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Full Length Article

Precipitation Variability in Agricultural Plain of Moghan, Iran

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ABSTRACT

The present study was accomplished with aim of investigation of precipitation variability in Moghan plain in the north-west of Iran for identifying and analyzing their probably changes directions. Precipitation data series from 1984 to 2000 were analyzed and results were compared with those belong to 1967-1986 period. Annual precipitations for the first and second periods were respectively 299 and 259 mm. The maximum and minimum precipitation occurred in October and July. While, the highest change was for October, where precipitation increased about 3 mm per annum, whereas the lowest change was for July. Therefore, it is recommended that planting date in rainfed lands should be adjusted considering the changing trend of precipitation occurrence. In addition, a monthly and yearly increase was found in days having precipitation more than 5 mm (DP>5). For every five years, increase was as one day in October. While, there were no change for December, January, August, July and March. According to the return period for precipitation occurrence, it is expected for an occurrence as 267 and 319 mm for 1 and 12 years. There was no difference between mean precipitations acquired from two periods of 1967-1986 and 1984-2000. In addition, the annual precipitation was modeled as a function of seasonal precipitation. Finally, drought assessment was made by SIAP index and results showed that Moghan experienced drought in years of 1985, 93, 96 and 98. Accordingly, in 1998 Moghan, Tabriz and Sarab have experienced a drought with high intensity. While in 1993, Moghan plain has experienced a drought with high intensity but it was low or normal condition for Sarab and Tabriz. This is due to difference in mean sea level of Moghan, Tabriz and Sarab.

Key Words: Precipitation; Drought assessment; Climate changes

INTRODUCTION

Climate change is one of the basic challenges to agro-meteorological research. Reduction in precipitation (up to 10%) with increasing air temperature up to 1 to 2°C can decrease the runoff quantities as 40 to 70% (Alizadeh, 1994). Therefore, decrease in rainfall can cause confrontation of wide area of agricultural lands with water deficit, overthrow of many plants species, limitation of extension and quality in civil living, confrontation of environment with serious damages.

Sivakumar (1992) reported that average precipitation considerably changed since 1960 in Niger and were often blow normal quantities. Alizadeh (1993) has derived the maximum intensities for durations from 10 min to 6 h and has investigated probability of distributions of annual maximum series of rainfall durations from 10 to 60 (with increment of 10) min and for 2 to 6 (with increment of 1) h. Furthermore, the mathematical relations of intensity-duration were derived in this study. Ghahraman and Sepaskhah (1994) with computation of the 24 h Probable Maximum Precipitation (PMP) by various statistical methods have presented a new scheme for determination of PMP in southern Iran. Ghayoor and Masoudian (1996) reported that Iran has generally experienced a drought period during 1959 to 1971 and a wet period during 1972 to 1987. Gorbani and Soltani (2002) showed that precipitation annually reduced as 4.3 mm during a 40 years period in Gorgan. Khalili and Bazrafshan (2003) have introduced the standard index of annual precipitation (SIAP) as an effective index for annual drought assessment from meteorological point of view. Furthermore, Ghavidel-Rahimi (2005) has analyzed precipitation for East Azarbaijan, Iran over 43 years and has estimated drought and wet years. According to results, the standardized precipitation index was recognized as a better index in comparison to other indices. It was also found that study area has experienced drought with different classes in all related stations.

The Moghan plain located in the north-west of Iran is one of the important regions for agriculture. Therefore, the changes in precipitation can affect rainfed and irrigated lands production. Therefore, the aim of present study was to investigate precipitation changes in this plain for identifying and analyzing changes directions.

