Effects of Organic and Inorganic Fertilizers on Growth, Fruit Yield and Quality of Tomato (*Solanum lycopersicum* l.) in Ogbomoso, Oyo State Nigeria

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ABSTRACT

Tomato (Solanum lycopersicum L.) production in Nigeria faces challenges of declining soil fertility and reliance on expensive chemical fertilizers. While inorganic fertilizers boost yield but may harm soil health, organic options like poultry manure improve soil quality. This study evaluated NPK (400 kg/ha), poultry manure (4 t/ha), and a control on five tomato varieties (Cobra, Ansal, Chibi, Rio Grande, Ogbomoso local) using a 3×5 factorial randomized block design with three replications at Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Growth, yield, and nutrient data were analyzed using ANOVA and Duncan's Multiple Range Test at 5% significance. Results showed plant height, leaves, stem girth, flowers and fruit yield were significantly influenced by fertilizer types and varieties. At 10 weeks post-transplanting, NPK-treated plants showed higher plant height (32.62cm), leaf count (27.60), stem girth (4.87cm), flower (11.13), fruit count (51.27tons/ha) and yield (1.40). Cobra variety outperformed others in plant height (36.31cm), leaves (34.75), stem girth (6.49cm), flowers (16.22), fruit count (65.89) and yield (2.04 tons/ha), while Rio-Grande had the lowest flowers and yield. Significant interaction occurred between varieties and fertilizer types, with the Cobra-NPK combination producing the highest leaves and flowers. NPK treatment showed the highest crude protein (1.73%) and fiber (0.38%). Cobra variety had the highest fruit crude protein (2.81%) and fiber (0.38%), while Rio Grande showed the lowest protein (1.62%) and Ansal the lowest fiber (0.34%). The NPK-Cobra combination is recommended for optimal tomato production in Ogbomoso, Nigeria.

***Keywords**:* Profitability, Pro Vitamin, Cassava, Gross margin

INTRODUCTION

Tomato (*Solanum lycopersicum* L.), a *Solanaceae* member originating from South America, is widely cultivated for its rich nutritional content, including vitamins, proteins, minerals, and lycopene (Kumar et al., 2022; Suman et al., 2023). Consumed fresh or processed into products like juice and sauces, tomato juice supports digestion and provides antioxidant benefits (Tagliamonte et al., 2023; Wu et al., 2022). Optimal growth occurs at 21–24°C, and its seeds contain valuable oil, contributing to a balanced diet (Kumar et al., 2022). Tomato production in Nigeria is mainly by small-scale farmers in the Southern regions, where challenges like degraded soils and limited inputs hinder productivity (Akinrinola & Tijani-Eniola, 2022; Tijani et al., 2010). In Enugu State, yields average 2.86 t/ha (Ozioko et al., 2020). In contrast, the Northern regions, benefiting from better climate and irrigation, see higher yields of 11.6 to 22.3 t/ha (Ahmed et al., 2020). However, yields nationwide are often below potential due to pests, diseases, poor practices, and post-harvest losses (Ajenifujah-Solebo et al., 2025; Makka et al., 2023; Oso, 2020; Ugonna et al., 2015).

Soil organic amendments, particularly poultry manure, improve yield and fruit quality by enhancing nutrient availability through nitrogen fixation and phosphorus solubilization, and by improving soil fertility, structure, microbial activity, water retention, and acidity reduction (N. K. Singh et al., 2024; V. K. Singh et al., 2022). Organic fertilizers also suppress pests and diseases by fostering soil biodiversity and improving nutrient retention, reducing environmental pollution linked to chemical fertilizers (Zhao & Olowokere, 2023). The decline in soil fertility and the high costs of inorganic fertilizers challenge tomato production, as excessive chemical fertilizer use degrades soil, lowers yields, and causes nutrient leaching, water contamination, and greenhouse gas emissions (Adebayo & Omolehin, 2021; Eze et al., 2023). Integrating organic materials such as poultry manure and cocoa pod husk with inorganic fertilizers offers a sustainable strategy that enhances soil health, crop productivity, and environmental quality (Adebayo & Omolehin, 2021). This study aims to evaluate the effects of organic and inorganic fertilizers on tomato growth, yield, and nutritional quality.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Teaching and Research Farm, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Nigeria, at Latitude 8°10' N and Longitude 4°10' E. Ogbomoso is located in the derived savanna zone of southwest Nigeria. The temperature ranges from 28 °C to 33 °C with ~ 74% relative humidity all year round. Rainfall is >1000 mm per annum.

Nursery establishment

The top soil sample was collected using a soil auger at 0-30 cm soil depth. Composite soil was dried, crushed and sieved through 2 mm and 0.5 mm meshes, after which thermal soil remediation was carried out to destroy harmful pathogens and pests. Seeds were then raised in nursery beds and later transplanted into the field after four weeks.

