Pyrex Journal of Plant and Agricultural Research

Pyrex Journal of Plant and Agricultural Research
Vol 2(1) pp. 37-43 April, 2016

http://www.pyrexjournals.org/pjpar

Full Length Research Paper

Soil Suitability Assessment for Pearl Millet Cropping in Musawa Area, Katsina State, Nigeria

Salisu Mohammed and Musa Musawa Ahmed*

Department of Geography, Bayero University Kano, Nigeria.

Received 23 March, 2016; Accepted 04 April 2016

Abstract

Composite soil sampling method for the collection of soil samples between the depth of 0-15cm was adapted. The soil samples were collected from sampled plots under pearl millet sole (major cropping) and tested for some physical and chemical properties. The result reveals that mean temperature, rainfall, relative humidity and average pH were optimum for pearl millet cultivation. Soil properties including average clay (8.71%), AWHC (1.17cm), P (14.57ppm) and CEC (1.583me/100g) were found under pearl millet sole cropping to be low. The 'suitability rating' of temperature, rainfall, relative humidity and pH were found to be suitable (S1), nitrogen and organic carbon were found to be marginally suitable (S3); available phosphorus, potassium, calcium, magnesium and CEC were temporary not suitable (N1) for the crop in the area. Analysis of variation (ANOVA) revealed that there is no variation among the soil samples. Therefore, the findings of this study indicate that, pearl millet crop cultivation has effect on soil which led to low suitability. Mixed cropping systems, integration of organic and inorganic fertilizers and improvement in traditional fertility management such as tillage and early clearing should be maintained to increase pearl millet production to meet the people's demand for sustainable development.

Key word: Soil, pearl millet, katsina.

INTRODUCTION

Considering the dominance and important of pearl millet in northern Nigeria, it is very useful to understand the climatic requirements of pearl millet. This is to compare with matching edaphic requirement to assess suitability. According to Anaso *et al.,* (1998) soils of pearl millet sole cropping are sandy to very fine sandy loam these are susceptible to nutrient depletion. Efficient utilization of soil nutrients depends on the fertility of the soils as a rooting medium. In these soils, the clay content is often less than 10%, the moisture control and soil management problem of soil are frequent. Continuous pearl millet sole cropping lead to decrease in soil nutrients and poorly developed weak structure profile which deteriorates with continuous cultivation and compaction (Khairwal *et al.,* 2007). They further added that poor structure is attributable to low organic matter content necessary to induce aggregate binding. The soils are however sufficiently deep for the growth of arable crops, but the weak structure often results in soil crusting with obvious consequences of severe runoff, restricted root penetration and reduced infiltration and available water. Therefore, impact of pearl millet cultivation on soil properties could be a serious problem and can dictate the suitability of growing of the crop in a particular area.

Yoana *et al.,* (2010) pointed that the best temperature for cultivation of pearl millet ranges from 23^{o}C to 42^{o}C. Poor emergence of seedling growth may result, if planted before soil temperature reach 23^{o}C. The requirement of rainfall ranges between 600mm and 800mm. Mitscherlich's theory related plant growth to the soil nutrients. He observed that when plants were supplied

Corresponding Author E-mail: ammusawa01@gmail.com

with adequate amount of all but one nutrient, their growth was proportional to the amount of this one limiting element that was supplied to the soil (Tisdale, Nelson, Beaton and Havlin, 2003). They further added that Bray's nutrient mobility concept stated that as the mobility of nutrient in the soil decreases, the amount of that nutrient needed in the soil to produce a maximum yield increases from a value determined by the magnitude of the yield and the optimum composition of the crop, to a constant value. Thus, soil suitability assessment should be carried out for pearl millet to improve its productivity.

Yusuf (2011) said that land suitability is the ability of a given land to support a defined use. The process of land suitability assessment is the appraisal and grouping of specific areas of land interms of their ability for a defined use or uses. The FAO evaluation procedure is a step-by-step approach including, the evaluation (soil survey), the definition of the crop growth and production requirements, and their matching with the land data of the area under consideration (Verheye *et al.,* 2006). The FAO evaluation however, requires vigorous evaluation and classification of land for suitability assessment. But in a given area suitability matching can be made in terms of the soils of the area that to continue supporting the particular crop.

