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Growth Performance of Tomato Varieties as Influenced by Rates and Time of Poultry Manure Application in the Savanna Zone of Nigeria

*Tama, N. Y., Adesoji, A. G. and Sanusi, J.

Department of Agronomy, Federal University Dutsin-Ma, Katsina State, Nigeria
*Corresponding author's email: nurayusuftama@gmail.com

Abstract
A field experiment was conducted at the Teaching and Research Farm, Federal University Dutsin-Ma, Badole and Danja in the Sudan and Northern Guinea Savanna zones of Nigeria, respectively, to assess the influence of rates and time of poultry manure application on the growth performance of two tomato varieties. The treatments made of factorial combinations of two tomato varieties (UTC GRAPTOR and SUDANA), four rates of poultry manure (0, 5, 10, and 15t ha^{-1}), and three times of poultry manure applications (two weeks before transplanting, at transplanting, and two weeks after transplanting). The design for the experiment was a randomized complete block design (RCBD) and the experiment was replicated three times. The varietal effect was significant ($P<0.05$) on growth parameters measured where UTC GRAPTOR variety produced significantly ($P<0.05$) higher growth performance than SUDANA variety. Application of poultry manure significantly ($P<0.05$) increased growth parameters, such as number of leaves, branches, plant height, stem girth, dry weight, and leaf area index, where application of 15t ha^{-1} of poultry manure produced significantly ($P<0.05$) higher values of the growth parameters than other rates of poultry manure. Time of poultry manure application significantly ($P<0.05$) increased growth parameters measured where applying poultry manure at two weeks before transplanting gave significantly ($P<0.05$) higher values of these measured parameters than other times of poultry manure application. Conclusively, the application of 15t ha^{-1} of poultry manure at two weeks before transplanting on soil grown with UTC GRAPTOR variety of tomato was the most suitable for the study areas.
Keywords: Poultry manure, variety, application times, tomato, and savanna

Introduction

Tomato (*Solanum lycopersicum* L.) is a well-known fruit vegetable in Nigeria. It has gained popularity because of its usefulness in human diets and reputation as a well-established source of minerals and vitamins. Tomato fruits can be eaten raw or processed, such as puree, sauce, ketchup, powder, soup, or paste (Battistuzzi, 2012). Its fruit can add colour and make salads, especially green ones, more attractive (Ano & Agwu, 2005). Medically, tomato contains lycopene, an antioxidant that can reduce the hazard of prostate and other types of cancer and heart-related diseases (Barber and Barber, 2002). Despite the importance of tomatoes in the human diet, it is low in production in Nigeria. The total annual production of tomatoes in 2022 was 186.1 million tonnes with an average yield of 37844 kg ha^{-1} (FAO, 2024). Nigeria produced 3.7 million tonnes with an average yield of 5247 kg ha^{-1}, which gave 1.99% of the world's total output in 2022 (FAO, 2024). Egypt was the highest producer of tomato in Africa, producing 6.3 million tonnes in 2022 with an average yield of 43695 kg ha^{-1} (FAO, 2024). The vast gap between tomato yield per hectare in Nigeria and that of Egypt in 2022, according to FAO (2024), vividly shows the deficient state of tomato production in Nigeria.

Poor soil fertility has been reported as one of the chief factors hindering the production of tomatoes in Africa (Mbah, 2006). Soil infertility has been one of the elements causing the low production of tomato, even in Nigeria. The soils of the savanna zone of Nigeria, where the bulk of tomato in Nigeria is produced, are known to have poor fertility status. Adesoji *et al*. (2018) reported that worthwhile crop production can only be actualized in Nigerian savanna soils if only a strategy for soil fertility improvement through organic or inorganic fertilizer is implemented. For sustainable crop production, organic sources of soil nutrients are most desirable because of their capacity to generate organic matter, which is recognized to increase soil fertility, quality, and health aimed at enhanced crop production. The application time of organic manure plays a vital role in making available the embedded nutrients for proper use in the crop. Most farmers apply organic manures indiscriminately without minding the timing needed for decomposition and mineralization to make the embedded nutrients available for the crop when needed. It has been established that organic manures can be a well-treasured resource for increased crop production when they are correctly applied to soil (Ajari, 2003). In the light of the challenges mentioned above, this trial aimed to assess the growth performance of tomato varieties as affected by the rate and time of poultry manure application.

