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Estimation of growth rate and biomass production of native savanna forage shrub species

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The growth and long-lived growth patterns observed in many Savanna shrubs may be advantageous for survival in harsh physical environment. This study was conducted to estimate the growth potential and biomass yield of *Securinega virosa, Cajanus cajan, Stylosanthes mucronata* and *Tephrosia purpurea* in the northern region of Ghana. A total of 16 experimental beds of size 4 x 4 m with 1 m spacing between beds were constructed. Observation after sowing was made daily to record emergence. Plant growth parameters were taken fortnightly for 13 weeks on four representative plants randomly selected from each species. The biomass production data were subjected to two-way analysis of variance (ANOVA) assuming a complete randomised design. *C. cajan* had the highest germination of 75% observed from 3-5 days after planting, while *S. virosa* recorded the least germination of 63% observed from 5-8 days after planting. *C. cajan and T. purpurea* had the highest growth rate, while *S. virosa* showed very low growth rate. *S. mucronata* had the largest mean stem diameter, followed by *C. cajan* and *T. purpurea* and *S. virosa* being the smallest. Similarly, *S. mucronata* obtained the highest mean number of shoots followed by *S. virosa,* while *T. purpurea* had the least. Linear and positive relationships were observed among plant height, stem diameter and number of shoots of all the shrubs. No significant difference in mean total dry matter yield among the shrub species and among the different maturity stages was recorded. All the shrubs except *S. virosa* produced seeds. Livestock farmers are encouraged to adopt and integrate these shrubs in their farming system to provide adequate forage to boost animal production.

Key words: Indigenous shrubs, animal feed, germination, plant growth, biomass yield.

INTRODUCTION

In West Africa, pasture species evaluation with the objective of identifying the most productive and adapted species has been of interest for some years (Babatoundé, 2005). Biomass, especially above-ground

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biomass is one of the central traits in functional plant ecology and growth analysis. It is the key parameter in many allometric relationships (Niklas and Enquist, 2002).

Repeated measurements of biomass are the basis for the calculation of net primary production and growth rates and thus a basis for quantifying physiological responses of plants to environmental conditions and their development processes (Cornelissen et al., 2003). Like other vegetal formations, biomass or phytomass is a key structural variable in the investigations of the dynamics of ecosystems, the level of biodiversity they sustain, their role in the carbon cycle and their sustainability (Cerrillo et al., 2006). In addition, the quantification of above ground biomass resources constitutes necessary information for numerous studies, including the analysis of fixed-emission of carbon dioxide (Nabuurs and Mohren, 1995).

There is an increasing need to improve the accuracy of biomass estimates as they determine the actual amount of carbon reaching the atmosphere (IPCC, 1996). Traditionally, biomass estimation in forest ecosystems has been obtained through direct methods (destructive or extractive) or indirect methods (dimensional analysis) (Wharton and Griffith, 1993). The destructive methods are based on harvesting and weighing all the plants in the sample plot. They give very accurate estimates but the extraction of a large number of samples is very laborious and costly. Indirect methods are based on the measuring of different morphological variables used in mathematic models to estimate vegetal biomass. These methods give estimates that can reach prediction levels of the former methods and in addition permit a large number of observations at a relatively low cost (Montes et al., 2000). Indirect methods to determine biomass are based on developing a relationship between plant weight and an easier-to-measure attribute such as plant height, rainfall or cover. Although, non-destructive methods are less accurate in a per sample unit basis than cutting methods, they take less time per observation and involve less physical effort by the operator. According to Mannetje (2000), these non-destructive or indirect methods can be grouped into three categories, viz, visual estimation, height and density measurements, and measurements of non-vegetative attributes that can be related to dry matter yield. This study therefore seeks to determine the growth rate of *Cajanus cajan, Stylosanthes mucronata, Tephrosia purpurea* and *Securinega virosa*, estimate and compare the biomass yield of the shrubs at three maturity stages and to assess the seed production potential of the shrubs.

MATERIALS AND METHODS

Experimental site

This field experiment was carried out from October, 2014 to February, 2015 at the experimental farm of the Faculty of Renewable Natural Resources, University for Development Studies, Nyankpala Campus, Ghana. This area is located within the savanna ecosystem on latitude 09° 25' N and longitude 00° 55' W and with an altitude of 183 m above sea level. Further description of the study area is in Ziblim et al. (2015).

Experimental design

Completely randomized design (CRD) was used in this experiment involving four native savanna forage shrub species with four replications. The land at the site was cleared of debris, ploughed to a fine tilth and furrowed. Experimental plot of size 4 x 4 m was constructed. Seeds of the shrub species were planted onto the plots and their emergence monitored. An average of two seeds were placed in a hole of 0.5 cm depth and covered with light soil. Plant height, number of shoots per plant and root collar diameter were determined on four (4) randomly selected plants of each shrub species. Measurement of the growth parameters was done fortnightly, beginning a month after emergence. On each plot, 16 plants spaced 1 m between rows and 1 m within rows were planted. Watering was done throughout the experimental period. Routine weed control was also carried out by hand weeding to avoid competition with the planted shrub species and to also loosen the soil to facilitate aeration.

Study shrubs

Four indigenous forage shrub species were considered; they were *C. cajan* (“Adua”), *S. virosa* (“Susugra”), *S. mucronata* or *S. fruticosa* (Retz.) (“Mamongmakpam”) and *T. purpurea* (“Banglari”). Seeds of these shrub species were harvested from the wild and sown directly onto seedbeds. These shrub species were selected based on a preliminary survey that was carried out with livestock farmers on the various species and were considered palatable and used by their animals.

Sampling for dry matter and seed yield

Dry matter yield was estimated from four (4) representative plants of each shrub at 7, 10, and 13 weeks after plant establishment (WAE) (Larbi et al., 2005). The estimation of the dry matter yield was carried out by uprooting the representative plants of each shrub using the destructive technique. The sample plants were separated into leaf, stem and root fractions. Fresh weights were taken directly and were oven-dried to constant weight at 80°C for 48 h for determination of dry matter yield. The fodder yield per plant was divided by the total above ground biomass and multiplied by 100 to estimate the percent fodder (Larbi et al., 2009). Total biomass was calculated by adding the oven-dried weights of the three fractions.

