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Yield Evaluation of Camel's foot (Piliostigma reticulatum) (Hochst.) pods in the rangeland of Kebbi State

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Abstract: The study was carried out to evaluate the yield of *Piliostigma reticulatum* commonly known as Camel's foot within two locations (grazing reserves and fallow areas) in the three senatorial districts of Kebbi State. Three sample plots (100m x 100m) were laid out on transect of about 5 km in nine randomly selected areas and their locations across the senatorial districts. Physical parameters (plant heights and crown diameter) of selected trees in 100m x 100m plot were measured and the pods harvested at maturity, dried and weighted across the selected areas. All the parameters measured were significantly different ($p<0.05$) among the areas. There is a higher pod weight (22.97kg) of *P. reticulatum* in Kebbi south senatorial district than in Kebbi north senatorial district (9.86kg) and Kebbi central senatorial district (6.39kg) which was due to higher plant height (5.29m) and crown diameter (7.27m) recorded in Kebbi south. The pod weight values recorded in Kebbi south especially in its grazing reserves were higher (15.97kg) than its fallow areas (7.00kg). The regression analysis reveals that the tree crown diameter and the plant height had positive significant association with the pod yield. The pod weights is strongly correlated with the magnitude of the plant heights (R^2 = 0.866, 0.716, 0.679) and crown diameters (R^2 = 0.673, 0.905, 0.864) in the north, central and south senatorial districts of Kebbi state respectively. A long study of the pod productivity would provide guidance for a sustainable use of this species by rural populations.

Key words: Yield evaluation, Camel's foot, pods, Senatorial districts, Kebbi State

Introduction

Browses constitute an abundant biomass in farmlands, bush fallows and forest in the humid and savannah tropical environment of Nigeria. However, the productivity of browse plants is not well known and very difficult to measure accurately (Amodu and Otaru, 2004). It may however be stated that it is closely related to rainfall and ecological zones and varies from 100kg to 1000kg of edible Dmha-^{1} per year.

Browse productivity is not well known for a number of reasons among which are the difficulty of accurately measuring growth and consumable primary production. However, measuring productivity in artificial plantations presents no problem, owing to their homogenous nature in terms of age, phenology, size and spacing. The various productivity values are spread over a range according to ecological conditions and above all, mean annual rainfall and soil productivity (Pamo and Pieper, 1987). Browse production is influenced by many environmental factors such as climate, soil, and topography and management background involving exploitation by animals, lopping and burning forested areas (Ademosun, 1974).

The constraints in browse edible biomass evaluation related to the cost and tediousness of methods used in estimation have led to the development of allometric relations for indirect estimation of the production. Most of the studies on the regression of biomass production of browse plants in the Sahel (Poupon, 1976; Cisse, 1980; Bille, 1980) reported the trunk diameter (circumference) as the best predictor of edible biomass production, and is also easily measurable. The height is sometimes considered too, but rarely is the crown (Hadja, 2007). Cisse (1980) found a good correlation between the foliage biomass and the crown area of *Pterocarpus lucens* (0.97, compared to 0.96 for trunk circumference and height). Bille (1980) expressed the logarithm of the edible biomass linearly as a function of the logarithm of stem circumference and proposed a mean equation (log edible biomass = 21og (Diameter) + 1), that could constitute an acceptable approximation in the Sahel zone. This equation is close to the one obtained with *G. senegalensis* trunk diameter, but different from *A. senegalensis* and *P. lucens*. Crown diameter appeared to be the best parameter to predict edible biomass production. Many other authors have stressed the reliability of crown measurements in estimating edible biomass production (Hughes *et al.*, 1987; Paton *et al.*, 2002; Northup *et al.*, 2005; Yelemou *et al.*, 2007., Muftau *et al.*, 2016). The crown displays the leaves, which capture the radiant energy for photosynthesis, which provides for the renewal of the leaves. Thus,

crown surface area is a useful index of growth and it is shown to be strongly correlated with the growth of the tree (Brack, 1999).

Studies on browse yield evaluation of Camel's foot are scarce in the Sahel area and missing in the study area limiting the comparison of results with other data especially for the specie investigated which is not cultivated but well known and abundant in the grazing reserves and fallow areas of Kebbi State (Muftau *et al*., 2018). The evaluation of browse production and estimation is a complex task especially for indigenous species in natural rangelands, marked by the diversity of species and the great heterogeneity in plant size.

There is an urgent need to study the productivity of *P. reticulatum* in order to plan for its utilization. Better knowledge of *P. reticulatum* would allow for a better management of its populations through applications of sylvicultural practices that take into account the populations needs.

