**Agronomic Performance of Three Tomato (*Solanum lycopersicum* L.) Varieties to Foliar Application of Neem Leaf Extract and Poultry Manure**

**ABSTRACT**

Soil fertility and improved environmental quality are both important goals of today’s agriculture, the mere application of chemical fertilizers to degraded or over-cropped soil does not trigger crop productivity. For these highly leached soils, it is necessary to provide a balance of nutrients and to neutralize the acidity simultaneously with the use of animal manures and organic residues. Pot experiment was carried out in a hoop-house at the Teaching and Research Farm of Rivers State University from August 2020 to February 2021 cropping season to evaluate the agronomic performance of three Tomato (*Solanum lycopersicum* L) varieties (Jos, Beef and RVF) to the exogenous applications of Neem leaf extract (NLE) and poultry manure (PM). The NLE were applied at 30ml of 0, 5 and 10 litres concentrations with 20t/ha PM singly and in all possible combinations, in a Completely Randomized Design (CRD) in three replications. The tested parameters were percentage emergence, days to 50% flowering and fruiting, plant height, number of branches, leaves, flowers, fruit, and fresh fruit weight. The results showed that applications of NLE (priming and foliar spray) and PM had significant (p≤0.05) effects on tested parameters over the control at all growth stages and on fruit yield; however, the combination of NLE and PM gave a better performance. Between the two levels of NLE, both the single and combined applications, NLE 10 gave a better growth and yield performance than NLE 5. The combination of NLE and PM gave a better performance on growth and yield than their single applications and the control. The combination of NLE10+PM exhibited the highest number of flowers, number of fruits and the heaviest fruits. Plants treated with neem leaf extract recorded zero pest infestation when compared to the control and PM treatments. Among the varieties, the Jos variety treated with NLE and PM single and in all combinations recorded the best and highest values in all growth and yield parameters, followed closely by RVF, while the Beef variety was the least. The significant effect of NLE and PM on the growth, yield, and insect pest control of the three tomato varieties suggests that NLE and PM can be used as a source of nutrients to grow tomato plants.

Keywords- NLE, PM, Tomato (Jos, Beef and RVF), Neem Leaf Extract and Poultry Manure

**INTRODUCTION**

“Tomato (*Solanum Lycopersicum* L) belongs to the family *Solanaceae* and is one of the most widely eaten vegetables in the world which popularly stems from the fact that they can be eaten fresh or in multiple of processed forms. In recent decades, the consumption of tomatoes has been associated with the prevention of several diseases mainly due to the content of antioxidants, including carotenes (Lycopene as well as 𝛽-carotene), ascorbic acid, and phenolic compounds” (Willcox *et* *al*., 2003 and Sharoni *et* *al*., 2006). Tomato is also rich in vitamins (B, C, and E) and folic acid, thus, it plays a significant role in human fertility, food metabolism, neurological system preservation, and maintenance of the immune system (Rao and Agarwal, 1999). Tomato is produced as a warm-season annual crop despite being a perennial crop because of their susceptibility to harsh environmental circumstances, which necessitates a moderately cool, dry climate for maximum production and quality products. Tomatoes may be cultivated in both open fields and greenhouses (protected culture). When the outdoor climatic conditions are not favorable to growth, the protected culture is extensively employed. Tomato is one of the world's most important food crops (Frusciante *et al*., 2000); its cultivation, however, is mostly limited to cool-mild and dry areas, with some exceptions in hot and dry seasons (Hanson *et al.*, 2001, IFPRI/PBS, 2007). Commercial tomato cultivation in Nigeria is limited to the savannah agro-ecology of the north and a few damp savannah agro-ecologies of the South (Umeh *et al,* 2002). Nigeria, having a population of roughly 160 million people and a tomato production of 1,701,000 tons per year, produces only 5 percent of what China produces and 12 percent of what the United States produces (FAO, 2008), and demand for fresh tomatoes in Nigeria exceeds supply, especially during the off-season (Tijani, 2001). According to IFPRI/PBS (2007), one of the factors that limits production of tomato in Nigeria is the limitation of production to a specific season, which results in times of excess and shortage, resulting in high price of fresh fruits, as well as the cultivation of exotic varieties that are not well adapted to local environmental conditions.

