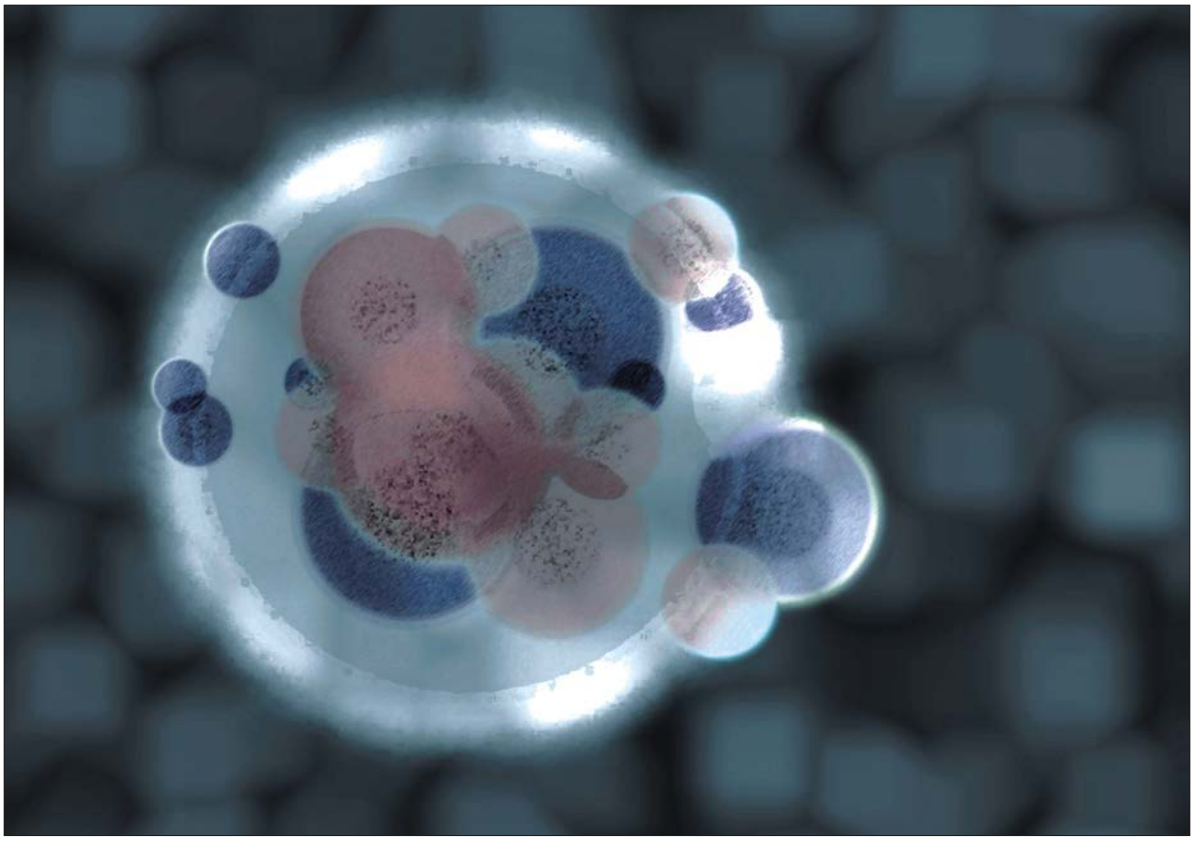

Journal of Biological Sciences

ISSN 1727-3048

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Biological Sciences 7 (6): 985-988, 2007
ISSN 1727-3048

Aboveground Biomass Production of *Cenchrus ciliaris* in Tunisian Arid Zone

[1]Idi Abdelkader, [1]Ali Ferchichi and [2]Mohamed Chaieb
[1]Institute of Arid Regions, Médenine, 4119, Tunisia
[2]Faculty of Sciences, Sfax 3052, Tunisia