However, a research on peal millet involving production and processing in Nigeria revealed the suitability of some soils of the millet growing areas such of Funtua in Katsina State (Ajayi *et al.,* 1998), but this study has never been conducted in Musawa area. Thus, importantly Musawa area has annual rainfall of 850mm and annual maximum temperature of 39^{o}C. Therefore, it is of paramount important to assess soil suitability for the crop in the area. In addition, pearl millet is the major crop cultivated in Musawa and is used as staple food. Hassan et al (2010) observed that the response to three millet varieties to nitrogen fertilizer in Maiduguri the Semi-Arid region of north-east Nigeria revealed that millet remove 34.6, 5.0 and 48.8kg/ha of N, P and K from the soil compared with 30.7, 3.7 and 26.0kg/ha of N, P and K removed by sorghum and 23.4, 3.5 and 16.6kg/ha by maize. This indicated that millet is more likely to deplete soil nutrients at a faster rate than maize and sorghum (Hassan et al, 2010), but there has not been a research conducted on impact of pearl millet cultivation on soil properties and establish suitability of the crop in Musawa area.

STUDY AREA

Musawa is located at the center of Katsina State along Charanchi to Kurkujan road, between latitude 11^{o}58'N –12^{o}16'N and longitude 7^{o}28'E–7^{o}56'E, (Panning Unit, 2013). Climate refers to generalization of weather condition of a given area for a period of 30years (Ayoade, 2004). The rainy season of Musawa area is between the month of May to September and it has its peak in the month of August. The rainfall ranges of 5 – 6months (750mm – 850mm annual), based on average of 10years from 2000 to 2009. It is characterized by conventional rain fall (dry and wet climate) followed by long dry season of 6 – 7 months(Meteorological Unit, 2012).The mean maximum temperature of Musawa area is 39^{o}C in the month of April and May. At the high of rainy season, average maximum temperature is 38^{o}C and in December, average temperature is 20^{o}C (Meteorological Unit, 2012). Wind is moving air in motion. It results from differences in atmospheric pressure. The wind speed of Musawa is 1.5km/h in the month of July to September and higher as 3.2km/h around December to January. The direction of wind is north-east to south-west and dry in December to January, and it is south-west to north-east direction and wet from April to October. Relative humidity denotes the amount of water vapour in the atmosphere (air) compared to what the air can hold when fully saturated. The minimum relative humidity of Musawa is 18% in December to January and maximum as 95% around July to September, (Meteorological Unit, 2012).

Soils are the mixture of rock particles loosened by weathering, mineral salts and dead vegetation matter. In the southern part of Katsina State, the covering material is largely clayey soil, about five meters in depth, and very fine in texture. The soils of Musawa are light clay in nature, but due to drift deposits resulting into sandy soils (Chude et al, 2012). Below are figures 1 and 2 showing the study area?

