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Evaluation of the Effect of Plantain Peel and Tithonia Leaves as Nutrient Sources on the Performance and Mineral Accumulation of Tomato (*Solanum lycopersicum*)

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Abstract
Field experiments were conducted in 2019 and 2020 cropping seasons at the Teaching and Research Farms of Landmark University, Omu-Aran, Kwara State, Nigeria to determine the potentials of the application of different rates of plantain peel and *Tithomia diversifolia* (sole and combined) as organic amendments in comparison with the application of inorganic fertilizer. Treatments consist of two types of organic materials: - plantain peel (0, 10 and 20 t ha^{-1}), and *T. diversifolia* (0, 10, and 20 t ha^{-1}). In-organic fertilizer (NPK 20:10:10) was also applied for comparison. The treatments were arranged in a Randomised Complete Block Design. Parameters assessed were vegetative, yield and heavy metal composition of tomato fruits. Data collected were subjected to Analysis of Variance (ANOVA) using SAS Computer Package version 9.0 statistical software. Study revealed that, the combined application of plantain peel and *T. diversifolia* increased vegetative parameters which were comparable with the application of inorganic fertilizer. There was no significant difference between the yield responses of tomato to the application of NPK fertilizer and combined application of plantain peel and *T. diversifolia.* Higher rates of plantain peel and *T. diversifolia* leaves $P_{20}T_{20}(T_7)$ resulted in a significant drop in the vegetative parameters, but increased yield parameters which was statistically similar to the application of $P_{10}T_{10}(T_6)$. Application of NPK resulted in a significant reduction in the values for heavy metals. Accumulation of the heavy metals (Fe, Cu, Mn and Zn) in tomato fruits was lower than the recommended maximum tolerable levels as proposed by the Joint FAO/WHO Expert Committee on Food Additives. Application of $P_{10}T_{10}(T_6)$ is therefore recommended for the growth and yield of tomato in the agro-ecological zone without adversely increasing the heavy metal composition of the fruit.

Keywords: Tomato, Plantain peel, Tithonia leaves, Performance, Quality

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important fruit vegetables of the tropical region in the world belonging to the family Solanaceae (Jules, 2001). It is not only one of the most valuable horticultural crops but also important because of its economic and nutritional value. Tomato plays a very important role in human diet because it supplies some of the nutrients that are deficient in other food materials (Biwasi, 1999). Tomato fruits are rich in minerals and vitamins (Aboyeji *et al.*, 2018).

Application of organic manure supplies the required nutrients, improves soil structure, water holding capacity, porosity, bulk density, moisture retention, increases microbial population and maintains crop quality (Adeleye *et al.*, 2010). Organic fertilizers from plant and animal sources have the ability to improve the physical conditions of the soil via soil aggregation improvement, reduction of soil hydraulic conductivity, mechanical resistance and bulk density (Bhattacharyya *et al.*, 2007).

Tithonia diversifolia (Hemsl.) A. Gray is a species of flowering plant in the Asteraceae family that is commonly referred to as Mexican sunflower, tree marigold, Japanese sunflower or Nitobe chrysanthemum. It is native to Eastern Mexico and Central America, but has a nearly pan tropical distribution as an introduced species (USDA, 2011). It has shown great potential in raising the soil fertility in soils depleted in nutrients (Achieng *et al.*, 2007). In Southwest Nigeria, application of *T. diversifolia* significantly increased soil moisture content and reduced temperature irrespective of the tillage method (Agbede and Ogundele, 2015). *T. diversifolia*, just like other organic materials also contains substantial amounts of micronutrients (Reis *et al.*, 2018) and is hence regarded as a complete fertilizer. *T. diversifolia* increases yields of vegetables such as Celosia in Nigeria (Babajide *et al*., 2012). Yields of tomatoes increased by 130% with application of *T. diversifolia* compared to the control with no nutrient inputs in Cameroon (Ngosong *et al*., 2015).

