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ORIGINAL RESEARCH

Tomato genotype response to organic and synthetic fertilizers

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Abstract

Purpose: The study investigated how selected tomato genotypes performed with combined applications of cocoa pod (CP) + poultry manure (PM), kola nut pod (KP) + poultry manure (PM), and NPK fertilizer, focusing on fruit yield, mineral content, and vitamin composition.

Method: The trial was carried out at Landmark University Teaching and Research Farm, Omuaran, Nigeria during the 2020 and 2021 planting seasons. The experiment utilized a completely randomized design with three treatments, each replicated three times. The treatments are: CP+PM; KP+PM; and NPK 15:15:15. Data were taken on yield and related traits, mineral and vitamin composition of tomato fruits. Data collected were subjected to a two-way statistical Analysis of Variance (ANOVA).

Results: NGB00711 exhibited superior fruit quality, whereas NGB00696 achieved the highest yield. Additionally, the combination of cocoa pod + poultry manure enhanced tomato yield, while kola nut pod + poultry manure boosted fruit nutrient content.

Conclusion: Genotypes NGB00711 and NGB00696 were identified as good candidates for the development of high-yielding tomatoes under organic nutrient regimes. Moreover, the application of 6.5g/plant of CP+PM and 6.4g/plant KP+PM appeared to improve both the yield and quality of tomato fruit compared to NPK Fertilizer. The combination of CP + PM seemed to result in higher fruit yield compared to other manure types..

Keywords: Plant crops; Cocoa pod; Kola pod; Poultry manure; Fruit yield; Minerals; Vitamins

Introduction

The Tomato (*Solanum lycopersicum* L) holds considerable importance as one of the most economically attractive crops in the country, owing to its high yield and short growing season. Tomato is considered one of the cheapest sources of vitamins A and C, as well as, minerals such as iron and phosphorus. Vitamin K components of tomatoes are essential in performing minor repairs in the bones and tissues (Law-Ogbomo and Egharevba 2008). Tomato reduces damage caused by smoking and provides essential antioxidants that neutralize harmful radicals in the blood. It also helps to reduce cholesterol levels and therefore lowers blood pressure. It reduces the risk of kidney stones, and it is also good for vision. (Law-Ogbomo and Egharevba 2008).

The demand for organically produced crops is rising worldwide (Hai et al. 2010; White and Broadley 2009). Organically produced crops provide superior taste and higher levels of vitamins and minerals compared to those grown with inorganic manure. (Fuertes-Mendizabal et al. 2010)). Organic farming has gained increased attention over the past two decades due to its consistently high-quality output. (Farhad et al. 2018; Rodrigues et al. 2006). Inorganic fertilizers are costly and scarce, particularly in underdeveloped nations.Organically produced crops command more value than inorganic ones (Delate and Camberdella 2004). Similar to this, organic cropping systems are more effective at using nutrients than inorganic farming systems (Hildermann et al. 2010). Organic manures improve soil physiochemical properties, enhancing soil fertility, microbial activity, and moisture-holding capacity (Abbas et al. 2012; Meagy et al. 2016). Excessive use of chemical fertilizers in crop production results in pollution of surface water, groundwater, and the atmosphere through leaching, runoff, and volatilization. (Galloway et al. 2008). Since organic manures serve a variety of purposes in agroecosystems, they are essential for improving soil quality and crop output (Jones et al. 2007). Their contributions generally benefit the overall health of the agro-environment. (Jedidi et al. 2004). However, combining organic manures with synthetic fertilizers gives crops vital nutrients, increasing crop yields and reducing environmental risks (Yadvinder-Singh et al. 2009). The management of wastes and the use of organic fertilizers improve the soil's microbial composition (Naeem et al. 2009). Organic manure enhances soil water retention capacity, reduces porosity, and consequently mitigates leaching.Continuous use of synthetic fertilizer, besides being expensive and not readily available, leads to organic matter depletion and subsequent adverse effects on the chemical and physical properties of the soil.The residual effects of continuous application of inorganic plant nutrient is a threat to human and animal health (Van der Berge et al. 2000). Quest for organic manure as an alternative plant nutrient is now worldwide. Moreover, organic manures or Agricultural waste are easily available to farmers at avoidable prices relative to synthetic Fertilizers (Alam et al. 2007). In addition, organic fertilizers are richer in essential macro and micro nutrients which lead to higher growth, yield, and fruit qualities of tomatoes. Organic amendments remain one of the cost-effective options to support long-term improvements in agricultural productivity (Hartmann et al. 2014; Kumar et al. 2014; Coulibaly et al. 2019). Household waste, animal excreta, sewage sludge, and agricultural residues are valuable under-utilized sources of plant nutrients (Mankoussou et al. 2017). Most of these agricultural residues are abandoned on the spot in the production areas after harvesting and processing. A typical example is Cocoa shells, which are valuable but utilize organic residues that are available in large quantities in most of the cocoa-producing farm's countries, e.g. Nigeria, and Côte d'Ivoire which happened to be the largest producer in the world. It would be more economical to add value to these agricultural products, utilize them for bio-fertilizer production, and offer them to local farmers at affordable prices.