Seed yield was estimated from four (4) representative plants of each shrub species that were labeled and monitored throughout the growing period (Larbi et al., 2009). Flowering period of each shrub species was observed and recorded. Mature seeds at the end of the growing season were hand-harvested, air-dried, cleaned and weighed. Seeds harvested from each plant were bulked at the end of the study and total seed yield estimated per shrub species.

Statistical data analysis

The biomass production data of the shrubs and their interactions at the various maturity stages were subjected to a two-way analysis of

Table 1. Emergence, flowering and fruiting dates and seed yield of the shrubs.

Shrub species	Emergence		Flowering (days)	Fruition (days)	Mean seed yield (kg/ha)
	Days	Emergence (%)			
C. cajan	3-5	75	72	80	161.46
T. purpurea	5-8	65	45	51	41.67
S. mucronata	3-5	74	49	55	15.63
S. virosa	5-8	63	-	-	--

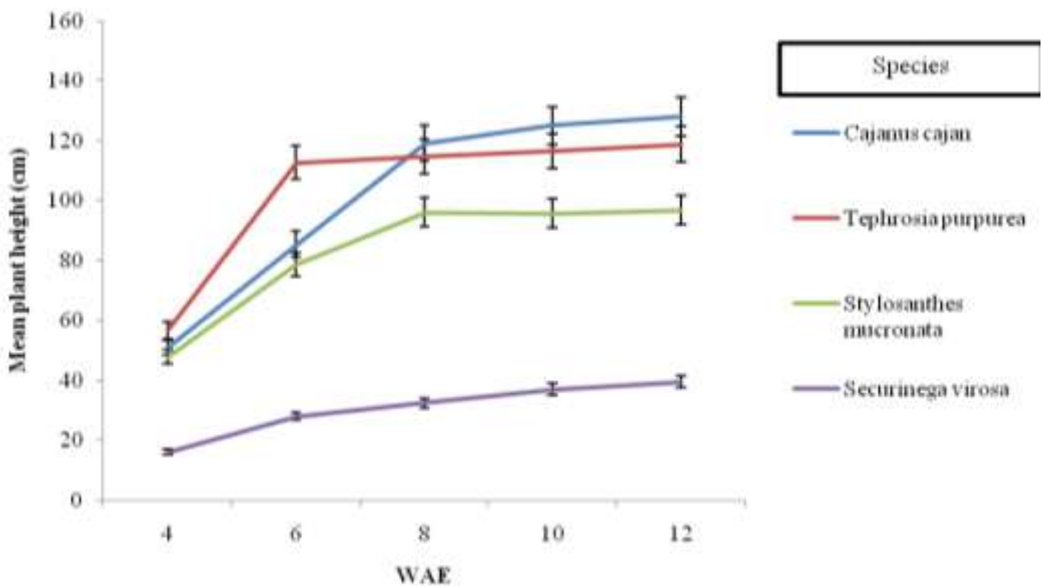

Figure 1. Trend in mean plant height of the different indigenous shrub species from October to December, 2014. The error bars used are standard error (SE).

variance (ANOVA) assuming a complete randomised design. Genstat Release 10.3 DE (2011) was used. The mean height of shrubs, mean stem diameter and mean number of shoots per plant were graphically represented to show trend in growth with error bars indicating the differences. Excel spreadsheet was used to plot the graphs. Total seed yield of the different shrub species were estimated by weighing the seeds harvested from the representative plant. The relationship among plant height, number of shoots and stem diameter was established using scatter diagrams with goodness-of-fit lines. Significant treatment means were separated using Fisher's protected least significant difference (LSD) at 5% probability. Unless otherwise specified, the level of significance was declared at $p<0.05$.

Results

Agronomic properties of the selected shrub species

Table 1 below indicates the emergence, flowering and fruiting dates and seed yield of the shrub species investigated. It can be observed from Table 1 that both *C. cajan* and *S. mucronata* took the least number of days (3 to 5) to emerge, while *T. purpurea* and *S. virosa* had higher number of days (5 to 8). Percentage emergence was highest (75 %) for *C. cajan*, while *S. virosa* recorded the lowest (63 %). On flower initiation, *C. cajan* took the highest number of days (72) while *T. purpurea* used the least number of days (45). Flower as well as fruit initiation could not be observed in *S. virosa* during the experiment. All the species showed monopodial shoot growth pattern after emergence.

Growth rate and biomass production

Growth rate

Shrub species showed significant difference ($p<0.05$) in growth rate during the period of the experiment from October, 2014 to February, 2015. The mean plant height, mean stem diameter and mean number of shoots of *C. cajan, S. mucronata, T. purpurea* and *S. virosa* over 13 weeks period are shown in Figures 1, 2 and 3,

