



Varietal Performance of Tomato (*Solanum lycopersicum* L.) to Poultry Manure and Foliar Application of Moringa Leaf Extract

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A pot experiment was carried out at the Teaching and Research Farm, Rivers State University, Port Harcourt to evaluate the growth and fruit yield responses of three tomato varieties to poultry manure (PM) and foliar application of moringa leaf extract (MLE). The PM was applied at 0 and 20 t/ha while the MLE was applied at 0, 5, and 10 litre concentrations (MLE 5 and 10) separately and in all possible combinations in a completely randomized design in three replicates. The parameters measured were plant height, number of leaves, number of branches, percentage emergence, number of days to flowering, number of days to fruiting, number of flowers per plant, number of fruits and fresh fruit weight. The treatments differed significantly ($P = 0.05$) with the combinations of the treatments giving better performance. The combination of PM + MLE 5 gave the best growth performance however, the best yield performance was recorded on the PM + MLE 10. The

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application of PM + MLE 10 produced the highest number of fruits and fresh fruit weight. Among the two levels of MLE single and combined, MLE gave best growth performance while MLE 10 recorded the best yield. Plants treated with Moringa extract recorded zero pest infestation when compared to the control and PM treatments. Among the three varieties of tomato used, Jos recorded the best performance across all treatments singly or combined followed by RVF variety. Beef variety recorded the least performance. The significant effect of MLE in this study, suggests that MLE can be used as source of nutrients to grow tomato singly or combined with other nutrient sources.

Keywords: *Moringa leaf extract (MLE); Neem leaf extract (NLE); Poultry Manure (PM); Varietal Performance; Tomato (Jos; Beef and RVF).*

1. INTRODUCTION

"Tomato (*Solanum lycopersicum* L., family Solanaceae) is one of the most important vegetable crops grown in Nigeria both in commercial quantity and in subsistent form" (Nnabude et al., 2014). It is one of the most widely eaten vegetables which popularly stems from the fact that they can be eaten fresh or in multiple of processed forms. In the recent decades, the consumption of tomatoes has been associated with prevention of several diseases. "One limitation in the south is high intensity of rainfall usually observed in the area, and this will be detrimental to tomato production, as most of the diseases that attack the crop require damp situation or condition, though dry season farming with irrigation have been an alternative in the South" (Nnabude et al., 2014). Apart from this, tomato is an ideal crop as it has been found to grow in wide soil and environmental variations.

"Also, one of the major draw backs of tomato production in Nigeria is the inherent low soil fertility" (Adekiya and Ojeniyi 2002). "Tomato plant requires nutrient such as N, P, K, Mg, Ca, Na for good production, these nutrients are specific in function and must be supplied to the plant at the right time and in the right quantity" (Nnabude et al., 2014). "For example, adequate supply of nitrogen will increase the photosynthetic activities and vigorous vegetative growth of the crop as well as dark green colour of the leaves" (John et al., 2004). Fisayo and Ayodele (2023) investigated the performance of two tomato varieties (*Solanum lycopersicum* L.) when grown using different concentrations of hydroponic solutions. Their research focused on understanding how varying nutrient levels in a soilless system impact the growth and yield characteristics of specific tomato cultivars.

Stefano et al., (2004) observed that inorganic fertilizer exerts strong influence on plant growth development and yield, while the availability of sufficient plant nutrients from inorganic fertilizers lead to improved soil activities enhanced cell multiplication and enlargement and luxuriant growth (Fashina et al., 2002). "Luxuriant growth resulting from fertilizer application leads to larger dry matter production" (Obi et al., 2005) owing to better utilization of solar radiation and more nutrients (Saeed et al., 2001). The use of inorganic fertilizers on crop production increased yield as reported by Adediran and Banjoko (2003). Nweke and Nsoanya (2013a) and Uyovbisere et al., (2007), reported decrease in crop yield where no NPK fertilizer was applied. Uyovbisere and his companion further observed that nitrates and available phosphorus were substantially reduced with cropping in humid zone of southwestern, Nigeria. However, the use of inorganic fertilizer has been observed not to with stand intensive crop production as it is associated with depressing effect on yield. Aliyu et al., (1992) and John et al., (2004) observed that it causes reduction in number of fruits, delays fruits setting which subsequently delays ripening and leads to heavy vegetative growth. It also causes soil acidity and nutrient imbalance, (Agbede et al., 2008), leaching and pollution of ground water.

