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Growth and Yield Components of Some Turmeric Varieties (*Curcuma Longa L.*) As Affected by Inorganic Fertilizer Levels in Umudike, South-Eastern, Nigeria

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Abstract

A research on growth and yield components of some turmeric varieties (*Curcuma longa L.*) as affected by inorganic fertilizer levels in Umudike, South Eastern Nigeria was carried out at the teaching and research farm of the University, during 2018/2019 cropping seasons. It was laid out in a split plot design with three replications. Results, showed that plant height and number of tillers for both varieties and fertilizers levels increased at 2, 4, and 6 months after planting (MAP) during 2018 and 2019 cropping seasons. Variety 021 and 400 NPK (15:15:15) Kg^{-1} produced tallest plants and highest number of tillers over other varieties and fertilizer levels. Crop growth rate was positive at 2 – 4 MAP and negative at 4 – 6 MAP, with 021 and 400 NPK (15:15:15) kgha^{-1} producing higher growth rate. Heaviest rhizomes fresh weight (kg plot^{-1}) of 3.74 and 3.75, rhizome dry matter content of 14.49 and 16.8%, rhizome dry weight of 23.57 and 23.90g and harvest index of 2.60 and 2.70% was yielded by UMT 021 variety over other varieties. The level of 400 NPK (15:15:15) kg ha^{-1} produced heaviest rhizome fresh weight of 4.47 and 4.57 kg plot^{-1}; rhizome dry matter content of 19.42 and 25.8%; rhizome dry weight of 27.54 and 27.8g and harvest index of 2.81 and 3.20%, over other levels. Consequently, variety 021 and 400 NPK (15:15:15) kgha^{-1} are recommended for sole production of turmeric in Umudike, South Eastern Nigeria.

Keywords: Growth, Yield, Turmeric, Varieties, Inorganic fertilizers, Levels.

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Contents

Contribution of this paper to the literature
The research has shown that turmeric requires lot of nutrients for growth and yield. However, excessive application of such nutrient might also be non-profitable to the farmers, due to the seemingly drop in both growth and yield attributes. A benchmark on inorganic fertilizer application for turmeric production has also been established.

1. Introduction

Tumeric (*Curcumalonga* L.) is a very important commercial crop grown for its aromatic rhizomes, which is used both as a spice and also in the preparation of different medicines. Tumeric is a native of tropical South Asia and its cultivation is mostly confined to South East Asian countries. Nigeria and Bangladesh together contribute about 6% of the global turmeric production [1]. Turmeric is a tropical perennial monocotyledonous herb belonging to the family Zingiberaceae [2, 3]. Tumeric can be propagated vegetatively, through mother rhizomes (primary rhizomes), finger rhizomes or split mother rhizomes. Tumeric thrives best in well drained sandy or clay loamy soils, well rich in organic matter. The ideal pH is 4.5 – 7.5, while water logged and alkaline soils must be avoided. It also performs well in humid climatic conditions with temperature range of 20°C to 35°C and annual rainfall range of 80mm to 2500mm respectively. Perhaps, this was the reason [4] reported that variation in turmeric yield could be due to variety used, the type of soil and the prevailing weather situations during the cropping seasons.

Turmeric rhizomes and the ground powder are used as spice or colouring agent. It helps in treating some diseases such as asthma, rheumatism, diabetes, wounds, cancers, urinary tract infections and liver ailments [5]. Tumeric also helps in reducing the level of cholesterol in the human body. It helps to regulate the level of blood sugar as well as possess some antibacterial and antiseptic properties. The average composition of turmeric include: moisture (6.0%); protein (6.5%); ash (6.0%); crude fibre (3.0%), starch (5.0%); oil (3.5%); volatile oil (4.5%) and curcumin (3.1%) [6]. It is also used as a natural dye for cloth, leather, silk, fibre, wool and cotton. Adeniji [7] and Frances [8], stressed that the demands for turmeric is increasing because of its uses in the food and pharmaceutical industries. Several studies have reported that nitrogen has significant effect on growth yield and yield components of turmeric [9, 10]. It has also been reported that nitrogen not only increases the yield of turmeric but also enhances the quality attributes [9]. Application of nitrogen also enhances the efficacy of other nutrients like P and K, that improve the yield of turmeric [11]. N is involved in chlorophyll formation and influences stomatal conductance and photosynthetic efficiency and is responsible for 26 – 41% of crop yields Ivonyi, et al. [12]. Ojikpong [13], in his research on effect of planting dates and NPK (15:15:15) fertilizer on the growth and yield of turmeric reported that 300 kgha^{-1} gave best values for all the measured growth and yield components.