Some authors argue that nutrients from organic fertilizers are released at a slower rate compared to inorganic fertilizers.A combination of organic and synthetic fertilizers is therefore considered to be more adequate for crop fruit yield and related traits. Thus, this combined application increases the use of readily available organic waste materials/manure and reduces the usage of costly and non-readily available inorganic plant nutrient sources. Many authors have concluded that the application of a combination of organic and inorganic fertilizers is recommended for improved crop performance in terms of fruit yield, quality, and enhancement of soil physio-chemical properties.

Different plant genotypes may exhibit varied responses to both organic and inorganic fertilizer sources for yield and fruit nutrient composition.According to Bahrman et al. (2004); and Shivay et al. (2010), wheat grains cultivated using organic fertilizers had higher protein levels than wheat grains grown with chemical fertilizers. This study was therefore conducted to investigate the comparative responses of some tomato genotypes to the application of Cocoa pod (CP) + poultry manure (PM), Kola pod (KP) + PM, and NPK fertilizers for fruit yields and nutrient quality in derived Savannah region.

Materials and methods

Five tomato genotypes used for the study namely, NGB00696, NGB00711, NGB00713, NGB00694, and NGB00725 were obtained from National Centre for Genetic Resource and Biotechnology (NACGRAB), Ibadan. The study was carried out at Landmark University's Teaching and Research Farm in Omu-Aran, Nigeria, during the agricultural season of 2020–2021. The location is between 8.9oN latitude and 50o61E longitude of the equator. Between April and October, there is an annual rainfall pattern that runs from 600 mm to 1200 mm, while October and March are dry. The Landmark University Omu-Aran Teaching and Research Farm's nursery was used to raise the Tomato seedlings and transplanting was done three weeks after sowing. The experiment was laid out in a complete randomized design comprising 3 treatments, replicated 3 times. The treatments are; Cocoa pod (CP) + poultry manure (PM); Kola pod (KP) + poultry manure (PM); NPK 15:15:15. Formulated agricultural wastes (cocoa pod/poultry and kola nut pod/poultry manure) obtained through microbial decomposition were applied each at 10t/ha which is equivalent to 6.50g/tomato stand of formulated cocoa pod/poultry manure and 3.20, 6.40, and 9.60 g pot-1 of formulated kola nut pod/poultry manure (FKP). Mineral and microbial composition of bio-fertilizer from kola pod + poultry dropping and Mineral and microbial composition of bio fertilizer from cocoa pod + poultry drooping are presented in Tables 1 and 2 respectively. Application of the amendments was made 4 days after transplanting to allow for nutrient release, while the application of inorganic fertilizer (NPK 15:15:15) was made two weeks after transplanting. Data were collected on plant height, number of leaves/plant 6,8,10,12 weeks after transplanting (WAT), stem girth, days to 50% flowering, and yield traits. Representative fruits were taken per treatment and per variety to analyze fruit quality at the project research laboratory of Landmark University Omu-Aran, Kwara State.

Table 1. Mineral and microbial composition of bio-fertilizer from kola pod + poultry dropping**.**

S/N	**Mineral Composition**	**VALUE**
1.	pH	7.95±0.05
2.	Copper	1.12±0.02 (ppm)
3.	Calcium	15.88±0.03 (%)
4.	Iron	0.28±0.02 (ppm)
5.	Magnesium	9.40±0.01 (%)
6.	Manganese	0.007±0.01 (ppm)
7.	Phosphate	0.62±0.02 (%)
8.	Sulphate	3.96±0.03 (ppm)
9.	Potassium	1.62±0.02 (%)
10.	Nitrogen	9.36±0.01 (%)
11.	Phosphorus	1.28±0.02 (%)
12.	Zinc	4.68±0.02(ppm)
13.	Aluminium	0.13±0.01(%)

Bacteria	**TBPC (cfu/mL)**	**Fungi**	**TFC (cfu/mL)**
Bacillus sp.	6.0 x 106	Aspergillus niger	2.0 x 102
Fusobacterium sp.		Aspergillus flavus	
Clostridium sp.			
Porphyromonas sp.			

TBPC = Total Bacteria Plate Count, TFC = Total Fungal Count.

Determination of tomato fruits Vitamin C

Samples of the tomato were ground, and 2 grams for each sample were taken into the beaker and diluted with 50 distilled water, after 50 minutes, the solution was filtered into a 100 mL volumetric flask and filled with distilled water up to 100 mL. 10 mL of the filtrate was titrated against oxalic acid containing 10 mL ascorbic acid and indophenol dye was used as the indicator to determine the vitamin C content of the samples.

Vitamin C = $0.5 \times V2 \times 100 \times 100$

$V1 \times 5$ mL × Weight of sample

V1 = Blank

V2 = Titer Value

Table 2. Mineral and microbial composition of bio fertilizer from cocoa pod + poultry drooping.

S/N	Mineral Composition	VALUE
1.	pH	7.30±0.01
2.	Copper	0.65±.02 (ppm)
3.	Calcium	14.00±0.02 (%)
4.	Iron	0.14±0.01 (ppm)
5.	Magnesium	4.80±0.02 (%)
6.	Manganese	0.003±0.01 (ppm)
7.	Phosphate	0.30±0.01 (%)
8.	Sulphate	1.94±0.05 (ppm)
9.	Potassium	1.22±0.02 (%)
10.	Nitrogen	9.18±0.03 (%)
11.	Phosphorus	0.62±0.01 (%)
12.	Zinc	3.46±0.01 (ppm)
13.	Aluminium	0.08±0.01 (%)

Microbial Composition

Bacteria	**TBPC (cfu/**mL)	**Fungi**	**TFC (cfu/mL)**
Bacillus sp.	5.0 x 106	Aspergillus niger	1.0 x 102
Fusobacterium sp.		Aspergillus flavus	
Clostridium sp.			
Porphyromonas sp.			
Bcteroides sp.			