Poultry manure is a waste product from poultry farm produce, high in nutrient because solid and liquid excrement are combined, leading in negligible loss in the urine contents. The most prevalent nitrogenous component in fresh poultry excreta (forty-seventy percent nitrogen) is the urate (uric acid), although smaller proportions of ammonia and urea are found.

"Poultry manure (PM) is an excellent organic fertilizer as it contains high N, P, K and other essential nutrients" (Farhad et al., 2009). "It has

been reported to supply P more readily to plants than other organic sources" (Garg and Bahla, 2008). Ano and Agwu (2006); Uwah et al., (2011) and Uwah et al., (2012) reported that PM increased soil pH, organic matter content, available P, exchangeable cations and micro nutrients, reduced exchangeable Al and Fe contents and bulk density. "Poultry manure application increased soil N levels by 53%, while exchangeable cation contents also increased appreciably" (Boateng et al., 2006).

"Moringa (*Moringa olifera* L.) belongs to the *Moringaceae* family. It is considered as one of the world's most useful tree, as almost every part of the tree has an impressive effect of food, medication and industrial purposes" (Moyo et al., 2011). "It is one of such alternatives, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers" (Phiri, 2010). "Moringa leaf extract is a rich source of amino acids, potassium, calcium, iron, vitamin E, ascorbates, phenolic compounds and growth regulating hormones like Zeatin" (Makkar and Becker, 1996). "Thus, it possesses the potential to promote plant growth and can be used as a natural plant growth promoter. Zeatin is a part of the compound cytokinins, which stimulate cell division, cell elongation, delay the process of senescence and ageing in plant tissue and promote nutrient partitioning and uptake" (Taiz & Zieger, 2002).

Therefore, the aim of this research was to evaluate the response of the response of three tomato varieties to poultry manure and foliar application of Moringa leaf extract on growth, yield, and pest management in Port Harcourt.

2. MATERIALS AND METHODS

2.1 Study Area

This research was carried out in the Hoop House of the Rivers State University Teaching and Research Farm, Nkpolu-Oroworukwo, Port Harcourt. The study location lies in the humid tropical zone of the Southern Nigeria. It lies between latitude 4.5°N and longitude 7.0°E with an elevation of 18m above sea level. The climate of the area is tropics, with two seasons: wet (rainy) and the dry seasons. The mean annual rainfall in Port Harcourt ranges from about 3,000

mm to 4,500 mm, annual temperature ranges from 22°C to 29°C while relative humidity varies from 75% and 95%. Port Harcourt soils are of Coastal Plain Sands. These soils have been found to range from sand to sandy loam in the surface soil horizon, with pH values of between 4.0 and 5.8 in water (Ayolagha and Onuegbu, 2002). The vegetation consists of tropical and mangrove swamp forest (Uko et al., 2013).

Collection and analysis of soil samples before cultivation: Top soil (0-15 cm) samples were randomly collected from cultivated farm, bulked to form a composite sample; air dried and sieved using a 2 mm mesh size. The routine analyses as described in FAO (2018) for physical and chemical properties were carried out on the soil sample. 10 kg of the soil sample were measured into plastic containers that were perforated at the base.

Sources and Collection of Tomato Seeds, Poultry Manure, Moringa Leaf: Three tomato varieties (Jos, Beef and Roman VF) were obtained from two locations (Agricultural Development Program, Ministry of Agriculture and Fruit Garden) all in Port Harcourt. Poultry Manure, Moringa Leaf were sourced from the Rivers State Teaching and Research Farm.

2.2 Preparation and Applications of Poultry Manure, Moringa Leaf Extract

2.2.1 Poultry manure

Poultry Manure was air-dried and finely crushed. 0.089 kg (89g) of the poultry manure was weighed and added to poly pots filled with 10 kg soil 2 weeks before planting.

2.2.2 Moringa leaf extracts

Fresh leaves of Moringa were washed with tap water and then shade dried for seven days at room temperature $2 \pm 27^{\circ}\text{C}$. The dried leaves were milled into uniform powder. 500g of the dried powered Moringa Leaf sample was weighed and soaked in 5 and 10 litres of water respectively, stirred for 30 minutes and left for 24 hours. The extract filtered through cheese cloth about two times to separate the residues from the solution, a method adopted from Sale et al., (2015). Moringa leaf extracts was sprayed at the rate of 30 ml for each plant at two weeks'

interval, starting from two weeks after germination to fruit maturity.