Fruit peel wastes are accumulated in large quantities on daily basis at domestic and industrial levels. Most frequently, people remove fruit skin and throw away as waste. It is a vital issue, especially at industrial level that needs to be appropriately managed (Jariwala and Syed, 2016) to make the environment free from pollutants. Fruit peels are very rich in macro and micro nutrients that are indispensable for plant growth (Ibrahim *et al*., 2016). In Nigeria and many other parts of Africa, plantain (*Musa paradisiaca*) serves as a major staple food (Oladele and Khokhar, 2011). Plantains can be consumed in the unripe, fairly ripe, ripe and over-ripe stages. There is a large consumption rate of this crop in Nigeria, either as 'dodo' (fried ripe fruit), 'dodo Ikire' (from over-ripped fruit), chips (fried unripe fruit), or processed to produce plantain flour and local beer (Babayemi *et al*., 2009). The major wastes of plantain processing in Nigeria are their peels which account for about 40% of the total weight of fresh plantains and these peels are currently either used as fertilizer or discarded in many countries (Okorie, 2015).

Increasing interest in the recycling of organic materials as soil amendments has now raised concern about possible metal contamination from its use (Eun-Hye *et al*., 2010). Potentially harmful metal contents in soils may come not only from the bedrock itself, but also from anthropogenic sources like solid or liquid waste deposits, agricultural inputs, and fallout of industrial and urban emissions (Wilson and Pyatt, 2007). Excessive accumulation in agricultural soils may result not only in soil contamination, but also has consequences for food quality and safety. Laboratory determination of the nutrient elements of plantain peel and *T. diversifolia* revealed that they both contained nutrient elements in varying quantities suitable for the cultivation of tomato. The prospect of *T. diversifolia* as green biomass has been discovered by a number of researchers (Aboyeji *et al*., 2019), while there is scanty information on the recycling and reuse of plantain peel as organic material. The study was therefore conducted to determine the potentials of the application of different rates of plantain peel and *T. diversifolia* (sole and combined) as organic amendments in comparison with the application of inorganic fertilizer.

Materials and Methods

Experimental site

The experiment was carried out during the 2019 and 2020 growing seasons at the Teaching and Research Farm of Landmark University Omu-Aran, Kwara State. The site is located at Latitude 8° 8' 0"N and Longitude 5° 6'0"E which is 1000 m above sea level, in a derived savannah zone of Nigeria. The rainfall spans between April and October with peaks in May-June and September-October. The average annual rainfall is between 600 mm-1200 mm. The dry season extends from November to March.

Soil sampling and analysis

In order to determine some physical and chemical properties of the experimental field, pre-cropping soil samples were randomly taken at a depth of 0-15cm and bulked to obtain composite samples for laboratory analysis.

Sources of materials

Unripe plantain peel was collected from a plantain processing farm, Edidi, Kwara State, Nigeria. The peel was sun-dried for five days and milled. Fresh *T. diversifolia* leaves were obtained from the Teaching and Research Farm of Landmark University, Omu-Aran while inorganic fertilizer was purchased from a reputable agro-allied shop. The samples of both amendments were taken to the laboratory to determine their nutrient composition.

Experimental design and treatment combination

Treatments consist of two types of organic materials viz: - plantain peel (0, 10, and 20 t ha^{-1}), and *T. diversifolia* (0, 10, and 20 t ha^{-1}). In-organic fertilizer (NPK 20:10:10) was also applied for comparison. The treatments were arranged as follows in a Randomised Complete Block Design:-Control(T_1), $P_0T_{10}(T_2)$, $P_0T_{20}(T_3)$, $P_{10}T_0(T_4)$, $P_{20}T_0(T_5)$, $P_{10}T_{10}(T_6)$, $P_{20}T_{20}(T_7)$, and NPK(T_8)

Cultural practices

Field pulverization was carried out using a disc plough and harrow. Thereafter, the field layout was done to mark out the appropriate number of treatments per plot. The size of each plot in the experiment was 1.5 m x 1.5 m = 2.25 m^2 and there were 8 plots per replicate (2.25 m x 8 = 18 m^2) which was replicated four times. The size of the whole experimental plot was 18 m x 4 = 72 m^2.

