# Comparative Effect of Poultry Manure and Inorganic fertilizer rates on Major and Trace Elements of *Moringa oleifera*Grown in Zaria

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**Abstract**
*Experiments were conducted in 2018 and 2019 rainy seasons at the Teaching and Research Farm of Nuhu Bamalli Polytechnic, (latitude $11^{o}$ 11' N) and (longitude $07^{0}$ 38'E) Zaria to evaluate the effect of poultry manure (PM) and NPK 15-15-15 fertilizer (IF) application rates on the levels of major and trace elements in moringa leaf. Four levels of PM (10, 15, 25 and 35 tonnes ha $^{-1}$) and IF (0, 60, 120 and 170 Kg ha $^{-1}$) are laid out in Randomised Complete Block Design (RCBD) and replicated three (3) times. Timely agronomical practices are applied as recommended. Data obtained were evaluated to determine the level of elements present in leaves during the stated period through the collection and analyses of moringa samples in the laboratory. At 3 WAS, plant height, stem diameter, branches, fresh and dry weight were measured and the levels CP. P, K, Ca, Mg, Fe and Zn evaluated. Analysis of Variance, Means Separation and Duncan Multiple Range Tests were conducted. The results shows that application of PM and IF rates on moringa in both rainy seasons have no significant differences on the element content listed. Application of IF has significantly produce a higher CP content but levels of P, K and Ca elements were not affected by the different levels of treatment applied. Similarly, application of PM had no significant effect on levels of Mg, Fe and Zn in moringa leaf. It is recommended that moringa farmers in Zaria should plant it with cheaply available PM for higher leaves and essential elements content needed for proper growth and development.*

**Keywords:** Moringa,Poultry Manure, Inorganic Fertilizer, Major and Trace elements, Growth and Yield

## INTRODUCTION

Moringa, (*Moringa oleifera* LAM), belongs to the family Moringaceae and is the most widely cultivated among the 13 different species of moringa with about 8 species being endemic to the horn of Africa (Gopal, 2002; Grubben and Denton, 2004). According to Davis, (2000) and Gopal, (2002), the tree has several common names (drumstick tree, miracle tree, horseradish tree, etc.). Moringa originated in India and Pakistan but it is now widely grown in the tropics and sub-tropics, including many African Countries (Kalbi and Kuo, 2002). It is an exceptionally nutritious vegetable shrub with a variety of potential uses since every part of the tree (roots, leaves, etc.) are beneficial to humanity (Havard, 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 – 1,500mm, and altitude of about 600m - 1,200 mm. It prefers a well-drained sandy loam soil with good drainage and tolerates a soil pH of 4.5 – 9.0 (Palado and Chang, 2003). Moringa is one of the most useful tropical shrub. 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 crop can be cut every 33 – 40 days or 6 – 8 months for proper production. Foidl *et al*, (2011) reported that at a density of 1,000,000 plants ha $^{-1}$

(10cm x 10cm) with adequate fertilization, irrigation, and nine (9) cuttings per year, a yield of 45 tons $ha^{-1}$ (dry season) and 115 tonnes $ha^{-1}$ (raining season) can be achieved.

Moringa provides high protein content and protein quality to meet the estimated amino acids requirements pattern of protein for children of age 2 to 5 years (Kalbi and Kuo, 2002). The perennial shrub is a promising food source in the tropics during the dry season when other foods are typically scarce. Moringa leaf can be eaten fresh, cooked or stored as dried powder for many months without refrigeration or loss of nutritional value. In reviewing the medical evidence of *Moringa oleifera* for the nutritional, therapeutic and prophylactic properties

Farley, (2005) reported that, *t*he leaves are good source of proteins, vitamin A, B, and C with minerals (Ca and Fe). Moringa leaf is a good source of proteins (22 – 35%), vitamin A, B, and C, Ca, Fe, S methionine. cysteine and carbohydrates in varied quantities. Research on moringa plant have shown that gram for gram, moringa has two (2) times the amount of protein of yogurt; four (4) times the amount of vitamin A as carrots; three (3) times the amount of potassium as bananas; four (4) times the amount of calcium as cows' milk; seven (4) times the amount of vitamin C as oranges (Farley, 2005 Kalbi and Kuo, 2002). The crop does not receive adequate professional horticultural attention especially in Northern Guinea Savannah (NGS) Zone where native soil fertility is lacking. Most of the essential nutrients needed by the plants were reported to be insufficient. (NRC, 2006).

The study is specifically aimed at determining the effect of poultry manure and NPK 15-15-15 fertilizer rates on the level of protein, P, K, Ca, Mg, Fe and Zn content of moringa leaves grown in Zaria during the experimental period. The findings from this work could be useful to current farmers, extension workers and researchers on moringa and in the near future.