Materials and Methods

The experiment was performed at the Teaching and Research Farm, Federal University Dutsin-Ma, Badole, Katsina State (11^0 58" N, 80^0 26" E and 475m above sea level) in Sudan Savanna and Danja in Danja Local Government Area of Katsina State (11^0 22' 37.56" N and 7^0 33' 39.49" E and 619m above sea level) in the Northern Guinea Savanna). The experiment was conducted in the 2019/2020 dry season. The soils of the sites of the experiment were sandy loam for Badole and clay loam for Danja. The treatments made up 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, during transplanting, and two weeks after transplanting). The randomized complete block design (RCBD) was the design for the experiment, which had factorial combinations of varieties, poultry manure levels, and times of poultry manure application. The experiment had three replications. The gross size was 2m x 3m (6 m^2), and the net plot was 1.5m x 2m (3m^2). The UTC GRAPTOR and SUDANA tomato varieties were sown and allowed to grow for four weeks on a seedbed before being transplanted into 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 a hoe in basins for irrigation. The application of poultry manure rates was done at various times. The poultry manure was incorporated and thoroughly mixed with soil. The seedlings were 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. Manual weeding was done at 3 and 6 weeks after transplanting (WAT). Pests and diseases were managed 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. Starting from the fourth week after transplanting, the following growth parameters were measured every two weeks from the five randomly tagged plants, and the average was recorded. These parameters include the number of leaves per plant, number of branches per plant, plant height (cm), stem girth (cm), plant dry weight (g) and leaf area index (LAI). Analysis of variance (ANOVA), as defined by Gomez and Gomez (1984), was applied to the data gathered from the observations. Duncan's Multiple Range Test was employed to separate the significant treatment means at 5% level of probability (Duncan, 1955).

Results

Physical and Chemical Properties of the Experimental Site Soils and Chemical Properties of Poultry Manure Used

The soil analysis conducted at the two experimental sites showed that the soil types at Badole and Danja are sandy loam and clay loam, respectively (Table 1). Both sites were low in nitrogen and organic carbon. For Badole and Danja, the corresponding available phosphorus concentrations were 19.38 and 19.26 g kg^{-1}, respectively. The soils of the two locations were slightly basic, with pH of 8.0 and 8.2, respectively. The two locations had cation exchange capacities of 8.69 and 8.24 g kg^{-1} for Badole and Danja, respectively. Table 1 equally displays the results of the analysis conducted on poultry manure used for the experiment showed the following properties: pH (H_2O), 5.6; organic carbon, 2.39 g kg^{-1}; total nitrogen, 1.65 g kg^{-1}; available phosphorus, 23.29 g kg^{-1}; and exchangeable cations (cmol kg^{-1}) of Ca^{2+}, 0.86; Mg^{2+}, 1.95; K^+, 2.45; and Na^+, 0.17.

Number of Leaves per Plant

The two varieties were not significant (P>0.05) at 4 and 6 WAT at Badole and Danja on the number of leaves per plant (Table 2). However, at 8 WAT in both locations, there was a significant difference (P<0.05) in the number of leaves where UTC GRAPTO produced significantly more leaves than the SUDANA variety (Table 2). Application of poultry manure significantly (P<0.05) increased the number of leaves per plant in all the sampling periods in both locations, where the application of 15 t ha^{-1} produced a significantly higher number of leaves than other rates. Zero poultry manure gave the lowest performance on the number of leaves per plant (Table 2). Poultry manure application at two weeks before transplanting produced significantly (P<0.05) greater number of leaves per plant than any other times of poultry manure application in all the sampling periods in both locations (Table 2). There was no significant interaction.

