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# Effect of organics on growth, yield and quality attributes of turmeric (*Curcuma longa* L.) Cv. tall clone

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**Abstract**
An experiment was carried out during 2016-17 to study the effect of organics on growth, yield and quality attributes of turmeric. The experiment comprised of seven different organic treatments laid out in randomized block design. The treatments were $T_1$: recommended dose of fertilizer, $T_2$: *In-situ* incorporation of Dhaincha (*Sesbania aculeata*), $T_3$: FYM @ 10t ha$^{-1}$, $T_4$: Enriched compost ≈ FYM @ 10 t ha$^{-1}$ in the furrow at planting, $T_5$: Vermicompost ≈ FYM @ 10t ha$^{-1}$ + Microbial consortia as slurry for treatment of rhizome at planting, $T_6$: Microbial consortia as slurry for treatment of rhizome with vermiwash (1:7) + Vermiwash spray (1:7) every month up to seven months of planting, $T_7$: FYM@ 10 t ha$^{-1}$ + Microbial consortia as slurry for treatment of rhizome at planting. The experimental results revealed that maximum plant height (167.23 cm), number of leaves per plant(23.46) number of tillers per plant (3.90), leaf area of a single leaf (648.33 cm$^2$), leaf area per plant(15209.82 cm$^2$), leaf area index (12.42 ) were observed in $T_1$,they were followed by treatment $T_7$ and $T_4$ and the minimum was recorded in $T_6$.The recommended dose of fertilizer ($T_1$) also registered the highest number of mother rhizome (2.15), number of primary rhizome(6.54),number of secondary rhizome(16.79), number of tertiary rhizome(6.12),length of mother rhizome (11.16 cm),length of finger rhizome(11.35),girth of mother rhizome(6.62 cm),girth of finger rhizome (3.57 cm),fresh weight of rhizome(424.25g),dry weight of rhizome (72.08 g) and yield(335.25 q ha$^{-1}$) which were followed by $T_7$ and $T_4$ and these parameters were lowest in treatment $T_6$. Among the treatments $T_7$ exhibited best performance in terms of curing percentage (18.09%) and curcumin content (3.62%).

**Keywords:** Turmeric, organics, growth, yield, quality

## Introduction
Turmeric (*Curcuma longa* L.) is an herbaceous perennial plant belongs to the family Zingiberaceae was originated in South East Asia. It is widely cultivated in tropical and subtropical regions of the world. Turmeric is one of the most important ancient spices of India and a traditional item of export, which is used daily by all classes of people for preparation of tasty curried dishes and as an ingredient of medicinal preparations. Turmeric is also called as "Indian Saffron''. India is the largest producer, consumer and exporter of turmeric in the world. Indian turmeric is considered the best in the world market because of its high curcumin content (Devi and Sanghamitra, 2011) [6]. The price of turmeric is directly related to its curcumin content (Anonymous, 2007) [2]. Turmeric rhizomes contains 1.8 to 5.4 per cent curcumin, a crystalline substance ($C_{21}$ $H_{20}O_6$) which imparts yellow colour, 2.5 to 7.2 per cent of essential oil, turmerol, 5.0 per cent fat, 3.5 per cent minerals and 69.4 per cent carbohydrates (Barrero and Carreno, 1999) [4]. It is widely used in food, beverages, confectionery and medicine and because of its multifarious uses the demand for trading is increasing day by day. India being the world largest producer of turmeric, gains importance for oleoresin and curcumin having medicinal value and ample export opportunity has been created in the world trade (Tamil Selvan *et al.*, 1999) [26]. Oleoresin compounds are present in its rhizome at the rate 6-13% (Mannikeri, 2006) [10].

Turmeric is grown for its underground rhizome which is mainly used as spice or condiments. Turmeric can be grown in diverse tropical conditions from sea level up to 1500 meters altitude at a temperature range of 20-35 ºC with an annual rainfall of 1500 mm or more under rainfed or irrigated condition. Though it can be grown on different type of soil, it performs best in well drained sandy loam soil of p$^H$ 4.5 to 7.5.

Considering the worlds demand for organic food, soil health, productivity and the availability of local resources, it becomes essential to encourage the farmer to take the advantage of the international demand for organically produced spice, aromatic and medicinal products.

Use of organic manure for crop production is gaining momentum as the organically produce products get high economic return and they are environmentally safe compared with inorganic fertilizers. Moreover, organic manures have beneficial effects on soil health and productivity.

