Response Of Four Genotypes Of Wheat To Irrigation Schedules

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Abstract. Field study was carried out for two growing seasons (1994 and 1995) on sandy loam soil in the central region of Saudi Arabia (Riyadh area). The aim of study was to examine the effect of three irrigation schedules (50 mm of water in each irrigation at 50, 100 and 150 mm of cumulative pan evaporation, CPE) on yield productivity and water use efficiency (WUE_b) of four wheat genotypes (Yecora Rojo, L.9, L.11 and L. 18). No significance differences were found between the two irrigation schedules (50 and 100 mm) in tillers number, straw and grain yields. However, the irrigation of CPE 100 mm resulted in higher water use efficiency 28.6 and 31.8 kg ha^{-1} mm^{-1} compared to 23.0 and 24.5 kg ha^{-1} mm^{-1} at CPE 50 mm in 1994 and 1995, respectively. Genotypic variations for straw yield and WUE_b were found (at $P = 0.05$) in both growing seasons but not for grain yields. This study has demonstrated the potential usefulness of CPE techique for scheduling irrigation under our arid region compared to the traditional irrigation applied method, which depends basically on time intervals. Also, this study indicated that irrigation schedules at 100 mm CPE (600 mm of seasonal water applied) is more efficient and resulted in higher WUE_b, so a portion of irrigation water can be conserved.

Key Words: Irrigation scheduling; CPE; Yield; WUE_b; Genotypes; Wheat.

Introduction

Saudi Arabia is an arid country with limited water resources. Water is the major limiting factor for crop productivity in many arid and semiarid regions of the world (Boyer, 1982; Hussain and Al-Jaloud, 1995; Ghandorah *et al.*, 1997). Wheat is a major crop of such areas. Although, wheat is considered as being fairly tolerance to drought, its yield is drastically reduced due to low water irrigation (Kiem and Kronstad, 1979; Schonfeld *et al.*, 1988; Kramer and Boyer, 1995; Alderfasi *et al.*, 1999). Agricultural production in Saudi Arabia has been encouraged by Saudi government to reach self-efficiency in many crops production. However, this policy demands much of irrigation water, therefore, it was necessary to develop efficient, reliable and economically irrigation management stratagies for effective use of the existing limited water resources. The traditional method for irrigation scheduling under our local area is basically depending on time intervals either weekly or less or more depends on growing season. However, this

Table 1. Effect of irrigation schedules on tiller/m^2 and straw yield of wheat in 1994 and 1995 growing seasons.

Irrigation Treat. At CPE, mm	Mean water appplied (mm)	Tillers numbers/m^2		Straw yield (t/ha)	
		1994	1995	1994	1995
50	800	506	623	13.5	14.5
100	600	471	610	12.3	14.0
150	400	394	550	10.2	12.5
LSD (0.05)	-	45	50	1.4	1.3

Table 2. Effect of irrigation schedules on grain yield and water use efficiency of wheat in 1994 and 1995 growing seasons.

Irrigation Treat. At CPE, mm	Mean water appplied (mm)	Grain yield (t) ha)		WUE_b (Kg/ha/mm)	
		1994	1995	1994	1995
50	800	5.42	5.50	23.0	24.5
100	600	5.00	4.90	28.6	31.8
150	400	3.57	4.00	34.6	41.0
LSD (0.05)	-	1.41	0.70	5.5	6.9

traditional method is improper irrigation management practices and do waste scarce and expensive water resources. Therefore, a proper irrigation practice should be developed. The irrigation scheduling which determine the amount and frequency of irrigation is governed by many complex factors, but climate plays a major role (Wanjura *et al.*, 1990; Imtiyaz *et al.*, 2000). The meteorological-based scheduling irrigation approach, such as cumulative pan evaporation (CPE) and ratio between irrigation water applied and CPE was used by many researchers due to its simplicity and data availability (Singh, 1987; Pawar *et al.*, 1991; Singh and Mohan, 1994; Singh *et al.*, 1997; Imtiyaz *et al.*, 2000). In Saudi Arabia, evaporation from USWB class A an open pan is being available in many research stations but none of these stations have been started to use it for irrigation scheduling. Due to lack of proper irrigation scheduling techniques, the average yield of wheat and other field crops is low either due to excess or deficit soil moisture regimes. Therefore, the objectives of the present study were to examine the effect of irrigation schedules on yield productivity and water use efficiency of four wheat genotypes and to determine which of these three schedules is more efficient and conservative under our local arid area.

