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Original Article

Rainfed Cereals Response to Interseasonal Rainfall Variability in Semiarid Regions of Khorasan

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Abstract

Rainfed wheat and barley production are low in semiarid regions of northeast of Iran where the rainfall is limited and highly variable. The objective of this study was to investigate wheat and barley grain yields historical trend and its relation to rainfall in six agricultural centers (Mashhad, Birjand, Bojnourd, Sabzevar, Gochan, and Torbat-h) in semiarid regions of northeast of Iran. According to local sowing and harvesting date of rainfed wheat and barley for all locations, growth period of both crops were divided to three periods including early growth period, mid growth period, and end of growth period. Grain yield trend and the association between cumulative rainfall amounts of each time period with long term average yield of each study location was calculated. The results showed that the highest raise in average yield of rainfed wheat and barley obtained in Gochan, Torbat-h, and Birjand where higher annually rainfall occurs compared to other locations. In addition, the end of growth period indicated highest correlation between rainfall amounts and average yield for both crops in all locations. It is concluded that rainfed wheat and barley yield could be increased by changing sowing dates or employing supplement irrigation in semiarid regions of northeast of Iran.

Keywords: barley, grain yield, growth season, wheat

1.Introduction

Wheat (*Triticum aestivum*) is counted among the ”big three” cereal crops, with over 600 million tons annual harvest. The total world harvest in 2007 was about 607 million tons compared with 652 million tons of rice and 785 million tons of maize [11]. Currently, about 95% of the wheat grown worldwide is bread wheat, and most of the remaining 5% being durum wheat [6].

Barley (*Hordeum vulgare* L.) is a supplementary cereal crop after maize, wheat and rice in the world [5]. Barley is one of the important crops in arid and semiarid regions, as it is relatively resistant to drought and salinity and requires less water than wheat and corn.

Furthermore it can be cultivated in areas where irrigation water is less easily obtainable [8]. Approximately 90% area of Iran is considered as arid and semiarid and barley is a major crop in local cropping systems [3]. About 1.7 million hectare of the farming areas in Iran is under barley cultivation which contributes 56 percent of rainfed area [4]. Furthermore, Khorasan province with 9% land under wheat cultivation and 8.3% production carry the first and third ranks across the country, respectively [4]. Rainfed agriculture plays a dominant role in providing food and livelihoods for an increasing world population especially, in arid environments [9]. Rainfall variability has been reported a significant effect on the dry countries economy and food production. There have been reports of rainfall variability and drought associated with food shortages [2]. In the semi-arid regions, it is not the amount of rainfall that is the limiting factor of production but rainfall distribution also plays vital

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role on yield determination [11]. By contrast, in the arid zone, crop water requirement often exceeds total rainfall, causing absolute water scarcity [9]. The main objective of this study was to determine the time periods in wheat and barley growing season which rainfall occurrence and distribution is more influential, in different dry regions of northeast of Iran.

2. Material and method

2.1. Study area

The study area cover the six agricultural centers (Mashhad, Birjand, Bojnourd, Sabzevar, Gochan, and Torbat-h) in northeast of Iran in the province Khorasan that lies between 38°S and 30°N latitude and 55°W and 61°E longitude, a semiarid location with area of 248,000 km^2 (fig. 1). Cereals are the major crops in this region. Cereals (wheat and barley in this study) are mainly produced under rainfed condition with cultivation area of 210,734 ha and 44,561 ha, respectively [3]. These regions situated in north to south of northeast of Iran. Birjand location is driest part of this region, annually rainfall of Birjand is 169 mm and Gochan has the highest annual rainfall of 275 mm. Other locations annual rainfalls are between 197 to 269 mm (fig. 1).

