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Full Length Research Paper

Estimating the production in two shrub species of *Atriplex canescens* and *Haloxylon ammodendron* using some morphological parameters

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In this study, the relationship between production as an independent variable and small diameter, large diameter, height, canopy cover, volume, average diameter height as dependent variables in *Atriplex canescens* and *Haloxylon ammodendron* were evaluated to select the best variables for estimating production in these species. The study site was located in Yousef Abad Neyshabur Rangelands, North East of Iran, Khorasan Razavi Province. Samplings were done random-systematic along Transects with 300 m length and 100 m distance from each other (samplings were done at the first, middle and end of each Transect and in the plots with dimensions of 2 × 4 m^2 in *H. ammodendron* and 4 × 4 m^2 in *A. canescens*). Production was measured by clipping and weighting method. Parameters like small and large diameter, height and canopy cover were also measured. To evaluate the relationship between dependent variables and production as independent variable, the multiple variables regression analysis and stepwise regression were performed. The results showed that volume in *At. canescens* and height in *Ha. ammodendron* was the most effective factors for estimating production.

Key words: Shrub production, cover, stepwise regression, *Atriplex canescens, Haloxylon ammodendron*, Yousef Abad Neyshabur, Arid rangelands.

INTRODUCTION

In addition to problems such as soil erosion, in sensitive arid region ecosystems, providing fodder for livestock is an other concern. For the fact that overgrazing has had irrecoverable impacts on plants in these areas and intensified soil erosion, considering the amount of available forage and grazing capacity is inevitable. For sustainable management of these ecosystems, methods that exactly estimate the production, has been used extensively. Plants that are adaptable to the unfavorable environmental conditions in arid and semi-arid areas belonging to Chenopodiacae family plants, such as: *Atriplex canescens* and *Haloxylon ammodendron* has been cultivated extensively in Iran. In addition to soil conservation these plants also serve as forage supply.

At. canescens is a shrub with 1 to 2 m height and 1 m diameter, dicious or rarely monoecious, with linear or spoon leaves, non Petiole or short Petiole. The fruit is achenes with 4 wings, the time of flowering is at the end of summer and the fruits ripen in autumn. The native vegetation of this species is in arid regions of South America and it has been cultivated in various parts of Iran and the Iran-Turanian region (Asadi, 2001). Among the non-native species, this genus is planted extensively and primarily in dry regions. It is highly resistant to high and low temperatures and has the ability of water absorption, maintenance and storage. Possessing C4 photosynthesis system, it is a real Halophyte. The optimum soil type for its growth is medium texture but it can reside in neutral and alkaline pH of about 8.5. Average annual rainfall requirement ranges from 250 to 300 mm and suitable

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depth of underground water is 3 - 7 m (Moghimi, 2005).

Ha. ammodendron is also a shrub or rarely tree, with about 4 m height, the leaves are very small and flaky shape, sometimes absolutely consumptive, with single flowers. Flowering season is at the beginning of spring and fruits ripen in fall. In steppe of Iran-Turanian region this plant is usually seen on sandy hills and has been cultivated in desert regions (Center, North East, East, South and South East) (Asadi, 2001).

Poormeidani et al. (2005) studied the heritability and phenotype-genotype correlation of traits in different genotypes of *Ha. ammodendron* and concluded that many of important characteristics such as shrub height, diameter of the main trunk, large and small diameter of canopy cover, had positive and significant correlations with each other at both phenotypic and genotypic levels in all the years.

Salar et al. (2005) studied the morphological traits correlation in genotypes of *Ha. ammodendron*, including plant height, canopy cover, collar diameter, plant height from the collar to the first branch, the percentage of surviving (establishment), seeding, contamination with termite, contamination to trips and Psylla. The result of analysis showed that 3 traits including percentage of contamination with termite, plant height from the collar to the first branch and plant height, with the direct effects of -0.744, -0.516 and 0.352 respectively are the most important traits affecting the canopy cover area.