**Roles played by major and trace elements on crop production and leaf yield quality.**

Improper application of inorganic fertilizers can lead to low productivity due to loss of soil fertility, soil degradation, depletion of soil macro and micro nutrients and poor management practices. Lack of available nutrients is a limiting factor after soil moisture. Both macro and micro nutrients have various roles to play in different soils and their removal by different crops vary with different seasons and areas. Therefore, a balanced of both organic and inorganic fertilizer application is essential for vegetative growth to achieve both quality and quantity in crop production.

Some of the essential nutrients needed for proper crop growth and development are N, P, K, Ca, S, Mg, Zn, Fe, and Co. They improve crop quality by serving as raw materials for the synthesis of various plant components which have food value to humans and animals. The elements N and S are raw materials for protein synthesis; Ca, P, Zn and Fe are needed in enzyme synthesis, activation or as electron carriers while Mg & K are mostly engaged in enzyme activation, transportation of sugars from points of synthesis to sites of loading. Crop quality is also determined by synergistic and antagonistic interactions in various nutrients uptake and utilization. This makes balanced nutrition to be of paramount importance.

Plant growth is influenced by temperature, available water, light and available nutrients in the soil. There are seventeen (17) nutrients classified as essential for plant growth [Tucker (1999); Jones and Jacobsen (2001) and Marschner (1995)]. Each one of them had meet the four (4) criteria of essentiality: (it must be needed

by a plant to complete its life cycle; its function cannot be replaced by another element; it is directly involved in plant growth and reproduction; and it must be needed by most plants [Jones and Jacobsen (2001) and Foth and Ellis, (1998)].

Carbon (C), hydrogen (H) and oxygen (O) are the non-mineral nutrients derived from the air and water. [Jones and Jacobsen, 2001] There are six macronutrients: N, P, K, Ca, Mg, and S; and eight micronutrients: B, Cl, Cu, Fe, Mn, Mo, Ni and Zn [Tucker, (1999) and Brady and Weil (2008)]. Beneficial elements are not among the above listed 17 essential elements but are needed in specific cases (Jones and Jacobsen, 2001). Each of them is needed in different amounts and carries specific functions in the plant.

**Nitrogen:** Among the three (3) major/primary nutrients (NPK) needed by plants, N is needed in the largest amount due to its numerous functions. It promotes rapid growth, increase leaf sizes and quality, enhances fruit and seed development; formation of amino acids (building blocks of proteins) and enzymes, which are involved in catalysing most biochemical processes [Brady and Weil (2008); Foth and Ellis (1998)]. It plays a role in almost all metabolic processes. Nitrogen influences the rate of crop growth and crop quality. It increases the plumpness of the cereal grains, the protein content of both seeds and foliage, and the succulence of crops such as lettuce and radish [Foth and Ellis (1998)]. Increased protein content and physical grain quality in grains is observed with increasing N application [Havlin *et al* (2005); Blumenthal *et al*(2008)].

**Calcium:** Calcium is used in large amounts by plants second only to N and K [Brady and Weil (2008).]. It is a major component of the middle lamella (Ca-pectates) of the cell wall. It strengthens the cell walls, is involved in cell elongation and division, membrane permeability, and activation of several critical enzymes [Brady and Weil (2008).]. It is important in N metabolism and protein formation by enhancing $NO^{3-}$ uptake and it is also important in translocation of carbohydrates and other nutrients Havlin *et al* (2005)

**Magnesium:** Magnesium is another secondary nutrient element. It is important as a primary constituent of chlorophyll and as a structural component of ribosomes, it helps in their configuration for protein synthesis [Havlin *et al* (2005)]. It is also required for maximum activity of almost all phosphorylating enzymes in carbohydrate metabolism. Usually, the first things to be noticed due to influence of Mg are chlorophyll level, photosynthesis (photosynthetic $CO_2$ fixation), and protein synthesis, however, recently, distribution of carbohydrates among shoot and root organs have been reported as well [Cakmak and Yazidi (2010)]. These in turn affect quality of plant product depending on which part is used for food by humans or animals.

**Micronutrients:** Micronutrient elements such as Zn, Fe, Bo, Mo, Cu, Mn, Cl and Ni are known to be essential for plant growth. Others such as selenium (Se) and Co, which are needed in specific cases are commonly referred to as beneficial elements. For instance, Co is required by bacteria that fix nitrogen in legumes. Zinc (Zn) and iron (Fe) are some of the most important micronutrients essential for plant growth [Muthukumararaja and Sriramachandrasekharan (2012), Kumar *et al* (2012)]. Zinc is a major metal component and activator of several enzymes involved in metabolic activities and biochemical pathways [Grotz and Guerinot (2002); Kabata-Pendias and Pendias (2001)]. It is a functional, structural or regulatory co-factor of a large number of enzymes [Grotz and Guerinot (2002)]. It is required in a large number of enzymes and plays an essential role in