TBPC = Total Bacteria Plate Count, TFC = Total Fungal Count.

Determination of the Nitrogen content of tomato fruits

Total N was determined by the Kjeldahl digestion and distillation method as described by Kjeldahl, 1 gram of the fruit sample was placed in a Kjeldahl flask with an addition of 1 gram of copper sulphate and 5 grams of K_2SO_4 + 10 mL of H_2SO_4. The solution was digested for 1 hour and allowed to cool down before being taken it to the distiller for distillation. 30 mL of the solution was placed at the other end in a conical flask. The distilled sample was taken for titration and the titer values were used for estimating the nitrogen content of the tomato fruits. Nitrogen content of the fruit sample was calculated as:

Percentage of nitrogeninthesample=1.4V∗N/W

Where,

· V = acid used in titration (mL)

· N = normality of standard acid

· W = weight of sample (g)

Determination of Calcium and magnesium in tomato fruits

EDTA titration was used for the determination of calcium and magnesium. 1 gram of tomato fruits was ashed in a muffle furnace, and the ash was afterward dissolved in 2 mL of 2NHCl and left for 15 minutes. The sample was filtered into a volumetric flask and filled with distilled water up to 100ml. In calcium and magnesium determination, 20 mL of dissolved tomato ashed was taken into a conical flask containing 100ml of distilled water with 15 mL of concentrated ammonia solution and 10 drops of 2% KCN plus 10 drops of 5% hydroxyl ammonium chloride ($NH_2OH{\cdot}HCl$) were added. The solution was titrated with 0.001M EDTA using Eriochrome as the indicator. To determine calcium content, 20 mL of the solution was taken into a conical flask containing 100 mL of distilled water with 15 mL of KOH, 10 drops of 2% of KCN, 10 drops of 5% hydroxyl ammonium chloride ($NH_2OH{\cdot}HCl$), and a pinch of calcine indicator. The solution was titrated with 0.001M EDTA. The concentration of magnesium in the solution is shown by the difference between the first and second titers.

$(Ca+Mg) - Ca = Mg \times 0.5$

Potassium determination of tomato fruits

Potassium in the ash solution as described for Ca + Mg above was determined using a flame photometer. The instrument is an analytic device that uses the basic principle of atomic spectrometry for qualitative analysis.

Sodium determination of tomato fruits

Sodium in the ash solution as described for Ca + Mg above was determined using a flame photometer. The instrument is an analytic device that uses the basic principle of atomic spectrometry for qualitative analysis. Data collected were subjected to a two-way analysis of variance (ANOVA) using GenStat Discovery, 2014. The significant. treatment means were compared using Duncan Multiple Range Test (DMRT) at a 0.05 level of probability.

Result and discussion

The soil had an acidic pH, extremely low nitrogen concentration (0.15%), high phosphorus availability, and low exchangeable potassium content. However, the exchangeable sodium, calcium, and magnesium contents were all suitable. (Table 3). Sand content was high but soil organic matter was low, and silt and clay content were both comparatively low, the texture can thus be classified as Sandy Loam.

Variation due to plant height was significantly different among the tomato genotypes at 4,6,8,10,12 WAT (Fig. 1). Highest and significant plant height were recorded by genotype NGB00694 across the tested weeks except 12 WAT where genotype NGB00696 recorded the highest and significant plant height (81.44cm). From 4-10 weeks WAT, a combination of kola nut pod and poultry manure had the highest plant height compared to other combinations (Fig. 2), indicating that this combination readily releases plant nutrients for plant use earlier than other combinations, probably because kola pod is more succulent than cocoa pods, additional application of this combination recorded no significant increase in plant height in later weeks. However, the highest and most significant plant height was recorded by a combination of poultry manure and CP (76.54cm) at 12 WAT. This indicates that the CP in the latter combination may not readily release nutrients for plant use due to its hardiness that might have prolonged its mineralization, the study however revealed that it's richer in essential nutrients for plant growth at a later growing stage. Except at week 6 WAT, the application of cocoa pods and chicken manure in combination had no appreciable influence on plant height compared to the application of NPK fertilizer and the control. Except for week 10 WAT, there was no discernible difference in plant height between applications of NPK fertilizer and the control group (Fig. 2). The study also revealed that organic waste or manure improved the growth of tomato plant better than inorganic Fertilizer application. Alam et al. (2007) hypothesized that organic fertilizers are richer in essential macro and micronutrients which lead to higher growth, yield, and fruit qualities of tomatoes.

Table 3. Pre- cropping soil physicochemical analysis.

