IJSGS

ISSN: 2488-9229
FEDERAL UNIVERSITY
GUSAU-NIGERIA

INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY

Effects of Pearl Millet (*Pennisetum typhiodes*) Sole Cropping on Soil Chemical Properties in Musawa Area, Katsina State, Nigeria

Musa M. Ahmed*, Muhammad N. Danjuma and Maharazu A. Yusuf

Department of Geography, Bayero University Kano, Nigeria
*Correspondence: ammusawa01@gmail.com

Received: September, 2016 Revised and Accepted: November, 2016

Abstract

Pearl millet is the 6th most important world cereal. The study assessed the effects of Pearl Millet (Pennisetum typhoides) on soil properties in Musawa area, Katsina state, Nigeria. Methods for the study involved: soil sampling were composite method was used to collect soil samples on 10 farmlands in five study villages of the area. The 10 samples were collected from five sampled plots under pearl millet sole (major cropping) and five control plot of mixed cropping. The samples were air dried, packaged in labeled polythene bags and transported to soil laboratory of Department of Geography, Bayero University Kano for analysis. Soil properties tested are: pH, CEC, OC, N, P, K and Ca. Results show that while average pH (6.12) and CEC (1.583me/100g) were found under pearl millet sole cropping to be high and low respectively, pH (6.06) and CEC (2.159me/100g) under mixed cropping system were low and high respectively. Nitrogen, potassium, calcium as well as boron and exchangeable bases were found to be low, possibly declined due to millet sole cropping. Furthermore, under pearl millet sole cropping, soil was found to be low in OC, N, K, Ca and CEC respectively. It is recommended that mixed cropping systems traditional fertility management practices should be encouraged for the soils to withstand the continuous pearl millet cultivation in the study area.

Keywords: Pearl millet; sole cropping; soil chemical properties; Musawa; Nigeria.

1.0 INTRODUCTION

Pearl Millet reportedly was domesticated over 4,000 years ago in the West African Sahel, spreading later to East Africa and India. It is dominantly grown in the semi-arid and drylands of Africa and Southeast Asia (Baltensperger, 2002). The world's area planted to millet is about sixty five million hectares, with the major part in India and Africa (Nene and Singh, 1975).Pearl millet is one of the most important cereals in drought-prone areas and is the staple grain for 150 million people in Africa and India (Food and Agriculture Organization, 1997). Pearl millets are adapted to a wide range of ecological conditions often growing on skeletal soils that are less than 15 cm deep. It does not demand rich soils for their survival and growth. Hence, for the vast dryland area, they are a boon. Pearl millet is well adapted to areas characterized by poor soils (Hajor *et al.*, 1996).In the semi-arid environment where the mean rainfall lies between 250mm-1000mm, pearl millet is the main staple food crop grown (Bauhin *et al.*, 1998). Pearl millet tolerates rocky sandy soils which are prevalent in Nigerian semi-arid region (Ugherughe, 1998). Millets are astonishingly low water consuming crops (Sathya *et al.*, 2013).