DNA transcription [Kumar *et al* (2012)]. Other functions of zinc include: catalysing the process of oxidation in plant cell and is vital for the transformation of carbohydrates; and influencing the formation of chlorophyll and auxins, the growth promoting compounds [Mamatha (2007)]. On the other hand, Fe in a constituent of enzyme system which brings about oxidation-reduction reactions in the plant, it regulates respiration, photosynthesis, reduction of nitrates and sulphates [Mamatha (2007)]. These reactions are essential to plant development and reproduction. It should be noted that as the case with other plant. Zn and Fe limit plant growth when they are present both in low concentrations and in excessive concentrations due to deficiency and toxicity respectively [Conolly and Guerinot (2002), Alloway (2008)].

All the nutrients' elements influence crop quality that's manifested by differences in quality attributes of different crops with different rates of nutrient elements applied to various crops. Undersupplying and oversupplying of nutrients may lead to reduced crop quality. This can result from the nutrient being a raw material for synthesis of a product but also from its involvement in enzymatic activities, for instance low N (as a raw material) will lead to reduced number of proteins whereas low K will lead to reduced amount of proteins due to reduced activation of enzymes that metabolize carbohydrates for synthesis of amino acids and proteins. Too much $NH_4$-N will suppress uptake of Ca and its functions. On the other hand, low levels of Mg and K will lead to reduced distribution of carbohydrates. Nutrients do not work in isolation; therefore, balanced nutrition is needed to optimize crop quality.

## MATERIALS AND METHODS

**Experimental site:** The experiments were conducted during 2018 and 2019 rainy seasons at Teaching and Research Farm, Nuhu Bamalli Polytechnic. Zaria (latitude ($11^0$ 11'N) and longitude ($07^0$ 38'E) and 680 m high in Northern Guinea Savannah Zone of Nigeria.

**Soil samples collection***: S*oil samples were randomly collected from the experimental site at the depth of 0 -15 cm and 15 -30 cm. The samples were bulked, air-dried, sieved through a 2 mm mesh and analysed for physio - chemical properties using standard procedure (Black, 1965). Data on rainfall, temperatures, relative humidity and sunshine were collected from meteorological station of Institute for Agricultural Research (IAR). Ahmadu Bello University, Zaria for both years

**Analysis of Soil sample:** Before applying PM, the soil was analysed for pH, Organic P. K, Ca, and Mg. The pH was determined using a saturated paste. PM carbon content was measured by a modified Walkley - Black method (Nelson and Sommers, 1996). Bray 2 method was used to determine available P (Olsen and Sommers, 1982). Exchangeable Ca, Mg and K were determined with a $NH_4O$ ac, pH 7 extract and an atomic absorption spectrophotometer (AOAC, 1990). The sample of PM was analysed for physio - chemical properties. Proximate Analysis determined levels of Total N, Available P, K and pH using Kjeldahl method, Bray and Kurtz - Dry Ashing and pH meter methods respectively.

**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 replications.

**Land preparation:** The field was cleared, ploughed and harrowed. However, two (2) weeks before land preparation a knapsack sprayer was used to spray a chemical herbicide. [Combination of Glyphosate (BUSH FIRE) and Paraquat Dichloride (DRAGON) was applied prior to first ploughing and after harrowing operations] to control weeds infestations.

**Sowing and crop establishment:** Two (2) seeds were sown per hole at a depth of 2 cm and later thinned to 1 seedling/stand at 2 WAS at a spacing of 20 cm x 50 cm. PM was broadcasted a week prior to the establishment at varied rates of trials while NPK fertilizer was applied per treatment. Incidence of pests and diseases were not observed throughout the experimental periods. Three (3) manual weeding's were carried out at 3, 5 and 8 WAS to augment chemical control.

**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) up to the end of the 3 months experimental period to obtain a total of three cuttings during the study. Data were collected on the following parameters; 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 computed at 3 weeks intervals (3, 6 and 9 WAS).

i. Plant height (cm) was measured from five tagged plants (each plant is measured from ground level to terminal bud) using a meter rule and then average taken.
ii. The Stem diameter (cm) was taken using a thread and a metre rule manually followed by computation of means for each treatment.
iii. Number of branches per plant was determined by counting the number of branches of the five tagged plants.
iv. Fresh weight per plant (g) involves cutting the number of branches of five tagged plants at first harvest with average computed at 3, 6 and 9 WAS for each treatment
v. Dry weight per plant (g) was determined when the five plants per plot were cut and the samples placed in a libelled envelops carefully before it is conveyed to the laboratory, 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 determined.
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.

