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THE EVALUATION OF TIME OF APPLICATION OF ORGANIC LIQUID- FERTILIZER ON PERFORMANCE OF TUMERIC IN UMUDIKE.

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ABSTRACT

*A study was conducted at the experimental farm of the National Root Crops Research Institute (NRCRI), to evaluation of time of application of organic liquid- fertilizer on performance of Tumeric in Umudike. Two improved turmeric varieties developed by NRCRI were used in the experiment. The treatments included applications at 4, 8, and 12 weeks after planting (WAP), with a control (no fertilizer) for each variety. The experiment was laid out in a randomized complete block design (RCBD) in three (3) replications. Data were collected on plant height, plant girth, leaf area, number of leaves, leaf area and rhizome yield. The statistical analysis was conducted using R software version 4.3.1. A two-way analysis of variance (ANOVA) was performed using the function within a linear model framework, following a Randomized Complete Block Design (RCBD) to assess the effects of fertilizer timing and variety on all measured growth and yield parameters. Pearson's correlation coefficients between plant traits were calculated. The results show strong and statistically significant differences among the varieties for plant height, as indicated by the low CV (1.5%) and a small LSD value of 1.5, confirming high precision in measurement. Variety L4 recorded the tallest plants (52.9 cm), followed closely by L12 (46.9 cm) and X4 (42.4 cm). The results for plant height show that treatments produced statistically meaningful differences at the LSD of 12.7. From the correlation analysis (P<0.05), plant height and a highly significant correlation with leave area (r= 0.78**), plant girth (0.55**) and number of leaves (0.52**). Also the relationship between plant height and mother rhizome was also significant (0.48*) but not as high as leave area, plant girth and number of leaves. A significant relationship was also established between plant girth with mother rhizome (0.54*), secondary rhizome (0.48**) and primary rhizome (0.62*).*

Keywords: *Turmeric, organic liquid- fertilizer, rhizome yield, plant girth, leaf area*

INTRODUCTION

Turmeric (*Curcuma longa* L.) is one of the most widely grown spice crop in southwestern part of Ethiopia. It is a versatile remunerative cash crop and their primary product is the cured dried rhizome. Principally, turmeric has a wide range of values such as orange colouring powder in textile industry, food industry and medicinal values, for its appreciated aroma and flavour., and for its oleoresin (Addisu *et al.,* 2014). According to Girma et al., 2008, turmeric is well known in every Ethiopian dish (kitchen) as source of ingredient in the preparation of local sauces "Wot". Turmeric has become one of the most important cash crops in Ethiopia. Its commercial cultivation in the country is picking up and is likely to become a cash crop with good economic return especially for resource poor farmers. It has also been commercialized in large private farm and huge investment projects at national level, which indicates the bright future of the crop in Ethiopia. The crop offers a good scope for diversification of the existing Arabica coffee (cash crop) based cropping system of south western Ethiopia. Ethiopia export turmeric mainly in their dried forms and, little as oleoresin or essential oils extract (Maseresha *et al.,* 2010). In 2013, turmeric accounts 8% (USD 2.1 million) of the total spices export in Ethiopia (Herms *et al.,* 2015). The production and productivity of turmeric crop, however, is still low as compared to other major turmeric producing countries. According to Addisu 2014, the national productivity of turmeric in Ethiopia was 2.4 tones ha-1 in the contrary to 4.0 tones ha-1 in India. This production gap could be due to several factors among which declining soil fertility is one. Several studies reported that turmeric is a nutrient exhaustive crop, particularly nitrogen (Singh *et al.,* 2001; Agere and Shiferaw 2015). The high nutrient requirement of turmeric is due to their shallow rooting, prolonged growing period (up to nine months) and the potential Turmeric (Curcuma longa L.) is one of the most widely grown spice crop in south western part of Nigeria. It is a versatile remunerative cash crop and their primary product is the cured dried rhizome. Principally, turmeric has a wide range of values such as orange colouring powder in textile industry, food industry and medicinal values, for its appreciated aroma and flavour and for its oleoresin (Addisu *et al.,* 2014). According to Agere and Shiferaw (2015), turmeric is well known in every Ethiopian dish (kitchen) as source of ingredient in the preparation of local sauces "Wot". Turmeric has become one of the most important cash crops in Ethiopia. Its commercial cultivation in the country is picking up and is likely to become a cash crop with good economic return especially for resource poor farmers.

