Comparing the Effect of Poultry Manure and Inorganic Fertilizer Rates On Growth and Leaf Yield of Moringa Grown in Zaria.

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Abstract
Experiments were carried out in 2018 and 2019 rainy season at the Teaching and Research Farm of Nuhu Bamalli Polytechnic, Zaria (latitude 11° 11' N) and (longitude 07^{0} 38'E) Kaduna State. The treatments consisted of four levels of Poultry manure (PM) (10, 15, 25 and 35 tonnes ha $^{-1}$) and four levels of NPK 15-15-15 Inorganic Fertilizer (IF) rates (0, 60, 120 and 170 Kg ha $^{-1}$) laid out in Randomised Complete Block Design replicated three times. Soil samples at depth of 0–15 cm and 15–30 cm were collected and analysed for physical and chemical properties using the standard procedure method of soil analysis. Recommended agronomic practices were carried out timely and data were collected to evaluate various growth and yield parameters of moringa (height, stem diameter, branches, fresh and dry weight etc.). Analysis of Variance and Means Separations were carried out by Duncan Multiple Range Tests. The results show a positive and significant correlation between crop leaf yield and growth parameters. Application of 35 tonnes ha $^{-1}$ of PM gives the highest plant height (32.60 cm), stem diameter (3.73 cm), total fresh leaf weight (1.84 kg) and total dry leaf weight (1.29 kg). The least growth and leaf weight of moringa was obtained with application of 60 kg ha -^{1} of NPK fertilizer. Application of 35 tonnes ha $^{-1}$ of PM is recommended for sustainable leaves and dry matter production of moringa in Zaria.

Key Words: Moringa, Poultry manure, NPK 15-15-15 fertilizer, Growth and Yield

INTRODUCTION

Moringa, (*Moringa oleifera* LAM), a perennial shrub of the family Moringaceae is the most widely cultivated species among the 13 different species of Moringa with about 8 species being endemic to the horn of Africa (Grubben and Denton, 2014). The shrub has several common names (drumstick tree, miracle tree, horseradish tree, etc.). It originated in India and Pakistan but it is now widely grown in the tropics and sub-tropics, including many African Countries (Kalb and Kuo, 2002). It is an exceptionally nutritious crop with a variety of potential uses since (roots, leaves, stems, etc.) are beneficial to humanity (Howard, 2009).

Moringa thrives in a wide range of environmental conditions. It grows best at temperature of 25 – 35 ^{0}C, drought tolerant, needs an annual rainfall of 250 – 1500m, and altitude of about 600m - 1,200 m in the tropics. Moringa prefers a well-drained sandy loam or loamy and clay soil with good drainage and tolerates a soil pH of 4.5 – 9.0 (Palado and Chang, 2001). Moringa is one of the most useful tropical trees. India is the largest producer of moringa with an annual production of 1.1 – 1.3 million tons of tender fruits from an area of 300 km^{2}. For fresh green matter production, the tree can be cut every 33 – 40 days or 6 – 8 months for fibres production. At a density of 1,000,000 plants ha $^{-1}$ (10 x 10cm) with adequate fertilization and irrigation, and nine cuttings/year, yield of 45 tons ha^{-1} can be obtained during the dry season to as high as 115 tonnes ha $^{-1}$ in the raining season (Foidl *et al*, 2011).

Moringa is one of the world's most nutritious crops and has been used to combat malnutrition among infants and nursing mothers using the leafy vegetables

(Awwalu, 2018). It provides both high protein content and protein quality to meet the estimated amino acids requirements pattern of protein for children of age 2 – 5 years (Kalbi and Kuo, 2002).
The crop is promising as a food source in the tropics during the dry season when other foods are typically scarce. The leaf can be eaten fresh, cooked or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value. The leaves are good source of proteins, Vitamin A, B, and C and minerals such as Calcium and Iron. The leaves contain about 22 – 35 % proteins together with all essential amino acids and is high in sulphur containing amino acids methionine, cysteine and carbohydrates of varying levels. It has more vitamin A and beta – carotene than carrots, more Ca than milk, more Fe than spinach, more vitamin than orange, more K than banana, more protein than pears (Farley, 2005; Kalb and Kuo, 2002).

Moringa is very useful as green manure, as a live fencing crop to demarcate boundaries of farmlands, plots and houses, as a raw material or an ingredient in pharmaceutical industries for the production of drugs, syrups, cosmetics and as a food component that aid lowering of Blood Pressure among the patients with cardiac problems. Moringa serve as a good material for mulching of soils in gardens and nurseries to minimised effects of soil and wind erosion particularly in the Savannah Ecological Zones of Nigeria. Despite all these benefits and potentials of moringa farmers in Zaria do not pay much attention to the production and processing of this promising crop hence the growth and yield of moringa is low or very poor as such the crop is not intensively cultivated for domestic or commercial uses. If given due attention, moringa will be a promising source of nutrients and income to the farmers. Poultry manure and NPK 15-15-15 fertilizer are among the richest concentrated source of nutrients to be applied in order to boost luxuriant growth of the crops. There is need for a cheap and affordable source of proteins, minerals and vitamins rich vegetable for the majority of Nigerians. When properly handle and used Poultry manure can serve as an excellent source of plant nutrients for moringa.

Although moringa can thrive in Zaria but still how to grow it best is far uncertain. Therefore, there is need to evaluate the most economically viable and easy ways of obtaining nutrient rich food substances for the poor rural and urban dwellers. *M. oleifera* could be promising if given due attention. The crop received inadequate professional horticultural attention and has not been subjected to formal comparative trials (NRC, 2006). Application of optimum level of both organic and inorganic fertilizers that will enhance optimum yield of moringa is lacking or insufficient especially in NGS zones where native soil fertility is lacking. Most of the essential nutrients needed by the plants were reported to be insufficient.