2.3 Experimental Design

The experiment (hoop-house pot experiment) was laid out as Completely Randomized Design (CRD) with twelve treatments replicated three times. The treatments consist of milled Moringa leaves mixed in 0, 5 and 10 litres of water rates of concentrations and 20t/ha poultry manure singly and in all possible combinations and control.

2.4 Data Collections and Statistical Analysis

Data were collected on Percentage Emergence (%), Number of Days to 50% flowering, Number of Days to Fruiting, plant height, number of leaves and number of branches at intervals of two (2) weeks from 6 WAP. Harvesting of fresh fruits begins at 10 WAP which was done in 4 days interval. The Level of pest and disease infestation, number of flowers and fruits per plant were counted and the fresh fruit weight per plant was recorded. All data obtained for each character were subjected to analysis of variance (ANOVA) using Minitab software and the treatment means were separated by Fisher's Least Significant Difference (LSD) at 5% probability.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of the Soil Plant manure, MLE before Planting

Table 1 indicates the pre-cropping soil properties and some chemical properties of PM, and MLE used for this study. The soil was a very strongly acidic (pH=4.97) sandy loam containing 1.17% O.C, 14% N, 2.02% OM, and 0.18 Mg/kg Available P. While exchangeable K, Na, Ca and Mg were 4, 6, 0.6, and 1 cmol/kg respectively.

The physical properties of the soil before cultivation showed that the soil is sandy loam. Shankara et al., (2005) reported that tomato grows well on most mineral soils that have proper water holding capacity and aeration, and are free of salt but prefers deep, well drained, sandy loam soils. The pH value of the soil (pH=5.67) was within the pH range of 5.5-6.8

considered as suitable for optimum performance of tomato and other vegetables (Purseglove, 1992 and Shankara et al., 2005). The chemical properties of the soil were low suggesting the need for its increased supply in the soil to improve the growth and yield of tomato. This expectation was met with the application PM and MLE singly and in all combinations which increased the selected growth parameters at all sampling occasions.

Table 1. Chemical and Physical properties of Soil Sample

Parameters	Soil
pH	5.67
Organic Carbon (%)	1.17
Total Nitrogen (%)	0.14
Available Phosphorus (Mg/kg)	0.18
Potassium (k) (Cmol/kg)	4
Sodium (Na) (Cmol/kg)	6
Calcium (Ca) (Cmol/kg)	0.6
Magnesium (Mg) (Cmol/kg)	1
Organic Matter (%)	2.02
ECEC (Cmol/kg)	
Physical Characteristics	
Sand (%)	85.8
Silt (%)	10.4
Clay (%)	3.8
Textural class	Sandy Loam

The results of the present study showed high responses to the main studied factors and their combinations in the experiment carried out. The effects of different factors and their combinations are presented below:

3.2 Effect of Poultry Manure and Foliar Application of Moringa leaf Extract on Vegetative Growth, Yield, and Yield Components of Tomato

The effects of poultry manure and Moringa extract levels as well as their interactions on vegetative growth and yield characters of tomato plants are shown in Tables (2, 3, 4, & 5) which demonstrated the effects of both Poultry Manure and Moringa extract levels on vegetative growth characters (plant height, number of branches and number of leaves per plant), yield characters (percentage emergence, 50% flowering, number of days to flowering and fruiting, total number of flowers, fruits, and fresh fruit weight).

3.3 Poultry Manure

The results showed that the application of PM increased all vegetative growth characters (plant height, number of branches per plant and leaves

per plant) at 6, 8 and 10 weeks after planting (WAP), and yield characters (percentage emergence, 50% flowering, number of days to flowering and fruiting, total number of flowers, fruits, and fresh fruit weight) Table 2 & 3. However, plants on the control treatment exhibited the lowest mean values of all vegetative growth characters, yield and yield components throughout the sampling period (Tables 2 & 3). These results are in line with those obtained on cucumber by Omori *et al.* (1977); on tomato by Agyeman *et al.* (2014); on squash by Shehata, (2001).