“Low and declining soil fertility is also a major concern in small-holder farms and has been aggravated by continuous cultivation without adequate soil fertility enhancement measures in Nigeria” (Nandwa, 2001). “Use of inorganic fertilizers can improve crop yields, but their use is limited due to scarcity, high cost, nutrient imbalance, and soil acidity” (Okwu and Ukanwa, 2007). “Organic manure has received renewed attention with emphasis on long-term sustainability of agricultural system because it can be used as a source of soil nutrients and alternative to maintenance of soil fertility” (Ali, 1999), but green manure as a source of soil fertility is not a common practice among vegetable crop production, especially tomato in this region.

“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).

“Neem (*Azadirachta* *indica*) has great importance around the world due to its multiple applications in medicine and cosmetics” (Rodrigues *et* *al*., 2011). It was reported by Rodrigues *et* *al*. (2011) that “neem tree contains about three hundred or more secondary metabolites, one 3rd of which are limonoids (tetra triterpenoids) having various biological applications”. The most active compound is azadirachtin having an effective curative or healing role” (Subapriya *et* *al*., 2005; Rahmani *et* *al*., 2018). “Neem leaves contain various active compounds like ascorbic acid, amino acids, nimbolide and nimbin, etc.” (Rodrigues *et* *al*., 2011; Sarah *et* *al*., 2019). “Some polyphenolic compounds (e.g., quercetin and ß-sitosterol) are also extracted from neem leaves, showing antifungal and antibacterial properties” (Alzohairy, 2016).

“Since enhanced soil fertility and improved environmental quality are both important goals of today’s agriculture, the mere application of chemical fertilizers to degraded or over-cropped soil does not trigger crop productivity. For these highly leached soils, it is necessary to provide a balance of nutrients and to neutralize the acidity simultaneously with the use of animal manures and organic residues. Soil enhancing benefits from these manures in addition to those from macro and micro nutrients are related to the organic matter that improves soil structure, moisture relations, and increases mobility of P, K, and micro nutrients, and also stimulates microbial activities” (Marerere *et al*., 2001; Garg and Bahla, 2008). Stefano *et* *al*. (2004) observed that “inorganic fertilizer exerts a strong influence on plant growth, development, and yield”, while “the availability of sufficient plant nutrients from inorganic fertilizers leads to improved soil activities, enhanced cell multiplication and enlargement, and luxuriant growth” (Fashina *et* *al*., 2002).

Therefore, this research aimed to evaluate the effect of poultry manure amendment and foliar application of neem leaf extract on growth, yield, and pest management on three varieties of tomato in Port Harcourt.

**MATERIALS AND METHODS**

**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 Southern Nigeria. It lies between latitude 4.5 oN and longitude 7.0oE with an elevation of 18m above sea level. The climate of the area is tropics, with two seasons: wet (rainy) and dry seasons. The mean annual rainfall in Port Harcourt ranges from about 3,000mm to 4,500mm, annual temperature ranges from 22 oC to 29 oC 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 a cultivated farm, bulked to form a composite sample, air dried, and sieved using a 2mm mesh size. The routine analyses, as described in Udo *et* a*l*. (2009) for physical and chemical properties, were carried out on the soil sample. 10 kg of the soil sample was measured into plastic containers that were perforated at the base.

**Sources and Collection of Tomato Seeds, Poultry Manure, Neem 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, neem leaf were sourced from the Rivers State Teaching and Research Farm.

**Preparation and Applications of Poultry Manure, Neem Leaf Extract**

**3.5.1 Poultry manure**

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

**3.5.2 Neem Leaf Extracts**

Fresh leaves of neem were washed with tap water and then shade dried for seven days at room temperature 2± 270C. The dried leaves were milled into uniform powder. 500g of the dried powered neem 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 was filtered through cheesecloth about two times to separate the residues from the solution, a method adopted from Sale *et al*., 2015. Neem leaf extracts was sprayed at the rate of 30ml for each plant at two-week interval, starting from two weeks after germination to fruit maturity.

**Experimental Design**

The experiment (hoop-house pot experiment) was laid out as a Completely Randomized Design (CRD) with twelve treatments replicated three times. The treatments consist of milled neem 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.

**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-day interval. The Level of pest and disease infestation, number of flowers and fruits per plant, was counted, and the fresh fruit weight per plant were 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.

