International Journal of Herbal Medicine
Available online at www.florajournal.com

E-ISSN: 2321-2187
P-ISSN: 2394-0514
IJHM 2017; 5(1): 14-17
Received: 04-11-2016
Accepted: 05-12-2016

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Estimating medicinal plants production by using non-destructive parameters in North East Rangelands of Iran

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Abstract
Plant biomass is an important factor for determining arid and semi-arid rangelands medicinal plants capacity. The typical methods for measuring biomass are destructive and time-consuming. Thus, they do not allow the development of individual plants to be followed and they require many individuals to be cultivated for repeated measurements. Non-destructive methods do not have these limitations. Green biomass was estimated by using dimensional parameters including Canopy cover, length and wide of diameter and plant height. For each species, 50 flowering stage individual plants of different sizes were randomly selected. The data were analyzed by stepwise regression. The results showed that the dry biomass was significant positive correlations with canopy cover, plant volume, plant height, the length and width of diameters of *Ziziphora clinopodioides* and *Origanum vulgare* medicinal plants. The results of stepwise regression showed that just canopy cover and plant volume (canopy cover * height) were remained in the final model, so that 72% of biomass variations were explained by canopy cover and volume in both species.

Keywords: Medicinal plants biomass, regression, dimensional analysis, clipping and weighing method

1. Introduction
Plant Production is an important factor for determining arid and semi-arid rangelands medicinal plants capacity. It is one of the central attributes in revenue plant ecology and growth analysis. Plant biomass is the key parameter in many allometric relationships [1, 2]. Repetitive measurements of Plant biomass are the fundament for the calculation of net primary production and growth rates, and thus a foundation for quantifying physiological responses of plants to environmental state and their dilation processes [3]. The vertical biomass distribution is noticed to be a principle assignment of competitive strong in plant species [4, 5].

The Clipping and weighing method for biomass determination of individual plants is to measure fresh biomass or the more commonly used oven-dried biomass after clipping [5, 6]. However, measurements of these attribute are slow, expensive, and destructive, and the monitoring of changes in biomass, which is essential to understand variable and allometric in plant species [7].

In most of the researches, indirect methods may be selected over direct methods to obvious biomass because they are non-destructive and usually less time consuming. Indirect methods are graded on extending a relationship between plants weight and an easier to measure trait such as plant cover, height, or rainfall. One of the indirect methods is based on using many different traits depicting plant dimensions to obvious plant biomass that is known as dimensional analysis. Dimensional analysis is carried to confirm the regression relationship, with biomass as the dependent variable [8, 9].

It is evident that a method of measuring production is admissible that has higher accuracy and integrity. Asad pour *et al.* [10] in assessing relationship between dry biomass of *Sphaerocoma aucheri* Boiss (Caryophyllaceae) and its vegetative characteristics showed that 77% biomass variation explained by plant cover percentage. There was similar relationship between these two variables in Patagonian steppe for *Stipa speciosa*, *Stipa humilis* and *Poa ligularis* [11] but the case was different for shrub species. Mokhtari Asl and Mesdaghi [12] investigated relationship between dry biomass on two species *Salsola dendroides* and *Atriplex verrciferum* and stated that in both species canopy cover was appropriate criterion to estimate yield. Arzani *et al.* [13] assessed the relationship between foliage cover and biomass in three different vegetation types including grassland, grass-shrub land and shrub land. They concluded that canopy cover in all species and foliage cover in most of the species had close, rational and acceptable relationship with biomass.

Ziziphora clinopodioides and *Origanum vulgare* belongs to Lamiaceae family and mainly distributed in the Mediterranean mountainous regions of Europe, Asia and Africa. These plants are two of the most important medicinal plants had been used in traditional medicine in natural sites of mountainous areas of Iran [14]. The aim of this study was to expand regression relationships between *Ziziphora clinopodioides* and *Origanum vulgare* biomass and plant dimensional variables to assess the possibility of providing applicable statistical models as indirect method of determining medicinal plants biomass.

2. Materials and methods

2.1. Study area

The research region was located in arid rangelands of Bojnourd city in North East of Iran (North Khorasan Provinces). This area is situated between 37° 23' to 37° 36' North latitude and 57° 7' to 57° 15' East longitudes. The region is approximately 5300 hectares with elevation ranging from 1200 m to 1900 meter. The means of precipitation is 295mm/year that maximum and minimum of precipitation occur in April and July respectively. The mean of annual temperature is 11.28 ℃. The average maximum temperature is 26 ℃ in July and minimum temperature is -6.8 ℃ in January. The climate of this region with using of Emberger method is cold arid. The Embrothermic diagram show that drought period is for five months of year and wet season start in November and continues until May (Figure1). These plants generally prefer sandy loam texture, lime, alkaline pH and non-saline soils.