Among all the sources of organic matter used in crop production, poultry manure has been reported as one of the richest nutritionally and most concentrated form of farm manure (Yayock & Awoniyi, 1974; Sharifai, 2012). The use of organic matter in crop production on cereals and legumes by subsistence farmers all over the world has been emphasized. Little or no report is available on the effect of organic manure on growth and leaf yield components of moringa. There is need therefore to explore into the most favourable conditions for cultivating this crop that can thrives well under different ecological conditions but whose optimal requirements / limits are not known (NRC, 2006). It is essential to determine the level of poultry manure and NPK 15-15-15 fertilizer rate for the growth and yield of moringa in Zaria, Kaduna State, Nigeria. It is believed that such findings will be useful to farmers, extension workers and researchers. The research is

designed to achieve two main objectives; to determine the effects of poultry manure on growth and leaf yield of moringa in Zaria and to determine the effects of NPK 15-15-15 fertilizers on growth and leaf yield of moringa in the study area.

MATERIALS AND METHOD

Experimental Site: Field experiment was conducted during the 2018 and 2019 rainy seasons at Teaching and Research Farm of Nuhu Bamalli Polytechnic. Zaria which is located at latitude (11^0 11'N) and longitude (07^0 38'E) and 680 meters above sea level in Zaria in the Northern Guinea Savannah (NGS) Zone of Nigeria.

Soil Analysis: *S*oil samples were randomly collected at the depth of 0-15 cm and 15 - 30 cm from the experimental site. The samples were bulked, then air-dried, sieved through a 2 mm mesh and analysed for physical and chemical properties using standard procedure as described by (Black, 1965).

Meteorological Data: Data on rainfall, temperatures, relative humidity and solar radiation were collected from meteorological station of Institute for Agricultural Research (IAR). Ahmadu Bello University (ABU), Zaria for 2018 and 2019 rainy seasons.

Chemical Analysis of Poultry Manure: The sample of PM to be used in the site was collected and sent for Laboratory analysis to determine both its physical and chemical properties. The Proximate Analysis determines the levels of Total N, Available P, K and pH using Kjeldahl method, Bray and Kurtz – dry-ashing and pH meter methods respectively. This analysis is necessary prior to PM application since the result will indicate the level of pH, organic carbon, P, K, Ca and Mg. The pH is by using saturated paste; Organic carbon by a modified Walkley - Black method (Nelson and Sommers, 1996); Available P by Bray 2 method (Olsen and Sommers, 1982); Exchangeable Ca, Mg and K by using Ammonium acetate ($NH_4CH_3CO_2$), pH 7 extract and an atomic absorption spectrophotometer method. (AOAC, 1990).

Treatments and Experimental Design: The treatments consisted of four (4) levels of NPK 15-15-15 fertilizer rates (0. 60. 120 and 170 kg ha $^{-1}$) and four (4) levels of poultry manure (10. 15. 25 and 35 tonnes ha $^{-1}$). The treatments were laid out in a Randomised Complete Block Design (RCBD) replicated three (3) times. The plot size measured 3m x 3m with a gross plot of eight (8) rows and three rows net plot. An alley of 1m by 0.5m was left between the plots.

Agronomic Practices: The field was cleared, ploughed and harrowed. Two weeks prior to land preparation, herbicide was applied to control weeds infestations. Two (2) seeds were sown per hole at a depth of 2 cm and later thinned to one seedling per stand at 2 WAS. The plants were spaced at 20 cm x 50 cm. Poultry manure was broadcasted a week prior to the establishment at varied rates of trials while NPK 15-15-15 fertilizer was applied per treatment. Incidence of pests and diseases were not observed throughout the experimental periods. Three **(**3) manual weeding were carried out at 3, 5 and 8 WAS. The plants were harvested at three weeks intervals during the three months experimental period.

Data Collection and computation: Five (5) plants were tagged using small size pegs placed by the side of the selected plants in each net plot and used for measuring growth and yield parameters commencing from 3 WAS and continues at 3 weeks intervals (3, 6 and 9 WAS) to obtain up to a total of three (3) cuttings by the end of the 3 months experimental period. Parameters used are plant height, stem diameter, number of leaves per plant, number of branches per plant, fresh leaf weight per

plant, dry leaf weight per plant, total fresh leaf weight and total dry leaf weight. The means for each parameter was then computed.

i. Plant height (cm) was determined from five tagged plants with each tagged plant measured from ground level to terminal bud using a meter rule and average taken.
ii. Stem diameter (cm) of 5 tagged plants was taken with Vernier calliper or by manually using a thread and a metre rule followed by mean computation of each treatment.
iii. Number of branches per plant was determined by counting the number of branches of the 5 tagged plants.
iv. Fresh weight per plant (g) was obtained by cutting the number of branches of 5 tagged plants at first harvest with average computed at 3, 6 and 9 WAS for each treatments
v. Dry weight per plant (g) was determined when the 5 plants per plot were cut, samples placed in a labelled envelops carefully, conveyed to the laboratory and oven dried to a constant weight at 70 ^{O}C before weighing with a balance. The means of the dry matter (DM) per plot was then computed.
vi. The total fresh weight (kg) was obtained by weighing total biomass before drying and mean calculated per plant.
vii. Total dry leaf weight (g) was determined by weighing the harvested DM after oven drying at a constant weight and the means of the DM per plant was calculated.