In Nigeria, about 19 States are prominent in turmeric production and it is given many names depending on the locality (Olojede, *et al.,* 2011). Turmeric being a long duration crop extracts lot of the nutrients from the soil. Utilization of farm yard manure in agriculture is recommended for retaining productivity of problem soils, reducing the usage of chemical fertilizer, improving economy in agriculture and minimizing environmental problems (Xiao.,2006). Turmeric is grown under rain-fed conditions without any application of fertilizers as north coastal hilly area is treated as organic zone. The farmers in this zone are cultivating turmeric two to three years instead of eight to nine months' duration and incurred persistent losses towards cultivating turmeric. This is mainly because lack of proper knowledge in usage of nutrient sources and also limited information on organic turmeric cultivation (Kandianna and Chandaragiri, 2008; Roy and Hore, 2011). This work focuses on the effect of time of application of organic liquid fertilizer on the productivity of Tumeric

Materials and Method.

The study was conducted at the experimental farm of the National Root Crops Research Institute (NRCRI), Umudike, located in the humid rainforest zone of South-Eastern Nigeria. The site lies at latitude 05°29′N and longitude 07°33′E, with an elevation of approximately 122 m above sea level. The climate is characterized by an average annual rainfall ranging from 1800 to 2500 mm, and temperatures between 25°C and 32°C. The soil is predominantly loamy with a pH of 5.5–6.5, which is conducive to turmeric cultivation. Air temperature and relative humidity during the experimental period averaged 21.2–33.6°C and 60–83%, respectively. The planting materials consisted of two improved turmeric varieties developed by NRCRI:

1. Variety 1: *Curcuma xanthorrniza* (local variety commonly grown in Umudike)
2. Variety 2: *Curcuma longa* (improved variety with higher yield potential and enhanced resistance to pests and diseases)

The organic liquid fertilizer used was "Boost Extra," applied as a foliar spray. Other materials included fungicide (1% Mancozeb) for rhizome treatment, field marking tools (ropes, measuring tapes, pegs), and manual weeding implements. The organic liquid fertilizer (*Boost Extra*) was applied as a foliar spray. Treatments included applications at 4, 8, and 12 weeks after planting (WAP), with a control (no fertilizer) for each variety. Applications were made using a knapsack sprayer during the cooler hours of the day. The experimental layout was RCBD consisting of 8plots with 3 replications totalling 24 plots.

Data Collection

Data were collected on the following parameters at specified intervals

Parameter	Measurement Timing (Weeks After Planting)
Germination count (%)	4, 8
Plant height (cm)	4, 8, 12, 16
Leaf area (cm²)	4, 8, 12, 16
Number of leaves	4, 8
Plant girth (cm)	4, 8
Rhizome yield (t/ha)	At harvest (4 months after planting) (16wap)

Statistical Analysis

The statistical analysis was conducted using R software version 4.3.1. A two-way analysis of variance (ANOVA) was performed using the function within a linear model framework, following a Randomized Complete Block Design (RCBD) to assess the effects of fertilizer timing and variety on all measured growth and yield parameters. Where ANOVA indicated significant treatment effects ($p < 0.05$), post-hoc mean separation was carried out using the fisher's least Significant Difference (F-LSD) test, implemented. Pearson's correlation coefficients between plant traits were calculated using the function. The coefficient of variation (CV) and standard error (SE) were computed for key variables to assess data variability and precision. Data management and visualization were facilitated using the *tidyverse*, *readxl*, and *Performance Analytics* packages

RESULTS AND DISCUSSIONS

Mean Performance of Turmeric Varieties to Number of Leaves Per Plant, Plant Girth, Plant Height and Leaf Area at 12 Weeks After Planting.

Table 1 summarizes the mean performance of the time of application of organic liquid fertilizer on the number of leaves per plant, plant girth, plant height and leaf area of turmeric at twelve (12) weeks after planting (WAP). The results show strong and statistically significant differences among the varieties for plant height, as indicated by the low CV (1.5%) and a small LSD value of 1.5, confirming high precision in measurement. Variety L4 recorded the tallest plants (52.9 cm), followed closely by L12 (46.9 cm) and X4 (42.4 cm). In contrast, X8 produced the shortest plants (15.5 cm), significantly lower than all other varieties. This wide variation suggests that genetic differences among the varieties strongly influenced vertical growth. The performance of L-series varieties, particularly L4 and L12, indicates superior growth vigour, whereas X8 reflects a genetically weaker or stress-sensitive genotype.