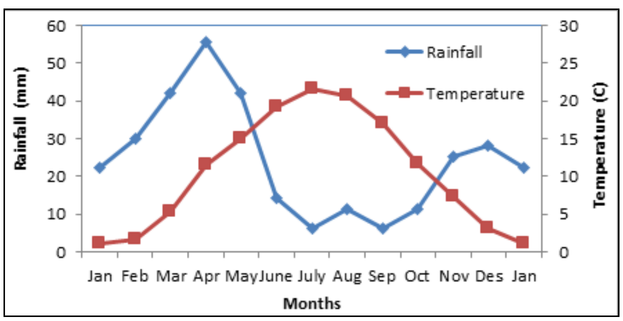

Fig 1: Embrothermic curve in the study region.

2.2. Data analysis

To estimate the yield of *Ziziphora clinopodioides* L. and *Origanum vulgare* L. clipping and weighing method was employed. For each species, 50 flowering stage individual plants of different sizes were randomly selected. Canopy cover, length and wide of diameter and plant height were measured to the nearest centimeter. To determine the amount of current yield, the aerial part of plants were harvested. Any dead material from previous growing seasons was removed. Aerial parts of plants were oven-dried at 70°C for 2 days and weighed.

The correlation coefficient between the measure of production and the dimensional parameters were tested for significance. For biomass evaluation, multiple regression equations were fitted to the data. Biomass (y), the dependent variable, was regressed on height, length and wide of diameter, canopy cover and plant volume as the independent variables. Best subset regression analysis was used to expand predictive equations for plant biomass. Models of regression were assessed using the coefficient of determination (R^2) and Mallows' Cp criteria. The R^2 statistics rate the kindness of apt of a regression model. The Cp gives an index of bent in adapted response introduced by not including an essential independent variable in the model. Proper models have Cp values near to or less than the number of variables in the model [15]. All statistical analyses were performed using software's SPSS 17 and MINITAB 16.

3. Results & Discussion

A statistical summary of measured variables reflected the inherited differences among the two species (Table 1). Based on these accomplished studies, *Origanum vulgare* had the higher height, long diameter, short diameter, canopy cover, plant volume and biomass. The highest coefficients of variations were belonging to volume and production in both species. Large standard deviations were observed in canopy cover and individual plant production in both species. Such high variations are usually to be expected in natural vegetation [16] suggesting a need for more observations. However, all other measured variables have relatively low to moderate variability (Table 1).

Table 1: Statistical summary of measured variables for *Ziziphora clinopodioides* and *Origanum vulgare*.

Traits Name	*Ziziphora clinopodioides*			*Origanum vulgare*		
	Mean	**SD**	**CV**	**Mean**	**SD**	**CV**
Height	29.55	7.12	24.11	50	8.10	16.2
Long Diameter	29.66	5.45	18.38	48.53	17.92	36.93
Short Diameter	22.44	5.41	24.1	32.41	9.66	29.81
Canopy cover	537.28	202.89	37.76	1334.27	789.03	59.14
Canopy cover * Height	16454.47	9075.55	55.15	70129.36	48938.86	69.78
Production	17.11	7.24	42.319	30.14	20.49	67.97

The correlations between attributes are shown in Table 2. Plant biomass were significantly correlated ($p<0.01$) with plant height, long diameter, short diameter, canopy cover and canopy cover * height in both species. The highest correlation between of *Ziziphora clinopodioides* and *Origanum vulgare* species biomass and other variables was related to the canopy cover* height and canopy cover respectively.

Table 2: Pearson correlation between traits for *Ziziphora clinopodioides* and *Origanum vulgare*

Variables	Species	Pearson correlation
Height	*Ziziphora clinopodioides*	.664**
	Origanum vulgare	.694**
Long Diameter	*Ziziphora clinopodioides*	.679**
	Origanum vulgare	.841**
Short Diameter	*Ziziphora clinopodioides*	.673**

	Origanum vulgare	.748**
Canopy Cover	*Ziziphora clinopodioides*	.704**
	Origanum vulgare	.849**
Canopy cover * Height	*Ziziphora clinopodioides*	.853**
	Origanum vulgare	.846**

**= Significant at 1% probability levels

The results of stepwise regression are shown at table 3. Regression equations using canopy cover* height and canopy cover as predictors of plant biomass exhibited the best fit models in these species, so that 72.2% biomass variation can be explained by canopy cover* height and canopy cover in both species.

