SUITABILITY ASSESSMENT OF SOILS AND CLIMATE FOR THE PRODUCTION OF NAPIER GRASS (Pennisetum purpureum) FOR EXTENSIVE GRAZING IN KANO STATE, NIGERIA

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Abstract – This study examined the suitability of the soil and climate in Kano State, Nigeria, for the production of Napier grass. Soil sample were collected from the area using systematic random sampling procedure, at depth of 0-20 cm. Soil samples were analyzed for their physico-chemical properties and evaluated for Napier grass cultivation base on rating factor of Boonman (1997) and environmental indicators of degree of suitability of soils for agricultural use. Results of the study showed that the climate was highly suitable while the soils were moderately suitable for Napier grass production. Soil properties limiting the suitability to Napier grass cultivation includes OC, OM, available P, exchangeable K and total N excluded in L and Z (B) and ABCOA. Application of both organic and inorganic fertilizers especially the organic fertilizer is recommended to improve fibre, fodder or yield of Napier grass in the study area.

Keywords: Napier grass, soil, climate, suitability assessment and yield.

INTRODUCTION

Napier grass is a fodder grass that produces a lot of high protein forage. It's also known as "elephant grass", "Uganda grass" or "king grass". Its scientific name is *Pennisetum purpureum*. It is a fast growing, deeply rooted, perennial grass growing up to 4 m tall that can spread by underground stems to form thick ground cover. Napier is easy to establish and persistent; drought tolerant; suitable for cutting and very good for silage making. Napier grass is a high yielding fodder crop with good palatability, highly nutritious especially when young, dark green leaves and less than 1 m tall. It is also used as a soil stabilizer in soil conservation methods and can be intercropped with various forage legumes. Napier is not suitable for direct grazing since stumping results in poor regeneration. It is vulnerable to disease and pest attacks. It takes up a lot of nutrients from the soils and is highly demanding on nutrient recycling/fertilizer application.

Soil information is a vital component in the planning process, reflecting directly upon land-use suitability (Coleman and Galbraith 2002). The land suitability is the process of assessing the suitability or ability of a given type of land. Land suitability classification process is the evaluation and grouping of specific areas of land in terms of their suitability for define agricultural use. Land suitability analysis is a pre requisite for sustainable agricultural practices. It involves evaluation of the factors like climate, terrain, soil, etc. Land suitability is a function of crop requirements provides suitability. Suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use" (FAO, 1976). Land suitability classification aims at evaluating and classifying land units on the basis of specific land and soil features and their limitations.

Soil-site suitability studies provide information on the choice of crops to be grown on best suited soil units for maximizing the crop production per unit of land, labour, and inputs. The land suitability for a defined use and the impact of that use on the environment is determined by land conditions and land qualities. The suitable land use depends on soil resilience that is the balance between soil restorative and soil degradation processes. Ecologically every factor of environment exerts directly or indirectly as specific effect on growth and development of the plants. However, it varies from habitat to habitat and determines the suitability of a plant to any particular environment. For planning and effective utilization of soil resources, the information relating to the soil-site characteristics for utilization of soil resources, the information relating to the soil-site characteristics for cultivation of crops is necessary (Naidu, 2006).

Physical and chemical properties of the land as well as climatic factors are the major determinants for crop suitability of a given land. The physical land properties of the study area are evaluated, including the soil texture, drainage, and soil depth. The slope of the land is also considered. Climate (Temperature and Rainfall) of the study area is also used for crop suitability analysis. The chemical properties of soil like pH (negative log hydrogen ion concentration), CEC (cation exchange capacity), EC (electrical conductivity) and ESP (exchangeable sodium percentage) are also taken for soil site suitability analysis.

Nigerian livestock owners are mostly operating under extensive system of management. This activity leads to depletion of the naturally occurring nutritive and palatable pasture. Furthermore as a result of increase in dairy processing companies the traditional method of providing good quality and palatable fed for the livestock particularly dairy animal for producing high quantity of yield milk is inefficient. Therefore it becomes necessary for the government and related organizations to ensure adequate provision of feed to livestock especially dairy Animals.

