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Influence of Rate and Time of Poultry Manure Application on Yield and Yield Components of Tomato Varieties in the Semi-Arid Environment of Nigeria

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Abstract
A Field trial was carried out in the Nigerian savanna at the Federal University Dutsin-Ma, Teaching and Research Farm, Badole, and Danja. The trial was conducted in the dry season of 2019/2020 to assess the influence of applying poultry manure at different rates and times on tomato varieties' yield and yield components. The treatments consisted of two tomato varieties (UTC GRAPTOR and SUDANA), four poultry manure application rates (0, 5, 10, and 15 t ha^{-1}), and three poultry manure application times (two weeks before transplanting, at transplanting, and two weeks after transplanting). The experiment was laid out using randomized complete block design (RCBD) with three replications. UTC GRAPTOR (13500 Kg ha-^{1}) gave a significantly higher fruit yield than SUDANA (12480 Kg ha-^{1}) at Badole only. Application of 15 t poultry manure ha^{-1} performed significantly ($P<0.05$) higher than other poultry manure rates on tomato yield components. Application of 15t ha^{-1} poultry manure produced significantly ($P<0.05$) higher tomato fruit yield, 13500 and 13440 Kg ha^{-1}, for Badole and Danja, respectively, than what was obtained with application of either 0, 5, or 10t ha^{-1} poultry manure. Poultry manure application at two weeks before transplanting gave significantly ($P<0.05$) higher tomato fruit yield and yield components except fruit diameter. Hence, applying of 15t poultry manure ha^{-1} to soil grown with UTC GRAPTOR tomato variety at two weeks before transplanting is the most appropriate for production of tomato in the study areas.
Keywords: Poultry manure, variety, time of application, tomato, and savanna

Introduction

Soil infertility has remained a major limiting factor militating against production of crop in Nigeria, especially tomato (*Solanum lycopersicum* L.) production. A large percentage (70%) of Nigerian soils contains low-activity clay soils, which, on a continuous level, cannot naturally quarantine crop production (Ogunkunle, 2009). The low fruit yield of tomato has been attributed, among other factors, to soil fertility depletion, soil acidity, and imbalance in soil nutrients from inorganic fertilizer continual usage (Obi and Akinsola, 1995). The home of tomato production in Nigeria is the savanna region. However, the savanna soils of Nigeria are low in total nitrogen, organic carbon, available phosphorus, exchangeable cations, and effective CEC, together with clay and silt contents (Singh, 1987).

Similarly, the depletion in soil fertility triggered by continuous cropping with the absence of concerted efforts in nutrient supplies, particularly organic fertilizer, regularly leads to poor soil fertility and productivity and, consequently, poor crop yield (Adesoji *et al*., 2019). Thus, adding soil fertility improvers as organic or inorganic fertilizers for increased tomato yield becomes pertinent. Arisha and Bardisi (1999) reported that over-reliance on expensive inorganic fertilizers may cause adverse environmental challenges like water pollution and an increase in greenhouse gas production, triggering global climate change. Soil fertility changes caused by an imbalance in fertilizer use and persistent use of high-analysis fertilizers with the absence of the use of organic manure induce challenges like declining organic matter and mining of soil nutrients, especially those that were not added in adequate amounts (Venugopal *et al*., 2015). The use of chemical fertilizers to mitigate the problems of poor soil fertility for increased crop production in the Savanna zone of Nigeria is restricted by exorbitant prices and undependable availability of chemical fertilizers; even the few farmers who make use of these fertilizers find it so difficult to have enough funds to care of the recommended rates (Loks *et al*., 2016). Confessedly, the quick response of nutrient-deficient soils to judicious application of mineral fertilizers is well recognized by farmers. However, the deleterious effects on the soil afterward make seeking alternatives like poultry manure necessary.