Abstract: The main objective of this study was to establish a non destructive method for estimating the aboveground biomass of a plant species in the Tunisian arid area. We attempted to establish some models that could be used to predict the species biomass production. Field experiments were carried out on a Poaceae of a high range value *Cenchrus ciliaris*. The allometric relationships between the plant volume and aerial biomass were studied in autumn 2005 and spring 2006 seasons in southern Tunisia. Linear and nonlinear regressions were tested to establish the best correlations between individual aboveground biomass and plant volume parameters. Measured parameters were the plant height (H) and canopy diameters. Firstly, a model of volume (canopy elliptical cylinder) was tested as a predictor of plant biomass using nonlinear regression. Secondly, It was tested various relationships between the plant biomass and the mean canopy diameter (as the average of the longest canopy diameters maintained perpendicular to each other). Correlations between the aerial biomass production of individuals and their volumes produced a relatively high coefficient of determination (R^2 = 0.68). Also, correlations between the mean canopy diameter and the biomass production of individuals produced the best significant relationships with the highest R^2. The use of the mean canopy diameter seems to be more practical for the plant biomass prediction.

Key words: *Cenchrus ciliaris*, biomass prediction, nonlinear regression, Tunisian arid zone

INTRODUCTION

The improvement of native perennial forage for sustainability of Mediterranean ecosystems is of very important interest. The Tunisian arid zone was for many years ago subjected to some factors of disturbance. The change in the local population life mode from nomadic to sedentary model, associated to the increase of demography, had a great effect on the rangeland state (Auclair, 2001; Nefzaoui and Skouri, 2002). Overgrazing, rainfall deficit and soil fertility decrease are the most constraints of species productivity (Floret *et al*., 1976; Bendali *et al*., 2001; Omer *et al*., 2006). At this level, phytomass estimation of perennial grasses became important for range management which constitutes a very important approach to ecosystem productivity evaluation. Biomass production of plant species has taken an important part of research in the last decades. There is an enormous literature reporting on the aboveground biomass prediction (Williamson *et al*., 1987; Johnson *et al*., 1988; Thomson *et al*., 1998; Montès *et al*., 2004) with much emphasis on shrubs (Hughes *et al*., 1987; Thomson *et al*., 1998; Häfliger *et al*., 2006). In Tunisia, there has been some relatively recent initiatives concerning plant biomass prediction, particularly shrubs and trees (*Acacia cyanophylla*) (Ammari *et al*., 1996; Abdelmoula *et al*., 2004). All world researchers have concerned themselves with forage plant with the establishment of linear and nonlinear models (Johnson *et al*., 1988; Thomson *et al*., 1998; Brandeis *et al*., 2006). Diverse parameters were used to measure plant biomass: basal diameter, plant height and crown volume with the aim of establishing the best and practical method to estimate plant biomass. The main objective of this study was to test some linear and nonlinear regression models to evaluate the aboveground biomass of a Poaceae, *Cenchrus ciliaris*. This species which has a high range value is widespread in the Tunisian arid area.

MATERIALS AND METHODS

Field experiments were conducted in the National Park of Bou Hedma in the arid area of Tunisia (34° 15' N and 9° 15' E). This study site was characterized by a savanna vegetation, dominated by *Acacia raddiana* and *Ziziphus lotus* associated to a chamaephytic vegetation. Perennial grasses are the dominant species in this site. The major ones are *Cenchrus ciliaris*, *Digitaria nodosa*, *Stipagrostis ciliata*, *Heteropogon contortus* and *Tricholaena teneriffae*. The soil is a calcareous plain with clay-alluvium and sandy deposits. The area has a mean

Corresponding Author: Idi Abdelkader, Institute of Arid Regions, Rte Djorf-Km 22, Médenine 4119, Tunisia

annual precipitation of 180 mm, predominantly in autumn and winter. The average monthly temperatures vary between 3.8°C in January and 37.5°C in July. Experiments were carried out in autumn 2005 and spring 2006. For each experiment, 17 individuals of *Cenchrus ciliaris* were selected for measurements. These individuals were randomly sampled. The plant height (H) and the canopy diameters taken at the widest part of the tuft (longest diameter (d_1) and the greatest diameter (d_2) perpendicular to d_1) were measured.

