Response of Dryland Wheat Production and Precipitation Water Productivity to Planting Date

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Abstract: This study was conducted to investigate dryland wheat production and precipitation water productivity response to planting dates of wheat variety of Sabalan at the Dryland Agricultural Research Institute in Maragheh located at the Northwest of Iran. Four planting dates 2 Oct., 12 Oct., 22 Oct. and 1 Nov. treatments were laid out in complete randomized blocks for three years. Results revealed that grain yield affected by planting dates. The planting date of 2 Oct. (with single irrigation at the sowing time) with seasonal precipitation of 504 mm produced the highest yield of 3422 kg ha⁻¹. To describe the relationship between grain yield and received water from precipitation and single irrigation a linear model (r = 0.96) was developed being well agreement between measured and predicted values. Also, results showed that received water productivity averaged 0.46 and ranged from 0.32 to 0.68 kg m⁻². Planting date of 2 Oct. with single irrigation at the sowing time produced the highest water productivity and grain yield. Therefore date of 2 Oct. for planting with supplemental irrigation and date of 12 Oct. in dryland condition can be recommended as the optimum planting date of wheat in Maragheh and similar climate condition.

Key words: Dryland wheat, water productivity, single irrigation

INTRODUCTION

Wheat is a main source of nourishment and the principal food grain in Iran being grown on more than 5.5 million hectares over the country due to its wider adaptability. Dryland wheat is sown in winter months in Iran and has its own specific requirements for precipitation water, temperature and light. In addition, proper sowing time being one of the important factors for achieving optimum yield of wheat in dryland regions. Previous researches showed that optimum sowing gave higher grain yield than later sowing (Rajput and Verma, 1994). While too early sowing produces weak plants with poor root system. Moreover, the temperature being above the optimum during too early sowing leads to irregular germination. Late planting results in poor tillering and more chances of winter injury (Joshi et al., 1992). Also, another research at the Northern Jordan showed that optimum planting time in rainfed areas is from Nov. 14 to Nov. 19. Planting wheat one month earlier and later than the optimum date leads to the loss of 292 and 359 kg ha⁻¹, respectively (Samarah and Al-Issa, 2006). Furthermore, delayed planting may decrease grain yield. Stoppler et al. (1990) reported that sowing of wheat after 10th Nov. reduced yield due to poor emergence, low plant population and lighter grains. Also, McLeod et al. (1992) concluded that wheat yield declined 30 to 40% when seeding delayed from early Sep. to late Oct. in SW Saskatchewan. Witt (1996) found that delayed planting of winter wheat from 1 Oct. to 1 Dec. in Kansas decreased grain yield by 18% per month. Hameed et al. (2003) reported that days to emergence, emergence m⁻², tillers m⁻², days to heading and plant height was significantly affected by different planting dates, seed rates and nitrogen levels for wheat in Pakistan. Recently, Samarah and Al-Issa (2006) concluded that the improvement in grain yield of the early planted barley might be due to the increase in field emergence and the number of plants and spikes per unit area. Also, planting date had no effect on seed quality.

Water Use Efficiency (WUE) is applied to compare the efficiency of use of applied irrigation water and precipitation water productivity (PIWP) for received water by crop from precipitation. Evidently, WUE and PIWP values depend on used water and produced yield. Under deficit condition WUE are higher, on applying irrigation at critical growth stages (Nasseri and Fallahi, 2007; Lal, 1985). Preceding studies have resulted that WUE ranged from 0.54 to 1.9 kg m⁻³ (Nasseri, 1999; Nasseri and Fallahi, 2007). The main objective of the present study is to investigate dryland wheat production and precipitation water productivity response to different planting dates.

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MATERIALS AND METHODS

The field experiments were conducted at the Dryland Agricultural Research Institute (DARI) in Maragheh, Iran (37°, 15' N, 46°, 22' E and 1720 m MSL). The maximum and minimum air temperature averaged as 36.7 and 4.8°C. Dryland wheat variety Sabalan was used for experiments. Field soil classified as clay loam. Soil preparation was made normally for dryland farms. Four planting dates 2 Oct., 12 Oct., 22 Oct., and 1 Nov. treatments were laid out in complete randomized blocks with four replications for three cropping years ended up in 1993. Seeding rate was 90 kg ha⁻¹ with plot size of 5·4 (= 20) m². Nitrogen up to 25 kg ha⁻¹ was applied to the soil in the sowing time and 25 kg ha⁻¹ in the Apr. and P₂O₅ as 50 kg ha⁻¹ was applied before sowing. All treatments received water from precipitation but treatment with date of 2 Oct. received water form precipitation and single irrigation at the sowing time (IW = 15 mm). After maturity plots were harvested for grain in Aug. each cropping year. The collected data during the experiment was analyzed according to RCB design and mean values compared with Least Significant Differences (LSD) test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Precipitation during growth season: Monthly distribution of precipitation during three cropping years was shown in Fig. 1. Occurred precipitation in the first, second and third years on Mar. were 106, 96 and 11 mm and on Apr. were 73, 73 and 93 mm and on May were 57, 107 and 122 mm, respectively.

