39.85     |
| m t$^5$    | 36.8      | 42.25     | 44.93     |
| m t$^6$    | 37.90     | 39.58     | 42.18     |
| m t$^7$    | 38.16     | 41.95     | 44.00     |
| m t$^8$    | 27.20     | 30.35     | 32.75     |
| m t$^9$    | 31.55     | 36.95     | 37.35     |
| m t$^{10}$ | 27.40     | 31.50     | 34.05     |
| m t$^{11}$ | 29.23     | 36.60     | 38.90     |
| m t$^{12}$ | 25.08     | 38.00     | 38.13     |
| m t$^{13}$ | 38.22     | 40.75     | 43.03     |
| m t$^{14}$ | 35.08     | 36.70     | 40.98     |
| m t$^{15}$ | 35.15     | 40.53     | 43.88     |
| CD         | 1.34      | 0.60      | 0.72      |

Table 2: Effect of mulch and nutrients on number of leaves/plant.

| Treatments | 4th month | 6th month | 8th month |
|------------|-----------|-----------|-----------|
| (Mulches)  |           |           |           |
| M          | 113.92    | 165.25    | 230.78    |
| M$^1$      | 93.65     | 149.48    | 186.46    |
| M$^2$      | 80.57     | 124.40    | 143.91    |
| M$^3$      | 105.05    | 148.12    | 176.97    |
| CD         | 3.510     | 3.840     | 1.660     |
| (Fertilizers) |         |           |           |
| T          | 69.78     | 120.08    | 163.68    |
| T$^1$      | 127.10    | 173.38    | 210.24    |
| T$^2$      | 90.25     | 141.41    | 172.89    |
| T$^3$      | 106.17    | 152.38    | 191.32    |
| CD         | 2.560     | 3.550     | 4.090     |
| (Interaction) |         |           |           |
| m t        | 78.12     | 134.41    | 190.82    |
| m t$^1$    | 152.99    | 206.31    | 284.79    |
| m t$^2$    | 86.36     | 150.26    | 199.90    |
| m t$^3$    | 102.76    | 170.01    | 247.63    |
| m t$^4$    | 67.88     | 111.55    | 152.94    |
| m t$^5$    | 125.59    | 189.59    | 212.66    |
| m t$^6$    | 84.03     | 135.79    | 182.88    |
| m t$^7$    | 97.10     | 161.02    | 197.37    |
| m t$^8$    | 55.04     | 110.17    | 139.17    |
| m t$^9$    | 102.45    | 132.49    | 157.16    |
| m t$^{10}$ | 75.57     | 127.89    | 135.95    |
| m t$^{11}$ | 89.25     | 127.07    | 143.39    |
| m t$^{12}$ | 78.08     | 124.19    | 171.79    |
| m t$^{13}$ | 126.96    | 165.14    | 186.37    |
| m t$^{14}$ | 115.07    | 151.73    | 172.83    |
| m t$^{15}$ | 135.59    | 151.42    | 176.90    |
| CD         | 5.100     | 7.110     | 8.180     |
had no significant effect on leaf production in ginger. Dayankatti and Sulikkeri (2000) studied the effects of different levels nitrogen on (50, 75, 100 and 125 kg ha\(^{-1}\)) on ginger and reported that number of leaves (13.36 per shoot) were the highest at 125 kg N ha\(^{-1}\).

**Number of tillers/plant:** Organic mulches increased the number of tillers and the highest tiller was obtained in 4\(^{th}\) to 8\(^{th}\) month in M\(_2\) (30 t ha\(^{-1}\)) (Table 3) followed by plastic mulch (M\(_1\)). The number of tillers at 8\(^{th}\) month was 14.88 for M\(_1\) and 14 for M\(_2\). Agrawal et al. (2001) in a field experiment on ginger found that the mulch treatment was better over control in terms of plant height, number of tillers per plant, number of leaves per plant and also reported that the performance of organic mulches was better than synthetic mulches. An increase in tiller was observed in treatment T\(_2\) (150:100:100 kg ha\(^{-1}\)) at all periods of observation and it was in accordance with the findings of Pradeepkumar et al. (2001) who reported that the increase in N and K rates (0, 75, 150, 225 kg ha\(^{-1}\)) increased the number of tillers in ginger. Tiller number was more at 8\(^{th}\) months in mulches @ 30 t ha\(^{-1}\) and fertilizer dose of 150:100:100 kg ha\(^{-1}\) (m\(_1\)t\(_1\)) which was on par with m\(_1\)t\(_2\) on 8\(^{th}\) month of observation.

