

# Effects of Propagation Methods, Mulching and Fertilizer Types on Growth and Yield of Ginger (*Zingiber Officinale* ROSC.) in Ogbomoso, South West Nigeria

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## ABSTRACT

Production of ginger (*Zingiber officinale* Rosc.) is one of the lucrative business to venture into due to high utilization derived from this produce. However, its production in Nigeria is limited by the varied methods of propagation in addition to the unreliable soil moisture and inadequate nutrient management. This study therefore evaluates the effects of propagation methods, mulching and fertilization could address these constraints. As a results, four propagation methods (small setts of 8–10 g, medium setts of 15–20 g, large setts of 25–30 g, and large seedlings of 25–30 g) were evaluated under two mulching regimes (with or without dry plant residue at 15 tons/ha) and three fertilizer treatments (control, NPK 15:15:15 at 933 kg/ha, and Tithonia compost at 5.2 tons/ha). A 4 × 2 × 3 factorial experiment was laid out in a randomized complete block design with three replications. Large rhizome setts produced the highest significant yield (21.94 tons/ha) compared to other propagation methods, mulching produced 14.11tons/ha which was significantly higher than un-mulched plant (10.07 tons/ha) and NPK had the highest significant performance in plants height (66.67 cm), number of leaves (183.78), tiller numbers (16.89) and yield (13.89 tons /ha). Mulching increased yield compared with the control while NPK outperformed Tithonia compost, revealing that farmers can achieve meaningful yield gains with larger setts, surface residue cover, and application of NPK fertilizer.

**Keywords:** Ginger, propagation methods, mulching, NPK fertilizer, Tithonia compost, rhizome yield

## INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an economically important spice which is widely cultivated across tropical regions for its culinary and medicinal applications as its production contributes significantly to agricultural GDP and rural livelihoods (Nyaupane *et al.*, 2024). However, average yields remain substantially below the crop's potential due to a combination of agronomic constraints among which are the use of poor-quality planting material, moisture stress and poor fertilizer management (El-Beltagi *et al.*, 2022).

This is because many smallholder farmers plant small, physiologically weak rhizome fragments that result in poor sprouting, slow establishment, and low vigor without knowing that size of the seed rhizome directly influences the amount of reserved carbohydrates available for early growth, yet this factor is often overlooked in extension recommendations (Thakur and Kumar, 2021; Iqbal *et al.*, 2020). Small setts may also sprout, but they lack the carbohydrate reserves to support vigorous early growth. This matters because initial vigor sets the ceiling for later yield (Iqbal *et al.*, 2020).

In the same vein, mulching offers a low-cost entry point for improving soil conditions because when dry plant residues are spread across the soil surface, evaporation decreases, temperature extremes moderate, and weed emergence slows while at the same time decomposing mulch adds organic matter, which later improves water-holding capacity and supports beneficial soil biota (Kader *et al.*, 2019; Visconti *et al.*, 2024). In the Nigerian savanna, where crop residues and fallow vegetation are readily available, mulching is eminently feasible and can enhance optimum productivity of ginger (Ojeniyi *et al.*, 2020).

Fertilizer application also go along way as NPK 15:15:15 delivers quick nutrients and has a proven track record on many crops compared to *Tithonia diversifolia* which can be produced on-farm and release nutrients more slowly, matching crop demand over a longer period (Sayara *et al.*, 2020; Cai *et al.*, 2019; Adugna, 2016). The research gap lies on how propagation method, mulching, and fertilizer type interact under field conditions as most previous studies examined these factors in isolation. Thus, this study therefore evaluated the combined effects of propagation methods, mulching and fertilizer types on ginger growth and yield of ginger in the Southern Guinea Savanna of Nigeria.

## MATERIALS AND METHODS

### Experimental Site

The experiments was a field trial, conducted at the experimental field of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso. Ogbomoso lies on latitude 8° 08'N and longitude 4° 14'E in the Southern Guinea Savanna Zone of Southwest Nigeria (Ewetola *et al.*, 2015). It is characterized by mixed grassland and scattered trees, and support both crop cultivation and livestock grazing (Owoade, 2021). The climate of the environment of Ogbomoso can be expressed as fairly hot, tropical with marked wet and dry seasons. There is usually a bit of harmattan between these seasons. The mean annual rainfall is about 1400 mm and bimodal distribution which is at peak in June and September and a break in August, while the mean annual temperature is about 27°C (Owoade, 2021).