MATERIALS AND METHODS

The study area is Moghan, which located at the north-

west of Iran. Data series were gathered from 1984 to 2000 from Parsabad weather station, Ardebil province, Iran (Iranian Meteorological organization, 2006). The following factors selected for investigation and analysis; (a) annual precipitation (mm), (b) days sum having precipitation more than 10 mm (DP>10), (c) days sum having precipitation more than 5 mm (DP>5) and (d) days sum having precipitation more than 1 mm (DP>1). The variations of factors during months and years were investigated using linear regression. The slope and correlation coefficient, *r*, of the equation Pi= Slope (Year) with a set of data (Year, Pi) determined using the following:

$$\text{Slope} = \frac{n\sum(\text{Year})(\text{Pi}) - \sum\text{Year}\sum\text{Pi}}{n\sum(\text{Year}^2) - (\sum\text{Year})^2} \quad (1)$$

$$r = \frac{n\sum(\text{Year})(\text{Pi}) - \sum\text{Year}\sum\text{Pi}}{\left[n\sum(\text{Year}^2) - (\sum\text{Year})^2\right]\left[n\sum(\text{Pi}^2) - (\sum\text{Pi})^2\right]^{0.5}} \quad (2)$$

Where years were from 1984-2000, which are taken from 1 to 18 and Pi is monthly precipitation from January to December. Pi in Eqs (1) and (2) substitute with DP>10, DP>5 and DP>1 for factors of days sum having precipitation more than 10, 5 and 1 mm, respectively. A comparison was made for data series of 1984-2000 and 1967-1986 periods. An index known as standard index of annual precipitation, SIAP, proposed by Khalili and Bazrafshan (2003) was applied to investigate trend of drought and wet years as:

$$\text{SIAP} = \frac{\text{Pi} - \overline{\text{P}}}{\text{SD}} = \frac{\text{Pi} - \overline{\text{P}}}{\left[\frac{\sum(\text{Pi} - \overline{\text{P}})^2}{n-1}\right]^{0.5}} = \frac{n\text{Pi} - \sum\text{Pi}}{n\left[\frac{n\sum\text{Pi}^2 - (\sum\text{Pi})^2}{n(n-1)}\right]^{0.5}} \quad (3)$$

Where Pi and $\overline{\text{P}}$ are precipitation in *i*th year and mean precipitation during study period, respectively; and SD is standard deviation for precipitation series. The drought classes are presented in Table I (Khalili & Bazrafshan, 2003).

RESULTS AND DISCUSSION

Precipitation variation analysis. The mean precipitation for months and coefficient of variation for monthly precipitation are given in Figs. 1 and 2. Precipitation during July and August were similar (=8 mm/month), moreover precipitation in April, September and November was also same (=25 mm/month) and June, February and December precipitation was also identical (=19.5 mm) with each other. Precipitation in May and October (=36 mm) was also similar (Fig. 1).

The mean and coefficient of variation (CV) for annual precipitation were respectively as 259 mm and 19.2% (Fig. 3). The coefficient of variation for precipitation in January,

Table I. The drought classes based on SIAP

Drought classes	SIAP
Normal	0.25 to -0.25
Low intensity	-0.25 to -0.52
Medium intensity	-0.52 to -0.84
High intensity	-0.84 to -1.28
Very high intensity	<-1.28

Fig. 1. Mean precipitation (mm) with standard deviation for months. Verticle bars are SE of means