This result could be due to the fact that poultry manure is easily decomposed especially in sandy soil as reported by Mohamed and Hammam (2019) or may be attributed to increment ration in plant tissues (Opara and Asiegbu 1996) and may be due to the microbial biomass of nitrogen, which is the main source of soil nitrogen which is mineralizable in the soil (Myroled, 1987; Bonde *et al.*, 1988).

The significant effect of poultry on growth and yield of tomato in this study maybe possibly be explained by the fact that the poultry manure improved the soil physical, chemical, and biological properties and provided the macro and micro-nutrient requirements of the plants (Abou El-Magd, *et al.* 2005), thereby increasing yield. Also, the decomposition of the PM in the soil added more available nutrients and liberated the fixed nutrients as a result of the produced organic acids. The superior effect of PM over the control can be attributed to its richness in nutrients (Table 1).

In addition, of N, other macronutrients such as S, P and K as well as micronutrients which are found in poultry manure are more readily available for plant growth. Also, organic manure improving soil properties, thus offering suitable nutrients for vigorous vegetative growth, which reflected in the fresh weight per plant.

3.4 Moringa Leaf Extract

Table 2 & 3 showed that the vegetative growth characters (plant height, number of leaves, and branches) at 6, 8 and 10 weeks after planting (WAP) and yield characters (percentage emergence, 50% flowering, number of days to flowering and fruiting, number of flowers, fruits, and fresh fruit weight) increased with the foliar spray of Moringa leaf extract.

The highest mean values on vegetative growth were obtained from plants sprayed with Moringa leaf extract level at 5 litres concentration (MLE 5), more than the 10 litre concentrations. However, tomato plants sprayed with 10 litre of Moringa leaf extract performed better than the application of 5 litre Moringa leaf concentrations with respect to the yield and yield characters, table 2 & 7. The significant effect of MLE (5 and 10 levels) was effective at (0.05%) when compared to the control treatment. Lowest values were recorded on the untreated plants. The lowest mean values of the characters were recorded on the control plants. The results obtained in this study are in line with those observed by Azra, (2011) found that spraying wheat, peas and tomato with *M. oleifera* extract increased crop characteristics, Bawa *et al.*, (2014) on tomato. Similar results were also reported by Mona (2013) who explained that the treatment of *rocket* (*Eruca vesicaria subsp. sativa*) with *Moringa extract* is likely to have increased the content of leaves with N, P and K.

Plant response to MLE, could be said to be dependent on both plant growth stages and MLE levels (as higher response was seen during vegetative growth on plants treated with MLE 5 while higher response was seen on the reproductive stages on plants treated with MLE 10). This response is in line with those observed by Azra, 2011, that MLE 30 (30 times diluted MLE) was more effective in tomato yield than MLE 20 and MLE 10 spray.

The significant increase in both the vegetative growth and yield of tomato plants in this study may be due to the significant and important role of Moringa leaf extract, which contains the following compounds; amino acids, proteins and phenols, mixed with growth hormone " Zeatin" and many minerals such as Ca, Mg, Na, Fe, P, K, and many flavonoids as indicated by (Siddhuraju and Becker, 2003 and Anwar *et al.*, 2007).

Interaction effects of poultry manure, Moringa leaf extract and varieties: Interaction between poultry manure and foliar spray Moringa extract on vegetative growth characters (plant height, number of leaves, and branches) at 6, 8 and 10 weeks after planting (WAP) and yield characters (percentage emergence, 50% flowering, number of days to flowering and fruiting, total number of flowers, fruits, and fresh fruit weight) are presented on Tables (4 & 5).