Mokhtari and Mesdaghi (2007), in their research on estimating the production in two bushy species of *Atriplex verrciferum* and *Salsola denderoides* using canopy cover and volume as parameters concluded that in both species canopy cover was suitable variable for estimating the production.

Mohammadi et al. (2008) evaluated the relationship between weight of forage and diameter of canopy cover, height and the multiplying of these two in some range species and found that the most efficient factor to estimate production was multiplying of average diameter of canopy cover and height in growth year.

Fakhimi et al. (2009) studied species of *Artemisia sieberi* and their results showed significant linear relationship between diameter of canopy cover and production in level of 1% probability and r^2 = 77%.

Sanon et al. (2007), in their study on food biomass on some species in West Africa concluded that the diameter of canopy cover was the best parameter to predict total edible biomass production and value of R^2 ranged from 90% in *Guiera senegalensis* to 98% in *Pterocarpus lucens.*

Parthenium incanum is an important shrub which is naturally distributed in Chihuahuan and Sonoran deserts. To evaluate the relationship between above ground surface biomass and four factors (height, the biggest diameter of canopy cover, smallest diameter of canopy cover and volume of canopy cover) regression analysis the r values ranged from0.73 to 0.98 (Villalobos, 2007).

The aim of this study is to estimate the production of *At. canescens* and *Ha. ammodendron* using some morphological parameters. In this way, the accuracy of these methods in estimating the production of these species can be assessed which leads to efficient planning of sustainable use in these rangelands.

MATERIALS AND METHODS

The study was carried out Yousefabad ranges (25 km Southeast of Neyshabur) of Khorasan Razavi Province, North East of Iran. The range has 500 ha of area and between 59º 00' and 59º 05' geographical lengths and 36º 00' up 36º 05' latitude. The average of height is 1200 m above the sea level, the average of long-term rainfall based on the nearest stations (Eshgh Abad- Neyshabur) is 213 mm and the average of temperature is 14.8℃. The average of maximum monthly temperature is 27.6 in July and average minimum temperature is 2℃ in January. The soil of the area is sandy and clay, alkali with relatively good drainage; the structure is amorphous and is poor in organic matter compounds. The minerals composition is made up of gypsum and clacic. Soil depth is 20 – 50 cm and the lower class, in foothills areas is gypsum and clacic. The study site is flat having numerous foothills. The maximum slope is 10% which has East-West direction mostly. The area has seasonal winds starting to blast at second half of spring and continue up to summer, their direction is usually East-West with intensity of about 24 km/h. The wind causes erosion in the area therefore to prevent erosion and sand transport to the villages, *At. canescens* and *Ha. ammodendron* species have been planted. These rangelands are winter pastures which are grazed by the village livestock (Behzad Nia and Bagheri, 1996).

Sampling method

After visiting the area, using 1:50000 topographic maps and GPS, the distribution area of these species was identified. Then, Minimal area in each region was calculated and using equation (1), number of the required plots for sampling was determined. Equation 1:

$$n = \frac{t^2 \left(\frac{s\bar{x}}{\bar{x}}\right)^2}{p^2}$$

Where n = Total plot required, t = t student with the degree of freedom $d_f = n - l$, $s\bar{x}$ =Error of the mean, $\bar{x}$ = Mean, p = Amount of acceptable error = 5%

Samplings were done random-systematic along transects with 300 m length and 100 m distance from each other (in the 2 × 4 m^2 plots for *Ha. ammodendron* along 7 Transects and 4 × 4 m^2 in 11 Transects for *At. canescens*, sampling were inside the plots at the first, middle and end of each Transects) and parameters such as small diameter X_1, large diameter X_2, height X_3 (m) and production (Y) (using clipping and weighing method) kg of per shrubs, was measured. Using these methods, to some extent one can estimate the production of each shrub, but to estimate the production for the unit of area, density of each species in unit of area is needed. To calculate the area of canopy cover, considering the dominant form of this species in the nature, using averages of small and large diameters and getting the ratio of large to small diameter which was slightly more than one, indicating a brief elongation along large

Table 1. Correlation matrix between variables for *At. canescens**and **significant relation in level of 95 and 99% respectively.

