Original Research Article

EFFECT OF NITROGEN FERTILIZER AND INTER ROW SPACING ON LEAVES WIDTH OF RHODES GRASS (*Chloris gayana* Tan) IN THE DRY SUB HUMID ZONE OF SOKOTO, NIGERIA

ABSTRACT

A field experiment was conducted during the 2016 and 2017 rainy seasons at Centre for Agriculture and Pastoral Research (CAPAR) of the Usmanu Danfodiyo University Sokoto, Nigeria to study the effect of nitrogen fertilizer and inter-row spacing on Leave length and Leave width of Rhodes grass as indices of growth. A factorial combination of five fertilizer levels (0, 100, 120, 140 and 160 kgNha^{-1}) and three inter row spacing (30, 50 and 70cm) were used, making fifteen treatments combinations, which were laid out in a RCBD replicated four times. Determination of leave length and leave width was done at 3, 6, 9 and 12WAS using a meter rule. The data obtained were statistically analyzed by using analysis of variance (ANOVA), using the GenStat 64-bit Release 17.1 (software) to elucidate the valid information from the data. The result revealed that, application of 160KgNha^{-1} generally produced plants with longer and broader ($P<0.05$) leaves compared to the rest of the treatments, however there was generally significant ($P>0.05$) effect of inter row spacing in both 2016, 2017 and the years combined, inter-row spacing of 70cm showed superiority amongst the treatments in the leaves length and leave width parameters investigated as compared to 50 and 30cm spacings.

Keywords: Leave length, leave width, Centre for agricultural and pastoral research, nitrogen fertilizer, inter row spacing, Rhodes grass.

INTRODUCTION

Ruminant livestock in Nigeria which includes 52.5 million Cattle, 33 million Sheep and 16.2 million Goat, in Nigeria account for about 85% of the domestically produced meat in the country (FAO, 2009). These animals form an important part of the nation's agricultural production system there by providing income to the farmer and foreign exchange to the nation. In addition to providing manure for arable farming, hides and skins, for leather and tanning industries social security and as insurance for food security, to mention but just a few (Tarowili *et al.,* 2004; Olson *et al.,* 2004, Peden *et al.,* 2005).

According to Simbaya (2000), Malami (2005) Aregheore (2009) and Ogunbasoye and Babayemi (2010), the major limitation to ruminant animal production in the savannah zone of Nigeria are inadequate supply and low quality of the pasture feed during the long dry season. Thus, there is need to increase availability of the forage feed through intensive production of improved pastures species which are capable of producing high quality forage for the ruminant animals in the country.

The increasing demand for animal and animal related products can be met through the use of improved pasture species supplementation to satisfy animal's dietary requirements. It is therefore more economical to use grassland as a source of meat and milk because grass herbage cannot be used directly by man but can be used indirectly through animals that convert it to edible products. In Nigeria, pasture production and utilization has not been developed except on government farms, university experimental, teaching and demonstration farms. Ruminant livestock in Nigeria depends largely on natural grasslands that are nutritionally poor. The savanna zone characterised by low annual rainfall of shorter duration, lighter sandy soils and longer dry season, has low potential for natural forage production (Umunna and Iji, 1993; Adamu and Odion, 2002).

Therefore, in order to meet the feed requirements of the ruminants animals in Nigeria; there is need to increase the forage production in the savanna region of the country. This requires production of improved pasture species with potential to high herbage production and nutritive value in the different sub regions of the savanna. Thus dependence on natural pasture that provides the cheapest source of nutrients for ruminants has resulted in failure to meet the nutritional demands of livestock throughout the year.

Excess fertilizer application, on the other hand, can be detrimental as ‘fertilizer burn’ may occur when too much fertilizer is applied resulting to drying out of leaves and damage or even death of the plant (FAO, 2006). Therefore, determination of optimum fertilization level is important for better crop production. Peacock *et al.* (1991) reported that Rhodes grass responds well to nitrogen and phosphorus fertilizer application and higher yields are obtained when N is given after a basic application of Phosphorus. Fertilizer also increases the proportion of leave in the herbage, but when applied after flowering it can increase the proportion of stem (Bogdan, 1977). Khair (1999) noted that Rhodes grass responded well to nitrogen fertilizer when applied in separate doses.