Poultry manure is a popular producer of organic manure. Delate and Camberdella (2004) reported that organic manures are cheap and could be used as a substitute for mineral fertilizers. Organic manures can mollify the harmful effects of chemical fertilizers, enhance soil health, and rejuvenate the environment for increased profitable and sustainable crop production (Adesoji, 2015). Adding organic manures has been reported to facilitate long-term cropping because of their slow mineralization capacity that enhances crop yield for an extended period of time (Gambo *et al*., 2008). Time is one of the chief factors determining the release and availability of nutrients from the added organic materials in the soil. Most farmers need to be aware that the correct timing matters a lot in the availability of nutrients from the added organic manures. Some add these materials without knowing that they need time to decompose and mineralize. Barak and Raban (2007) affirmed that well-organized fertilization schedules should target synchronizing plant nutrient supply with precise time and composition to meet plant growth needs at an exact location to facilitate efficiency of uptake and with precise dosage to curtail wastage and contamination. Application time of organic manure is a very significant issue in crop production because it enhances the effective use of the manure by matching mineralized nutrient supply with the crop demand for increased crop growth and yield (Lukman and Adesoji, 2021). Concerning the challenges mentioned above facing production of tomato, the experiment was carried out to assess the influence of the rate and time of poultry manure application on the yield and yield components of tomato varieties in the savanna zone of Nigeria.

Materials and Methods

Field experiments were conducted at two locations in Katsina State: Danja, Northern Guinea savanna (located at 475 meters above sea level) and the Teaching and Research Farm of the Federal University Dutsin-Ma, Badole, Sudan savanna (located at 110 58' N, 80 26' E, and 475 meters above sea level). The two experiments were carried out during the dry season of 2019/2020. The Badole site had sandy loam soil, while Danja site had clay loam soil based on the soil analysis of the experimental sites. The treatments consisted of two tomato varieties (UTC GRAPTO and SUDANA), four rates of poultry manure (0, 5, 10, and 15t ha^{-1}) and three different times of poultry manure application (two weeks before transplanting, at transplanting, and two weeks after transplanting). The experiment was laid out using a randomized complete block design (RCBD) and had factorial combinations of varieties, poultry manure levels and times of application. The experiment had three replications. The gross plot and net plot were $6m^2$ and $3m^2$, respectively. The UTC GRAPTOR and SUDANA tomato varieties were planted and transplanted after four weeks into already prepared plots. The experimental sites were ploughed and harrowed to give a fine tilth and made into raised beds of 2m x 3m size, constructed with hoe in basins for irrigation. The application of poultry manure rates was done at various times. The poultry manure was broadcast and incorporated thoroughly into the soil. The seedlings were raised in the nursery for four weeks before transplanting to the field. Two seedlings were transplanted per stand at 50cm x 50cm and thinned to one seedling per stand after two weeks of transplanting. The weeding was done manually at 3 and 6 weeks after transplanting (WAT). Pests and diseases were controlled by applying a 500 ml ha^{-1} dose of Cypermethrin and Dimethoate (Perfection) and 2.27 kg/ha of TEXAPHENE to the plant and the soil surrounding the basins to prevent cutworms. The observations collected and recorded in the study include the number of fruits per plant, number of fruits per hectare (kg ha^{-1}), number of seeds per fruit, fruit diameter (cm), fruit weight per plant (g), and fruits yield per hectare (kg ha^{-1}). Analysis of variance (ANOVA), as reported by Gomez and Gomez (1984), employing SAS package (9.0) of statistical analysis (SAS, 2002). Duncan's Multiple Range Test was employed to separate the differences between significant treatment means (Duncan, 1955). The treatment means were found significant at 5% level of probability.

Results

Physico-chemical Properties of the Soil of the Experimental Sites and Chemical Properties of the Poultry Manure

Table 1 shows the physical and chemical characteristics of the experimental sites at Badole and Danja during the 2019/2020 dry season. The textural class of soils of the experimental sites was sandy loam and clay loam for Badole and Danja, respectively. The soil was basic, with pH 8.0-8.2. The experimental site soils contained low content of the following: organic carbon, total nitrogen, available phosphorus, and potassium. The cation exchange capacity of the sites was equally low. The full details are shown in Table 1. The table 1 equally shows the chemical analysed results of the poultry manure used in carrying out the experiment.