Number of Branches per Plant

The varietal effect was only significant (P<0.05) on number of branches per plant at 6WAT in both locations and at 8WAT in Badole, where UTC GRAPTO produced a significantly higher number of branches per plant than the SUDANA variety (Table 2). Poultry manure application significantly increased the number of branches per plant in all the sampling periods in both locations (Table 2). The application of 15 t ha^{-1} produced a significantly higher number of branches per plant than other rates of poultry manure, and plots without poultry manure gave the lowest values for the number of branches (Table 2). Poultry manure application at two weeks before transplanting produced significantly (P<0.05) higher number of branches per plant than any other times of poultry manure application in all the sampling periods in both locations (Table 2). The interactions were not significant.

Plant Height (cm)

The varietal effect was only significant (P<0.05) on plant height at 6WAT and 8WAT in both locations where UTC GRAPTO produced significantly taller plants than SUDANA variety (Table 3). Poultry manure application significantly increased plant height in sampling periods of both locations (Table 3). Application of 10 t ha^{-1}, though at par with the application of 15 t ha^{-1}, produced significantly (P<0.05) taller plants than other rates of poultry manure except at 8WAT in Badole where the application of 15 t ha^{-1} gave taller plants than other rates of poultry application. However, plots without poultry manure gave the shortest plants (Table 3). Time of poultry manure application was only significant (P<0.05) at 6 and 8WAT in both locations where poultry manure application at two weeks before transplanting produced significantly (P<0.05) taller plants than any other times of poultry manure application (Table 3). The interactions were not significant.

Stem Girth (cm)

The variety effect was only significant (P<0.05) on stem girth at 4WAT at Danja, and 6 and 8WAT at Badole, where SUDANA produced significantly larger stem girth than UTC GRAPTO variety (Table 3). Application of poultry manure significantly increased tomato stem girth at 6 and 8WAT in both locations (Table 3). Application of 15 t ha^{-1} of poultry manure produced significantly (P<0.05) larger stem girth than other rates of poultry manure except at 8WAT in Danja where there was no significant (P>0.05) difference between applying 10 and 15 t ha^{-1} poultry manure on stem girth. However, plots without poultry manure gave the lowest values of stem girth (Table 3). Poultry manure application at two weeks before transplanting produced significantly (P<0.05) larger stem girth than any other times of poultry manure application at 6 and 8WAT in both locations (Table 3). The interactions were not significant.

Plant Dry Weight (g)

The varietal effect was not significant (P>0.05) on plant dry weight in all the sampling periods in both locations (Table 4). Application of poultry manure significantly increased plant dry weight at 6 and 8WAT in both locations (Table 4). Application of 15 t ha^{-1} of poultry manure produced significantly (P<0.05) higher plant dry weight than other rates of poultry manure. However, plots without poultry manure gave the lowest values of plant dry weight (Table 4). Poultry manure application at two weeks before transplanting produced significantly (P<0.05) higher plant dry weight than any other times of poultry manure application at 6 and 8WAT in both locations (Table 4). The interaction between the time of poultry manure application and poultry manure rates was significant (P<0.05) at 8WAS in both locations (Table 5). At Danja, the application of 15t poultry manure ha^{-1} at two weeks before transplanting gave the highest plant dry weight, which was at par with the application of 15t poultry manure ha^{-1} at transplanting or two weeks after transplanting while no poultry manure application at any time of application produced the smallest plant dry weight (Table 5). The same trend was observed at Badole. Other interactions were not significant.

Leaf Area Index (LAI)

The variety effect was only significant (P<0.05) on the leaf area index at 6WAT in both locations and 8WAT at Badole, where SUDANA produced a significantly larger leaf area index than the UTC GRAPTO variety (Table 4). Application of poultry manure significantly increased tomato leaf area index at 6 and 8WAT in both locations (Table 4), where application of 15 t ha^{-1} of poultry manure produced significantly (P<0.05) more extensive leaf area index than other rates of poultry manure. However, plots without poultry manure produced the lowest leaf area index values (Table 4). Poultry manure application at two weeks before transplanting produced significantly (P<0.05) more extensive leaf area index than any other times of poultry manure application at 6 and 8WAT in both locations (Table 4).