Inter-raw spacing is also an important cultural practice that affects crop productivity. The close spacing produces thin, slow growing and weaker plants. The wide spacing, on the other hand produces crop with lose canopy resulting to poor absorption of solar radiation, leading to low photosynthesis rate resulting to poor productivity of the crop. Wide spacing also expose crop to high weed infestation and production of low quality herbage. Optimum spacing is therefore necessary for effective growth, yield and quality of crops. If seedlings are widely scattered (spaced) Rhodes grass can quickly produce a dense stands that means that close spacing produces thin, slow growth and weaker sword (Mannetja and Kersten, 1992).

Materials and Methods

Experimental Site

This study was conducted at the Center for Agriculture and Pastoral Research (CAPAR), formally Dabagi Farm, of Usmanu Danfodiyo University Sokoto, during the 2016 and 2017 raining season. The farm is geographically located on latitude, 12°45ᴵN and longitude 5°25ᴵE and on 350m altitude. The farm is situated at 33 kilometers away from Sokoto metropolis, along the Sokoto-Gusau road, in Dange shuni local government area of Sokoto State, Nigeria. The farm has a total land area of about 512 ha, (CAPAR, 2010). Dabagi farm falls within the Sudan-Savanna vegetation zone. Isah and Shinkafi (2000) said, the climate is characterized by alternating wet and dry seasons. The rainy season starts normally in June/July and ends in September/October with approximate annual rainfall of 500 - 900 mm with wide inter annual variations, (SERC, 2017), while the dry season covers from October to April/May. Relative humidity is moderate to high (51 – 79 %) during the rainy season and very low (10 – 25%) during the dry season. Mean monthly temperatures vary widely; from about 14^{o}C in December/January to about 41^{o}C in April with annual mean of about 28^{o}C (Mamman *et al.*, 2000; SERC, 2010). The vegetation at the Dabagi farm of Usmanu Danfodiyo University, Sokoto, Nigeria, was described as Shrub-savannah, typical of the disturbed Sudan Savannah vegetation, composed of scattered trees; mainly of *Balanites eagyptica, Gueira senegalensis, faidebia albida, zizipus spinachristi* and *azadirachta indica* species, and many species of shrubs grasses and herbaceous legumes and forbs (Isah and Shinkafi, 2000).

The total annual rainfall during the 2016 and 2017 were 663.42mm and 606.18mm respectively. The soil texture was sandy loam; with sand, silt and clay represented at 92.7%, 5.9% and 1.4% respectively.

The treatments for this research consisted of five Nitrogen fertilizer levels (0, 100, 120, 140, and 160Kg/ha) and three inter row spacings (30, 50, and 70cm), which were combined factorially and laid out in a randomized complete block design (RCBD) replicated four times. The forage was sown on 15th and 8th of July 2016 and 2017 respectively. The fertilizer treatments were applied at three (3) weeks after sowing. Leave length and leave width was measured by using a Meter rule. The data was statistically analyzed by analysis of variance (ANOVA), using the GenStat 64-bit Release 17.1.

Table 1: Physical and chemical properties of the soil at the experimental site

Soil properties	2016	2017	Mean
Chemical properties			
pH (in water)	5.5	5.6	5.6
Organic carbon (%)	8.4	8.3	8.4
Total nitrogen (%)	0.84	0.85	0.85
Available P (gkg$^{-1)}$	0.96	0.95	0.96
Exchangeable bases			
Calcium Ca^{2+} (cmolkg^{-1})	0.65	0.65	0.65
Magnessium Mg^{2+} Mg (cmolkg^{-1})	0.40	0.41	0.41
Phosphorus K^{+}(cmolkg-1)	0.92	0.93	0.93
Sodium $^{Na+}$ (cmolkg-1)	0.29	0.28	0.29
Cation exchange capacity CEC (cmolkg-1)	5.6	5.7	5.7
Physical properties			
Sand (gkg^{-1})	927	926	927
Silt (gkg^{-1})	59	60	59
Clay (gkg^{-1})	14	14	14
Textural class	Loamy sand	Loamy sand	Loamy sand