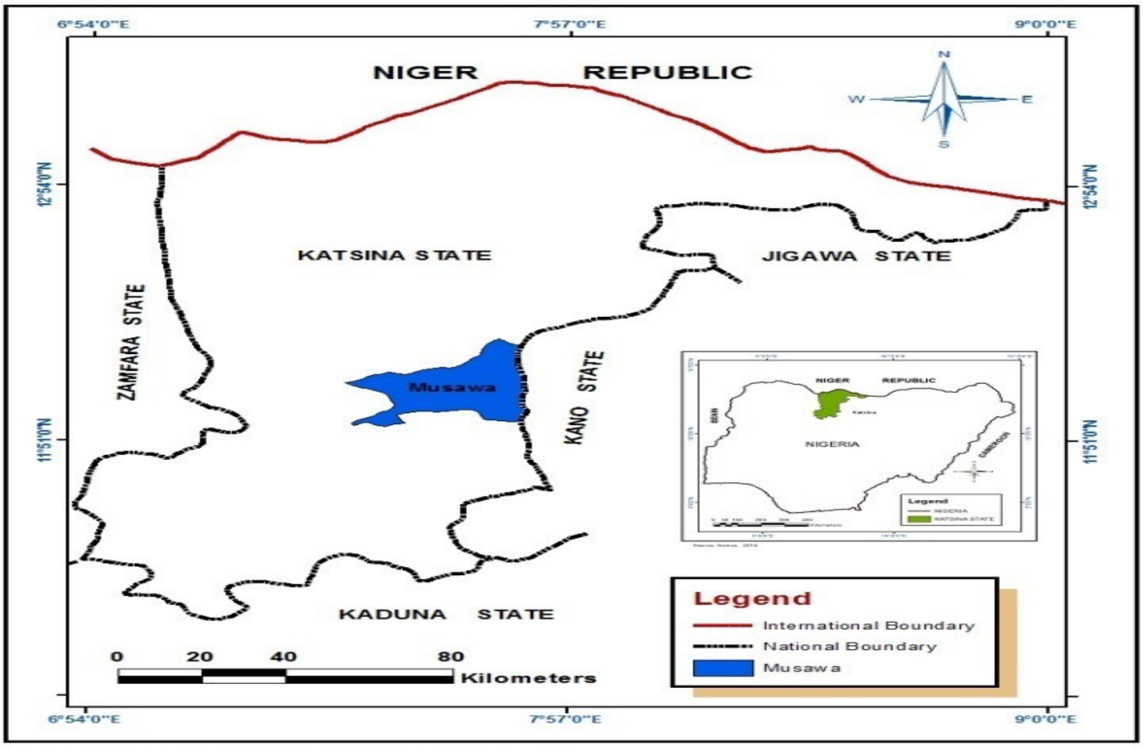
Pearl millet is a serious nutrient miner. Bationo *et al*. (2011) stated that nutrient balances are negative for many cropping systems suggesting that farmers in West African countries are mining their soils. According to Ikwelle *et al* (1998) an estimated 44gN/ha, 22kgP_2O_5/ha and 15kgK_2O/ha are removed from the soil where pearl millet is grown the Sahelian and Sudanian zones of Africa. Khairwal *et al* (2007) stated that with continuous pearl millet cropping, soils with medium or high potassium levels will not show a yield response to added potassium fertilizer.

Various studies have indicated that Pearl millet sole cropping on leads to soil nutrients depletion especially nitrogen, phosphorus and potassium. In Burkina Faso, estimates indicate that for a total of 6.7 million hectares of land cultivated, soil nutrient mining amounted to a total loss of 95,000 tonnes of N, 12,100 tonnes of P and 65,000 tonnes of K. Maman *et al.* (2013) reported nutrient depletion under sole cropping is a major factor in decreasing agricultural productivity since the 1960s. Low organic matter content (0.15 to 0.7%), acid soils (pH4.5 – 7), available phosphorus (0.4 to 3.4ppm) and nitrogen are generally considered limiting also especially in sole cropping systems (Maman *et al*., 2013).Shahin *et al.* (2013) increasing nitrogen fertilization rates caused significant effect in many growth attributes of pearl millet as well as forage yield such as plant height at the rate of 80kg N/ha.

Comparable data for soil chemical properties under annual cropping are dominated by considerable reports of nutrient losses. Numerous studies have shown substantial negative balances of chemical properties of soil under sole cropping systems (Islam et al., 2011).However, these studies appear to converge on macro nutrient depletion under sole cropping. There is a need for thorough studies of all chemical components of soil, thus this study assessed the effect of pearl millet sole cropping on soil chemical in Musawa Area, Nigeria with a view to recommending various means for maintaining fertility in the area.