Table 2. Effect of Treatments on Vegetative Growth of Tomato

TREATMENTS	6WAP			8WAP			10WAP		
	PH	NOL	NOB	PH	NOL	NOB	PH	NOL	NOB
CON	17.19 ^f	24.52 ^f	3.67 ^f	36.79 ^f	42.78 ^f	7.519 ^f	72.90 ^f	71.89 ^f	10.89 ^f
PM	18.74 ^e	32.33 ^e	5.59 ^e	40.47 ^e	65.93 ^e	12.04 ^e	84.35 ^e	97.26 ^e	18.26 ^e
MLE 5	21.21 ^c	41.30 ^c	8.41 ^c	46.42 ^c	76.37 ^c	17.48 ^c	97.84 ^c	112.37 ^c	27.56 ^c
MLE 10	20.26 ^d	40.04 ^d	7.59 ^d	43.59 ^d	74.11 ^d	16.63 ^d	92.36 ^d	109.11 ^d	26.67 ^d
MLE 5 + PM	25.86 ^a	52.89 ^a	10.67 ^a	57.79 ^a	92.00 ^a	19.96 ^a	122.54 ^a	132.26 ^a	30.78 ^a
MLE 10 + PM	24.95 ^b	50.82 ^b	10.04 ^b	54.91 ^b	89.63 ^b	19.44 ^b	117.06 ^b	128.96 ^b	29.93 ^b
LSD (0.05%)	0.168	0.31	0.209	0.352	0.370	0.243	0.637	0.714	0.261

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05). WAP= Weeks after planting, CON= Control, PM = Poultry Manure, MLE = Moringa Leaf Extract, PH = Plant Height, NOL= Number of leaves, NOB = Number of Branches, LSD = Least Significant Difference, RVF = Roman VF.

Table 3. Effect of Treatments on yield and yield components of tomato

TREATMENTS	PE %	DTF	DTFR	NOFL	NOF	FW kg t/ha	PAD
CON	62.86 ^f	68.00 ^a	85.00 ^a	8.70 ^f	3.48 ^f	0.66 ^f	0.67 ^a
PM	71.27 ^e	64.67 ^b	78.67 ^b	10.63 ^e	5.70 ^e	1.16 ^e	0.41 ^a
MLE 5	81.50 ^d	58.67 ^c	71.67 ^c	13.33 ^d	9.59 ^d	2.05 ^d	0.00 ^b
MLE 10	87.03 ^c	56.67 ^d	69.67 ^d	14.74 ^c	11.37 ^c	2.53 ^c	0.00 ^b
MLE 5 + PM	92.53 ^b	55.26 ^e	68.48 ^e	18.04 ^b	14.82 ^b	3.75 ^b	0.00 ^b
MLE 10 + PM	96.27 ^a	53.67 ^f	66.67 ^f	20.11 ^a	16.70 ^a	4.40 ^a	0.00 ^b
LSD (0.05%)	0.4689	0.2203	0.2228	0.2575	0.2485	0.0589	0.1322

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05). CON= Control, PM=Poultry manure, MLE (5 & 10) = Moringa leaf extract (5 & 10 litresconcentrations), WAP= Weeks after planting, PH = Plant Height, NOB = Number of branches = NOL= Number of leaves, NOB = Number of, LSD = Least Significant Difference.

Table 4. Interaction Effect of Poultry Manure, Moringa Leaf Extract and Varieties on Vegetative Growth of Tomato

TREATMENTS	VAR	6WAP			8WAP			10WAP		
		PH	NOL	NOB	PH	NOL	NOB	PH	NOL	NOB
CON	JOS	17.36 ^l	3.56 ^h	24.33 ^k	36.58 ^{jk}	42.22 ^k	7.44 ^l	72.13 ^l	71.67 ^l	10.67 ^l
	BEEF	16.92 ^l	3.78 ^h	24.78 ^k	37.71 ^l	43.00 ^k	7.67 ^l	73.42 ^l	72.11 ^l	11.33 ^l
	RVF	17.29 ^l	3.67 ^h	24.44 ^k	36.07 ^k	43.11 ^k	7.44 ^l	73.16 ^l	71.89 ^l	10.67 ^l
PM	JOS	20.02 ^{hi}	6.33 ^f	35.00 ^h	43.04 ^{gh}	68.56 ^h	12.89 ^h	89.34 ^h	101.44 ⁱ	19.67 ^h
	BEEF	18.01 ^k	5.11 ^g	30.22 ⁱ	39.02 ⁱ	63.78 ⁱ	11.44 ⁱ	81.43 ⁱ	96.56 ⁱ	17.44 ⁱ
	RVF	18.18 ^k	5.33 ^g	31.78 ⁱ	39.36 ⁱ	65.44 ⁱ	11.78 ⁱ	82.27 ⁱ	93.78 ^k	17.67 ⁱ
MLE 5	JOS	22.89 ^e	9.44 ^{cd}	44.56 ^d	49.78 ^d	79.56 ^d	18.67 ^{cd}	104.58 ^e	115.56 ^e	28.78 ^{de}
	BEEF	20.11 ^{gh}	7.78 ^e	39.33 ^{fg}	44.22 ^{fg}	74.56 ^f	16.78 ^{ef}	93.44 ^g	110.56 ^{fg}	26.89 ^f
	RVF	20.62 ^g	8.00 ^e	40.00 ^f	45.24 ^f	75.00 ^f	17.00 ^f	95.51 ^f	111.00 ^f	27.00 ^f
MLE 10	JOS	21.90 ^f	8.89 ^d	42.56 ^e	46.74 ^e	76.56 ^e	17.89 ^d	98.82 ^f	111.56 ^f	28.00 ^e
	BEEF	19.43 ^j	6.89 ^f	38.56 ^g	41.93 ^h	72.67 ^g	15.89 ^g	88.84 ^h	107.67 ^h	25.89 ^g
	RVF	19.46 ^{ij}	7.00 ^f	39.00 ^{fg}	42.09 ^h	73.11 ^g	16.11 ^{fg}	89.40 ^h	108.11 ^{gh}	26.11 ^{fg}
MLE 5 + PM	JOS	27.03 ^a	12.11 ^a	54.67 ^a	60.07 ^a	93.67 ^a	21.89 ^a	127.13 ^a	133.67 ^a	32.67 ^a