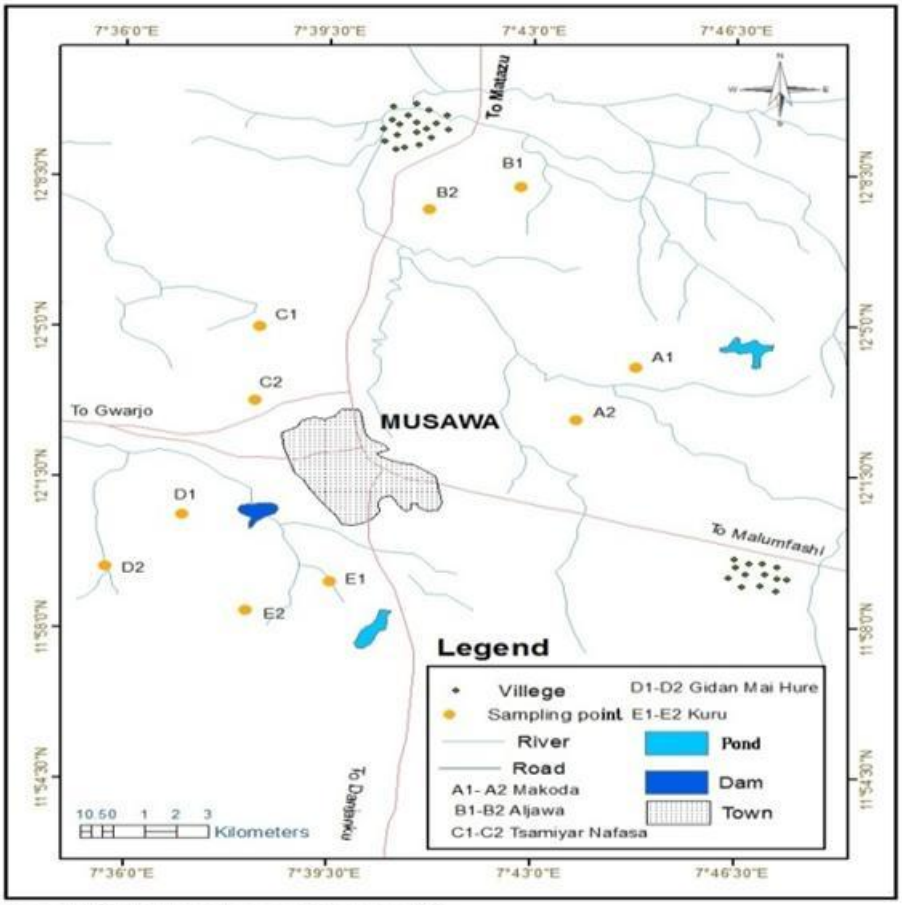
MATERIAL AND METHODS

The study area is characterized by homogeneity interns of topography, climate and microclimate, parent materials, organism, geology as well as farm management (Ahmed, 2014). Therefore, sampling points in the area have uniform features taken into consideration.

Field Work

Jaiswal (2003) stated that a portion of the entire soil mass taken from its natural occurrences for analysis in order to describe the properties of the soil is referred as soil sample. There are various methods of sampling farm plots irrespective of the method used, the sample collected must be representative of the area or plot. The study area was sampled into five, and five farms under pearl millet cultivation (sole cropping) for many years were selected. For each farm plot a composite sample was collected randomly, where 7 samples of top (0-15cm depth) were collected on 19th May, 2013.

This makes 35 samples with average 5 collected from plots each under pearl millet sole cropping. For each plot, samples were mixed vigorously and obtained one sub sample for analysis. Soil samples collected must represent the populations of every sample and should



Source; NASA/NOA Sport Image and Field Work 2013

Figure 1.2: Map of Musawa Area Showing Sampling Points

have the same volume and weigh at least 500g. In each farm plot observation was made in terms of homogeneity of the farm before taking the composite sample. The top 0-15cm depth was considered because the major roots of pearl millet are within and most agricultural activities do not go beyond this limit.