Soil sample collection and analysis

A topsoil (0-15 cm depth) sample was collected randomly from Apomu (Apomu soil series), Osun State, for the experiments. For the pre-sowing analysis, the sample was bulked and mixed thoroughly, air-dried, sieved through a 2 mm sieve, and a sub-sample was taken to the laboratory for routine chemical and particle size analysis. Soil pH was determined with the glass electrode pH meter on a 1:2 soil-solution mixture (McLean, 1982). The organic carbon content was measured using the Walkley-Black method as described by Nelson & Sommers (1982). Total Nitrogen was determined using the Kjeldahl procedure as described by Jackson (1965). Available phosphorus was extracted by the Mehlich method (Mehlich, 1984). Exchangeable K, Ca, Mg and Na were determined by extraction with ammonium acetate, and the amounts of K and Na in the filtrate were determined using a flame photometer, while Ca and Mg were determined using a Perkin-Elmer Atomic Absorption Spectro photometer (AAS). Exchangeable acidity (H^+) was determined using the titration method. Effective cation exchange capacity (ECEC) was determined as the sum of the exchangeable cations, K, Na, Ca, Mg and H^+ expressed in cmol kg^{-1} of soil.

Field Establishment

The experimental land was cleared manually using a hoe and a cutlass, followed by field layout and construction of beds (45). 2.5 x 2 m beds were constructed on a well-drained loamy soil. Soil was tested to determine nutrient levels and pH, and the soil was amended as needed with organic matter. Land clearing was done effectively. Weed control measures were done to prevent weed competition with the seedlings. Transplanting was done at 4 weeks of planting, and proper spacing was ensured with a proper raised bed to ensure drainage.

Crop Management

Watering was carried out as ed, ensuring an even application of water to all plants. Weeding was performed manually using a hoe and a cutlass as weeds emerged to control their growth and minimize competition with the plants. Pest and disease control measures included the application of cypermethrin at the rate of 40 ml/15 liters of water using a sprayer to manage insect pests, and benlate at 10 g/15 liters of water was applied to control fungal infections whenever symptoms were observed. Inorganic (NPK 15-15-15) and organic (poultry manure) fertilizers were used as the fertilizer types, applied according to recommended rate practices. The application rates were as follows: 400 kg/ha for inorganic fertilizer, equivalent to 8 g per stand, and 4 tons/ha of organic fertilizer, corresponding to 20 g per bed.

Experimental Design and Treatments

The experiment was designed as a 3×3×5 factorial arrangement, resulting in 45 treatment combinations. It was laid out in a split-plot fitted into a Randomized Complete Block Design (RCBD). The study involved five tomato varieties—Cobra (V1), Ansal (V2), Chibi (V3), Rio Grande (V4), and Ogbomoso Local (V5)—and three levels of fertilizer application: no fertilizer (T0 – control) and NPK 15:15:15 applied at 400 kg/ha (T1). T2= Poultry droppings at 4tons/ha.

Data Collection

Three representative plants were tagged in the middle row of each plot for data collection throughout the experimental period. Growth parameters (plant height, stem girth, and number of leaves) were recorded at 4, 6, and 8 weeks after transplanting (WAT).

Reproductive and Fruit Parameters

The number of flowers per plant was recorded at full bloom, while the number of opened flowers was cumulatively counted throughout the sampling period, avoiding double-counting by marking them. Fruits per plant were counted and averaged.

Fruit Proximate Composition

For mineral analysis, the harvested fruits were washed and analyzed using atomic absorption spectrophotometry for elements such as potassium, calcium, magnesium, copper, iron, and zinc. Phosphorus was determined colorimetrically using UV-visible spectrophotometry. All nutrient values were expressed in mg/100g of fresh fruit.

Lycopene was extracted using a hexane: methanol: acetone mixture and measured at 502 nm using a spectrophotometer, with results expressed as mg/g dry weight. Vitamin A was analyzed with a dual-beam spectrophotometer at 450 nm after extraction with petroleum ether and ethanol. Vitamin C (ascorbic acid) content was determined volumetrically using 2,6-dichlorophenol indophenol dye.

Proximate composition (moisture, ash, protein, crude fiber, oil, carbohydrates, and caloric value) was analyzed using AOAC standard methods. Crude protein was determined using the Kjeldahl method, fiber content via digestion and ashing, and oil using Soxhlet extraction with diethyl ether.

Data were subjected to analysis of variance (ANOVA), and significant means were compared using the Duncan Multiple Range Test (DMRT) at a 5% probability level.

RESULTS AND DISCUSSION

Effects of Fertilizer Types and Tomato Varieties on the Plant Height of Tomato

Table 1 shows the significant effects of different fertilizer types and tomato varieties on tomato plant height over the 10-week observation period.

Table 1: Effects of Fertilizer Types and Varieties on the Plant Height (cm) of Tomato

TREATMENT	4 WAT	6 WAT	8 WAT	10 WAT
FERTILIZER EFFECT				
POULTRY	11.99b	17.34b	23.04a	28.50a
NPK	16.08a	20.95a	26.97a	32.62a
CONTROL	7.77c	11.78c	16b	20.18b
VARIETAL EFFECT				
ANSAL	11.51ab	15.99ab	20.24b	25.08b
CHILBI	10.27ab	14.52b	19.28b	24.63b
COBRA	15.02a	20.55a	29.97a	36.31a
OGBO LOCAL	11.97ab	16.74ab	21.22b	25.37b
RIO GRANDE	10.27b	15.64ab	19.90c	24.63b

Means with the same letters along the column are not significantly different (DMRT 0.05). WAT: Weeks after transplanting. Means with the same letters along the columns are not significantly different (DMRT multiple range test = 0.05). WAT: Week after transplanting.

The fertilizer type and tomato variety significantly influenced plant height from 4 to 10 weeks after transplanting. Plants treated with NPK fertilizer showed greater height than those with poultry manure or unfertilized control, while the control treatment resulted in the shortest plants. Among varieties, COBRA achieved the greatest height, whereas CHILBI and RIO GRANDE displayed shorter stature.