Number of fruits per plant

The effects of variety, time, and rates of poultry manure application on the number of fruits per plant in both locations are presented in Table 2. The number of fruits per plant was significantly ($P<0.05$) affected by variety at the two locations where UTC GRAPTO produced significantly ($P<0.05$) more tomato fruits per plant than SUDANA. Poultry manure rates recorded a significant ($P<0.05$) influence on the number of fruits per plant at the two locations. Application of each rate of poultry manure significantly ($P<0.05$) increased the number of fruits per plant up to the highest rate of 15 t ha^{-1} than the zero poultry manure plots at both locations. Application of poultry manure at two weeks before transplanting significantly ($P<0.05$) produced a higher number of fruits per plant than at other times of application at both locations.

Number of fruits per hectare

The effects of variety, time, and rates of application of poultry manure were significant ($P<0.05$) on number of fruits per hectare in both locations (Table 2). The number of fruits per hectare was significantly ($P<0.05$) influenced by variety at the two locations where UTC

GRAPTO produced significantly higher tomato fruits per hectare than SUDANA. Poultry manure rates recorded a significant ($P<0.05$) effect on the number of fruits per hectare at the two locations. Increasing the application of poultry manure from 0 kg ha^{-1} up to 15 t ha^{-1} significantly ($P<0.05$) increased the number of fruits per hectare at both locations. Application of poultry manure at two weeks before transplanting significantly ($P<0.05$) produced a higher number of fruits per hectare than at other times of application at both locations (Table 2). The significant interaction between the time of application of poultry manure and poultry manure rate on the number of fruits per hectare at Badole is presented in Table 3. Application of 15t ha^{-1} of poultry manure at two weeks before transplanting produced the highest number of fruits per hectare but was not significantly different from the application of 15t poultry manure ha^{-1} at the time of transplanting and at two weeks after transplanting. The lowest number of fruits per hectare was obtained when no poultry manure was applied at any of the times of poultry manure application.

Number of seeds per fruit

Effects of variety and poultry manure rate on the number of seeds per fruit of two tomato varieties during the 2019/2020 dry season at Badole and Danja are presented in Table 4. Variety was not significant ($P>0.05$) on the number of seeds per fruit at Danja. However, it was significant ($P<0.05$) at Badole, where UTC GRAPTO significantly ($P<0.05$) produced a higher number of seeds per fruit than SUDANA (Table 4). Increasing poultry manure application rates up to 15 t ha^{-1} significantly increased the number of seeds per fruit at both locations (Table 4). The time of poultry manure application showed no significant ($P>0.05$) difference in number of seeds per fruit at both locations. The interactions were not significant.

Fruit diameter (cm)

The effects of variety, rate, and time of poultry manure were significant ($P<0.05$) on fruit diameter (cm) of two tomato varieties during the 2019/2020 dry season at Badole and Danja (Table 4). The varietal effect was significant ($P<0.05$) at both locations where SUDANA significantly produced higher fruit diameter than UTC GRAPTO. The time of poultry manure was significant ($P<0.05$), where the application of poultry manure at two weeks before transplanting produced significantly higher fruit diameter than the application of poultry manure at transplanting and two weeks after transplanting (Table 4). Poultry manure application at 15t ha^{-1} significantly produced higher fruit diameter than other rates of poultry manure but at par with 10 t ha^{-1} of poultry manure at Badole (Table 4). The interaction between the time of poultry manure application and poultry manure rate was significant ($P<0.05$) on fruit diameter at Danja (Table 5), where application of 15t poultry manure ha^{-1} at any of the times of application gave the largest fruit diameter of tomato while no poultry manure plots at any of the times of application gave the smallest fruit diameter of tomato. Other interactions were not significant.

Fruit weight per plant (g)

The effects of variety, time, and rates of poultry manure application on fruit weight per plant are presented in Table 6. Variety significantly influenced fruit weight per plant at Badole only, where UTC GRAPTO significantly ($P<0.05$) produced higher fruit weight per plant than SUDANA. Increasing application of poultry manure from 0 kg ha^{-1} up to 15 t ha^{-1} significantly ($P<0.05$) increased fruit weight per plant at both locations. Poultry manure application at two weeks before transplanting gave significantly ($P<0.05$) higher fruit weight per plant than other application times at both locations. The interactions were not significant.