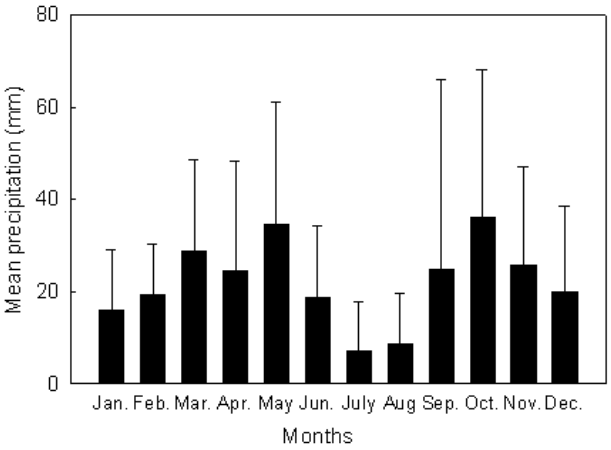
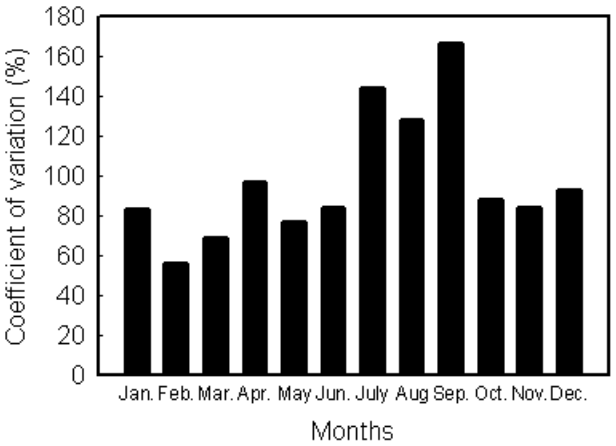


Fig. 2. Coefficient of variation (%) of precipitation for months



June, October, November and December are nearly identical (CV=80%). While, for July and August were high and varied from 130 to 140%. The highest (CV=170%) was for September.

Maximum monthly precipitation occurred in October as 36.3 mm with CV=88% (Fig. 2). The share of October precipitation was 15% of annual precipitation (Fig. 3). Minimum precipitation occurred in July as 7.3 mm with CV=140% (Fig. 2) with the share of 3% of annual precipitation (Fig. 3). Also, for January and March averaged, respectively as 16 and 29 mm.

The probably variations of precipitation during months and years were investigated using linear regression. Results

Table II. Monthly variation of precipitation for Moghan climate condition

Months	Precipitation		DP>1[a]		DP>5[b]		DP>10[c]	
	Slope	r	slope	r	slope	r	slope	r
January	1.556	0.404*	0.348	0.62*	0.061	0.196ns	0.000	0.000ns
February	1.717	0.945**	0.406	0.91**	0.107	0.498*	0.027	0.378ns
March	2.749	0.563*	0.418	0.93**	0.189	0.389ns	0.045	0.027ns
April	1.887	0.715**	-0.139	0.33ns	0.115	0.858**	0.050	0.549*
May	2.417	0.937**	0.463	0.93**	0.177	0.999**	0.047	0.763**
June	1.584	0.597*	0.179	0.29ns	0.121	0.490*	0.037	0.460ns
July	0.556	0.444ns	0.076	0.68*	0.029	0.400ns	0.022	0.334ns
August	0.706	0.426ns	0.102	0.56*	0.037	0.400ns	0.015	0.417ns
September	2.316	0.283ns	0.188	0.41ns	0.128	0.338ns	0.079	0.320ns
October	2.949	0.646*	0.412	0.89**	0.212	0.541*	0.082	0.420ns
November	2.003	0.730**	0.353	0.95**	0.135	0.616*	0.046	0.408ns
December	1.477	0.725**	-0.132	0.26ns	0.081	0.83**	0.027	0.389ns
Annual	0.506	0.023ns	-0.051	0.032ns	-0.142	0.145ns	-0.011	0.333ns

[a] Days sum having precipitation more than 1 mm; [b] Days sum having precipitation more than 5 mm; [c] Days sum having precipitation more than 10 mm

are presented in Table II and annual and monthly variations from 1984 to 2000 are given in Fig. 4 revealing significant changes in precipitation for most months and slight changes for years. The highest change (3 mm/year) was for October (r=0.646 & slope=2.949*). For March, May and November increasing were respectively as 2.7 (r=0.56), 2.4 (r=0.94) and 2 mm (r=0.73) per year. The lowest escalating belonged to July with annual increment of 0.55 mm (r=0.44). Consequently, it seems an increasing change in precipitation during crop growing season, which will be caused an escalating in crop yield. Therefore, it is recommended that planting date in rainfed lands could be revised with taking into consideration of precipitation changes trends.