**Data analysis:** The collected data were subjected to analysis of Variance (ANOVA) as described by Snedecor and Cochran (1967) using (SAS, 2003). The treatment means were separated using Duncan Multiple Range Test (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 Sampled:**This is shown in Table 1 below. The texture of the soil was classified as Sandy loam. The level of $Ca^{+}$, $PO_4^{+}$, Cat ion Exchange Capacity, pH in

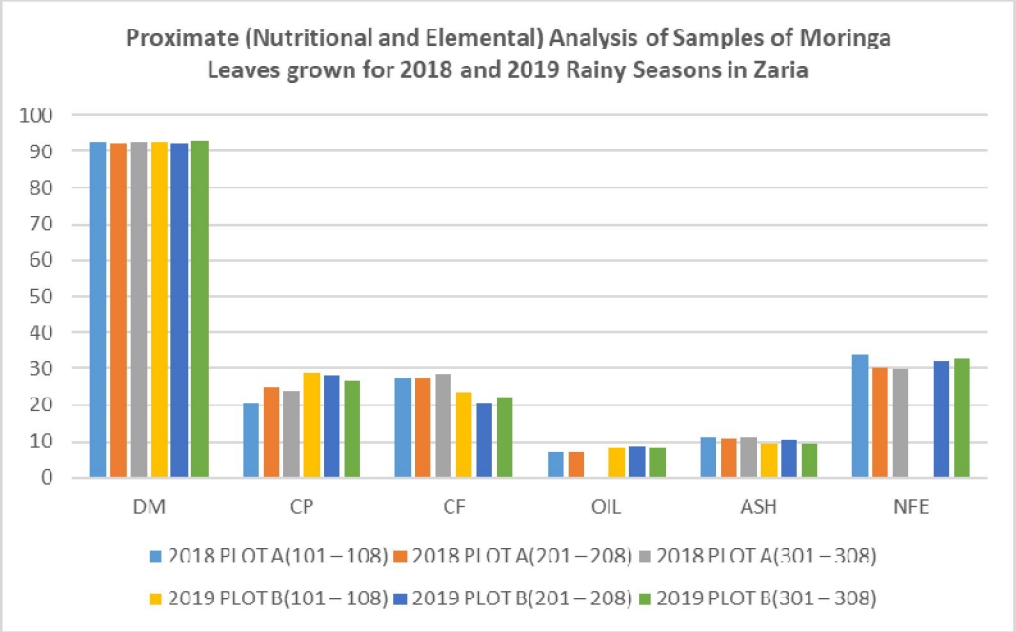
water and pH in $CaCl_2$ are of moderate quantity while level of Mg, K, Na, and Total Nitrogen (N) were low. Therefore, a positive response from addition of poultry manure and NPK 15-15-15 fertilizer on the crop growth and yield will be achieved.

**Meteorological Data:** *Appendix I and II shows* the weather records of 2018 and 2019 rainy seasons respectively. The total annual rainfall received was 1039.97cm (2018) and 1320.70 cm (2019) with means of 86.64 cm and 110 cm respectively. The mean annual temperature range recorded during same period were 27 to 37 $^0$C for 2018 and 19 to 27$^o$C for 2019. The Relative Humidity (R.H.) and Solar radiation of 84 and 8 hrs (2018) and 45 and 6 hrs (2019) were also recorded. These figures are within the expected range for proper growth and development of grown crops. There was no case of dry spell throughout.

**Table 1. Physical and Chemical Analysis of Soil Samples (2018 and 2019 Rainy Seasons)**

| Soil property | 2018 rainy season | | 2019 rainy 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 |
| Echangeable 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 |
| Poultry manure 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 | 14.0 |

**Nutritional and Elemental Analysis of Samples of Moringa Leaves in both Seasons:** It is aimed at determining the elemental composition of samples of moringa leaves grown. The CP, P, K, Mg, Ca, Fe, Mn. and Zn contents of the leaves in the study area was determined at first harvest. The Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), OIL, ASH and Nitrogen Free Extract (NFE) levels were recorded and presented below.