Fruit yield per hectare (kg ha^{-1})

The effect of variety, time, and rates of applying poultry manure were significant ($P<0.05$) on fruit yield per hectare (Table 6). Variety significantly ($P<0.05$) influenced fruit yield per hectare at Badole only, where UTC GRAPTO significantly ($P<0.05$) produced higher fruit yield per hectare than SUDANA. Poultry manure application significantly ($P<0.05$) influenced tomato fruit yield, where the application of 15t ha^{-1} poultry manure gave the highest value of fruit yield of tomato. In contrast, the lowest value was obtained from plots without poultry manure. Application of 5, 10, and 15t poultry manure ha^{-1} produced 81.3, 228.9 and 301.8% increases in tomato fruit yield per hectare in Badole and 55, 192.8, and 273.3% increases in tomato fruit yield per hectare in Danja, respectively, when compared with zero poultry manure application. Poultry manure application at two weeks before transplanting gave significantly ($P<0.05$) higher fruit yield per hectare than other application times at both locations, and increasing application rate of poultry manure significantly ($P<0.05$) increased fruit yield per hectare at both locations (Table 6). The interaction between time of poultry manure application and poultry manure rates was significant ($P<0.05$) on fruit yield per hectare at Badole (Table 7). The application of 15 t poultry manure ha^{-1} at any time of application produced the highest fruit yield per hectare, but the application of 15t ha^{-1} poultry manure two weeks before transplanting the tomato performed better than other transplanting times (Table 7). However, no poultry manure plots at any time of application gave the smallest fruit yield per hectare of tomato. Other interactions were not significant.

Discussion

Soil of the Experimental Soil

The soils of the experimental sites were low in organic carbon, total nitrogen, available phosphorus, potassium, and CEC. This confirms the reports that the soils of the savanna zone are low in the above nutrients. This equally affirms the report of Adesoji *et al*. (2018) that worthwhile crop production can only be achieved in savanna soils by implementing soil fertility strategies of improving fertility status by adding organic or inorganic fertilizers. This would suggest that getting the highest yield was challenging when cropping the soil without adding fertilizer or soil amendment. For plant growth, development, and yield formation, these three major nutrients; N, P, and K are necessary. It is reasonable to anticipate that applying poultry manure would improve the soil's fertility status. Organic fertilizers, like poultry manure, are great substitutes for mineral fertilizers because of their high organic matter content, which enhances soil quality, improves soil microbial population, releases nutrients of soil gradually, and keeps the soil safe and healthy (Adesoji, 2015).

Varietal Response of Tomato

It is possible to attribute the significant varietal response to yield and yield parameters, such as the number of fruits per plant and per hectare, the number of seeds per fruit, the fruit diameter and weight of the fruits per plant, to genetic variations within each variety as well as environmental factors like moisture, nutrients, sunshine, crop competition, and soil condition. This finding aligns with the research conducted by Olaniyi (2007), which proposed that yield variations among tomato varieties could be explained by differences in their ecological distribution. Due to genetic differences between the two cultivars, UTC GRAPTOR outperformed SUDANA as demonstrated in their differences in the number of fruits per plant, number of seeds per plant, fruit weight per plant, and fruit yield per hectare. Nevertheless, Isah *et al.* (2014) found that the genotype potential, the availability of resources on time, and the increase in growth and yield productivity affected the productivity of tomato at a given location. These factors can only be met when tomato are grown using improved varieties and agro-techniques. The notable variation in fruit yield per hectare where UTC GRAPTO outperformed SUDANA might have resulted from UTC GRAPTO significantly better performance than SUDANA on yield parameters, which could have cumulatively led to a higher fruit yield overall on UTC GRAPTO than SUDANA. This corroborates the findings of Agyenma *et al.* (2014), who claimed that increasing tomato productivity requires breeding tomato varieties with high yields and disease resistance. According to Algeri *et al.* (2021), several factors including crop variety, affect how plants react when manure is applied. Additionally, it was reported that hybrid tomato varieties were advised because they yielded larger, more aesthetically pleasing fruits that could be easily sold.