RESULTS AND DISCUSSION

Physical and Chemical Properties of the Soil at the Experimental site

Results of physical and chemical properties of the soil at the experimental site are presented in Table 1. The result indicated that the soil had a strongly acidic properties (pH in water) = 5.1 - 5.6). The soil had low organic carbon (0.89gkg^{-1}), while the total nitrogen was extremely high (0.84 – 0.85 cmolkg^{-1}). However, the available P (0.96gkg^{-1}), calcium (0.65 cmolkg^{-1}), organic carbon, (8.4gkg^{-1}) and Cation exchange capacity CEC (5.6 cmolkg^{-1}) were all low. The soil also had moderate magnesium content (0.40cmolkg^{-1}), high in sodium (0.39cmolkg^{-1}) and extremely high in potassium (0.92 cmolkg^{-1}). The soil texture was sandy loam; with sand, silt and clay represented at 92.7%, 5.9% and 1.4% respectively. These necessitated the need for additional supply of nutrients to the soil, especially nitrogen and phosphorus which are required by plants as recommended by the Federal Department of Agriculture and Livestock Resources (FDALR 1990). The top soil, owing to its particle size distribution (927 gkg^{-1} sand, 59 gkg^{-1} silt and 14 gkg^{-1} clay) was sandy loam (Table 1) as described by Soil Survey Staff of America (SSSA 2010), Adeoye and Agbola (1985) and Sabulo and Osiname (1981). This shows that the soil requires only a light tillage to prepare the land for plant cultivation (SSSA 2010; Adeoye and Agbola 1985; Sobulo and Osiname 1981).

Leaf Length

Results on leaf length (cm) of Rhodes grass as influenced by nitrogen fertilizer and inter row spacing during 2016 and 2017 rainy seasons and the years combined is presented in Table 2. Fertilizer application had significant (P<0.05) effect on leaf lengths at 3, 6, 9 and 12 weeks after sowing (WAS) in the 2016, 2017 and the years combined results. Leaf length increase linearly with the age of the plant from 6.62 cm at 3 WAS to 24.03 cm at 12 WAS. At 3WAS, application of 140 $kgNha^{-1}$produced longer ($P<0.05$) leaves in 2016, 2017 and the years combined results, which were similar ($P>0.05$) to the leaves of plants on application of 160$kgNha^{-1}$ in the 2017 and the years combined results, compared to rest of the treatments. At 6WAS, longer ($P<0.05$) leaves were produced by plants on the application of 160 $kgNha^{-1}$ in the 2016, 2017 and the years combined compared to rest of the treatments. At 9WAS both 140 and 160$kgNha^{-1}$ treatments produced plants with longer ($P<0.05$) leaves in the 2016, 2017 and the years combined results compared to the rest of the treatments. At 12WAS also, application of 160$kgNha^{-1}$ produced plants with longer ($P<0.05$) leaves in the 2016, 2017 and the years combined compared to the rest of the treatments. Inter row spacing had significant effect ($P<0.05$) on leaf length at 3, 6, 9 and 12WAS in the 2016, 2017 and the years combined. The 70cm inter row spacing generally produced plants with longer ($P<0.05$) leaves from 3 to 12 WAS, as compared to 50 and 30cm spacing in the 2016, 2017 and the years combined results.