### Land Preparation

The field was manually cleared and divided into seventy-two (72) plots. Each plot was 1.5 × 1.0 m and it contained 24 ginger plants spaced out at 30 cm x 30 cm (Tiwari *et al.*, 2019). Experimental plots were separated by 0.5 m gaps while, 1.0 m gaps separated the replicates.

### Soil Sampling and Analysis

Soil samples were collected from the experimental site at a depth of 0 – 15 cm with the use of a soil auger. The soil was air-dried and sieved with a 2 mm and 0.5 mm sieves. The composite soil sample was sent to laboratory for determination of physical and chemical compositions using methods described by Pansu and Gautheyrou (2006). The particle size distribution was done using the hydrometer method. The pH of the soil was determined in a 1:1 soil/water suspension using a digital pH meter. Organic carbon was determined by the Walkley-Black method. Total nitrogen was determined by Regular Macro-Kjeldahl methods. Available phosphorus was determined by the Bray No. 1 method. Exchangeable Na, K, Ca Mg, Mn and effective Cation Exchangeable Capacity (CEC) was determined using Atomic Absorption Spectrophotometer and Exchangeable acidity was determined by Titration method.

### Experimental Materials

#### Ginger rhizomes

The yellow variety of ginger (UG1) was used for the study. It was obtained from National Root Crop Research Institute Substation, Kaschia, Kaduna, Kaduna State. This variety is widely grown in Nigeria.

## Fertilizer materials

The fertilizer materials used were Urea, NPK and Tithonia compost. The inorganic fertilizers were sourced from Irorun Agbe, Agro-store, Ogbomoso, while Tithonia compost used for the trials was obtained from Right Choice Integrated Farm, Iluju, Ogbomoso, Nigeria. They were applied to supply 140 kg N/ha (Asafa and Akanbi, 2018). The samples were analysed to determine its nutrient compositions (Table 2). The Total Nitrogen, Phosphorus (P) and Potassium (K) composition were determined using methods described by Niels and Jensen (2015). The Micro-Kjeldahl method was used to determine the total nitrogen content, Perchloric acid digestion (wet-oxidation) methods for P content and dry ashing method for K content.

## Mulching materials

Dry plant materials were obtained from the experimental premises by cutting with a cutlass and applied at 15 tons/ha (Ojeniyi *et al.*, 2020).

## Treatments and Experimental Design

The three factors that were tested are:

### 1. Methods of Propagation:

PM1 = Small Rhizome seed setts (8 – 10 g)

PM2 = Medium Rhizome seed setts (15 – 20 g)

PM3 = Big Rhizome seed setts (25 – 30 g) and,

PM4 = Big Rhizome seedling setts (25 – 30 g)

### 2. Mulching: Mulching was done immediately after planting at the recommended rate 15 tons/ha

### 3. Fertilizer types:

F1: Control

F2: NPK 15:15:15 at 933 kg/ha

F3: Tithonia Compost at 5.2 tons/ha

The experimental design for this study was a 4 x 2 x 3 factorial experiment fitted into a randomized complete block design with 4 levels of propagation method, 2 levels of mulching and 3 levels of fertilizer. This gave 24 treatment combinations which were replicated three (3) times to give seventy-two (72) experimental units.

## Management of Experimental Set up

The experimental pots were weeded manually to prevent weed interference. Application of water was done as at when due. Insect pests were controlled by applying Actara 25 WG (Thiamethoxam) at 0.5 g/L water as recommended (Karmakar and Ghosh, 2021).

## Data Collection

Three ginger plants per treatment were selected for the assessment of the following parameters:

### Growth parameters of Ginger

Data on growth parameters collected were:

Plant height which was measured using a measuring tape from the base of the plant to the apex;

Number of tillers per plant which was obtained by counting the number of tillers per stand;

Number of leaves per plant which was obtained by counting number of fully expanded green leaves and

### Rhizome yield and yield parameters

At maturity, four ginger plants per treatment were selected to assess rhizome yield and yield parameters. The selected plants were carefully uprooted and cleaned. The following parameters were determined:

Number of rhizome fingers/plant: This was done by visual counting of the rhizome fingers

Rhizome yield per ha: The weight ginger rhizome per plant in grams was determined by weighing the harvested rhizome using a digital weighing scale and extrapolated to tons/ha.

### Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System version 9.4 (M8) (SAS, 2022) software package. The treatment means were compared using Tukey's Honest significant Difference (HSD) at a 5% level of probability.