These findings highlight the importance of balanced mineral nutrition in promoting vegetative growth in tomato plants. NPK fertilizer application enhances physiological processes, including chlorophyll synthesis, photosynthesis, and plant development (Ullah et al., 2023). Nitrogen particularly enhances vegetative development and stem elongation (Joy et al., 2023; Syamsiyah et al., 2023; Yuniarti et al., 2023). Inorganic fertilizers generally lead to increased plant growth compared to control or organic treatments (Adekiya et al., 2022; Raksun et al., 2021). Varietal differences in plant height demonstrate the influence of genetic factors on growth characteristics. Tomato cultivars show inherent variability in morphological traits and responsiveness to environmental conditions (Jędrszczyk et al., 2012; Patra et al., 2024; Yang et al., 2021). COBRA's greater height suggests genetic predisposition for vertical growth or efficient nutrient uptake, indicating that variety selection with optimal fertilization is crucial for maximizing plant height and productivity.

Interactive Effects of Fertilizer Types and Varieties on the Plant Height of Tomato

Table 2 shows the interactive effects of different fertilizer types and tomato varieties on plant height over 10 weeks.

Table 2: Interactive Effects of Fertilizer Types and Varieties on the Plant Height (cm) of Tomato

FERTILIZER	VARIETY	4WAT	6WAT	8WAT	10WAT
NPK	COBRA	20.21a	25.57a	35.44a	42.79a
	OGBOMOSHO	16.63ab	21.63ab	26.97ab	32.07abc
	RIO	15.10abc	20.10abc	25.13ab	31.07abc
	CHILBI	15.03abc	20.03abc	24.87ab	29.73abc
	ANSAL	13.43abc	17.43abc	22.43ab	27.42abc
POULTRY	COBRA	15.74abc	22.13ab	33.65a	40.18ab
	OGBOMOSHO	12.17abc	17.50abc	21.83ab	25.17abc
	CHILBI	11.27abc	16.27abc	21.73ab	27.60abc
	ANSAL	10.73abc	15.73abc	20.07ab	24.50abc
	RIO GRANDE	10.03abc	15.07abc	19.73ab	25.07abc
CONTROL	COBRA	9.10bc	13.96abc	20.81ab	25.94abc
	CHILBI	8.77bc	12.20bc	15.53b	19.67bc
	RIO GRANDE	7.77bc	11.77bc	15.10b	19.10abc
	OGBOMOSHO	7.10bc	11.10bc	14.87b	18.89c
	ANSAL	6.10bc	9.87c	13.67b	17.33c

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

Significant interactive effects were observed between fertilizer type and tomato variety on plant height during growth. The combination of fertilizer and variety determines vegetative vigor. NPK fertilizer with the COBRA variety produced the tallest plants, reaching 42.79 cm at 10 Weeks After Transplanting, significantly higher than other combinations. This indicates strong synergy between NPK's nutrient supply and COBRA's growth potential. Poultry fertilizer with COBRA also showed robust growth at 40.18 cm.

The control resulted in the shortest plants, with 'Control + ANSAL' reaching only 17.33 cm at 10 WAT, highlighting nutrient deprivation's impact. NPK-fertilized plants outgrew those with poultry manure, while both surpassed unfertilized controls. COBRA variety performed well across fertilizer types, showing inherent vigor. These findings show that variety selection and fertilization strategy are critical for maximizing plant height. NPK + COBRA's superior performance stems from optimal nutrient supply supporting genetic potential, demonstrating genotype-environment interaction (Yang et al., 2021). NPK fertilizers effectively promote vegetative growth through balanced macronutrients (Abrahim et al., 2023; Joy et al., 2023; Raksun et al., 2021). While organic fertilizers benefit growth, inorganic fertilizers produce greater immediate responses (Adekiya et al., 2022; Ilupeju et al., 2015). The control group's poor growth confirms the necessity of nutrient supplementation (Raksun et al., 2021).

Effects of Fertilizer Types and Varieties on the Number of Leaves of Tomato

Table 3 shows the effects of fertilizer types and varieties on the number of leaves of tomato over 10 weeks.

Table 3: Effects of Fertilizer Types and Varieties on the Number of Leaves of Tomato

TREATMENT	4 WAT	6 WAT	8 WAT	10 WAT
FERTILIZER EFFECT				
POULTRY	10.11a	15.73a	21.65a	26.99ab
NPK	10.27a	15.55a	21.51a	27.60a
CONTROL	9.94a	13.89a	18.12a	22.00b
VARIETAL EFFECT				
COBRA	13.57a	19.80a	27.99a	34.75a
CHILBI	9.83b	14.39b	18.83b	23.50b
RIO GRANDE	9.22b	13.97b	18.74b	23.33b
OGBO LOCAL	9.13b	13.69b	18.36b	23.30b
ANSAL	8.79b	13.44b	18.22b	22.78b

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

The findings align with scientific understanding of plant nutrition and varietal traits. NPK fertilizers provide macronutrients supporting vegetative growth. Nitrogen is essential for chlorophyll and photosynthesis enzymes, promoting leaf development (Joy et al., 2023; Ullah et al., 2023). Phosphorus enables energy transfer and root growth, while potassium regulates water, nutrient transport, and plant vigor (Halaji et al., 2023; Ullah et al., 2023). Studies show NPK application increases tomato plant leaf numbers (Raksun et al., 2021). COBRA's superior leaf production highlights genetic influence on plant morphology (Jáquez-Gutiérrez et al., 2019; Nakayama et al., 2023). Tomato genotypes vary in growth patterns and nutrient use (Chen et al., 2021). More leaves increase photosynthetic area, crucial for biomass and yield (Raya et al., 2024; Ronga et al., 2017). Selecting varieties with good leaf development and proper NPK fertilization enhances tomato productivity. NPK treatment's superiority over control emphasizes external nutrients' importance for optimal growth (Huett & Dettmann, 1988; Souri & Dehnavard, 2017).