Return periods for precipitation. The return periods for precipitation occurrence were estimated based on 1984-2000 data. It is expected a precipitation will respectively occur as 267, 293, 303 and 319 mm for 1, 2, 3 and 12 years (Fig. 5).

Also, the monthly mean precipitation from 1967 to 1986 compared with monthly mean from 1984 to 2000 periods by paired t-statistics (t= -1.62). On the other hand, according to the P-value in Table III, there is not a statistically significant difference between the means of precipitations acquired from previously mentioned two periods (Fig. 6) at the 95% confidence level.

But slight differences were seen in January, February, March, April, May, November and December. Finally, annual precipitation for 1967-1986 and 1984-2000 periods, respectively obtained as 299 and 258.9 mm. therefore, annual precipitation had a decrease trend in 1984-2000 relative to 1967-1986 periods.

The annual precipitation was modeled as a function of seasonal precipitation by multiple regressions and the least square procedure as follow:

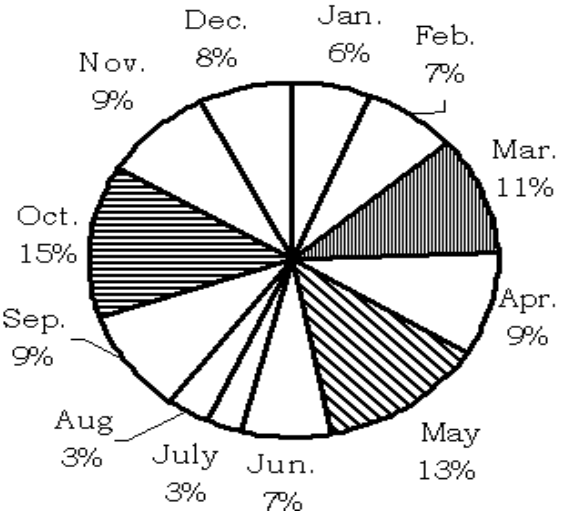
$$\text{Annual precipitation (mm)} = 1.04\text{SP} + 0.85\text{SUP} + 1.04\text{FP} + 1.01\text{WP}$$
$$R2 = 0.995 \qquad (4)$$

Where SP, SUP, FP and WP are respectively precipitation in seasons of spring, summer, fall and winter in mm.

Table III. Analysis of variance for decomposes the variance of the data into two components of between and within periods

Source	df	Mean square	F-ratio	P-value
Between periods	1	84.345	0.80	0.3809
Within periods (months)	22	105.49		
Total	23			

Fig. 3. Percent of monthly precipitation relative to annually ones



The obtained R-squared indicating that 99.5% of variations in annual precipitation can be explained by seasonal precipitations. Fig. 7 demonstrated that predicted values by acquired model and observed data are in very satisfactory agreement.

Drought assessment. To investigate trend of drought and wet years, SIAP index was estimated based on annual, mean and standard deviation of precipitation. Results indicating that a drought with very high intensity occurred for years of 1993, 96 and 98 (Fig. 8). While a drought with high and low