Turmeric being a long duration (8-9 month) exhaustive crop responds well to nutrition, so optimum dose of nutrients is very much essential to produce good yield. The organic manure gives better quality produce as compared to those grown with inorganic sources of fertilizer. (Abusaleha and Shanmugavelu, 1985) [1]. They are superior with respect to desirable ingredients such as minerals, vitamin(B1,B2 and C), carbohydrate, protein and free amino acid as well as organic acids (Woese *et al*.,1997) [31].

In developing countries land application of organic manures have been the traditional means of maintaining soil fertility, ecological balance and in recent years there is a great demand for the organically produced turmeric worldwide, especially in European countries. The adverse effects of continuous use of high dose of chemical fertilizers on soil health and environment were realized; hence the farmers are also showing considerable inclination towards traditional farming with least usage of fertilizers. The negative effect of chemical fertilizer and pesticides in agriculture could be reversed by the correct utilization of different organic substances to produce healthy and quality crop and also to sustain soil fertility. Organic farming uses nature as the best role model for agriculture and considers soil as living. Hence, it is the need of the hour to know the best source of organic manure which could help in increasing the yield and quality and need to encourage the good management practices which are environmental friendly and ecologically balanced. Keeping these facts in view, the present investigation was conducted to evaluate the effect of organic nutrients on growth, yield and quality attributes of turmeric.

**Materials and Methods**

To assess the growth, quality and yield attributing characters of turmeric under different organic treatment an experiment was laid out at the Instructional cum Research Farm, Department of Horticulture, Biswnath College of Agriculture, Assam Agricultural University, Biswanath Chariali during 2016-17. The experiment was laid out in an organic block where experiment was continued for the last two consecutive years under NICRA, All India Coordinated Research Project for Dry land Agriculture, BNCA. The cultivar was 'Tall Clone'**.** The prevailing climatic condition of Biswanath Chariali is subtropical having hot and humid summer, dry and cool winter and high relative humidity. The soil of the experimental plot was well drained, sandy loam and acidic (5.0) with good water holding capacity. Certified organic block with already laid out plot was used for planting of turmeric rhizome. The final plot was prepared by ploughing and cross ploughing with a manual hoeing followed by laveling. Then the land was saturated with irrigation water and prepared by successive laddering and furrow making. The experiment comprised of seven treatments replicated four times in randomized block design. The treatments were $T_1$: recommended dose of fertilizer(RDF), $T_2$: *In-situ* incorporation of Dhaincha, $T_3$: FYM @ 10t $ha^{-1}$, $T_4$: Enriched compost≈ FYM @ 10 t $ha^{-1}$ in the furrow at planting, $T_5$: Vermicompost ≈ FYM @ 10t $ha^{-1}$ + Microbial consortia as slurry for treatment of rhizome at planting, $T_6$: Microbial consortia as slurry for treatment of rhizome with vermiwash (1:7) + Vermiwash spray (1:7) every month up to seven months of planting, $T_7$: FYM@ 10 t $ha^{-1}$ + Microbial consortia as slurry for treatment of rhizome at planting. Rhizomes were planted at a spacing 45cm x 25cm in furrows at 10cm depth in the month of April. Rhizomes were treated with Biofor PF at the time of planting by preparing slurry. Nitrogen, phosphate and potassic fertilizer were applied in the form of urea, SSP and MOP. Half dose of N and whole dose of $K_2O$ and $P_2O_5$ were applied two days ahead of planting. The remaining half dose of N was applied at the time of earthing up(3months after planting).The well grown green manuring crops, dhaincha (*Sesbania aculeata*) were cut into small pieces and incorporated into the soil in treatment $T_2$ plots at 45 days after sowing of dhaincha seed. The FYM, vermicompost and enriched compost were applied treatment wise at the time of final bed preparation. Microbial consortium as slurry for treatment of rhizome was mixed with compost and soil at the time of final planting. Vermiwash was applied as foliar spray at seven days interval from one month after planting. The experiment was conducted under mulched conditions where legume stubbles were used. The cultural operations were carried out as and when required as per package of practices. The crop was harvested manually by digging the soil with the help of hoe.

Plant emergence count was recorded at 60 days after planting. The data on plant emergence have been recorded from the entire plot and expressed as percentage. Plant height was measured from the ground level to the tip of the longest leaf at 180 days after planting and the average was calculated and expressed in centimeter. The numbers of fully opened leaves from the main shoot along with tillers for number of leaves per plant of the ten tagged plants were counted and the average number was worked out. The number of tiller produced by the ten tagged plants were recorded and the average number of tillers per plant was calculated. Leaf area of 3rd leaf from the base of the turmeric plant was measured with the help of leaf area meter at 180 days after planting and multiplying this leaf area with the total number of leaves per plants, the leaf area per plant was calculated. Leaf area index were estimated by following the formula given by Watson (1947) [30].