Soil is the foundation for the production of food, fibre and drugs. Moreover both Government and individual are conducting a lot of research to find ways of boosting livestock feed production through proper field and laboratory analysis of soil as well as climate suitability. In general, this study addresses the problem of soil fertility decline in such diver's soils requires an appropriate integrated soil fertility management (ISFM) intervention for sustainable Napier grass production. This study was there for meant to complement the information by assessing the soil fertility status, performing spatial soil fertility evaluation for Napier grass production and suggesting appropriate soil management options.

The objective of this research work was to assess the Suitability of soils and climate for the production of Napier grass and extensive grazing in Kano State, Nigeria

METHODOLOGY

Study area

The study was conducted at Kano state which is located in Northwestern region of Nigeria with coordinates of $11^0$30' N $8^0$30'E/11.500^{0}N 8.500^{0}E and the total Area of 20, 131 km^2. The study area is located at an altitude of 470 m (1539 feet) above the sea level. The vegetation type of the study area is characterized by few trees sparsely apart and abundant grass which signifies that the area is within Sudan Savanna zone of Nigeria. In terms of Agriculture, subsistence and commercial agriculture mostly practiced in the outlying district of the State. Some of the food crops cultivated within Kano State are millet, cowpea, sorghum, maize and rice for local consumption while ground nut and cotton are produced for export and industrial purposes. However, four locations were selected across the State for physic-chemical properties of soil, The locations are Bagauda Agricultural Research Station `(BGD), Kano University of Science and Technology Research and Commercial farm, Gaya (G.CUL and G.UNCUL), L and Z Farm (A and B) and Audu Bako College of Agriculture Research Farm (ABCOA) which they are all located at Bebeji, Gaya, Kumbotso and Dambatta local government areas respectively. Climatic data of study area was shown in Figures 1- 3.

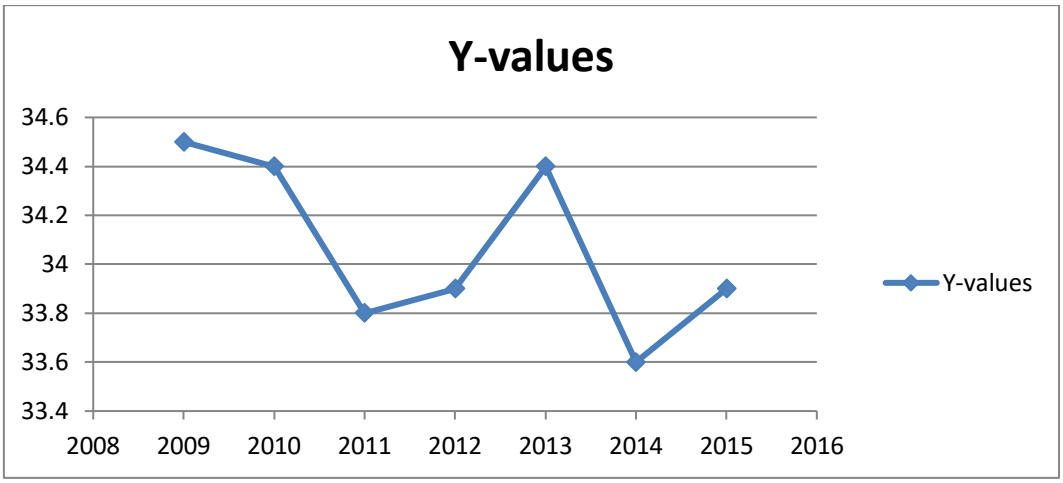

Figure 1: Mean maximum temperature (^{0}C)