Materials and Methods

Study area

The study was conducted in Kebbi State situated between latitudes 10° 8′ N – 13° 15′ N, and longitudes 3° 30′ E – 6° 02′ E. The annual rainfall varies between 500mm and 750mm, with over 60% falling during July and August (Mammam *et al*., 2000). Kebbi State experiences peak rainfall between July and August while harmattan (cold season) is usually from November to February and is characterized with strong winds. The mean annual temperature of about 27°C is recorded in all locations, but temperature is generally high. However, during the harmattan season, the lowest temperature is 21°C. Temperatures can go up to 40°C during the months of April to June (Onlinenigeria, 2012). The average relative humidity during the wet season is 80 %, but it is generally low (40 %) for most of the year.

The vegetation is classified as Guinea and Sudan savannah and comprises of variety of trees and shrubs such as *Piliostigma reticulatum, Combretum micranatum, Combretum glutuinosum, Azadirachta indica, Cassia arereh, Vitalleria paradoxa, Parkia biglobosa, Prosopis africana, Mimosa pigra, Daniella oliveri* and *Guiera senegalensis*. The herbaceous layer of natural pastures and fallow areas are patchy with many bare spots. In addition, important plantations such as cashew, mangoes, guava, gum arabic, Moringa are also found in the state. Commonly cultivated crops in the state include millet, sorghum, cowpeas, groundnut, rice and cotton during the

rainy season. While cattle, sheep, goats and poultry are the predominant livestock reared by the people (KARDA, 2016).

Sampling of Camel's foot stands

Three (3) areas were selected from each of the three (3) Senatorial districts of the State using a Stratified Purposive Random Sampling. In Kebbi north; Arewa, Shiko and Tsamia were selected. In Kebbi central; Dalijan, Hilema and Andarai were selected. In Kebbi south; Ribah, Birnin Yauri and Giron Masa were selected. A reconnaissance survey was conducted in the study area to determine the population stands of camel's foot. Each selected area was divided into two locations (fallow area and grazing reserve). Three sampled plots taken along a transect of about 3km from the fallow area and the grazing reserve measuring each (100m x 100m) were mapped out at random using a measuring tape and demarcated with pegs giving a total of six plots per each area. Plant height and the east-west and north-south diameter of the crown of each selected tree were measured to determine the yield estimation by using measuring tape and the pods harvested at maturity, dried and weighted by using weighing balance.

Table 1: Geographical locations and Vegetation zones of the selected areas

Areas	Latitude	Longitude	Senatorial district	Vegetation zone
Kangiwa	12.5378^0 N	3.7740^0 E	Kebbi north	Sudan savanna
Shiko	11.7949^0 N	3.8452^0 E	Kebbi north	Sudan savanna
Tsamia	12.9487^0 N	5.7153^0 E	Kebbi north	Sudan savanna
Dalijan	12035^i11^i N	$4031i9^i$ E	Kebbi central	Sudan savanna
Hilema	12.3500^0 N	3.9000^0 E	Kebbi central	Sudan savanna
Andarail	11.8994^0 N	4.3886^0 E	Kebbi central	Sudan savanna
Ribah	11.3971^0 N	5.4856^0 E	Kebbi south	Guinea savanna
Birnin Yauri	$10^046'56.28"$ N	$4^048^i40.86"$ E	Kebbi south	Guinea savanna
Giron Masa	$11^011^i45"$ N	$4^034'3"$ E	Kebbi south	Guinea savanna

Source: KARDA (2016).

Results

The mean plant height, crown diameter and the weight of pods of camel's foot in Kebbi north senatorial district were presented in Table 2. The results from Kebbi north indicated that the areas had significant effect ($p<0.05$) on plant height, crown diameter and pod weight except for plant height and crown diameter in Shiko and Tsamia areas respectively. The grazing reserve and fallow area of Tsamia had significantly ($p<0.05$) taller plant height (4.09m and 5.10m respectively) than Kangiwa and Shiko areas. Likewise, the crown diameter was significantly ($p<0.05$) higher in the grazing reserve (5.99m) and fallow area (5.41m) of Tsamia than those in Kangiwa and

Shiko areas. Also the grazing reserve and fallow area of Tsamia had significantly ($p<0.05$) higher pod weights (2.17kg and 3.37kg respectively) than those in Kangiwa and Shiko areas. There are no stands of *P. reticulatum* at Kangiwa fallow area.