Materials and Methods

The field experiment was conducted during the winter crop-growing season of 1994 and 1995 at the Agricultural Research Station (24° 42' N latitude and 46° 44' E longitude, Alt 600 m), near Riyadh, Saudi

Table 3. Mean genotypic variations for tillers/m^2 and straw yield of wheat tested at three irrigation schedules in 1994 and 1995 growing seasons.

Wheat genotypes	Tillers numbers/m^2		Straw yield (t/ha)	
	1994	1995	1994	1995
L.9	472	571	12.5	13.5
L.11	473	580	13.7	16.0
L.18	400	590	10.5	12.0
Yecora Rojo	482	596	11.0	14.4
LSD (0.05)	65	NS	1.6	1.8

Table 4. Mean genotypic variations for grain yield and water use efficiency of wheat tested at three irrigation schedules in 1994 and 1995 growing seaasons.

Wheat genotypes	Grain yield (t/ha)		WUE_b (kg ha^{-1} mm^{-1})	
	1994	1995	1994	1995
L.9	4.62	4.10	29.5	29.3
L.11	4.61	4.80	32.2	35.0
L.18	4.64	4.81	26.3	28.2
Yecora Rojo	4.83	4.33	27.7	31.2
LSD (0.05)	NS	NS	3.2	3.5

Arabia. The mean monthly maximum, minimum air temperature, relative humidity, pan evaporation, rainfall and solar radiation during the crop growing season (December to April) ranged from 20.5 to 32.5 °C, 8.6 to 16.8 °C, 42.2 - 71.2%, 2.6 - 7.0 mm/day, 10-84.4 mm/month and 10-23.1 MJm^{-2} d^{-1}, respectively. The climate in this part of the country has been classified as arid with cold winters and hot summers. The soil in the experimental site was sandy loam with EC = 1.3 dS m^{-1}. Four genetically divers genotypes were used in this study. The genotypes include one commercial variety (Yecora Rojo) and three advanced lines (L.9, L.11 and L.18) selected from the wheat-breeding program of the plant production department at College of Agriculture. The experiment was laid out in a split-plot design with three replications. The whole plots consisted of three treatments formed by irrigation schedules at cumulative pan evaporation (CPE) of 50, 100 and 150 mm during the entire crop growth period with the depth of 50 mm at each irrigation (this depth of irrigation water is good enough to bring the soil to its field capacity). The CPE was calculated as a sum of daily-recorded evaporation from USWB Class A open Pan. The pan was located at the climate station adjacent to the irrigation experimental field. The irrigation in the respective treatment was applied when CPE reached, 50, 100 and 150 mm. The irrigation during the crop growing season was applied by flooding irrigation system through line pipes provided by meter gages for measuring water applied (50 mm) in each irrigation. The genotypes were randomly assigned as sub-plots and they were sown on December 14 in both

1993 and 1994 in 3.0 by 3.0 m plot with a 20 cm row spacing and seeding rate of 140 kg/ha. A basal dose of 100 kg N per ha was applied uniformly to the experimental plots in three split equal parts at sowing, tillering and one moth later, while 70 kg P_2O_5 per ha was added before seeding. The other cultural practices were carried out according to the conventional production practices followed in Riyadh area. At maturity, the inner four rows of each sub-plot were harvested to estimate yield productivity under different irrigation schedules. Water use efficiency was calculated based on dry biomass production (WUE_b) as kg per hectare per each mm depth seasonal water used during the growing season. Data were statistically analyzed in each growing season for genotype, irrigation and genotype x irrigation interaction using an analysis of variance procedure for a split-plot design (Gomez and Gomez, 1984). Statistical differences among irrigation and genotypic means for study traits and their interaction were tested with Fisher's least significant difference test, LSD (SAS Institute Inc., 1985).