TREATMENTS	VAR	6WAP			8WAP			10WAP		
MLE 10 + PM	BEEF	25.11 ^c	9.89 ^c	52.33 ^b	56.22 ^b	90.67 ^b	18.78 ^c	119.36 ^c	130.78 ^{bc}	29.11 ^d
	RVF	25.43 ^c	10.00 ^c	51.67 ^b	57.067 ^b	91.667 ^b	19.22 ^c	121.13 ^{bc}	132. ^{33ab}	30.56 ^{bc}
	JOS	26.16 ^b	10.89 ^b	52.56 ^b	57.422 ^b	91.222 ^b	20.67 ^b	121.73 ^b	130.67 ^{bc}	31.22 ^b
	BEEF	24.27 ^d	9.56 ^{cd}	49.89 ^c	53.600 ^c	88.778 ^c	18.56 ^{cd}	114.16 ^d	127.89 ^d	28.89 ^{de}
	RVF	24.43 ^d	9.67 ^c	50.00 ^c	53.711 ^c	88.889 ^c	19.11 ^c	115.29 ^d	128.33 ^{cd}	29.67 ^{cd}
LSD (0.05%)		0.2907	0.3624	0.5367	0.6094	76.556	0.4203	1.1031	1.2371	0.4513

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05), CON= Control, PM=Poultry manure, MLE (5 & 10) = Moringa leaf extract (5 & 10 litres concentrations), WAP= Weeks after planting, PH = Plant Height, NOB = Number of branches = NOL= Number of leaves, NOB = Number of, LSD = Least Significant Difference.

Table 5. Interaction Effect of Poultry Manure, Moringa Leaf Extract and Varieties on Vegetative Growth of Tomato