Statistical Analysis of Data: The data collected from the experiment were subjected to analysis of Variance (ANOVA) as described by Snedecor and Cochran (1967) using computer package (SAS, 1988). The treatment means were computed. A 0.05 probability level was used for the test of significance using Duncan Multiple Range Test - DMRT (Duncan. 1955). Simple correlation co-efficient between important growth and yield components were determined as described by Dewey and Lu (1959) to assess the magnitude of the relationship among variables.

RESULTS.

Physical and Chemical Properties of the Soil in Experimental Field: Table 1 below shows the Physical and Chemical Properties of soil in the experimental sites for both rainy seasons. The texture of the soil was classified as sandy loam. The level of Calcium (Ca), Available phosphorus (PO_4^+) Cation Exchange Capacity (CEC) as well as pH in water and pH in $CaCl_2$ are moderate while level of Magnesium (Mg), Potassium (K), Sodium (Na), and Total Nitrogen (N) are low. It simply means we should expect a positive response from any addition of Poultry manure and or NPK 15-15-15 to the soil on crop growth and yield.

Meteorological Data: Appendix I and II shows the weather records of 2018 and 2019 rainy seasons. The total annual rainfall received was 1039.97cm for 2018 and 1320.70cm for 2019 and a mean of 86.64 cm and 110 cm respectively. The mean annual temperature range is 27 to 37°c for 2018 and 19 to 27°c for 2019 respectively. The R.H. and radiation recorded were 84 and 8 hrs (2018) and 45 and 6 hrs (2019). These figures are within the expected range needed for proper crop growth. No case of any dry spell occurs during the two seasons.

Physical and Chemical Analysis of Poultry Manure Used: Appendix III and IV shows that nutrients content of poultry manure used in experimental periods of 2018 and 2019 seasons are both within the standard composition range of an ideal chicken manure. No serious abnormality was observed in samples presented to the laboratory as per the report of the analysis

carried out in the laboratory. The nutrients content for both major nutrients (N, P K Ca and Mg) and trace elements (Fe Mn Zn Cu Cd and Pb) were found to be within the standard levels in each case.

Physical and Chemical Analysis of NPK 15-15-15 Fertilizer for both Seasons: Appendix V and VI shows that both the Physical and Chemical Analysis of NPK 15-15-15 fertilizer used tend to be within the expected range of composition. No serious abnormality was observed in the samples. The nutrients content for both major (N, P, K, Ca,) and trace elements (Fe, Mn, Zn, Cu, Cd and Pb) are found to be within the expected level in both cases.

Moringa oleifera LAM in Zaria during both Rainy Seasons.

Table 1. Chemical and Physical Analysis of Field Soil Samples for Growing of

Soil property	2018 raining season		2019 raining season	
	0 – 15 cm	15 – 30 cm	0 – 15 cm	15 – 30 cm
Particle size distribution (gkg^{-1})				
Sand (%)	730	740	650	630
Silt (%)	150	130	240	410
Clay (%)	120	130	120	160
Soil textural class	Sandy loam	Sandy loam	Sandy Loam	Sand loam
Exchangeable bases ($cmol\ kg^{-1}$)				
Calcium	4.22	4.32	2.70	2.30
Magnesium	0.98	0.67	0.88	0.49
Potassium	0.30	0.33	0.26	0.20
Sodium	0.33	0.30	0.20	0.18
CEC ($cmol\ kg^{-1}$)	5.81	6.60	0.21	0.16
pH in H_2O (1: 2.5 w/v)	6.50	6.80	5.90	6.10
pH in $Cacl_2$ (1: 2.5 w/v)	5.70	5.50	5.30	4.10
Organic carbon (%)	0.50	0.30	0.99	0.80
Total nitrogen (%)	0.49	0.40	0.80	0.60
Available phosphorus ($mgkg^{-1}$)	10. 11	8.30	15.0	14.00

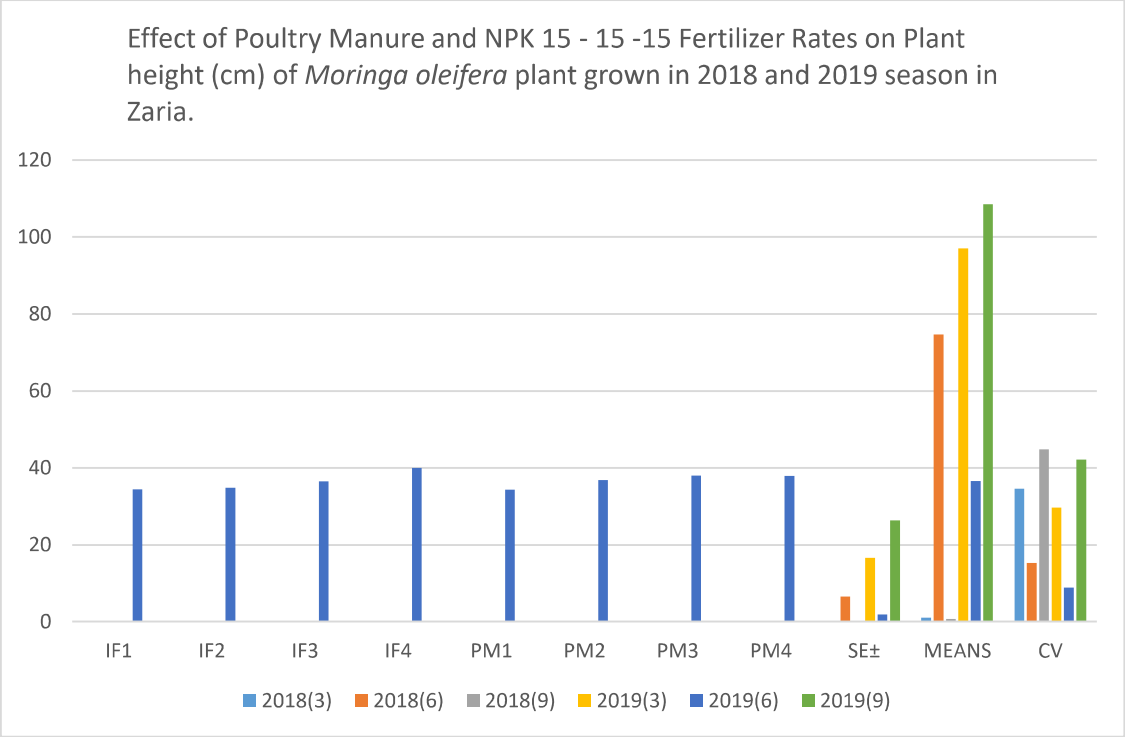
Plant Height of Moringa:

The field experimental design consisted of two treatments of Poultry manure (PM) and NPK 15-15-15 Inorganic Fertilizer (IF). There are four levels of PM (10, 15, 25 and 35 tonnes ha^{-1}) and four levels of IF rates (0, 60, 120 and 170 Kg ha^{-1}) laid out in Randomised Complete Block Design replicated three times. Therefore, the IF rates in Kg ha^{-1} (IF1 = 0; IF2 = 60; IF3 = 120 and IF4 = 170) and four (4) levels of Poultry manure (PM) in tonnes ha^{-1}(PM1 = 10; PM2 = 15; PM3 = 25 and PM4 = 35 tonnes ha^{-1}).

The result for plant height of moringa shows that at 3 Weeks after Sowing (WAS) during the 2018 rainy season, there was no any significant difference on results obtained from the application of PM and IF rates on plant height of moringa. However, at 6 WAS, significant differences ($P > 0.05$) were observed among the treatments. The PM applied at the rate of (PM3) statistically produce the tallest plants while IF3, PM1 and PM4 gave the least plants height. Similarly, IF2 and IF4 have the least plant height compared to IF1. At 9 WAS, IF4, PM1, PM2 and PM3 statistically produce the tallest plants compared with other treatments.

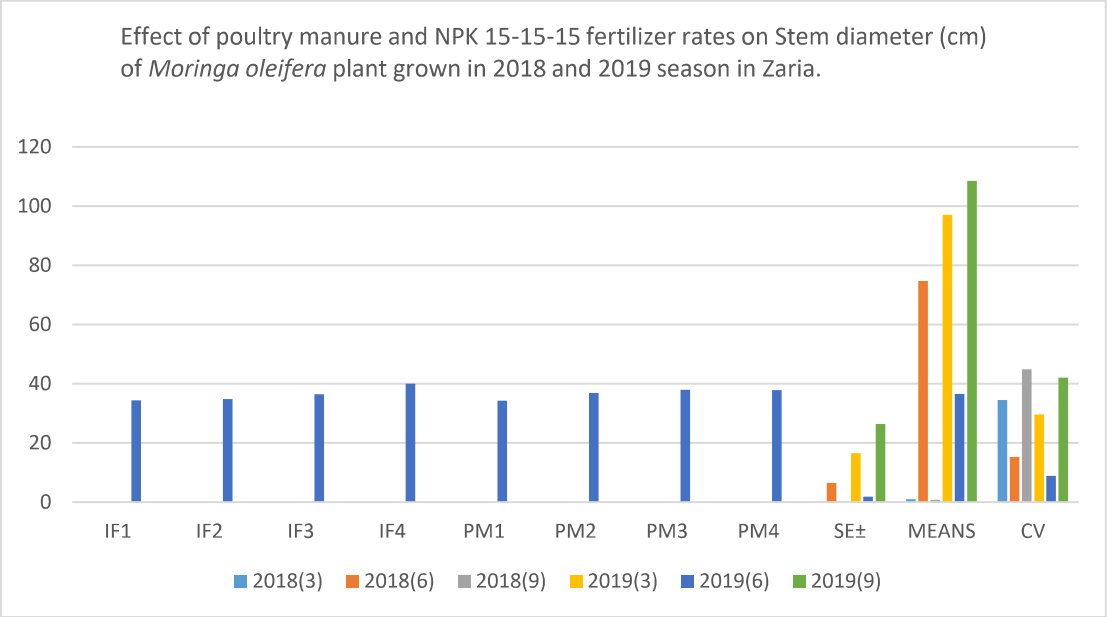
In 2019 cropping season, there was no significant difference on plant height at 3 WAS and 9 WAS. However, at 6 WAS, the PM1, PM3 and PM4 statistically produce

tallest plants compared with IF3 and IF4. The least plant height was obtained from IF1 and IF2. From the combine data on plant height (cm), varying the levels of PM and NPK fertilizer rates had no significant variations among the treatments. At 3 WAS, poultry manure and NPK fertilizer had no significant difference on plants height. However, at 6 WAS and 9 WAS significant differences was observed because the application of PM significantly produces taller plants while shorter plants were observed in NPK plots.