The significantly ($P<0.05$) longer leaves of Rhodes grass produced from application of the higher dose of nitrogen fertilizer (160 $kgNha^{-1}$) during 2016 and 2017 trials and the years combined (Table 2), is similar to the findings by Bogdan (1977) Duke (1997) and Khair (1999) on Rhodes grass, who reported longer leaves from application of higher levels of nitrogen fertilizer. The significant effect of inter row spacing observed from the wider inter row spacing of 70cm during 3 - 12WAS in the 2016, 2017 and the years combined (Table 2) indicated that the wider inter row spacing was required to produce longer leaves of Rhodes grass in the study area. This is similar to the findings by Samson (2005) and Tanko (2013) who reported a significantly higher number of leaves per plant at wider row spacing on *Sesamume indicum* L. and *Lablab purpureus* (L.) sweet plants, respectively, in the dry sub humid zone of Nigeria. The significantly ($P<0.05$) longer leaves of Rhodes grass produced from application of 160 $kgNha^{-1}$ and 70cm inter row spacing during 6 - 12WAS in the 2016 and the years combined results (Table 2) may indicate the optimum fertilizer level and inter row spacing for Rhodes grass production in the study area up to 12WAS. This is similar to the findings of Kumbhar and Sonar (1980), Alam *et al.*, (2014), Shukla *et al*. (2005) and Singh and Tripath (2008), who reported significantly higher productivity from high N fertilizer application and wider spacing among different rice varieties, accentuated from increase in length of leaves, elongation of stem/tillers and panicles or in general increased vegetative growth of plants. It can be said that nitrogen stimulates the biosynthesis and export of cytokinin hormone from roots to leaves that causes increasing cell division and increasing length and width of the leaves.

Table 2: Leaf length of Rhodes grass (Chloris gayana) as at 3, 6, 9 and 12WAS as affected by fertilizer levels and inter row spacing, during 2016 and 2017 rainy seasons and the years combined in the dry sub humid zone of Sokoto, Nigeria

	3WAS			**6WAS**			**9WAS**			**12WAS**		
Treatment	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Fertilizer (F) (kgNha^{-1})												
0 (F0)	3.38^{e}	3.11^{d}	3.36^{c}	6.94^{e}	6.38^{d}	6.67^{e}	9.46^{e}	8.98^{d}	9.35^{d}	10.29^{e}	10.07^{e}	8.20^{e}
100(F1)	4.68^{d}	4.25^{c}	4.84^{b}	11.03^{d}	10.01^{c}	10.52^{d}	13.05^{d}	16.53^{c}	15.03^{c}	17.20^{d}	16.36^{d}	16.80^{d}
120(F2)	5.87^{b}	5.70^{b}	5.78^{b}	13.54^{c}	15.46^{b}	14.51^{c}	14.84^{c}	17.51^{b}	16.21^{b}	18.46^{c}	19.04^{c}	18.78^{c}
140(F3)	6.53^{a}	6.71^{a}	6.62^{a}	16.72^{b}	16.93^{b}	16.83^{b}	18.17^{a}	18.74^{a}	18.50^{a}	19.68^{b}	20.33^{b}	20.02^{b}
160(F4)	5.48^{c}	6.63^{a}	6.05^{a}	17.12^{a}	17.40^{a}	17.30^{a}	18.32^{a}	18.09^{a}	18.22^{a}	23.99^{a}	24.06^{a}	24.03^{a}
LSD	0.213	0.384	0.480	1.117	3.235	0.477	0.752	1.532	0.426	1.647	2.170	1.295
Significance	*	*	*	*	*	*	*	*	*	*	*	*
Spacing (S) (cm)												
30(S1)	5.16^{ab}	5.28^{ab}	5.22^{ab}	12.18^{b}	12.61^{b}	12.40^{b}	14.21^{b}	17.01^{b}	16.14^{c}	15.23^{c}	15.78^{c}	15.13^{c}
50(S2)	4.92^{b}	5.07^{ab}	4.99^{b}	12.66^{b}	12.98^{b}	12.82^{b}	14.01^{b}	17.85^{b}	16.00^{b}	16.49^{b}	17.40^{b}	16.94^{b}
70(S3)	5.49^{a}	5.49^{a}	5.49^{a}	15.58^{a}	17.29^{a}	16.44^{a}	17.28^{a}	18.86^{a}	18.08^{a}	19.77^{a}	20.94^{a}	20.40^{a}
LSD	0.165	0.288	0.372	0.862	2.500	0.369	1.123	1.191	0.330	0.961	1.611	1.003
Significance	*	*	*	*	*	*	*	*	*	*	*	*