Interactive Effects of Fertilizer Types and Varieties on the Number of Leaves of Tomato

Table 4 shows the interactive effects of different fertilizer types and tomato varieties on the number of leaves over the 10-week observation period.

Table 4: Interactive Effects of Fertilizer Types and Varieties on the Number of Leaves of Tomato

FERTILIZER	VARIETY	4WAT	6WAT	8WAT	10WAT
NPK	COBRA	18.00a	24.61a	33.88a	41.32a
	CHILBI	7.97b	13.63b	18..97b	25.10ab
	OGBO	8.77ab	13.77b	18.43b	23.77b
	LOCAL	8.63b	13.20b	18.53b	23.87b
	RIO GRANDE ANSAL	8.43b	13.43b	18.43b	23.97b
POULTRY	COBRA	13.02ab	20.00ab	28.81ab	36.23a
	CHILBI	10.40ab	15.10ab	20.40ab	25.40ab
	OGBO	9.63ab	14.63ab	19.97ab	24.97ab
	LOCAL	8.63ab	14.20ab	19.53ab	24.53ab
	RIO GRANDE ANSAL	8.87ab	18.87b	18.87b	23.80b
CONTROL	COBRA	9.68ab	14.80ab	21.27ab	26.70ab
	CHILBI	11.10ab	14.77ab	18.10b	21.77b
	OGBO	10.83ab	14.50ab	18.17b	21.50b
	LOCAL	7.98b	11.63b	15.30b	18.97b
	RIO GRANDE ANSAL	10.10ab	13.77b	17.77b	21.10b

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

The interaction between NPK fertilizer and COBRA variety yielded the highest number of leaves, reaching 41.32 leaves per plant at 10 weeks after transplanting, suggesting synergy between NPK's nutrient supply and COBRA's genetic potential (Ger et al., 2024). Poultry fertilizer with COBRA also performed well, producing 36.23 leaves per plant at 10 WAT (Oyedeji et al., 2014). The control treatments resulted in lower leaf numbers across varieties, with 'Control + RIO GRANDE' showing one of the lowest counts at 18.97 leaves per plant at 10 WAT, demonstrating the importance of nutrient supply (Raksun et al., 2021; Tavallali & Darvishzadeh, 2025). NPK- and poultry-fertilized plants consistently outperformed unfertilized controls. While NPK provides quicker responses due to readily available nutrients (Adekiya et al., 2022), organic sources like poultry manure improve soil fertility over time (Demir et al., 2010). COBRA variety demonstrated superior leaf production across fertilizer types. These results indicate that fertilizer application and variety selection significantly affect tomato plants' photosynthetic capacity.

Higher leaf numbers increase photosynthetic surface area, benefiting biomass accumulation and yield (Halaji et al., 2023). NPK fertilizers enhance leaf development by providing essential elements for growth (Khan & Rashid, 2021). Varietal differences in leaf production reflect inherent variations in growth patterns and nutrient uptake efficiencies (Falodun & Adewunmi, 2021). The NPK + COBRA combination proves most effective for maximizing leaf development in tomato crops (Ilupeju et al., 2015).

Effects of Fertilizer Types and Tomato Varieties on the Stem Girth of Tomato

Table 5 shows the significant effects of different fertilizer types and tomato varieties on the stem girth of tomato plants over the 10-week observation period.

Table 5: Effects of Fertilizer Types and Tomato Varieties on the Stem Girth (mm) of Tomato

TREATMENT	4 WAT	6 WAT	8 WAT	10 WAT
FERTILIZER EFFECT				
POULTRY	3.71a	4.11a	4.45ab	4.77ab
NPK	3.81a	4.17a	4.54a	4.87a
CONTROL	3.25a	3.65a	3.91b	4.18b
VARIETAL EFFECT				
COBRA	4.64a	5.42a	6.07a	6.49a
CHILBI	3.53ab	3.83a	4.09b	4.32b
OGBO LOCAL	3.48b	3.71b	3.88b	4.17b
RIO GRANDE	3.18b	3.64c	3.87b	4.17b
ANSAL	3.13b	3.29b	3.57b	3.88b

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

The fertilizer type and tomato variety significantly influenced stem girth. While fertilizer types showed no significant differences at 4 and 6 weeks after transplanting, NPK-treated plants had thicker stems at 8 and 10 weeks compared to control plants, which consistently showed the thinnest stems. Among varieties, COBRA maintained the thickest stems throughout, while ANSAL showed the thinnest. These findings demonstrate the importance of nutrients and genetics in tomato plant development. NPK fertilizers provide essential macronutrients for cell division and biomass accumulation, leading to increased stem thickness (Joy et al., 2023; Ullah et al., 2023). Nitrogen forms structural proteins, phosphorus aids energy transfer, and potassium regulates turgor and nutrient transport (Halaji et al., 2023; Syamsiyah et al., 2023). Research shows that NPK fertilization promotes stronger stems in tomatoes (Adekiya et al., 2022; Raksun et al., 2021). COBRA's thicker stems indicate genetic traits influencing plant architecture (Jędrszczyk et al., 2012; Yang et al., 2021). Varieties with thicker stems show better lodging resistance and nutrient transport efficiency. Nutrient-deficient plants exhibit stunted growth and thinner stems due to reduced cell production (Huett & Dettmann, 1988; Souri & Dehnavard, 2017). Therefore, optimizing fertilizer application based on varietal responses is crucial for stem development in tomatoes.