It was observed that the pod yield increases as the plant height and the crown diameter increased in all the areas and their locations. The relationship between plant height, crown diameter and pod weight shows positive gradient. The linear model obtained from Kebbi North which can be used as a prediction formula is as follows:

(i) YKN = - 0.336 + 0.657 X1 KN (ii) YKN= -0.239 + 0.479 X2 KN

Pod weight (Y), Kebbi North (KN), Plant height (X1), Crown diameter (X2)

The degree of relationship between the plant height and pod weight, crown diameter and pod weight is highly significant ($p<0.01$) with a correlation values of 0.931 and 0.951 respectively in Kebbi north senatorial district. The pod weight is strongly correlated with the magnitude of the plant height ($R^2 = 0.866$) and crown diameter ($R^2 = 0.673$) in Kebbi north senatorial district.

Table 2: Plant height, crown diameter and pod weight of camel's foot in Kebbi North Senatorial District during the 2015 dry season

Areas	Parameters		
	Plant heights (m)	Crown diameter (m)	Pod weights (kg)
Kangiwa			
Grazing reserve	2.68[a]	4.14[a]	1.03[a]
Fallow area	0.00[b]	0.00[b]	0.00[b]
SEM	0.29	0.34	0.32
Significance	*	*	*
Shiko			
Grazing reserve	2.82[b]	3.73[b]	0.96[b]
Fallow area	3.41[b]	4.32[a]	2.33[a]
SEM	0.20	0.04	0.06
Significance	NS	*	*
Tsamia			
Grazing reserve	4.09[b]	5.99[a]	2.17[b]
Fallow area	5.10[a]	5.41[a]	3.37[a]
SEM	0.12	0.09	0.07
Significance	*	NS	*

Means in a column followed by the same superscripts at 5% level were not significantly ($p<0.05$) different. * (Significant), NS (Not Significant).

In Kebbi central, the plant heights, crown diameter and the pod weights were significantly ($p<0.05$) affected by their areas with the exception of the crown diameter and the pod weights at Dalijan areas (Table 3). The grazing reserve and the fallow area at Dalijan had significantly ($p<0.05$) taller plant height (5.51m and 6.02m respectively) than the areas at Hilema and Andarail. The crown diameter in the grazing reserve (5.49m) and the

fallow area (5.94m) at Hilema and Andarail respectively were significantly ($p<0.05$) higher than those at Dalijan area. The pod weights at Hilema grazing reserve (2.03kg) and Andarail fallow area (1.71kg) were significantly ($p<0.05$) higher than those of Dalijan areas. There are no stands of *P. reticulatum* at Hilema fallow area and Andarail grazing reserve.

It was observed that the pod yield increased as the crown diameter increases with an increase in plant heights in most of the areas and their locations.

The relationship between plant height, crown diameter and pod weight shows positive gradient. The linear model obtained from Kebbi Central which can be used as a prediction formular is as follows:

(i) YKC = 0.150 + 0.271 X1 KC (ii) YKC= -0.02+ 0.296 X2 KC

Weight of pods (Y), Kebbi Central (KC), Plant height (X1), Crown Diameter (X2)

The degree of relationship between the plant height and pod weight; crown diameter and pod weight is highly significant ($p<0.01$) with a correlation values of 0.820 and 0.846 respectively in Kebbi central senatorial district. The pod weight is strongly correlated with the magnitude of the plant height ($R^2 = 0.716$) and crown diameter ($R^2 = 0.905$) in Kebbi central senatorial district.

Table 3: Plant height, crown diameter and pod weight of camel's foot in Kebbi Central Senatorial District during the 2015 dry season

Areas	Parameters		
	Plant heights (m)	Crown diameter (m)	Pod weights (kg)
Dalijan			
Grazing reserve	5.51[b]	4.87[b]	1.49[c]
Fallow area	6.02[a]	5.34[b]	1.16[c]
SEM	0.11	0.24	0.10
Significant	*	NS	NS
Hilema			
Grazing reserve	4.99[a]	5.49[a]	2.03[a]
Fallow area	0.00[b]	0.00[b]	0.00[b]
SEM	0.22	0.13	0.03
Significant	*	*	*
Andarai			
Grazing reserve	0.00[b]	0.00[e]	0.00[e]
Fallow area	3.65[a]	5.94[a]	1.71[b]
SEM	0.04	0.32	0.06
Significant	*	*	*

Means in a column followed by the same superscripts at 5% level were not significantly ($p<0.05$) different. * (Significant), NS (Not Significant).

In Kebbi south, the plant heights, crown diameter and the pod weights were significantly ($p<0.05$) affected by their areas with the exception of the plant heights and crown diameter at Birnin Yauri and Giron Masa

respectively (Table 4). The grazing reserve and the fallow area at Binin Yauri had the tallest ($p<0.05$) plant heights (5.29m each) than the Ribah and Giron Masa areas. Likewise the crown diameter was significantly higher ($p<0.05$) in the grazing reserve (7.27m) and the fallow area (5.72m) at Birnin Yauri than Ribah and Giron Masa areas. The grazing reserve at Birnin Yauri and the fallow area at Giron Masa produced significantly largest ($p<0.05$) pod weights (6.52kg and 4.01kg respectively) than at Ribah and Giron Masa grazing reserves and Birnin Yauri fallow area. There are no stands of *P. reticulatum* at Ribah fallow area.