Property	Value
Sand (%)	69.2
Silt (%)	14.5
Clay (%)	16.3
Soil texture	Sandy loam
PH (water)	5.62
Organic matter (%)	1.88
Total N (%)	0.15
Available P (mg kg-1)	9.71
Exchangeable K (cmol kg-1)	0.14
Exchangeable Ca (cmol kg-1)	2.45
Exchangeable Mg (cmol kg-1)	0.34

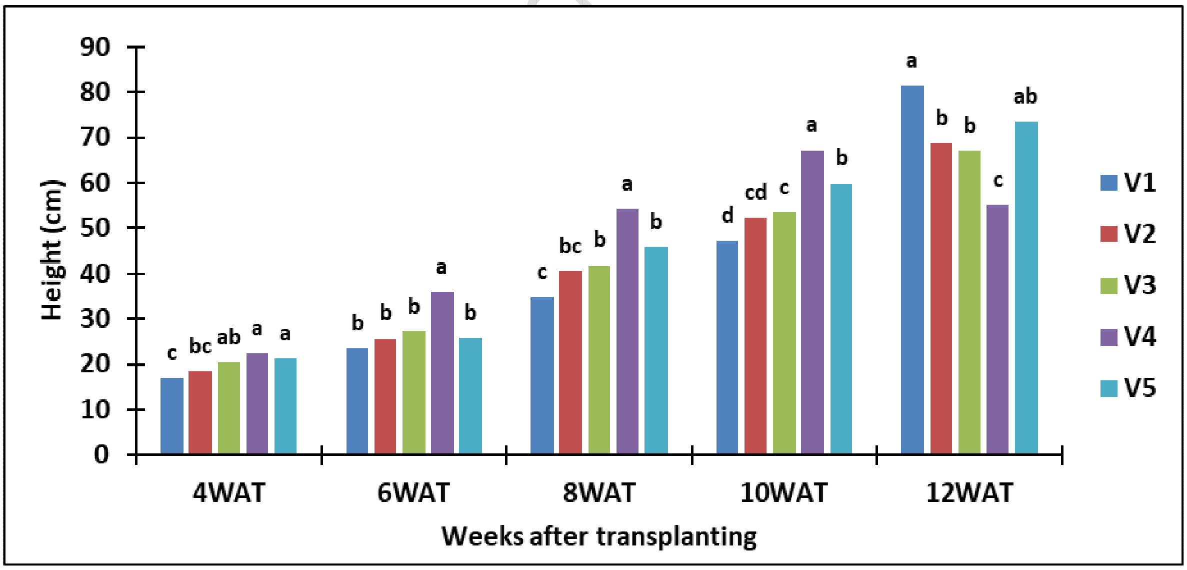

Fig 1. Plant height at 4 weeks after planting to 12 weeks after planting.

V1: NGB00696 V2: NGB00711 V3: NGB00713

V4: NGB00694 V5: NGB00725

V1 – V5 = Tomato Genotypes

WAT = Weeks after transplanting

Bars with different letters are significantly different ($p < 0.050$)

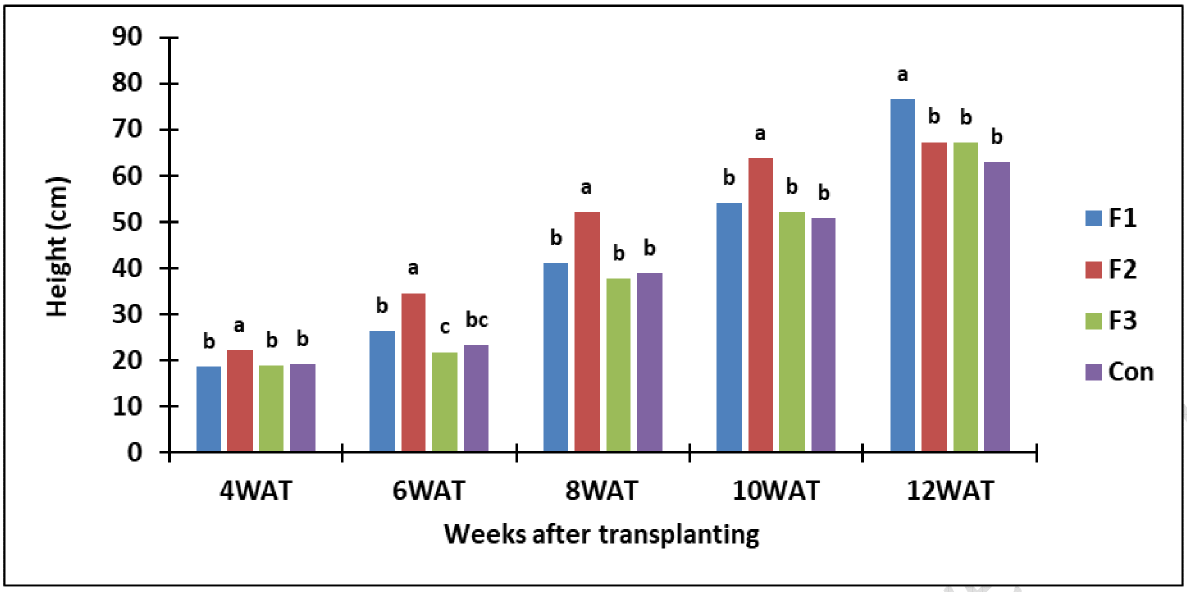

Fig 2. Fertilizer effects on plant height 4 WAT to 12 WAT.