Response of Tomato to Rate of Poultry Manure

The significant increases observed after the application of poultry manure on the number of fruits per plant, number of fruits per hectare, number of seeds per fruit, fruit diameter, fruit weight per plant, and fruit yield per hectare could be attributed to the contributions of organic matter generated from the added poultry manure which might have enhanced the soil physical, chemical, and biological properties, hence increased growth and subsequently increased fruit yield. This finding supports the observations of Oyewole *et al.* (2011), who found that organic manures are good sources of major nutrients such as calcium, phosphorus, potassium, and nitrogen that boost crop yield. This could be explained by the poultry manure capacity to increase the soil organic matter and liberate mineralized soil nutrients essential for plant growth and development. This marked increases noticed in tomato yield parameters due to the poultry manure application could also be ascribed to the roles of organic manure in causing soil to retain more water and increasing the drainage and organic acids that help to dissolve soil nutrients and then cause them to be available for the use of crops (Deskissa *et al*., 2008). The finding from this study revealed that the application 15t poultry manure ha^{-1} substantially produced the highest yield and yield parameters; this could be that the rate was adequate for maximum production of fruit yield of tomato. This result corroborates the findings of Isah and Adesoji (2019), who discovered that the poultry manure application at 15 t ha^{-1} resulted in a significant increase in number of fruits per hectare and fruit yield per hectare of tomato. Similarly, in research done in the southwest Nigerian rainforest, Akanni and Ojeniyi (2007) suggested using 15-20 t ha^{-1} of poultry manure for tomato cultivation for increased growth and yield. The significant increase noticed in tomato fruit yield could also be attributed to the significant increases noted in number of fruits per plant, number of fruits per hectare, number of seeds per fruit, fruit diameter, and fruit weight per plant, which cumulatively led to the increase observed on the fruit yield. Adesida *et al*. (2020) affirmed that organic manure is crucial for the healthy growth of plants because it contains specific nutrients that promote faster and higher-quality growth.

Response of Tomato to Time of Poultry Application

Significant increases observed in number of fruits per plant, number of fruits per hectare, number of seeds, fruit weight per plant, and fruit yield per hectare of tomato as affected by time of poultry application could be because time is a prime factor necessary for decomposition of the applied poultry manure and its consequent mineralization for the release of embedded nutrients in the poultry manure. It has been established that synchronizing the time of fertilizer application with the period of active nutrient absorption by plants is severe and vital in nutrient management (Ntia *et al.*, 2017). Higher performance displayed by the number of fruits per plant, number of fruits per hectare, number of seeds, fruit weight per plant, and fruit yield per hectare of tomato as a result of applying poultry manure at two weeks before transplanting could be that the two weeks were enough for the poultry manure to decompose, mineralize and release to the soil the embedded nutrients for the use of the tomato, hence the increases observed in the parameters. Ekeoma and Adesoji (2018), working on cucumber, reported that the better performance observed on the measured parameters after applying poultry manure two weeks before planting could be that the time was sufficient to cure the manure and speed up the process of decomposition and consequently, manure mineralization. Ndukwe *et al.* (2011) found that applying poultry manure sooner guaranteed no or less nutrient losses than applying it later, after times of crop demand, which ultimately leads to resource waste. The marked increase in tomato fruit yield could be because the mineralized nutrients from the manure were available to tomato plants at the appropriate time. Similarly, Ntia *et al*. (2017) reported that manure application must be synchronized with the crop nutrient needs because it causes us to appropriate the economic and fertilizing advantages of organic manures. Similarly, Kolawole (2014) revealed that applying poultry manure two weeks before planting increased crop yield and nutrient uptake compared to applying it at planting and two weeks afterward. According to reports by Abdulmaliq *et al.* (2015) and Adeyemo *et al*. (2019), crop yield increased when poultry manure was added at two weeks before planting. This could be due to the poultry manure ability to decompose quickly, making nutrients available for crop yield at a critical time.

Interaction

The significant interaction between poultry manure rate and time of poultry manure application on the number of fruits per hectare at Badole, fruit diameter at Danja, and fruit yield per hectare at Badole could be that the addition of 15t poultry manure ha^{-1} at two weeks before transplanting enabled the poultry manure to have reasonable time to decompose, mineralize and release the mineralized nutrients to match the demands of these nutrients on these parameters. Hence, the interaction gave the highest values of the parameters.