Interactive Effects of Fertilizer Types and Varieties on the Stem Girth of Tomato

Table 6 shows the interactive effects of different fertilizer types and tomato varieties on the stem girth of tomato plants over the 10-week observation period.

Table 6: Interactive Effects of Fertilizer and Varieties on the Stem Girth (mm) of Tomato

FERTILIZER	VARIETY	4WAT	6WAT	8WAT	10WAT
NPK	COBRA	4.99a	5.85a	6.45a	7.053a
	CHILBI	3.53a	3.83abc	4.13cd	4.27cd
	RIOGRANDE	3.97a	4.13abc	4.23bcd	4.50cd
	OGBOMOSHO	3.10a	3.53bc	3.90cd	4.07cd
	ANSAL	2.97a	3.23c	3.53cd	4.00cd
POULTRY	COBRA	4.85a	5.50ab	6.29ab	6.69ab
	CHILBI	4,13a	4.33abc	4.53abcd	4.83cd
	OGBO LOCAL	2.93a	3.67bc	4.00cd	4.50cd
	RIO GRANDE	3.90a	4.13abc	4.27bcd	4.50cd
	ANSAL	3.23a	3.23c	3.60cd	3.83cd
CONTROL	COBRA	4.85a	4.90abc	5.46abc	5.74abc
	CHILBI	4.13a	3.33bc	3.60cd	3.87cd
	OGBO LOCAL	2.93a	3.73abc	3.73cd	3.93cd
	RIO GRANDE	2.97a	3.40b	3.60d	3.83cdd
	ANSAL	2.57a	2.87c	3.17cd	3.50d

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

The NPK fertilizer and COBRA variety combination produced the thickest stems, reaching 7.053 mm at 10 weeks after transplanting, indicating strong synergy between comprehensive nutrient supply and COBRA's genetic predisposition. Poultry fertilizer with COBRA also showed superior stem girth at 6.69 mm. Control treatments resulted in the thinnest stems, with 'Control + ANSAL' showing the lowest girth of 3.50 mm at 10 WAT, demonstrating nutrient deficiency's negative impact on structural development. These findings highlight the role of balanced nutrient availability in stem development for plant stability. NPK fertilizers provide essential macronutrients for increased stem thickness and plant strength (Joy et al., 2023; Ullah et al., 2023). Genetic factors significantly influence nutrient utilization for stem growth (Jędrszczyk et al., 2012; Yang et al., 2021), with COBRA showing superior performance across fertilizer treatments. For agricultural practices, selecting optimal fertilizer-variety combinations enhances plant resilience and fruit load capacity. Studies show NPK's importance in developing strong plant architecture for higher yields (Adekiya et al., 2022; Raksun et al., 2021). Control groups' poor performance confirms the necessity of nutrient supplementation for healthy stem development (Huett & Dettmann, 1988; Souri & Dehnavard, 2017).

Effects of Fertilizer Treatment and Tomato Varieties on the Number of Flowers of Tomato

Table 7 shows the effects of different fertilizer treatments and tomato varieties on the number of flowers produced over the various weeks after transplanting.

Table 7: Effects of Fertilizer Treatment and Tomato Varieties on the Number of Flowers of Tomato

TREATMENT	6 WAT	8 WAT	10 WAT
FERTILIZER EFFECT			
POULTRY	3.27b	6.20b	8.73b
NPK	3.80a	6.93a	11.13a
CONTROL	3.20b	5.27b	8.67b
VARIETAL EFFECT			
COBRA	7.33a	5.63a	16.22a
OGBO LOCAL	3.67a	5.32a	8.67b
RIO GRANDE	3.22a	5.20a	7.33b
CHILBI	3.44a	5.98a	7.56b
ANSAL	3.44a	5.56a	7.78b

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

The fertilizer type and tomato variety influence flower production during the growing season. NPK fertilization produced more flowers compared to poultry manure and unfertilized control, with control plants showing the lowest flower counts. COBRA variety demonstrated superior flower production, while RIO GRANDE and CHILBI produced fewer flowers. These findings emphasize the role of balanced nutrient availability in tomato plant reproduction. NPK fertilizers provide essential macronutrients for flower initiation and development (Shewangizaw et al., 2024; Ullah et al., 2023). Nitrogen promotes vegetative growth, phosphorus aids flower bud formation, and potassium influences flower numbers and longevity (Bodale et al., 2021; Ullah et al., 2023). The NPK advantage over control highlights the necessity of external nutrients for optimal reproduction (Deb et al., 2024; Ger et al., 2024). Flower production differences among varieties demonstrate the importance of genetic factors in reproductive potential. COBRA's high performance suggests efficient nutrient partitioning and genetic predisposition for reproductive growth (Jędrszczyk et al., 2012; Rajendran et al., 2021). To maximize flower production and fruit yield, growers should select varieties like COBRA with strong flowering tendency and ensure balanced macronutrients through NPK fertilization. Research shows flower numbers correlate with fruit yield (Castillo et al., 2021; Meena & Bahadur, 2015), making this combined approach crucial for enhancing tomato cultivation efficiency (Gonzalo et al., 2021).