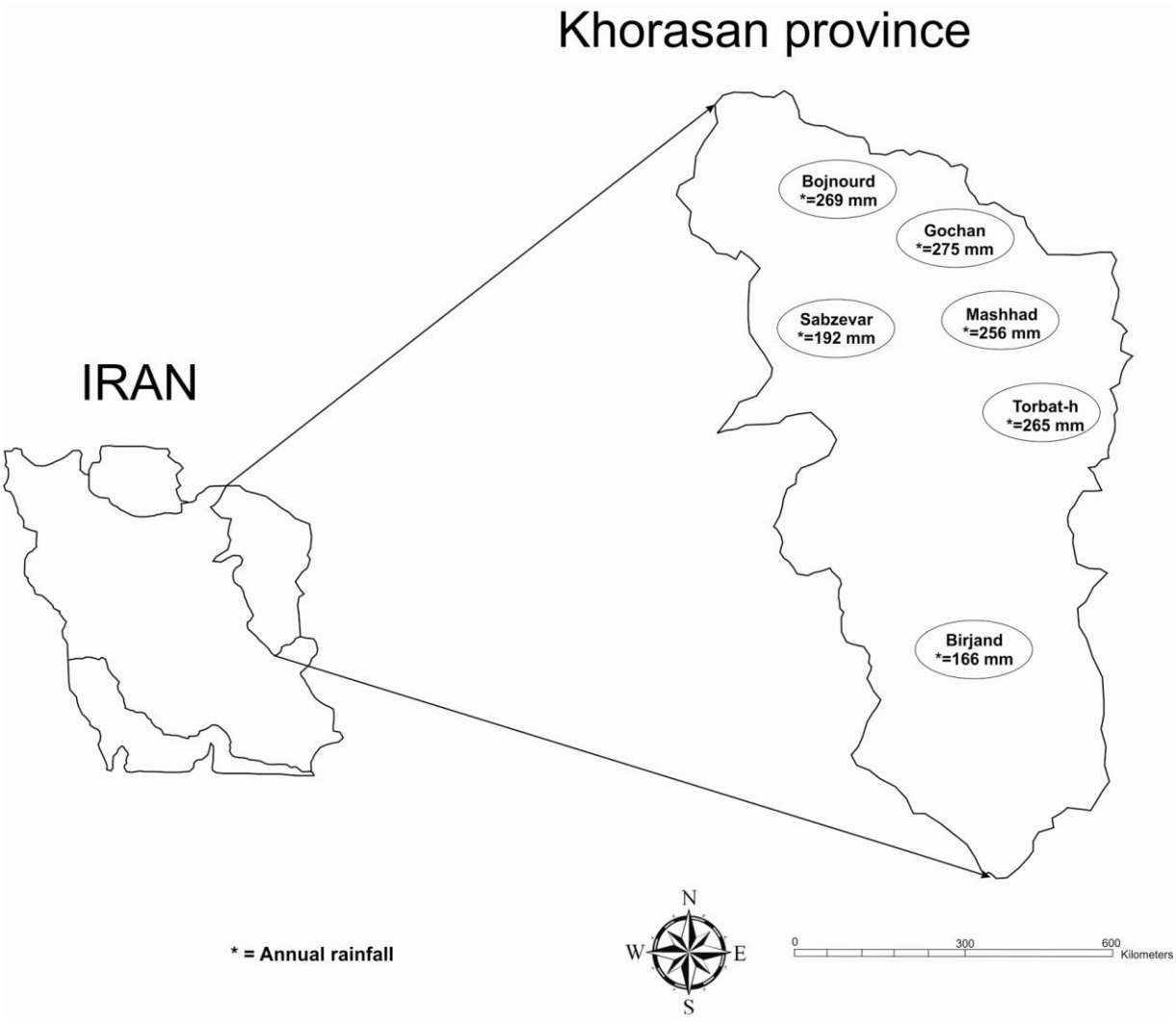

Figure 1. Study area in northeast of Iran

2.2. Data

Wheat and barley are two main rainfed crops in northeast of Iran and the local farmers economy depends on the production of these two crops [3]. The planting date of these two crops is not on a specific date but mainly depends on fall precipitation and their harvest also depends on late spring or the early summer temperature. In general, rainfed wheat and barley usually was cultivated in mid Oct to end of Oct in all study locations. Growth season length

of rainfed wheat and barley are about 160 and 150 days for dry locations (Birjand and Sabzevar), and 190 and 170 days for semi-dry locations (Mashhad, Torbat-h, and Bojnourd). Historical crop yields (1985 - 2005) at the county level for wheat and barley which are produced under rainfed conditions for six locations were obtained from Khorasan Agricultural Research Station. Daily rainfall data from 1985 to 2005 of six different locations across the study region were obtained from meteorological station at each location.

2.3. Data analysis

Growth period of both crops divided into three equal temporal portions as early growth period, mid growth period, and end of growth period for both crops (54 days periods for 160 days growth period, 50 days periods for 150 days growth period, 64 days periods for 190 days growth period, and 57 days periods for 170 days growth period). These growth period durations were based on local knowledge. For each growth period, cumulative daily rainfall values were calculated in all locations (fig. 2). Average wheat and barley yield trend was calculated for study period and correlation between observed average yield and cumulative rainfall values for all growth periods and locations was obtained using Minitab 14 software. Coefficients of correlation (r) were used to indicate the strength of the relationship between rainfall and average yield in each growth period.