F1: 6.5g of CP+PM F2: 6.4g of KP+PM F3: 5g of NPK

Con: Control WAT = Weeks after transplanting

Bars with different letters are significantly different ($p < 0.050$)

Genotypes NGB00696 recorded the least number of leaves per plant at 4WAT. However, genotypes NGB00711 had the highest number of leaves per plant from weeks 6-12 after planting. Genotype NGB00696 ranked next to the aforementioned genotypes on leaf counts (Fig. 3). The figure above showed continuous variation among the tested genotypes in terms of leaf counts.

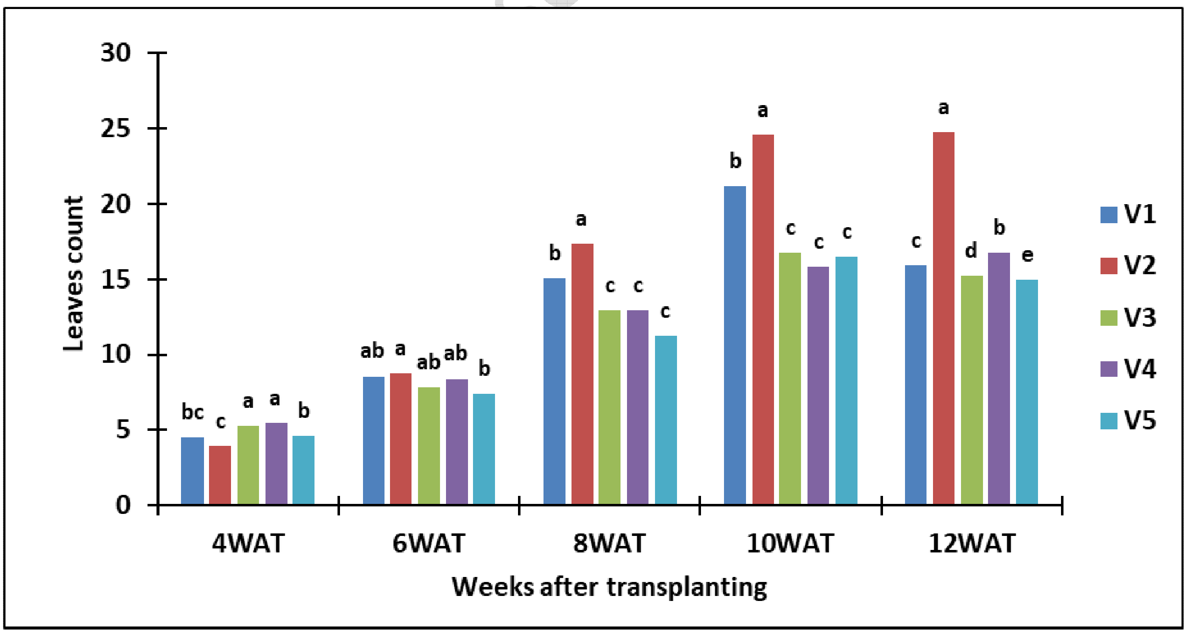

Fig 3. Leaves counts 4 WAT to 12 WAT among the five genotypes tested.

V1: NGB00696 **V2:** NGB00711 **V3:** NGB00713

V4: NGB00694 **V5:** NGB00725

WAT = Weeks after transplanting

Bars with different letters are significantly different ($p < 0.050$)

Fertilizer-type effects on leaf count were significant across the five tested weeks (Fig. 4). However, a combination of CP + PM recorded the highest leaf count per plant from 6 – 12 after, even though the same fertilizer combination recorded the least leaves count at 4WAT. This further revealed that the combination of CP + PM is richer in plant nutrients, more importantly, nitrogen for vegetative growth than other types of fertilizer and combination (Table 2), though may not immediately release it for plant use.

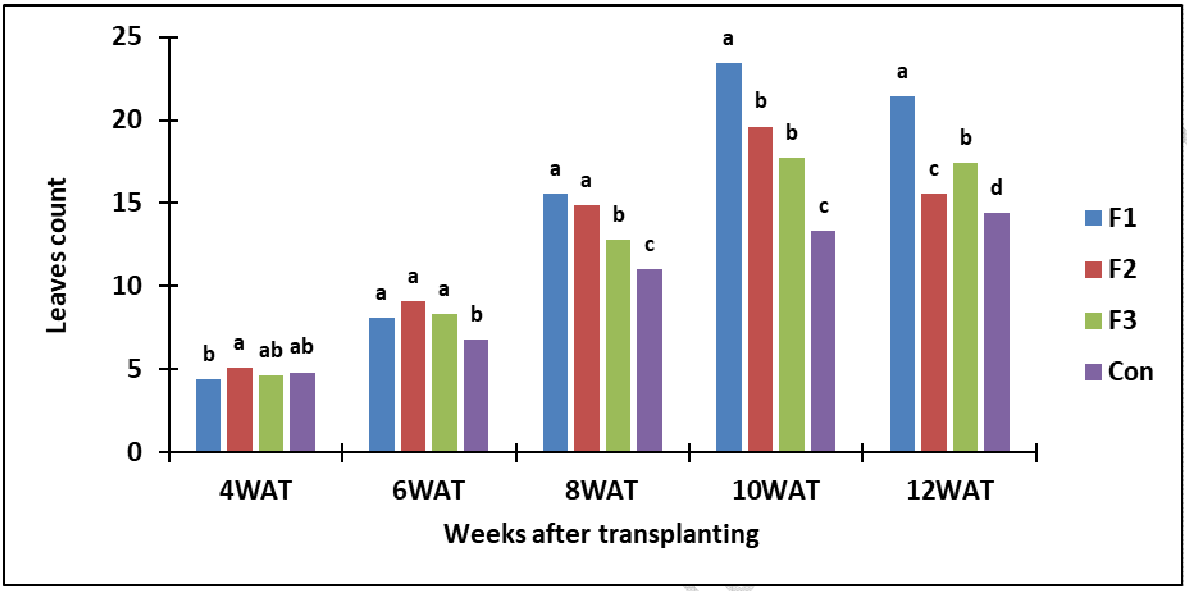

Fig 4. Fertilizer effects on Leaves counts 4 WAT to 12 WAT among the five genotypes tested.