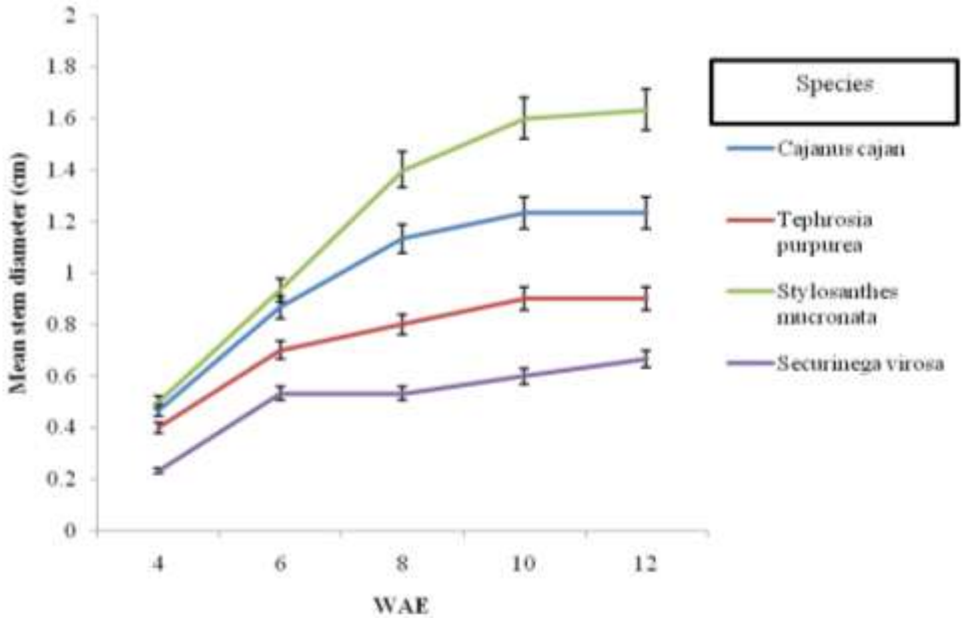

Figure 2. Trend in mean plant stem diameter of the different indigenous shrub species from October to December, 2014.

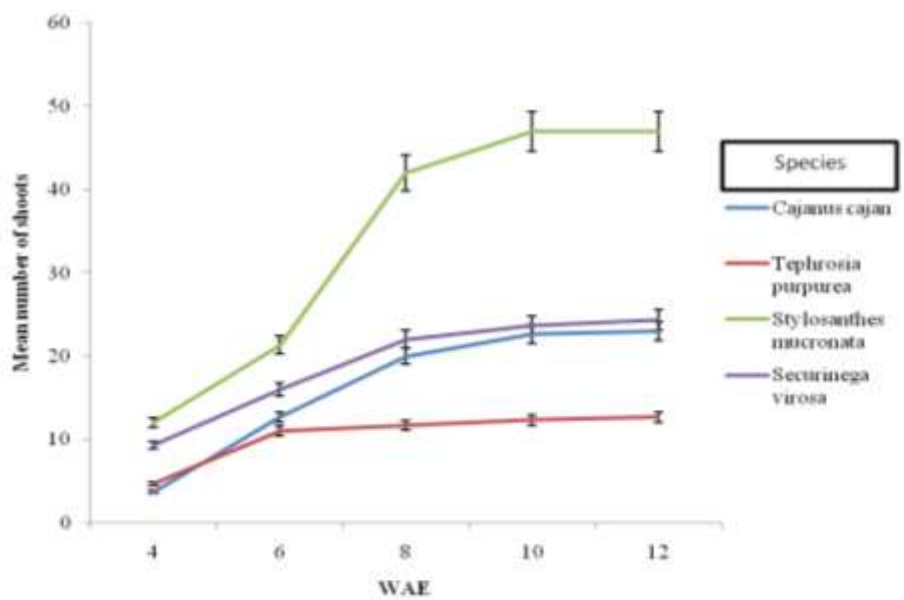

Figure 3. Trend in mean number of shoots of the different shrub species from October to December, 2014.

respectively. The highest mean plant height was observed in *C. cajan* and *T. purpurea*, while *S. virosa* had the lowest. The mean plant height among the species ranged from 39.3 to 128 cm. Based on plant height at the end of the 13th WAE, the shrub species could be classified into fast (*C. cajan* and *T. purpurea*), slow (*S. mucronata*) and very slow growth rate types (*S. virosa*) (Figure 1).

At 4 weeks after establishment, *C. cajan, T. purpurea* and *S. mucronata* had similar growth rate in terms of

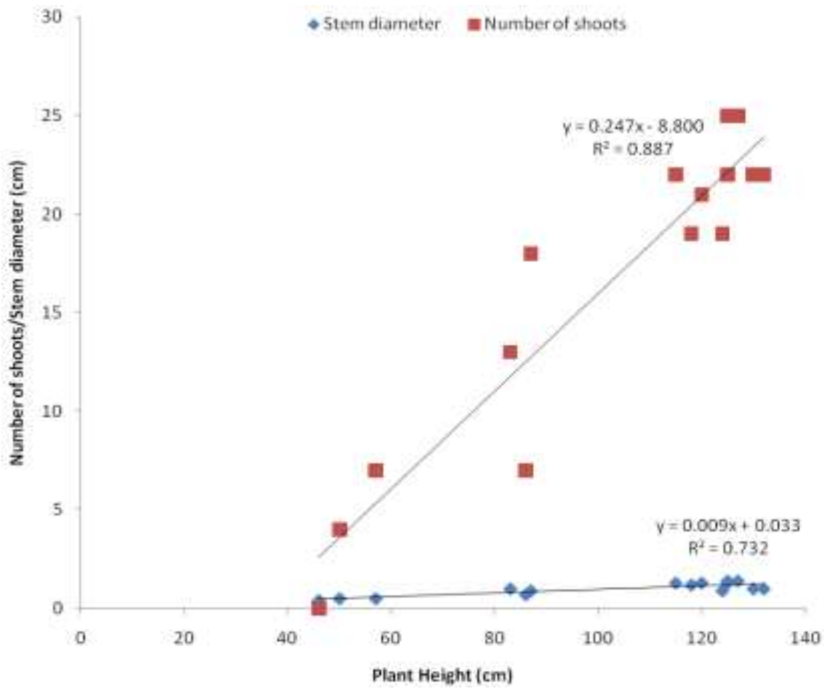

Figure 4. Relationship among the height, number of shoots and stem diameter of *C. cajan.*

height. Also, at 8, 10 and 12 WAE, no significant difference (p>0.05) in height was recorded between *C. cajan* and *T. purpurea*. However, both *C. cajan* and *T. purpurea* were significantly different ($p < 0.05$) from *S. mucronata*. *S. virosa* was observed to have significantly lower ($p < 0.05$) growth rate (height) among the four shrubs.

S. mucronata recorded the highest mean stem diameter (1.6 cm), while *S. virosa* had the lowest (0.7 cm) (Figure 2). It was observed from Figure 2 that *C. cajan* and *S. mucronata* were not significantly different (p>0.05) from each other at 4 and 6 WAE. At 8, 10 and 12 WAE, all the shrubs were significantly different (p<0.05) from each other.