Discussion

The soils from the sites of the experiment were low in concentrations of the major nutrient elements, according to the soil analysis results. The soil was sandy loam at Badole and clay loam at Danja. The organic carbon, nitrogen, phosphorus, and potassium contents of the soils of the locations were low. This suggested that getting the maximum yield was challenging when cropping the soil without adding fertilizer or soil amendment. Nitrogen, phosphorus, and potassium are vital plant nutrients needed for growth, development, and yield. Therefore, the application of organic manure, such as poultry manure, could have corrected these low levels of nutrients because the experimental sites received the additions of poultry manure. Poultry manure holds nutrient elements that enhance crop production, increase the physical and chemical properties of soil, improve the moisture holding capacity of soil, and support lateral water movement, increasing irrigation efficiency and reducing the general dryness familiar with sandy soils (Amanullah *et al*., 2010). The significant varietal response on growth parameters like the number of leaves, branches, height, stem girth, dry weight, and leaf area index could be attributed to the genetic composition of each variety and environmental elements like sunlight, moisture, nutrients, and crop competition, as well as soil conditions. This result aligns with the findings of Olaniyi (2007), who suggested that variations in the ecological distribution of tomato varieties could cause varietal differences in growth. Due to genetic differences between the two varieties, UTC GRAPTO outperformed SUDANA regarding leaf area index, plant height, number of leaves, branches, and plant dry weight. This outcome is in line with the research conducted by Isah *et al*. (2014), who found that the genotype's potential determines tomato productivity at a particular location, the timely availability of resources, and the increase in growth and yield productivity that can only be attained when tomatoes are grown using improved varieties and agro techniques. A study by Agyenma *et al.* (2014) revealed that breeding high-yielding and disease-resistant tomato varieties is necessary to boost productivity. Algeri *et al*. (2021) found that tomato varieties with rapid growth exhibit enhanced photosynthesis due to increased absorption of sunlight by their leaves and branches, thereby leading to higher yields.

The marked increases observed in growth components such as the number of leaves, branches, plant height, stem girth, dry weight, and leaf area index in the plots treated with poultry manure could be linked to the significant contributions of poultry manure to generate organic matter which might have improved the physical, chemical and biological properties of soil the that received poultry manure. The increases in tomato growth components have been attributed to the improvements in soil structure, which caused a more favourable water-holding capacity, decreased soil compaction, and added essential elements. Tomatoes are among the crops with the highest nutrient requirements. This result corroborates with the observations made by Oyewole *et al*. (2011), who noted that organic manures are excellent providers of nitrogen, potassium, calcium, and phosphorus nutrient elements critical for crop growth. Applying 15t ha^{-1} of poultry manure significantly recorded the highest growth parameters. This may be explained by the poultry manure's ability to raise the organic matter content of the soil and release mineralized nutrients necessary for plant growth. This result agrees with the findings of Isah and Adesoji (2019), who found that applying organic manure resulted in noticeably more leaves and branches than applying inorganic fertilizer. They attributed this to poultry manure's ability to raise the organic matter content of the soil and subsequently release nutrients in a form that is useful to plants. In a related study, Akanni and Ojeniyi (2007) examined a rainforest region of Nigeria and suggested using 15-20 t ha^{-1} of poultry manure for tomato cultivation. Adesida *et al.* (2020) reported that organic manures are essential for the proper development of plants as they offer rapid growth with superior quality by containing some nutrients that are necessary for the better development of crops. In a similar vein, the significant performance on the number of leaves, number of branches, plant height, stem girth, plant dry weight, and leaf area index at both locations as influenced by time of poultry application could be, as a result, that time is a significant factor in the decomposition and mineralization of the applied poultry manure. Poultry manure was applied two weeks before transplanting; this could have been done to give the manure time to decompose and eventually mineralize, releasing embedded nutrients for plants to absorb. The significant increases in the growth parameters observed when the poultry manure was applied two weeks before planting could have been that the two weeks were enough to decompose the added poultry manure and eventually mineralize it, releasing the embedded nutrients for plants to absorb. Ekeoma and Adesoji (2018) reported that the timing of organic materials' addition to the soil for nutrient improvement affects both the rate of decomposition and the status of their nutrient release. Examples of these materials include chicken manure. This results in notable increases in the number of leaves per plant and the vine length per plant. This might be because adding chicken manure requires time to break down and mineralize. Ndukwe *et al*. (2011) reported that the application of poultry manure earlier also ensured no or fewer nutrient losses than when applied later after periods of crop demand which, in the long run, resulted in the wastage of resources. The significant increases in tomato growth observed in areas where poultry manure was applied two weeks before transplanting might also have resulted from the availability of mineralized nutrients from the manure at the precise moment when tomato plants required them. Similarly, Kolawole's (2014) experiment revealed that applying poultry manure two weeks before planting enhanced crop performance and nutrient uptake compared to applying it at planting and two weeks afterwards.