F1: 6.5g of CP+PM F2: 6.4g of KP+PM F3: 5g of NPK

Con = control

Bars with different letters are significantly different ($p < 0.050$)

Stem Girth

Genotype effects on stem girth were significant across the weeks. Genotype NGB00694 had the highest stem girth across weeks 4, 6, 8, 10, and 12 after planting. Stem girth variation in response to the tested amendments was significant across weeks (Fig. 5), indicating that genotypes respond differently to soil amendments for an increase in plant stem girth.

Fertilizer-type effects on stem girth were significant across the five different weeks (Fig. 6). Combination of Kola pod + PM recorded the highest stem girth continuously across the five tested weeks while combination CP + PM ranked next to the aforementioned combination. This further suggests that the growth performance of tomatoes is strongly influenced by the sources of plant nutrients. Nevertheless, organic sources appear to promote tomato development more effectively than inorganic fertilizers.

Days to flowering and fruiting were delayed in genotype NGB00711 (Table 4). However, days to flowering and fruiting were earliest in genotype NGB00694. There were significant differences in days of flowering and fruiting among the five tested tomato genotypes. However, the highest number of fruits per plant was recorded by genotype NGB00696, these same genotypes recorded the highest leaves count from weeks 6-12 after planting. It indicates the positive correlation between leaf number and fruit-bearing. It suggested that more leaves per plant favor the photosynthetic actions that resulted in more fruit formation. The fruit number per plant did not show significance among the genotypes. However, the fruit weight per plant exhibited significant differences among tomato genotypes, with genotype NGB00696 recording the highest fruit weight.It indicates variation in the sizes of with the application of nutrients types and genotypes. It also revealed the presence of gene pools in the tomato genotypes that can be manipulated for the development of high-yielding tomatoes in the tested tomato genotypes.

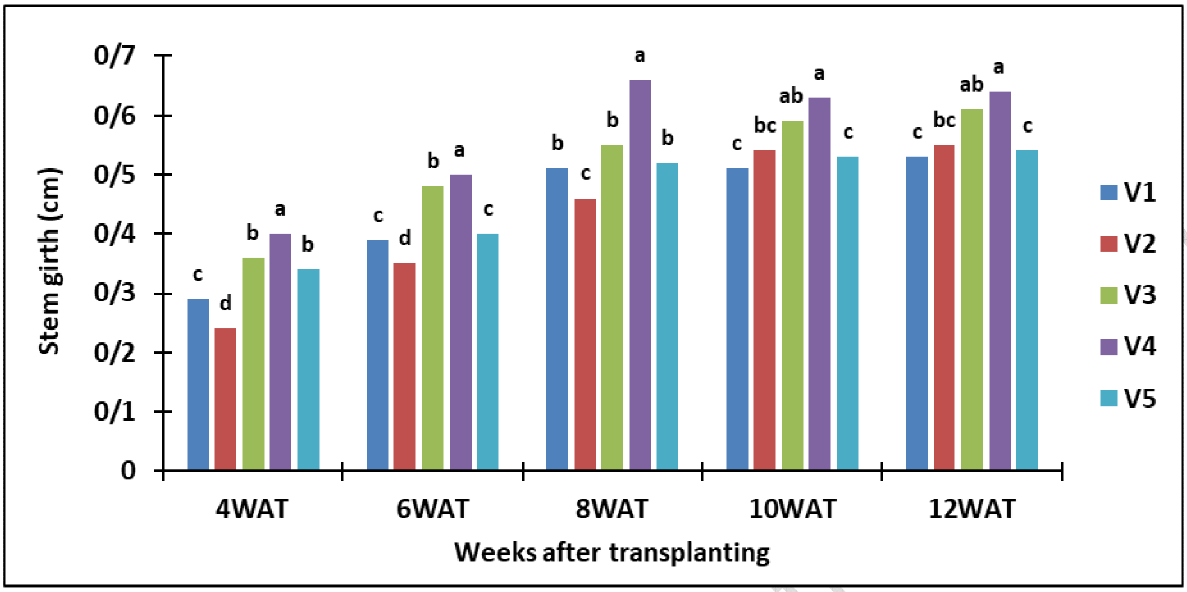

Fig 5. Stem girth 4 WAT to 12 WAT among the five genotypes tested**.**

Stem girth 4 WAT to 12 WAT among the five genotypes tested

V1: NGB00696 **V2:** NGB00711 **V3:** NGB00713

V4: NGB00694 **V5:** NGB00725

Bars with different letters are significantly different ($p < 0.050$)

