International Journal of Botany

ISSN: 1811-9700

International Journal of Botany 4 (1): 109-112, 2008
ISSN 1811-9700

Estimation of Aboveground Biomass of *Artemisia herba-alba* in Tunisian Arid Zone

[1]Idi Abdelkader, [1]Ali Ferchichi and [2]Mohamed Chaieb
[1]Institute of Arid Regions, Medenine, 4119, Tunisia
[2]Department of Eco-Physiology, Faculty of Sciences, Sfax 3052, Tunisia

Abstract: The main objective of this study was to evaluate the biomass production of *Artemisia herba-alba*, a North African plant species. This chamephytic species is well searched for its pastoral and medicinal utility. The technique of clipping was the method used for the aboveground biomass production estimation. Twenty spontaneous individuals of *Artemisia* species were used in this present study. The biomass and the bio-volume parameters of individual plant were estimated from height and diameter measurements. Correlations between the biomass production and these parameters were statistically tested. Results showed a high relationship between the total biomass and the bio-volume (R^2 = 0.63), as well as with the mean diameter (R^2 = 0.85) of the studied individuals. Whereas, linear regressions were found between the annual biomass production (yearly fresh matter) and: i) the bio-volume (R^2 = 0.52) and ii) the mean diameter (R^2 = 0.68) of individuals.

Key words: Aboveground biomass, *Artemisia*, Tunisia, arid zone

INTRODUCTION

Research of mathematical equations to evaluate the biomass production of plant species is very important in rangeland management. Establishing such equations could contribute to fast estimation of the aerial biomass of plant species (Williamson *et al*., 1987; Aboal *et al*., 2005; Salis *et al*., 2006; Xu *et al*., 2006). During last decades, several techniques have been used to assess aboveground biomass production of various plant species. Approaches and parameters considered in these experiments were multiples and diversified. Some authors have reported that the knowledge of the aboveground biomass of plant species could be very efficient in estimating its productivity (Johnson *et al*., 1988; Pilli *et al*., 2006; Arevalo *et al*., 2007). Various approaches have been used to illustrate the efficiency of plant biomass evaluation. However, research involving a non destructive method remained the main objective of recent researches. Several attempts have been achieved in different parts of the world concerning evaluation and prediction of biomass production of plant species (Johnson *et al*., 1988; Montès *et al*., 2004; Xu *et al*., 2006). These researches contributed at establishing a lot of mathematical models which were depending on measured species parameters retained for measurements. For trees, the diameter at breast height (1.3 m above the ground) was commonly used for characterizing their productivities (Sebei *et al*., 2004; Pilli *et al*., 2006). However, crown diameters and plant height were the common measured parameters for characterizing the productivity of shrubs.

Application of different plant volume models was among the techniques which were used to evaluate shrubs and fodder species production (Johnson *et al*., 1988; Bartelink, 1996).

In general, studies carried on grasslands have concerned the natural ecosystem productivity taking account all existing species as a whole entity. However, work on species' production could be of great interest in evaluating their biomass availability (Hughes *et al*., 1987; Montès *et al*., 2004). In fact, the knowledge of the biomass production of plant species could contribute to the improvement and the management of natural ecosystems where spontaneous vegetation remains the basic resource of livestock (Xu *et al*., 2006).

In this study, we aimed to evaluate the aboveground biomass of a chamephyte, *Artemisia herba-alba*, which is of great interest according to its range value and its medicinal utility. Establishment of mathematical models between the aerial biomass and the volume parameters of species could be an efficient method for predicting its productivity. The measure of the bio-volume seemed to be an excellent method which could reveal the availability of aerial biomass of range species. Johnson *et al*. (1988) applied such approach on *Agropyron desertorum* in Tintic Valley, Utah.