Means within a column followed by the same letters are statistically not significant at 5% level of probability using Least Significant Difference (LSD)at 5% probability level.*=Significant at 5% probability level, NS = not significant at 5% probability level.
F= Fertilizer, S = Spacing, F*S = Interaction between Fertilizer and Spacing
WAS = Weeks after Sowing

Leaf Width

Results on leaf width of Rhodes grass as influenced by nitrogen fertilizer application and inter row spacing during 2016, 2017 rainy seasons and the years combined is presented in Table 3. The result showed that fertilizer application had no significant effect (P>0.05) on leaf width at 3WAS in the 2016 and 2017 rainy seasons. However, in the years combined, significant effect was observed. Similarly, significant (P<0.05) effect was observed at 6, 9 and 12WAS during 2016, 2017 rainy seasons and the years combined. At 3WAS in the years combined, 160 KgNha^{-1} produced broader (P<0.05) leaves as compared to the rest of the treatments. At 6WAS 160 kgNha^{-1} produced broader (P<0.05) leaves in 2016, 2017 rainy seasons and the years combined, compared to the rest of the combinations. At 9WAS fertilizer application of 160, 140 and 120 kgNha^{-1} produced broader (P<0.05) leaves in 2016, 2017 and years combined analysis compared to the rest of the combinations. At 12WAS fertilizer application of 140 and 160 kgNha^{-1} in 2016, 2017 and the years combined produced broader (P<0.05) leaves as compared to the rest of the combinations.

Inter row spacing had no significant (P>0.05) effect on leaf width at 3WAS in 2016, 2017 and the years combined, at 6WAS there was no significant (P<0.05) effect of inter row spacing on leaf width in 2017, however significant (P<0.05) effect was observed in 2016 and the years combined analysis. At 9WAS significant (P<0.05) effect of inter row spacing on leaf width was observed in 2016, 2017 and the years combined analysis and at 12WAS in 2017.

The significantly (P<0.05) broader leaves recorded from Rhodes grass plants on 160KgNha^{-1} during 3 - 12WAS in the 2016, 2017rainy season and the years combined results (Table 3), indicated higher growth potential by the Rhodes grass at higher nitrogen fertilizer dose of 160 kgNha^{-1}. The mean leaf width recorded for the Rhodes grass plant at 12WAS in this study (2.46 - 2.59 cm) was higher than the 0.3 – 0.9 cm reported by Duke (1978).This may be due to differences in the cultivars used, higher nitrogen levels, better soil conditions, good moisture regime, wider spacing and most likely better agronomic practices or may indicate a better adaptation by the Rhodes plant to the Sokoto Semi-arid environment.

The significant effect of inter row spacing observed from the wider row spacing (70cm) during 3 - 12WAS in the 2016, 2017 and the years combined results (Table 3) indicated that the wider inter row spacing was required to produce broader leaves of Rhodes grass in the study area. This is similar to the findings by Mannetja and Kersten (1992) on Rhodes grass plants in East Asia, where broader leaves were recorded from wider inter row spacing. Kutu and Asiwe (2009) explained that plant spacing is an important agronomic attribute which affects light interception by plant during which photosynthesis takes place. It also enables the plants to utilize more effectively the soil moisture and nutrient and avoid excessive competition among the plants (Obi, 1991).

