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Determining the best statistical models for estimating the forage yield of *Atriplex canescens* (Purush) Nut. in Kahrizak area (Iran)

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Abstract

Determining the grazing capacity of pastures and estimating the yield of pasture plants is one of the most essential cases in planning and managing of pastures. One of the methods for estimating the yield of pasture plants is the use of variables that are associated with the yield, and can be easily measured. In this research, the relationship between forage yield of *Atriplex canescens* in the pastures in Kahrizak area (Iran) with 3 factors of canopy, volume, plant height and the interaction of these three factors were studied through regression analysis. Results showed that two variables including canopy and volume have close relationship to the forage yield and the forage yield can be estimated with good precision and accuracy through these two variables but using the factor of plant height cannot give a precise estimate of the yield. The equations to estimating the forage production of *Atriplex canescens* in studied area are: $Y= 0.331 + 0.474 X_1$ and $Y= 0.355 + 0.325 X_2$.

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Introduction

Atriplex genus belonging to chenopodiaceae family containing about 300 species and often found on saline soils throughout temperate and subtropical areas of the world. Several species of this genus are salt-tolerant shrubs Ullah *et al.*, (2008) and have a great potential for improving saline rangelands because they are highly tolerant to drought and salinity Dehghani *et al.*, (2012), Ullah *et al.*, (2008). One of these species is *Atriplex canescens* (Purush) Nut. or fourwing saltbush that originates from north America and introduced as a source of fodder in plantation Aouissat *et al.*, (2011), Sanderson *et al.*, (1989) and could be provide an important part of the diet for livestock in arid and semi-arid areas Tajali (2005) also the excess of leaves can be harvested, dried, stored and used to feed animals Meneses *et al.*, (2012) that do not have access to this forage during the dry period. In Iran, planting the different species of *Atriplex* especially *Atriplex canescens* is common that often their growth and establishment have been successful Moghimi (2005). On the other hand, because determining the grazing capacity of pasture is one of the most essential cases in planning and managing the pasture, it is required that the yield rate of this species is estimated with a reasonable and clear method Mesdaghi (2010). So far, several methods have been developed to estimate the yield of pasture plants that simplicity of method, adequate accuracy, less time, lower costs, the number of experts and technicians are considered to measure in each method Mesdaghi (2010), Moghadam (1998). One of the methods used to estimate the yield of pasture plants is the use of variables that are associated with the yield and can be easily measured and through which the yield can be easily estimated with good precision and accuracy Mesdaghi (2010). Javadi *et al.*, (2011) showed that the volume of *Atriplex canescens* was the most effective factor for estimating the forage production and has the most correlation with yield. Mohammadi *et al.*, (2008) evaluated the relationship between forage production and canopy and height in some range species and found multiplying of these factors has the most relationship with forage production. Mokhtari *et al.*, (2007) stated canopy cover is a suitable variable for estimating the forage production of *Atriplex verrciferum*. In this paper, the relationship between forage yield of *Atriplex canescens* in the pastures in Kahrizak area (Iran) with 3 factors of canopy, volume, plant height and the interaction of these three factors were studied through regression analysis so that the yield of this plant could be estimated with good precision and accuracy through the best equation obtained.

Materials and methods

The area studied is located 20 km from the south of Tehran. The Latitude of area is 35°, 51′, 59″ in north and its longitude is 51°, 36′, 22″ in east. The average annual rainfall is 268 mm and the average temperature is 17.8 °C. For determining the number of required sample the formula of $N=t^2 (sx/x)^2 / P^2$ was used;

where: N = minimum the number of required samples, T = the number given in T student table, Sx = the mean standard error, X = the average original samples, P = estimated error that is usually equal to the average of 5%.

According to the original samplings and using the above formula, 20 samples were determined but in order to increase the accuracy of sampling 30 samples were selected in a random way and then the following parameters were measured separately for each plant:

plant height in meter

size of measuring the large diameter of plant in meter (W_1)

size of measuring the small diameter of plant in meter (W_2)

Calculation of the total yield of plant forage by clipping method (cutting and weighting).

After measuring above parameters, canopy of each plant were calculated in terms of square meter and its volume was calculated in terms of cubic meter as follows:

Calculation of the plant canopy area

The plant canopy was calculated from the following formula. Given that the plant canopy area is considered as a circle but given that it's not a perfect circle, to calculation of its radius, half of large diameter (W_1) of plant is summed with half of small diameter (W_2) of plant and its average is considered as the radius of the hypothetical circle that shows product of the square of the radius obtained and Pi of the canopy area in terms of square meters.