2.0 STUDY AREA

Musawa is located between latitude 11°58'N – 12°16'N and longitude 7°28'E – 7°56'E (Planning Unit, Katsina State, 2013). The rainy season in Musawa area is between the month of May to September and it has its peak in the month of August. Based on average of 10years from 2000 to 2009, the area receives rainfall of 750mm – 850mm annually (Meteorological Unit, 2012).The mean maximum temperature of Musawa area is 39°C in the month of April and May. At the high of rainy season, average maximum temperature is 38°C and in December, average temperature is 20°C (Meteorological Unit, 2012). The minimum relative humidity of Musawa is 18% in December to January and maximum as 95% around July to September, (Meteorological Unit, 2012). Soil of Musawa area is light clay in nature, but due to drift deposits resulting into sandy soils (Chude *et al*., 2012).



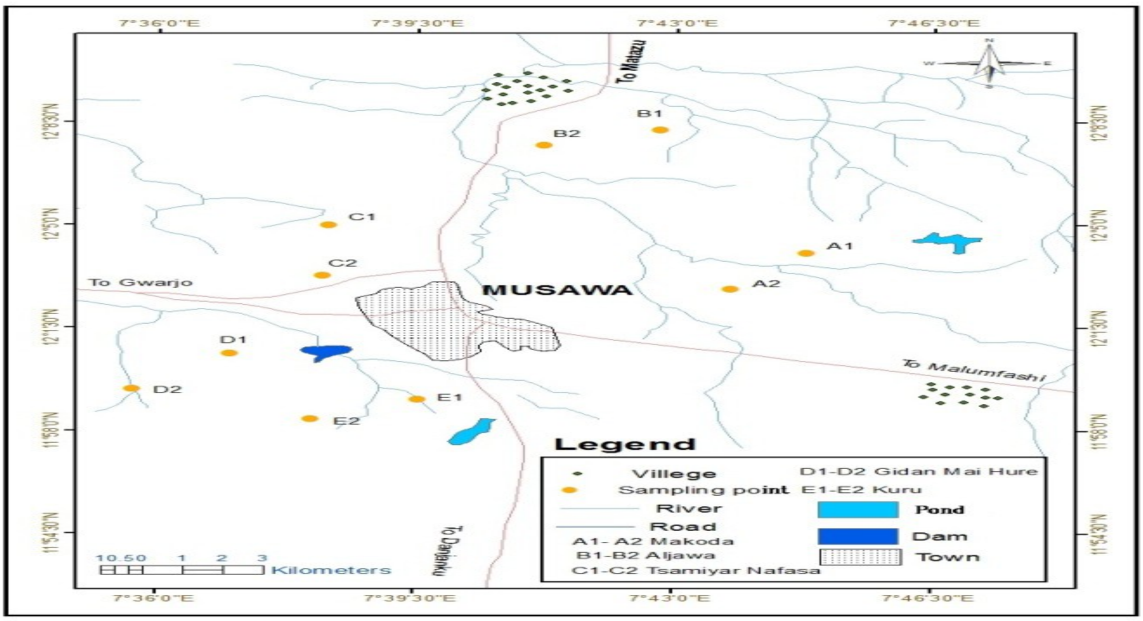
Source:Administretive Map of Nigeria NASRDA. 2013

Figure 1.1: Katsina State Showing Musawa LGA

3.0 METHODS

3.1 Soil Survey and Sampling

Snowball sampling technique was used to select five farms under sole cropping of pearl millet for 30 years and above in the study area. The farms are located in: Makoda, Aljawa,Tsamiyar Nafasa,Gidan maihure and Kuru villages (Figure 1.2). In order to be able to validate the findings of this study, adjacent farms which were not under pearl millet cultivation in recent years were also sampled along each farm selected under sole cropping. These serve as controls. This equals to 10 farm plots for the study.