Seed variety used and its characteristics

Copra F1 tomato variety was used for the experiment; it has a semi-determinate growth habit; resistant to fusarium wilt disease. It is known for its extended shelf life, very good vigour, fruit firmness and high productivity. It is also very popular for processing into cans and tomato paste.

Seed Sowing/Transplanting

Seedlings were raised inside the screen house using a germinating tray and sterilized soil as nursery media. Each groove of the germinating tray was filled to ¾ capacity and slightly covered the remaining ¼ with the nursery media after seed sowing. The trays were placed on a raised platform thereafter to improve drainage and reduce the incidence of water logging. Six vigorous and disease-free seedlings were transplanted on each raised bed twenty-one days after sowing. Inter and intra-row spacing of 1 m x 0.5 m were used to give a plant population of 26, 667 plants ha^{-1}.

Laboratory analysis of dried plantain peel and T. diversifolia leaves

Analysis of the amendments used for the experiments was carried out to determine their nutrient compositions. The analysis was done for organic carbon (OC), pH total N, P, K, Ca, Mg, Cu, Mn, Zn, and Na (AOAC, 2003).

Application of amendments and weed control

Plantain peel and *T. diversifolia* leaves were applied two weeks before transplanting for mineralization to take place. The application rate for the two amendments was 0, 10, and 20 t ha^{-1} which is equivalent to 0, 18, and 32 kg $plot^{-1}$. Inorganic (NPK 20:10:10) fertilizer was applied at the rate of 120 kg NPK ha^{-1} two weeks after sowing by side placement 8 cm away from the base of the plant. Pre-emergence herbicide (Xtra-force) was applied at the rate of 2.5 kg a.i ha^{-1} two weeks before transplanting and was supplemented with manual weeding at 6 and 10 weeks after transplanting.

Harvesting

Harvesting was carried out on mature and ripe fruits at an interval of 3 days for 2 weeks before the termination of the experiment. Harvested fruits were weighed, recorded and a sample of each treatment was taken to the laboratory for heavy metal determination.

Observation and data collection

During the experimental study, the following parameters were collected and measured - plant height, number of leaves, number of branches, yield parameters, and heavy metal composition of tomato fruits.

Laboratory determination of heavy metals in tomato fruits

Representative tomato fruit samples were taken per plot and per replicate to analyze for the levels of heavy metals contained in the fruit at the crop and soil laboratory of Landmark University, Omu-Aran, Nigeria. Mature fresh tomato fruits were collected, oven-dried for 24 hours at 80°C, and ground in a Willey mill. Mineral elements were determined according to the methods as recommended by the Association of Official Analytical Chemists (AOAC, 2003). One gram (1 g) of each sample was digested using 12 cm^3 of the mix of HNO_3, H_2SO_4, and $HClO_4$ (7:2:1 v/v/v). Contents of Fe, Mn, Cu, and Zn were determined by an atomic absorption spectrophotometer.

Statistical analysis

Data obtained from these studies were subjected to statistical analysis of variance (ANOVA) using SAS computer package version 9.0 (SAS Institute, 2002) statistical software. Significant treatment means were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

Results

Initial Soil Properties

The results of the laboratory analysis of the soil before planting are shown in Table 1. The soil pH was strongly acidic, with a textural class of sandy loam. It was deficient in organic matter and nitrogen which are the major determinants of soil fertility in tropical soils. The available phosphorus was not adequate, and the exchangeable potassium was moderate, while the exchangeable Ca was low and the Na and Mg are all in suitable quantity.

Chemical composition of T. diversifolia leaves and dried Plantain peel

Table 2 shows that *T. diversifolia* leaves had varying quantities of nutrients, it had higher values for N and Mg compared to plantain peel. However, dried plantain peel had higher values for P, K, Ca, Na, Fe, Mn, Cu, Cr, and Zn.