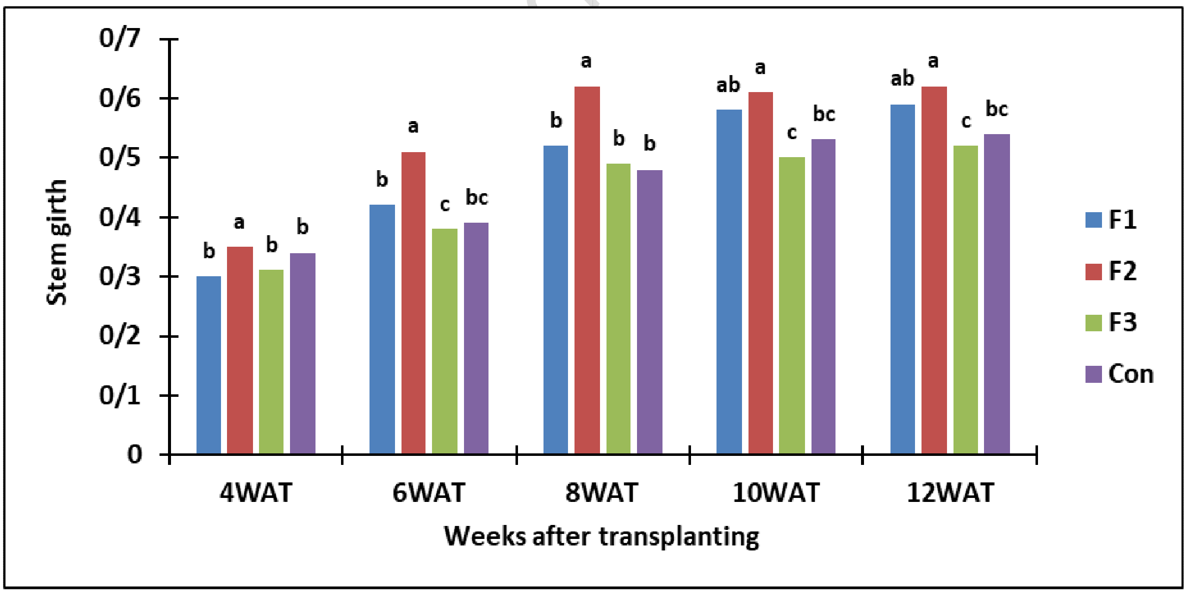

Fig 6. F1: Fertilizer effects on stem girth 4 WAT to 12 WAT among the five genotypes tested

6.5g of CP+PM; F2: 6.4g of KP+PM; F3: 5g of NPK.

Con = control

Bars with different letters are significantly different ($p < 0.050$)

It also revealed the presence of gene pools in the tomato genotypes that can be manipulated for the development of high-yielding tomatoes in the tested tomato genotypes. Effects of the application of combinations CP + PM and KP + PM on days to flowering and fruiting were significantly different, which indicates that sources of organic amendments can hasten or delay the day to flowering in tomato production. The highest days to flowering were recorded by a combination of CP + PM, while the lowest days to flowering were observed when KP + PM was applied. This study showed that the application of KP + PM favored early flowering, probably because this combination is less in nitrogen (N) content compared with CP + PM with a higher level of (N) (Table 2) that encouraged vegetative growth that may delay flowering time. The combination CP + PM resulted in the highest fruit number and weight per plant, highlighting its favorable effects on tomato growth and yield compared to other nutrient sources, both organic and inorganic.Least fruit number and weight were observed with the application of KP + PM compare to other nutrients applied. Genotype effects on days to flowering and fruiting were numerically but non-significant different. Genotype x fertilization interaction effects were significant for days to flowering and fruiting, and the weight of fruit per plant. This indicates that genotypes exhibited distinct responses to fertilizer sources in terms of days to flowering, fruiting, and fruit weight per plant. Genotype x fertilization interaction effects were significant for fruit weight per plant, suggest the differential influence of nutrient sources on fruit weight per plant.

Table 4. Genotypes and fertilizer sources effects on the yield traits of tomato.

Varieties	DTFL (days)	DTFR (days)	NOF (no)	WOF (g/plant)
NGB00696	19.60ab	35.05	12.50a	2534a
NGB00711	20.33a	39.11a	10,00a	839c
NGB00713	17.11c	33.61c	10.44a	1911bc
NGB00694	18.19bc	30.44d	10.50a	1639b
NGB00725	19.87ab	34.13bc	10.00a	2425a
Fertilizer				
6.5g/plant of CP+PM	19.96a	35.75b	10.55a	2982a
6.4g/plant of KP+PM	19.27ab	37.55a	10.7a	1567b
0.5g/plant of NPK	19.56a	35.00b	11.9a	1832ab
Control	17.82b	30.68c	9.98a	1426b
Variety (V)	*	*	Ns	*
Fertilizer (F)	*	*	Ns	*
V x F	*	*	Ns	*

Means with the same letter(s) in a column are not significantly different at $p<0.05$.

WAT = weeks after planting, DTFL= days to flowering, DTFR = days to fruiting, NOF= number of fruits, WOF= weight of fruits.