Several studies have acknowledged that turmeric is a heavy feeder crop with high demand for N [10, 14, 15]. The high nutrient requirements of turmeric as reported by Singh, et al. [14] is due to shallow rooting and potential to produce large amount of dry matter per unit area. Also, the crop has a long growing period, extending up to 9 – 10 months, thereby making nutrient requirements period also prolonged. In view of the high nutrient demanding status of turmeric, there is a greater need to frequently boost the fertility status of soils, through prompt fertilizer application. This research therefore, evaluated the growth and yield components of some turmeric varieties (*Curcumalonga* L.) as affected by inorganic fertilizer levels in Umudike, South Eastern, Nigeria.

2. Materials and Methods

The research was conducted at the teaching and research farm of Michael Okpara University of Agriculture, Umudike, South Eastern, Nigeria during 2018 and 2019 cropping seasons. Umudike is located on latitude 05°29` North, longitude 07° 23` East at an altitude of 120.0m above sea level. It has a bimodal rainfall pattern with rainy season commencing from March to July and a dry spell in August followed by another rainfall session from September to November. Annual rainfall pattern ranges from 2074.3mm to 2420mm mean, maximum and minimum temperatures and relative humidity are 31.4°C, 28°C and 63.4°% respectively [16].

The research was laid out in a split plot design with three replications. The main plot comprised NPK (15:15:15) fertilizer levels of 0, 200, 400 and 600 kgha^{-1}, while the subplot comprised the adopted turmeric varieties (UMT 016, UMT 019, UMT 021). There varieties were on the field for 8 months while the rhizomes were sourced from the National Root Crops Research Institute (NRCRI) Umudike. The research layout was 29.5m x 8m or 0.0236ha. The main plot measured 7m x 2m, while the subplot measured 2m x 2m. The distance between plots and replicates were 0.5m and 1m respectively. Healthy, pests and disease – free mother rhizomes (primary rhizomes) with healthy buds were used for planting. Planting was conducted on 15th May for both cropping seasons on beds at the spacing of 20cm x 20cm, resulting in the population of 100 stands per plot and 250,000 stands per hectare.

The plots were mulched after 3 days of planting with dry guinea grass (*Panicummaximum*) at the rate of 20tha^{-1} [17]. Fertilizer application was done by placement method at 3 weeks after planting, while weeding was conducted three times. Mosquito nets were used to protect the entire research layout against rodents, squirrels and associated destructive pests [16]. Harvesting of the rhizomes was manually conducted at 8 months after planting, when to plant becomes brownish and the leaves have fallen. Digging forks and hand trowels were used to soften the soil, before the clumps were carefully pulled out of the soil. The mother (primary) and finger rhizomes were properly washed thereafter. Plant height was conducted by measuring the height of four stands from the base to the terminal point at 2, 4 and 6 MAP, while the total was divided by four. The total number of tillers from four stands were divided by four to have number of tillers per plant. Crop growth rate was obtained from the formula below:

$$CGR = \frac{W_2 - W_1}{S_A (t_2 - t_1)} \quad (gm^{-2} day^{-1})$$ [18]

Where:
W_1 & W_2: Crop dry weight at the beginning and end of the interval.
t_1 & t_2: Corresponding days.
S_A: Soil area occupied by the plant.

Rhizome fresh weight (Kg plot^{-1}) was by weighing total rhizomes harvested from four stands of turmeric per plot and subsequently converted through the formular:

$$= \frac{\text{weight of rhizomes per plot}}{\text{plot size}} \times 1000$$

Rhizomes dry matter content (%) was by the formular:

$$\frac{\text{Rhizome dry weight}}{\text{Rhizome fresh weight}} \times \frac{100}{1}$$

Rhizome dry weight per plant was by weighing the total number of rhizomes from four stands, while the total weight was subsequently divided by four. Harvest index was obtained through this formular:

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \text{ or } \frac{\text{rhizomes fresh weight}}{\text{shoot dry weight}}$$