Subsequently, each individual plant was clipped and separately weighed. Fresh matter was then dried in the laboratory at 70°C to a constant dry weight. The dried plant biomass were related to I) the Mean Diameter (MD) (as the average of the two canopy diameters) and ii) the plant volume (BV) as a conic form ($BV = {}^{2}/_{3}\ \pi * (H*d_1/2*d_2/2)$) (Johnson *et al*., 1988; Thomson *et al*., 1998). Different regressions were so tested statistically, using SPSS 10.0 computer program and the best significant relationships were retained.

RESULTS AND DISCUSSION

The range in the height, mean canopy diameter and dry weight of species was, respectively, 7-15.5 cm (mean 10 cm, standard deviation (SD): 1.98 cm), 9-24.75 cm (mean 18.48 cm, SD: 3.9 cm) and 1.15-18 g (mean 9.43 g, SD: 4.55 g). The aboveground biomasses of all individuals (2005-2006) were related to their plant volume (bio-volume). The regression model fitted a high significant relationship (R^2 = 0.68), whereas nonlinear regression applied to the autumn plants fitted the highest significant relationship between bio-volume and the aboveground biomass (R^2 = 0.90) (Fig. 1a). It seems that the plant productivity is well correlated to bio-volume in the autumn season (Fig. 2a). This was due to early autumnal precipitations which start the growth period of the species. In fact, the area received 61.5 mm rainfall in September 2005. This contributed to a rapid increase in individual biomass. At the end of spring which has a total rainfall of 9.5 mm, species had achieved the growing phase. Small individuals were more productive than others. For these reasons, the biomass production of small individuals appeared well correlated to their bio-volumes.

When individuals were ranked by size and linear-nonlinear regressions were tested, the models established produced high significant R^2 (Table 1). This could be an advantage for the prediction of the aboveground biomass at various scales.

The best relationships were found when the aboveground biomass was related to the Mean Diameter (MD) (Fig. 1b and 2b).

Table 1: Regression models between the aboveground biomass (Y) and the mean diameter and the bio-volume (X) according to the range size of individuals of *Cenchrus ciliaris* (H: height, MD: mean diameter, R^2: coefficient of determination)

Range size (cm)	X	Regression equation	R^2
H ≤ 10	Bio-volume	$Y = 4.92x^{1.41}$	0.76
	Mean diameter	$Y = 0.005x^{2.56}$	0.79
H > 10	Bio-volume	$Y = 4.68x^{0.9}$	0.73
	Mean diameter	$Y = 0.02x^{2.15}$	0.77
MD ≤ 20	Bio-volume	$Y = 4.79x^{1.46}$	0.71
	Mean diameter	$Y = 0.002x^{3}$	0.79
MD > 20	Bio-volume	$Y = 7.92x^{0.45}$	0.27
	Mean diameter	$Y = 0.01x^{2.18}$	0.32

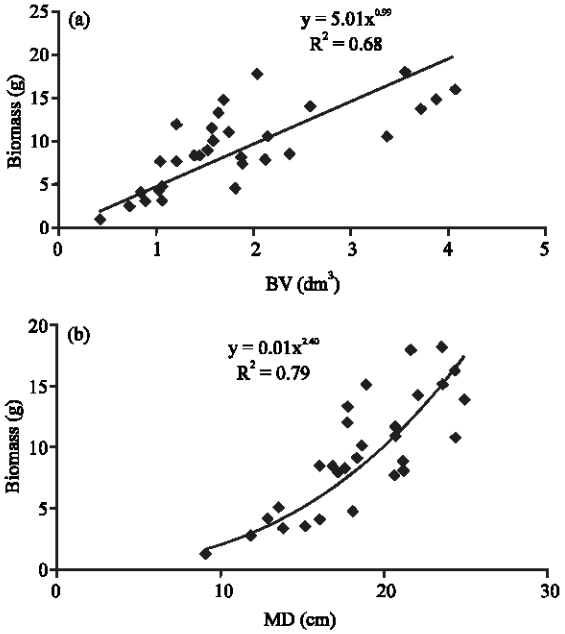

Fig. 1: Relationships between the aboveground biomass production and I) the bio-volume (a) and ii) the mean diameter (b) of *Cenchrus ciliaris*