Table 3: Leaf width of Rhodes grass (Chloris gayana) as at 3, 6, 9 And 12WAS as affected by nitrogen fertilizer levels and inter row spacing during 2016 and 2017 rainy seasons and the years combined in the dry sub humid zone of Sokoto, Nigeria

	3WAS			6WAS			9WAS			12WAS		
Treatment	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**	**2016**	**2017**	**Combined**
Fertilizer (F) (kgNha^{-1})												
0(F0)	0.32	0.46	0.39^{b}	0.83^{c}	0.76^{d}	0.76^{d}	1.02^{b}	1.17^{c}	1.097^{c}	1.57^{c}	1.57c	1.57^{c}
100(F1)	0.39	0.60	0.49^{ab}	1.58^{a}	1.25^{c}	1.25^{c}	1.75^{a}	1.49^{b}	1.62^{b}	2.00^{b}	1.89^{b}	1.94^{b}
120(F2)	0.49	0.66	0.58^{ab}	1.64^{a}	1.36^{bc}	1.36^{bc}	1.79^{a}	1.69^{a}	1.75^{a}	2.00^{b}	1.98^{b}	1.97^{b}
140(F3)	0.48	0.64	0.39^{b}	1.34^{b}	1.45^{b}	1.45^{b}	1.74^{a}	1.82^{a}	1.86^{a}	2.39^{a}	2.49^{a}	2.48^{a}
160(F4)	0.79	0.66	0.73^{a}	1.79^{a}	1.61^{a}	1.61^{a}	1.86^{a}	1.86^{a}	1.78^{a}	2.46^{a}	2.59^{a}	2.49^{a}
LSD	0.419	75.651	0.213	0.202	0.186	0.136	0.189	0.165	0.126	0.257	0.147	0.145
Significance	NS	NS	*	*	*	*	*	*	*	*	*	*
Spacing (S) (cm)												
30(S1)	0.42	0.57	0.49	1.29^{b}	1.11	1.20^{b}	1.56^{b}	1.60^{ab}	1.58^{b}	2.10	1.93^{b}	2.11
50(S2)	0.47	0.65	0.53	1.40^{ab}	1.15	1.27^{ab}	1.61^{ab}	1.53^{b}	1.57^{b}	2.04	1.99^{b}	2.02
70(F3)	0.59	0.59	0.63	1.50^{a}	1.26	1.38^{a}	1.73^{a}	1.69^{a}	1.72^{a}	2.09	2.18^{a}	2.14
SE	0.114	20.53	0.059	0.055	0.050	0.037	0.051	0.050	0.035	0.069	0.040	0.039
LSD	0.325	58.59	0.165	0.156	0.144	0.105	0.146	0.144	0.097	0.199	0.114	0.112
Significance	NS	NS	NS	*	NS	*	*	*	*	NS	*	NS

Means within a column for factor followed by the same letters are not statistically different at 5% level of probability using Least Significant Difference (LSD) at 5% probability level.*=Significant at 5% probability level, NS = not significant at 5%probability level.
F= Fertilizer,S = Spacing, F* S = Interaction between fertilizer and spacing
WAS = Weeks after Sowing

CONCLUSION AND RECOMMENDATION

From the outcome of this research, it may be concluded that, increase in nitrogen fertilizer increases the growth (Leave length and Width) of Rhodes grass proportionately. The optimum fertilizer level for growth and good quality forage in the study area is found to be 160kgNha^{1}, vigorous production can be maximize with the addition of 160kgNha^{1}, around the dry sub humid zone of Sokoto Nigeria or environment with similar soil type, humidity and rainfall pattern. Spacing of 70cm produces the highest growth parameters (Leave length and Width) of Rhodes grass in the study area.

Based on the results obtained it is recommended that the best and optimum fertilizer level is 160kgNha^{-1} and the best spacing is 70cm spacing which is recommended for Rhodes grass production in the study area. Rhodes grass evaluated in this study have showed appreciable adaptation and optimum herbage productivity in the study area, and hence recommended for production and further trials with different varieties (Cultivars) in the study area.

REFERENCES

Adamu, A. M. &Odion, E. C. (2002). Improving crop-livestock systems in the dry Savanna zone of Nigeria. In*Improving Crop-Livestock Systems in West and Central Africa*. http://www.iita.org/info/crop-livestock/arti15.pdf.Accessed; 10th November, 2015.