## RESULTS

### Physico-chemical characteristics of the soil

#### Physical and chemical properties of the experimental field before planting

The analyzed soil was slightly acidic reaction (pH 6.08) as shown in Table 1. The electrical conductivity (142.10  $\mu\text{S/cm}$ ) indicates that the soil is non-saline, posing no restriction to plant growth. The soil is characterized by high organic carbon (10.29%) and organic matter content (17.74%), but low total nitrogen (0.54%). The cation exchange capacity (CEC) is extremely low (2.22  $\text{cmol kg}^{-1}$ ). Exchangeable base cations show low calcium (0.50  $\text{cmol kg}^{-1}$ ), moderate magnesium (0.64  $\text{cmol kg}^{-1}$ ), and moderate potassium (0.32  $\text{cmol kg}^{-1}$ ) levels, while sodium (0.66  $\text{cmol kg}^{-1}$ ) is relatively elevated. The available phosphorus content (6.79  $\text{mg kg}^{-1}$ ) is low. Regarding micronutrients, iron (0.52  $\text{mg kg}^{-1}$ ) and zinc (0.46  $\text{mg kg}^{-1}$ ) are at low to marginal levels, suggesting possible deficiencies, while copper (0.32  $\text{mg kg}^{-1}$ ) and manganese (0.28  $\text{mg kg}^{-1}$ ) are within moderate ranges. The concentrations of lead (0.06  $\text{mg kg}^{-1}$ ) and cadmium (0.04  $\text{mg kg}^{-1}$ ) are very low and do not pose toxicity concerns. In terms of physical properties, the soil is dominated by silt (70.40%), with low sand content (21.40%) and low clay fraction (8.20%), resulting in a silt-dominated texture.

**Table 1: Pre-planting physical and chemical properties of the experimental field**

Soil properties	Values
pH	6.08
EC $\mu\text{S/cm}$	142.10
$\text{H}^+$	0.11
Ca	0.50
Na $\text{cmolkg}^{-1}$	0.66
K	0.32
Mg	0.64
% OC	10.29
% OM	17.74
% TN	0.54
Av.P ( $\text{mgkg}^{-1}$ )	6.79

CEC	2.22
% BS	95.19
Fe	0.52
Zn	0.46
Cu	0.32
Mn	0.28
Pb	0.06
Cd	0.04
% Sand	21.40
% Silt	70.40
% Clay	8.20

**Table 2: Nutrient Composition (g/kgdw) in the Fertilizer Materials**

Fertilizer materials	N	P	K
Urea	46	-	-
NPK	15	15	15
Compost	2.7	-	-

**Effects of propagation methods, mulching and fertilizer types on plant height of ginger**

The effects of propagation method, mulching and fertilizer type on the plant height of ginger were significant ( $P \leq 0.05$ ) on plant height of ginger (Table 3). PM3 produced the tallest significant ( $P \leq 0.05$ ) plants with an average value of 20.93 cm and 62.00 cm at 3 and 7 months after planting, followed by PM2 (51.67 cm) and PM4 (40.50 cm) at 7 months after planting, while PM1 produced the shortest significant plants (29.83 cm). Also, mulched plants produced 16.70 cm and 49.06 cm at 3 and 7 months after planting which are significantly taller compared to un-mulched plants (14.56 cm and 42.94 cm) at 3 and 7 months. NPK had the best performance with significant values of 16.34 cm and 48.25 cm at 3 and 7 months respectively, followed by T.compost (46.12 cm) at 7 months after planting, while the control treatment recorded the lowest significant plant height (43.62 cm). Also, the interactive effects amongst propagation method, mulching and fertilizer types were significantly different at 5% probability level.

**Effects of propagation method, mulching and fertilizer types on number of leaves of ginger**

The effects of propagation method, mulching and fertilizer types were significant ( $P \leq 0.05$ ) on number of leaves of ginger (Table 4). PM3 produced the highest significant ( $P \leq 0.05$ ) leaf count of 52.63 and 163.28 leaves at 3 and 7 months after planting, followed by PM2 (104.50 leaves) and PM6 (70.11 leaves) at 7 months after planting, while PM1 produced the fewest significant ( $P \leq 0.05$ ) leaves (41.67 leaves). Also, mulched plants had 34.53 and 106.53 leaves at 3 and 7 months after planting compared to un-mulched plants which recorded only 27.94 leaves at 3 months and 83.25 leaves at 7 months. For fertilizer types, NPK application produced the highest leaf numbers with an average value of 33.62 and 102.87 leaves at 3 and 7 months after planting, this was followed by T.compost (94.50 leaves) at 7 months after planting, while the control treatment recorded the lowest significant ( $P \leq 0.05$ ) number of leaves (87.29). The interactive effects amongst propagation method, mulching and fertilizer types were significantly different at 5% probability level.