Fig. 4. Measured and predicted values of precipitation for months of year

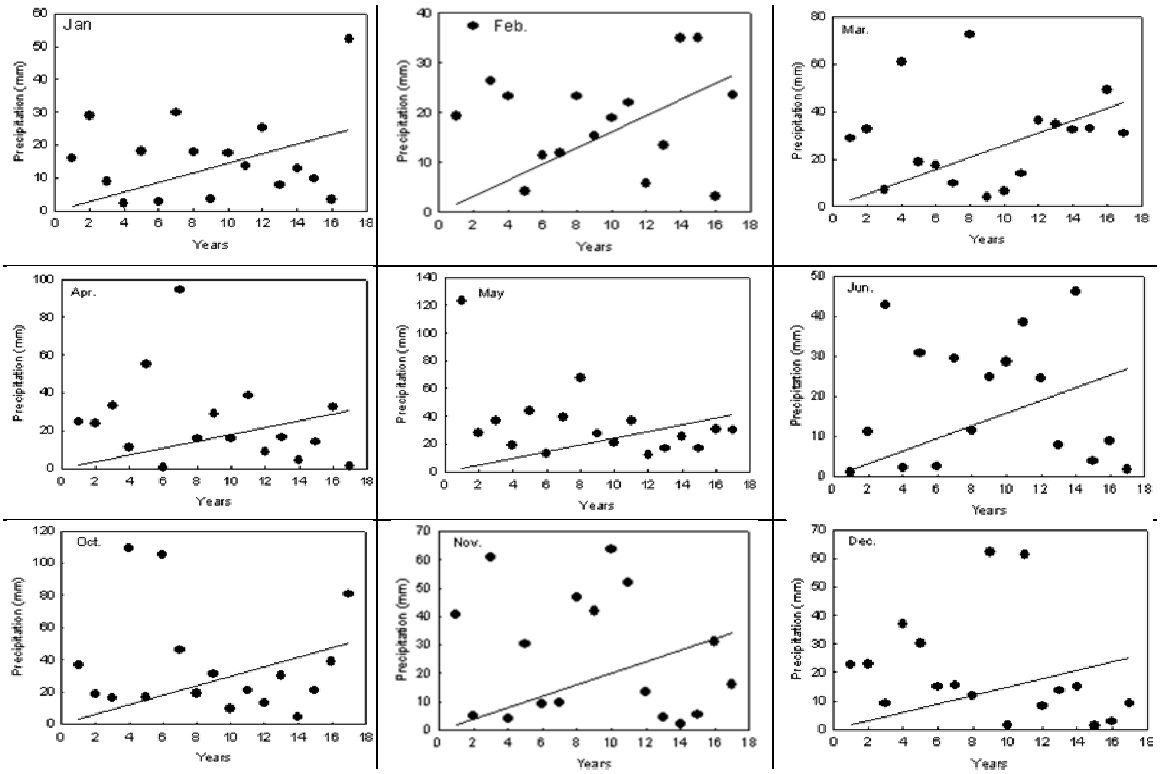


Fig. 5. Annual precipitations versus return periods estimated based on 1984-2000 data

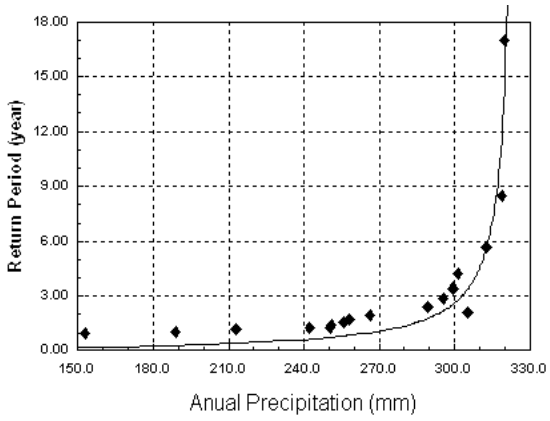
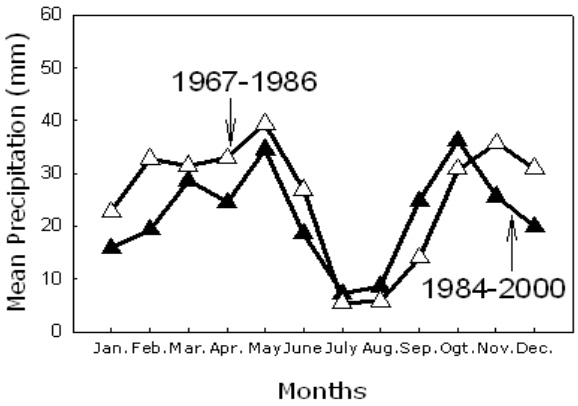


Fig. 6. Mean precipitation versus months for 1967-1986 and 1984-2000 periods



intensity were respectively occurred for 1985 and 84. As well, occurred condition for other years from 1984 to 2000 were normal. This finding is not according with that found by Ghayoor and Masoudian (1996) reported that Iran has experienced a wet period during 1972 to 1987.