MATERIALS AND METHODS

This present study was carried out at the region of Beni Khedache, North West Medenine from southern Tunisia (33° 19' North and 10° 04' East). The study site

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

was located under arid bioclimate. The mean annual precipitations (238.5 mm) were spread on the autumn and winter seasons and could even continue until the spring. Annual precipitations recorded during the study periods (2003 and 2004) were, respectively 228.9 and 344.4 mm (Table 1). These rainfall quantities were essentially spread over the wet seasons (autumn and winter) and even during a large period of the spring (March and April). Vegetation was essentially represented by chamephytic species where *Artemisia herba-alba* was the major dominant shrub. The plant species used in this present study is a chamephytic species: *Artemisia herba-alba*. Such species is well searched by herds (sheep and goats) and have a widely medicinal use. Data were collected by measuring different volume parameters of twenty spontaneous individuals of *Artemisia* species. At this level, the measured parameters were: the height of the species (h) and mean canopy diameter (Md) (which corresponds to the average of the great diameter (d_1) and the small diameter (d_2) maintained perpendicular to each other and measured at the widest part of the tuft). After these measures, each individual was clipped and weighed. Then, we removed the annual fresh matter (leaves and new shoots) which were dried, at 70°C to a constant weight and weighed again. Measurement involved twenty individuals plant which were randomly selected in 2003 and 2004. Firstly, the volume occupied by the aboveground portion of the species was simulated to a spheroid model. This approach was applied by Johnson *et al.* (1988) on wheatgrass (*Agropyron desertorum*) from Tintic Valley, Utah and by

Table 1: Monthly rainfall quantity (mm) registered during the biological years 2002/2003 and 2003/2004

Months	2002/2003	2003/2004
September	7.7	95.1
October	25.0	0.0
November	19.5	25.9
December	5.1	54.8
January	2.7	30.0
February	74.7	0.0
March	40.5	95.5
April	28.7	36.6
May	0.0	5.5
June	0.8	1.0
July	0.8	0.0
August	5.4	0.0
Total rainfall (mm)	228.9	344.4

Thomson *et al.* (1998) on *Atriplex canascens* from Balochistan Province. Volume model attributed to individuals of *Artemisia* was a spheroid [bio-volume = $^4/_3\ \pi\ (Md/_2)^2\ h$]. Different relationships between the volume parameters and (i) the total biomass production (Tp) and (ii) the annual biomass production (Ap), were estimated. Secondly, different linear regression equations were generated between the individual biomass production and the mean diameter and best models were retained.

RESULTS AND DISCUSSION

Concerning the biomass production of the plant species, diverse correlations were tested. The main objective was to establish the best models which could explain, with a high degree of significance, diverse relationships between the aerial biomass production (total and annual production) and the bio-volume of *Artemisia*.

Models summary involving the species biomass production and both the mean diameter and height of individuals were shown in Table 2.

As shown in Table 3, total biomass production (Tp) of individuals appeared well correlated with the bio-volume parameters (h, d_1 and d_2) where mathematical relationships fitted a high degree of significance (R^2 = 0.92). The annual biomass production (Ap) fitted also a high significant relationship (R^2 = 0.70). Linear regressions between plant biomass production (Tp and Ap) and canopy diameters (d_1 and d_2) also fitted high relationships (R^2 was respectively 0.68 and 0.88 for Ap and Tp). Based on these results, it could be possible to estimate the biomass production of this species according to volume parameters measurements (Thomson *et al.*, 1998). However, these models required the measurement of all bio-volume parameters. For this reason, we tried to look for more practical methods which could estimate the biomass production with high accuracy.

Table 2: Principal characteristics of volume parameters and biomass production of *Artemisia*

Parameters	Min.	Max.	Mean	SD
Height (cm)	13.00	27.00	17.40	3.89
Mean canopy diameter (cm)	16.50	29.20	21.56	3.61
Bio-volume (dm^3)	3.71	23.08	9.19	5.23
Annual biomass production (g)	0.42	14.90	5.66	4.96
Total biomass production (g)	1.91	39.57	12.48	8.99

Table 3: Mathematic relationships between the individual biomass production of *Artemisia herba-alba* and of the volume parameters (h: height, d_1 and d_2: great and small diameters, R: Correlation coefficient, R^2: Coefficient of determination, SE: standard error)