3. Results

3.1. Yield trend

Yield trend analysis indicated that annual grain production of rainfed wheat and barley enhanced in all study locations except wheat yield in Sabzevar (R_{wheat} = -0.17) (fig. 3). Highest raise in both crop yields was obtained in Gochan (R_{wheat} = 0.67 and R_{barley} = 0.63) where showed highest average rainfall (fig. 3).

Rainfed wheat yield increase was more than barley in all study locations (fig. 3). Highest significant increase of wheat yield during study period obtained in Gochan location (R_{wheat} = 0.67 and R_{barley} = 0.63) however, Bojnourd location indicated maximum average of wheat and barley yield across study period (fig. 3).

Birjand showed the lowest increase and average yield of wheat and barley yields across study locations (R_{wheat} = 0.01 and R_{barley} = 0.02) (fig. 3).

Torbet-h ranked second for increase in wheat and barley yield. There was low increase in wheat and barley grain yield (R = less than 0.2) in other locations across study years (fig.3).

3.2. Yield-rainfall relationship

3.2.1. Wheat

Due to different rainfall distribution in various times within wheat growth season, there were differences between correlation values of cumulative rainfall and average yield of barley across all study locations (table 1).

Lowest correlation between average grain yield and cumulative rainfall obtained at mid growth season period in all study locations (table. 1). Though, average yield of Bojnourd showed (R = 0.37) relatively high correlation with rainfall on mid growth season. Early growth season specified slight correlation average wheat yield with cumulative rainfall amounts.

However, this correlation was not significant at early growth season (table 1). End of growth period showed strong positive correlation between average yields of wheat with rainfall in all locations (table 1). The results showed that Gochan (R = 0.71) and Sabzevar (R = 0.29) reached highest and lowest correlation values at the end of growth period of wheat across study locations (table 1).

3.2.2. Barley

The results showed that there were sharp differences among different growth periods for correlation values of cumulative rainfall and average yield of barley, in all locations (table 2).

Generally, early growth season rainfall showed lowest correlation and with average grain yield in all study locations. However, average grain yield of some locations such as Birjand (R = 0.18) showed relatively moderate correlation with cumulative rainfall on that part of growth season. In addition, mid growth season indicated negligible correlation values and cumulative rainfall amounts did not show significant impact on average grain yield of barley in this period (table 2).

In contrast, average yield of barley illustrated strong positive correlation with rainfall at the end of growth period in all locations (table 2). Bojnourd (R = 0.42) and Birjand (R = 0.33) indicated highest and lowest correlation values at end of growth period of barley across study locations (table 2).

4. Discussion

Rainfed cereals production in arid and semi-arid regions is extremely depends on the availability of water in the different stages of crop establishment, growth and development [13].

Rainfed wheat and barley yield trend analysis indicated that the increase of wheat yield was more than barley yield during last 23 years in northeast of Iran (fig. 3).