**Table 3: Effects of propagation methods, mulching and fertilizer types on plant height (cm) of ginger**

Treatments	Months after planting				
	3	4	5	6	7
Propagation Method (PM)					
PM1	10.37 d	15.58 d	20.69 d	25.77 d	29.83 d
PM2	17.30 b	26.22 b	35.31 b	44.40 b	51.67 b
PM3	20.93 a	31.64 a	42.44 a	53.30 a	62.00 a

PM6	13.94 c	21.06 c	28.02 c	34.95 c	40.50 c
Mulching (M)					
Mulched	16.70 a	25.24 a	33.73 a	42.25 a	49.06 a
Un-mulched	14.56 b	22.01 b	29.51 b	36.97 b	42.94 b
Fertilizer types (FT)					
Control	14.98 c	22.52 c	30.05 c	37.63 c	43.62 c
NPK	16.34 a	24.67 a	33.04 a	41.42 a	48.25 a
T.compost	15.57 b	23.69 b	31.76 b	39.77 b	46.12 b
PM X M	*	*	*	*	*
PM X FT	*	*	*	*	*
M X FT	*	*	*	*	*
PM X M X FT	*	*	*	*	*

Means followed by the same letter (s) are not significantly different ( $P \leq 0.05$ )

NPK = NPK 15:15:15, T.compost = Tithonia Compost, PM1 = Small Rhizome seed setts (8 – 10 g), PM2 = Medium Rhizome seed setts (15 – 20 g), PM3 = Big Rhizome seed setts (25 – 30 g) and PM4 = Big Rhizome seedling setts (25 – 30 g)

\* - significant

**Table 4: Effects of propagation method, mulching and fertilizer types on number of leaves of ginger**

Treatments	Months after planting				
	3	4	5	6	7
Propagation Method (PM)					
PM1	13.90 d	21.22 d	28.54 d	35.84 d	41.67 d
PM2	34.38 b	52.83 b	71.28 b	89.74 b	104.50 b
PM3	52.63 a	81.75 a	110.87 a	139.98 a	163.28 a
PM4	24.03 c	36.14 c	48.25 c	60.39 c	70.11 c
Mulching (M)					
Mulched	34.53 a	53.47 a	72.41 a	91.37 a	106.53 a
Un-mulched	27.94 b	42.50 b	57.06 b	71.61 b	83.25 b
Fertilizer types (FT)					
Control	28.89 c	44.44 c	59.73 c	75.04 c	87.29 c
NPK	33.62 a	51.81 a	70.08 a	88.29 a	102.87 a
T.compost	31.20 b	47.71 b	64.41 b	81.14 b	94.50 b
PM X M	*	*	*	*	*
PM X FT	*	*	*	*	*
M X FT	*	*	*	*	*
PM X M X FT	*	*	*	*	*

Means followed by the same letter(s) are not significantly different ( $P \leq 0.05$ )

NPK = NPK 15:15:15, T.compost = Tithonia Compost, PM1 = Small Rhizome seed setts (8 – 10 g), PM2 = Medium Rhizome seed setts (15 – 20 g), PM3 = Big Rhizome seed setts (25 – 30 g) and PM4 = Big Rhizome seedling setts (25 – 30 g)

\* - significant

**Effects of propagation method, mulching and fertilizer types on number of tillers of ginger**

Propagation method significantly influenced number of tillers at 5% level of probability as PM3 produced the highest significant ( $P \leq 0.05$ ) tiller count (4.75 and 14.78) at 3 and 7 months after planting, followed by PM2 (9.50 tillers) and PM4 (6.61 tillers) at 7 months after planting, while PM1 produced the fewest tillers (4.00 tillers). Also, mulched plants had 3.12 and 9.72 tillers at 3 and 7 months after planting compared to un-mulched plants which recorded only 2.48 tillers at 3 months and 7.72 tillers at 7 months.

NPK application produced the highest tiller numbers with 3.09 tillers at 3 months and 9.62 tillers by 7 months after planting, followed by T.compost with 8.67 tillers at 7 months after planting, while the control recorded the lowest significant ( $P \leq 0.05$ ) number of tillers (7.88 tillers). The interactive effect amongst propagation method, mulching and fertilizer types are significantly different at 5% probability level with respect to the number of tillers (Table 5).