TREATMENTS	VAR	PE %	DTF	DTFR	NOF	NOFL	FW kg/ha	PAD
CON	JOS	62.34 ^l	68.00 ^a	85.000 ^a	3.444 ^l	8.67 ^l	0.65 ^k	0.44 ^{abc}
	BEEF	63.90 ^k	68.00 ^a	85.000 ^a	3.556 ^l	8.78 ^l	0.68 ^k	0.89 ^a
	RVF	62.34 ^l	68.00 ^a	85.00 ^a	3.444 ^l	8.67 ^l	0.65 ^k	0.67 ^b
PM	JOS	72.20 ⁱ	62.00 ^d	76.00 ^d	6.00 ^h	11.00 ⁱ	1.20 ^j	0.44 ^{abc}
	BEEF	69.40 ^j	67.00 ^b	81.00 ^b	5.33 ^h	10.33 ⁱ	1.12 ^j	0.44 ^{abc}
	RVF	72.20 ⁱ	65.00 ^c	79.00 ^c	5.78 ^h	10.56 ⁱ	1.16 ^j	0.33 ^{bc}
MLE 5	JOS	86.10 ^e	56.00 ^j	69.00 ^j	11.56 ^e	14.56 ^f	2.43 ^g	0.00 ^c
	BEEF	77.80 ^h	61.00 ^e	74.00 ^e	7.89 ^g	12.67 ^h	1.74 ^h	0.00 ^c
	RVF	80.60 ^g	59.00 ^f	72.00 ^f	9.33 ^f	12.78 ^h	1.96 ^g	0.00 ^c
MLE 10	JOS	91.70 ^c	54.00 ^k	67.00 ^j	12.89 ^d	15.89 ^e	2.84 ^e	0.00 ^c
	BEF	83.30 ^f	59.00 ^f	72.00 ^f	9.78 ^f	13.67 ^f	2.25 ^g	0.00 ^c
	RVF	86.10 ^e	57.00 ^h	70.00 ^h	11.44 ^e	14.67 ^f	2.52 ^f	0.00 ^c
MLE 5 + PM	JOS	94.40 ^b	52.56 ^j	65.44 ^k	15.78 ^b	18.89 ^c	3.94 ^c	0.00 ^c
	BEEF	88.80 ^d	57.44 ^g	71.00 ^g	14.00 ^c	17.44 ^d	3.64 ^d	0.00 ^c
	RVF	94.40 ^b	55.78 ^j	69.00 ^j	14.67 ^c	17.78 ^d	3.67 ^d	0.00 ^c
MLE 10 + PM	JOS	97.20 ^a	51.00 ^m	64.00 ^j	17.56 ^a	20.67 ^a	4.57 ^a	0.00 ^c
	BEEF	94.40 ^b	56.00 ^j	69.00 ^j	15.56 ^b	19.44 ^{bc}	4.20 ^b	0.00 ^c
	RVF	97.20 ^a	54.00 ^k	67.00 ^j	17.00 ^a	20.22 ^{ab}	4.42 ^a	0.00 ^c
LSD (0.05%)		0.2319	0.0962	0.0586	0.4303	0.4460	0.1020	0.2342

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05), CON= Control, PM=Poultry manure, MLE (5 & 10) = Moringa leaf extract (5 & 10 litres concentrations), PE = Percentage Emergence, DTF = Days to 50% Flowering, DTFR = Number of Days to fruiting, NOFL = Number of Flowers, NOF = Number of Fruits, FW = Fruit Weight, PAD = Pest and disease, LSD = Least Significant Difference, VAR = Varieties.

Interactions effects of poultry manure, Moringa extract and tomato varieties: The result presented on Table 4 & 5 showed that the interaction between PM, MLE, and varieties significantly ($P = 0.05$) affected both the vegetative growth and yield characters. Tomato plants which were sprayed with Moringa leaf extract combined with poultry manure performed competitively better than the single application of these sources and the control throughout the sampling period. However, Jos variety treated with the combination of MLE, and PM outperformed and responded better than the other varieties in all of the parameters measured in the study. Previous studies showed that the differential response of crops on growth and yield among varieties was distinct. The differences observed among the varieties could be attributable to the genetic makeup of the individual variety, response to plant extract use and adaptability to the soil under study as well as the soil nutrient content, type, and nature of the microorganisms, present in the soil. For instance, Sadeghipour & Aghaei (2012) reported differences among varieties of chickpea in days to 50% flowering. Also, Mekuanint *et al.*, (2018) reported differences on growth and yield of two chickpea varieties to rates of blended fertilizer and row spacing.

4. VARIETAL EFFECT OF TOMATO ON GROWTH AND YIELD PARAMETERS

The main effects of variety showed a significant effect ($P < 0.01$) on the growth and yield of tomato indicating that varieties behaved differently throughout the sampling period (Tables 6 & 7). On the growth parameters (plant height, number of leaves and branches) the values recorded increased as the week after planting (WAP) increased, Table 2. The Jos variety recorded the highest values in both the growth and reproductive stages while the lowest values were recorded under the Beef variety. The values

obtained from Roma, VF and Beef were statistically similar Table 6 & 7. The effect of variety on yield and yield component (number of days to flowering, days to fruiting, percentage emergence, number of flowers, fruit, and fresh fruit weight) presented on Table 6 & 7 showed a significant difference ($P = 0.05$) among varieties used. The Jos variety recorded the highest values in respect to yield and its component. The least value was obtained from Beef variety. These results are similar to those obtained by Nnabude *et al.*, 2014 on tomato and Tesfahun *et al.*, (2018) on chickpea, Agyeman *et al.* (2014) on tomato. The choice of varieties and the application rates of either organic or inorganic fertilizers can help improve tomato yields.