Cumulative precipitation during growing months for different planting dates and for cropping years was shown in Fig. 2. Cumulative precipitation were respectively for the first, second and third years as 376, 487 and 489 mm for date of 2 Oct., as 371, 478 and 489 mm for date of 12 Oct., as 365, 469 and 489 mm for 22 Oct. and as 352, 441 and 466 mm for date of 1 Nov. In general, cumulative precipitation in the third year is the highest and in the second year is more than in the first year.

Grain yield response: Results for three cropping years showed that planting date effect on grain yield was statistically significant (p<0.05, ANOVA table was not shown). Planting dates of 2 Oct., 12 Oct. and 22 Oct. produced mean yield of 2321, 2150 and 2145 kg ha⁻¹ were classified in similar group and date of 1 Nov. with yield of 1781 kg ha⁻¹ was classified in another group (Table 1).

Fig. 1: Occurred precipitation during growing months for three cropping years

Fig. 2: Cumulative precipitation during growing months for different planting dates and for three cropping years
Table 1: Obtained grain yield from plots cultivated at the different planting dates

<table>
<thead>
<tr>
<th>Planting dates</th>
<th>Grain yield (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Oct.</td>
<td>2304±972a</td>
</tr>
<tr>
<td>12-Oct.</td>
<td>2135±832a</td>
</tr>
<tr>
<td>22-Oct.</td>
<td>2145±934a</td>
</tr>
<tr>
<td>1-Nov.</td>
<td>1791±809b</td>
</tr>
</tbody>
</table>

Values with different letter(s) are significantly different at p<0.05

Table 2: Grain yields acquired from plots cultivated with different planting dates in three cropping years

<table>
<thead>
<tr>
<th>Cropping years</th>
<th>Planting dates</th>
<th>1-Nov</th>
<th>22-Oct</th>
<th>12-Oct</th>
<th>2-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td></td>
<td>1224</td>
<td>1712</td>
<td>1637</td>
<td>1830</td>
</tr>
<tr>
<td>Year 2</td>
<td></td>
<td>1434</td>
<td>1502</td>
<td>1702</td>
<td>1601</td>
</tr>
<tr>
<td>Year 3</td>
<td></td>
<td>2688</td>
<td>3221</td>
<td>3110</td>
<td>3422</td>
</tr>
</tbody>
</table>

Therefore, date of 2 Oct. produced the highest yield. This is originated from suitable condition of climate especially from occurred Seasonal Precipitation (SP) as 466 mm and single irrigation water as 15 mm. Also, Increasing grain yield on date of 2 Oct. relative to the others may be due to increase in gain no per unit area and 1000-grain weight. Grain yield was affected by cropping years, as well. The produced yields in the first and second years averaged, respectively as 1601 and 1575 kg ha⁻¹ and in the third yield averaged as 3109 kg ha⁻¹ (Table 2). This result may be mainly originated from occurred precipitation during cropping years with average of 366, 469 and 483 mm for three successive years, respectively.

The interaction cropping years with planting dates was not statistically significant. The combination factor of planting date of 2 Oct. in the third year (with yield of 3422 kg ha⁻¹, with SP 504 mm + IW 15 mm) and 1 Nov. in the first year (with yield of 1224 kg ha⁻¹, with SP of 352 mm) produced the highest and lowest yield and were respectively classified in the first and fourth classes.

The highest grain yield were respectively 1830 (with SP of 376 mm + IW of 15 mm), 1702 (with SP of 478 mm), 3422 kg ha⁻¹ (with SP of 489 mm + IW of 15 mm) and acquired from planting dates of 2 Oct., 12 Oct. and 2 Oct. for the three consecutive years (Table 2). Results showed that in the two cropping years, planting date of 2 Oct. with single irrigation produced the highest grain yield. Therefore, 2 Oct. with applying single irrigation at the sowing time can be recommended as the optimum date for planting wheat. For dryland condition any irrigation) date of 12 Oct. produced the higher grain yield with average of 2150 kg ha⁻¹ than others (Table 1).

The lowest grain yields were respectively 1224 (with SP of 352 mm), 1434 (with SP of 441 mm) and 2688 (with SP of 466 mm) acquired from planting dates of 1 Nov. (Fig. 3) for the three cropping years. Since in the three cropping years 1 Nov. produced the lowest grain yield. Therefore, this date can not be recommended for planting dryland wheat. Precipitation distribution and its cumulative values caused difference in the highest and lowest grain yields acquired during three years.