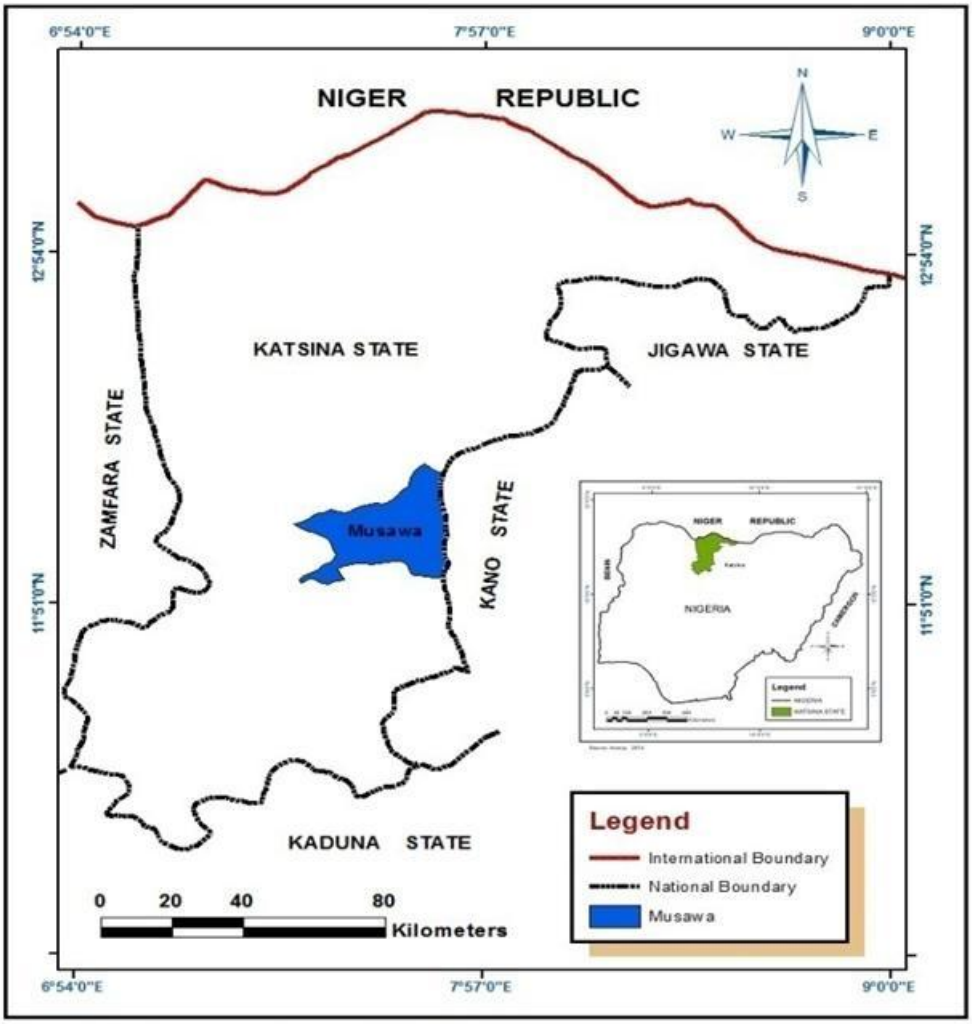
Laboratory and Statistical Analysis

The samples were subjected to air dried and sieved to pass through 2mm. Particle size distribution was carried out by hydrometer method and the hydrometer readings were inserted in computer and obtained water holding capacity. Soil pH was obtained in 1:25 water ratio method (Eno *et al.,* 2009). They further added that organic carbon was determined by dichromate solution method, total N by macro-kjeldehl method, available P by centrifuge method, exchangeable cations by NH_4OAC solution, where Na and K were determined by reading flame photometer while Ca and Mg by atomic absorption meter and CEC was calculated by the sum of exchangeable bases. According to Lamofor *et al.,* (1990) Boron was determined by sodium acetate solution method. Co-efficient of variation and analysis of variation (ANOVA) were used to examine the variation among the soil samples in the study area. However,

simple percentage method was used to determine percent effect of pearl millet on soil properties. Non-parametric suitability classification method was used to establish suitability rating of the soils under pearl millet cultivation based on the results obtained from analysed soil samples to achieve the objectives of the study.

RESULT AND DISCUSSION

The results are stated as follows; According to Udoh *et al.,* (2012), the determination of land suitability classes using the FAO framework (1976), involves the matching of land qualities or characteristic with the land use requirements. Therefore, the climatic and edaphic requirements of pearl millet are shown in table 1. The table also showed the potential range of climatic elements and ranges of e