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1						
X_1	0.58**	1					
X_2	0.64**	0.8**	1				
X_3	0.63**	0.74**	0.75**	1			
X_4	0.66**	0.95**	0.91**	0.77**	1		
X_5	0.67**	0.91**	0.86**	0.89**	0.97**	1	
X_6	0.67**	0.73**	0.78**	0.9**	0.82**	0.9**	1

diameter, the plane of these two plants was supposed to be oval. So following equation used to calculate the area of canopy cover: Equation 2:

$A= \frac{1}{4} \pi x_1 x_2$

Where X_1 = Small diameter (m), X_2 = Large diameter (m).

To obtain volume of each shrub according to its spatial form, nearest geometric shape, an inverted cone with elliptic plane was assigned for canopy cover then Volume (m^3) of shrubs was calculated (Figure 1). Production was evaluated at the end of the flowering stage and beginning of the seeding stage.

Data analysis

Regression analysis is one of the most common methods used in data analysis which enables the researcher to predict the change of a dependent variable through the changes of independent variables and determine the role of each of them in explaining the dependent variable. Stepwise method is one of multiple regression techniques which compares all the independent variables with greatest impact to the equation. To evaluate the relationship between production as a dependent factor and other independent measured variables, acquired data entered Microsoft Excel, and six independent variables (including Small diameter, Large diameter, Height, Canopy cover, Volume and average of diameter * height) introduced the regression model and multiple variable regression applied as follows:

Equation 3: $Yi=\beta0+\beta1Xi1+\beta2\ Xi2+\beta3Xi3+\beta4Xi4+\beta5Xi5+\beta6Xi6\ +\varepsilon$

Yi = Production (kg), X1= Small diameter (m), X2 = Large diameter (m), X3 = Height (m), X4 = canopy cover (m^2), X5 = volume (m^3), X6=average of Diameter * height (m^2), β = Regression coefficients, ε = Random errors.

Stepwise regression used to determine the most appropriate model and the most effective factor to predict production. Regression analysis was performed using SPSS11 software (Mokhtari and Mesdaghi, 2007).

RESULTS

Atriplex canescens

The results show that all factors studied, have a significant relationship of about 99% with production, Small diameter(X_1) with correlation coefficient of 0.58 has the minimum correlation to production. Volume (X_5) and average of diameter * height (X_6) has the maximum correlation coefficient (0.67). A high correlation coefficient between two factors of canopy cover (X_4) and volume (X_5) was determined (0.97). Small diameter (X_1) has the lowest correlation with average of diameter * height (X_6) and height (X_3), with coefficients of 0.73 and 0.74 respectively (Table 1). In this species, the results of stepwise regression indicates that 0.67% of production changes is explained by plant volume and this variable is the most efficient factor to estimate the production of *At. canescens* (Table 3).

Haloxylon ammodendron

The results indicate that all factors studied have a significant relation with production in level of 99% (except for small diameter (X_1), which has significant relationship at level of 95% with production). Small diameter (X_1) with correlation coefficient of 0.5 at level of 95% has the minimum correlation to production. Height (X_3) and average of diameter * heights (X6) have the maximum correlation (with correlation coefficients of 0.88 and 0.86 at level of 99% respectively) which is significant. Also, there is a high correlation coefficient between the volume (X_5) and average of diameter * height (X_6) and volume (X_5) with canopy cover (X_4) (0.97 and 0.96 respectively). Small diameter (X_1) has the lowest correlation with large diameter (X_2) (0.48 at the level of 95%) (Table 2). The results of stepwise regression indicate that in this species, 0.89% of production changes is explained by plant height and the most efficient variable to estimate the production of *Ha. ammodendron* is height of the shrubs (Table 3). Other results on statistics of studied variables of these two species are shown in Table 4.