The relationship between the plant height, crown diameter and pod weight shows positive gradient. The linear model obtained from Kebbi South which can be used as a prediction formular is as follows:

(i) YKS = 0.094+0.901 X1 KS (ii) YKS= -0.291+0.826 X2 KS

Weight of pods (Y), Kebbi South (KS), Plant height (X 1), Crown diameter (X2)

The degree of relationship between the plant height and pod weight and crown diameter and pod weight is highly significant ($p<0.01$) with a correlation values of 0.824 and 0.930 respectively in Kebbi south senatorial district. The pod weight is strongly correlated with the magnitude of the plant height ($R^2 = 0.679$) and crown diameter ($R^2 = 0.864$) in Kebbi south senatorial district.

Table 4: Plant height, Crown diameter and Pod weight of Camel's foot in Kebbi South Senatorial District during the 2015 dry season

Areas	Parameters		
	Plant heights (m)	Crown diameter (m)	Pod weights (kg)
Ribah			
Grazing reserve	5.02[a]	6.76[a]	5.76[a]
Fallow area	0.00[b]	0.00[b]	0.00[b]
SEM	0.04	0.04	0.13
Significant	*	*	*
Giron Masa			
Grazing reserve	4.16[b]	5.02[c]	3.69[b]
Fallow area	5.08[a]	5.12[c]	4.01[a]
SEM	0.15	0.15	0.06
Significant	*	NS	*
BirninYauri			
Grazing reserve	5.29[c]	7.27[a]	6.52[a]
Fallow area	5.29[c]	5.72[b]	2.99[b]
SEM	0.50	0.25	0.36
Significant	NS	*	*

Means in a column followed by the same superscripts at 5% level were not significantly ($p<0.05$) different. * (Significant), NS (Not Significant).

Discussion

The variations of crown diameter and the plant height that exists among the areas in the senatorial districts of Kebbi State affected the pod yield of *P. reticulatum*. This was in agreement with the findings of Yelemou *et al*. (2007); Muftau *et al*. (2016) that the fruit productivity of *P.reticulatum* was related to the magnitude of the tree's crown. At plants maturity, the crown magnitude determines the abundance of the flowers, therefore of the pods. The density and size of the leaves and their distribution on the branches could also have considerable importance (Hadja, 2007) in determining the yield of camel's foot across the areas. This explains the reason for the higher pod weights of the plant in Kebbi South than in Kebbi North and Kebbi Central which was due to higher crown diameter and plant height values recorded in Kebbi South especially in the grazing reserves than in the fallow areas. The linear regression analysis showed a significant relationship between the plant height, crown diameter and the pod yield indicating that the pod yield is strongly related to the plant height and the crown diameter across the areas.The variation of pod yield among the areas in the senatorial districts could be explained by varied ecological conditions such as edaphic factors, rain and soil nutrients (Yelemou *et al*., 2007). The higher rainfall experienced in Kebbi South could be a factor that influenced the higher productivity of *P. reticulatum* than in the other areas that have low rainfall (KARDA, 2016). Plant age could also be a factor that can affect the variation in the pod yield across the areas. This was in agreement with the report of Yelemou *et al*. (2009) that the old populations produced more pods than the less aged ones (8kg against 1kg). Pod yield in all the areas were statistically different in this study. There were more pod yields in Kebbi South (22.97kg) than in Kebbi North (9.86kg) and Kebbi Central (6.39kg). This may be due to variations between the crown diameters from one area to another as a result of variation in climatic conditions especially rainfall and soil types existing among the areas as reported by Ademosun (1974).

The absence of *P. reticulatum* in some areas might be due to the demand for fuel and farmer's cropping practices that remove the shrub for crop land expansion as it was observed in this study, which reduced pasture availability. This observation was in agreement with the findings of FAO (1996) that farming activities into rangelands have greatly reduced pasture availability in semi-arid Africa at an annual rate of 2.5 to 3%.

Conclusion

The pod productivity of *P. reticulatum* depends on the ecological conditions of the areas particularly rainfall. The pod yield in the grazing reserves and the fallow areas in Kebbi State increases in relation to the magnitude of the plant heights and the crown diameter in most of the areas. A long study of the pod productivity would provide guidance for a sustainable use of this species by rural populations.

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