LAI = Total leaf area of the crop/Total ground area of the crop

After harvesting of rhizomes, the total number of mother, primary, secondary and tertiary rhizomes produced by randomly selected plants were recorded separately and their average value was expressed as number of mother, primary, secondary and tertiary rhizomes per plant. Ten randomly selected mother rhizomes were dissected and length was computed by measuring the length of a dissected mother rhizome with thread and scale. Ten representative mother rhizomes were selected randomly for taking the girth. The fresh rhizome produced per plant of each treatment was separated, cleaned and weighed and expressed as the total fresh rhizome yield (g) per plant. Then fresh weight of rhizomes of each plot were weighed with the help of digital balance and converted to q/ ha yield. After drying the fresh samples in the sun for a day were kept in a hot air oven at 60 ºC until constant weight was obtained and the average value was expressed as dry weight of rhizome per plant in grams.

After harvest a known quantity of fresh weight of both mother and finger rhizomes from each plot was boiled till the rhizome frothing occurred with emission of characteristic odour and fingers becoming soft. After boiling, rhizomes were dried under the sun followed by oven drying at 60 ºC till the

constant weight was obtained. The curing percentage was then worked out by following the formula.
Curing (%) = Cured turmeric yield/Raw turmeric yield x100
The Curcumin content in rhizomes was estimated by adopting the method given by Manjunath *et al*. (1991) [9]

**Staistical analysis**
The observations recorded during field experiment were subjected to the statistical analysis of variance by Randomized Block Design (RBD). Significance and non-significance of the variance due to different treatments were determined by calculating the respective 'F' value as the method described by Panse and Sukhatme (1985) [18].