Source:Administretive Map of Nigeria NASRDA. 2013

Figure 1.1: Katsina State Showing Musawa LGA

Table 1. Climatic and Edaphic Requirements of Pearl Millet

Nutrient	Range
Rainfall	500 – 900mm
Temperature	23 – 35^{o}C
Relative Humidity	20 – 80%
Clay	10 – 20%
AWHC	1.3 – 3.5cm
pH	6.0 – 7.0
Organic Carbon	0.8 – 1.6%
Nitrogen (N)	0.8 – 1.5%
Available (P)	30 – 60ppm
Potassium (K)	2.5 – 5.0 cmolkg^{-1}
Calcium (Ca)	06 – 12 cmolkg^{-1}
Magnesium (Mg)	2.50 – 10 cmolkg^{-1}
CEC	5.0 – 25 cmolkg^{-1}

Source: Adapted from the work of Ajayi *et al.,* (1998)

Table 2. Pearl Millet Suitability Rating and Matching Requirement

Sample	Rainfall	T	Hum.	Clay	AWHC	pH	OC	N	P	K	Ca	Mg	CEC
Pearl Millet Requirement	500 – 900	23-35	20-80	10-20	1.3-3.5	6-7	0.8-1.6	0.8-1.5	30-60	2.5-5	6-12	2.5-10	5-25
A1	700-800	20-39	18-95	9.0	0.6	6.2	0.12	0.08	12.88	0.140	0.313	0.149	1.025
B1	700-800	20-39	18-95	8.64	0.76	6.4	0.28	0.6	1.15	0.057	0.223	0.075	1.155
C1	700-800	20-39	18-95	8.64	3.14	6.2	1.54	0.51	21.76	0.199	1.562	0.075	2.436
D1	700-800	20-39	18-95	8.64	0.71	6.0	0.24	0.62	18.32	0.296	0.580	0.075	1.951
E1	700-800	20-39	18-95	8.64	0.66	5.8	0.76	0.69	17.75	0.148	0.448	0.150	1.346

Source: Ajayi et al (1998): **Key**: A1 = Makoda, B1 =Aljawa, C1 =Tsamiyar Nafasa, D1 = Gidan maihure, E1 = Kuru

Table 3. Suitability Scores and Classification for Pearl Millet in the Study Area.

Nutrient/Area	A1	B1	C1	D1	E1
Rainfall	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Temperature	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Relative Humility	S1 (100)	S1 (100)	S1 (100)	S1 (100)	S1 (100)
Clay	S3 (49)	S3 (43)	S3 (43)	S2 (53)	S3 (43)
AWHC	N1 (20)	S3 (25)	S1 (100)	N1 (23}	N1 (22)
pH	S1 (88)	S1 (91)	S1 (88)	S1 (85)	S1 (82)
OC	N1 (09)	N1 (22)	S1 (100)	N1 (19)	S2 (50)
N	N1 (05)	S3 (40)	S3 (34)	S3 (41)	S3 (46)
P	N1 (22)	N1 (01)	S3 (36)	S3 (31)	S3 (30)
K	N1 (02)	N1 (04)	N1 (03)	N1 (05)	N1 (02)
Ca	N1 (06)	N1 (05)	S3 (31)	N1 (12)	N1 (09)
Mg	S3 (49)	N1 (03)	N1 (03)	N1 (03)	N1 (05)
C.E.C	N1 (04)	N1 (05)	N1 (10)	N1 (08)	N1 (05)

Source: Udoh et al (2012)
Key: A1 = Makoda, B1 = Aljawa, C1 = TsamiyarNafasa
D1 = Gidanmaihure E1 = Kuru
S1 (100-75) = Highly Suitable S2 (74-50) = Moderately Suitable ,S3 (49 -25) = Marginally Suitable.
N1 (25-01) =Temporary Not Suitable

requirements under pearl millet cultivation. This will be compared with values of climatic soil properties of the study area to establish suitability of the crop. Therefore, characteristics or potentiality of climate and soils under pearl millet cultivation in the area are stated below in tables 2 and 3 for matching and the individual scores for assessment of soil qualities with the land requirements that shows the summary of soil suitability classification under pearl millet growing in Musawa area.

It revealed the matching climatic requirements with edaphic requirements for growing pearl millet in accordance with requirements and their potentiality in the study area. Climatic potentials in the area are at optimum level compared with the requirements. And edaphic qualities are below average.