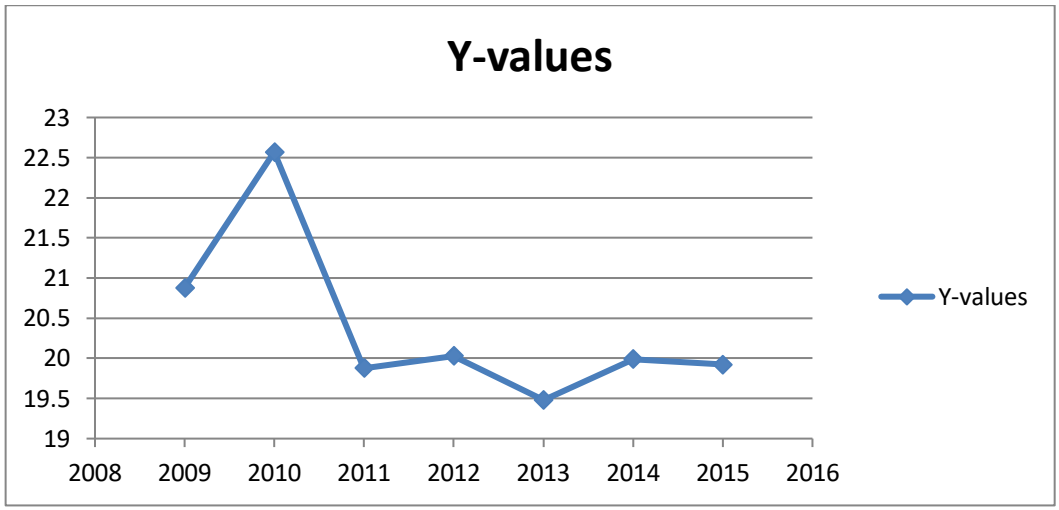

Figure 2: Mean minimum temperature (^{0}C)

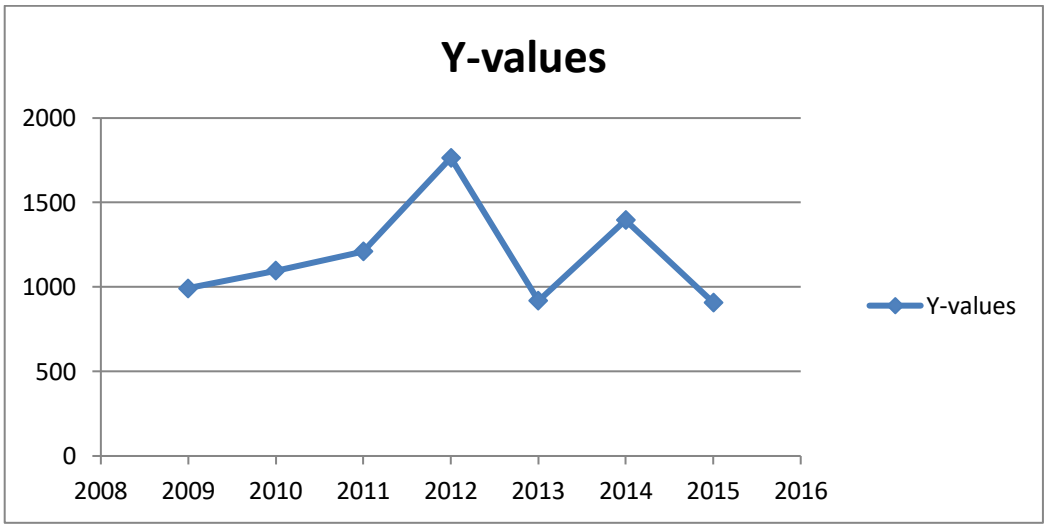

Figure 3: Mean annual rainfall (mm)

SOIL SAMPLING AND PREPARATION

In all the four different selected locations, the bulk soil samples were taken from the research area, a total of 60 sub soil samples were collected at the depth soil 0-20 cm, using soil auger and six composite samples were drawn from sixty representative samples. The collected samples were weighed and convey to the laboratories in uncontaminated polythene bags with labeled differently without allowing mix-up and then were taken to the laboratory for analysis. The soil samples collected from the field were air dried and grounded using mortar and pestle and pass through 2 mm aperture sieve. Each of the six soil samples were subjected to routine analysis in the laboratory for different variables separately.

LABORATORY ANALYSIS

The soil samples were analyzed for physical and chemical properties by using standard analytical methods. Particle size distribution analysis was carried out using Bouyoucos Hydrometer method as described by Black (1965). The Textural class name of the soil was obtained using Marshalls textural triangle (Palma and Troech, 1977). The chemical properties such as pH are determine through standard method for pH-water and pH-$Cacl_2$ (1:2.5), organic carbon (by Walkley-Black wet digestion method), Total nitrogen was determined by macro-Kjeldhal digestion method as described by (Bremner and Mulvaney, 1987). Organic carbon was determined using the method (Walkley and Black, 1934), available phosphorus (by bray 1 extraction fallowed by quantification with UV-Vis spectrophotometer), Electrical conductivity (EC) was determined in the 1:2.5 (soil-water ratio) using EC meter model Crison Conductivity 522 (Rhoades, 1987). Exchangeable bases were determined by the NH_4AOc (pH 7.0) extraction method; Ca^+ and Mg^{2+} were determined titrimetrically with EDTA while Na^+ and K^+ was determined by flame photometer (Chapman, 1965).