According to the preceding results, models relative to the biomass evaluation could be established for plant species of the Tunisian arid zone. Applied methods on *Cenchrus ciliaris* showed high significant relationships between different volume parameters and the biomass production. At this level, biomass production could be estimated simply through mathematic equations. This approach was adopted by several authors. Based on bio-volume models, Johnson *et al*. (1988) applied various models of volume to establish the best correlations to estimate the aboveground biomass production. Researches suggested the best choice of the volume model of species (spheroid, elliptic, conic…). For this reason, further investigations should be realised in present case of study to establish suitable and accurate model estimation of the aboveground biomass.

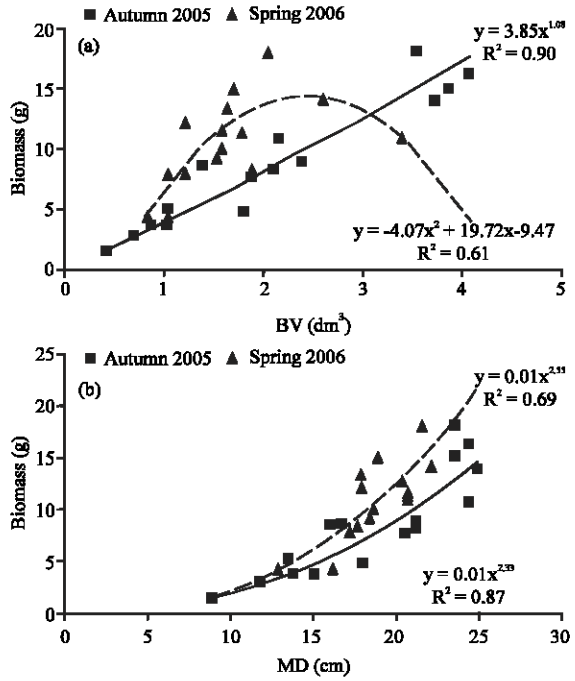

Fig. 2: Relationships between the aboveground biomass production and (a) the bio-volume and (b) the mean diameter of *Cenchrus ciliaris* in autumn and spring seasons

According to results in Table 1, the best correlations fitted polynomial regressions. This could be explained by an irregularity in biomass production. However, low significant relationships were found for individuals having mean diameter more than 20 cm. This could be attributed to the physiological behaviour and the age of individuals. Generally, the increase in plant size is related to plant age as well as microclimate conditions. The trade-off between reproductive and vegetative allocation of resources could also contribute to the irregularity of biomass production (M'seddi *et al*., 2002). More investigations could help understanding the species behaviour in such conditions.

In the present case, it appears that the mean canopy diameter produced the highest coefficients of determination (R^2). This could be explained by the morphologic behaviour of *Cenchrus ciliaris*, which develops in diameter more than in height as many other species (Thomson *et al*., 1998). In field, application of this method could be most practical where the canopy diameters were the easily measured variables. This method is suggested by several authors such as Salis *et al.* (2006). To establish more accurate models for the aboveground biomass production of plant species, various investigations and other statistical studies are required.