Source; NASA/NOA Sport Image and Field Work 2013

Figure 1.2: Map of Musawa Area Showing Sampling Points

The study area is homogenous in terms of topography, climate, geology, soils as well as farm management (Ahmed, 2014). Hence a total of 7 samples were collected at 15cm depth in each farm plot which was considered to be best location of Pearl millet roots within the soil. A total of 35 samples were taken in 5 plots each under pearl millet sole cropping and control sites. Samples were collected in May 2013 with augar, stored in polythene bags and marked (1-under pearl millet sole cropping and 2-under control sites). The labels are as follows: Makoda (A1, A2), Aljawa (B1, B2) Tsamiyar Nafasa (C1, C2), Gidan maihure (D1, D2) and Kuru (E1, E2) respectively. The samples were mixed vigorously to form composites. In order to avoid contamination, the composite samples were dried in the air, sieved using a 2mm sieve, and then brought to soil laboratory of Bayero University Kano for the analysis of nine (9) chemical properties (Table 1).

3.2 Procedures for Analysis of Soil Sample

Various procedures are used to test soil properties in the laboratory. This study makes use of the techniques:

Table 1: Methods for Analysis of Soil Samples

Soil properties	Methods
Soil pH	pH meter
Organic Carbon (OC)	Walkley black
Total nitrogen	Micro kjeldahl
Total Phosphorous	Flame photometry
Potassium	Flame photometry
Calcium	Atomic absorption photometry
Magnesium	Atomic absorption photometry
Cation exchange capacity (CEC)	Leaching (with ammonium acetate)
Boron	Solution method (with Sodium acetate)

4.0 RESULTS AND DISCUSSION

4.1 Soil Chemical Properties

Soil nutrient depletion is always with us but its causes, extent and severity vary spatially over the globe. Soil nutrients tested in many works distinguished productivity statuses and declines caused by various factors under different management regimes. As no essential element can substitute for another, it is critically important to identify where and when such deficiencies occur (Estefan, Sommer, and Ryan, 2013).

Average pH of 6.12 under pearl millet is slightly higher than that of control plots 6.06 (Table 3). Though, the values are at good level for agricultural soils when compared with pH 6.09 in Cairo (Shahin *et al*., 2013). Organic carbon is seriously below average under pearl millet (0.59%) compared to (1.45%) for control sites.

Soils under pearl millet recorded average nitrogen (0.5%) and is lower compared with control site plots (0.64%). Nitrogen is essential in plant growth ranging from 0.8 to 1.6% requirement for pearl millet (Ikwelle *et al.*, 1998). It is higher compared with average 0.5% in the area. This led to the reduction in soil nutrients as well as fertility. Agbede (2009) said that phosphorus 0.1 to 1.0 % is in plant tissue and 30 to 60ppm is required for pearl millet growth and development.

Table 3: Soil Chemical Properties in the Study Area

Sample	pH	OC%	N%	P ppm	K me/100g	Ca me/100g	Mg me/100g	CEC me/100g	B me/100g
(a) Under Pearl Millet									
A1	6.2	0.12	0.08	12.88	0.140	0.313	0.149	1.025	0.066
B1	6.4	0.28	0.6	1.15	0.057	0.223	0.075	1.155	0.033
C1	6.2	1.54	0.51	21.76	0.199	1.562	0.075	2.436	0.066
D1	6.0	0.24	0.62	18.32	0.296	0.580	0.075	1.951	0.049
E1	5.8	0.76	0.69	17.75	0.148	0.448	0.150	1.346	0.033
Average	**6.12**	**0.59**	**0.5**	**14.37**	**0.168**	**0.625**	**0.104**	**1.583**	**0.049**
SD	0.04	0.55	0.22	7.19	0.0001	0.08	0.04	0.53	0.013
CV%	0.7	93.22	44	50.03	0.05	12.80	38.46	33.48	26.53
(b) Under Control Sites									
A2	5.6	0.28	0.56	13.86	0.262	1.965	0.075	3.702	0.082
B2	6.4	3.07	0.65	13.86	0.182	0.760	0.075	1.617	0.033
C2	6.2	1.80	0.60	21.76	0.199	1.160	0.150	2.309	0.082
D2	6.2	0.32	0.66	17.75	0.267	0.893	0.150	1.910	0.033
E2	5.9	1.80	0.73	20.04	0.131	0.580	0.150	1.261	0.049
Average	**6.06**	**1.45**	**0.64**	**17.45**	**0.208**	**1.071**	**0.120**	**2.159**	**0.056**
SD	0.26	1.10	0.05	3.07	0.05	0.49	0.10	0.84	0.04
CV%	4.29	75.86	7.81	17.59	24.03	45.75	83.33	38.91	71.42