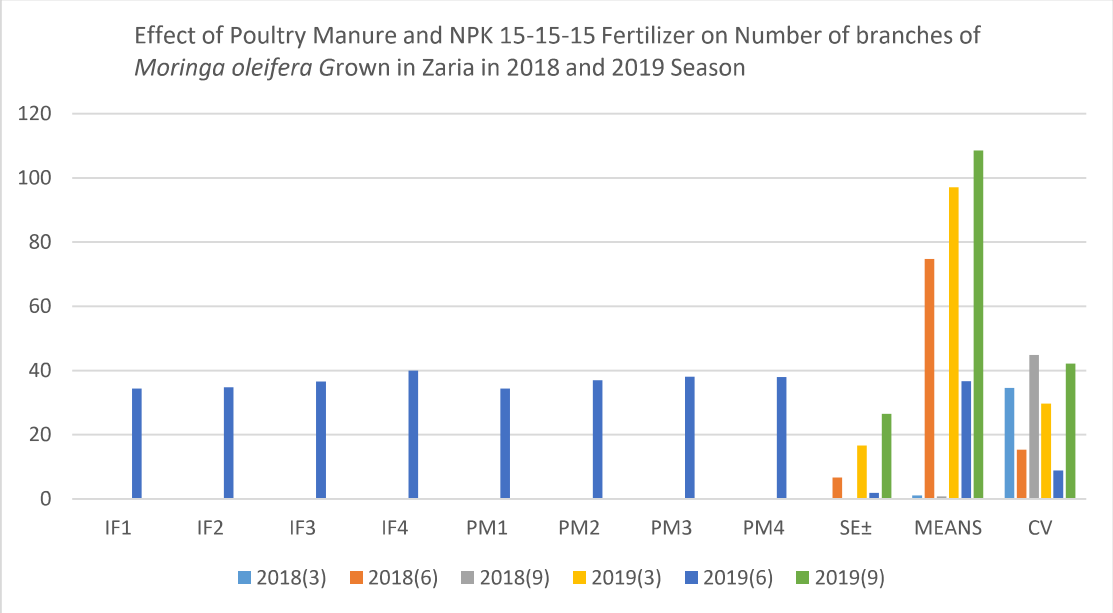


Stem Diameter of Moringa: Results of crop stem diameter indicated that at 3 WAS during the 2018 cropping season, there was significant ($P< 0.05$) difference among the treatments. PM1, PM4, IF4 and PM2 statistically produce smaller stem diameter compare with other treatments application. At 6 WAS PM2 had ($P<0.005$) higher stem diameter but no statistically difference was recorded from other treatments. Similarly, at 9 WAS, PM4 has higher stem diameter but no statistical difference was recorded from other treatments.

However, during the 2019 cropping season, at 3 WAS and 9 WAS no significant difference was recorded among the treatments on stem diameter. At 6 WAS, PM4 significantly produce higher stem diameter compared with IF3 but no statistical difference was recorded among other treatments. The combined data of 2018 and 2019 shows that varying PM and IF applied revealed significant influence on Stem diameter in the combine analysis as it gave plants with thicker stem diameter while plants with thinner diameter were observed where NPK fertilizer was applied.

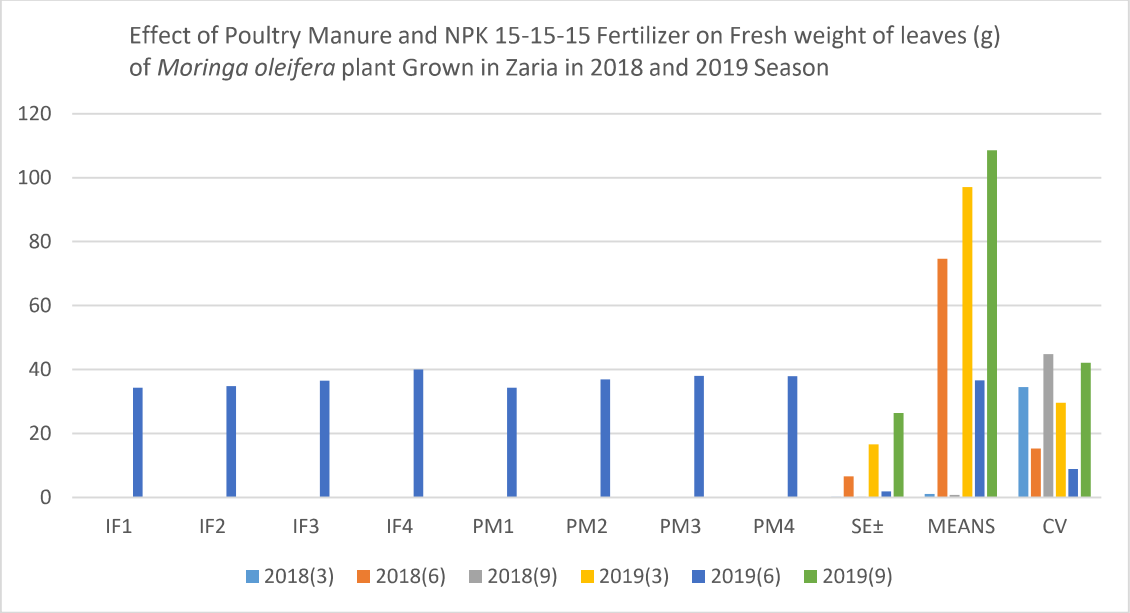


Number of branches plant: The combine data recorded during the 2018 and 2019 rainy season on the number of branches per plants shows that number of branches were not affected by the application of varied treatments in all the experimental years except at 6 WAS where poultry manure applied significantly gave plants with higher number of branches while the least number of branches were recorded in plots where NPK fertilizer was applied.