Conclusion

Based on the findings from the study, the UTC GRAPTO variety of tomatoes was significantly better than the SUDANA variety in most growth parameters measured. Application of 15 t ha^{-1} of poultry manure produced significantly better tomato growth performance than other rates of poultry manure and gave the highest values of the measured growth parameters. Application of poultry manure at two weeks before tomato seedling transplanting gave significantly higher tomato growth responses than other timings and best values of the growth parameters. In short, the application of 15t ha^{-1} of poultry manure two weeks before tomato seedling transplanting on UTC GRAPTO variety of tomato is the most appropriate for the growth of tomatoes in the study areas.

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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 analytical laboratory of Soil Science Department, Ahmadu Bello University, Zaria, Nigeria

Table 2: Effect of time and rates of poultry manure application on number of leaves and branches per plant of two tomato varieties at 4, 6 and 8 WAT at Badole and Danja during the 2019/2020 dry season

	Number of leaves per plant						Number of branches per plant					
	4WAT		6WAT		8WAT		4WAT		6WAT		8WAT	
	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja
Treatment												
Variety (V)												
UTC GRAPTO	9.9	9.4	13.7	13.8	20.2^{a}	19.9^{a}	1.7	2.6	5.5^{a}	4.8^{a}	7.5^{a}	6.9
SUDANA	10.2	8.8	14.2	13.1	17.7^{b}	19.0^{b}	1.8	2.3	4.8^{b}	4.5^{b}	6.2^{b}	6.6
SE±	1.16	1.01	1.39	1.34	0.78	0.25	0.36	0.58	0.21	0.77	0.43	0.94
Poultry Manure (P) t ha^{-1}												
0	8.5^{c}	6.9^{d}	10.0^{d}	8.9^{d}	11.1^{d}	10.9^{d}	1.7^{b}	1.7^{c}	2.2^{c}	2.0^{c}	2.4^{c}	2.1^{d}
5	9.9^{b}	8.3^{c}	13.0^{c}	11.8^{c}	18.1^{c}	14.9^{c}	1.6^{b}	2.5^{b}	3.0^{b}	2.9^{b}	3.2^{b}	3.0^{c}
10	10.4^{b}	9.7^{b}	15.3^{b}	15.3^{b}	20.6^{b}	22.0^{b}	1.6^{b}	2.5^{b}	3.7^{b}	3.2^{b}	3.9^{b}	3.5^{b}
15	11.7^{a}	11.3^{a}	17.4^{a}	17.7^{a}	27.3^{a}	28.8^{a}	2.9^{a}	3.0^{a}	3.8^{a}	3.7^{a}	4.9^{a}	4.1^{a}
SE±	0.47	0.43	0.73	0.67	1.31	2.05	0.12	0.12	0.19	0.15	0.27	0.16
Time of Poultry Manure Application (T)												
Two weeks before transplanting	20.3^{a}	9.8^{a}	15.3^{a}	15.0^{a}	20.8^{a}	19.5^{a}	2.1^{a}	2.6	3.3^{a}	5.2^{a}	8.0^{a}	7.8^{a}
At transplanting	8.8^{b}	8.1^{b}	13.3^{b}	13.1	18.9^{b}	17.5^{b}	1.6^{b}	2.4	2.8^{b}	4.6^{b}	6.7^{b}	6.5^{b}