Conclusion

This study has shown that UTC GRAPTOR tomato variety performed better than SUDANA variety; therefore, UTC GRAPTOR variety is the better variety in the study areas. Application of poultry manure significantly influenced tomato yield and yield components, where applying 15t ha^{-1} poultry manure was established to give the best performance among the poultry manure rates and is the most suitable rate for tomato production in the study areas. The poultry manure application at two weeks before transplanting was the most appropriate time, hence, this resulted in the highest tomato yield and yield component values at both experiment locations.

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Table 1: Physical and Chemical properties of soil of the experimental sites and chemical properties of the poultry manure used

Soil Characteristics	**Soil depth (0-30cm)**		**Poultry Dropping**
Experimental Sites	Badole	Danja	
Particle Size Distribution (%)			
Sand (%)	74	62	-
Silt (%)	14	21	-
Clay (%)	12	17	-
Textural Class	Sandy loam	Clay loam	-
Chemical Composition			
pH in H_2O (1:2.5)	8.0	8.2	5.6
Organic Carbon (g kg^{-1})	2.0	1.90	2.39
Total Nitrogen (g kg^{-1})	1.05	0.92	1.65
Available Phosphorous (g kg^{-1})	19.38	19.26	23.29
Exchangeable Bases (Cmol kg^{-1})			
Calcium (Ca)	6.2	5.8	0.86
Magnesium (Mg)	0.77	0.81	1.95
Potassium (K)	0.5	0.30	2.45
Sodium (Na)	0.22	0.27	0.17
CEC (Cmol kg^{-1})	8.69	8.24	

Analysis was done at the analytical laboratory of the Soil Science Department, Ahmadu Bello University, Zaria, Nigeria

Table 2: Effects of rate and time of poultry manure application on number of fruits per plant and number of fruits per hectare of two tomato varieties at Badole and Danja during the 2019/ /2020 dry season

	No. of fruits/plant		**Number of fruits/ha**	
	Badole	**Danja**	**Badole**	**Danja**
Treatment				
Variety (V)				
UTC GRAPTO	15^{a}	13^{a}	450000^{a}	390000^{a}
SUDANA	13^{b}	12^{b}	390000^{b}	360000^{b}
SE±	0.55	0.31	462.30	392.22
Poultry Manure (P) t ha^{-1}				
0	4^{d}	4^{d}	120000^{d}	120000^{d}
5	7^{c}	6^{c}	210000^{c}	180000^{c}
10	13^{b}	12^{b}	368329^{b}	339996^{b}
15	15^{a}	14^{a}	450000^{a}	450000^{a}
SE±	1.92	1.53	958.90	1038.22
Time of Poultry Manure Application (T)				
Two weeks before transplanting	15^{a}	14^{a}	450000^{a}	420000^{a}
At transplanting	13^{b}	12^{b}	390000^{b}	360000^{b}
Two weeks after transplanting	11^{c}	10^{c}	330000^{c}	330000^{c}
SE±	0.56	0.55	986.88	730.21
Interaction				
VxP	NS	NS	NS	NS
VxT	NS	NS	NS	NS
PxT	NS	NS	*	NS
VxPxT	NS	NS	NS	NS

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT. * = Significance at 5% level of probability; NS= Not Significant

Table 3: Interaction between poultry manure rate and time of poultry manure application on number of fruits per hectare at Badole during the 2019/200 dry season

	Time of poultry manure application		
Treatments	**Two weeks before transplanting**	**At transplanting**	**Two weeks after transplanting**
Poultry manure (t ha^{-1})			
0	142500^{d}	127500^{d}	112500^{d}
5	165000^{c}	150000^{c}	135000^{c}
10	204582^{b}	189582^{b}	174582^{b}
15	225000^{a}	210000^{a}	195000^{a}
SE+		479.45	

Mean followed by the same superscript(s) within the same treatment are not significantly different at 5% level of probability using DMRT

Table 4: Effects of rate and time of poultry manure application on number of seeds per fruit and fruit diameter of two tomato varieties at Badole and Danja during the 2019/2020 dry season