Recently, Rezaei Banafsheh and Nouri-Ogour Abad (2008) showed that Tabriz plain (1363 m above mean sea level), which located at the north-west of Iran has experienced a drought with high intensity in 1998. While in 1984, 85, 93 and 96 occurred drought had low intensity. Also, Karami and Baiati-Khatibi (2008) found that Sarab (1634 m above mean sea level) in the north-west of Iran has experienced a drought with high intensity in 1996 and 98. While conditions for 1984 and 1993 were normal and for 1985 was drought with relative high intensity. Accordingly, in 1998 Moghan, Tabriz and Sarab have experienced a drought with high intensity. While in 1993, Moghan plain has experienced a drought with high intensity but it was low or normal condition for Sarab and Tabriz. This is due to difference in mean sea level of Moghan, Tabriz and Sarab.

Fig. 7. Predicted annual precipitations versus return periods estimated based on 1984-2000 data

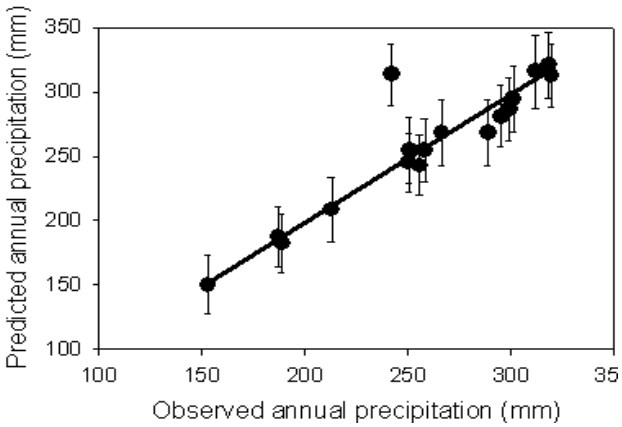
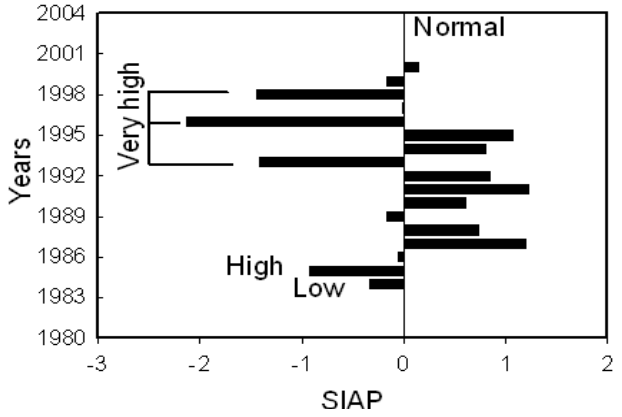


Fig. 8. SIAP index for years



CONCLUSION

Annual precipitations for the 1967-86 and 1984-2000 periods were respectively 299 and 259 mm. The maximum (36.3 mm) and minimum (7.3 mm) precipitation were for October and July. It is expected a precipitation occurrence as 267 and 319 mm for every 1 and 12 years. The annual precipitation can be analyzed via seasonal precipitation. Drought assessment by SIAP index showed that Moghan experienced drought in years of 1985, 93, 96 and 1998 and experienced normal condition for other years. Due to increasingly changes in precipitation during crop growing season, it is recommended that planting date in rainfed lands should be revised with considering of changes trends in precipitation.

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