Before the commencement of the research, composite soil samples were collected randomly at the depth of 0 – 20cm from the research site for physico – chemical analyses. Particle size distribution was determined by the Bouyocous hydrometer method as described by Benton [19]. Soil pH in soil to water and soil to $Cacl_2$ at the ratio of 1:2:5, soil water and soil – $CaCl_2$ respectively, was by using glass electrode pH meter [20]. Organic carbon was by wet oxidation method [21]. Available P was determined by Bray 11 method of Bray and Kurtz [22] as described by Udo, et al. [20]. Total nitrogen was done by the macro Kjeildhal digestion method [23]. Calcium and Mg were determined by atomic absorption spectrometry, while potassium and sodium were by flame photometry [24]. Both growth and yield data were subsequently subjected to analysis of variance (ANOVA) method [25], while Fisher's Least Significant difference (F – LSD) was adopted to compare significant means at 5% probability level.

3. Results and Discussions

3.1. Meteorological Properties of the Research Site

Meteorological properties of the research site Table 1, revealed that the months of January, February and March recorded the lowest rainfall situations of 75.4 and 0.0mm; 84.8mm and 43.7mm as well as 40.8mm and 78.7mm during 2018 and 2019 cropping seasons. Monthly rainfall situations increases from May and dropped in November, preparatory for dry period (Table 1). Both maximum and minimum temperatures and relative humidity fluctuated in favour of rainfall patterns with dry months recording high temperatures and low relative humidity Table 1. The relevance of weather to the productivity of turmeric was earlier reported by Karthikeyan, et al. [4], that variation in turmeric yield could be caused by prevailing weather situations during cropping seasons.

Table-1. Meteorological properties of the research site during 2018 and 2019 cropping seasons.

Months	Rainfall (mm)		Tempt °C				R/H (%)	
			Max.		Min.			
	2018	2019	2018	2019	2018	2019	2018	2019
Jan	75.4	0.0	32.0	33.4	22.0	21.5	31	49
Feb	84.8	43.7	33.0	33.9	24.0	23.2	36	38
Mar	40.8	78.7	33.0	33.2	22.0	23.4	66	54
Apr	92.8	136.8	32.0	32.2	22.0	23.5	70	62
May	466.1	249.2	31.0	31.9	23.0	23.4	72	71
June	239.4	281.8	29.0	30.5	23.0	24.2	72	79
July	280.5	114.9	30.0	30.0	22.0	24.0	81	78
Aug	237.1	436.5	34.0	29.6	23.0	23.3	81	78
Sept	318.0	412.4	30.0	29.8	22.0	22.9	77	73
Oct	184.8	169.1	30.0	31.0	23.0	23.6	69	74
Nov	99.5	147.4	32.0	31.6	23.0	23.5	64	65
Dec	90.8	0.0	32.0	32.7	22.0	21.8	51	48
TOTAL	**2210.0**	**2068.5**						

Table-2. Soil physico-chemical properties of the research site, during 2018 and 2019 cropping seasons.

Soil properties	Values	
Sand (%)	72.4	74.2
Silt (%)	12.8	11.4
Clay (%)	14.8	11.4
Textural Class	Sandy loam	Sandy loam
Chemical properties		
pH	5.09	5.04
Phosphorus (mgkg^{-1})	11.06	12.4
Nitrogen (%)	0.38	0.27
Organic carbon (%)	0.3	0.62
Calcium (Cmolkg^{-1})	3.6	3.2
Magnesium (Cmolkg^{-1})	1.24	2.0
Potassium (Cmolkg^{-1})	0.65	0.52

3.2. Soil Physico-Chemical Properties of the Research Site

The physico-chemical properties of the research site Table 2, showed that the textural class of the site was sandy loamy soil with <80% sand fraction for both cropping seasons. Some elements like phosphorus (11.06 and 12.4 mgkg^{-1}) and organic carbon (0.3% and 0.62%) during 2018 and 2019 cropping seasons were low Table 2. The pH of 5.09 and 5.04 for both cropping seasons were moderate and capable of sustaining the production of turmeric. Apart from nutrient availability, Hossain and Ishimine [26], attributed the performance of turmeric in the field to soil properties including: soil pH, moisture contents, bulk density, aeration and soil microbial activities.