**RESULTS**

**Physical and Chemical Properties of the Soil before Planting**

The soil physicochemical properties are given in (Table 1) which showed that the soil of the study area is sandy loam and strongly acidic (pH=4.9) with low organic carbon (1.17%), 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 chemical composition of PM manure and neem leaf used for the study is presented in Table 1. It showed that the poultry manure had a pH value of 7.20, which is neutral, 36.80% organic matter organic carbon was 8.30%, 2.5% total nitrogen, available P 6.90 Mg/kg, while P, K, Na, Ca and Mg were 0.09, 0.12, 3.09 and 1.57 Cmol/kg, respectively.

**Table 1: Physical and Chemical Properties of the Soil before Planting**

|  |  |
| --- | --- |
| **Parameter** | **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 |

**Effect of Poultry Manure, Neem and Variety on the Growth of Tomato**

The result of the study presented on Tables 2 and 6 indicate that, there was significant difference among the varieties used in respect to the growth parameters; plant height, number of leaves at 4, 6 and 8 weeks after planting (WAP), percentage emergence, days to 50% flowering, number of days to flowering and fruiting. The values recorded for each of the varieties on plant height, number of leaves and branches increased as the week after planting (WAP) increased. The Jos variety showed the highest performance regarding these growth parameters at all sampling stages and the least performance was observed in the Beef variety. There was also a significant (P = 0.05) difference between the Jos variety, the RVF and beef varieties; however, the difference between RVF and Beef was not significant.

The application of poultry manure (20t/ha) significantly affected the vegetative growth parameters (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,) when compared to the control, Table 3 and 5.

Tables 3 and 5 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) increased with the foliar application of neem leaf extract. However, tomato plants sprayed with 10 litres of neem leaf extract performed better than the application of 5 litres of neem leaf concentration throughout the sampling with respect to the vegetative and yield characters, Table 3 & 5 the significant effect was effective at (0.05%) when compared to the control treatment. The lowest values were recorded on the untreated plants.

The results in Tables 3 and 5, indicate that the sole application of PM and neem leaf extract was effective on the growth of tomato; however, the combined application of PM (20t/ha) and Neem extract was better than the single application of these sources and the control. Maximum effect was recorded on the combined application of PM + NLE 10 at all growth stages, while the lowest value was recorded on the control treatment.

The result presented on Tables 4 and 7 showed that the interaction between PM, NLE, and varieties significantly (P = 0. 05) affected 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). The interaction effect of PM, NLE, both singly or combined and varieties indicates that varieties Jos and RVF significantly recorded the highest values than Beef. However, Jos recorded the best values for the RVF and Beef varieties. The data recorded also showed that the interaction between the treatments PM, NLE and varieties was effective as the WAP increased on plant height, number of leaves and branches.

**Table 2: Effect of Varieties on the Vegetative Growth of Tomato**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **VARIETIES** | **6WAP** |  |  | **8WAP** |  |  | **10WAP** |  |  |
|  | PH | NOL | NOB | PH | NOL | NOB | PH | NOL | NOB |
| **JOS** | 21.84a | 41.11a | 7.94a | 47.21a | 73.35a | 15.76a | 98.53a | 108.07a | 24.22a |
| **BEEF** | 20.15b | 37.98c | 6.74b | 44.19b | 70.33c | 14.69b | 91.75b | 104.94b | 22.89b |
| **RVF** | 20.27b | 38.65b | 6.87b | 44.08b | 71.09b | 14.54b | 92.02b | 105.11b | 23.00b |
| **LSD (0.05%)** | 0.1177 | 0.2121 | 0.1238 | 0.2343 | 0.2536 | 0.1699 | 0.4019 | 0.5000 | 0.1813 |

Note: Means that do not share the same letter on the same column are significantly different at Fisher’s 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 3: Effect of Poultry Manure and Foliar Spray Neem Leaf Extract on the Vegetative Growth of Tomato**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TREATMENTS** | **6WAP** |  |  | **8WAP** |  |  | **10WAP** |  |  |
|  | PH | NOL | NOB | PH | NOL | NOB | PH | NOL | NOB |
| **CON** | 17.19f | 24.52f | 3.67f | 36.79f | 42.78f | 7.52f | 72.90f | 71.89f | 10.89f |
| **PM** | 18.74e | 32.33e | 5.59e | 40.47e | 65.93e | 12.04e | 84.35e | 97.26e | 18.26e |
| **NLE 5** | 19.52d | 38.85d | 6.96d | 42.00d | 71.96d | 15.89d | 87.06d | 106.19d | 25.96d |
| **NLE 10** | 20.13c | 39.52c | 7.56c | 43.25c | 73.52c | 16.52c | 90.75c | 108.48c | 26.56c |
| **NLE 5 + PM** | 24.02b | 49.67b | 9.37b | 53.04b | 86.67b | 18.63b | 112.93b | 124.74b | 28.74b |
| **NLE 10 + PM** | 24.94a | 50.59a | 9.96a | 55.42a | 88.70a | 19.37a | 116.64a | 127.70a | 29.82a |
| **LSD (0.05%)** | 0.1665 | 0.2999 | 0.1750 | 0.3313 | 0.3586 | 0.2403 | 0.5684 | 0.7071 | 0.2564 |