	No. of seeds/fruit		Fruit diameter(cm)	
	Badole	**Danja**	**Badole**	**Danja**
Treatment				
Variety (V)				
UTC GRAPTO	62.7^{a}	54.8	4.1^{b}	3.7^{b}
SUDANA	59.8^{b}	56.4	4.9^{a}	4.6^{a}
SE±	0.47	2.11	0.16	0.25
Poultry Manure (P) t ha^{-1}				
0	36.2^{d}	33.7^{d}	3.1^{c}	3.0^{d}
5	47.8^{c}	56.6^{c}	4.2^{b}	3.6^{c}
10	79.1b	62.5^{b}	5.0^{a}	3.8^{b}
15	92.2^{a}	96.8^{a}	5.8^{a}	5.1^{a}
SE±	3.43	3.17	0.23	0.35
Time of Poultry Manure Application (T)				
Two weeks before transplanting	66.1	67.2	4.9^{a}	4.6^{a}
At transplanting	64.3	63.4	4.2^{b}	3.8^{b}
Two weeks after transplanting	261.1	57.6	3.4^{c}	3.1^{c}
SE±	2.97	2.76	0.20	0.30
Interaction				
VxP	NS	NS	NS	NS
VxT	NS	NS	NS	NS
PxT	NS	NS	NS	*
VxPxT	NS	NS	NS	NS

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT. * = Significance at 5% level of probability; NS= Not Significant

Table 5: Interaction between poultry manure rate and time of poultry manure application on fruit diameter at Danja during the 2019/200 dry season

Treatments	Time of poultry manure application		
	Two weeks before transplanting	**At transplanting**	**Two weeks after transplanting**
Poultry manure (t ha^{-1})			
0	1.9^{d}	2.0^{d}	2.0^{d}
5	3.1^{c}	2.6^{c}	2.6^{c}
10	4.0^{b}	3.5^{b}	3.0^{b}
15	4.7^{a}	3.8^{a}	3.4^{a}
SE+		0.04	

Means followed by the same superscript(s) within the same treatment are not significantly different at 5% level of probability using DMRT

Table 6: Effects of rate and time of poultry manure application on fruit weight per plant (g) and fruit yield per hectare (kg ha^{-1}) of two tomato varieties at Badole and Danja during the 2019/2020 dry season

	Fruit weight/plant (g)		Fruit yield (kg ha^{-1})	
	Badole	**Danja**	**Badole**	**Danja**
Treatment				
Variety (V)				
UTC GRAPTO	450^{a}	377	13500^{a}	11310
SUDANA	416^{b}	372	12480^{b}	11160
SE±	7.83	3.20	206	83.2
Poultry Manure (P) t ha^{-1}				
0	112^{d}	120^{d}	3360^{d}	3600^{d}
5	203^{c}	186^{c}	6090^{c}	5580^{c}
10	390^{b}	372^{b}	11050^{b}	10540^{b}
15	450^{a}	448^{a}	13500^{a}	13440^{a}
SE±	56.16	47.6	847.30	830.70
Time of Poultry Manure Application (T)				
Two weeks before transplanting	450^{a}	448^{a}	13500^{a}	13440^{a}
At transplanting	390^{b}	384^{b}	11050^{b}	11520^{b}
Two weeks after transplanting	364^{c}	372^{c}	10313^{b}	9240^{c}
SE±	8.12	3.62	807.33	1221.10
Interaction				
VxP	NS	NS	NS	NS
VxT	NS	NS	NS	NS
PxT	NS	NS	*	NS
VxPxT	NS	NS	NS	NS

Means followed by the same superscript(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT. * = Significance at 5% level of probability; NS= Not Significant

Table 7: Interaction between poultry manure rate and time of poultry manure application on fruit yield (kg ha^{-1}) at Badole during the 2019/200 dry season

Treatments	Time of poultry manure application		
	Two weeks before transplanting	At transplanting	Two weeks after transplanting
Poultry manure ($t\ ha^{-1}$)			
0	8520^{d}	7560^{d}	6420^{d}
5	9510^{c}	8550^{c}	7410^{c}
10	11990^{b}	11030^{b}	98900^{b}
15	13440^{a}	12480^{a}	11340^{a}
SE+		676.41	

Means followed by the same superscript (s) within the same treatment are not significantly different at 5% level of probability using DMRT