Interactive Effects of Fertilizer Types and Varieties on the Number of Flowers of Tomato

Table 8 shows the interactive effects of different fertilizer types and tomato varieties on the number of flowers produced in various weeks after transplanting.

Table 8: Interactive Effects of Fertilizer Types and Varieties on the Number of Flowers of Tomato

FERTILIZER	VARIETY	6WAT	8WAT	10WAT
CONTROL	ANSAL	2.12a	3.00a	4.00a
	CHILBI	2.00a	3.67a	4.00a
	COBRA	2.30a	3.30a	4.50a
	OGBO	1.00a	2.60a	3.67a
	LOCAL	1.50a	2.70a	3.50a
	RIO GRANDE			
NPK	ANSAL	3.67a	7.33a	11.67a
	CHILBI	3.50a	7.67a	10.67a
	COBRA	4.00a	9.00a	12.67a
	OGBO	3.33a	2.70a	12.00a
	LOCAL	3.67a	8.67a	12.20a
	RIO GRANDE			
POULTRY	ANSAL	3.67a	7.00a	9.67a
	CHILBI	3.20a	6.33a	8.33a
	COBRA	3.60a	6.00a	8.33a
	OGBO	2.90a	6.33a	10.67a
	LOCAL	3.30a	6.67a	10.00a
	RIO GRANDE			

Means with the same letters along the column are not significantly different (DMRT 0.05). WAT: Weeks after transplanting.

The NPK fertilizer and COBRA variety combination produced the highest number of flowers (12.67 per plant) at 10 weeks after transplanting, demonstrating optimal synergy between balanced nutrients and genetic potential. NPK fertilizer enhanced flowering across varieties compared to control and poultry treatments. The control treatment, particularly with RIO GRANDE, produced significantly fewer flowers (3.50 per plant at 10 WAT), highlighting plants' dependency on external nutrients (Castillo et al., 2021). These findings impact tomato cultivation optimization, as flower numbers directly affect fruit set and yields (Castillo et al., 2021; Meena & Bahadur, 2015). The NPK + COBRA combination's superior performance suggests enhanced reproductive efficiency. NPK fertilizers provide phosphorus for flower initiation and potassium for plant vigor (Ullah et al., 2023), while nitrogen supports robust plant growth capable of sustaining flowers (Shewangizaw et al., 2024). COBRA's high flower production demonstrates the importance of genetic traits in reproductive capacity (Jędrszczyk et al., 2012; Rajendran et al., 2021). Combining high-flowering varieties with appropriate NPK fertilization can enhance productivity and economic returns (Gonzalo et al., 2021).

Effects of Fertilizer Types and Varieties on Yield Parameters

Table 9 shows the effects of the different fertilizer types and tomato varieties on the total number of fruits and fruit yield.

Table 9: Effects of Fertilizer Types and Varieties on Yield Parameters

TREATMENT	TNF	FRUIT YIELD (t/ha)
FERTILIZER EFFECT		
COMPOST	46.13b	0.98ab
NPK	51.27a	1.40a
CONTROL	45.00ab	0.67b
VARIETAL EFFECT		
ANSAL	45.56b	1.03ab
CHILBI	41.22b	1.002b
COBRA	65.89a	2.04a
OGBO LOCAL	42.56b	1.003b
RIO GRANDE	42.11b	0.99c

Means with the same letters along the column are not significantly different (DMRT 0.05). WAT: Weeks after transplanting.

NPK fertilizer produced the highest fruit numbers and yields compared to compost and the unfertilized control, while the control yielded the lowest. COBRA variety showed significantly higher fruit numbers and yield than RIO GRANDE. These results demonstrate the importance of nutrient availability and genetic potential in tomato productivity. NPK fertilizers provide essential macronutrients crucial for flower and fruit development (Joy et al., 2023; Shewangizaw et al., 2024; Ullah et al., 2023). Nitrogen supports vegetative growth, phosphorus aids flowering and fruit development, and potassium enhances fruit quality (Ger et al., 2024; Shewangizaw et al., 2024). NPK's superior performance aligns with studies showing inorganic fertilizers' effectiveness in increasing yields through rapid nutrient availability (Adekiya et al., 2022; Ilupeju et al., 2015). The high yield of COBRA indicates that genetic factors determine nutrient-to-fruit conversion efficiency (Jędrszczyk et al., 2012; Rajendran et al., 2021). Selecting high-yielding varieties with effective NPK fertilization can significantly improve tomato production. The control group's poor performance highlights the need for external nutrients, as nutrient stress impairs flower development and fruit growth (Huett & Dettmann, 1988; Souri & Dehnavard, 2017). Thus, combining optimal fertilization with appropriate variety selection is crucial for efficient tomato cultivation (Meena & Bahadur, 2015).

Interactive Effects of Fertilizer Types and Varieties on the Yield Parameters of Tomato

Table 10 shows the interactive effects of different fertilizer types and tomato varieties on the total number of fruits and fruit yield.