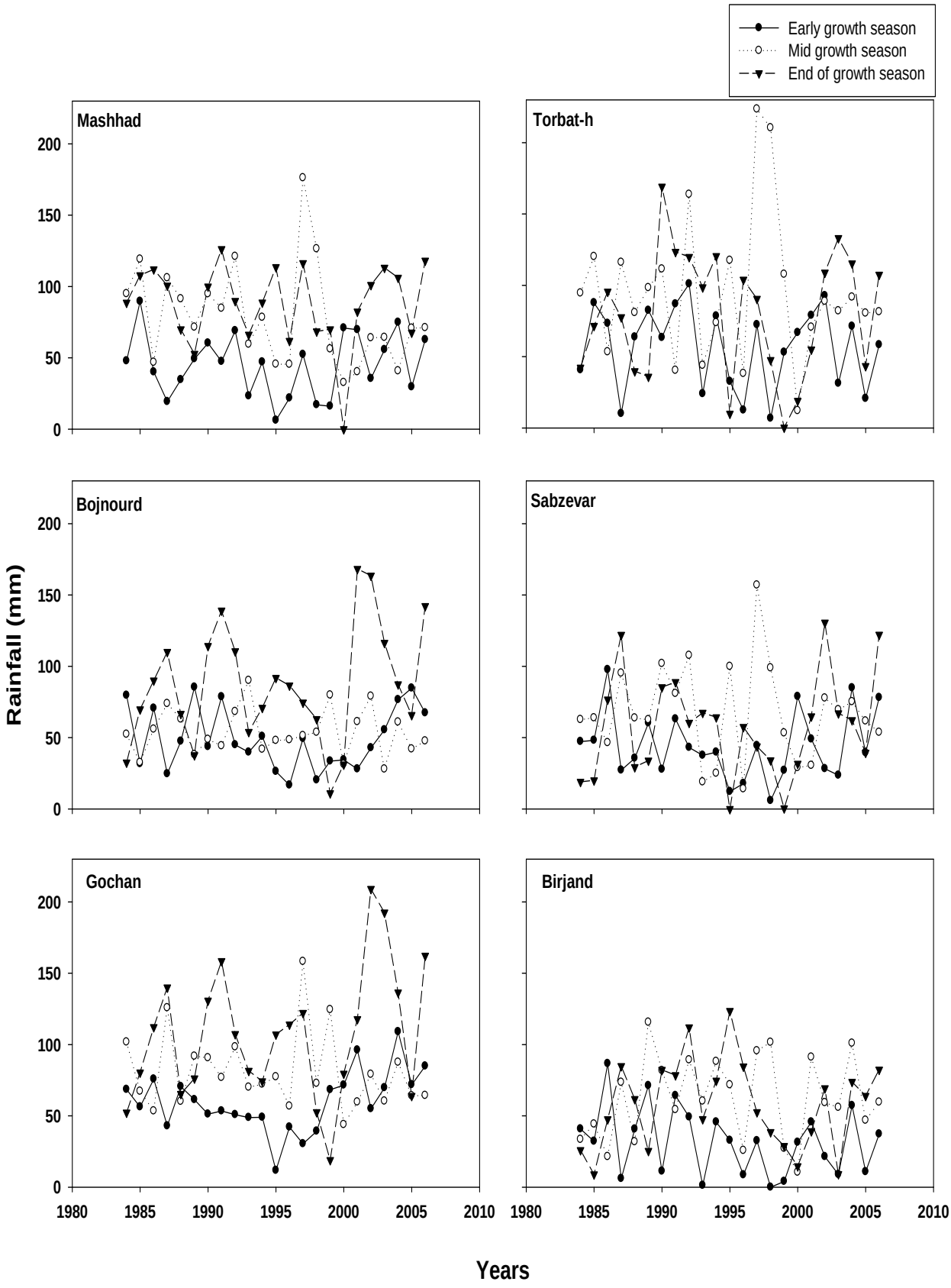

Figure 2. Rainfall trend in different parts of growth season in various locations of northeast of Iran