CONCLUSIONS

The prediction of the aboveground biomass production of species seems to be of great interest. Such a method is of benefit to the suitable estimation of species productivity. According to all results cited before, it seems the use of the plant bio-volume as a predictor for plant biomass production requires the best choice of the volume model of the species. For this reason, diverse volume models must be tested. The mean diameter appeared more practical and it illustrates the best significant relationships with the plant biomass. At this level, it can be stated that model prediction of species productivity differs according to the size of individuals. The establishment of mathematical models for the prediction of species biomass, at a high significant level, could help evaluate their productivity. This could be useful in estimating the aboveground biomass of species of high range value and even for medicinal and aromatic plants.

REFERENCES

Abdelmoula, K., A. Khaldi and E. Rigolot, 2004. Physical phytomass characterization of three shrubs and livestock rate consumption effect on firewood cutting in Djebel Mansour (Tunisia). Options Méditerranéennes, 62: 175-179.

Ammari, Y., Z. Abdenbi, M. Ksontini, M. Qarrou and N. Rejeb, 1996. How to manage cutting techniques for *Acacia cyanophylla* Lindl. for pastoral purpose in arid zones. Revue des Régions Arides, Special Issue: 327-334.

Auclair, L., 2001. Population and desertification in Tunisia during the XXth century. Régulations Démographiques Environ., 18: 237-245.

Bendali, F., C. Floret, E. Le Floc'h and R. Pontanier, 2001. The dynamics of vegetation and sand mobility in arid regions of Tunisia. J. Arid Environ., 18: 21-32.

Brandeis, T.J., M. Delaney, B.R. Parresol and L. Royer, 2006. Development of equations for predicting Puerto Rican subtropical dry forest biomass and volume. Forest Ecol. Manage., 233: 133-142.

Floret, Ch., E. Le Floc'h and R. Pontanier, 1976. Soils of Tunisia: Desertification sensitivity Map, central and southern Tunisia. Bulletin de la division des sols, 8:1-69.

Häfliger, P., M. Schwarzländer and B. Blossey, 2006. Impact of *Archanara geminipuncta* (Lepidoptera: Noctuidae) on aboveground biomass production of *Phragmites australis*. Biol. Contr., 38: 413-421.

Hughes, H.G., L.W. Varner and L.H. Blankenship, 1987. Estimating shrub production from plant dimensions. J. Range Manage., 40: 367-369.

Johnson, P.S., C.L. Johnson and N.E. West, 1988. Estimation of phytomass for ungrazed crested wheatgrass plants using allometric equations. J. Range Manage., 41: 421-425.

Montès, N., C. Ballini, G. Bonin and J. Faures, 2004. A comparative study of aboveground biomass of three Mediterranean species in a post-fire succession. Acta Oecologica, 25: 1-6.

M'seddi, K., M. Visser, M. Neffati, D. Reheul and M. Chaieb, 2002. Seed and spike traits from remnant populations of *Cenchrus ciliaris* L. in South Tunisia: High distinctiveness, no ecotypes. J. Arid Environ., 50: 309-324.

Nefzaoui, A. and M. Skouri, 2002. Djebel Bou-Hedma Biosphere Reserve in Tunisia: An example of the rehabilitation of degraded drylands. Unesco-Mab Drylands Series, 2: 29-35.

Omer, R.M., A.J. Hester, I.J. Gordon, M.D. Swaine and S.M. Raffique, 2006. Seasonal changes in pasture biomass, production and offtake under the transhumance system in northern Pakistan. J. Arid Environ., 67: 641-660.

Salis, S.M., M.A. Assis, P.P. Mattos and A.C.S. Piao, 2006. Estimating the aboveground biomass and wood volume of savanna woodlands in Brazil's Pantanal wetlands based on allometric correlations. Forest Ecol. Manage., 228: 61-68.

Thomson, E.F., S.N. Mirza and J. Afzal, 1998. Predicting the components of aerial biomass of fourwing saltbush from shrub height and volume. J. Range Manage., 51: 323-325.

Williamson, S.C., J.K. Detling, J.L. Dodd and M.I. Dyer, 1987. Nondestructive estimation of shortgrass aerial biomass. J. Range Manage., 40: 254-256.