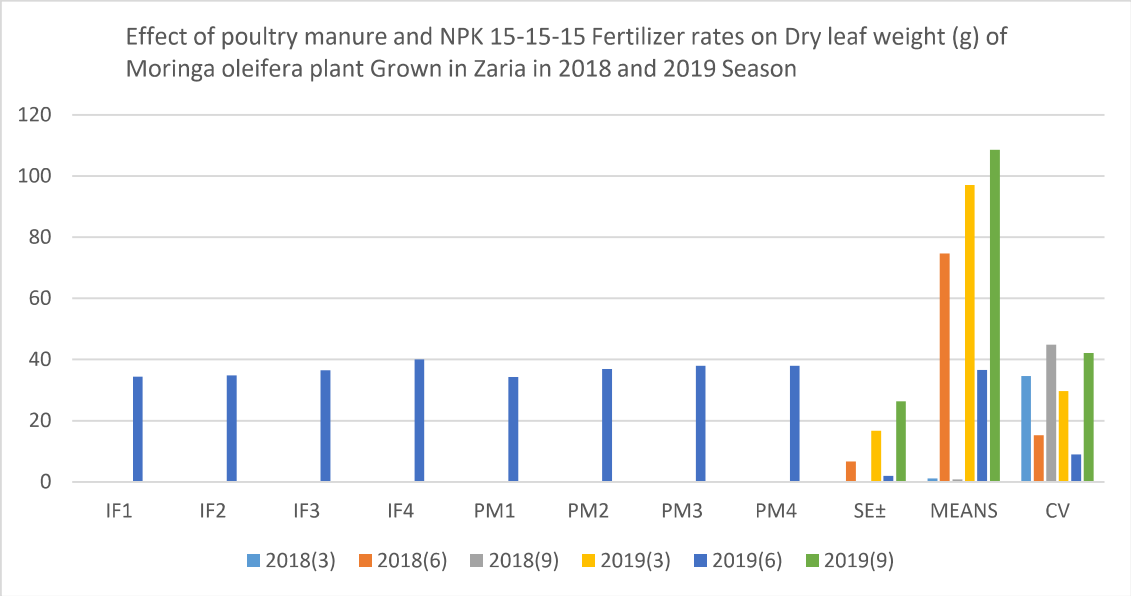


Fresh leaf weight per plant: The 2018 rainy season record indicated that at 3 and 6 WAS application of both PM and IF rates did not show any significant effect on fresh weight per plant. However, at 9 WAS application of PM significantly gave heavier fresh weight per plant while plants with lighter fresh weight were observed

where NPK fertilizer was applied. In 2019 rainy season it was observed that both PM and NPK fertilizer rates had non-significant effect on fresh weight per plant throughout the period of measurement. For the combined data of 2018 and 2019, the application of varying levels of PM and IF had only manifested at 9 WAS. The results reveal that PM added had significantly gave heavier fresh weight per plant while the least fresh weight per plant was recorded in plots with NPK.

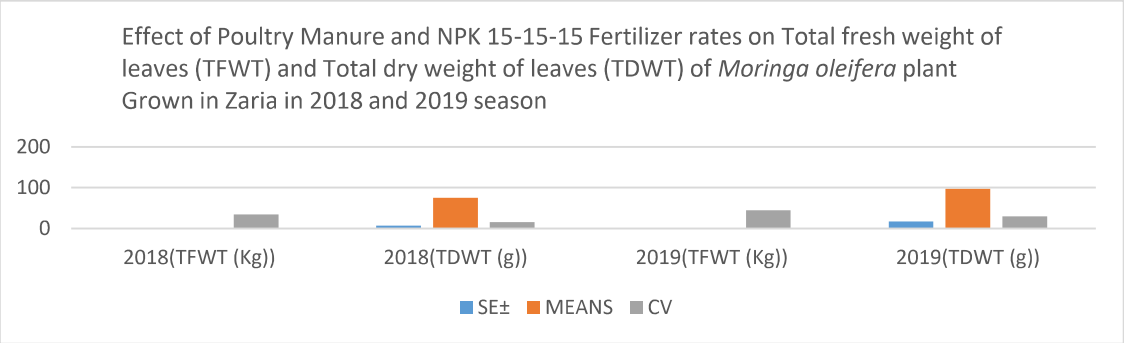


Dry leaf weight per plant: In 2018 rainy season, it was observed that application of both PM and IF rates had non-significant influence at 3 and 9 WAS. However, at 6 WAS, significant effect of both treatments was observed. PM significantly produced heavier DM than NPK fertilizer. In 2019, treatments administered had no significant effect on DM per plant throughout the sampling period. In the combined 2018 and 2019 season the results show a significant difference on DM weight at 9 WAS with PM because it produces heavier DM weight per plant while the lighter fresh weight per plant was recorded with NPK 15-15-15 fertilizer was applied.



Total fresh weight (TFW) and Total dry weight (TDW): The result indicated that in 2018, the crop significantly ($P<0.05$) given higher TFWT when PM3 and PM4 was applied compared with PM1 and PM2. The least TFWT was obtained when NPK 15-15-15 was applied. On the TDWT, application of PM at PM1, PM3 and PM4 as well as application IF at rate of IF2, IF3 and IF4 significantly produces similar weight of moringa leaves compared with IF1 and PM2. The least TDWT was with PM application rate of 15 tonnes per ha $^{-1}$ was used. However, in 2019, the use of PM at the rate of PM1, PM2, PM3 and PM4 statistically produces similar fresh leaves weight compared with IF4 that's at par with other treatments.