At Makoda area (A1), clay and AWHC values are below the requirements. The pH (6.2) is critical compared with the requirement. Soil nutrients such as OC, N, P, K, Ca and CEC are below average. However, TsamiyarNafasa (C1) is almost the same with Aljawa (B1) in terms nutrients, with exception in clay (3.14%) and OC (1.54%). Though, GidanMaihure (D1) and Kuru (E1) areas recorded low values.

However, in matching the climatic and edaphic requirements for pearl millet with current climatic and soil potentials in the area, it shows that climate falls within the requirement and soil quality is below. It can be understood that climatic potentials are suitable and

Table 4. Suitability Rating of Pearl Millet on Soil Properties

Nutrient/Area	A1	B1	C1	D1	E1
Climate	VS	VS	VS	VS	VS
Clay	LS	LS	LS	LS	LS
AWHC	VLS	LS	VS	VLS	LS
pH	VS	VS	VS	VS	VS
OC	VLS	VLS	VS	VLS	S
N	VLS	LS	LS	LS	LS
P	VLS	VLS	LS	LS	LS
K	VLS	VLS	VLS	VLS	VLS
Ca	VLS	VLS	LS	VLS	VLS
Mg	S	VLS	VLS	VLS	VLS
C.E.C	VLS	VLS	VLS	VLS	VLS

Source: Udoh et al (2012)
Key: VS = Very Suitable, S = Suitable, LS = Low Suitable, VLS = Very Low Suitable, A1 = Makoda, B1 = Aljawa, C1 =TsamiyarNafasa D1 = Gidanmaihure

edaphic potentials fall below the average for pearl millet cultivation. Thus, suitability rating percent is calculated by value value of parameter over higher range of climatic or edaphic requirement as stated in table 4. It can be understood that climate and pH potentials in the study area are very suitable for pearl millet cultivation by scoring (S1). According to Udoh et al (2012) scores range 100-75% (S1) are suitable for the crop and most of the nutrients in the area scored below this range. It recorded nutrients as (N1) with exception of clay and Mg (S3) at Makoda. At B1 (Aljawa) area OC, P, K, Ca, Mg and CEC recorded as (N1). The values at C1 (TsamiyarNafasa) recorded (N1) for K, Mg and CEC, while AWHC and OC recorded as (S1). However, clay, N, P and Ca scored (S3) respectively. It revealed that clay scored (S2), N and P (S3). The remaining scored (N1) at D1 (GidanMaihure) area. At E1 (Kuru) area, clay, N and P scored (S3) and OC (S2). Conclusively, soil pH is suitable and nutrients are below average. Based on the above result, suitability rating under pearl millet on soil properties was established in table 4.

The result also showed that soil properties at A1 (Makoda) recorded AWHC, OC, N, P, Ca and CEC as VLS (very low suitable). This indicated the depletion of soil nutrients which led to low soil fertility. At B1 (Aljawa) area the nutrients were classified the same as Makoda and C1 (TsamiyarNafasa) with exception of AWHC ansd OC which are rated as VS (very suitable). However, at D1 (GidanMaihure) and E1 (Kuru) areas, nutrients were rated almost the same as Makoda VLS (very low suitable). It can be understood that soil nutrients such as OC, N, P, Ca, Mg and CEC in the area are seriously below average and rated very low suitable level. Farmers should be encouraged to integrate organic and inorganic fertilizers and mixed cropping systems to address the problem. This could lead to improve the production of pearl millet in the area to meet the people's demand for food.

CONCLUSION AND RECOMMENDATIONS

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 by 59,31%, 17.65ppm, 41.64% and 26.68% respectively. Thus, this led to decreased in soil quality and crop yields in the area. Suitability rating has shown that mean temperature, rainfall, relative humidity and average pH were found to be optimum and suitable (S1) for pearl millet. Most of the soil nutrients in the area were found to be temporary not suitable (N1). This led to decline in yields of pearl millet.