Vegetative parameters

The results of the vegetative parameters of tomato in 2019 and 2020 are presented in Table 3. The effects of treatments were found to be statistically significant on the vegetative parameters in both years of study. The highest values for plant height and number of leaves were archived in plots treated with in-organic fertilizer, values of which were statistically similar to plant treated with $P_{10}T_{10}(T_6)$. The number of branches increased significantly in all plots treated with plantain peel when compared with plots treated with *T. diversifolia.* Other treatments gave varying values for all the vegetative parameters with the unfertilized plots having the least values.

Yield parameters

The results of the ANOVA on the yield and yield parameters of tomato in 2019 and 2020 showed that treatments had effects on these traits (Table 4). In both years, the highest values for the number of fruits/ plant, the weight of fruits/plant and yield were observed in the inorganic treatment, followed by the application of $P_{10}T_{10}(T_6)$, and $P_{20}T_{20}(T_7)$. The difference between $P_{10}T_{10}(T_6)$, $P_{20}T_{20}(T_7)$ and $NPK(T_8)$ was not significant. Values obtained from $P_{10}T_{10}(T_6)$, $P_{20}T_{20}(T_7)$ and $NPK(T_8)$ were significantly higher than values obtained from other treatments. The least value for all the parameters was obtained in the control plots.

Mineral accumulation

The results of the present study indicated that the effects of all the treatments were significant on all the heavy metals analysed except Mn (Table 5). All treatments containing plantain peel recorded higher and statistically similar values for Fe, Cu and Zn. There was no significant difference in the values for Fe, Cu and Zn in the control plots and when inorganic fertilizer was applied. Concentrations of Fe, Mn, Cu and Zn were all below the recommended limits as suggested by the Joint FAO/WHO Expert Committee on Food Additives (JEFCA, 2010).

Discussion

Results obtained from the laboratory analysis of the physical and chemical properties of the soil prior to planting suggested that the soil used for the experiment was relatively low in nutrients, therefore, rapid response of the test crop to the applied amendments could be attributed to the fertility status of the soil prior to planting. The low nutrient content of the experimental soil is a general characteristic of most Alfisols of the derived savannah zone of Nigerian which indicated that the soil could not be cropped profitably without application of amendments for optimal productivity (Shehu *et al*., 2018). There were positive effects of the application of plantain peel, *T. diversifolia*, and NPK on the vegetative parameters in both years of study. Combined application of plantain peel and *T. diversifolia* increased vegetative parameters which was comparable with the application of inorganic fertilizer. Increased vegetative parameters as a result of combined application of plantain peel and *T. diversifolia* could be attributed to low C: N ratio, high nitrogen and moisture content of *T. diversifolia* leading to early mineralization and fast release of nutrients. This result is in line with the findings by Agbede *et al.* (2013) where they found that *T. diversifolia* leaves have low C: N ratio leading to their faster mineralization thereby allowing for increased vegetative and yield performance of cocoyam. Increased vegetative parameters could also be attributed to the integrated application of plantain peel and *T. diversifolia* leading to increased availability of soil nutrients. Aboyeji *et al*. (2019) found that incorporating green manures increased the availability of soil for OM, N, P, K and Mg in the soil which invariably had a positive effect on radish vegetative parameters. Organic manure provides essential nutrients to crops when decomposed and also act as soil conditioners (Makinde *et al*., 2007). Increase in yield and yield parameters of tomato under NPK fertilizer compared to other treatments may be due to the fact that NPK fertilizers are made up of nutrients in their mineralised forms that are readily available for plant absorption. This result is similar to the findings of Isah *et al*. (2014) where they found that higher response of tomato to yield might be due to the availability of essential elements from inorganic fertilizer. There was no significant difference between the yield responses of tomato to the application of NPK fertilizer and combined application of plantain peel and *T. diversifolia.* Increased yield and yield parameters as a result of combined application of plantain peel and *T. diversifolia* could be that the nutrients contained in the organic amendments were sufficient to nourish the crop. It could also be attributed to the availability of micronutrients contained in the plantain peel. Aboyeji *et al*. (2019) found that incorporating green manures and agricultural wastes increased the availability of OM, N, P, K and some micronutrients for soil which invariably had a positive effect on radish vegetative and yield parameters. Banana and plantain waste materials are rich in nutrient and minerals (Clarke, 2008). The findings of this study also revealed that integrated use of plantain peel and *T. diversifolia* was found to be better than using each alone. Chemical composition of *T. diversifolia* leaves and dried plantain peel showed that plantain peel contained higher concentrations of P, K, Ca, Na, Fe, Mn, Cu, Cr, and Zn than *T. diversifolia* leaves. Nitrogen and Mg are deficient in plantain peel and this has been provided by the application of *T. diversifolia* leaves. Soil pollution by heavy metals is of great concern to public health (Goyer, 1996). The source of heavy metal in plant is the environment in which they grow and their growth medium (soil) from which heavy metals are taken up by roots or foliage of plants (Okonkwo *et al*., 2005). Plants grown in polluted environment can accumulate heavy metals at high concentration causing serious risk to human health when consumed. Moreover, heavy metals are toxic because they tend to bio-accumulate in plants and animals, bio-concentrate in the food chain and attack specific organs in the body (Akinola *et al.,* 2008). The concentration of Fe, Cu, and Zn increased with increasing levels of plantain peel. Laboratory analysis of plantain peel showed that it contained higher levels of the heavy metals than the *T. diversifolia.* In their experiment, Okorie *et al*. (2015) found that unripe plantain peel contains sizable amount of heavy metals. The results of the study indicated that values of heavy metal composition obtained on the application of plantain peel, *Tithonia diversifolia* and NPK showed that they were all below the permissible level as stipulated by the Joint FAO/WHO Expert Committee on food additives to ensure the safety of the consumers (2010).