Similarly, application of PM at the rate of PM3 and PM4 significantly gave higher TDWT compared with other treatments rates. This means significant differences exist in TFW and TDW obtained in the two years of experiment and combine data. During the 2018 rainy season, PM produces larger quantity of TFW than NPK fertilizer even though there is no significant difference between the two treatments on the yield obtained in TDW. Similarly, in 2019 rainy season, PM manure gave higher TFW than where IF was applied and there is no significant difference between the two treatments on yield obtained in TDW The Combine data of TFWT and TDWT (Kg) of moringa plant grown in Zaria during both season shows that a significant difference occurs between the two treatments because the PM plot produces significantly higher TFW and TDW while NPK plots gave lower yields.



Correlation Co-efficient between yield and various growth characters of moringa

The correlation coefficient between yield and various growth characters of moringa in Zaria during 2018 and 2019 rainy season (combine data)

	1	2	3	4	5	6	7	8
1	1.00000							
2	0.11233	1.00000						
3	0.31457	-0.20970	1.00000					
4	0.23203	0.17128	0.14493	1.00000				
5	-0.00540*	0.10065	0.18609	0.05639	1.00000			
6	0.31032	-0.28094	0.42072	0.02116*	0.06215	1.00000		
7	0.36942	0.50416	0.00232*	0.18174	0.02179	-0.10631	1.00000	
8	0.07544	-0.28228	0.66591	0.18417	0.14911	0.43376	0.02155*	1.00000

Note: 1. Total dry matter (DM) 2. Stand count @ 9WAS 3. Plant height @ 9WAS 4. Stem diameter @ 9WAS 5. Number of branches @ 9WAS 6. Fresh @ 9WAS 7. Dry weight @ 9WAS 8. Total fresh weight 9WAS

DISCUSSION

Soil physical and chemical properties of the research site: The soil of the experimental farm was classified as Sandy Loam in texture. According to Olaitan (1984), the sandy loam nature of the soil may be attributed to parent material from which the soil was formed and the climatic nature of the study area. This is in line with Brandy and Weil (2013). The low level of total Nitrogen and Organic matter of the study area can be attributed to high temperature which lead to rapid decomposition of organic matter due to high solar radiation and moisture that usually favoured microbial activity in the soil (Brandy 2013). The calcium content and available phosphorus could be attributed to the parent materials where the soil was formed. There is slight level of exchangeable acidity in all the years which might have improve the condition of the soil and enhance growth and yield recorded in both 2018, 2019 and combine data. The higher growth and yield components observed in both 2018 and 2019 and combination could be attributed to better weather condition recorded throughout the experimental periods.

Moringa response to poultry manure application: Application of PM to moringa in Zaria significantly influence growth and yield traits of the evaluated crop. The results clearly shows that application of PM at various rates significantly affect growth parameters like Plant height, Stem diameter, Number of branches/plants, Fresh weight/plant, Dry weight/plant, Total fresh weight, Total dry weight and the Chemical content of the leaves. This trend was expected considering the positive role that PM plays in growth and development of crops particularly when it is applied in soils with low natural fertility as was the characteristics of the soil of experimental site. The higher values of growth parameters observed could be due to role of PM in assimilating nutrients products which could later be directly converted into high dry matter production of taller plants, thicker stem diameter, number of branches, higher fresh weight per plant, dry weight per plant, total fresh weight and total dry weight. This result is in conformity with the findings of Rodovich (2009) who reported that moringa tree benefited from organic manure by increasing production three folds.

Moringa response to NPK 15-15-15 fertilizer application: The importance of interaction among the three basic elements N, P and K on growth and yield parameters cannot be over looked. The significant response of moringa to these parameters recorded shows that good yield and yield components were observed. This observation could be attributed to favourable weather condition of the study area particularly favourable temperature range, solar radiation and relative humidity which coincided with rainfall distribution in both the year 2018 and 2019. Fuglie and Sneeja (2010) reported that N, P and K applied to moringa encourages root development, leafy canopy and increases final yield.

Poultry Manure Verses NPK 15-15-15 Fertilizer: The significant response of plant height, stem diameter, number of branches per plant, fresh weight per plant, dry weight per plant, total fresh weight and total dry weight signifies the significant role of poultry manure and NPK 15-15-15 fertilizer on growth and development of moringa. The application of poultry manure in all the parameters evaluated during the experimental periods revealed that poultry manure significantly gave the higher yield. This is in agreement with the report of Rodovich where he reported that poultry manure was found to yield positive response of moringa production.

Correlation Co-efficient: The significant and positive relationship between leaf yield of moringa and other growth characteristics most especially plant height, stem diameter, number of branches per plant, fresh weight per plant, dry weight per plant, total fresh weight and total dry weight indicates the roles of these parameters in assimilating production. A large canopy cover means higher interception of light energy and greener photosynthesis resulting in higher assimilate production. The important and positive correlation observed between leaf yield and parameters like plant height, stem diameter, number of branches per plant, fresh weight per plant, dry weight per plant, total fresh weight and total dry weight has identified these parameters as important yield determinants. These could be due to the higher assimilate produced and converted to the final leaf yield.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The experimental site has Sandy Loam soil which according to Olaitan (1984) is attributed to soil parent material and the climatic nature of the study area as agreed by Brandy and Weil (2013). Low level of total N and O.M in Zaria is due to high

temperature, rapid O.M decomposition, high solar radiation and moisture that usually favoured microbial activity in the soil (Brandy 2013). The Ca and available P is linked to soil parent materials. There is slight level of exchangeable acidity in all the years which might have improve the condition of the soil and enhance growth and yield recorded in both seasons. Higher growth and yield components in both years may be due to better weather condition recorded throughout the experimental periods.