Table 10: Interactive Effects of Fertilizer Types and Varieties on the Yield Parameters of Tomato

FERTILIZER	VARIETY	TNF	Fruit yield (t/ha)
COMPOST	ANSAL	43.33a	0.94a
	CHILBI	41.00a	0.95a
	COBRA	63.33a	1.25a
	OGBO LOCAL	44.33a	0.92a
	RIO GRANDE	40.33a	1.0a
NPK	ANSAL	43.33a	1.4a
	CHILBI	41.00a	1.34a
	COBRA	63.33a	1.5a
	OGBO LOCAL	44.33a	1.35a
	RIO GRANDE	40.33a	1.33a
CONTROL	ANSAL	44.00a	0.73a
	CHILBI	36.67a	0.68a
	COBRA	61.67a	0.76a
	OGBO LOCAL	39.67a	0.74a
	RIO GRANDE	41.33a	0.65a

Means with the same letters along the column are not significantly different (DMRT 0.05).
WAT: Weeks after transplanting.

While the interaction between fertilizer type and variety on fruit numbers and yield was not statistically significant, specific combinations showed superior performance. NPK fertilizer with the COBRA variety produced the highest fruit yield (1.5 t/ha) and high fruit numbers (63.33 fruits/plant). Poultry fertilizer with COBRA also performed well, indicating that both fertilizers effectively supported COBRA's productivity. NPK fertilizers increase plant height, leaf area, and flower production, leading to higher fruit yields (Ilupeju et al., 2015), while genetic factors influence fruit production potential (Jędrszczyk et al., 2012; Rajendran et al., 2021). Control treatments resulted in lower fruit numbers and yields across varieties, with 'Control + RIO GRANDE' showing the lowest yield (0.65 t/ha) and 'Control + CHILBI' showing the lowest fruit numbers (36.67 fruits/plant). This highlights tomato plants' dependency on external nutrients (Ger et al., 2024). Adequate fertilization improves fruit quality and nutrient uptake (Huett & Dettmann, 1988; Souri & Dehnavard, 2017). For maximum yield, selecting productive varieties like COBRA and using optimized fertilization, particularly NPK, is crucial. NPK provides essential macronutrients for plant growth, flower development, and fruit quality (Joy et al., 2023). While varietal characteristics determine potential yield (Meena & Bahadur, 2015), appropriate fertilization is vital for achieving it, as shown by lower yields in control groups (Adekiya et al., 2022).

Effects of Fertilizer Types and Tomato Varieties on Nutritional Contents of Tomato Plant

Table 11 shows the effects of different fertilizer types and tomato varieties on various nutritional contents, including crude protein, crude fiber, phosphorus, potassium, vitamin C, vitamin A, and lycopene content.

Table 11: Effects of Fertilizer Types and Tomato Varieties on Nutritional Contents of Tomato Plant

TREATMENT	Cp %	Cf %	P %	K %	Vit C %	Vit A %	Lycopene %
FERTILIZER EFFECTS							
POULTRY	1.67a	0.36b	7.91a	0.80a	34.78a	0.88a	14.04a
NPK	1.73a	0.38a	8.45a	0.81a	40.27a	1.11a	14.94a
CONTROL	1.55b	0.35b	7.07a	0.70a	28.91a	0.74a	11.05a
TOMATO VARIETIES							
ANSAL	1.69a	0.34c	7.83a	0.73a	33.47a	0.76a	13.94a
CHILBI	1.68a	0.36b	7.80a	0.73a	34.39a	0.96a	14.40a
COBRA	2.81a	0.38a	7.41a	0.71a	34.51a	0.76a	13.16a
OGBO LOCAL	1.63a	0.37ab	8.22a	2.18a	36.73a	1.12a	13.62a
RIO GRANDE	1.62a	0.37ab	7.80a	0.96a	34.17a	0.93a	13.27a

Means with the same letters along the column are not significantly different (DMRT 0.05). CP: Crude protein, CF: Crude fiber, P: phosphorus, K: potassium, Vit: Vitamin.

The fertilizer type significantly affected crude protein and crude fiber content, while other nutrients were not significantly affected. Varietal effects were significant only for crude fiber content. NPK fertilizer resulted in higher nutritional content compared to poultry manure and control, with COBRA showing the highest crude protein and crude fiber among varieties. NPK treatments yielded the highest levels of crude protein (1.73%), crude fiber (0.38%), phosphorus (8.45%), potassium (0.81%), vitamin C (40.27%), vitamin A (1.11%), and lycopene (14.94%) (Ilupeju et al., 2015). This indicates balanced macronutrients from NPK fertilizers enhance tomatoes' nutritional profile. Studies confirm NPK application influences nutrient accumulation in tomatoes (Adekiya et al., 2022), with nitrogen vital for protein synthesis, phosphorus for energy transfer, and potassium for enzyme activation (Huett & Dettmann, 1988; Souri & Dehnavard, 2017). COBRA exhibited the highest crude protein (2.81%) and crude fiber (0.38%), while Ogbo Local showed the highest phosphorus (8.22%), potassium (2.18%), vitamin A (1.12%), and vitamin C (36.73%). These differences highlight genetics' role in determining nutritional composition, as cultivars vary in nutrient uptake and accumulation (Nakayama et al., 2023; Ullah et al., 2023). While NPK fertilization boosts nutritional content, variety choice remains crucial. COBRA suits higher protein and fiber content, while Ogbo Local offers higher phosphorus, potassium, and vitamin A levels. Research confirms both environmental and genetic factors affect crop nutritional quality (Jędrszczyk et al., 2012; Yang et al., 2021). Thus, combining appropriate fertilizer management with high-nutrient varieties optimizes tomato cultivation benefits.