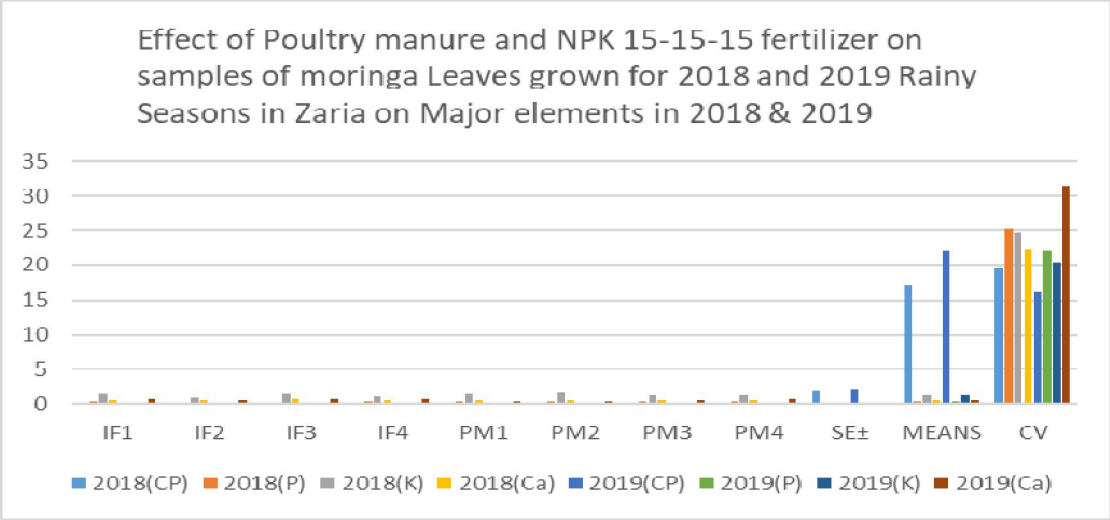

**Effect of Poultry manure and NPK fertilizer on major elements during both season**

It was observed that during 2018 rainy season, application of IF1 leads to production of higher levels of major plants nutrient elements [19.40 (CP); 0.40 (P); 1.45 (K) and 0.56 (Ca)] but lower quantity of same elements is produced with the application of IF4 [17.48 (CP) 0.32 (P) 1.05 (K) and 0.56 (Ca) respectively.

In the same year (2018), application of IF2 produce the highest quantity of nutrients [18.11 (CP); 0.38 (P); 1.58 (K) and 0.52 (Ca)] while least quantity of the major elements is produced with application of IF4 [11.70 (CP); 0.37 (P) 1.30 (K) and 0.54 (Ca)] respectively.

However, in 2019, application of IF1 produces high level of plants major elements [25.64 (CP); 0.41 (P); 1.27 (K) and 0.66 (Ca)] and the least quantity of same elements were produced with application of IF4 [17.01 (CP) 0.23 (P) 1.36 (K) and 0.80 (Ca) respectively.

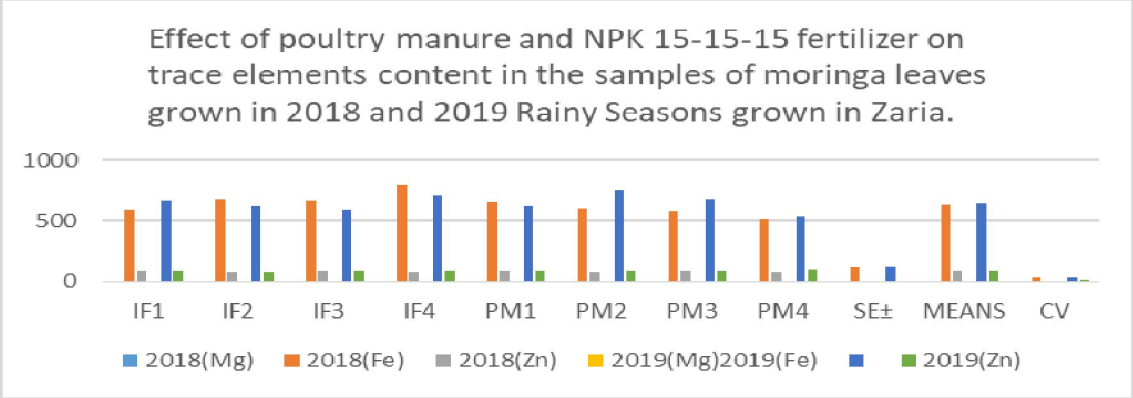
In the same year (2019), application of IF2 produce the highest quantity of major nutrients [24.96 (CP); 0.35 (P); 1.29 (K) and 0.45 (Ca)] while least quantity was produced with application of IF4 [19.79 (CP); 0.45 (P) 1.36 (K) and 0.66 (Ca)] respectively.