Plant canopy area = $[(1/2 * w_1 + 1/2 * w_2)/2]^2 * 3.14$

Table 1. Regression equations based on 1 Variable and coefficient correlation (adjusted).

Variable	regression equation	R^2
X_1	$Y = 0.138 + 0.833\, X_1$	89.6%
X_2	$Y = 0.247 + 0.503\, X_2$	92.4%
X_3	$Y = -0.052 + 0.404\, X_3$	67.1%

Table 2. Regression equations based on 2 and 3 Variable and coefficient correlation (adjusted).

Variable	regression equation	R^2
X_1, X_2	$Y = 0.208 + 0.266\, X_1 + 0.35\, X_2$	91.8%
X_1, X_3	$Y = 0.073 + 0.649\, X_1 + 0.130\, X_3$	91.7%
X_2, X_3	$Y = 0.241 + 0.493\, X_2 + 0.010\, X_3$	90.9%
X_1, X_2, X_3	$Y = 0.143 + 0.403\, X_1 + 0.202\, X_2 + 0.073 X_3$	90.4%

Table 3. Regression equations based on interaction of variables and coefficient correlation (adjusted).

Variable	regression equation	R^2
A	$Y = 0.330 + 0.685\, A$	86.0%
B	$Y = 0.304 + 0.321\, B$	86.7%
C	$Y = 0.358 + 0.453\, C$	80.5%

Calculation of the plant volume

After calculating canopy area, the plant volume is obtained from the product of plant height in canopy area in terms of cubic meter: plant volume= plant height * plant canopy area

Calculation of forage yield per plant

For calculating the forage yield of samples clipping method (cutting and weighting) was used that give the most accurate estimates of forage yield. Thus, after sampling and measuring the height, large diameter and small diameter of plant, the forage of each plant was cut separately and weighted after drying in the oven.

Analysis data

In order to determine an appropriate statistical model for estimating forage yield of *Atriplex canescens* in given area, after collecting the data of area using regression models, analysis of the data was done. In the first stage, the super plots of each of the parameters (independent variables) with the forage yield (dependent variable) were formed. The results of this stage showed that the selection of linear model can be suitable among the independent variables with the forage yield in forming the regression equation. So in the next stage, first the regression equation for each of the canopy variables (X_1), plant volume (X_2), plant height (X_3), were calculated with the yield (Y). In order to better study of regression equations, the different aspects of these three variables (including 2 and 3-variable regression equations) were calculated with yield. Since the interaction between mentioned factors (canopy(X_1), plant volume(X_2), plant height(X_3) can show more correlation with yield so in next stage the interaction of these three factors were calculated and then the relation of each of them to the total yield was calculated as follows:

$A = X_1 * X_2$, $B = X_2 * X_3$, $C = X_1 * X_2 * X_3$

Results and discussion

Based on mentioned methodology the regression equations and correlation coefficient of each equation for estimating the forage production of *Artiplex canescens* are as follows:

Table 4. Correlation matrix between variables for estimating the forage production of *Artiplex canescens*.

	Y	X_1	X2	X3	A	B	C
Y	1						
X_1	0.954	1					
X2	0.967	0.966	1				
X3	0.847	0.772	0.871	1			
A	0.938	0.950	0.977	0.769	1		
B	0.941	0.920	0.989	0.907	0.963	1	
C	0.913	0.915	0.966	0.780	0.994	0.968	1

Considering the calculated equation, we can conclude that two variables of canopy and volume have close relationship to the forage yield. The forage yield can be estimated with good precision and accuracy through these two variables but using the factors of plant height can't give a precise estimate of the yield. The interactions of three main factors studied don't have a significant effect in increasing the accuracy of the equations and they can't be used alone to estimate the forage amount and only with use of these factors (canopy and volume) we can estimates the forage production of *Atriplex canescens* with lower costs, less time and adequate accuracy that confirm Javadi *et al.*, (2011), Mohammadi *et al.*, (2008) and Mokhtari *et al.*, (2007). Other advantages of this method are ease to measurement of diameter and height for calculating the cover canopy and volume of bush plants and in general simplicity of procedure (less time and lower costs). Also it should be noticed since many of environmental factors especially annual rainfall could be effect on plant growth in dry or wet years the long term researches are necessary to calculate such statistical models Javadi *et al.*, (2011).Since because of the enormous growth of *Atriplex canescens,* lower parts of plant become woody, it is better that the cultivated plants will be cut from a certain height (or grazing by livestock) so that the amount of correlation between the variables and forage yield doesn't decrease to estimate while the fresh forage will be available for livestock always.

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