Table 3: Results of stepwise regression in final models for biomass as dependent variable and other traits as independent variables

Species	Model	Regression Coefficient	T Test
Ziziphora clinopodioides	Intercept	2.445	2.262*
	Canopy cover * Height	0.01	8.78**
Origanum vulgare	Intercept	1.991	0.61ns
	Canopy cover	0.021	8.04**

Ns= not significant and *, **= Significant at 5% and 1% probability levels, respectively

The results of best subset regression indicated that single variable is not generally enough for predicating weight of the two species and multivariate regression will have better explanatory power (Table 4). Despite the relatively high coefficients of determination when either canopy cover or plant volume (canopy cover* height) were used in the predicting model of *Origanum vulgare* biomass (R^2 = 72·1, 71·5, respectively), Cp values were relatively low (-1 and -0·5, respectively). Similarly, a high coefficient of determination was associated with a low Cp value (R^2 = 72·7, Cp = 0·4), by using plant volume (canopy cover* height) as a weight predictor for *Ziziphora clinopodioides* (Table 4). Canopy cover alone explained only 49.6% of the variation in *Ziziphora clinopodioides* biomass with a high Cp value. As it can be seen, between all five variables, plant volume had the highest R^2 and the lowest Cp that is representative of explanatory power of the variable in both species (Table 4). So plant volume can be considered as the best predicator of biomass. Therefore, no single variable would likely be useful in predicting plant biomass in any of the two species.

Table 4: The results of best subset regression for selecting the best predicators

Variables	*Ziziphora clinopodioides*							*Origanum vulgare*						
	Height	Long Diameter	Short Diameter	Canopy cover	Canopy cover * Height	C_P	R^2	Height	Long Diameter	Short Diameter	Canopy cover	Canopy cover * Height	C_P	R^2
1					X	0.4	72.7				X		-1	72.1
1				X		23.6	49.6					X	-0.5	71.5
2				X	X	1.9	73.2		X			X	0.1	73.3
2	X				X	2	73.1				X	X	0.5	72.8
3			X	X	X	3.3	73.9		X		X	X	2	73.4
3	X		X		X	3.7	73.4		X	X		X	2.1	73.4
4		X	X	X	X	4	75.1		X	X	X	X	4	73.4
4	X		X	X	X	5.2	73.9	X	X		X	X	4	73.4
5	X	X	X	X	X	6	75.1	X	X	X	X	X	6	73.4

Biomass is considered as an essential indicator of ecological and management processes in the vegetation. Harvesting is a much slower and more expensive technique. Uresk *et al.* [9] evaluated that clipping *Artemisia tridentata* phytomass was 120 times more expensive than using dimensional analysis. Dimension measurements of biomass are non-destroyer methods and necessitate little educating and time to apply. Therefore dimensional analyses to assign plant weight have recently acquired increasingly regards. Easily deliberate crown diameters and heights were successfully used to evaluate phytomass of *Ziziphora clinopodioides* and *Origanum vulgare* species. The high values of R^2 show that both volume and canopy cover are good predictors of aboveground biomass in these species.

Similar researches have been carried out in rangelands having natural vegetation treatment with several species. Wilson and Tupper [17] stated that canopy cover due to easy and quick measurement can be used as an indicator of biomass. Uresk *et al.* [9] and Thomson *et al.* [18] obtained dimension measurements and biomass data from shrub plants and then established regression equations for estimating aerial biomass from plant volume. Ghasemi Aryan *et al.* [19] introduced plant volume as the best parameters to estimate yield of *Artemisia sieberi*. Kargar *et al.,* [20] states that evaluated relationship among yield to big, small diameter, average canopy diameter and canopy percent of *Artemisia aucheri* using regression. They carried out that small diameter, mean diameter, area and canopy cover percent have close and reasonable relationship but there was not significant relationship between big diameters to yield. Froghbakhash *et al.,* [21] dealt with relationship between yield and canopy cover using regression analysis which their final results are in line with relationship between yield and canopy cover. Application of plant canopy volume model was among the techniques which were used to estimate Alfalfa (*Medicago sativa*) Biomass [22]. With concentrations to stout correlation between the biomass and the canopy cover and volume, this ability in general can help to estimate medicinal plant biomass and capacity as a non-destructive method.

4. Conclusion

Origanum vulgare is widely recognized as a very whirling plant with many curative functions (diaphoretic, carminative, antispasmodic, antiseptic, tonic) being used in traditional medicine systems in many countries and Ziziphora clinopodioides have been used as antiseptic, carminative and sedative agent to treat cold, flu, cough, stomach ache and diarrhea. The results of the correlations between attributes indicated that Plant biomass were significantly correlated ($p<0.01$) with plant height, long diameter, short diameter, canopy cover and volume (canopy cover * height) in both species. The highest correlation between of *Ziziphora clinopodioides* and *Origanum vulgare* species biomass and other variables was related to the canopy cover* height and canopy cover respectively.

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