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, NLE (5 & 10) = Neem 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 4: Interaction Effect of Poultry Manure, Neem 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 | 17.36j | 24.33l | 3.56j | 36.58ij | 42.22k | 7.44j | 72.13i | 71.67l | 10.67i |
|  | BEEF | 16.92j | 24.78l | 3.78j | 37.71i | 43.00k | 7.67j | 73.42i | 72.11l | 11.33i |
|  | RVF | 17.29j | 24.44l | 3.67j | 36.07j | 43.11k | 7.44j | 73.16i | 71.89l | 10.67i |
| **PM** | JOS | 20.02g | 35.00i | 6.33h | 43.04f | 68.56h | 12.89h | 89.34f | 101.44i | 19.67g |
|  | BEEF | 18.01i | 30.22k | 5.11i | 39.02h | 63.78j | 11.44i | 81.43h | 96.56j | 17.44h |
|  | RVF | 18.18i | 31.78j | 5.33i | 39.36h | 65.44i | 11.78i | 82.27h | 93.78k | 17.67h |
| **NLE 5** | JOS | 20.60f | 41.22e | 8.22f | 44.09f | 74.22e | 17.00f | 91.34e | 108.22f | 27.22e |
|  | BEEF | 18.97h | 37.11h | 6.22h | 40.93g | 70.33g | 15.22g | 84.87g | 105.00h | 25.22f |
|  | RVF | 18.99h | 38.22fg | 6.44gh | 40.98g | 71.33g | 15.44g | 84.96g | 105.33gh | 25.44f |
| **NLE 10** | JOS | 21.59e | 42.44d | 8.89e | 46.18e | 76.44d | 17.78ef | 97.02d | 111.44e | 27.89de |
|  | BEEF | 19.38h | 37.44gh | 6.78gh | 41.76g | 71.44fg | 15.78g | 87.51f | 106.33fgh | 25.78f |
|  | RVF | 19.43h | 38.67f | 7.00g | 41.82g  | 72.67f | 16.00g | 87.71f | 107.67fg | 26.00f |
| **NLE 5 + PM** | JOS | 25.34b | 51.33a | 10.00b | 55.69b | 88.33b | 19.33ab | 119.93a | 126.33bc | 29.44b |
|  | BEEF | 23.34d | 48.67c | 9.00de | 51.69d | 85.67c | 18.22cde | 109.38c | 123.89d | 28.33d |
|  | RVF | 23.37d | 49.00bc | 9.11cde | 51.73d | 86.00c | 18.33de | 109.47c | 124.00cd | 28.44cd |
| **NLE 10 + PM** | JOS | 26.14a | 52.33a | 10.67a | 57.71a | 87.78b | 20.11a | 121.42a | 129.33a | 30.44a |
|  | BEEF | 24.29c | 49.67bc | 9.56bcd | 54.02c | 88.00b | 18.89bcd | 113.98b | 126.78b | 29.22bc |
|  | RVF | 24.38c | 49.78b | 9.67bc | 54.53c | 90.33a | 19.11bc | 114.53b | 127.00ab | 29.78ab |
| **LSD (0.05%)** |  | 0.2883 | 0.5195 | 0.3032 | 0.5739 | 0.6211 | 0.4162 | 0.9844 | 1.2247 | 0.4441 |

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, NLE (5 & 10) = Neem 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.