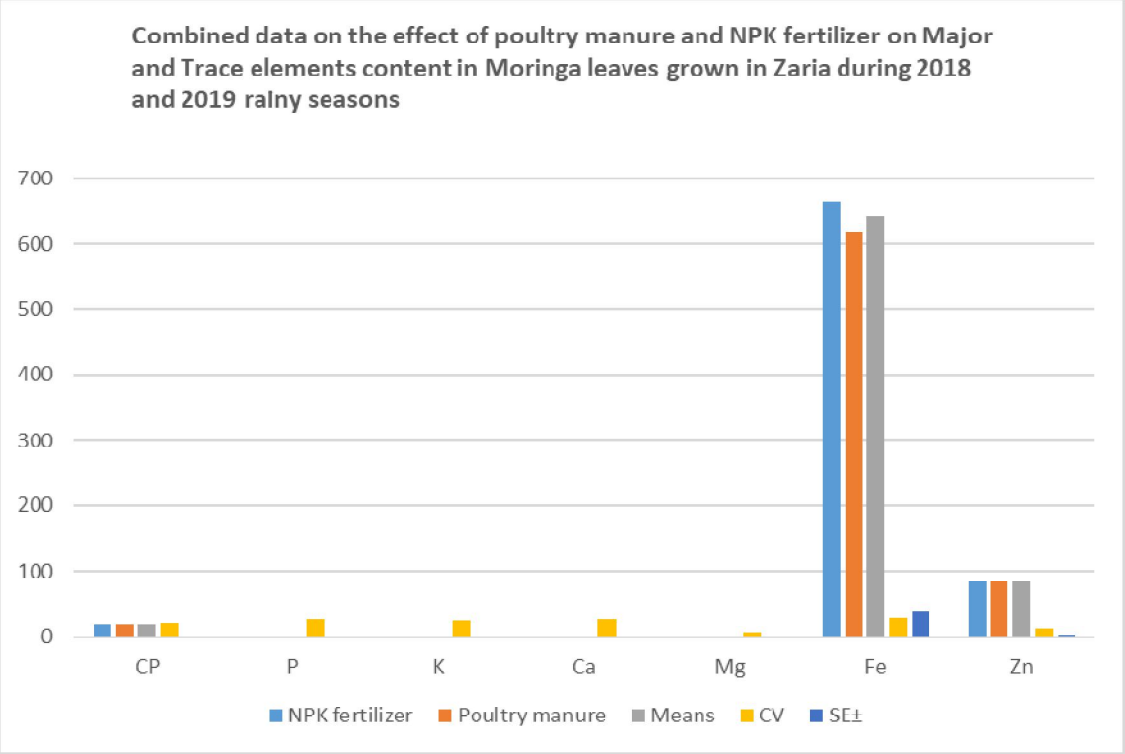

**Effect of Poultry manure and NPK fertilizer on trace elements in 2018& 2019**

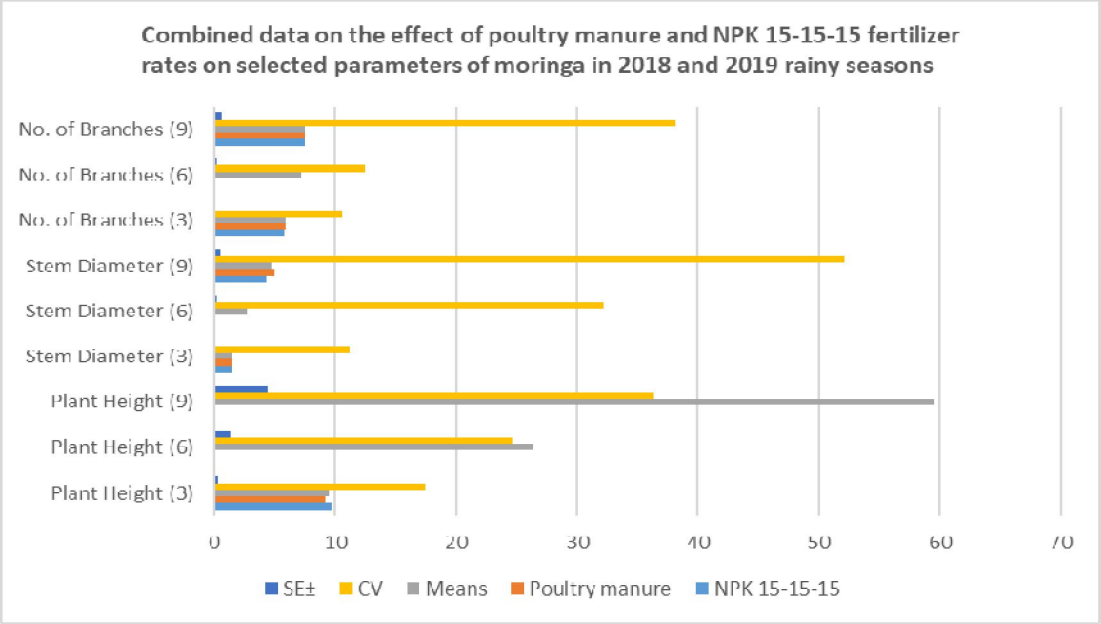
The result shows the influence of trace elements in both seasons. In 2018 rainy season, application of IF1 gave the least number of plants nutrients in moringa leaves [0,167 (Mg); 591.7 (Fe) and 83.250 (Zn)] which are trace elements and the highest quantity of these elements were produce with the application of IF4. [0.170 (Mg) 796.4 (Fe) and 76.00 (Zn)] respectively. In the same year, application of PM1 produce the highest quantity of nutrients [0.167 (Mg); 657.3 (Fe) and 67.00 (Zn)] which are trace elements and the least quantity of these elements were produce with the application of IF4; [0.167 (Mg); 516.1 (Fe) and 87.00] respectively.