A linear model was worked out as follows to describe the relationship between grain yield and received water from precipitation and single irrigation:

\[ r = 0.96 \quad GY = 4.76 \text{RW} \]  

where, GY and RW, respectively denote grain yield (kg ha⁻¹) and received water (mm). So that, variation as 1 cm in precipitation and/or irrigation water caused a change as 48 kg ha⁻¹ in grain yield. Figure 3 shows measured and predicted values by developed model showing a well agreement between measured and predicted values.

Water productivity response: In general, the mean precipitation and single irrigation water productivity (PIWP) of wheat for both of planting date and three experimental years averaged 0.46 kg m⁻³ and ranged from 0.32 to 0.68 kg m⁻³. These values are less than those reported by Nasseri (1999) and Nasseri and Fallahi (2007) for irrigated wheat. Evidently, in dryland condition, wheat may not be received water at critical growth stages and this caused a considerable decrease in yield and consequently in water productivity.

The cropping year effect on PIWP was significant (p<0.01, ANOVA table was not shown). The highest (0.64 kg m⁻³) and lowest (0.33 kg m⁻³) values acquired in the third and second years with seasonal precipitation of 487 and 473 mm, respectively (Table 3). It seems in addition to cumulative precipitation during cropping season, PIWP affected by monthly distribution of precipitation, as well.

The planting date effect on PIWP was statistically insignificant. Moreover, the highest (0.49 kg m⁻³) and lowest (0.42 kg m⁻³) PIWP values respectively produced by date of 2 Oct. and 1 Nov. The differences in PIWP are
Table 3: Precipitation use efficiency versus planting date for three experimental years

<table>
<thead>
<tr>
<th>Cropping years</th>
<th>Planting dates</th>
<th>1-Nov</th>
<th>22-Oct</th>
<th>12-Oct</th>
<th>2-Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td></td>
<td>0.35</td>
<td>0.47</td>
<td>0.44</td>
<td>0.47</td>
</tr>
<tr>
<td>Year 2</td>
<td></td>
<td>0.33</td>
<td>0.32</td>
<td>0.36</td>
<td>0.35</td>
</tr>
<tr>
<td>Year 3</td>
<td></td>
<td>0.61</td>
<td>0.69</td>
<td>0.61</td>
<td>0.68</td>
</tr>
</tbody>
</table>

due to occurred precipitation that averaged 466 (IW - 15 mm) and 420 mm for three cropping years. Note that PIWP from plots cultivated at the 12 Oct. and 22 Oct. were 0.48 kg m\(^{-2}\).

For the first, second and third years, the highest values of PIWP were, respectively 0.47 (with SP of 391 mm+ IW of 15 mm), 0.36 (with SP of 478 mm) and 0.68 kg m\(^{-2}\) (with SP of 504 mm+ IW of 15 mm) and produced by planting date of 2 Oct., 12 Oct. and 2 Oct. (Table 3). The lowest values of PIWP were respectively 0.35 (with SP of 352 mm), 0.32 (with SP of 469 mm) and 0.58 kg m\(^{-2}\) (with SP of 465 mm) and produced by planting date of 1 Nov., 22 Oct. (nearly identical with those produced by date of 1 Nov.) and 2 Oct. (identical with those produced by date of 1 Nov.) for the first, second and third years, respectively (Table 3). Also, PIWP, respectively averaged for three cropping years as 0.43, 0.33 and 0.64 kg m\(^{-2}\). In general, the difference between PIWP is due to seasonal precipitation and in the third year may be originated from precipitation distribution over growth season and other effectual factors of climate on PIWP.

On the other hand for four planning dates of 2 Oct., 12 Oct., 22 Oct. and 1 Nov. PIWP values averaged as 0.49, 0.48, 0.42 and 0.43 kg m\(^{-2}\). Since planting date of 2 Oct. produced the highest PIWP. Therefore, applying single irrigation this date is recommendable as optimum planting date and for dryland condition dates of 12 or 22 Oct. can be recommended as optimum planting dates for dryland wheat for Maragheh climate condition.

CONCLUSION

The effect of planting date on dryland wheat production and precipitation and irrigation water productivity was studied. The results support the following conclusions:

- Applying single irrigation at the sowing time, the highest water productivity and grain yield (3422 kg ha\(^{-1}\)) produced with planting date of 2 Oct. For dryland condition (without any irrigation) date of 12 Oct. is recommended as the optimum date for planting dryland wheat in Maragheh and similar climate condition.
- In according to the developed model for describing grain yield as a function of received water, variation as 1 cm in precipitation and/or irrigation water caused a change as 48 kg ha\(^{-1}\) in grain yield.
- Further studies are required on supplemental irrigation the other growth stage and interaction of nitrogen application and supplemental irrigation on yield and yield components of wheat.

REFERENCES