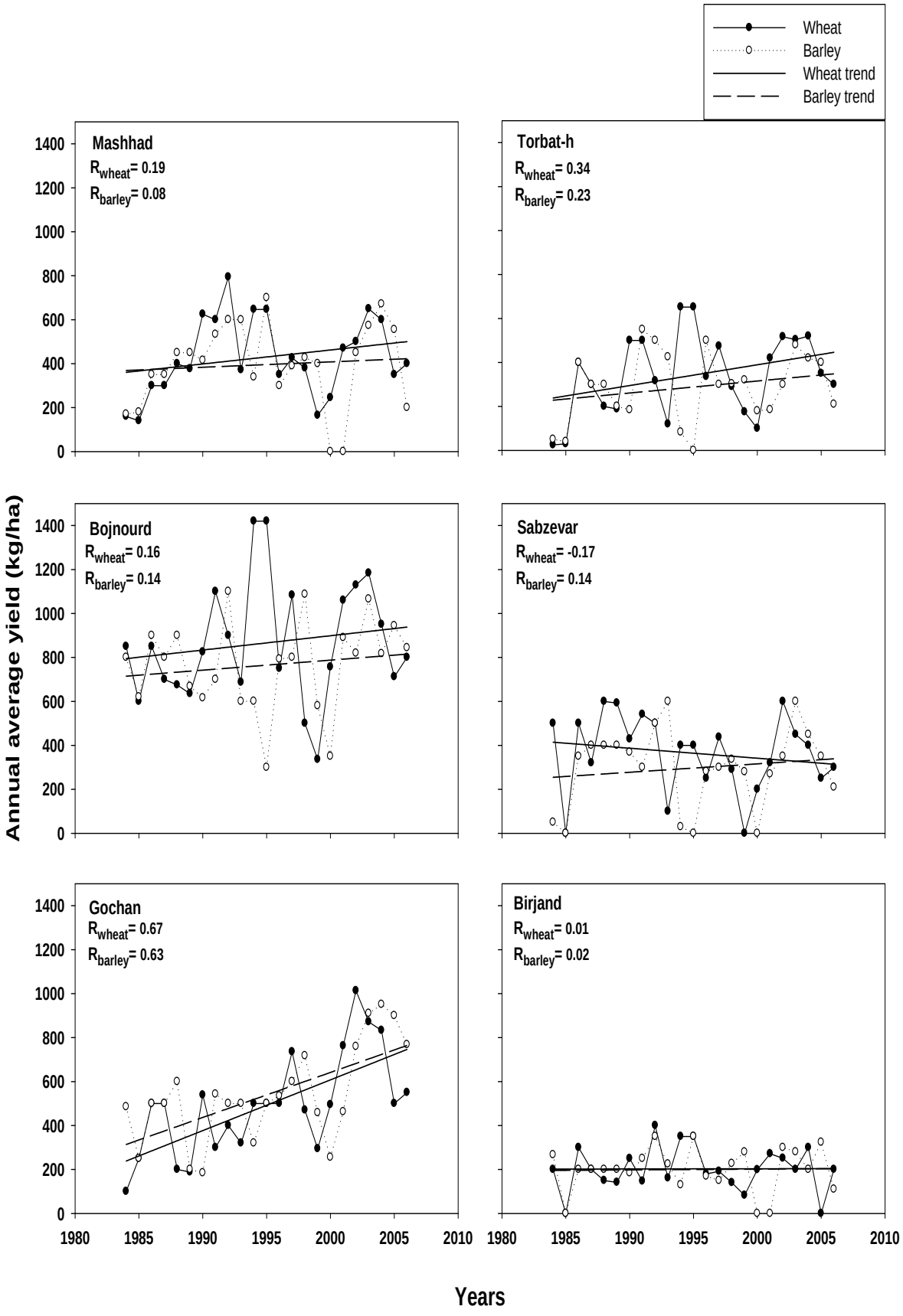

Figure 3. Average rainfed wheat and barley grain yield trend in various locations of northeast of Iran

Table 1. Correlation values (r) between cumulative rainfall amounts in different times within wheat growth season and average grain yield in various locations of northeast of Iran.

Location	Early growth period	Mid growth period	End of growth period
Mashhad	0.11	0.07	0.37
Sabzevar	0.12	0.34	0.29
Torbat-h	0.11	0.09	0.46
Gochan	0.16	-0.02	0.71
Bojnourd	0.37	0.32	0.54
Birjand	0.09	-0.22	0.50

Table 2. Correlation values (r) between cumulative rainfall amounts of different parts of barley growth season and average grain yield in various locations of northeast of Iran.

Location	Early growth period	Mid growth period	End of growth period
Mashhad	-0.37	0.05	0.35
Sabzevar	-0.08	0.14	0.36
Torbat-h	-0.10	-0.12	0.40
Gochan	0.28	-0.05	0.38
Bojnourd	-0.14	0.06	0.42
Birjand	0.18	0.11	0.33

Gochan, Torbat-h and Bojnourd as locations with more rainfall than others showed higher increase of yield than drier locations, however, extreme drought such as drought occurrence in 1998 - 2000 decreased this positive trend [12].

It seems, new cultivars and technologies might have quite less impact on rainfed cereals yield on drier locations such as Birjand in northeast of Iran. Despite, advances in technology, rainfall amount are still the dominant factor in determination of rainfed cereals yield [12]. Evaluation of wheat and barley average grain yield relationship with cumulative rainfall amounts showed that the end of growth period is the most sensitive stage of rainfed crops growth to water.

It seems water supply during anthesis and grain filling period of rainfed cereals is most critical stages for yield determination in semi-arid regions of Iran. Owing to the fact that the water supply from rainfall during this period will affect the survival and fertilization of ears and grains [1]. Agricultural locations with higher grain yield of wheat and barley showed more cumulative rainfall at the end of growth period (fig. 2).

5.Conclusion

Although, cumulative rainfall amounts was indicated slight difference in drier locations in study period.

In conclusion, modification of management practices such as change in sowing date and supplement irrigation practice at the end of growth period could improve average yield of rainfed wheat and barley in northeast of Iran.

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