For leaf area in Table 2, significant differences were also observed, supported by an extremely low CV (0.3%) and an LSD of 3.3. Variety L0 produced an exceptionally large leaf area (1326.9 cm²), far exceeding all other treatments. This outlier performance indicates a unique genetic capacity for expansive canopy development. The next highest leaf areas were recorded for X4 (290.4 cm²), L4 (285.0 cm²), X8 (282.1 cm²), and L8 (276.3 cm²), though none approached the magnitude of L0. The smallest leaf area was observed in X12 (89.6 cm²). These wide disparities imply that certain varieties prioritize leaf expansion more strongly than others, which may translate into differences in photosynthetic potential and overall biomass accumulation. Ebel and Kissmann (2019) as well as Ebel (2020) made similar observations and stated that proper timing aligns nutrient availability with peak demand, resulting in improved growth parameters such as plant height, leaf area, and biomass accumulation, leading to higher yields.

In terms of plant girth in table 3 significant differences were detected (HSD = 2.7; CV = 15.3%). Variety L0 again performed best with the largest stem girth (5.1 mm), suggesting strong structural development and potential for better nutrient translocation and lodging resistance. All other varieties produced significantly smaller girths, ranging from 5.0 mm (X8) to 6.4 mm (L12 and X12). The dominance of L0 in both leaf area and girth indicates a robust growth pattern favouring both canopy and stem development, whereas X8 consistently exhibited weaker performance.

In terms of number of leaves, the varieties showed significant differences as indicated by the LSD value (3.0). Varieties L8 and L4 produced the highest number of leaves per plant, 11.0, 12.00 and 12.0, respectively, whereas X12 (6.0 leaves) and X8 (7.3 leaves) recorded the lowest leaf counts. The moderate CV of 11% suggests acceptable consistency across replications. The higher leaf count recorded for L8 and L0 aligns with their strong performance in other vegetative traits, indicating vigorous overall growth. On the other hand, the poor performance of X12 and X8 suggests that these varieties may possess genetically lower leaf production potential or may have had reduced capacity to utilize available growth resources.

In summary, the results reveal clear genetic differences among the varieties. The most vigorous variety, consistently excelling in leaf area, stem girth, and leaf production. L4 and L12 also demonstrated strong vegetative performance, particularly in plant height and leaf number. In contrast, X8 and X12 ranked lowest across most traits, indicating comparatively weak growth potential. The statistically significant differences across all parameters highlight the importance of variety selection in optimizing growth performance.

Mean Performance of the Time of Application of Organic Liquid Fertilizer on Plant Height, Leaf Area, Plant Girth, Number of Leaves Per Plant, Stand Count, Mother Rhizomes and Secondary Rhizomes.

Table 4 shows the mean performance of the time of application of organic liquid fertilizer on plant height, plant girth, number of leaves per plant stand count, mother rhizomes, secondary rhizomes and leaf area of turmeric at twelve (12) weeks after planting (WAP). The results for plant height show that treatments produced statistically meaningful differences at the LSD of 12.7. Treatment L12 recorded the highest plant height (37.3 cm), followed closely by L8 (35 cm), while X0 had the lowest height (23 cm). However, most treatments fell within the same significance group, meaning that although numerical differences exist, many treatments performed similarly. The moderate CV (14.6%) suggests acceptable variability. Overall, the L-series treatments, especially L12 and L4, tended to support taller plant growth compared to X0.. The CV (19.8%) is moderately high, suggesting noticeable within-treatment variation. Nonetheless, the general pattern indicates that treatments L8, L4, and L12 supported broader leaf expansion compared to X0. The results for plant girth according to Table 4 reveal significant treatment effects, with an LSD of 3.6. X12 produced the thickest stem girth (11.5 mm), which is statistically superior to all other treatments. X8 also showed relatively high girth (6.8 mm), while X0 recorded the smallest value (2.8 mm). The CV of 23.5% indicates considerable variability, but the strong performance of X12 suggests a distinct advantage in structural vigour and stem robustness compared to other treatments. This may reflect enhanced resource allocation to stem thickening under X12. For number of leaves, no treatment effect was detected, as all values fall within the same significance group. Leaf number ranged from 1.0 to 2.2 leaves per plant, and the high CV (40.4%) suggests substantial natural variability. This indicates that leaf production was not substantially influenced by the treatments applied, or that the variability masked potential differences. Regarding stand count, no statistically significant differences were observed (HSD = 15.1). Stand count values were relatively stable, ranging from 25.7 (L0) to 39 (L12), indicating good field establishment across treatments. The moderate CV (15.4%) confirms consistency of seedling survival. For mother, secondary, and primary rhizomes, all treatments showed statistically similar performance, as indicated by shared significance groupings. Although numerical differences exist (e.g., mother rhizomes ranged from 1.7 to 2.5), these differences were statistically insignificant. Relatively high CVs (27–30%) suggest variability among replicates, which may have obscured treatment effects. Still, treatments L12, X12, and X8 numerically produced more rhizomes, implying better underground biomass development under these treatments.