**Results and Discussion**
The data on plant emergence per cent was recorded at 60 days after planting (Table-1) and was found to be non significant. However, among the treatments highest plant emergence (97.47%) was recorded under $T_7$ and the lowest number of emergence (95.07%) was observed in $T_6$. The turmeric rhizome could maintain sufficient reserve food materials that could successfully nourish the developing sprouts till their establishment as new plants without taking much nutrients from the soil. Plant height was significantly influenced by different treatments. Maximum plant height (167.23 cm) was recorded in $T_1$ and minimum (110.81 cm) was in $T_6$ The number of leaves and number of tillers increased significantly with the advancement of plant growth from 150 to 180 days after planting in all the treatments. Maximum number of tillers per plant (2.68, 3.88 and 3.90) and number of leaves per plant (16.41, 23.46 and 22.77) at 150, 180 and 210 days after planting respectively were observed in $T_1$ and minimum were recorded in $T_6$. The best performance by $T_1$ (recommended dose of inorganic fertilizer) might be due to the fact that inorganic fertilizers kept the nutrients in readily available form in $T_1$ plots for uptake and translocation by the turmeric plants compared to other organic manures treated plots that required relatively more time for making the nutrients in readily available form for absorption by the plants. Nair, 1964 [14]; Marchner, 1983 [11]; Rao and Swami, 1984 [20] and Shashidhar *et al.*, 1997 [24] also reported the favourable effect of N, P, and K in promoting the growth of turmeric plants. The higher nutrient content due to mineral fertilization in soil accelerated the vegetative growth of turmeric plants in terms of plant height, leaf number and tiller number (Borah and Langthasa, 1994; Anonymous, 2009 and Padmapriya and Chezhiyan, 2009) [5, 3, 17]. Among the organic manure treatments $T_7$ (FYM@ 10 t $ha^{-1}$ + Microbial consortia as slurry) performed the best in respect to these morphological characteristics followed by $T_4$ ( Enriched compost≈ FYM @ 10 t $ha^{-1}$ ) while $T_6$ (Microbial consortia as slurry for treatment of rhizome with vermiwash (1:7) + Vermiwash spray (1:7) every month up to seven months of planting) recorded the poorest performance. It might be due to the positive effect of incorporated FYM on physico-chemical and fertility properties of soil that finally helped to release nutrients required by turmeric. The similar findings in turmeric were also reported by Rao (2000) [19] and Krishnmoorthy *et al*. (2002) [8].
The leaf area of single leaf ($cm^2$), leaf area per plant ($cm^2$) and leaf area index showed a significant difference due to the effect of different treatments (Table 2).Among the treatments the highest single leaf area (648.33 $cm^{2)}$ and leaf area index (12.42) was observed in treatment $T_1$ which was followed by treatment $T_7$ and $T_4$. Significantly highest leaf area per plant (15209.82$cm^2$) was recorded in $T_1$ Which was statically at par with the $T_7$ and $T_4$. The lowest single leaf area (489.19 $cm^2$), leaf area per plant (7753.66 $cm^2$) and leaf area index (6.32) was exhibited by $T_6$. According to Richards (1981) [21] and Marchner (1986) [12] NPK had direct effect on biosynthesis of cytokinin and their transport in the plant system. Being a plant growth hormone cytokinin has a positive co-relation with leaf area increment. These nutrient were very much essential for increasing photosynthetic assimilatory surface area (Khare, 1985 and Naidu *et al*., 2000) [7, 13]. Among the organics the better performance of $T_7$ and $T_4$ might be due to the positive effect of FYM and Azotobacter on soil health and fertility status which helped to provide nutrients required by turmeric plant to maintain vigorous vegetative growth with higher leaf area and thereby high leaf area index. The Azotobacter produces antifungal substances as well as biologically active growth substances such as auxins, gibberellins and vitamins etc. which have beneficial effect on plant growth (Naumova *et al*.,1962; Tein *et al*., 1979 and Wange and Kale, 2004) [15, 27, 29]. Selverajan and Chezheyan, 2001 [23] reported that the growth hormones produced by microbes near the root zone helped in root growth and also the absorption of nutrients from the soil.
The number of rhizomes, size, length and girth were significantly influenced by different organic treatment (Table 3). $T_1$ recorded maximum number of mother rhizome (2.15), primary (6.54), secondary (16.79) and tertiary (6.12) rhizome per plant, length (11.16 cm) and girth (6.62 cm) of mother rhizome which was followed by $T_7$ and $T_4$. Maximum length (11.35 cm) and girth (3.57cm) of finger rhizome, fresh (424.25 g) and dry (72.08 g) weight of rhizome per plant and yield (335.25 q/ha) were recorded in $T_1$(Table 4) and followed by $T_7$ and $T_4$. Significantly lowest value for all these parameters were recorded in $T_6$. The promotion of rhizome number, size and weight in $T_1$ might be due to more availability of nutrients in soil. These nutrients together with photosynthetic products might lead to more growth of plant and accumulation of higher dry matter in turmeric rhizomes. These finding are in accordance with the findings of Tisdale *et al*, 1985 [28] and Mannikeri, 2006 [10].
The better performance of $T_7$ and $T_4$ might be due to the positive effect of incorporated FYM and manures which have positive influence on soil structure, better water holding capacity which in turn help for better nutrient availability to become favourable condition for good rhizome growth which increased the number, size and weight of turmeric rhizome. The results are in conformity with Nirmalatha *et al*. (2010) [16] who found significant effect of organic manures (FYM and Neem cake) on rhizome thickness in Kasthuri turmeric. FYM along with microbial consortia inoculants might have played a vital role in improvement in physical properties of the soil and increasing the rhizome yield.
The different organic treatments significantly influenced the quality parameters. Data presented in table 4 revealed that maximum curing percentage (18.09%) and curcumin content (3.62%) was found in $T_7$ which was followed by 17.37% and 3.03% respectively in $T_4$. The minimum value of curing percentage (15.40%) was recorded in $T_6$ and minimum curcumin content of 2.42% was also found in $T_6$ which was at par with $T_2$ (2.53%) and $T_3$ (2.61%). Improved physical condition of soil, available nutrient status and organic matter status of soil might have increased curing percentage and curcumin content. Sadanandan *et al*, 2002 [22] reported that application of organic manures and bio fertilizer increased the curcumin content in turmeric.

## Conclusion

From the present investigation, it can be concluded that after three years of cultivation organic manures like FYM@ 10 t $ha^{-1}$ + Microbial consortia as slurry for treatment of rhizome at planting ($T_7$) and Enriched compost ≈ FYM @ 10 t $ha^{-1}$ in the furrow at planting ($T_4$) could perform equally with inorganic fertilizers in terms of growth and yield and perform better than inorganic in respect of quality.

**Table 1:** Effect of organics on growth attributes (plant emergence (%), plant height (cm), number of tillers per plant & number of leaves per plant) of turmeric