The highest mean number of shoots was observed from *S. mucronata* (47 shoots per plant), while *T. purpurea* obtained the lowest (13 shoots per plant) (Figure 3). *S. mucronata* had significantly higher mean number of shoots. Shoot numbers in *C. cajan* and *S. virosa* were not significantly different (p>0.05) at 8, 10 and 12 WAE. *T. purpurea* registered significantly lower shoot number.

Relationship among growth parameters (goodness-of-fit)

Results of the analysis showed that there were relationships among plant height, number of shoots and stem diameter of all the shrubs under investigation. Figures 4, 5, 6 and 7 shows the graphical representation of the relationships. From Figure 4, it is noted that both number of shoots and stem diameter had very strong relationships (R^2 = 0.887 and R^2 = 0.732 respectively) with the height of *C. cajan*.

Similarly, very strong relationship (R^2 = 0.859) existed between the height and number of shoots, while strong relationship (R^2 = 0.661) was observed between stem diameter and height of *T. purpurea* (Figure 5). Very strong relationship (R^2 = 0.840) was noticed between plant height and stem diameter for *S. mucronata* but moderate relationship (R^2 = 0.530) existed between height and number of shoots (Figure 6).

From Figure 7, the line of goodness-of-fit indicated a strong relationship (R^2= 0.693) between plant height and number of shoots of *S. virosa*. However, moderate relationship (R^2 = 0.568) was observed between height and stem diameter.

Dry matter yield of some indigenous shrub species

Leaf dry matter yield varied significantly (p< 0.05) among the shrub species and ranged from 33.53 g/plant for *S. mucronata* at the 10 WAE to 45.86 g/plant for *T. purpurea* at *7* WAE*.* No significant differences (p> 0.05) in dry

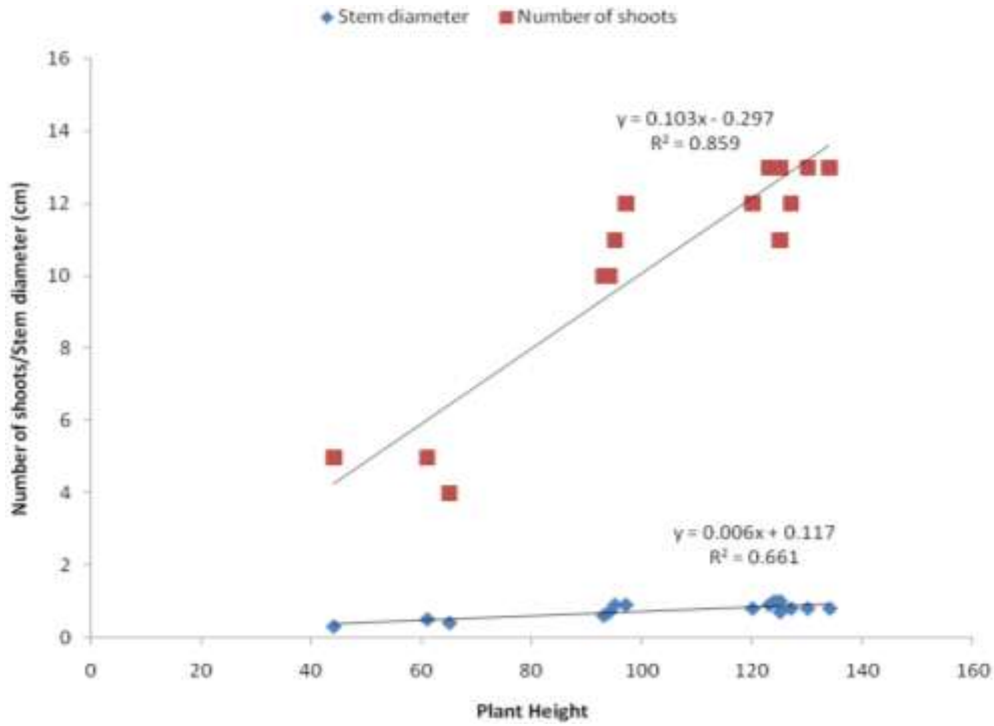

Figure 5. Relationship among the height, number of shoots and stem diameter of *T. purpurea.*

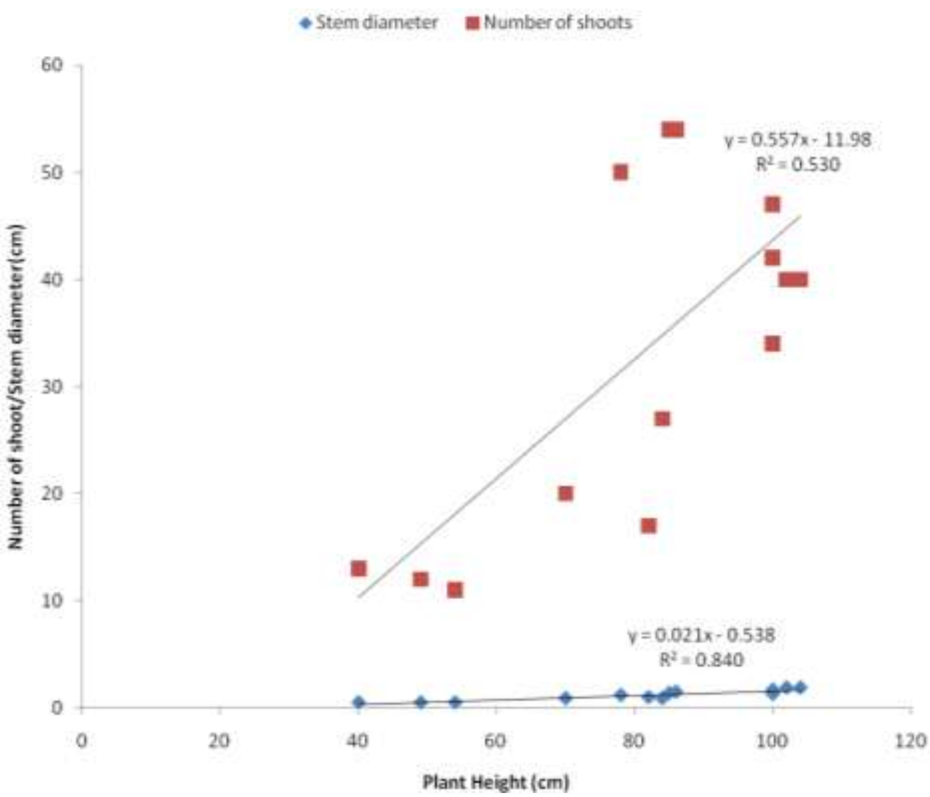

Figure 6. Relationship among the height, number of shoots and stem diameter of *S. mucronata*