The correlation analysis presented in table 5 showed the relationship between the plant attributes and rhizome yield measured during the experiment. From the table plant height and a highly significant correlation with leave area (r= 0.78**), plant girth (0.55**) and number of leaves (0.52**). Also, the relationship between plant height and mother rhizome was also significant (0.48*) but not as high as leave area, plant girth and number of leaves. The leave area from the result also had positive significant relationship with number of leaves but had non-significant relationship with other attributes measured. A significant relationship was established between plant girth with mother rhizome (0.54*), secondary rhizome (0.48**) and primary rhizome (0.62*). The relationship between plant girth and stand count significant but negative (-0.41*). The analysis also showed a highly significant correlation between number of leaf and stand count. Also the analysis showed that stand count had a positive significant relationship with secondary rhizome (0.72*) and primary rhizome (0.68**). The correlation analysis also showed that there exist a significant relationship between secondary rhizome and primary rhizome.

Conclusion

The strong correlations between traits such as plant height, leaf area, and stand count indicate that these parameters are interdependent and can be used as early indicators of plant performance. The research demonstrates that while fertilizer timing is a crucial agronomic factor for canopy development, achieving a significant increase in rhizome yield may require an integrated approach that combines optimal timing with other factors such as variety selection, nutrient composition, and long-term soil management.

Table 1. Mean performance of turmeric varieties to number of leaves, plant girth, Plant-height, and leaf area at twelve (12) WAP :

Table 1. Mean performance of turmeric varieties to number of leaves, plant girth, Plant-height, and leaf area at twelve (12) WAP

Treatments	Plant height	Leaf area	Plant girth	Number of leaves
L0	29.5 f	237.9 c	5.1 a	11.0 a
L12	46.9 b	355.2 a	6.4 a	10.7 a
L4	52.9 a	285.0 b	5.8 a	12.0 a
L8	35.6 d	276.3 b	5.2 a	12.0 a
X0	26.5 g	206.6 d	6.1 a	8.0 b
X12	31.7 e	89.6 e	6.4 a	6.0 c
X4	42.4 c	290.4 b	6.3 a	10.3 a
X8	15.5 h	282.1 b	5.0 a	7.3 bc
CV(%)	**1.5**	**5.3**	**15.6**	**11.0**
LSD 0.05	**1.5**	**23.0**	**1.6**	**1.8**

Means with the same letter are not significantly different (alpha=0.05): WAP: week after planting, LSD: Least significant difference, CV: coefficient of variation,

Table 2. Mean performance of turmeric varieties to plant height, leaf area, plant girth, number of leave per plant, stand count, weight of mother rhizome, weight of primary rhizome and weight of secondary in Umudike.