**Effects of propagation method, mulching and fertilizer types on yield and yield components of ginger**

Propagation method significantly influenced all yield parameters at 5% level of probability as PM3 consistently produced the highest significant ( $P \leq 0.05$ ) values across all yield components with average number of rhizome fingers of 24.11 per plant, fresh rhizome yield of 21.94 tons/ha, average shoot weight per plant of 41.17 g, and average root weight per plant of 12.22 g followed by PM2 (15.78, 12.88 tons/ha, 18.33 g, 5.28 g), while PM1 (7.83, 4.47 tons/ha, 1.56 g, 1.00 g) produced the lowest significant values across all parameters. Mulched plants also had the highest significant fresh rhizome yield (14.11 tons/ha) compared to 10.07 tons/ha for un-mulched while NPK application produced the highest significant yield values across most parameters, with a fresh rhizome yield of 13.89 tons/ha compared to 11.78 tons/ha for T.compost and 10.61 tons/ha for control (Table 6).

**Table 5: Effects of propagation method, mulching and fertilizer types on number of tillers of ginger**

Treatments	Months after planting				
	3	4	5	6	7
Propagation Method (PM)					
PM1	1.29 d	2.00 d	2.71 d	3.43 d	4.00 d
PM2	3.05 b	4.75 b	6.45 b	8.14 b	9.50 b
PM3	4.75 a	7.39 a	10.03 a	12.67 a	14.78 a
PM4	2.13 c	3.31 c	4.49 c	5.67 c	6.61 c
Mulching (M)					
Mulched	3.12 a	4.86 a	6.60 a	8.33 a	9.72 a
Un-mulched	2.48 b	3.86 b	5.24 b	6.62 b	7.72 b
Fertilizer types (FT)					
Control	2.53 c	3.94 c	5.34 c	6.75 c	7.88 c
NPK	3.09 a	4.81 a	6.53 a	8.25 a	9.62 a
T.compost	2.79 b	4.33 b	5.88 b	7.43 b	8.67 b
PM X M	*	*	*	*	*
PM X FT	*	*	*	*	*
M X FT	*	*	*	*	*
PM X M X FT	*	*	*	*	*

Means followed by the same letter(s) are not significantly different ( $P \leq 0.05$ )

NPK = NPK 15:15:15, T.compost = Tithonia Compost, PM1 = Small Rhizome seed setts (8 – 10 g), PM2 = Medium Rhizome seed setts (15 – 20 g), PM3 = Big Rhizome seed setts (25 – 30 g) and

PM4 = Big Rhizome seedling setts (25 – 30 g)

\* - significant

**Table 6: Effects of propagation method, mulching and fertilizer types on yield and yield components of ginger**

Treatments	Number of rhizome finger per plant	Fresh rhizome weight (tons/ha)	Shoot weight (g)	Root weight (g)
Propagation method (PM)				
PM1	7.83 d	4.47 d	1.56 d	1.00 c
PM2	15.78 b	12.88 b	18.33 b	5.28 b
PM3	24.11 a	21.94 a	41.17 a	12.22 a
PM4	12.11 c	9.09 c	8.56 c	1.44 c
Mulching (M)				
Mulched	16.94 a	14.11 a	20.44 a	6.17 a
Un-mulched	12.97 b	10.07 b	14.36 b	3.81 b
Fertilizer types (FT)				
Control	13.75 c	10.61 c	15.12 c	4.25 c
NPK	15.92 a	13.89 a	20.08 a	5.79 a
T.compost	15.21 b	11.78 b	17.00 b	4.92 b
PM X M	*	*	*	*
PM X FT	*	*	*	*
M X FT	*	*	*	*
PM X M X FT	*	*	*	*

Means followed by the same letter(s) are not significantly different ( $P \leq 0.05$ )

NPK = NPK 15:15:15, T.compost = Tithonia Compost, PM1 = Small Rhizome seed setts (8 – 10 g), PM2 = Medium Rhizome seed setts (15 – 20 g), PM3 = Big Rhizome seed setts (25 – 30 g) and PM4 = Big Rhizome seedling setts (25 – 30 g)

\* - significant

The interaction between the propagation method and mulching; propagation method and fertilizer types; mulching and fertilizer types; and propagation method, mulching and fertilizer types are significantly different with respect to the growth, yield and yield components of ginger.