Y*	Parameters	α (SE)	β (SE)	δ (SE)	θ (SE)	R	R^2	SE	F-test $_{(95\%)}$
Annual production (g)	h, d_1, d_2	0.61 (0.21)	0.49 (0.31)	-0.26 (0.22)	-14.32 (3.91)	0.83	0.70	2.94	12.68
Total production (g)	h, d_1, d_2	1.38 (0.19)	0.91 (0.28)	-0.61 (0.20)	-28.33 (3.52)	0.96	0.92	2.64	67.89
Annual production (g)	d_1, d_2	0.62 (0.21)	0.32 (0.28)	---	-16.01 (3.69)	0.82	0.68	2.97	17.85
Total production (g)	d_1, d_2	1.41 (0.24)	0.49 (0.31)	---	-32.27 (4.02)	0.94	0.88	3.24	64.45

*:Regression models were: $Y= \alpha\ d_1+\beta\ d_2+\delta\ h+\theta$ and $Y = \alpha\ d_1 + \beta\ d_2+\theta$

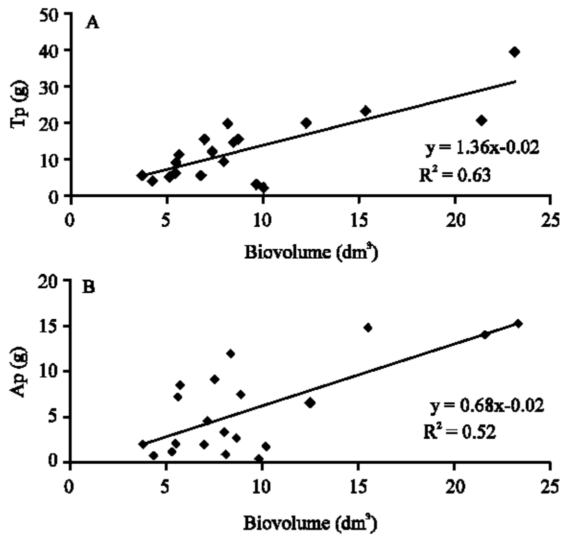

Fig. 1: Correlations between the total production: (A) the annual production and (B) the bio-volume of *Artemisia herba-alba*

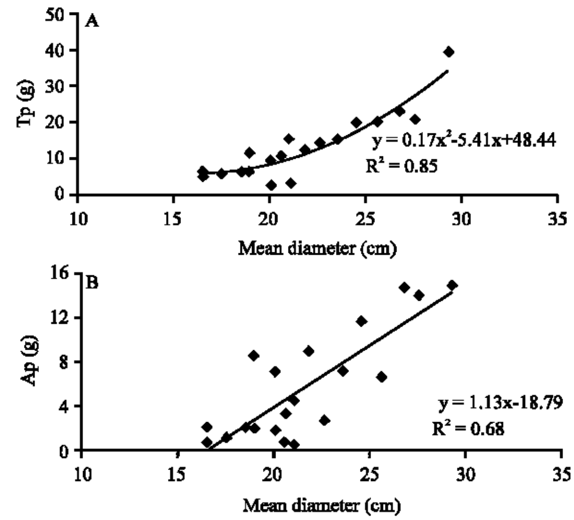

Fig. 2: Correlations between: (A) The total biomass production (Tp) and the mean diameter and (B) The annual biomass production (Ap) and the mean diameter

Relationships between the individual biomass and the bio-volume: Based on the results, various models linking individual biomass production and its bio-volume were tested. As noted before, volume model attributed to individuals of *Artemisia* was a spheroid. The best models were retained in Fig. 1. Concerning the total biomass (Tp), it also appeared well correlated to bio-volume ($R^2 = 0.63$) (Fig. 1A). However, low relationship was found between the annual biomass production and bio-volume. This last model fitted a linear regression with a coefficient of determination of 0.52 (Fig. 1B). Johnson *et al.* (1988) generated some models which differed from a year to another and so suggested that such experiments should be tested every year. The annual production seemed to vary from an individual to another (Fig. 1B) and this could be attributed to some other factors (plant age, grazing and microclimate conditions) (Pilli *et al.*, 2006). As reported by Johnson *et al.* (1988), correlations between the weight and the bio-volume change with the change in mathematical equation and also with the change in the volume model applied for the species. The choice of adequate volume model for the species is so important in establishing best mathematical relationships.