However, considering the above findings, it can be concluded that continuous pearl millet crop cultivations have effect on soil fertility and led to low suitability level in Musawa area. Therefore, measures should be taken in order to improve soil fertility and suitability for pearl millet cultivation to address the problems of agricultural production and sustainable developments. Pearl millet sole cropping problem measures should be taken. These include all relevant measures such as crop rotation, soil management and early clearing. These measures would reduce the removal of nitrogen by crops that stored starch and eradicate the problem of soil nutrients depletion which is shown to be the most potential causes

of soil infertility. The farmers should be encouraged to practice mixed cropping systems under pearl millet cultivation. 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. The impact of pearl millet cultivation on soil physical and chemical properties under pearl millet sole cropping should be properly managed. This could be done by integration of organic and inorganic fertilizers and improvement of organic matter through the remains of plants. Because chemical fertilizers do not arrest deterioration of fertility, but they slow it down. However, the efficiency of chemical fertilizer can only be enhanced if they are used in conjunction with organic residues coupled with soil fertility measures.

Farmers should be encouraged to maintain soil fertility through improvement in traditional farm management such as minimum tillage, strip cropping and organic matter. However, this could lead to ascertain the soil fertility, to take necessary measures or seek other alternative to improve food production.Pearl millet suitability assessment should be maintained. This could be done by matching the climatic and edaphic requirements with current climatic and soil potentials under pearl millet through the government agencies such as Katsina State Agricultural and Rural Development Authority (KTARDA) in the Ministry of Agriculture. This could help to improve the crop yields to meet the people demand for food and sustainable development.

REFERENCES

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

Ajayi O, Owonubi JJ, Uyoybisere EO, Zafari AB (1998). Climatic, Edaphic and Biological Factors Limiting Millet Yield 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.

Anaso AB, Ikwelle MC, Aminu-Kano M (1998). Medium Term Reach Plan for Pearl Millet 1996 – 2000, 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.

Ayoade JO (2004). Climate Change. Vontage Publishers, Ibadan.

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

FAO (1996) Land Use, Land Cover and Soil Sciences, The FAO Guidelines for Land Evaluation, Copied from Encyclopedia on 20/12/2013.

Hassan AM, Bibinu ATS (2010). Response of three millet varieties to nitrogen fertilizer in Maiduguri the Semi-Arid region of North-East Nigeria. J. Agronom., 4: 10-14.

Ikwelle MC (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.

Jaiswail PC (2003). Soil, Plant and Water Analysis: Kalyani Publishers, New Delhi.

Khairwal IS, Rai KN, Diwakar B, Sharma YK, Rajpurohit BS, Nirwan B, Bhattacharjee R (2007). Pearl Millet Crop Management and Seed Production Manual International Crops Research Institute for the Semi-Arid Tropics, Andhra Pradesh India.

Kumar AK (1993). Pearl Millet in West Africa, Production in Sorghum and Millet Commodity and Research Environment, Prentice Hall Publishers, India.

Kwari JD, Grema AK, Bibinu ATS (1998). Fertilizer Trials for Millet/Legume Mixtures with Emphasis on Nigerian Rates,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.

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

NAERLS and NFRA (2008)Agricultural Performance Survey for Katsina State Agricultural Development Authority, National Agricultural Extension and Research Liaison Services and National Food Reserve Agency A.B.U. Zaria.

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

Tisdale SL, Nelson WL Beaton JD, Havlin JL (2003). Soil fertility and fertilizers (5th Edition), Prentice Hall Limited New Delhi, India.

Udoh BT, Ogunkunle AO (2012). Land Suitability Evaluation for Maize (Zea Mays) Cultivation in A Humid Tropical area of South Eastern Nigeria, J. Nigerian Soil Sci. Soci., 22: 1-10.

Verheye W, Hoohafkan P, Nachtersele F (2006). Land Use, Land Cover and Soil Sciences Vol. II, The FAO Guidelines for Land Evaluation Encyclopedia Adapted on 22/6/2012.

Yusuf MA (2011). .Land Suitability Classification A Paper Prepared for Land Evaluation II, Post Graduate Diploma, Department of Geography BUK Kano.