Source: Field Work and Laboratory Analysis (2014)

Key: A1 – 2 =Makoda B1 – 2 =Aljawa C1 – 2 =TsamiyarNafasa
D1 – 2 = Gidanmaihure E1 – 2 = Kuru
SD = Standard Deviation
CV = Co-efficient of Variation

The average potassium is 0.168me/100g under pearl millet and 0.208me/100g under control sites. Average calcium 0.625me/100g under pearl millet is higher than 1.071me/100g under control sites. The average values of CEC in the area recorded 1.583me/100g and 2.159me/100g under pearl millet and control sites respectively. It also revealed that there is variation of 75.86, 83.33 and 71.42% in terms organic carbon, magnesium and boron respectively (Table 1). Therefore, it can be concluded that nutrients are degrading under pearl millet cultivation in the area. However, depletion in soil nutrients was shown under continuous pearl millet sole cropping compared to control site plots. Deviation from the norm may serve as a proxy for nutrient depletion under the two management types.

4.2 Farmland Management Practices Influencing Chemical Properties

Soils vary greatly throughout the world; they have inherent weakness, primarily deficiencies in nutrients that are essential to growing crops. Even when adequately supplied in the early stages of land cultivation, the nutrient-supplying capacity invariably diminishes with time. There are various management practices which directly or indirectly influence soil properties.

Table 2: Sampled Farmlands and their Characteristics.

Station	Sample	Years of Cultivation	Manuring	Cropping System	Cropping Pattern	Tillage	Date/Last Cropping	Farming system

Makoda	A1	40 years	Inorganic	Sole-Millet	100cm by 30cm	Ox-plough	Millet (12 yrs)	Subsistence
	A2	70 years	Organic & Inorganic	Mixed	75cm by 30cm	Ox-plough	Maize (4 yrs)	Subsistence
Aljawa	B1	35 years	Organic & Inorganic	Sole-Millet	75cm by 30cm	Ox-plough	Millet (12 yrs)	Subsistence
	B2	40 years	Organic	Mixed	75cm by 25cm	Ox-plough	Sorghum (6 yrs)	Subsistence
Tsamiyar Nafasa	C1	60 years	Inorganic	Sole-Millet	100cm by 30cm	Ox-plough	Millet (13 yrs)	Subsistence
	C2	60 years	Organic	Mixed	50cm by 25cm	Ox-plough	Maize (2 yrs)	Subsistence
Gidan Mai Hure	D1	60 years	Inorganic	Sole-Millet	75cm by 30cm	Ox-plough	Millet (14 yrs)	Subsistence
	D2	60 years	Inorganic	Mixed	75cm by 30cm	Ox-plough	Sorghum (11yrs)	Subsistence
Kuru	E1	70 years	Organic & Inorganic	Sole-Millet	100cm by 30cm	Ox-plough	Millet (15 yrs)	Subsistence
	E2	70 years	Organic & Inorganic	Mixed	75cm by 30cm	Ox-plough	Sorghum (7 yrs)	Subsistence

Sources: Field Work (2014)

Key: A1 = Sole millet farmland B1 = Sole millet farmland C1 = Sole millet farmland
A2 = Control farm B2 = Control farm C2 = Control farm
D1 = Sole millet farmland E1= Sole millet farmland
D2 = Control farm E2= Control farm

Soil sampling sites and management history were recorded in table 2. Farmers in the area are cultivating pearl millet for many years ranging from 40-70years and majority used inorganic fertilizer. Continuous pearl millet sole cropping recorded 10-14years, which lead to decrease in soil nutrients compared with control site plots. However, the farming system in the area is subsistence for domestic use which led to use local implements such as hoe, ox-plough for tillage. Therefore, removal of soil nutrient is higher compared with three millet varieties cultivation in Maiduguri (Hassan *et al*, 2010).