| Treatment | Plant emergence (%) | Plant height (cm) | Number of tillers per plant | | | Number of leaves per plant | | |
|---|---|---|---|---|---|---|---|---|
| | 60 DAP | 180 DAP | 150 DAP | 180 DAP | 210 DAP | 150 DAP | 180 DAP | 210 DAP |
| T1 | 97.03 | 167.23 | 2.68 | 3.88 | 3.90 | 16.41 | 23.46 | 22.77 |
| T2 | 96.86 | 143.49 | 1.95 | 3.13 | 3.14 | 13.83 | 20.08 | 19.48 |
| T3 | 96.05 | 151.90 | 2.05 | 3.16 | 3.19 | 14.25 | 20.22 | 19.74 |
| T4 | 97.00 | 165.26 | 2.22 | 3.63 | 3.65 | 14.92 | 22.33 | 21.69 |
| T5 | 97.20 | 144.18 | 2.17 | 3.02 | 3.05 | 14.68 | 19.62 | 19.09 |
| T6 | 95.07 | 110.81 | 1.57 | 2.18 | 2.20 | 12.33 | 15.85 | 15.43 |
| T7 | 97.47 | 166.60 | 2.42 | 3.82 | 3.83 | 15.31 | 23.15 | 22.42 |
| S Ed(±) | 1.30 | 6.30 | 0.33 | 0.26 | 0.24 | 0.26 | 0.29 | 0.23 |
| CD at 5% | NS | 12.80 | 0.69 | 0.53 | 0.47 | 0.53 | 0.59 | 0.47 |

**Table 2:** Effect of organics on leaf area of single leaf, leaf area per plant and leaf area index of turmeric

| Treatment | Leaf area of a single leaf($cm^2$) | Leaf area per plant ($cm^2$) | Leaf area index |
|---|---|---|---|
| T1 | 648.33 | 15209.82 | 12.42 |
| T2 | 544.09 | 10925.32 | 8.91 |
| T3 | 563.62 | 11396.39 | 9.30 |
| T4 | 617.60 | 13791.01 | 11.25 |
| T5 | 581.85 | 11415.89 | 9.31 |
| T6 | 489.19 | 7753.66 | 6.32 |
| T7 | 631.42 | 14617.37 | 11.93 |
| S Ed(±) | 45.30 | 334.50 | 0.38 |
| CD at 5% | 96.10 | 678.56 | 0.82 |

**Table 3:** Effect of organics on yield attributes of turmeric

| Treatment | Number of mother rhizome/plant | Number of primary rhizome/plant | Number of secondary rhizome/plant | Number of tertiary rhizome/plant | Length of mother rhizome (cm) | Girth of mother rhizome(cm) |
|---|---|---|---|---|---|---|
| T1 | 2.15 | 6.54 | 16.79 | 6.12 | 11.16 | 6.62 |
| T2 | 1.55 | 4.16 | 14.41 | 4.88 | 10.39 | 4.82 |
| T3 | 1.61 | 4.37 | 13.20 | 4.84 | 9.87 | 4.65 |
| T4 | 1.96 | 5.83 | 15.04 | 5.58 | 11.02 | 6.23 |
| T5 | 1.69 | 5.08 | 13.96 | 5.04 | 9.73 | 4.73 |
| T6 | 1.24 | 4.04 | 10.77 | 4.82 | 8.23 | 4.28 |
| T7 | 2.05 | 6.10 | 15.66 | 5.62 | 11.08 | 6.48 |
| S Ed(±) | 0.18 | 0.74 | 1.13 | 0.54 | 0.63 | 0.26 |
| CD at 5% | 0.37 | 1.52 | 2.29 | 1.11 | 1.26 | 0.54 |

**Table 4:** Effect of organics on yield and quality attributes of turmeric

| Treatment | Length of finger rhizome (cm) | Girth of finger rhizome (cm) | Fresh weight of rhizome (g/plant) | Dry weight of rhizome (g/plant | Yield (q/ ha) | Curing (%) | Curcumin Content (%) |
|---|---|---|---|---|---|---|---|
| T1 | 11.35 | 3.57 | 424.25 | 72.08 | 335.25 | 16.98 | 2.74 |
| T2 | 10.24 | 2.82 | 278.75 | 45.70 | 314.75 | 16.39 | 2.53 |
| T3 | 10.35 | 2.98 | 316.95 | 59.94 | 312.00 | 16.38 | 2.61 |
| T4 | 11.06 | 3.16 | 357.10 | 62.06 | 326.62 | 17.37 | 3.03 |
| T5 | 9.82 | 2.87 | 330.50 | 56.46 | 289.75 | 17.08 | 2.72 |
| T6 | 8.64 | 2.28 | 276.05 | 42.52 | 210.25 | 15.40 | 2.42 |
| T7 | 11.17 | 3.36 | 394.46 | 71.38 | 331.75 | 18.09 | 3.62 |
| S Ed(±) | 0.39 | 0.18 | 14.95 | 1.83 | 10.94 | 0.82 | 0.43 |
| CD at 5% | 1.26 | 0.37 | 30.32 | 3.71 | 22.20 | 1.68 | 0.88 |

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