Adeoye, G. O. &Agboola,A. A. (1985). Critical levels for soil pH, available P, K, Zn and Mn and Maize ear leaf content of P, Cu and Mn in sedimentary soil of Southeast Nigeria.*Fertilizer Research* 6:65-71.

Alam, A., Paul, S.K., Sarkar. M.A.R. & Islam, S.M.M. (2014). Effect of variety row arrangement and nitrogen dose on performance of transplant Aman Rice.*International Journal of Sustainable Crop Production* (IJSCP), 9(2):7 – 16.

Aregheore, E. M. (2009). Nigeria: Country Pasture/Forage Resource Profiles. http://www.fao.org/AGP/agpc/doc/Counprof/region/index.htm. [Accessed June 9, 2016].

Bogdan, A.V. (1977). *Tropical Pasture and Fodder Plants*. Longman Inc., New York. Pp77-86.

CAPAR, (2010).Statute Establishing the Centre for Pastoral and Agricultural Research, (CAPAR)Usmanu Danfodiyo University, Sokoto, Nigeria. Pp11.

Duke, J. A. (1997). Gamba grass (*Andropogon gayanus* Kunth). *In*: *Handbook of Energy Crops*

(Unpublished). Centre for New Crops and Plants Products, Purdue University. Accessed at; http://www.hort.purdue.edu/newcrop/default.htm (last edited June, 1997). Retrieved; December 3, 2009.

FAO (2006). Fertilizer use by crops. Food and agriculture organization of the United Nations. Vol 17. Pp 5-17.

FAO (2009). Rhode grass (Chloris gayana kunth) food and agricultural organization of the united nation. Retrieved from http://www.fao.org/ag/agp/agpc/doc/gbase/data/pf000199.htm [Accessed19thDecember, 2015].

FDALR (1990). The reconnaissance Soil survey of Nigeria. (1:650,00) Soil report Vol 3 (Bendenl, Lagos, Ogun, Ondo and Oyo states, Savanna) press LTD, Jos, Nigeria. P 338-339.

GenStat (2015). 64-bit Release Seventeenth Edition(17.1, PC/Windows 8)

Isah, A. D. and M. A. Shinkafi (2000). Soil and vegetation of Dabagi forest reserve in Sokoto

Khair, M.A.M. (1999). Principles of forage crop production. Agricultural Research corporation ARC, Training and publication administration, Ward madani Sudan (In Arabic).

Kumbar, D.D. & Sonar, K. R (1980). Dry matter production and nutrient uptake pattern of two rice varieties grown under upland conditions. *Journal of Indian Society Soil Science*,28(2) 178 – 183.

Kutu, F. R., &Asiwe, Gan (2009).Interactive effect of row spacing on weed infestation and yield of four cowpea varieties. In *African Crop Science Society Conference Proceedings.* Vol 9 Pp 293 – 297.

Mamman, A. B., J. O. Oyebanji and S. W. Peters (2000). *Nigeria: A people United, A Future Assured (Survey of States).* Vol. 2. Gabumo Publishing Co. Ltd. Calabar, Nigeria.

Malami, B. S. (2005). Balancing nutrient supply and requirement of ruminants in Zamfara Reserve, Northwestern Nigeria. Ph.D. Thesis. Department of Animal Science Usmanu Danfodiyo University, Sokoto, Nigeria.

Mannetje, T. L & Kersten S.M.M.(1992). *Clorisgayana* kunth.*Plant Resource of East Asia* In Mannetje, T' L. & Jones, R.M (Eds).

Obi, I. U. (1991). *Maize, its agronomy, disease, pest and food values*. Enugu: Optimal computer solution Ltd.