5.0 CONCLUSION

This research revealed the status of soil chemical properties under different management regimes of pearl millet.It shows that continuous pearl millet sole cropping is which increasingamong farmers led to increases in soil nutrients depletion. Soil chemical properties under pearl millet sole cropping were found to be declining compared with control sites. This was due to low values of average clay (8.71%), N (0.5%), P (14.37ppm) and K (0.168me/100g) under pearl millet sole cropping compared with clay (9.04%), N (0.64%), P (17.45ppm) and K (0.208me/100g) for control sites. This also led to soil fertility status in the area to be at low levels.

Impact of pearl millet cultivation on soil properties revealed that soil nutrients including organic carbon, phosphorus, calcium and CEC were found to be seriously degraded as indicated by 59.31%, 17.65ppm, 41.64% and 26.68% respectively.Findings of the study suggest that that continuous sole cropping which affected soil chemical properties in Musawa area should be avoidedin order to avert soil fertility decline in smallholder farmlands under pearl millet cultivation in the study area.

Based on the evaluation of soil quality indicators, the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass under pearl millet. This study therefore concluded that integrated use of inorganic and organic fertilizers can minimize excessive nutrients loss, maximize economic yield and improve soil health.

6.0 RECOMMENDATIONS

1. Crop rotation and mix cropping should be encouraged as these measures could reduce the removal of nitrogen by crops that stored starch such as pearl millet. Farmers can be encouraged to practice mixed cropping systems under pearl millet cultivation through a variety of way including but not limited to extension education and enlightenment campaigns in the radio. This measure will help in balancing of efficient use of soil N, K and P under pearl millet sole cropping for stability in food production generally.

2. Farmers should be encouraged on improved practice such as minimum tillage, strip cropping, farmer managed natural regeneration and agroforestry. This can be achieved through.

7.0 REFERENCES

Abd El-Lattief, E.A. (2011).Growth and fodder yield of forage pearl millet in newly cultivated land as affected by Date of planting and integrated use of mineral and organic fertilizers.*Asian Journal of Crop Science,*vol. 3: 35 – 42

Ahmed, M. (2014).*Effect of Pearl Millet Crop Cultivation on Soil Fertility in Musawa area, Musawa local government area Katsina State.* An M.Sc Dissertation, submitted to the Department of Geography, Bayero University Kano.

Bationo, A., Kihara, J., Waswa, B., Ouattara, B. and Vanlauwe, B (2011).*Technologies for sustainable Management of sandy Sahelian soils*. Journal of Tropical soil Biology and fertility Nairobi vol. 7: 262-269

Baltensperger, D.D. (2002). Progress with proso, pearl and other millets. **In:**Janick, J and Whipkey A. (eds.). *Trends in New Crops for New Uses.* ASHS Press, Alexandria.

Bauhin, G.K.A., Donhi, E.O. and Muhammad, Z. (1998).*Effecting Monotoring and Forecasting of Pest and Diseases Outbreaks in Millet Cropping System*, Pearl Millet in Nigerian Agriculture (Production, Processing and Research Priorities) Edited by Emechebe, A.M., Ikwelle, M.C., Ajayi, O., Aminu-Kano, M. and Anaso, A.B. Ramadan Press Limited, Bauchi.

Chude, V.O., Jayeoba, O.J. and Berding, F. (2012).*Soil Fertility Maps and Site/Crop Specific Fertilizer Formation for Katsina State*, Federal Ministry of Agriculture and Rural Development, Abuja.