Variations were observed in the effects of genotype and types of fertilizer on the levels of Ca, Mg, K, and Vitamin C constituents in tomato fruits. (Table 5). Application of 6.5 g of KP + PM to genotype NGB00711 recorded the highest values of Ca and Mg (2.25, 2.4 respectively). However, the addition of 6.5 g of CP + PM recorded the highest value of vitamin C compared to other genotypes and types of fertilizer. Moreover, the application of 6.5 g of CP + PM to NGB00694 gave the highest value of K among other types of fertilizer and genotypes. In most cases, the addition of fertilizer to the five tested genotypes numerically increases the four nutrients investigated in the study compared with the control. This study revealed that tomato nutrient composition varies with varieties and plant nutrient sources. It also indicated that levels of each nutrient component of tomato fruits are influenced by the types/sources of plant nutrients applied.

Continuous variation in tomato stem girth values in response to different fertilizer types indicates that various fertilizers or manure sources affect plant growth differently. The mineral and microbial analysis in this study revealed higher values.of N, P, and K in combination with KP + PM than CP + PM. Both types of manure combinations tested performed better than NPK fertilizer for vegetative growth. These also support the findings of Oyedeji (2014), who found that the application of organic manure to plants generally results in an increase in vegetative growth and that poultry manure ranks best among the manures due to its high concentration of N, P, and K as well as other micronutrients, which when decomposed add nutrients to the soil and improve growth and yield. Effects of fertilizer types on genotypes were significant for flowering and fruiting.

Table 5. Effect of genotype, fertilizer types on the nutrient constituents of tomato.

Varieties	Fertilizers	Ca (cmol·kg)	Mg (cmol·kg)	K (cmol·kg)	Vit. C
NGB00696	6.5g/plant of CP+PM	1.2	2.3	0.1	1.84
NGB00696	6.5g/plant of KP+PM	0.9	0.75	0.09	2.07
NGB00696	0.5g/plant of NPK	1.6	0.8	0.07	1.82
NGB00696	Control	0.75	0.65	0.06	1.53
NGB00711	6.5g/plant of CP+PM	1.5	1.55	0.08	2.51
NGB00711	6.5g/plant of KP+PM	2.25	2.4	0.08	1.89
NGB00711	0.5g/plant of NPK	1.5	0.65	0.12	1.73
NGB00711	Control	0.5	0.5	0.08	2.40
NGB00713	6.5g/plant of CP+PM	1.0	0.9	0.1	1.90
NGB0713	6.5g/plant of KP+PM	0.75	1.2	0.09	2.23
NGB00713	0.5g/plant of NPK	0.75	1.25	0.07	2.28
NGB00713	Control	0.75	1.25	0.06	2.32
NGB00694	6.5g/plant of CP+PM	0.4	0.6	0.27	1.70
NGB00694	6.5g/plant of KP+PM	1.0	0.55	0.07	1.93
NGB00694	0.5g/plant of NPK	1.15	1.15	0.1	2.10
NGB00694	Control	0.9	1.7	0.07	2.27
NGB00725	6.5g/plant of CP+PM	1.5	0.65	0.17	1.95
NGB00725	6.5g/plant of KP+PM	1.2	0.7	0.07	2.03
NGB00725	0.5g/plant of NPK	1.25	0.8	0.08	1.89
NGB00725	Control	1.55	0.6	0.14	1.89

Days to flowering and fruiting were influenced by both fertilizer types and genotypes. CP + PM was found to delay flowering, while KP + PM hastened the initiation of flowering. The interaction effect of genotype x fertilizer was highly significant for days to flowering and days to fruiting, but only showed numerical and non-significant effects for fruit number and weight per plant.Both genotypes and fertilizer types highly influenced the values of nutrients or minerals such as Ca, Mg, K, and Vit C in the tested tomato fruits. Application of KP + PM on genotype NGB00711 increased the values of Ca, Mg, and Vit C in tomato fruits, while application of CP + PM to NGB00694 gave the highest value of K compared to other genotypes and fertilizer types. A similar study reported that wheat grains planted with organic fertilizers have higher protein levels than wheat grains grown with chemical fertilizers (Bahrman et al. 2004; Shivay et al. 2010).

Activities of soil microbes were higher with the application KP + PM than CP + PM, however, both types of organic manure supported the activities of soil microbes compared to inorganic fertilizer. According to Abbas et al. (2012) and Meagy et al. (2016), organic manures increase the amount of organic matter in the soil, enhancing its fertility, microbial activity, water penetration, and moisture-holding ability.

Tomato has been reported to perform relatively well under organic and inorganic manure. Ghosh et al.2004 reported that mineral fertilizer alone resulted in the lowest fruit production of tomatoes, while higher fruit yield was obtained by the addition of chicken manure alone.

Conclusion

The experiment results demonstrated that supplementing cocoa pods with chicken dung significantly improved vegetative and yield parameters. Additionally, NGB00696, NGB00711, and NGB00694 exhibited higher numbers of leaves, plant height, and stem girth, respectively.The study revealed that applying 6.5g of cocoa pod + poultry manure per plant resulted in the highest yield, and NGB00696 demonstrated the highest yield in terms of fruit weight. This suggests that cocoa pod + poultry manure contains higher nutrient amounts compared to other plant nutrient sources.Both genotypes and fertilizer types highly influenced the values of nutrients or minerals such as Ca, Mg, K, and Vit C in the tested tomato fruits. Application of KP + PM on genotype NGB00711 increased the values of Ca, Mg, and Vit C in tomato fruits, while application of CP + PM to NGB00694 gave the highest value of K compared to other genotypes and fertilizer types.

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