DISCUSSION AND CONCLUSION

Estimating the production, using routine methods of range management, especially for shrubs such as *Ha. ammodendron* and *At. canescens* is not only difficult,

Table 2. Correlation matrix between variables for *Ha. Ammodendron*.

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1						
X_1	0.5*	1					
X_2	0.73**	0.48*	1				
X_3	0.88**	0.605**	0.81**	1			
X_4	0.67**	0.85**	0.82**	0.76**	1		
X_5	0.8**	0.72**	0.89**	0.86**	0.96**	1	
X_6	0.86**	0.64**	0.93**	0.94**	0.89**	0.97**	1

*and **significant relation in level of 95 and 99% respectively.

Table 3. Variable remained in the model using stepwise regression.

Species name	Variable entered in first step	Correlation coefficient (r)	Equation of estimated production
At. canescens	X_5	0.675	$Y = 0.108 + 0.839x_5$
Ha. ammodendron	X_3	0.888	$Y = 0.489 -+ 0.601x_3$

Table 4. Criteria measured for the two species *At. canescens* and *Ha. Ammodendron*.

Parameter	Average		Standard deviation	
	At. *canescens*	***Ha.*** *Ammodendron*	***At.*** *canescens*	***Ha.*** *Ammodendron*
Production per base Y (kg)	0.32	0.66	0.28(kg)	0.53(kg)
Small diameter X1 (m)	0.95	1.55	0.37(m)	0.62(m)
Large diameter X2 (m)	1.04	1.84	0.36(m)	0.84(m)
Height X3 (m)	0.79	1.91	0.21(m)	0.78(m)
Canopy cover X4 (m^2)	0.86	2.43	0.57(m^2)	1.43(m^2)
Volume X5 (m^3)	0.25	1.81	0.22(m^3)	1.34(m^3)
average of Diameter * height X6 (m^2)	0.79	0.66	0.42(m^2)	2.23(m^2)

destructive, expensive and time-consuming but also does not have enough accuracy in the same time. Therefore, according to the results, showing a high correlation between the production and volume of species in *At. canescens* and height in *Ha. ammodendron* using geometric forms of plants, we can develop easier methods with acceptable accuracy. In this regard, Mohammadi et al. (2008) concluded that by measuring the physical factors of plants, which are done easily, can estimate dry weight of forage with acceptable error. The advantages are the procedure simplicity and ease of height and diameter measurement and determining the volume of plants. With regards to the effects of environmental factors on plant growth, the relationships obtained for one species in a region, can not be used for the same species in other places. To exclude the time factor from the study all the samplings should be done in the same time and being easy for measuring the factors. Since that plants production is influenced by annual rainfall, long-term researches are necessary to estimate the production during drought and wet years (Mokhtari and Mesdaghi, 2007). As mentioned above, there is a correlation among all studied factors, but plant volume in *At. canescens* and plant height in *Ha. ammodendron* are introduced in the production estimate model. In *At. canescens* vegetative form and foliage seem to have a regular geometric shape with dense volume and there is a little free space between the foliage and the leaves, therefore volume of the plant can largely explain the variations of the production. The fact is shown in Figureure (1 -A). According to the observations, there is more free space between leaves and foliage in *Ha. ammodendron* and the leaves are not very compact, unlike *At. canescens* in which growth begins almost near the ground, the stem of *Ha. ammodendron* is above the ground surface, branches and leaves are at the top of the plant. Shrub height is increased by aging and growth development. Then it remains constant, it may help to explain how the production changes with shrub height in this species. Production measurement of shrub species with direct clipping and weighing methods is difficult and destructive. Therefore, using indirect methods combined with direct ones to estimate production in shrub species is less time-consuming, more economical and safe, providing acceptable estimation of the production. In this regard considering the spatial geometry of different species and their easily measured morphological parameters leads to better estimation. Considering climate changes and its effect on plant growth and production lead to more accurate equation to estimate the production in long-term.

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