Conclusion

The study revealed that combined use of plantain peel and *T. diversifolia* leaves had positive effects on growth and yield of tomato. Application of NPK fertilizer gave higher values for vegetative, yield and yield parameters and the effects were comparable with the application of combined plantain peel and *T. diversifolia* leaves. Higher rates of plantain peel and *T. diversifolia* leaves ($P_{20}T_{20}(T_7)$) resulted in a significant drop in the vegetative parameters but it increased yield parameters which was statistically similar to the application of $P_{10}T_{10}(T_6)$. Based on the findings of this study, application of $P_{10}T_{10}(T_6)$ and $P_{20}T_{20}(T_7)$ favourably competes with NPK fertilizer. Therefore, considering the fact that inorganic fertilizer has associated problems such as high cost of purchase, scarcity, leaching, volatilization, environmental unfriendliness, application of plantain peel and *T. diversifolia* leaves ($P_{10}T_{10}(T_6)$) is therefore recommended in the agro-ecological zone without adversely increasing the heavy metal composition of tomato fruit.

References

Aboyeji, C. M., Adekiya, A. O., Dunsin, O., Agbaje, G. O., Olugbemi, O., Okoh, H. O. and Olofintoye, T. A. J. (2019). Growth, yield and vitamin C content of radish (Raphanus sativusL.) as affected by green biomass of Parkia biglobosa and Tithonia diversifolia. *Agroforestry Systems*, 93: 803–812, https://doi.org/10.1007/s10457-017-0174-6

Aboyeji, C. M., Adekiya, A. O., Dunsin, O., Agbaje, G. O., Olofintoye, T. A. J., Olugbemi, O. and Okunlola, F. O. (2018). Performance, some nutrient elements and heavy metals accumulation in tomato under soil applied poultry manure, NPK and Zn SO_4 fertilizers. *Agriculturae Conspectus Scientificus,* 83: (4): 299-305.

Achieng, J. O., Ouma, G., Odhiambo, G. and Muyekho, F. (2007). Effect of *Tithonia diversifolia* (Hemsley) and inorganic fertilizers on maize yield on alfisols and ultisols of western Kenya. *Agriculture and Biology Journal of North America,* 1(5):740–747.