Two weeks after transplanting	7.6^{c}	7.0^{c}	11.4b	10.4^{c}	18.6^{b}	16.2^{c}	1.6^{b}	2.3	2.5^{b}	4.2^{b}	5.8^{c}	5.5^{c}
SE±	0.32	0.35	0.51	0.64	0.74	0.64	0.07	0.71	0.12	0.11	0.38	0.48
Interaction												
VxP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
VxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
VxPxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment are not significantly different at 5% level of probability using DMRT.
NS: Not significant

Table 3: Effect of time and rates of poultry manure application on plant height (cm) and stem girth (cm) of two tomato varieties at 4, 6 and 8 WAT at Badole and Danja during the 2019/2020 dry season

	Plant height (cm)						Stem girth (cm)					
	4WAT		6WAT		8WAT		4WAT		6WAT		8WAT	
	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja
Treatment												
Variety (V)												
UTC GRAPTO	19.1	26.2	35.7^{a}	33.8^{a}	45.8^{a}	38.7^{a}	0.6	0.5^{b}	1.0^{b}	0.8	1.2^{b}	1.3
SUDANA	19.3	26.8	34.1^{b}	32.4^{b}	44.1^{b}	35.1^{b}	0.6	0.6^{a}	1.1^{a}	1.0	1.8^{a}	1.5
SE±	0.85	1.61	0.41	0.26	0.52	1.10	0.09	0.02	0.03	0.15	0.07	0.13
Poultry Manure (P) t ha^{-1}												
0	18.5^{c}	19.7^{c}	25.6^{c}	24.6^{c}	31.8d	29.5^{c}	0.6	0.4	0.7^{d}	0.5^{d}	0.8^{d}	0.6^{c}
5	19.4^{b}	24.5^{b}	34.5^{b}	29.6^{b}	41.4^{c}	36.2^{b}	0.6	0.5	1.0^{c}	0.8^{c}	1.2^{c}	0.9^{b}
10	28.1^{a}	30.4^{a}	39.8^{a}	37.5^{a}	47.4^{b}	41.3^{a}	0.6	0.5	1.1^{b}	1.1^{b}	1.9^{b}	1.9^{a}
15	29.0^{a}	31.4^{a}	42.2^{a}	36.7^{a}	56.8^{a}	42.5^{a}	0.6	0.6	1.3^{a}	1.2^{a}	2.6^{a}	2.0^{a}
SE±	0.51	0.37	0.70	1.90	1.14	1.14	0.12	0.11	0.05	0.07	0.12	0.10
Time of Poultry Manure Application (T)												
Two weeks before transplanting	19.4	26.2	35.8^{a}	32.2^{a}	46.6^{a}	38.0	0.6	0.6	1.3^{a}	1.2^{a}	1.7^{a}	1.5^{a}
At transplanting	18.9	25.5	33.6^{b}	31.3^{b}	44.0^{b}	37.6	0.6	0.5	0.9^{b}	1.0^{b}	1.2a	1.4a
Two weeks after transplanting	19.2	24.6	31.7^{c}	31.1^{b}	43.2^{b}	36.7	0.6	0.5	0.7^{c}	0.7^{c}	1.1^{b}	1.0^{b}
SE±	1.04	1.97	0.63	0.55	0.56	3.07	0.11	0.12	0.06	0.08	0.08	0.08
Interaction												
VxP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
VxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
VxPxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment are not significantly different at 5% level of probability using DMRT.
NS: Not significant