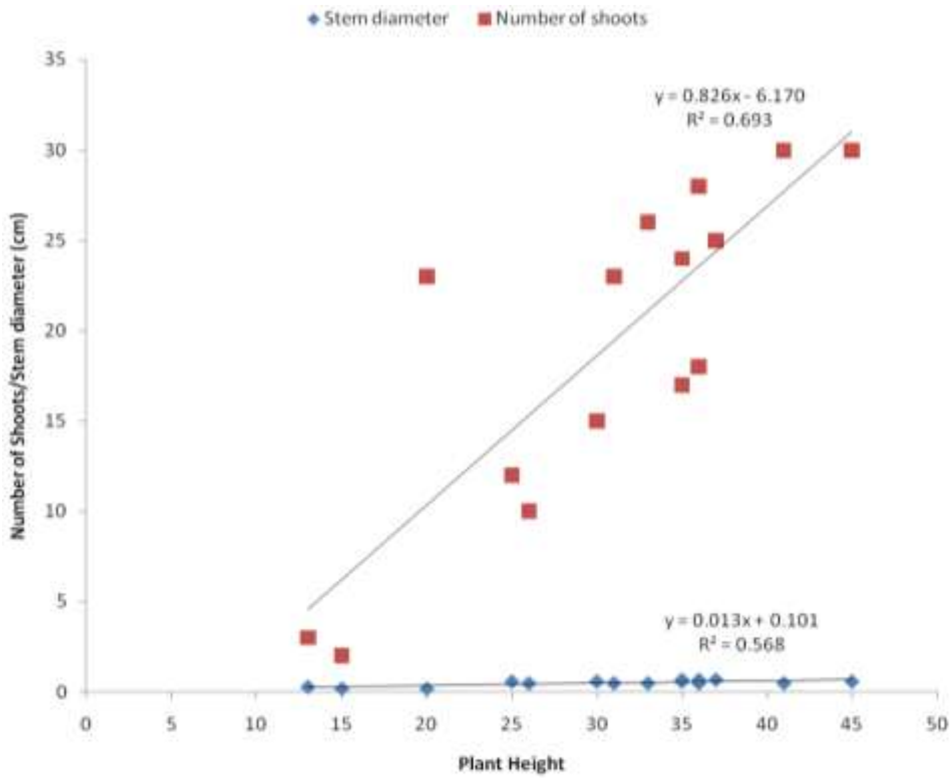

Figure 7. Relationship among the height, number of shoots and stem diameter of *S. virosa.*

matter yield, however, existed among the various harvest durations except in *C. cajan* where leaf yield at 10 WAE differed significantly ($p<0.05$) from that recorded at 13 WAE (Table 2).

Mean stem dry matter yield varied significantly ($p< 0.05$) among shrub species. Mean stem dry matter yield for *T. purpurea* and *S. virosa* was significantly higher($p< 0.05$) than that of *S. mucronata* and *C. cajan* at the various harvest periods except at 13 WAE where no significant difference ($p> 0.05$) in mean stem yield existed among the shrub species. Mean stem yield ranged from 38.37 g/plant to 50.88 g/plant. Mean stem yield of the individual shrub species across the three harvest periods was also observed. Except for *S. mucronata* and *T. purpurea* where mean stem yield varied significantly ($p< 0.05$) at 7 WAE, no significant difference ($p> 0.05$) in mean stem yield was noticed for *C. cajan* and *S. virosa* among the harvest periods (Table 2).

Mean root dry matter yield ranged from 39.67 g/plant for *S. virosa* to 63.46 g/plant *S. mucronata* (Table 2). *S. mucronata* recorded a significantly higher ($p< 0.05$) root dry matter yield at 7 WAE as compared to other species, while *T. purpurea* registered a significantly higher ($p< 0.05$) root dry yield at 13 WAE. Generally, mean root dry matter yield in all the species increased from the 7 WAE to the 10 WAE but declined in 13 WAE. Apart from *S. mucronata* where a significant difference in root yield was shown between 7 WAE and 10 and 13 WAE, no significant increase ($p> 0.05$) was observed for the other species across the harvest periods.

Total dry matter yield showed no significant difference ($p> 0.05$) among the shrubs. However, *S. mucronata* at 10 and 13 WAE recorded the lowest total dry matter yield. None of the shrub species showed significant difference ($p> 0.05$) in total dry matter yield among the harvest periods except *S. mucronata*. Total dry matter yield ranged from 116.20 to 145.39 g/plant (Table 2).

Moisture content also varied significantly ($p< 0.05$) among the shrub species and among the harvest durations. However, among the species and harvest durations, *S. virosa* was noted to have the lowest moisture content in all the parts examined. In general, moisture content increased from the 7 WAE to 10 WAE but declined in the 13 WAE.

DISCUSSION

Agronomic properties of the investigated shrubs

The results showed slight variations in emergence (number of days and percentage), flower and fruit

Table 2. Variations in mean dry matter yield (g/plant) among indigenous shrubs harvested at 7, 10 and 13 weeks after establishment.