Relationships between the individual biomass and the mean canopy diameter: Correlation between total individual biomass production (Tp) and the mean canopy diameter (Md) followed a parabolic trend. This model has a relatively high degree of significance ($R^2 = 85\%$) (Fig. 2). At the same way, the produced annual fresh matter (foliage and new shoots) (Ap) appeared well correlated to mean diameter (Md) of individuals with a high significant relationship ($R^2 = 0.68$). This could be explained by the contribution of the annual fresh matter to the volume increase of individuals. With the aim to more investigate the species behaviour, it appeared that for small individuals (Md less than 30 cm), annual fresh matter newly formed contributes to the increase in individuals' biomass and dimension. But when the individual mean canopy diameter is over than 30 cm, the biomass did not significantly change. Individual with relatively great dimension (Md over than 30 cm), become non productive. For this reason Le Houerou (1995) and Ammari *et al.* (1996) suggested that individuals species should be deprived of their old biomass to occur again and to be more productive.

CONCLUSIONS

On the light of the obtained results, evaluation of aboveground biomass of *Artemisia* could be illustrated at different degrees of significance. Based on the bio-volume parameters (h, d_1 and d_2), total and annual biomass (Tp and Ap) were estimated with high significant relationships. Correlations between weight and bio-volume require more analysis to select the adequate volume model that could follow, with high precision, high significant relationships. Best relationships were found when the aboveground biomass was correlated to canopy diameters (d_1 and d_2). Evaluation of the aboveground biomass of *Artemisia*, by measuring only the mean canopy diameter, followed high significant relationships. For these reasons, estimation of the aboveground biomass (Ap and Tp) could be calculated by measuring simply the mean diameter of individuals.

It appeared that the modelling of the aboveground biomass of range species was of very important benefit for a best understanding of plant species behaviour in their natural habitat. This simple and non destructive approach permitted to calculate the species production with a quick and efficient method. Its application for range species could help to appreciate the availability of grazing resources. This method could be generalized for a larger application such as for medicinal and aromatic plants.

REFERENCES

Aboal, J.R., J.R. Arevalo and A. Fernandez, 2005. Allometric relationships of different tree species and stand above ground biomass in the Gomera laurel forest (Canary Islands). Flora, 200: 264-274.

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, pp: 327-334.

Arevalo, C.B.M., T.C. Volk, E. Bevilacqua and L. Abrahamson, 2007. Development and validation of aboveground biomass estimations for four Salix clones in central New York. Biomass Bioenergy, 31: 1-12.

Bartelink, H.H., 1996. Allometric relationships on biomass and needle area of Douglas-fir. For. Ecol. Manage., 86: 193-203.

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.

Le Houerou, H.N., 1995. Biogeographic Considerations for the arid steppes of Northern Africa. Sécheresse, 6: 167-181.

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 Oecol., 25: 1-6.

Pilli, R., T. Anfodillo and M. Carrer, 2006. Towards a functional and simplified allometry for estimating forest biomass. For. Ecol. Manage., 237: 583-593.

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

Sebei, H., A. Albouchi, M. Rapp and M.H. El Aouni, 2004. Cork oak biomass productivity in a damaging sequence of cytisus cork oak forest in Kroumirie (Tunisia). Ann. For. Sci., 61: 347-361.

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.

Xu, B.C., P. Gichuki, L. Shan and F.M. Li, 2006. Aboveground biomass production and soil water dynamics of four leguminous forages in semiarid region, Northwest China. South African J. Bot., 72: 507-516.