Estefan, G., Sommer, R. and Ryan, J. (2013).*Methods of Soil, Plant, and Water Analysis: A manual for the West Asia and North Africa region*. Third Edition. International Centre for Agricultural Research in the Dry Areas, ICARDA, Beirut, Lebanon

Eno, J.U., Trenchard, O.I., Joseph, A.D., Anthony, O.A. and Ivara, E.E. (2009).*Manual of Soil, Plant and Water Analysis.* Sibon Book Ltd, Lagos

Food and Agriculture Organization (1997). *Economie mondiale du sorgho et du mil: Faits, tendances et perspectives.* Food and Agriculture Organization, Rome.

Hassan, A. M. and Bibinu, A.T.S. (2010).Response of three millet varieties to nitrogen fertilizer in Maiduguri the Semi-Arid region of North-East Nigeria.*Journal of Agronomy*, vol. 4: 10 -14

Hajor, A.S., Al-Hatalani, L.S and Khafagi, O.A. (1996).A comparative study on salt tolerance of millet (*Pennisetum glaucum* L.) and sorghum (*Sorghum bicolour* L.).*Alexandria Journal of AgricultureResearch*, 41(3):23-39.

Ikwelle, M.C. (1998).*Pearl Millet in Nigerian Agriculture* Pearl Millet in Nigerian

Agriculture (Production, Processing, and Research Priorities) Edited by Emechebe, A.M., Ikwelle, M.C., Ajayi, O., Aminu-Kano, M. and Anaso, A.B. Ramadan Press Limited Bauchi.

Islam, M.M., Karim A.J.M.S., Jahiruddin, M., Majid, N.M., Ahmed, M.M. and Hakim, M.A. (2011).Effects of organic manure and chemical fertilizers on crops in the radish-stem amaranth Indian spinach cropping pattern in homestead area. *Australian Journal of Crop science,* vol. 11: 1370 - 1378

Khairwal, I.S., Rai, K.N., Diwakar, B., Sharma, Y.K., Rajpurohit, B.S., Nirwan, B. and Bhattacharjee, R. (2007).*Pearl Millet Crop Management and Seed Production* Manual International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh India.

Nene, Y. L and Singh, S. D. (1975).*A Comprehensive review of downy mildew and ergot of pearl millet.*International Crops Research Institutefor the Semi-Arid Tropics, Hyderabad,India.

Lamofor, N.O.,Chude, V.O., Esu, I.E., Odeare, V. and Abalarin, O. (1990).*Selected Methods for Soil and Plant Analysis Department of Soil Science*, ABU Zaria.

Maman, N. and Mason, S. (2013).Poultry Manure and Inorganic Fertilizer to improve pearl millet yield in Niger.*African Journal of Plant Science*, vol. 7: 152 -158

MET (2012).*Annual Weather Report*, Meteorological Unit, Umaru Musa Yar'adua International Airport, Katsina.

Planning Unit (2013).*Mapof Katsina State,* Ministry of Land, Survey and Environment Katsina State of Nigeria.

Shahin, M.G., Abdrabou, R.T., Abdelmoemn, W.R. and Hamada, M.M. (2013).Response of growth and forage yield of pearl millet (pennisetumglaucum) to nitrogen fertilization rates and cutting height.*Journal of Agricultural science,*vol. 5 :153-162

Sathya M., Vinodhana, N.K and Sumathi, P. (2103). Hierarchial clustering of pearl millet (*Pennisetum glaucum*(L.) R.Br) inbreeds for morpho-physiological traits. *International Journal of Current Microbiology and Applied Sciences*, 2(12): 647-652.

Ugherughe, P.O. (1998).*Forage Potentials of Pearl Millet in Nigeria.* Pearl Millet in Nigerian Agriculture (Production, Processing and Research Priorities) Edited by Emechebe, A.M., Ikwelle, M.C., Ajayi, O., Aminu-Kano, M. and Anaso, A.B. Ramadan Press Limited Bauchi.