3.3. Effect of NPK (15: 15: 15) Fertilizer Levels on the Growth of Turmeric

Plant height for variety and fertilizer levels increased at 2, 4 and 6 MAP during 2018 and 2019 cropping seasons Table 3. Variety UMT 021 produced tallest plants of 11.8 and 12.3cm (2 MAP), 30.5 and 29.8cm (4 MAP), 69.6 and 70.2 cm (6 MAP) in 2018 and 2019 cropping seasons over other varieties. The 400 NPK (15: 15: 15) $kgha^{-1}$ produced tallest plants of 12.4 and 12.6cm (2 MAP), 38.5 and 38.2m (4 MAP); 77.3 and 76.6cm (6 MAP), compared with control (0 level) Table 3. Plant height was significantly ($P < 0.05$) affected by variety at 2 and 4 (MAP), while 6(MAP) was not significantly ($P > 0.05$) affected for both years. Plant height was significantly ($P <0.05$) affected by fertilizer levels at 2, 4 and 6 (MAP), while interaction (Variety x fertilizer levels) was not significant. Turmeric height will therefore vary with the cultivated variety and the level of inorganic fertilizer applied. The observed drop in height at 600 $kgha^{-1}$, suggested that fertilizer addition beyond 400 $kgha^{-1}$ will not be economical, and might lead to luxury consumption with attendant low yield. Atugwu, et al. [27], reported increased turmeric height with age, while Ojikpong [13], reported tallest turmeric at 300 NPK (15: 15: 15) $Kgha^{-1}$ as well as drop at 450 NPK (15:15:15) $kgha^{-1}$. This research therefore corroborates the earlier report by Ojikpong [13].

Table-3. Effect of NPK (15:15:15) fertilizer level on plant height of turmeric varieties at 2, 4 and 6 MAP during 2018 and 2019 cropping seasons.

Tumeric varieties	Plant height (cm)					
	2 MAP		4 MAP		6MAP	
	2018	2019	2018	2019	2018	2019
UMT 016	10.9	11.0	27.8	27.3	66.9	66.2
UMT 019	9.9	9.9	26.2	26.2	66.9	64.7
UMT 021	11.8	12.3	30.5	29.8	69.6	70.2
Fertilizer levels ($Kgha^{-1}$)						
0	9.0	9.1	16.7	16.5	52.1	51.0
200	10.9	11.1	29.0	28.1	68.4	66.6
400	12.4	12.6	38.5	38.2	77.3	76.6
600	11.2	11.5	28.3	28.1	73.4	74.8

MAP

	2		4		6	
	2018	2019	2018	2019	2018	2019
Variety	0.78	0.56*	1.78	1.64	ns	ns
Fertilizer	1.00*	0.79*	2.75*	2.94*	10.88*	9.14*
Variety x fertilizer	ns	ns	ns	ns	ns	ns

Note: F-LSD ($P< 0.05$).

Table-4. Effect of NPK (15:15:15) fertilizer levels on number of tillers of turmeric varieties at 2, 4 and 6 MAP during 2018 and 2019 cropping seasons.

Tumeric varieties	Plant height (cm)					
	2 MAP		4 MAP		6MAP	
	2018	2019	2018	2019	2018	2019
UMT 016	2.0	3.0	5.2	5.1	9.6	9.3
UMT 019	1.7	2.7	4.8	4.9	9.8	9.2
UMT 021	2.8	3.1	5.8	5.8	9.9	9.9
Fertilizer levels ($kgha^{-1}$)						
0	1.6	2.1	3.8	3.7	7.0	7.4
200	2.1	3.0	4.9	4.8	9.8	9.8
400	2.9	3.9	7.0	7.2	11.7	11.2
600	2.1	2.7	5.3	5.4	10.6	9.6

MAP

	2		4		6	
	2018	2019	2018	2019	2018	2019
Variety	0.52	ns	ns	0.68	ns	ns
Fertilizer	0.50*	0.74	0.80*	1.03*	1.52*	1.88
Variety x fertilizer	ns	ns	ns	Ns	ns	ns

Note: F-LSD ($P< 0.05$).