**Effect of Poultry Manure, Neem Leaf Extract, and Variety on the Yield and Yield Components of Tomato**

The effect of variety on the number of flowers, fruits and fresh weight of fruits was presented in Table 6. There was a significant difference (P = 0.05) among varieties used with respect to the number and weight of fruits. The Jos variety produced the highest number of flowers (13.352), fruits (9.5741), and weight of fruits (2.1715 kg/ha). The lowest values were obtained from Beef variety [number of flower (12.148), number of fruits per plant (8.3333), and weight of fruits (1.9767 kg/ha)] and RVF [flower (12.796), number of fruits per plant (9.0741) and weight of fruits (2.0928 kg/ha)]. The values obtained from Roma VF and Beef were statistically similar.

The results shown in Table 5 indicate that poultry manure amendment significantly affected the number of flowers (10.630), fruits (5.704), and the fresh weight of fruits (3.4030 kg/ha). These results demonstrated a notable difference compared to the control, which had a number of flowers (8.704), a number of fruits per plant (3.481), and a fruit weight of 3.6559 kg/ha.

Table 5 showed that yield characters (number of flowers, fruits, and fresh fruit weight) were enhanced following the foliar application of neem leaf extract on tomato. Between the two levels of NLE, NLE 10 recorded the highest number of flowers, fruits, and fruit weight than NLE 5 (Table 5)

The results in Table 7 showed that the interaction of treatments and varieties had a significant effect on the yield parameters. This effect indicates that the varieties responded differently to the treatments. Jos varieties significantly produced more flowers, number of fruits and fresh fruit weight than RVF and Beef across all treatments singly and combined. However, the maximum number of flowers, fruits, and fresh fruit weight was observed in the treatment combination of NLE 10 + PM across all three varieties, while the control treatment recorded the lowest values with regard to the yield parameters across all three varieties.

**Table 5: Effect of Poultry Manure and Foliar Spray Neem Leaf Extract on the Yield and Yield Components of Tomato**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **TREATMENTS** | **NOFL** | **NOF** | **FW** | **DTF** | **DTFR** | **PE** | **PAD** |
| **CON** | 8.70f | 3.48f | 3.66f | 68.00a | 85.00a | 62.86f | 0.67a |
| **PM** | 10.63d | 5.74e | 3.40e | 64.67b | 78.67b | 71.27e | 0.41a |
| **NLE5** | 10.89d | 7.89d | 1.93d | 60.67c | 73.67c | 77.80d | 0.00b |
| **NLE10** | 12.15c | 8.93c | 1.67c | 58.19d | 71.67d | 82.40c | 0.00b |
| **NLE5+PM** | 16.59b | 13.41b | 1.16b | 56.67e | 69.67e | 89.83b | 0.00b |
| **NLE10+PM** | 17.63a | 14.56a | 0.66a | 55.26f | 68.07f | 93.50a | 0.00b |
| **LSD (0.05%)** | 0.2514 | 0.2562 | 0.0579 | 0.0807 | 0.0524 | 0.1339 | 0.1352 |

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, NLE (5 & 10) = Neem 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.

**Table 6: Effect of Varieties on the Yield and Yield Component of Tomato**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **VARIETIES** | **NOFL** | **NOF** | **FW** | **DTF** | **DTFR** | **PE** | **PAD** |
| **JOS** | 13.35a | 9.57a | 2.17a | 58.33c | 72.19c | 81.22a | 0.15a |
| **BEEF** | 12.15c | 8.33c | 1.98b | 62.50a | 76.43a | 77.32c | 0.22a |
| **RVF** | 12.80b | 9.07b | 2.09a | 60.89b | 74.76c | 80.29b | 0.17a |
| **LSD (0.05%)** | 0.1778 | 0.1811 | 0.0410 | 0.0571 | 0.0370 | 0.0947 | 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.