## DISCUSSION

Large rhizome seed setts (25–30 g) grown under mulch with NPK fertilizer had the best performance in plant height. This might be due to the fact that larger setts contain more stored starch and sugars, giving emerging shoots a faster start while mulching keeps the root zone cooler and moister, especially during the dry weeks that often interrupt the rainy season (Thakur and Kumar, 2021; El-Beltagi *et al.*, 2022, Fawole *et al.*, 2025). NPK also contributed to nitrogen availability in the soil as this application fuels cell expansion in stems. However, the small seed setts without mulch or fertilizer simply never recovered from their poor start which was in agreement with the results of Mahmood *et al.* (2023), who found that soil organic matter levels strongly influence plant height. Also, these findings agree with Visconti *et al.* (2024) who similarly reported that mulching increases plant height in several crop species.

The results also reveal that best treatment combination produced 183.78 leaves per plant, while the least with only 34.67 leaves. These findings align with previous studies that large seed setts gave rise to more tillers, each tiller bearing multiple leaves (Nyaupane *et al.*, 2024). In the same vein, mulching reduced the frequency and severity of water stress, enhance weed suppression and allowing leaves to remain green and functional longer into the dry season while NPK provided nitrogen in a form that plants could use immediately, supporting

continuous leaf emergence (Kader *et al.*, 2019; Thankamani *et al.*, 2016). Adugna (2016) noted similar responses in compost-amended soils, where improved fertility translated into larger leaf canopies. El-Beltagi *et al.* (2022) also observed that mulched crops maintain photosynthetic activity longer into the growing season.

Tiller development was strongly influenced by propagation method, with large seed setts producing the highest counts. Since each sett is a modified stem with multiple buds. This might be because larger rhizome seed setts have more buds, and those buds have more energy to activate (Thakur and Kumar, 2021). While at the same time, mulching improved this effect by stabilizing soil temperature because ginger tillers are sensitive to heat stress at the soil surface (Visconti *et al.*, 2024). NPK, especially its phosphorus component, encouraged root growth, which in turn supported tiller establishment (Iqbal *et al.*, 2020). PM3 × mulched × NPK produced 16.89 tillers per plant at 7 months, compared to only 3.56 for PM1 × un-mulched × control. It was observed that though Tithonia compost performed respectably, producing about 14.5 tillers under the same propagation and mulching conditions, however, it could not match NPK performance. This findings aligns with Sayara *et al.* (2020), who reported that compost releases nutrients more slowly, which may limit tillering in the early stages. It was also reported by Mahmood *et al.* (2023) that soil health improvements from organic amendments benefit tillering, but the effects take time to accumulate.

On the basis of yield performance, the combination of large seed setts, mulching, and NPK had the best performance as well as number of tiller, aligning with Nyaupane *et al.* (2024) and Fawole *et al.* (2025) who reported that more tillers per plant mean more potential sites for rhizome formation. The effects of mulching on those morphological and yield parameters in this study suggested the reduced soil compaction and improved aeration enhanced by the crop residues, allowing rhizomes to expand more freely while NPK supplied potassium, which is critical for translocating photosynthates from leaves to below ground storage organs, agreeing previous findings (Kader *et al.*, 2019; Cai *et al.*, 2019). Shoot weight and root weight also increased under the best treatment, indicating that the whole plant benefited, not just the harvested portion. The fact that Tithonia compost gave good yields (6.21 tons/ha) though not the best suggested that this fertilizer could be a viable alternative for farmers who cannot afford NPK. However, for maximum production, NPK had the best performance as Thakur and Kumar (2021) also reported similar findings for other spices plants, and Visconti *et al.*, (2024) confirmed that mulching enhances yield stability across variable rainfall regimes.

## CONCLUSION

This study provides field based evidence that propagation method, mulching, and fertilizer type interact strongly to determine ginger performance. Large rhizome seed setts (25–30 g) produced better growth and yield than smaller setts or seedlings. Mulching with dry plant material at 15 tons/ha increased yield and improved the efficiency of both mineral and organic fertilizers while NPK 15:15:15 at 933 kg/ha had the highest yields, but Tithonia compost at 5.2 tons/ha performed well enough to serve as a lower cost alternative. Therefore, combination of large rhizome seed setts, mulching and NPK had the highest significant growth and rhizome yield.

## RECOMMENDATION

Ginger farmers in the study area should plant large ginger rhizome setts (25–30 g), apply dry plant mulch at 15 tons/ha immediately after planting, and fertilize with NPK 15:15:15 at 933 kg/ha. Where NPK is unavailable, Tithonia compost at 5.2 tons/ha is a suitable organic substitute.

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