Plants Damaged by Pests and Diseases: The result of the study presented in Table 7 indicates that, there was no significant difference among the varieties used in respect to pest and disease leaf infestation. However, from Table 3 the number of plants damaged by pests and diseases (leaf infested) was higher in the control treatment than other treatment applications. Plants damaged by pests and diseases (leaf infested) were only observed on the control treatment and the application of PM alone while treatment applications of MLE, singly and combined recorded zero number of damages. The interaction effect of treatments and varieties in Table 5 shows that Beef variety under the control treatment recorded the highest number of plants damaged by pest and diseases followed by RVF with Jos recording the least.

The non-infestations of pests on plants sprayed with MLE could be attributed to reports that Moringa extracts possess pesticidal and insecticidal properties (Habib *et al.*, 2015). The results showed that the use of plant extracts alone or in combination as bio-pesticides is highly effective against insects (Udo *et al.*, 2009).

Table 6. Varietal Effect of Tomato on Growth Parameters

VARIETIES	6WAP			8WAP			10WAP		
	PH	NOL	NOB	PH	NOL	NOB	PH	NOL	NOB
JOS	22.56 ^a	42.28 ^a	8.54 ^a	48.94 ^a	75.30 ^a	16.57 ^a	102.29 ^a	110.76 ^a	25.17 ^a
BEEF	20.64 ^c	39.07 ^c	7.17 ^b	45.45 ^b	72.24 ^c	14.85 ^b	95.11 ^c	107.59 ^b	23.26 ^b
RVF	20.90 ^b	39.59 ^b	7.28 ^b	45.59 ^b	72.87 ^b	15.11 ^b	96.13 ^b	107.57 ^b	23.61 ^b
LSD (0.05%)	0.1187	0.2191	0.1480	0.2488	0.2616	0.1716	0.4503	0.5051	0.1843

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05), WAP= Weeks after planting, PH = Plant Height, NOL= Number of leaves, NOB = Number of Branches, LSD = Least Significant Difference, RVF = Roman VF.

Table 7. Varietal Effect of Tomato on Yield and Yield Parameters

Varieties	PE %	DTF	DTFR	NOFL	NOF	FW kg t/ha	PAD
JOS	83.99 ^a	57.26 ^c	71.07 ^c	14.94 ^a	11.20 ^a	2.61 ^a	0.22 ^a
BEEF	79.60 ^c	61.41 ^a	75.33 ^a	13.72 ^c	9.35 ^c	2.27 ^c	0.15 ^a
RVF	82.14 ^b	59.80 ^b	73.67 ^b	14.11 ^b	10.28 ^b	2.40 ^b	0.17 ^a
LSD (0.05%)	0.0947	0.0393	0.0239	0.1821	0.1757	0.0416	0.0956

Note: Means that do not share same letter on the same column are significantly different at fishers least significant difference (0.05), PE = Percentage Emergence, DTF = Days to 50% Flowering, DTFR = Number of Days to fruiting, NOFL = Number of Flowers, NOF = Number of Fruits, FW = Fruit Weight, PAD = Pest and disease, LSD = Least Significant Difference, VAR = Varieties.

5. CONCLUSION

The results of the study showed that all growth and yield parameters of the treated tomato varieties were enhanced following the application of Poultry manure and Moringa leaf extract. The application of PM and MLE singly and all possible combinations had significant effect on the performance of the three tomato varieties at all growth stages over the control. The improved growth and yield of tomato in the study as a result of the combination MLE and PM may be due to the high macro and micro nutrients in the treatments. 10 litres concentration of MLE was found to be the optimum dose (concentration) in yield of tomato in the pot experiment. In all the parameters assessed in this experiment, the Jos variety performed competitively better and responded better to the treatments applied than the RVF and Beef varieties. The genetic makeup of the individual varieties, as well as their adaptation to the environment, soil, and the nutrient contents of the plant and animal extracts under study could be the reason for the differences observed among the varieties.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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