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Stimating long-term forage production using precipitation pattern in Dehshir Rangelands, Iran

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Abstract

Knowledge on changes of the factors affecting range forage production is the main prerequisite for understanding the processes and optimal management of rangelands. In this research, the effects of precipitation variables, were studied on long-term forage production of somedominant range species, in Dehshirrangelands, Yazd province, during 9 years (2004 to 2012). Regression analysis was used to examine the relationship between annual production and different precipitation pattern. According to the results, rainfall of past year in addition to rainfall of growing season has the greatest impact on forage production in site of Dehshir. Plant with platability class (I) and platability class (III) correlated with previous rainfall, respectively (r^2 = 0.9 & 0.88), andplatability class (II) with growing season rainfall (r^2 = 0.70). Long- term production is estimated at 243.15 (kg/ha).

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Introduction

Our country's rangelands are mainly located in arid and semi-arid regions. Due to the low amount of precipitation and high rate of evapotranspiration, water stress is considered as the most crucial environmental stress for vegetation in this region.

Therefore, the use of indirect methods based on climate data would be useful for anticipating forage yield (Bagestani and Zare, 2007). Several studies have demonstrated the relationship between climatic fluctuation and forage yield (Duncan and Woodmansee, 1975, Pumphery, 1980, Fetcher and Trlica 1980, Hanson *et al.*, 1982, Wight *et al.*, 1984, Smoliak, 1986, George *et al.*, 1989, Hien 2006, Bets *et al.*, 2006, Ehsani *et al.*, 2007 and Mrzaali *et al.*, 2011). Weather variables, especially precipitation in arid and semiarid ecosystems are the principal environmental factors influencing plant growth (George *et al.*, 1989). Composition, function and productivity of rangeland ecosystem are largely driven by yearly fluctuations in primarily precipitation. However, other factors, such as high grazing do have influence on the ecosystem (Fynn and Oonnor 2000, Sullivan and Rohed 2002).

Precipitation pattern has a major influence on forage production on rangeland (Mclean and Smith, 1973).

The establishment of quantitative relationships between weather variables and forage production has been expressed in regression models such as described by Murphy (1970), Shiflet and Dietz (1974), Duncan and Woodmansee (1975), Fetcher and Trlica (1980), Smoliak (1986), Georg *et al.* (1989), Khumalo and Holchek (2005), Andales *et al.* (2006) and Baghestani and Zare, (2007). They explored the relationship between forage production and precipitation and demonstrated a linear equation between forage production and Weather variables.

They suggested that the variations in forage production were more strongly affected by precipitation. George *et al.* (1989) reported that fall and winter precipitation, winter temperature and winter dry period patterns had a strong influence on peak standing crop. Willey *et al.* (1992) found a linear model to estimate forage production from the annual rainfall in Nigeria. Fall and winter precipitation, winter temperature, and winter dry period patterns have a strong influence on peck standing crop. According to the results of the study conducted by Ghaemi (2001), a direct relationship was found between precipitation and forage production while an inverse relationship was reported between temperature and production. Ehsani *et al.* (2007) reported that rainfall indicator in growing season and previous season was a variable playing fundamental role in production. Munkhteseg *et al.* (2007) in review the effects of rainfall and high temperature in rangelands of Mongolia, stated that increasing temperature with decreasing temperature in June were the main factors reducing production in this region rangelands. Mirzaali *et al.* (2011) found forage production more closely related to seasonal period precipitation instead of annual precipitation.

The present investigation focused on the relationships between precipitation pattern and forage production of the four native rangeland species of Ali Abad, Iran. The objective was to improve the predictability of functions relating forage production by including various climatic factors. This paper presents the results of simple correlation, regression and stepwise multiple regression analysis between precipitation pattern and forage production.

Material and methods

Site description

The study was conducted at watershed of Abarkooh-Sirjan (Rrangelands of Dehshir). This region is located 53° 47 E, 31° 11 N in center of Iranin Yazd province. Average altitude of region is 2350 m. Soil texture was silty loamy. The region has recognized as a semi-arid area. Average annual precipitation (January through December) based on 20-year period (1993 to 2012) is 230 mm. Most precipitation occurs as rain in the fall and winter, 70% of annual precipitations occur from October through April, 30% of annual precipitations occur in the growing season

(middle February through late July). Summer is warm and dry, but shower occurs in some years. Mean annual temperature and humidity are 14.4°C and 53%, respectively. The principal forage species include *Artemisia seiberi* ،*Hertiaangutifolia* ،*actucaserriola* ،*Euphorbia connata* ،*Convolvulus fruticosus*

Methods

Precipitation data were available in Dehshir synoptic station, about 9 km far from the Dehshir rangeland. Precipitation factors were collected during the growing season as well as different months of the year. Forage production data for species of plant were collected from 2003 to 2012 and classified to palatability. Sampling was done based on random – systematic method along 4 transects with 200 m length and 100 m distance from each other. Sixty plots ($2m^2$) were sampled and 15 plots protected from grazing by the portable cages, were clipped, air-dried and weighed annually (Arzani and King, 1994).