**Shoot weight:** M\(_1\) (30 t ha\(^{-1}\)) recorded the highest shoot weight on all periods of observation and an increase in shoot weight was observed from 24.54g to 45.05g (Table 4) from 4\(^{th}\) month to 8\(^{th}\) month of observation however Ajithkumar (1999) reported no significant effect of mulch on shoot weight in ginger with increasing levels of N and K. Abraham et al. (2016) reported that mulching with rubber leaves which was on par with control, panal and matty in ginger. In sub plot T\(_2\) treatment of double the dose of fertilizer recorded the highest shoot weight at all observations and a shoot weight of 43.80g was obtained in the 8\(^{th}\) month. This was in agreement with findings of Joseph (1992) in ginger who reported that shoot weight increased with increasing levels of NPK. Among the interaction mulching @ 30 t ha\(^{-1}\) and fertilizer dose of 150:10:100 kg ha\(^{-1}\) (m\(_1\)t\(_2\)) recorded the highest shoot weight on all periods of observation. In 4\(^{th}\) month m\(_1\)t\(_1\) and m\(_1\)t\(_2\) were on par and in the 6\(^{th}\) and 8\(^{th}\) months m\(_1\)t\(_2\) recorded highest shoot weight.

**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 8\(^{th}\) month (Table 5). This was followed by plots treated with plastic mulch (M\(_1\)) 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).

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### Table 3: Effect of mulches and nutrients on the no of tillers/plant.

| Treatments | 4\(^{th}\) month | 6\(^{th}\) month | 8\(^{th}\) month |
|------------|-----------------|-----------------|-----------------|
| (Mulches)  |                 |                 |                 |
| M\(_1\)    | 10.05           | 11.36           | 14.88           |
| M\(_2\)    | 9.60            | 11.60           | 14.88           |
| M\(_3\)    | 9.18            | 11.10           | 14.88           |
| M\(_4\)    | 8.75            | 10.60           | 14.88           |
| CD         | 0.233           | 0.369           | 0.334           |

| (Fertilizers) | 4\(^{th}\) month | 6\(^{th}\) month | 8\(^{th}\) month |
|---------------|-----------------|-----------------|-----------------|
| T\(_1\)       | 8.43            | 10.20           | 13.80           |
| T\(_2\)       | 8.75            | 10.45           | 13.80           |
| T\(_3\)       | 9.18            | 10.85           | 13.80           |
| T\(_4\)       | 9.55            | 11.05           | 13.80           |
| CD           | 0.369           | 0.355           | 0.334           |

### Table 4: Effect of mulches and nutrients on the shoot weight (g plant\(^{-1}\)).

| Treatments | 4\(^{th}\) month | 6\(^{th}\) month | 8\(^{th}\) month |
|------------|-----------------|-----------------|-----------------|
| (Mulches)  |                 |                 |                 |
| M\(_1\)    | 21.5            | 29.43           | 44.13           |
| M\(_2\)    | 25.93           | 33.93           | 47.73           |
| M\(_3\)    | 22.65           | 31.78           | 44.88           |
| M\(_4\)    | 24.15           | 30.95           | 43.48           |
| CD         | 0.55            | 0.973           | 0.631           |

| (Fertilizers) | 4\(^{th}\) month | 6\(^{th}\) month | 8\(^{th}\) month |
|---------------|-----------------|-----------------|-----------------|
| T\(_1\)       | 24.59           | 31.26           | 43.80           |
| T\(_2\)       | 22.66           | 28.39           | 43.80           |
| T\(_3\)       | 23.95           | 30.22           | 43.08           |
| CD           | 0.48            | 0.994           | 0.38            |

| (Interaction) | 4\(^{th}\) month | 6\(^{th}\) month | 8\(^{th}\) month |
|---------------|-----------------|-----------------|-----------------|
| m\(_1\) t\(_1\) | 25.03           | 30.38           | 42.85           |
| m\(_1\) t\(_2\) | 18.55           | 27.03           | 38.38           |
| m\(_2\) t\(_1\) | 22.00           | 27.88           | 39.20           |
| m\(_2\) t\(_2\) | 20.23           | 28.10           | 41.20           |
| m\(_3\) t\(_1\) | 21.08           | 29.93           | 42.45           |
| m\(_3\) t\(_2\) | 22.38           | 28.08           | 41.05           |
| m\(_4\) t\(_1\) | 24.75           | 27.10           | 42.25           |
| m\(_4\) t\(_2\) | 23.30           | 30.58           | 45.78           |
| CD           | 0.96            | 1.889           | 0.771           |
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 per cent as compared to no-mulch plots, respectively, due to improved weed control and augmented soil moisture retention through reduced evaporation.