Results and Discussion

In both growing seasons, maximum tillers/m2, straw yield and grain yield of wheat were recorded when irrigation was applied at cumulative pan evaporation (CPE) of 50 and 100 mm (Tables 1 and 2). However, the differences in tillers/m^2, straw yield and grain yield of wheat between CPE of 50 and 100 mm were statistically insignificant in both growing seasons (Tables 1 and 2). Therefore, further increases in irrigation level resulting from CPE of 50 mm did not increase the yield productivity significantly. Irrigation at CPE of 150 mm reduced the yield productivity by reducing tiller/m^2, straw and grain yields. These findings agree with Imtiyaz *et al.*, 1996 and Moustafa *et al.*, 1998 who reported similar results for wheat. Water use efficiency based on biomass production (WUE_b) was increased with decreasing of water applied in both growing seasons (Table 2). This increase in WUE_b due to higher reduction in water applied during the growing season with little change of biomass production (Hussain and AL-Jaloud, 1995; Imtiyaz *et al.*, 2000). The overall results showed that a fixed amount of 50 mm irrigation application at CPE of 100 mm (600 mm of seasonal water applied) resulted in higher yield productivity and improving in WUE_b of wheat grown under our arid conditions. Moustafa *et al.*, (1988) and Alderfasi *et al.* (1999) found similar results for wheat crop grown under similar conditions. These results indicated that irrigation scheduling based on CPE is useful and good strategy for practice under Saudi limited water resources.

Significant variations among genotypes were recorded for straw yield and WUE_b in both years of study (Tables 3 and 4). However, genotypic variation for tillers number per m^2 was observed only on the first growing season (Table 3), while grain yield was similar for all genotypes in both years (Table 4). This might be due to that grain yield trait is less sensitive for genotypic variations and more stable among selected genotypes under this study than other yield traits. The present results are in general agreement with those reported by Ghandorah *et al.*, 1997 and Alderfasi *et al.*, 1999 under the same environment conditions.

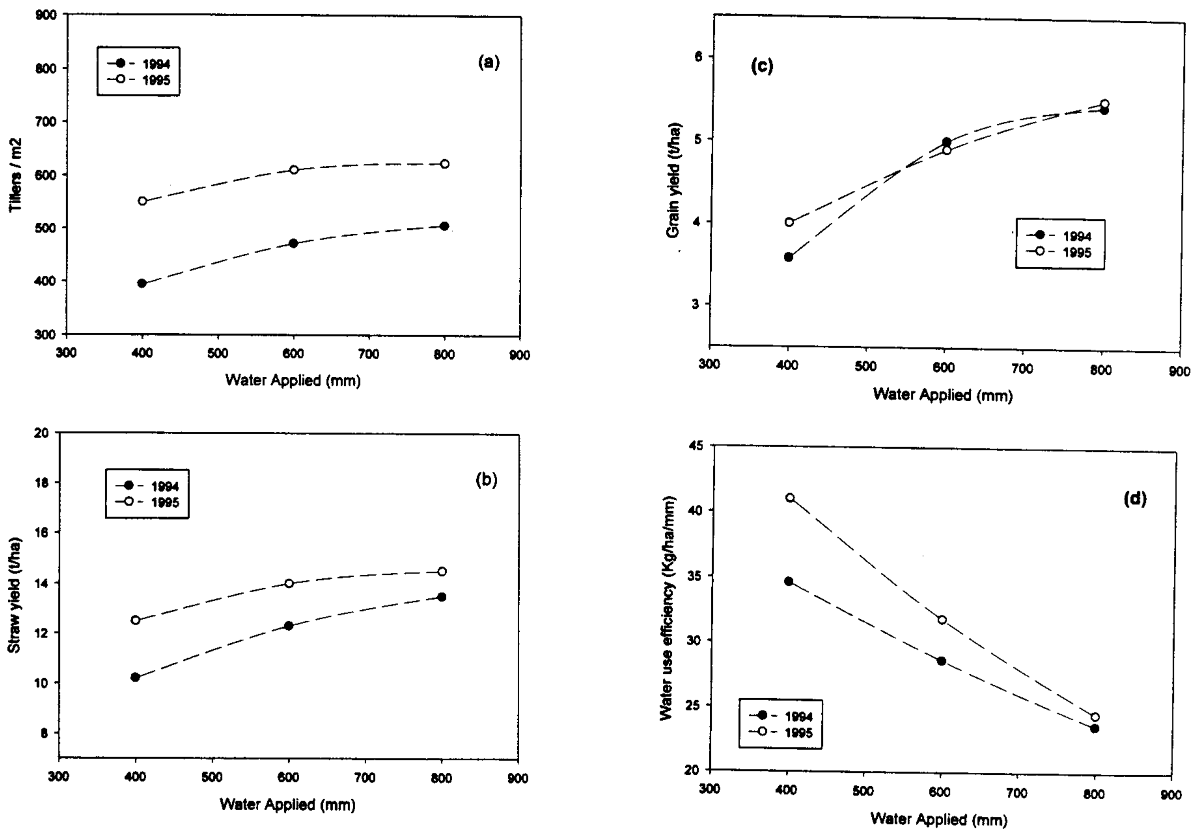

Fig 1. Relationship between water applied and tillers/m^2 (a), straw yield (b), grain yield (c), and water use efficiency (d) of wheat.