The portable cages were randomly distributed in large fields that were grazed by goats. Linear regression method was used to investigate the relationships between forage production and precipitation pattern. This model was used in previous studies (Smoliak 1986, George *et al*., 1989, Hien 2006, Baghestani and Zare 2007, Ehsani *et al*., 2007). A total of 17 variables precipitation, used in the analysis. All independent variables and nine years forage yields were subjected to correlation analysis. Significant variables were regressed on forage yields. Stepwise multiple regressions were used to investigate the most effective variable and the most appropriate model to estimated forage yield. To estimate the long –term production, the production value is greater than or, equal to 70 of value of production for many years, as along term production.

Results

List, palatability classes and lif form of plant in Dehshir Rangelands in Table 1.

Table 1. Forage yield of palatability classes(kg/ha) at the Dehshir rangelands.

Name	Family	Palatability class	Lif form
Artemisia seiberi	*Compositeae*	*I*	shrub
Hertiaangustifolia	*Compositeae*	*III*	Herb
Lactucaserriola	*Compositeae*	*III*	Herb
Euphorbia connata	*Ephedraceae*	*III*	Herb
Convolvulus fruticosus	*Convolvulaceae*	*III*	shrub
Launaeacanthodes	*Compositeae*	*III*	Herb
Stipabarbata	*Gramineae*	*II*	Herb
Astragalusinchredensis	*Compositeae*	*III*	shrub
Euphorbia connata	*Ephedraceae*	*III*	Herb
Stachysinflata	*Labiateae*	*III*	Herb
Acantholimonheratense	*Plumbaginaceae*	*III*	shrub
Echinopsceratophorus	*Compositeae*	*III*	shrub
Cousiniadeserti	*Compositeae*	*III*	Herb
Cousiniagedrosiaca	*Compositeae*	*III*	Herb
Noaeamacronata	*Chenopodiaceae*	*II*	shrub
Aeluropuslittoralis	*Gramineae*	*II*	Herb
Bromustectorum	*Gramineae*	*II*	Herb
Boissierasquarrosa	*Gramineae*	*III*	Herb

The annual dry weight forage production during study period is shown in Table 2.

Table 2. dry weight forage production during study period.

Year	*Production of platability class (I) (kg/ha)*	*Production of platability class (II) (kg/ha)*	*Production of platability class (III) (kg/ha)*	Total yield (kg/ha)
2004	160	20	130	310
2005	160	5	155	320
2006	100	10	100	210
2007	145	15	100	260
2008	130	5	115	250
2009	120	15	105	240
2010	130	20	100	230
2011	150	15	85	250
2012	120	15	140	275

All precipitation pattern including monthly, annual, and seasonal rainfall as well as previous rainfall; monthly, annual rainfall are presented in Table 3.

Table 3. Minimum (min), maximum (max) and mean precipitation (mm) and standard deviation (sd) at the Aliabad site on study period (2004 to 2012).

Month	Min	Max	Mean	Sd
October	0	0	0	0
November	0	10	3.7	4.9
December	0	52	17	18.2
January	0	48	10.43	14.2
February	0	20	9.17	7.30
March	2	34	6.15	11.27
April	0	33	13.33	19.71
May	0	30	8.98	9.73
June	2	54	6.07	13.87
July	0	26	2.99	8
August	0	2	1	1
September	0	230	0.1000	31
Annual rainfall (From October to December)	32	130	144.4	56.15
Rainy of growing season (March + April+May+June)	0	142	43.5	33.2
Winter rainfall (January+February +March)	0	135	54.7	40.65
Autumn rainfall (October +November + December)	0	62	40.68	33.1
Previous rainfall) Rainy of growing season+ Years ago)	71	220	135	39

The correlations between forage production and precipitation pattern are shown in Tables 4.The results showed that forage production in this region is influenced by rainfall patterns (Tables 4).

Table 4. Simple correlations (r) of forage yield with precipitation.