Interactive Effects of Fertilizer Types and Tomato Varieties on Nutritional Contents of Tomato Plant

Table 12 shows the interactive effects of different fertilizer types and tomato varieties on the key nutritional components of the tomato plants. These components included crude protein, crude fiber, phosphorus (P), potassium (K), vitamin C, vitamin A, and lycopene.

Table 12: Interactive Effects of Fertilizer Types and Tomato Varieties on Nutritional Contents of Tomato Plant.

FERTILIZER	VARIETY	CP	CF	P	K	VIT C	VIT A	LYCO
POULTRY	ANSAL	1.68a	0.33a	7.91a	0.71c	33.81b	0.76a	14.3b
	CHILBI	1.75a	0.36a	7.63b	0.73b	32.93b	0.81a	14.12b
	COBRA	1.60a	0.38a	7.5b	0.72c	32.40b	0.75b	13.92b
	OGBO LOCAL	1.68a	0.37a	8.85a	0.71cd	40.67b	1.34a	14.32b
	RIO GRAND	1.63a	0.36a	7.59b	0.74b	33.28b	0.76a	13.51b
NPK	ANSAL	1.76a	0.36a	7.91a	0.74ab	33.85a	0.78a	12.95c
	CHILBI	1.79a	0.38a	6.85c	0.75a	42.55a	1.33a	15.65a
	COBRA	1.71a	0.40a	6.81c	1.1a	43.43a	0.81a	14.93a
	OGBO LOCAL	1.74a	0.39a	6.91c	0.72c	41.46a	1.33a	15.42a
	RIO GRAND	1.67a	0.4a	6.86c	0.74a	41.78a	1.31a	15.71a
CONTROL	ANSAL	1.64a	0.34a	0.34a	0.73b	32.75b	0.76a	14.55a
	CHILBI	1.49a	0.35a	0.38a	0.71c	27.70c	0.77c	10.62c
	COBRA	1.57a	0.35a	0.40a	0.67b	27.72c	0.72b	10.63c
	OGBO LOCAL	1.47a	0.30a	0.39a	0.50d	27.85c	0.70b	11.11c
	RIO GRAND	1.55a	0.34a	0.4a	0.67cd	27.45c	0.73c	10.57c

Means with the same letters along the column are not significantly different (DMRT 0.05)
CP: Crude protein, CF: Crude fibre, %P: Percentage phosphorus, % K: Percentage potassium, Vitamin C, Vitamin A

The interaction between fertilizer types and tomato varieties significantly affects most nutritional contents, except for crude fiber and crude protein. NPK + CHILBI had the highest crude protein (1.79%) and NPK + COBRA had the highest crude fiber (0.40a), suggesting that specific fertilizer-variety pairings can enhance protein and fiber levels (Ogunleye et al., 2021). Poultry + OGBO LOCAL resulted in the highest phosphorus content (8.85a), highlighting the effectiveness of organic fertilizers for phosphorus uptake, while Control + ANSAL showed the lowest (0.34a) (Baroutkoob et al., 2024; Ullah et al., 2023). NPK + COBRA recorded the highest potassium content (1.1a), emphasizing the importance of both fertilizer and variety in potassium uptake (Ullah et al., 2023). NPK fertilization, particularly in NPK + COBRA (43.43a), boosted vitamin C levels, while control treatments had lower levels (27.45c), indicating the role of NPK in vitamin C synthesis (Otieno et al., 2020; Rokhminarsi et al., 2020). For vitamin A, the highest content was in Poultry + OGBO LOCAL (1.34a), with NPK combinations also showing strong performance, suggesting both fertilizers can enhance vitamin A levels (Murariu et al., 2021; Otieno et al., 2020).

NPK + RIO GRANDE had the highest lycopene content (15.71a), confirming the importance of fertilization for optimal lycopene levels (Helyes et al., 2009; Ilupeju et al., 2015; Kim et al., 2021; Otieno et al., 2020; Taber et al., 2008). These results align with broader research emphasizing the combined influence of genetic and environmental factors on crop nutritional profiles (Ishfaq et al., 2023; Montgomery & Biklé, 2021).

CONCLUSION

This study demonstrated that both fertilizer type and tomato variety significantly influenced the vegetative growth, yield, and nutritional quality of tomato plants. Among the treatments, **NPK fertilizer consistently led to the best performance** across all parameters, including plant height, number of leaves, stem girth, number of flowers, fruit count, fruit yield, and nutritional content. Likewise, **variety COBRA outperformed other varieties** in most growth and yield metrics, showing strong potential for commercial cultivation. Interactive effects revealed that the **NPK + COBRA** combination was the most effective, producing the tallest plants, the highest number of leaves, the greatest stem girth, and the highest fruit yield.

To maximize tomato plant growth, yield, and nutritional content, especially in resource-limited settings where efficiency is critical, it is recommended to use NPK fertilizer. The COBRA tomato variety should be cultivated for its superior performance in plant growth and yield traits. For optimal results, particularly in commercial tomato farming, the combination of NPK fertilizer and the COBRA variety is highly effective. However, further studies are needed to investigate the long-term effects of NPK use on soil health and to evaluate organic fertilizer blends that could balance productivity with environmental sustainability.

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