The relationship between seasonal water applied and tillers/m^2, straw yield, grain yield and water use efficiency (WUE_b) are shown in Fig. 1. In both years, wheat traits increased with increasing of the seasonal water application except WUE_b that decreased with increasing of water applied. The maximum yield productivity attained at the water applied of 600 to 800 mm and thereafter it tended to decline (Fig. 1). This result means that increase of water applied beyond 600 mm did not yield any significant increase in yield production. Also, any further increase in water applied beyond 800 mm would lead to reduction in yield productivity. Many researchers reported similar relations between seasonal water applied any yield for vegetable and field crops under a wide variety of irrigation systems and regimes (Musick *et al.*, 1976; Singh, 1987; Imtiyaz *et al.*, 1994 and 1996; Stone *et al.*, 1996; Farah *et al.*, 1997; Howell *et al.*, 1997). A negative relationship between seasonal water applied and WUE_b of wheat was reported in both growing seasons (Fig. 1). The efficiency of plant to use water for biomass production increased with decrease in irrigation levels. Tillers/m^2, straw yield and WUE_b were higher in 1995 compared to 1994 growing seasons (Fig. 1), this difference between the two growing seasons probably due to variation in climatic conditions.

Conclusion

This study has demonstrated the potential usefulness of cumulative pan evaporation (CPE) technique for scheduling irrigation under our arid region. This technique is the most common and simple approach for scheduling irrigation for field crops. The experimental results indicated that a fixed depth of 50 mm of irrigation application at CPE of 100 mm (December to April) is optimum for sandy loam soil in order to achieve maximum yield and higher crop water use efficiency with low seasonal irrigation water applied (600 mm) from irrigated wheat grown under our arid climate of Saudi Arabia.

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استجابة أربع تراكيب وراثية من القمح لجدولة الـــري

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تم اجراء دراسة حقلية لمدة موسمين زراعيين ١٩٩٤ و ١٩٩٥م على تربة رملية طميية في منطقة الرياض. كـان الهدف من إجراء التجربة هو اختبار تأثير ثلاث معاملات (جدولة) من الري على إنتاجية وكفاءة الاســتهلاك المــائي فـي محصول القمح. أوضحت هذه الدراسة أن الري عند فقد ٥٠ و ١٠٠ ملم بخر من سطح ماء حر أعطى أعلى إنتاجية إلا أنه لم يلاحظ أي فروقات معنوية بين المعاملتين. أيضا فإن الري عند فقد ١٠٠ ملم بخر أدى إلى زيادة في كفاءة الاستهلاك المـائي مقارنة بالري عند فقد ٥٠ ملم بخر. أظهرت التراكيب الوراثية للقمح فروقات معنوية في كل من محصـول القـش وكفـاءة الاستهلاك المائي إلا أن محصول الحبوب كان متشابها في كل التراكيب الأربعة وذلك خلال الموسمين الزراعيين. لقد أظهرت هذه الدراسة مدى أهمية جدولة الري بإستخدام طريقة البخر التراكمي من سطح ماء حر (CPE) حيث أوضحت نتـائج هـذه التجربة أن الري عند فقد ١٠٠ ملم بخر (٦٠٠ ملم ماء ري مضاف خلال الموسم الواحد) كانت الأفضل في إعطاء إنتاجيـة عالية وزيادة في كفاءة الاستهلاك المائي كما أدت إلى توفير في كمية ماء الري تقدر بحوالي ٢٥? مقارنة بالري عند فقد ٥٠ ملم بخر (٨٠٠ ملم ماء ري مضاف خلال الموسم الواحد). لذلك فإنه بناءً على نتائج هذه التجربة فإني أوصي باستخدام هـذه الطريقة في جدولة الري نظراً لسهولة تطبيقها واعتمادها على الظروف المناخية مما يؤدي إلى التقليل من الاستهلاك المـائي مقارنة بالطريقة التقليدية والتي تعتمد على فترات الري دون الأخذ في الاعتبار الأحوال المناخية.