Month	Production of palatability class (I)	Production of palatability class (II)	Production of palatability class (III)	Total production
October	0.18	0.31	0.23	0.37
November	0.34-	0.42	0.091	0.17
December	0.31-	0.52-	0.36-	0.26-
January	0.41	0.30	0.49	0.37
February	0.47	0.31	0.19	-0.43
March	0.26	0.57	0.43	0.47
April	0.009-	0.154-	0.52-	0.33-
May	0.52	0.41	0.43	0.55
June	0.41	0.44	0.12	0.33
July	0.28-	0.61-	0.32-	0.33-
August	0.14	0.14	0.18	0.214
September	0.14	0.331	0.193	0.16-
Annual rainfall (From October to September)	0.61	0.56	0.54	0.70*
Rainy of growing season (March +April+May +June)	0.48	0.76*	0.51	0.6
Winter rainfall (January+ February+ March)	0.54	0.17-	0.27	0.55
Autumn rainfall (October +November+ December)	0.42-	0.10-	0.32-	0.19-
Previous rainfall (Rainy of growing season +Years ago)	0.88**	0.59	0.70*	0.90**

Total production showed the correlation with annual rainfall and previous precipitation (rainfall of growing season + rainfall of years ago). But there was a stronger correlation between total production and previous precipitation (R=90). Regression equations

and the estimation of total production with mentioned parameters are presented in Table 5.

The Production of platability class (I) was correlated with previous rainfall. The results of simple and multiple regressions showed that previous rainfall could explain 88% of the variations observed in the production of platability class (I). A correlation was found between the production of platability class (II) and rainy of growing season. The regression equations are shown in Table 5.

The production of platability class (III) had a stronger correlation with the previous season's rainfall. Results equations are shown in Table 5. Stepwise regression showed that previous rainfall could explain about 70% of changes in production of these species (Table 5).

Table 5. Regression of forage yield (Y,kg^{-1}) on precipitation (mm) at Aliabad site.

	Regression equation	r^2	P
Total forage yield(Y, kg^{-1})	$Y=0.304\ P_{annual}$ +205.647	0.7	0.023
	$92.45 \div Y=0.307\ P_{previous}$	0.9	0.00
	+183.577 $Y=0.576$ $P_{previous}$	0.80	0.005
Palatability class (I) (Y, kg^{-1})	$254.45 \div Y=0.268$ $P_{previous}$	0.8	0.005
Palatability class (II) (Y, kg^{-1})	$Y=0.075\ P_{growing\ season}$+9.53	0.7	0.011
Palatability class (III)(Y, kg^{-1})	$82.55 \div Y=0.148\ P_{previous}$	0.7	0.023

Long- term production is estimated at 243.15 kg/ha. Because for many production, more than 70% of this value (Table6).

Discussion

The result of the study revealed that increasing the length of the precipitation period improved the relationship between precipitation and yield. Precipitation pattern had more strong influence on the variations of annual forage production, and various period of precipitation had different effects on annual yield of species. The various period of precipitation improved the relationship when correlated with forage production (Table4).

Table 6. Stimating long-term forage production using precipitation pattern in Dehshir Rangelands.

Year	Previous rainfall (mm)	Act production (kg/ha)	Estimated production (kg/ha)
1	159		241.16
1999	313.1		288.47
2000	225.7		261.63
2001	78.1		216.32
2002	368.6		305.5
2003	389.5	310	311.9
2004	400	320	315.15
2005	28	210	200.94
2006	300	260	284.45
2007	269	250	274.93
2008	99	240	222.74
2009	165.5	230	243.15
2010	211	250	257.12
2011	206	275	255.59
2012	360	345	302.87

Results of this research showed that rainfall of past year in addition to rainfall of growing season had the greatest impact on forage production in site of Dehshirof Yazd. The reason for a high correlation between plant with platability class (I), platability class (III) such as *Artemisia seiberi*، *Hertia-angutifolia* ،*Lactucaserriola* ،*Euphorbia connata* and total production is that the mentioned species and most species found in the study site were shrub with deep roots. Therefore, not only the rainfall of that same year, but rainfall in the previous year is able to be absorbed by their roots. Abdullahi *et al.* (2010) found that rainfall of previous season had impact on rangeland production. Ehsani *et al.* (2007) reported that rainfall indicator in growing season and previous season had the greatest impact on production. Because winter reduces the temperature and limits the growth of the species; therefore, plants are not

able to use the winter rainfall. Also, results showed that platability class (II) such as *Stipabarbata* had a robust correlation with growing season rainfall. Because roots level of this grass penetrates up to 30 cm of soil depth and can use the amount of water saturated in this depth. Therefore, much more rainfall outside of the growing season had no impact on plant growth. Studies of Abdullahi *et al.* (2010) confirmed the results of this research.

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