Number of tillers per plant Table 4, for both variety and fertilizer levels increased at 2, 4 and 6 MAP during 2018 and 2019 cropping seasons. Variety UMT 021 produced the highest number of tillers of 2.8 and 3.1 (2 MAP); 5.8 and 5.8 (4 MAP); 9.9 and 9.9 (6 MAP), over other varieties, while 400 NPK (15:15:15) $Kgha^{-1}$ recorded highest number of tillers of 2.9 and 3.9 (2 MAP); 7.0 and 7.2 (4 MAP) as well as 11.7 and 11.2 (6 MAP) compared with other levels for both cropping seasons. Number of tillers per plant was significantly ($P < 0.05$) affected by the variety at 2 MAP in 2018 cropping season, as well as 4 MAP in 2019 cropping season, while 6 MAP was not significantly ($P > 0.05$) affected by fertilizer levels at 2, 4 and 6 MAP. Interaction (Variety x fertilizer levels) did not significantly ($P > 0.05$) affect number of tillers for both cropping seasons. The observed reduction in number of tillers at 600 NPK (15; 15:15) $Kgha^{-1}$, suggested that it was not economical to the farmer. Number of tillers the research showed will equally vary with the variety planted and the level of fertilizer applied. The increased number of tillers with age, corroborates an earlier report by Atugwu, et al. [27], who reported increase in number of tillers per plant as turmeric grew older.

Crop growth rate Table 5, for variety and fertilizer levels increased positively at 2 to 4 MAP and as well dropped negatively at 4 – 6 MAP for both cropping seasons. Variety UMT 021 recorded highest growth rate of 0.518 and 0.503 $gm^{-2}day^{-1}$ at 2 – 4 MAP as well as -0.123 and -0.0932 $gm^{-2}day^{-1}$ at 4 – 6 MAP. The 400 NPK (15:15:15) $kgha^{-1}$ level equally produced highest growth rate of 0.655 and 0.661 $gm^{-2}day^{-1}$ at 2 – 4 MAP and also -0.105 and -0.1043 $gm^{-2}day^{-1}$ at 4 – 6 MAP. Crop growth rate was not significantly ($P > 0.05$) affected by variety at 2 – 4 and 4 – 6 MAP. Fertilizer levels significantly ($P < 0.05$) affected crop growth rate at 2 – 4 MAP, but was however not significant ($P > 0.05$) at 4 – 6 MAP for both cropping seasons. Interaction (Variety x fertilizer levels) did not significantly ($P > 0.05$) affect crop growth rate. This result has shown that growth processes in turmeric are active from 1 to 4 MAP and that the formation and bulking of tender rhizomes may likely commence before 4 MAP. This may cause the vegetative and early reproductive phases of turmeric to occur simultaneously. The early commencement of the reproductive phase of turmeric as well the effect of senescence during the steady growth phase may explain the negative growth rate and the crop grows older. Crop growth rate is likely to be influenced by the age of turmeric and fertility status of the soil.

Table-5. Effect of NPK (15:15:15) fertilizer levels in crop growth rates of turmeric varieties at 2 – 4 and 4 – 6 MAP during 2018 and 2019 cropping seasons.

Turmeric variety	Crop growth rate ($gm^{-2}day^{-1}$) 2 – 4 MAP 2018	2 – 4 MAP 2019	4 – 6 MAP 2018	4 – 6 MAP 2019
UMT 016	0.444	0.457	-0.089	-0.0751
UMT 019	0.426	0.416	-0.069	-0.0921
UMT 021	0.518	0.503	-0.123	-0.0932
Fertilizer rates ($kgha^{-1}$)				
0	0.463	0.429	-0.103	-0.0872
200	0.446	0.454	-0.098	-0.0872
400	0.655	0.661	-0.105	0.1043
600	0.286	0.291	-0.068	-0.0706

MAP

	2 – 4		4 – 6	
	2018	2019	2018	2019
Variety	Ns	ns	ns	ns
Fertilizer	0.146	0.1428	ns	ns
Variety x Fertilizer	ns	ns	ns	ns

Note: F-LSD ($P< 0.05$).

Table-6. Effect of NPK (15:15:15) fertilizer levels on rhizome fresh weight (kg $plot^{-1}$), rhizome dry matter content, rhizome dry weight and harvest index of turmeric varieties during 2018 and 2019 cropping seasons.