Shrub species	7 WAE	10 WAE	13 WAE	SEM
Leaf DM				
S. mucronata	$37.55^{A,b}$	$33.53^{A,a}$	$42.50^{A,a}$	0.80
C. cajan	$40.31^{AB,ab}$	$37.99^{B,a}$	$36.75^{A,a}$	0.59
T. purpurea	$45.86^{A,a}$	$38.26^{A,a}$	$40.94^{A,a}$	1.52
S. virosa	$45.35^{A,a}$	$39.95^{A,a}$	$40.81^{A,a}$	2.08
SEM	1.04	1.28	1.26	
Stem DM				
S. mucronata	$44.37^{A,ab}$	$38.61^{B,b}$	$40.61^{B,a}$	0.49
C. cajan	$40.11^{A,b}$	$38.37^{A,b}$	$40.72^{A,a}$	1.15
T. purpurea	$50.88^{A,a}$	$44.04^{B,a}$	$47.24^{AB,a}$	0.99
S. virosa	$48.62^{A,a}$	$46.53^{A,a}$	$45.12^{A,a}$	1.71
SEM	1.30	0.54	1.05	
Root DM				
S. mucronata	$63.46^{A,a}$	$44.06^{B,a}$	$46.05^{B,ab}$	1.23
C. cajan	$48.03^{A,b}$	$44.58^{A,a}$	$48.09^{A,ab}$	1.46
T. purpurea	$48.64^{A,b}$	$47.81^{A,a}$	$52.22^{A,a}$	2.12
S. virosa	$47.48^{A,b}$	$48.30^{A,a}$	$39.67^{A,b}$	2.34
SEM	2.10	0.94	1.53	
Total DM				
S. mucronata	$145.39^{A,a}$	$116.20^{B,b}$	$123.42^{B,a}$	1.97
C. cajan	$128.45^{A,b}$	$120.93^{A,ab}$	$131.31^{A,a}$	2.92
T. purpurea	$145.38^{A,a}$	$130.11^{A,ab}$	$140.40^{A,a}$	3.57
S. virosa	$141.45^{A,ab}$	$134.79^{A,a}$	$125.61^{A,a}$	2.99
SEM	2.47	2.25	2.83	

SEM– standard error of mean. Means in each row that do not have the same upper case letters are significantly different at $p < 0.05$. Means in each column with the same lower case letter are not significantly different.

initiation dates among the shrub species and these could be influenced by their physiological make up. It was observed that *C. cajan* with the biggest seed took the least number of days (3-5) to emerge and also had the highest percentage emergence (75 %) and *S. virosa* with the smallest seed had the least percentage emergence (63%) and took the highest number of days to emerge (5 to 8) (Table 1).

It was observed from Table 1 that percentage emergence significantly declined with reduction in seed size from *C. cajan* to *S. virosa*. This situation could have been influenced by the amount of carbohydrate reserves in the seeds. It has been noted that heavy and large seeds contain more food reserves than smaller ones which is helpful in germination and emergence by providing more energy (Lusk, 1995). The observed results have been similarly reported by Sharma and Sood (1990) and Singh and Shah (1992). However, smaller seeds germinated and emerged better in some *Cassia and Acacia* species as reported by Swaminathan and Srimathi (1994). The reason for this, probably is because large seeds need water uptake more than small seeds and it is assumed that small seeds absorb water more rapidly as compared to large seeds which result in increasing germination and emergence rate.

According to Lopez et al. (2000) and Naidu and Jones (2007) larger seeds of *Eucalyptus* germinated and emerged better than smaller seeds and this is of operational importance in nursery management as seeds can be sown according to size to improve uniformity within a crop. Gholami et al. (2009) observed increased germination percentage as well as greater germination in larger seeds compared with small seeds. Increase in seed size had also been observed to lead to higher germination and emergence (Mut et al., 2010).

Seed yield varied significantly among the shrubs, from zero for *S. virosa* to 161.46 kg/ha for *C. cajan* (Table 1). The differences in seed yield may partly be due to seasonal variation in flowering time among the shrubs. It could also be attributed to the size of the seeds. The results of the study show that all the shrub species under study except *S. virosa* have high potential for seed production for any shrub technologies. Availability of seed and other propagation materials is a major challenge to adoption of shrub technologies. It was noted that species with larger size seeds such as *C. cajan* produced higher seed yield (161.46 kg/ha) as compared to species with smaller seeds such as in *T. purpurea*. This observation is in line with Stougaard and Xue (2005) who indicated that the use of larger size seeds improved grain yield by 18% and the use of small seeds reduced yield by 16% in wheat. The significant differences in the seed yield could also be attributed to the tillering capacity of the different shrub species and the number of spikes per tiller. The higher the number of tillers, the higher the number of spikes that will yield more seeds.

Morphological traits of the selected shrubs

It was observed from the findings that *C. cajan* and *T. purpurea* attained the highest plant height while *S. virosa* had the least. This variation in the plant height could be genotypic and therefore expressed in the form of better adaptability to environmental conditions. Similarly, genetic variation in growth and biomass production among some browse species have been reported (Palmer and Ibrahim, 1996). The size of the shrub seeds could also be an influential factor affecting the height since *C. cajan* with larger seed size had the highest height and *S. virosa* with small seeds had the lowest plant height. This assertion is in line with Kolawole et al. (2011) who indicated that seedlings produced from large-sized seeds were significantly taller than those from medium-sized and small-sized seeds. The lower height observed for the small-sized seeds may be a function of delayed germination and emergence, which indicates that seedling growth, although indirectly an effect of seed size, may be directly linked to rate of germination (Kolawole et al., 2011).

The findings also showed some variation in stem diameter among the shrub species. *S. mucronata* registered the largest stem diameter and *S. virosa* recorded the least. The growth in stem diameter could be related to the seed size. However, this observation is in contrast to work by Kolawole et al. (2011) who noted that seedlings produced from large-sized seeds had significantly larger stem diameter than those from medium and small-sized seeds which did not differ significantly from each other. Moles and Westoby (2006) indicated that seedlings from large-sized seeds had been observed to have higher survival rates than seedlings from small-sized seeds.