Treatment	Plant height	Leaf area	Plant Girth	No. of leaves	Stand count	Mother rhizomes	Secondary rhizomes	Primary rhizomes
L0	25.3 bc	25.1 ab	4.1 c	1.0 b	25.7 c	1.7 a	1.7 a	1.2a a
L12	37.3 a	28.1 a	5.0 bc	2.2 a	39.0 a	2.5 a	2.1 a	1.7a a
L4	33.3 a	29.1 a	4.5 c	1.2 b	32.7 abc	2.4 a	1.7 a	1.5a a
L8	35.0 a	30.3 a	4.7 bc	1.8 ab	38.0 ab	2.2 a	1.7 a	1.2a a
X0	23.0 c	18.5 b	2.8 c	1.3 ab	38.7 a	1.8 a	1.3 a	1.4a a
X12	31.0 ab	27.3 ab	11.5 a	1.2 b	36.3 ab	2.4 a	2.0 a	1.5a a
X4	30.0 abc	32.8 a	4.3 c	1.7 ab	38.3 ab	2.2 a	1.3 a	1.4a a
X8	31.3 ab	26.5 ab	6.8 b	1.2 b	29.3 bc	2.3 a	2.1 a	1.2a a
CV	**14.6**	**19.8**	**23.5**	**40.4**	**15.4**	**27.0**	**26.8**	**29.9**
LSD	**7.79**	**9.32**	**2.22**	**0.99**	**9.24**	**ns**	**ns**	**ns**

Table 3. Correlation of linear relationship between multiple plant traits

	Leaf area	Plant girth	No of leaves	Stand count	Mother rhizome	Secondary Rhizome	Primary Rhizome
Plant height	0.788 **	0.55**	0.52**	0.26	0.48*	0.22	0.36
Leaf area		0.30	0.44*	0.16	-0.44	0.21	0.16
Plant girth			0.21	-0.41	0.54*	0.48**	0.62*
No. of leaves				0.84**	0.44	0.30	0.34
Stand count						0.72*	
Mother rhizome							0.68*
Secondary rhizome							0.42*
Primary rhizome							-

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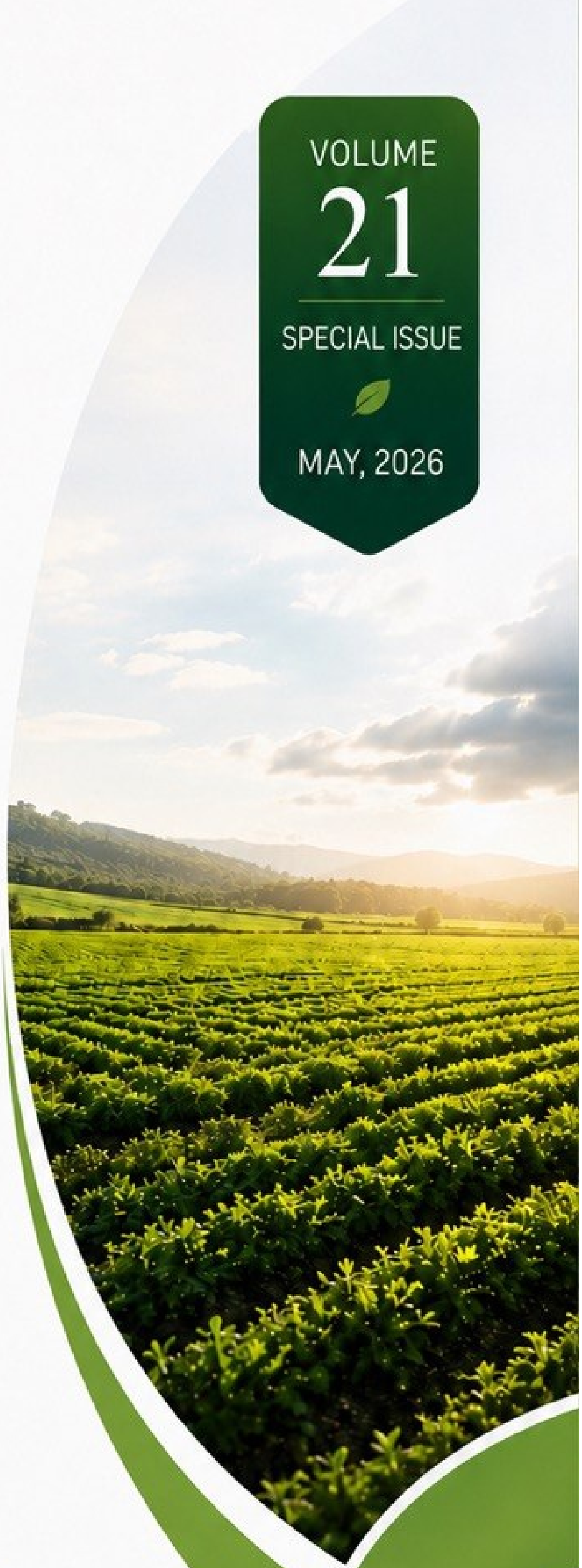

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