Turmeric variety	Rhizome fresh weight ($kgplot^{-1}$)		Rhizome dry matter content (%)		Rhizome dry weight (g)		Harvest Index (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
UMT 016	3.19	2.85	13.00	15.4	17.25	17.4	2.56	2.2
UMT 019	2.50	2.28	13.61	13.6	13.57	13.5	2.07	1.9
UMT 021	3.74	3.75	14.49	16.8	23.57	23.90	2.60	2.70
Fertilizer rates ($kgha^{-1}$)								
0	1.60	0.67	11.94	12.1	6.97	6.70	1.99	1.0
200	3.05	3.27	12.10	11.5	18.81	19.0	2.47	2.5
400	4.47	4.57	19.42	25.8	27.54	27.8	2.81	3.2
600	3.35	3.34	11.73	11.7	19.78	19.6	2.38	2.4

	Rhizome fresh weight ($kgplot^{-1}$)		Rhizome dry matter content (%)		Rhizome dry weight (g)		Harvest Index (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
Variety	ns	0.672	ns	ns	5.837	5.62	ns	0.52
Fertilizer	1.395	0.911	ns	4.08	6.177*	6.32*	ns	0.70*
Variety x Fertilizer	ns	ns	ns	7.17	ns	ns	ns	ns

Note: F-LSD ($P< 0.05$).

The evaluated yield parameters Table 6, showed that the heaviest rhizome fresh weight per plot ($Kgha^{-1}$) of 3.74 and 3.75 $Kgha^{-1}$; highest rhizome dry matter content of 14.49 and 16.8%; heaviest rhizome dry weight per plant of 23.57 and 23.90g and harvest index of 2.60 and 2.70 were yielded by UMT 021 variety compared with other varieties during 2018 and 2019 cropping seasons. The fertilizer level of 400 NPK (15:15:15) $kgha^{-1}$ equally yielded heaviest rhizome fresh weight of 4.47 and 4.57 kg $plot^{-1}$; rhizome dry matter content of 19.42 and 25.8%; rhizome dry weight per plant of 27.54 and 27.8g as well as harvest index of 2.81 and 3.20 for both cropping seasons. A drop in yield components was observed at 600$kgha^{-1}$ level, suggesting that fertilizer addition beyond 400 $kgha^{-1}$ will be uneconomical and may as well engender luxury consumption.

Rhizome fresh weight (Kg $plot^{-1}$) was significantly ($P < 0.05$) affected by variety in 2019 cropping season, while fertilizer levels significantly ($P < 0.05$) affected rhizome fresh weight (Kg $plot^{-1}$) in both cropping seasons. Rhizome dry matter content was not significantly ($P > 0.05$) affected by variety in both cropping seasons, while fertilizer levels significantly ($P < 0.05$) affected dry matter content only in 2019 cropping seasons. Rhizome dry weight was significantly ($P < 0.05$) affected by the variety and fertilizer levels in both cropping seasons. Harvest index on the other hand was significantly ($P < 0.05$) affected by both the variety and fertilizer levels only in 2019 cropping seasons. Interaction (Variety x fertilizer levels) significantly ($P < 0.05$) affected rhizome dry matter content in 2019 cropping season, while other yield parameters were not significantly ($P > 0.05$) affected. These results on yield components slightly support [13] who reported increases in yield components of turmeric at 300 NPK (15: 15: 15) kgha^{-1} as well as a drop in yield parameters at 450 NPK (15: 15: 15) kgha^{-1} respectively.

4. Conclusion

The research has revealed that variety UMT 021 and 400 NPK (15:15:15) kgha^{-1} performed better that other varieties and fertilizer levels respectively. This further suggests that UMT 021 variety was more adaptive to the research site while 400kgha^{-1} provided ample nutrients for the optimum growth and yield performances of turmeric. Consequently, for a successful production of turmeric as a sole crop in Umudike, South Eastern Nigeria, UMT 021 variety and 400 NPK (15:15:15) kgha^{-1}are recommended. Application of fertilizer up to 600 NPK (15:15:15) kgha^{-1} was unproductive due to the observed drop in both growth and yield parameters. This could lead to luxury consumption, often characterized by luxuriant growth with attendant low yield. The growth and yield performances of turmeric, the research revealed will likely vary with cultivated variety and the level of inorganic fertilizer applied.

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