Ogumbosoye, D. O. and O. J. Babayemi (2010). Potential values of some non-leguminous browse plants; as dry season feed for ruminants in Nigeria. *African Journal of Biotechnology*;9(18):2720-2726.Retrieved,from http://www.academicjournals.org/AJB December 27, 2015

Olson, J.M., Misana, S., Campbell, D. J., Mbonile, M. & Mugisha, S. (2004). Spartial pattern and root cause of land use change east Africa. LUCID Working paper 47. ILRI (*International livestock research institute*), Nairobi Kenya.

Peacock, W. L., Christensen, L. P. & Hirschfelt, D. J. (1991). Influences of the timing of Nitrogen Fertilizer Application on grapevines in the San Joaquin Valley. *Am. J. Enol. Vitis* 44,322-326. www.sawislibrary.co.za//177145 a pdf.

Peden, D., Freeman, A. Abiye, A.& Notembaert, A. (2005). Investment options for integral water-livestock-crop production in Sub Saharan Africa. ILRI (*International livestock research institute*), Adis Ababa, Ethiopia.

Sabulo, R,A. & Osiname,O.A. (1981). Soils and fertilizer use in western Nigeria. *Research bulletin*, No. 11. IAR and T., University of Efe, 5-9.

Samson, T. C (2005). Effect of Inter and Intra Row Spacing and form of Arrangement onthe Productivity of Sesame (*Sesamum indicum* L). An unpublished PGD Thesis submitted to Department of Agronomy ABU Zaria. Nigeria.

SERC (2010). Meteorological Data of Sokoto: 1999 – 2009 (Unpublished). Department of

Meteorology, Sokoto Energy Research Centre, Usmanu Danfodiyo University, Sokoto, Nigeria.

SERC (2017). Meteorological Data of Sokoto: 2016 – 2017 (Unpublished). Department of Meteorology, Sokoto Energy Research Centre, Usmanu Danfodiyo University, Sokoto, Nigeria.

Shukla, V.K., Tiwar, R.K., Malviya, D.K., Singh, S.K. & Ram, U.S. (2015). Performance of rice varieties in relation to nitrogen levels under irrigation condition. *African Journal of Agricultural Research*, 10(12):1517-1520.

Simbaya, J. (2000). Potential of fodder tree/shrub legume as a resource for dry season supplementation packages. Proc. Of the final review meeting of an IAEA technical cooperation Regional AFRA project organized by the joint FAO/IAEA division of nuclear techniques in food and Agricultural held in Cairo, Egypt. 25-29, Nov, 2000. Pp 163. http://www-naweb.iemzae.org/nafa/aph/public/iaea-techdoc-1294.pdf (2016)

Singh, U. N &Tripath, B.N. (2008). Response of Rice cultivars to Zinc sodic soil. *Ann. Plant Soil Research*, 10(1): 75 - 77.

Soil survey staff (2010). Keys to soil Taxonomy: (11th edition), United state department of agriculture/Natural resources conservation services, USA. Pp 338.

state, Nigeria. *Journal of Agriculture and Environment*, 1 (1): 79 -84.

Tanko, S. D. (2013). Influence of Intra-row Spacing and Weeding Regime on Growth, Yield and Chemical composition of *Lablab purpureus* (L.) in Semi-arid Sokoto of Nigeria. M. Sc. Dissertation, Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Nigeria. Pp 56.

Tarowili, S.A., Keating, J.D.H., Powell. J.M., Hiernaux, P., Lyasse, O.&Sanginga, N. (2004). Integrated natural resource management in West African crop-livestock production for improved livelihood and natural resources management in West Africa. IITA (International institute of tropical agriculture), Ibadan, Nigeria. Pp., 349-370.

Umunna,N .N & Iji,P.A, (1993). The natural feed resources in Nigeria. In Adamu, A.M.A, Mani, O.A., Osinowo, K.B. Adeoye, J.P.& Ajileye,E. O. (Eds), *Forage production and utilization in Nigeria*. Proceedings of national workshop held in Kaduna Nigeria, by the national livestock project division (NLPD), Kaduna, Nigeria. Federal ministry of agriculture and natural resources, Nigeria June; 1993.Pp, 16-31.