**Table 7: Interaction Effect of Poultry Manure, Neem Leaf Extract and Varieties on the Yield and Yield Component of Tomato**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **VAR** | **NOFL** | **NOF** | **FW** | **DTF** | **DTFR** | **PE** | **PAD** |
| **CON** | JOS | 8.67h | 3.44j | 0.65g | 68.00a | 85.00a | 62.34k | 0.44abc |
|  | BEEF | 8.78h | 3.56j | 0.68g | 68.00a | 85.00a | 63.90j | 0.89a |
|  | RVF | 8.67h | 3.44j | 0.65g | 68.00a | 85.00a | 62.34k | 0.67ab |
| **PM** | JOS | 11.00fg | 6.00i | 1.20f | 62.00e | 76.00d | 72.20h | 0.44abc |
|  | BEEF | 10.33g | 5.33i | 1.12f | 67.00b | 81.00b | 69.40i | 0.44abc |
|  | RVF | 10.56g | 5.78i | 1.156f | 65.00c | 79.00c | 72.20h | 0.33bc |
| **NLE5** | JOS | 11.56ef | 8.44fg | 1.75e | 58.00j | 71.00g | 80.60e | 0.00c |
|  | BEEF | 10.33g | 7.22h | 1.59e | 63.00d | 76.00d | 75.00g | 0.00c |
|  | RVF | 10.78fg | 8.00gh | 1.68e | 61.00f | 74.00e | 77.80f | 0.00c |
| **NLE10** | JOS | 13.44d | 10.11e | 2.12d | 55.44n | 69.00j | 86.10c | 0.00c |
|  | BEEF | 10.67g | 7.67gh | 1.69e | 60.56g | 74.00e | 77.80f | 0.00c |
|  | RVF | 12.33e | 9.00f | 1.98d | 58.56i | 72.00f | 83.30d | 0.00c |
| **NLE5+PM** | JOS | 17.00b | 14.00bc | 3.50b | 54.00o | 67.00l | 91.70b | 0.00c |
|  | BEEF | 15.89c | 12.56d | 3.26c | 59.00h | 72.00f | 86.10c | 0.00c |
|  | RVF | 16.89b | 13.67c | 3.44bc | 57.00l | 70.00i | 91.70c | 0.00c |
| **NLE10+PM** | JOS | 18.44a | 15.44a | 3.80a | 52.56p | 65.11m | 94.40a | 0.00c |
|  | BEEF | 16.89b | 13.67c | 3.52b | 57.44k | 70.56h | 91.70b | 0.00c |
|  | RVF | 17.56b | 14.56 b | 3.64ab | 55.78m | 68.56k | 94.40a | 0.00c |
| **LSD (0.05%)** |  | 0.4355 | 0.4437 | 0.1003 | 0.1398 | 0.0907 | 0.2319 | 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, NLE (5 & 10) = Neem 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.

**DISCUSSION**

“The pH value of the soil (pH=6.24) was within the pH range of 6–7 considered as suitable for optimum performance of vegetables” (Purselglove 1992). 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 of PM and NLE singly and in all combinations, which increased the selected growth parameters at all sampling stages.

The result of the study showed that the growth and yield parameters of the treated tomato varieties were enhanced following the application of poultry manure and neem leaf extract. Significant differences were recorded in all the treatments assessed in this trial. All the growth and yield parameters were found to increase as the week after planting increased. The differences in growth and yield parameters of the treated tomato plants may have resulted probably because of differences in plant nutrients in the rates of the treatments applied. The statistically similar values obtained in virtually all the parameters assessed under the control treatment could be attributable to the insufficient quantity of nutrients to stimulate the plant growth and yield, as several elements must be present in the soil for good crop production, and nutrients naturally found in soil are essential for the growth and yield of the plants. Also, the findings of Shuka and Naik (1993) showed that “tomatoes require nutrients such as N, P, K, Mg, Ca and 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”. Uzo (1971) also emphasized “the satisfactory balance of N, P, and K nutrient elements for the good production of tomato”.

From the values recorded, it was also observed that the Jos variety performed competitively better and responded better to the treatments applied more than the Roma VF and Beef varieties in all the parameters measured in this study. The differences observed among the varieties could be attributable to the genetic makeup of the individual variety, the adaptability of the varieties to the soil under study, as well as the nutrient content of the plant and animal extract used. For instance, Tripathi *et* *al*. (2013) reported “differences among varieties of chickpea in days to 50% flowering”. Also, Tesfahun *et* *al*. (2018) reported “differences in the growth and yield of two chickpea varieties to rates of blended fertilizer and row spacing”.

The results in table 3 to 7, showed that the application of “PM alone increased all vegetative growth (plant height, number of leaves and number of branches) and yield characters (number of days to 50% flowering, number of days to fruiting, numbers of flowers, fruits, and average fresh fruit weight) per plant over the control. This result could be because PM is easily decomposed as reported by Ismail *et al* 1988 or due to the microbial biomass of nitrogen as reported by” (Myroled, 1987; Bonde *et al*., 1988). “This could be possibly explained by the fact that the poultry manure improved the physical and biological properties of the soil and provided the macro and micro-nutrient requirements of the plants” (Abou El-Magd, Hoda, and Fawzy, 2005; Stephenson *et al.,* 1990), thereby increasing yield. The significant effect of PM in this study is similar to that obtained by Agyeman *et* *al.* (2014) on tomato. 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.