Adeleye, E. O., Ayeni, L. S. and Ojeniyi, S. O. (2010). Effect of poultry manure on soil physico-chemical properties, leaf nutrient contents and yield of yam *(Dioscorea rotundata)* on Alfisol in Southwestern Nigeria. *Journal of American Science*, 6(10): 871–878.

Agbede,,T. M. and Ogundele, J. O. (2015). Effect of Tillage Systems and *Tithonia diversifolia* Mulch on Soil Physical and Chemical Properties, Growth and Cocoyam Yield in a Tropical Alfisol. *British Journal of Applied Science and Technology*, 7:483-495.

Akinola, M. O., Njoku, K. L. and Ekeifo, B. E. (2008). Determination of lead, cadmium and Chromium in the tissue of an economically important plant grown around a textile industry at Ibeshe, Ikorodu Area of Lagos State, Nigeria. *Advances in Environmental Biology,* 2(1): 25–30.

AOAC (2003). Official methods of analysis of the Association of Official's Analytical Chemists, 17th edn. Association of Official Analytical Chemists, Arlington, Virginia.

Babajide, P.A., Akanbi, W.B.B., Olabode, O.S., Olaniyi, J.O. and Ajibola, A.T. (2012). Influence of pre-application handling techniques of *Tithonia diversifolia* Hemsl. A. Gray residues on sesame, in south-western Nigeria. *Journal of Animal and Plant Sciences,* 15: 2135-2146.

Babayemi, O.J., Khadijah, T.D., Abideen, A.A.K. and Davies, O.N. (2009). Determination of Potash alkali and metal Contents of ashes obtained from peels of some varieties of Nigeria Grown Musa species. *Bioresources*, 5: 1384-1392.

Bhattacharyya, R., Chandra, S., Singh, R. D., Kundu A, S., Srivastva, K. and Gupta, H. S. (2007). Long-term farmyard manure application effects on properties of a silty clay loam soil under irrigated wheat–soybean rotation. *Soil and Tillage Research,* 94(2):386-396.

Biwasi, E. C. (1999). Cumulative effect of different level of manure on the physical properties of soil, *Journal of Indian Soil Science,* 19:31-33.

Clarke, W.P., RadidgLaiTE, P., Jensen, P.D. and, Hardin, M.T. (2008). Digestion of waste banana to generate energy in Ausralia. *Waste Management*, 28:527-533.

Eun-Hye, L., Hye-Jung, Y., Mi-Sun, H. and Dong-Ho, B. (2010). Development of banana peel Jelly and its antioxidant and textural properties. *Food Science Biotechnology*, 19: 449-455.

Goyer, R.A. (1996). Toxic and essential metal interaction. *Annual Review of Nutrition,* 17**:**37–50.

Ibrahim, U. K., Kamarrudin, N., Suzihaque, M. U. H. and Hashib, S. A. (2016). Local fruit wastes as a potential source of natural antioxidant: an overview. IOP Conference Series: *Materials Science and Engineering*, 206: 1-3. https://doi.org/10.1088/1757-899x/206/1/012040

Isah, A. S., Amans, E. B., Odion, E. C. and Yusuf, A. A. (2014). Growth Rate and Yield of Two Tomato Varieties (*Lycopersicon esculentum Mill*) under Green Manure and NPK Fertilizer Rate Samaru Northern Guinea Savanna. *International Journal of Agronomy*, Article ID 932759, 8pp. https://doi.org/10.1155/2014/932759.

Jariwala, H. J. and Syed, H. S. (2016). Study on use of fruit peels powder as a fertilizer. National Conference on Recent Advances in Environmental Science and Engineering Technologies. Pp. 1-3.

JECFA (2010). Joint FAO/WHO Expert Committee on Food Additives, Evaluation of certain food additives, 59 Report of the Joint FAO/WHO Expert Committee on Food Additives, World Health Organization, Geneva, Switzerland.