Treatment T recorded the highest fresh yield on all periods and obtained 17855.03 kg ha⁻¹ at harvest followed by T₁ (17455.58 kg/ha) T₂ and T₃. 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. Satyaredi 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:P₂O₅:K₂O 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 (m₁t₁) gave the highest yield on all periods of observation and recorded 18.64 t ha⁻¹ in 8th month followed by m₁t₂ (18135.30 kg ha⁻¹) which was on par with m₁t₃, m₂t₁ and m₂t₂. 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 have contributed to the increase in yield in m₁t₁.

Dry yield: The treatment M, 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 3564.38 t ha⁻¹ (Table 6). The higher dry ginger yield m₁ 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 T₃ recorded highest dry yield on all periods and obtained 3.91

| Table 5: Effect of mulches and nutrients on fresh yield (kg ha⁻¹). |
|---------------------------------------------------------------|
| **Treatments** | **4th month** | **6th month** | **Harvest** |
| (Mulches) | (kg/ha) | (kg/ha) | (kg/ha) |
| M | 5435.78 | 10574.03 | 18093.53 |
| M₁ | 4675.43 | 10011.45 | 17241.15 |
| M₂ | 4053.15 | 9197.75 | 16385.18 |
| M₃ | 5234.23 | 9958.80 | 17567.25 |
| CD | 154.027 | 153.580 | 175.023 |
| (Fertilizers) | | | |
| T | 4501.65 | 9512.55 | 16746.15 |
| T₁ | 5241.23 | 10195.88 | 17855.03 |
| T₂ | 4660.95 | 9907.05 | 17230.35 |
| T₃ | 5082.75 | 10026.58 | 17455.58 |
| CD | 156.37 | 167.364 | 121.861 |

| Table 6: Effect of mulches and nutrients on dry yield (kg ha⁻¹). |
|---------------------------------------------------------------|
| **Treatments** | **4th month** | **6th month** |
| (Mulches) | (kg/ha) | (kg/ha) |
| M | 1024.58 | 2172.60 | 3828.15 |
| M₁ | 821.78 | 1910.93 | 3504.75 |
| M₂ | 729.45 | 1737.93 | 3328.05 |
| M₃ | 961.88 | 1867.50 | 3564.38 |
| CD | 25.52 | 35.941 | 44.317 |
| (Fertilizers) | | | |
| T | 765.68 | 1746.15 | 3319.73 |
| T₁ | 1013.25 | 2120.78 | 3911.10 |
| T₂ | 815.03 | 1879.95 | 3406.73 |
| T₃ | 943.73 | 1962.08 | 3587.78 |
| CD | 24.73 | 25.169 | 35.806 |
| (Interaction) | | | |
| m₁ | 863.10 | 1990.20 | 3640.50 |
| m₂ | 1286.40 | 2489.40 | 4316.10 |
| m₃ | 919.80 | 1995.90 | 3513.90 |
| m₁t₁ | 1029.00 | 2214.90 | 3842.10 |
| m₁t₂ | 733.50 | 1722.60 | 3257.40 |
| m₁t₃ | 971.10 | 2180.40 | 3811.10 |
| m₂t₁ | 750.90 | 1800.30 | 3299.10 |
| m₁t₂ | 831.60 | 1940.40 | 3581.40 |
| m₁t₃ | 614.40 | 1517.40 | 3096.00 |
| m₂t₂ | 830.10 | 2002.80 | 3635.40 |
| m₁t₄ | 672.30 | 1707.30 | 3164.70 |
| m₂t₄ | 801.09 | 1804.20 | 3416.10 |
| m₁t₅ | 851.70 | 1754.40 | 3285.00 |
| m₂t₅ | 965.40 | 1810.50 | 3881.80 |
| m₁t₆ | 917.10 | 2016.30 | 3649.20 |
| m₂t₆ | 1113.30 | 1888.80 | 3511.50 |
| CD | 49.473 | 50.329 | 71.612 |
t ha\(^{-1}\) at harvest. The dry ginger yield of T\(_3\) was 3.58 t ha\(^{-1}\) while that for T\(_1\) and T\(_2\) were 3.406.73 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\(_2\)O\(_5\) 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\(_1\)t\(_2\)) obtained highest dry yield on all periods of observation and recorded 4316.10 kg ha\(^{-1}\) at harvest followed by m\(_1\)t\(_3\) (3881.80 kg ha\(^{-1}\)) which was on par with m\(_2\)t\(_3\) (3842.10 kg ha\(^{-1}\)).

**CONCLUSION**

The results of the study indicated that of ginger transplants intercropped in coconut garden, with 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.

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