The mean tillers per plant in Figure 3 indicated that *S. mucronata* produced maximum number of tillers, while *T. purpurea* produced the least. The differences in tiller numbers among the various shrub species may be due to their genetic makeup. It was also noted from the results that species with thicker or bigger stem diameters tend to possess the highest number of tillers. This could mean that the species with the bigger stems have higher capacity of storing reserve food materials and will result in the production of tillers.

Edible forage production during the experimental period was low, probably due to reduced photosynthetic activity as a result of the lower moisture levels during the period. Similar results in *L. leucocephala* and *G. sepium* were obtained by Cobbina et al. (1990) who reported lower coppice productivity rates in the dry season relative to the wet season in southwestern Nigeria. Large seeds have the ability to store greater amount of carbohydrates in their cotyledons than small seeds (Milberg and Lamont, 1997). This may enable early development of an enlarged resource gathering system to produce a faster growing plant (Hewitt, 1998).

Relationship among growth parameters

The positive relationships between the height and number of shoots and stem diameter of the shrubs indicated that as the heights of the shrubs increased with the number of shoots as a result of the increased in lateral buds. This assertion is in line with Yang et al. (2008) who indicated that trees grow a lot of branches when they are growing in height. On *Cajanus cajan* and *Tephrosia purpurea*, very strong relationships were observed between plant height and number of shoots and this could mean that an increase in height of the shrubs resulted in corresponding increase in the number of shoots. However, with *S. mucronata*, there was moderate relationship between plant height and number of shoots and this could be that an increase in height resulted in a greater increase in the number of shoots. This could be genetically motivated. The relationship of plant height and number of shoots on *S. virosa* also showed that an increase in height resulted in corresponding increase in the number of shoots.

Similarly, there was positive relationship between plant height and stem diameter of all the shrubs. This was because as the plants increased in height, there was the need for corresponding increase in stem diameter to support the increasing weight of the plant. This assertion correlates with the findings of Henry and Thomas (2002) who observed that from a biomechanical perspective, stem diameter, stem stiffness and root anchoring must be sufficiently high relative to stem height to ensure the mechanical stability of plants against stem buckling or uprooting. Osunkoya et al. (2007) also indicated that under field conditions, plants must be strong enough to resist stem buckling and uprooting under additional loadings such as wind and precipitation. Mechanical stimuli such as wind exposure tend to result in increased stem diameter growth relative to height growth (Anten et al., 2005). The difference in relationships between height and stem diameter among the shrubs could be influenced by their genetic makeup. Interestingly, on *S. mucronata*, there was a very strong relationship between height and stem diameter. This could mean that as the plant increased in height, there was a greater corresponding increase in stem diameter.

Dry matter yield of the selected shrubs

The differences in dry matter yield among the shrubs may relate to variations in anatomic, physiologic and morphologic characteristics associated with the acquisition of moisture, sunlight and nutrients for biomass production (Dong and Zhang, 2001). They could also reflect differences among the shrubs in residual buds, leaf area index and amount of carbohydrates reserves (Oppong et al., 2008). The ranges in dry matter yield agree with reports on several shrubs (Ben-Salam et al., 2005).

The linear increase in total dry matter yield from the 10 WAE to 13 WAE could be partly attributed to the increases in the number of growing buds and new shoots (Perez and Mendelez, 1998). It could also be as a result of the greater light interception and stem carbohydrates reserves coupled with active growth during that period (Partey, 2011). There was however, a linear decline in total dry matter yield from 7 to 10 WAE and the reason for this decline is unclear but could be ascribed to inadequate moisture availability in the soil during the period (Duivenbooden et al., 1999). However, the insignificant mean total dry matter yield among the three stages of growth could be due to inadequate spacing among the stages.

Conclusion

All the shrubs studied showed very good growth potential that could be used in agroforestry technologies for better fodder productivity. In terms of plant height performance, *C. cajan and T. virosa* had fast growth rate, *S. mucronata* had slow growth while *S. virosa* showed very slow growth rate. On stem diameter, *S. mucronata* attained the largest, followed by *C. cajan* and *T. purpurea*. *S. virosa* had the smallest stem diameter. Similarly, *S. mucronata* obtained the highest number of shoots followed by *S. virosa*, while *T. purpurea* had the least. The study showed no significant difference in mean total dry matter yield among the shrub species and among the different maturity stages. All the shrubs except *S. virosa* produced seeds that could be relied upon as important avenue to ensure continuous propagation of the shrubs. Livestock farmers in the study area are encouraged to adopt and integrate these shrubs into their farms to boost forage production.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Anten NP, Casado-Garcia R, Nagashima H (2005). Effects of mechanical stress and plant density on mechanical characteristics, growth, and lifetime reproduction of tobacco plants. Am. Nat. 166(6):650-660.

Babatoundé S (2005) Etude et prédiction de la valeur alimentaire de graminées et de légumineuses fourragères en zone tropicale humide *du Bénin.* Thèse doct. Sci. Agron. Fac. Univ. Sci. Agron. Gembloux, Belgique, 165 p.

Ben-Salem H, Abdouli H, Nefzaoui A, El-Mastouri A, an Ben-Salem L (2005) Nutritive value, behaviour and growth of Barbarine lambs fed on oldman saltbush (*Atriplex nummularia L*.) and supplemented or not with barley grains or spineless cactus (*Opuntia ficus-indica f. inermis*) pads. Small Rumin. Res. 59:229-237.

Cerrillo RMN, Oyonarte PB (2006) Estimation of above-ground biomass in shrubland ecosystems of southern Spain. *Investigación agraria. Sistemas y recursos forestales.* 15(2):197-207.

Cobbina J, Atta-Krah AN, Meregini AO, Duguma B (1990). Productivity of some browse plants on acid soils of southeastern Nigeria. Trop. Grassl. 24:41-45.

Cornelissen J H C, Lavorel S, Garnier E, Diaz S, Buchmann N, Gurvich DE, Pausas J G (2003). A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. Aust. J. Bot. 51(4):335-380.

Dong X, Zhang X (2001). Some observation of the adaptations of sandy shrubs to the arid environment in the Mu Us Sandland: leaf water relations and anatomic features. J. Arid. Environ. 48:41-48.