Jules, J. (2001). Horticulture Review, Oxford University Press Ltd., United State of American. Pp. 240-296.

Makinde, E. A., Ayoola, O. T and Akande, M. O. (2007). Effects of organo-mineral fertilizer application on the growth and yield of egusi melon. *Australian Journal of Basic and Applied Science*, 1(1): 15-19.

Ngosong, C., Mfombep, P. M., Njume, A. C. and Tening, A. S. (2015). Integrated Soil Fertility Management: Impact of *Mucuna* and *Tithonia* biomass on tomato (*Lycopersicon esculentum* L.) Performance in smallholder farming systems. *Agricultural Sciences*, 6: 1176-1186.

Oladele, E. and Khokhar, S. (2011). Effect of domestic cooking on the polyphenolic content and antioxidant capacity of plantain (Musa paradisiaca). *World Journal of Dairy & Food Sciences*, 6: 189-194.

Okorie, D.O., Eleazu, C. and Nwosu, P. (2015). Nutrient and Heavy Metal Composition of Plantain (*Musa paradisiaca*) and Banana (*Musa paradisiaca*) Peels. *Journal of Nutrition and Food Science* 5: 370. doi:10.4172/2155-9600.1000370

Okonkwo, N. C., Igwe, J. C. and Onwuchekwa, E. C. (2005). Risk and health implications of Polluted soils for crop production. *African Journal of Biotechnology*, 4(13): 1521– 1524.

SAS (2002). Statistical Analysis Software. User's Guide: Statistics Version 9.00 for windows. SAS Institute, Inc., Cary, North Carolina.USA; 2002.

Shehu, B. M., Merckx, R., Jibrin, J. M., Kamara, A. Y. and Rurinda, J. (2018). Quantifying Variability in Maize Yield Response to Nutrient Applications in the Northern Nigerian Savanna. *Agronomy*, 8(2): 18. https://doi.org/10.3390/agronomy8020018

USDA (2011) *Tithonia diversifolia* (Hemsl.) A. Gray"Germplasm Resources Information Network.

Wilson, B. and Pyatt, F. B. (2007). Heavy metal dispersion, persistence, and bioaccumulation Around an ancient copper mine situated in Anglesey, UK. *Ecotoxicology and Environmental Safety*, 66: 224-231.

Table 1: Soil physical and chemical properties prior to planting (0-15 cm)

	Values	
Parameters	**2019**	**2020**
Sand %	76.22	76.00
Silt %	12.44	12.36
Clay %	11.34	11.64
Textural class	Sandy loam	Sandy loam
pH (H_20) 1:1	5.29	5.23
Total N (%)	0.17	0.15
Organic Carbon (%)	1.28	1.24
Exchangeable Bases		
K (cmol/kg)	0.23	0.22
Na (cmol/kg)	0.67	0.64
Ca (cmol/kg)	1.28	1.27
Mg (cmol/kg)	1.28	1.16
ECEC (cmol/kg)	5.73	5.70
Available Phosphorous	15.2	15.0
Zn (mg kg^{-1})	0.45	0.45

Table 2: Chemical composition of *T. diversifolia* leaves and dried plantain peel

Nutrient (mg kg^{-1})	**N**	**P**	**K**	**Ca**	**Mg**	**Mn**	**Na**	**Fe**	**Zn**	**Cu**	**Cr**	**C:N**
T. diversifolia	1.80	0.65	0.05	0.14	0.004	0.002	0.11	0.22	0.038	ND	ND	7.76
Plantain peel	0.37	57.10	1.84	1.62	0.0012	1.12	1.28	0.81	0.11	0.60	0.48	14.45

ND - Not Detected

Table 3: Effects of application of *T. diversifolia* leaves, dried Plantain peel and NPK fertilizer on the vegetative parameters of tomato in 2019 and 2020 farming seasons