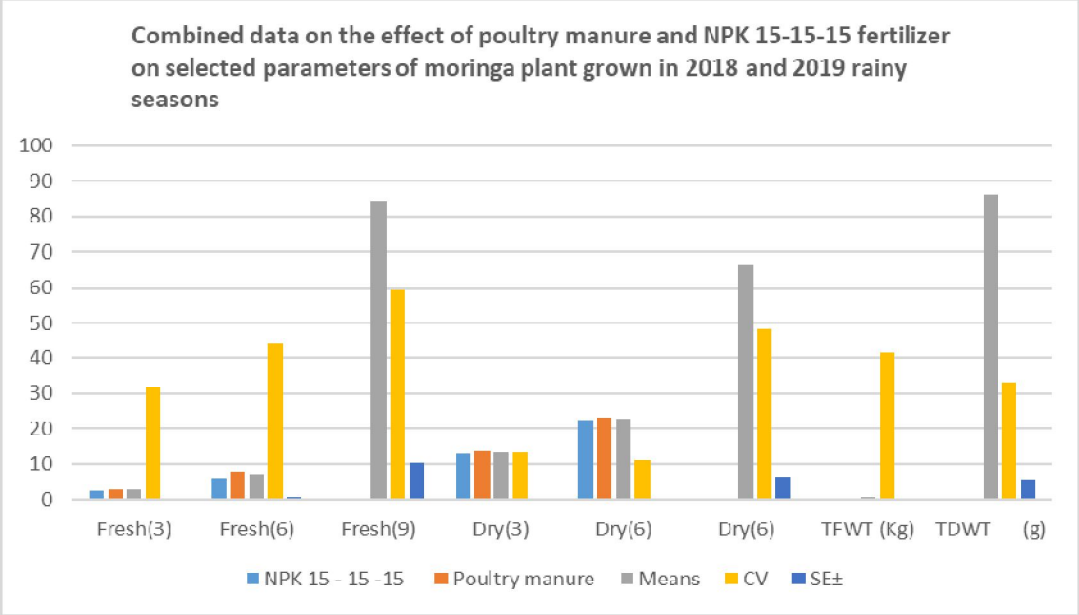
However, during the 2019 rainy season, application of PM1leads to production of high level of plants nutrients in moringa leaves [0.1600 (Mg); 619.3 (Fe) and 84.83 (Zn) which are trace elements and the least quantity of these elements were produce with the application of PM4 [0.1567 (Mg) 543.2 (Fe) and 92.83 (Zn)] respectively. In the same year, application of IF1 produce the highest quantity of moringa leaves nutrients [0.160 (Mg); 619.3 (Fe) and 84.83 (Zn)] which are minor elements and the least quantity of these elements were produce with the application of PM4 to give [0.1567 (Mg); 543.2 (Fe) and 92.83 (Zn)] respectively.



**Major and Trace Elements of moringa (Combined data 2018 and 2019):** This indicatesthe effect of poultry manure and NPK fertilizer rates on major elements (CP, P, K and Ca) in moringa leaf for the 2018 and 2019. It was revealed that the various treatments administered had no significant differences on major element content. It also indicates the effect of poultry manure and NPK fertilizer rates on trace elements (Mn, Fe, and Zn) of moringa leaf at Zaria in for the two rainy seasons revealed that the various treatments administered had no significant differences on trace element content. It was observed that application of NPK 15-15-15 fertilizer has significantly produce a higher CP content but P, K and Ca content were not affected by the different levels of treatment applied. Application of both poultry manure and NPK fertilizer rate had a significant difference on Mn, Fe and Zn content of moringa leaf.