RESULTS AND DISCUSSION

Suitability assessment of soil for the production of Napier grass is base on the soil condition criteria mostly from the soil characteristics. Tables 1, 2 and 3 contained the main soil factors for considering and generating the final suitability for the production of Napier grass in Kano State, Nigeria. The main important soil parameters are discussed below:

Considering the pH range obtained in both water and calcium chloride are non-acidic soil for the whole locations (Table 2) which means that the soil is highly suitable to moderate suitable for the production of Napier grass.

The value of E.C obtained in Table 2 indicates that the soil are non saline as the value ranged between 0.00 to 0.095 ds/m with the average standard of < 4 for any plant to absorb nutrient from the soil. The OC content of all soils were low to medium and ranged from 0.060 to 0.399% with a mean of 2% in surface layers (Table 2). This may be due to the prevalence of tropical condition where the degradation of organic matter occurs at faster rates coupled with low vegetation cover, thereby leaving less organic carbon in the soils.

The available N varied form 0.07 g/kg to 0.665 g/kg with a mean value of 0.15 which means L and Z (B) contained high available nitrogen while in the other locations having medium to low available N. low amount of organic carbon could be significant factor affecting the amount of available nitrogen The available phosphorus in the surface layers varied from minimum value of 5.58 mg/kg to maximum of 35.61 (mg/kg) (Table 2) with moderately suitable value of >22 which indicate that L and Z (B) and ABCOA having the highest amount of P while in other locations with low available P content might be possibly be due to low organic matter contents of the soil. Available K varied from 0.11 to 0.32 Cmol/kg with a suitable value of > 0.5, this suggest that in all the locations soil contain were low amount of K.

Table 1, the three textural class were occur in all the location viz Loamy sand, Sand and Sandy loam which means only in ABCOA poor or light (sand) that are not suitable for Napier grass production.

Table 1: Particle Size Distribution of soils at study area (0-20cm)

LOCATIONS	% Sand	% Silt	% Clay	Textural class
L and Z (A)	83.6	11.28	5.12	Loamy sand
G. CUL	85.6	9.28	5.12	Loamy sand
G. UNCUL	85.6	7.28	7.12	Loamy sand
L and Z (B)	81.6	15.28	3.12	Loamy sand
ABCOA	93.6	5.28	1.12	Sand
BGD	63.6	27.28	9.12	Sandy loam

Table 2: Some chemical properties of soils at study areas

LOCATIONS	pH (H_2O)	pH ($CaCl_2$)	EC (ds/m)	Acidity (Cmol/kg)	N (%)	P (mg/kg)	O.C. (%)	O. M. (%)
L and Z (A)	6.08	6.27	0.024	0.84	0.07	7.44	0.319	0.55
G. CUL	6.58	6.29	0.015	0.50	0.105	7.07	0.180	0.31
G. UNCUL	6.47	6.11	0.009	0.67	0.105	5.21	0.319	0.55
L and Z (B)	6.28	5.88	0.095	0.33	0.665	35.61	0.399	0.69
ABCOA	6.69	6.53	0.028	0.33	0.07	32.74	0.060	0.10
BGD	6.17	5.91	0.015	0.50	0.35	5.58	0.299	0.52

Table 3: Exchangeable bases and acidity of soils at the locations

LOCATIONS	Ca (Cmol/kg)	Mg (Cmol/kg)	Na (Cmol/kg)	K(Cmol/kg)
L and Z (A)	2.00	1.18	0.10	0.11
G. CUL	3.00	1.59	0.17	0.28
G. UNCUL	2.75	1.09	0.14	0.19
L and Z (B)	5.42	1.24	0.39	0.32
ABCOA	3.31	1.33	0.16	0.27
BGD	3.69	1.49	0.11	0.28