Table 4: Effect of time and rates of poultry manure application on plant dry weight (g) and leaf area index of two tomato varieties at 4, 6 and 8WATat Badole and Danja during the 2019/2020 dry season

	Plant dry weight (g)						Leaf area index					
	4WAT		6WAT		8WAT		4WAT		6WAT		8WAT	
	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja	Badole	Danja
Treatment												
Variety (V)												
UTC GRAPTO	6.0	4.1	11.8	8.6	19.8	14.7	1.0	0.8	1.3^{b}	1.3^{b}	2.2^{b}	1.7
SUDANA	5.7	4.1	11.4	8.8	20.4	14.0	1.0	0.9	1.8^{a}	1.7^{a}	2.6^{a}	2.0
SE±	0.88	0.70	1.19	0.40	1.47	1.86	0.10	0.10	0.13	0.12	0.13	0.14
Poultry Manure (P) t ha^{-1}												
0	5.3	2.7	7.0d	4.8d	10.2^{d}	6.3^{d}	0.7	0.6	1.9^{a}	1.2^{b}	1.2^{d}	1.1^{ad}
5	5.6	3.6	9.2c	7.1^{c}	15.6^{c}	9.5^{c}	0.9	0.9	1.4^{b}	1.2^{c}	2.3^{bc}	1.8^{b}
10	6.8	3.9	12.2^{b}	10.3^{b}	22.4^{b}	15.9^{b}	1.2	1.1	1.5^{b}	1.6^{b}	2.8^{b}	2.2^{b}
15	6.9	4.2	15.0^{a}	12.9^{a}	32.2^{a}	25.7^{a}	1.3	1.1	2.5^{a}	2.1^{a}	3.5^{a}	2.8^{a}
SE±	1.24	0.98	0.98	0.77	2.08	0.63	0.11	0.11	0.13	0.16	0.20	0.19
Time of Poultry Manure Application (T)												
Two weeks before transplanting	6.0	4.6	13.6^{a}	10.5^{a}	21.1^{a}	17.5^{a}	1.0	0.9	1.9^{a}	1.8^{a}	2.9^{a}	2.5^{a}
At transplanting	5.6	4.1	11.2^{b}	8.6^{b}	19.2^{b}	14.2^{b}	1.0	1.0	1.4^{b}	1.3^{b}	2.1^{b}	1.6^{b}
Two weeks after transplanting	5.7	3.7	11.0^{b}	7.2^{c}	18.4^{c}	11.3^{c}	1.0	1.0	1.5^{c}	1.2^{c}	2.1^{b}	2.4^{b}
SE±	1.07	0.85	0.46	0.49	0.38	1.0	0.09	0.18	0.11	0.14	0.17	0.24
Interaction												
VxP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
VxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
PxT	NS	NS	NS	NS	*	*	NS	NS	NS	NS	NS	NS
VxPxT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment are not significantly different at 5% level of probability using DMRT.
: Significant at 5% level of probability. NS: Not significant

Table 5: Interaction between poultry manure application rate and time of poultry manure on plant dry weight at 8 WAT at Danja and Badole during the 2019/2020 dry season

Treatments	Time of poultry manure application		
	Two weeks before transplanting	At transplanting	Two weeks after transplanting
Poultry manure (t ha^{-1})			
DANJA			
0	4.8d	4.6d	4.6d
5	5.6c	5.1c	5.3c
10	11.2b	9.8b	8.7b
15	13.6a	10.5a	10.4a
SE+		0.61	
BADOLE			
0	6.1d	6.2d	5.7d
5	7.3c	6.9c	5.6c
10	13.2b	10.8b	7.9b
15	14.3a	12.0a	11.2a
SE+		0.27	

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