Duivenbooden NV, Pala M, Studer C, Bielders CL (1999). Efficient soil water use: the key to sustainable crop production in the dry areas of West Asia, and North and Sub-Sahara Africa (No. 631.451 DUI. CIMMYT.), 496 p.

Gholami A, Shahsavani S, Nezarat S (2009). The effect of plant growth promoting rhizobacteria (PGPR) on germination, seedling growth and yield of maize. WASET 49:19-24.

Henry HA, Thomas SC (2002). Interactive effects of lateral shade and wind on stem allometry, biomass allocation, and mechanical stability in Abutilon theophrasti (Malvaceae). Am. J. Bot. 89(10):1609-1615.

Hewitt N (1998). Seed size and shade tolerance: a comparative analysis of North American temperate trees. Oecologia 114:432-440.

IPCC (1996). Climate change 1995: impacts, Adaptations and Mitigation of climate change. Scientific-Technical Analyses. Contribution of working group II of the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York, Cambridge University Press.

Kolawole OT, Abiona FE, Kolawole SO, Ayankunle AA, Olaniran OI (2011). Effect of *Momordica charantia* fruit extract on normal and alloxan diabetic rats. Int. J. Pharmacol. 7(4):532-535.

Larbi A, Anyanwu NJ, Oji U I, Etela I, Gbaraneh L D, Ladipo DO (2005). Fodder yield and nutritive value of browse species in west African humid tropics: response to age of coppice regrowth. Agrofor. Syst. 65:197-205.

Larbi A, Khatib-Salkini A, Jamal PB, Iniguez L (2009). Shrub yield and fodder quality variations in a non-tropical dryland environment in West Asia. Agrofor. Syst. 75(2):147-155.

Lopez J, France J, Dijkstra J, Dhanoa MS (2000). Model to interpret degradation profiles obtained from in vitro and in situ incubation of ruminant feed. In. Modeling nutrient utilization in farm animals. Eds. McNamara, J.P., France, J. and Beever, D.E 2000. CAB International, UK.

Lusk CH (1995). Seed size, establishment sites and species co-existence in a Chilean rain forest. J. Veg. Sci. 6:249-256.

Mannetje L't (2000). Measuring biomass of grassland vegetation. Field and Laboratory Methods for Grassland and Animal Production Research. Mannetje, L.'t., and R. M. Jones, ed. C.A.B.I. Publishing. Univ. Press., Cambridge, UK. Pp. 151-177.

Milberg BP, Lamont BB (1997). Seed/cotyledon size and nutrient content play a major role in early performance of species on nutrient-poor soils. New Phytol. 137:665-672.

Moles AT, Westoby M (2006) Seed size and plant strategy across the whole life cycle. Oikos 113:91-105.

Montes N, Gauquelin T, Badri W, Bertaudiere V, Zaoui YE (2000) A non-destructive method for estimating aboveground forest biomass in threatened woodlands. For. Ecol. Manage. 130:(1-3):37-46.

Mut Z, Akay H, Aydin N (2010) Effects of seed size and drought stress on germination and seedling growth of some oat genotypes (Avena sativa L.). Afr. J. Agric. Res. 5(10):1101-1107.

Nabuurs GJ, Mohren GMJ (1995). Modelling analysis of potential carbon sequestration in selected forest types. Can. J. For. Res. 25:1157-1172.

Naidu RD, Jones NB (2007). Effect of seed size on field survival and growth of Eucalyptus in KwaZulu-Natal, South Africa. South. Hemisphere For. J. 69(1):19-26.

Niklas KJ, Enquist BJ (2002). Canonical rules for plant organ biomass partitioning and annual allocation. Am. J. Bot. 89(5):812-819.

Oppong S K, Kemp PD, Douglas GB (2008). Browse shrubs and trees as fodder for ruminants: A review on management and quality. J. Sci. Technol. *28*(1):65-75.

Osunkoya OO, Omar-Ali K, Amit N, Dayan J, Daud DS, Sheng TK (2007). Comparative height–crown allometry and mechanical design in 22 tree species of Kuala Belalong rainforest, Brunei, Borneo. Am. J. Bot. 94(12):1951-1962.

Palmer B, Ibrahim TM (1996). Calliandra calothyrsus forage for the tropics- a current assessment. In: D. O. Evans (ed) International Workshop on the genus Calliandra, Bogor, Indonesia, Winrock International, Morrilton, USA. Pp. 183-194.

Partey ST (2011). Effect of pruning frequency and pruning height on the biomass production of Tithonia diversifolia (Hemsl) A. Gray. Agrofor. Syst. 83(2)181-187.

Perez J, Mendelez F (1998). The effect of height and frequency of defoliation on formation of buds in Leucaena leucocephala in the state of Mexico. Trop. Anim. Prod. 5:280.

Sharma KK, Sood OP (1990). Germination behaviour of seeds of Leucaena leucocephala as influenced by various treatments and seed sizes. Van Vigyan 28(3):99-105.

Singh V, Shah VK (1992). Effect of seed weight on germination and seedling growth in Silver fir (*Abies pindrow*). Van Vigyan 30:104-106.

Stougaard RN, Xue Q (2005). Quality versus quantity: spring wheat seed size and seeding rate effects on Avena fatua interference, economic returns and economic thresholds. Weed Res. 45(5):351-360.

Swaminathan C, Srimathi P (1994). Importance of seed management on germination and seedling growth of four tropical legumes, Range Manage. Agrofor. 15(1):43-47.

Wharton EH, Griffith DM (1993). Methods to estimate total forest biomass for extensive inventories: applications in the north-eastern US USDA Forest service Research Paper. USA, 681.

Yang Bo-gang, Zhang Baohong--gang, Feng Zhong-ke, Han Guang-shun (2008). Algorithm on branches number of a tree based on extended fractal square root law. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 37(Part B4):551-553.

Ziblim AI, Abdul-Rasheed S, Aikins TK (2015). Forage species used by livestock in the Kumbungu District of the Northern Region, Ghana. UDS Int. J. Dev. Stud. 1(1):18-29.