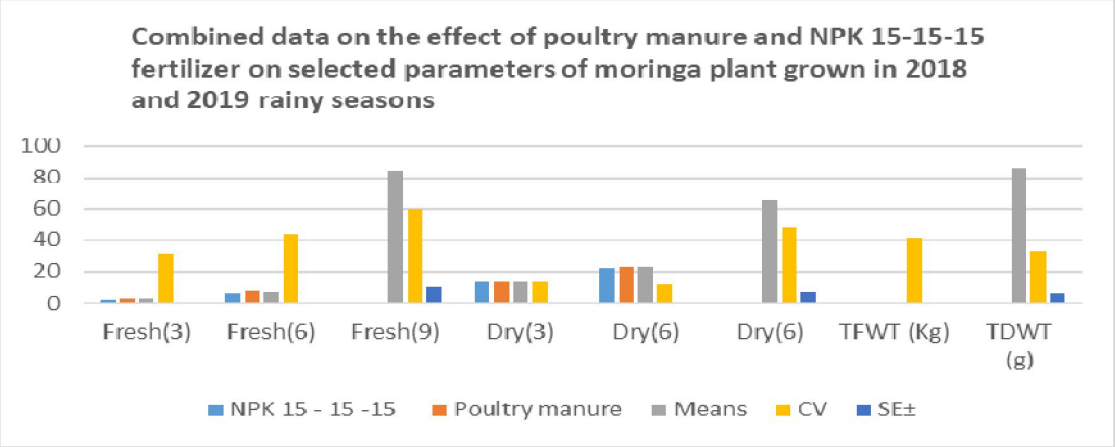




## DISCUSSION

**Physical and chemical properties of the Experimental Site:** The soil of the experimental farm was classified as Sandy Loam and this may be attributed to the parent material from which the soil was formed and the climatic nature of the study area. This is in line with opinion of Brandy and Weil (2013) and Olaiton *et al* (1984). The low level of total nitrogen and organic matter (O.M) of the study area can be attributed to high temperature that favoured rapid decomposition of O.M. due to high solar radiation and moisture facilitated by high-speed microbial activity in the soil (Brandy 2013). The Ca content and $PO_4^{2-}$ could be attributed to the parent materials where the soil was formed. There is slight level of exchangeable acidity in both years which might have improved the condition of the soil and enhanced the growth and yield as recorded in both 2018,

2019 and combined data. The higher growth and yield components observed and shown in Appendix I and II is attributed to better weather condition recorded throughout the experimental periods.

**Moringa response to poultry manure application:**This has significantly influence growth and virtually all the yield characters of the crop evaluated and the chemical / elemental content of the leaves. This trend was expected considering the positive role that poultry manure plays in growth and development of crops particularly when it is applied in soils with low nature of fertility as was the nature of the soil in experimental site. The higher values of growth parameters assess could be due to role of poultry manure in assimilate production which could later be directly converted into high DM production, taller and thicker stems plants. This result is in conformity with the findings of Rodovich (2009) who reported that moringa tree benefited from PM by increasing production three (3) folds.




**Moringa response to NPK fertilizer application:**The importance of interaction among the three (3) basic elements (NPK) on growth and yield parameters cannot be over emphasized. Poultry manure phosphorus is important in crop nutrition especially in soils of Western Nigerian as stated by Adepetu, (1975). The significant response of moringa in terms 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 were recorded. The results of these findings shows that good yield and yield components were observed. This observation could be attributed to favourable weather condition of the study area particularly solar radiation and relative humidity which coincided with rainfall distribution in both the year 2018 and 2019. Fuglie and Sneeja (2010) reported that NPK applied to moringa encourages root development and leafy canopy and increases final yield.

**Poultry Manure Verses NPK 15-15-15 Fertilizer:** 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 between yield and various growth characters of**

**moringa:**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. Larger 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 measured 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 correlation coefficient between yield and various growth traits 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

## CONCLUSION AND RECOMMENDATIONS

The results obtained shows that the poultry manure and NPK fertilizer applied responded to some of the growth and yield parameters tested. It was observed that application of poultry manure in all the growth and yield parameters evaluated had a significantly produced higher yield than these of NPK 15-15-15 fertilizer. However, for both 2018 and 2019 rainy season there is no significant differences on the content of both major elements (CP, P, K and Ca) and trace elements (Mn, Fe, and Zn). Although NPK fertilizer has significantly produce a higher CP content but the levels of P, K and Ca elements were not affected by the different levels of treatment applied. The application of poultry manure had not significantly affected the levels of Mn, Fe and Zn content of moringa leaves. It is therefore recommended that farmers in the study area should adopt the planting of the crop using chiefly available poultry manure to obtained higher yield of *Moringa oleifera* leaves composed of larger quantity of both major and trace elements. The findings of this study will be useful to current and future farmers of moringa in Zaria and beyond; extension workers, academic staff and students of agriculture and prospectus researchers in moringa plants

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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 10.00 (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. (min) $^0$C | Temp. (max) $^0$C | Relative humidity (R.H.) (max) (%) | (min) (%) | Sunshine 10.00 (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 |

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**Appendix IV: Physical Analysis of Poultry Manure for Both Seasons.**

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

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**Appendix V: Chemical Analysis of Poultry Manure (% by weight) for both Seasons.**

| Major Nutrient | Total soluble | Minor Nutrient | 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 VI: Physical Analysis of NPK 15-15-15 Fertilizer for both Rainy Seasons.**

| 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 VII. Chemical Analysis of NPK Fertilizer (% by wt.) for both Rainy 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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