The results of applying various rates of PM have significantly affect almost all the growth and yield parameters due to the positive role that PM plays in growth and development of crops particularly when it is applied in soils with low natural fertility like Zaria. The higher values may be due to role of PM in assimilating nutrients products which could later be directly converted into high dry matter production of taller plants, thicker stem diameter, number of branches, and high fresh weight per plant, dry weight per plant, total fresh weight and total dry weight. This result is in conformity with the findings of Rodovich (2009) who reported that moringa tree benefited from organic manure by increasing production three folds.

The importance of interaction among the three basic elements N, P and K on growth and yield parameters cannot be over looked. The significant response of moringa to these parameters recorded shows that good yield and yield components were observed and linked to favourable weather condition of Zaria (favourable temperature range, solar radiation and RH rainfall distribution in both the years. This concedes with Fuglie and Sneeja (2010) findings that N, P and K applied to moringa encourages root development, leafy canopy and increases final yield.

The significant response of growth and yield parameters shows the significant role of PM and IF on growth and development of moringa. The application of PM in all the parameters evaluated during the experimental periods revealed that PM significantly gave the higher yield. This is in agreement with the report of Rodovich where he reported that PM leads to positive response in moringa production.

A significant and positive relationship exist between leaf yield of moringa and other growth characteristics and indicates the roles of these parameters in assimilating production. A large canopy cover means higher interception of light energy and greener photosynthesis resulting in higher assimilate production. The important and positive correlation observed between leaf yield and parameters like plant height, stem diameter, number of branches per plant, fresh weight per plant, dry weight per plant, total fresh weight and total dry weight has identified these parameters as important yield determinants. These could be due to the higher assimilate produced and converted to the final leaf yield.

The results obtained shows that the PM and NPK fertilizer applied responded to some of the growth and yield parameters tested. It was observed that application of PM in all the growth and yield parameters evaluated had significantly produced higher yield than the NPK fertilizer. The results show a positive and significant correlation between crop leaf yield and growth parameters. Application of 35 tonnes ha $^{-1}$ of PM gives the highest plant height (32.60 cm), stem diameter (3.73 cm), total fresh leaf weight (1.84 kg) and total dry leaf weight (1.29 kg). The least growth and leaf weight of moringa was obtained with application of 60 kg ha -^{1} of NPK fertilizer. It is therefore recommended that farmers should adopt the planting of moringa using poultry manure for profitable moringa production in the study area. Application of 35 tonnes ha $^{-1}$ of PM is recommended for sustainable leaves and dry matter production of Moringa in Zaria. These findings will be useful to

current and future farmers of moringa in the study area and beyond; extension workers,

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APPENDICES

Appendix I: Annual Weather Record for 2018 Cropping Season.

Month	Rainfall (cm)	Temperature (max) ^{0}C	Temperature . (min) ^{0}C	R H (%)	Sunshine (Hrs)
June	60.73	31.23	22.03	71.9	7.13
July	88.23	29.53	21.5	43.97	6.03
August	102.13	27.03	21.4	74.27	6.43
September	59.17	29.3	21.33	75.23	7.27
October	22.33	32.83	22.67	73.43	7.80
November	NIL				
December	NIL				
Total	**1039.97**				
Mean	**86.64**	37.48	27.15	84.03	8.43

IAR ABU Samaru Zaria Weather Station

Appendix II: Annual Weather Record for 2019 Cropping Season.

Month	Rainfall (cm)	Temp (max) ^{0}C	Temp. (max) ^{0}C	RH (max) (%)	R.H. (min) (%)	Sunshine (hrs)
June	89.9	20.1	31.7	69.1	55.3	7.6
July	278.1.	20.3	30.2	77.1	64.2	6.1
August	299	241	28.9	80.1	76.1	1.8
September	340	23.1	30.4	81.2	62.8	3.0
October	99.8	19.1	30.1	58.1	51.1	8,4
November	NIL	12.9	33.7	26.6	24.1	9.3
December	NIL	15.1	32.2	21.7	18.3	9.4
Total	**1320.70**	230.5	655.8	545.50	429.7	82.5
Mean	**110.06**	19.21	54.65	45.46	35.81	6.88

IAR ABU Samaru Zaria Weather Station

Appendix III. Physical Analysis of Poultry Manure **(PM)**

Property	Remarks
State:	Powdery gritty material
Colour:	Dark brown
Odour:	Slightly putrid

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Appendix IV. Chemical Analysis of Poultry Manure (% by weight) in both Seasons

Major Nutrient	Total soluble	Minor Nutrient / Trace	Mg/kgw/w
Nitrogen (N)	1.96	Iron (Fe)	5657
Phosphorus P_2O_5)	2.08	Manganese (Mn)	120
Potassium (K)	1.32	Zinc (Zn)	137
Calcium (Ca)	1.37	Copper (Cu)	58

	Cadmium (Cd)	Trace

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Appendix V. Physical Analysis of NPK 15-15-15 Fertilizer.

Property	Remarks
Colour and State:	Light grey fine granules
Granular integrity:	Good
Dustiness:	Minimal
Fines:	Minimal
Flow:	Free flowing
Caking:	Non caking

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Appendix VI. Chemical Analysis of NPK Fertilizer (% by weight) in both Seasons

Nutrient/parameter	Acid soluble (%)	Water soluble (%)
Nitrogen (N)	14.84	------
Phosphorus (P_2O_5)	13.27	10.41
Potassium (K)	16.20	15.30
Calcium (Ca)	1.33	-------
	Mg/kgw/w	
Iron (Fe)	1795	-------
Manganese (Mn)	136	-------
Zinc (Zn)	49	-------
Copper (Cu)	90	-------
Cadmium (Cd)	Trace	------
Lead (Pb)	Trace	------

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