From the analysis in tables 2-9 the application of NLE significantly increased the vegetative growth and yield character of tomato varieties. Maximum vegetative growth and yield-related parameters per plant were higher in NLE 10 over NLE 5 at 6, 8 and 10 WAP across all varieties (Tables 3-7). From the observation in tables 8-.10, plants treated with neem aqueous extracts at 5 and 10 litres concentration, both single and in combination, produced higher yield over the control. The results also agree with the findings of Subbalakshmi (2012) that Neem application on crops helps to increase the yield.

“The performance of Neem leaf extract concentrations to improve tomato growth and yield characteristics in this study could be attributed to the high levels of N, P, K, Ca, and Mg delivered to the plants, as well as the availability of potential growth hormones in suitable amounts” (Kasarkar and Barge, 2016), and this is reflected in the significant increase of plant height, number of branches, number of leaves, number of days to 50% flowering, number of days to fruiting, number of flowers, fruit and fruit weight per plant over the control. This finding was also supported by Zhany *et al*. (2002), who reported that “Neem leaf and seed extracts enhanced nitrogen use efficiency in soils as well as increasing the yields of crops”. Also, Moyin-Jesu El (2012) reported that “the use of Neem leaf extract increased soil nutrients, growth, and yield parameters of tomato”. Okunlola and Ofuya (2013) conducted similar “research on the effects of *Azadirachta* *indica* and *Piper* *guineense* on jute growth and yield under single and mixed cropping”. “In comparison to the control, all growth indices improved, indicating that compounds having some qualities of hormones can stimulate or change biomass allocation in plants” (Andresen and Cedergreen, 2010).

Extracts from plants with medicinal properties contain saponins and polyphenols, which may be the active or main compounds responsible for the influence on plant growth and production as reported by Andresen and Cedergreen (2010). Gayatri and Rajani (2014) support the findings of this study, reporting that Neem-based formulations outperformed the control not only in terms of shoot height, number of leaves, number of buds, number of flowers and fruits, but also in terms of disease control (Tables 5-7).

The combined application of NLE and PM had the best growth and yield compared to the application of these sources alone and the control. However, the best performance was recorded on plants treated with NLE 10 + PM. “The significant difference in growth and yield of tomato plants treated with the combination of Neem leaf extract and poultry manure as compared with the control may also be attributed to the availability of the plant and animal nutrients in absorbable forms and at the required time as supplied” (Singh *et* *al*., 2004).

“The interaction of NLE, PM, and the varieties showed that the varieties responded differently to the treatments applied at all sampling stages. Jos variety treated with the combination of NLE and PM outperformed and responded better than the other varieties (RVF and Beef) in all 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” (Singh et al., 2004). For instance, Tripathi *et al*. (2013) reported “differences among varieties of chickpea in days to 50% flowering”. Also, Tesfahun *et* *al*. (2018) reported “differences in growth and yield of two chickpea varieties to rates of blended fertilizer and row spacing”. 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 (leaf infested) were only observed on the control treatment and on the sole application of PM. There was a significant difference between the treated plants and the control on the number of plants damaged by pests. The non-infestations of pests on plants treated by NLE could be attributed to reports that Neem extracts possess pesticidal and insecticidal properties” (Khan *et al.,* 1991). Similarly, the effect of foliar spray of neem leaf extract also fell in line with that of Pun *et* *al*. (2005), who reported that “treatment containing Azadirachtin significantly reduced the attack of okra pests and increased yield”. The results showed that use of neem products as bio-pesticides is highly effective against insects.

**CONCLUSION**

The study revealed the potential of the Neem leaf extract and poultry manure on growth and yield of three tomato varieties. The use of Neem extracts and poultry manure is a way to organic farming and an attempt to sustainable agriculture with less threat to the environment. The interaction between neem leaf extract, poultry manure, and tomato varieties significantly affected growth and yield parameters. The pronounced effects of NLE observed in the yield performance of tomato in this study were found to be concentration dependent because 10-litre concentration of NLE proved more effective as compared to 5-litre concentration. However, different concentrations of neem leaf extract in combination with poultry manure can be practiced for obtaining better yield. 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, based on the results recorded. 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 the study could be the reason for the differences observed among the varieties.

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