	2019			2020		
Treatments ($t\ ha^{-1}$)	**Plant height**	**Number of leaves**	**Number of branches**	**Plant height**	**Number of leaves**	**Number of branches**
Control(T_1)	32.90d	6.00c	11.50c	32.00c	5.83c	10.17c
$P_0T_{10}(T_2)$	52.70b	10.00b	14.00b	44.58b	9.00b	14.50b
$P_0T_{20}(T_3)$	53.80b	10.50b	15.00b	59.33a	10.33b	14.17b
$P_{10}T_0(T_4)$	44.95c	11.00b	19.50a	42.93b	10.50b	17.83a
$P_{20}T_0(T_5)$	46.85c	11.00b	20.50a	43.33b	10.50b	18.67a
$P_{10}T_{10}(T_6)$	60.05a	14.50a	19.50a	60.17a	12.50a	18.67a
$P_{20}T_{20}(T_7)$	54.95b	12.00ab	18.50a	44.50b	10.33b	17.33a
NPK(T_8)	61.23a	13.50a	18.50a	60.50a	10.67a	18.33a

Means followed by the same letter(s) are not significantly different from each other at 5% level of probability

Table 4: Effects of application of dried Plantain peel, T. diversifolia leaves and NPK fertilizer on yield of tomato in 2019 and 2020 farming seasons

	2019			2020		
Treatments ($t\ ha^{-1}$)	**Number of fruits /plant**	**Weight of Fruits/plant (g)**	**Yield kg/ha**	**Number of fruits / plant**	**Weight of Fruits/plant (g)**	**Yield kg/ha**
Control(T_1)	4.50c	117.40d	3130.59d	6.00c	125.20c	3338.58c
$P_0T_{10}(T_2)$	21.00b	415.50c	11079.72c	18.00b	420.30b	11207.70b
$P_0T_{20}(T_3)$	22.00b	425.80c	11354.38c	20.00b	435.80b	11621.04b
$P_{10}T_0(T_4)$	21.00b	510.10b	13602.33b	21.00b	480.90b	12823.68b
$P_{20}T_0(T_5)$	24.00ab	537.70b	14284.98b	23.00b	485.80b	12954.34b
$P_{10}T_{10}(T_6)$	28.00a	674.50a	17986.22a	30.00a	693.50a	18492.87a
$P_{20}T_{20}(T_7)$	29.00a	696.90a	18583.54a	28.00a	698.00a	18612.87a
NPK(T_8)	30.00a	700.10a	18668.87a	32.00a	715.00a	19066.19a

Means followed by the same letter(s) are not significantly different from each other at 5% level of probability

Table 5: Effects of application of *T. diversifolia* leaves, dried Plantain peel and NPK fertilizer on mineral accumulation (mg kg^{-1}) of tomato in 2019 and 2020 farming seasons

Treatments (t ha^{-1})	2019 Fe	Mn	Cu	Zn	2020 Fe	Mn	Cu	Zn
Control(T_1)	0.42d	0.001a	0.82b	0.46c	0.41c	0.002a	0.60c	0.49c
P_0T_{10}(T_2)	0.55c	0.001a	0.85b	0.48b	0.50b	0.001a	0.78b	0.52b
P_0T_{20}(T_3)	0.57c	0.001a	0.85b	0.51b	0.52b	0.001a	0.80b	0.56b
$P_{10}T_0$(T_4)	0.79b	0.001a	1.00a	0.65a	0.80a	0.002a	0.99a	0.67a
$P_{20}T_0$(T_5)	0.89a	0.001a	1.10a	0.66a	0.87a	0.002a	1.12a	0.67a
$P_{10}T_{10}$(T_6)	0.87a	0.001a	1.30a	0.66a	0.86a	0.002a	1.10a	0.67a
$P_{20}T_{20}$(T_7)	0.87a	0.001a	1.33a	0.68a	0.80a	0.000a	1.15a	0.69a
NPK(T_8)	0.45d	0.001a	0.86b	0.46c	0.42c	0.001a	0.62c	0.49c
WHO Permissible limit	425	500	10.00	99.4	425	500	10.00	99.4

Means follwed by the same letter(s) are not significantly different from each other at 5% level of probability