Table 4: Rating of Land Use Requirements for Napier Grass

Land Quality and Characteristics	100 -95 S1	94 -85 S2	84-40 S3	39-20 N1	19-0 N2
1. Climate (C)					
Annual Rainfall (mm)	1000-1400	1000-600	600-300	<300	
Length of Dry Season (days)	150-220	140-170	90-110	<90	
Mean Annual Max. Temp. (^{0}C)	25-35	25-40	35-40	>40	
Mean Annual Min. Temp. (^{0}C)	25-22	22-20	20-15	15-10	<10
Relative Humidity (%)	50-80	80-42	>80		
2. Topography (T)					
Slope (%)	<4	4-10	10-25	>25	
3. Wetness (w)					
Flooding	F0	NO	F1	Aeric	Poor
Drainage	Good	Moderate	Poor	Poor	Drainable
4. Soil Physical Characteristics (S)					
Texture/structure	Balance	Moderate heavy	Heavy	Light	
Coarse Fragment (%) 0 – 10cm	<10	10-30	30-60	>60	
5. Fertility					
C.E.C (Cmol/kg clay)	>40	40-20	20-10	<10	
Base Saturation	>50	35-50	20-35	<20	
Ph	7.3-6.7	6.7-5	5.5-4.5 or 8.0-9.0	<4.5 or 9.0	
O.C (%) 0 – 15cm	>2	>2	0.8-1.2	<0.8	
AV. P (mg kg^{-1})	>22	>22	7-13	3-7	<3
Total N (%)	>0.15	>0.15	0.08-0.10	0.04-0.08	<0.08
Ext K (Cmolkg^{-1+})	>0.5	>0.5	0.2-0.3	0.1-0.2	<0.1
O.M. %	>5	5-2	2-1	<1	

Source: Boonman (1997)

KEY : F0 = No flooding, F1 = Seasonal flooding, light = sand, loamy sand or sandy loam

Table 5: Napier Grass Soil and Climate Suitability Classes of the Locations

Land Quality and Characteristics	LOCATIONS					
	L and Z (A)	G. CUL	G. UNCUL	L and Z (B)	ABCOA	BGD
Land Quality						
Annual Rainfall	S1	S1	S1	S1	S1	S1
Mean Annual Max. Temp. (⁰C)	S1	S1	S1	S1	S1	S1
Slope (%)	S1	S1	S1	S2	S1	S2
Drainage	S2	S1	S1	S3	S2	S2
Land Characteristics						
Soil Texture	S2	S2	S2	S2	N1	S2
Soil pH (1:1 water)	S1	S1	S1	S1	S1	S1
Soil pH (calcium chloride)	S1	S1	S1	S2	S1	S2
O.C (%)	N1	N1	N1	N1	N1	N1
AV. P (mg kg^{-1})	S3	S3	N1	S1	S1	N1
Total N (%)	N1	S3	S3	S1	N1	S1
O.M.%	N1	N1	N1	N1	N1	N1
Limiting Characteristics	f	f	f	f	f	f

Land suitability class symbols: S1 = highly suitable; S2 = moderately suitable S3 = marginally suitable; N1 = currently not suitable and f = Soil fertility limitation.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The aim of this research work was to assess the Suitability of soils and climate for the production of Napier grass for extensive grazing in Kano State, Nigeria. The study was conducted at Gaya, Kumbotso, Bebeji and Danbatta local government areas, between September and November, 2016. A total of 60 soil auger points and 6 composite soil samples were drawn from sixty representative samples. Soil samples were prepared and analyzed for the key fertility parameters. These soils were evaluated qualitatively by comparing the requirements of Napier grass and quantitatively by calculating the total soil-available nitrogen, phosphorous and potassium. Soil fertility was found to be considerably low in the study areas, much lower in L and Z (A), G. CUL and G. UNCUL. Limitations common to both study areas are low in K and OC.

This study has proved that the climatic data for the all locations is similar and is highly suitable for the production of Napier grass and other certain crops such as millet, maize, sorghum, groundnut, cowpea, vegetables etc in the study area. While in other hands the soil fertility is considerably low in the study areas. The major parameters and essential plant nutrients such as P and K were very low in L and Z (A), G. CUL, G. UNCUL and ABCOA. Indeed, other important parameters obtained in the study areas such as OC, OM were very much low. Therefore, conclusively a decision for applying both organic and in organic fertilizers in Napier grass and other certain crops will therefore helpful to farmers in the study areas.The study recommends the following:

- Applying sufficient and right amount of N, P, and K fertilizers to improve fodder or crop yield

- Soil which showed remarkably low OC (< 0.5%), call for the efforts of organic matter enrichment such as mulching, application of manures and composts.
- Integrated farm management strategy which involves keeping livestock should be encouraged among farmers for both income diversification and nutrients cycling

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