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The Effect of Water Regimes on Corn and Wheat Production.

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ABSTRACT

Field experiments were conducted over four years from 1985/86 to 1987/88 seasons, two years for each crop, to investigate the effects of three irrigation regimes on the growth of corn and wheat, each crop was tested in two seasons. Each experiment consisted of three different regimes with six replicates: wet, medium and dry where the amount of water applied during the growing season differed in each regime for the two crops. Seven and five centimeters of water were applied irrigation for corn and wheat, respectively. Gypsum blocks were used to assist in determining time of irrigation. For the corn experiment, the results showed no significant differences between treatments and it seems that higher amounts of water are needed for satisfactory yield to be achieved. On the other hand , for wheat experiment, the wet regime gave significantly taller plants and higher grain and biological yields.

Key words: Corn, Wheat, Irrigation regimes, Growth, Yield, Kingdom of Saudi Arabia.

INTRODUCTION

Water deficit is the most limiting factor in the Kingdom of Saudi Arabia. Choosing an alternative crop for wheat, taking in account the water use for the crop, is a great challenge for the farmers. One of the most common field crops grown under irrigation in arid and semi-arid countries is corn (Zea mays) which is generally planted in summer. The soil temperature in the College Experimental Station reached up to 50 C during the experiments, thus the consumptive use of water is quite high. The corn yield is greatly affected by the temperature that prevails during the tasselling stage (Herrero and Johnson, 1980; Hassan et al., 1985). In addition to the effect of temperature, irrigated corn is greatly affected by water deficit in the semi-arid and arid areas (Eck, 1986). Many studies have been reproted on the effect of water stress on corn which was induced during or after pollination. The relationships between the yield and seasonal evapotranspiration has been reported by many researchers (Stewart et al., 1975;1983; Eck,1984 ; English et al.,1985) observed in their study that yields apparently do not decline preciptously under deficit irrigation and thus more research is needed in the area of deficit irrigation. Musick and Dusek (1980) developed functional relationship between yield and seasonal evapotranspiration . From their study and other studies it was found that irrigation of corn should not be practiced in the high evaporative demand area.

Irrigation water used in the Kingdom for wheat ranges from 700 to 1400 mm per season, depending

on the area, irrigation method, planting date and water quality. With the increase in wheat acreage in the last 5-10 years, irrigation water has become a limiting factor for further expansion in wheat production. Therefore reducing irrigation water of wheat without affecting the grain yield should have a priority in studying optimum conditions for wheat production.

This paper reports the results of four seasons field study conducted at Dirab Experimental Station to evaluate the effect of water regimes on corn and wheat yields.

MATERIALS AND METHODS

The study was conducted over four years from 1985 to 1988 seasons in the Experimental Station of College of Agriculture at Dirab. The soil of the site of the experiment is coasre-loamy, mixed (calcareous), hyperthermic Typic Torrifluvents, with 62% sand, 19% silt and 19% clay. pH,EC and SAR of soil used in the experiment were 7.7, 4.9 (ds/m) and 6.8, respectively. Soil pH is for the saturated paste, EC and SAR for the saturation extract. While pH, EC and SAR of irrigation water were 7.8, 5.5 (ds/m) and 7.0, respectively. For the corn experiment, one cultivar (Giza 2) was planted on Feb. 14, 1985 and Feb. 19, 1986. The early planting date was chosen to avoid the high temperature at the time of flowering as recommended by Hassan et al. (1985). The spacing between the rows was 60 cm and between the plants was 20 cm. The plot area was 22.5 m^2. The plants

were irrigated using basin irrigation system. The experiment consisted of three irrigation regimes; wet, medium and dry. Seven centimeters of water were applied at each irrigation, one plot at a time using a hose with a meter attached to it. For the wet irrigation regime , 1190 mm of water were added in 17 irrigations in the first season and 840 mm in 12 irrigations in the second season. In the medium regime, 840 and 560 mm of water were given for first and second seasons, respectively, while the corrosponding amounts for the dry regime were 770 and 420 mm of water. For the wheat experiment, one cultivar (Yecora Rojo) was planted on the first of December 1986 and 12 December 1987. For wheat, 5 cm of water were applied at each irrigation. For the wet treatment, 800 mm of water were added in 16 irrigations in the first season and 850 mm in 17 irrigations in the second season. For the medium regime, 550 mm in 11 irrigations for the first season and 650 mm in 13 irrigations in the second season. While in the dry regime 350 and 450 mm were given for the first and second seasons, respectively (Table 1). In both seasons the seed rate used was 150 kg/ha. All plots in both experiments and in each season, received 250 kg N/ha in form of urea (46%N) in two split applications, 40% of this quantity before sowing and 60% after 40 days from seedling emergence. Potassium (KCl)and phosphorus (superphosphate), at rate of 60 kg K_2O/ha and 200 kg P_2O_5/ha, respectively, were given as a single basal dose.

In each experiment, soil moisture distribution in two plots were measured at sowing and harvest and

in some irrigation cycles the soil moisture distribution were measured also using gravimetric method.

The amount of water applied during the growing seasons are presented in Table 1. Gypsum block at depth of 30-40 cm were used to assist in determining the time of irrigation. The irrigation water was applied when the mean resistance of the Boyoucos meter of the plots reached approximately 900 ohm (80% of available water), 2600 ohm (50% A.W.) and 8000 ohm (30% A.W.) for wet, medium and dry regimes, respectively (Fig. 1 and 2).

In each season the total yield, number of ears per 100 plants and kernel weight of 1000 seeds were taken at harvest of corn. Plant height at heading, 1000 grain weight, grrain and biological yields were determined for wheat and analysis of variance of these parameters were carried out using completely randomized design with six replications and three irrigation regimes as treatments.

RESULTS AND DISCUSSION

Corn Experiment

The results obtained showed that the yield of corn was not significantly affected by the water regime treatments. This might be attributed to the amount of water applied and to the water quality itself. Figure (3) showed the water content distribution for the wet soil profile, Water was extracted

Table(1) Seasonal water use of corn and wheat as affected by the irrigation regime.

Irrigation regime	Growing period	Amcunt of irrgation	Amount Of rainfall	Amount of water stored in soil	Water use	U.S. Class A Pan Evap
	day	mm	mm	mm	mm	mm
		corn 1985				
wet	125	1190	31	0	1221	1423
med	125	84o	31	20	891	1423
dry	125	770	31	43	844	1423
		corn 1986				
wet	126	840	135	0	975	1181
med	126	560	135	0	695	1181
dry	126	420	135	20	575	1181
		weat 1986/87				
wet	141	800	52	13	865	832
med	141	550	52	41	643	832
dry	141	350	52	44	446	832
		weat 1987/88				
wet	130	850	128	0	978	768
med	130	650	128	0	778	768
dry	130	450	128	0	578	768

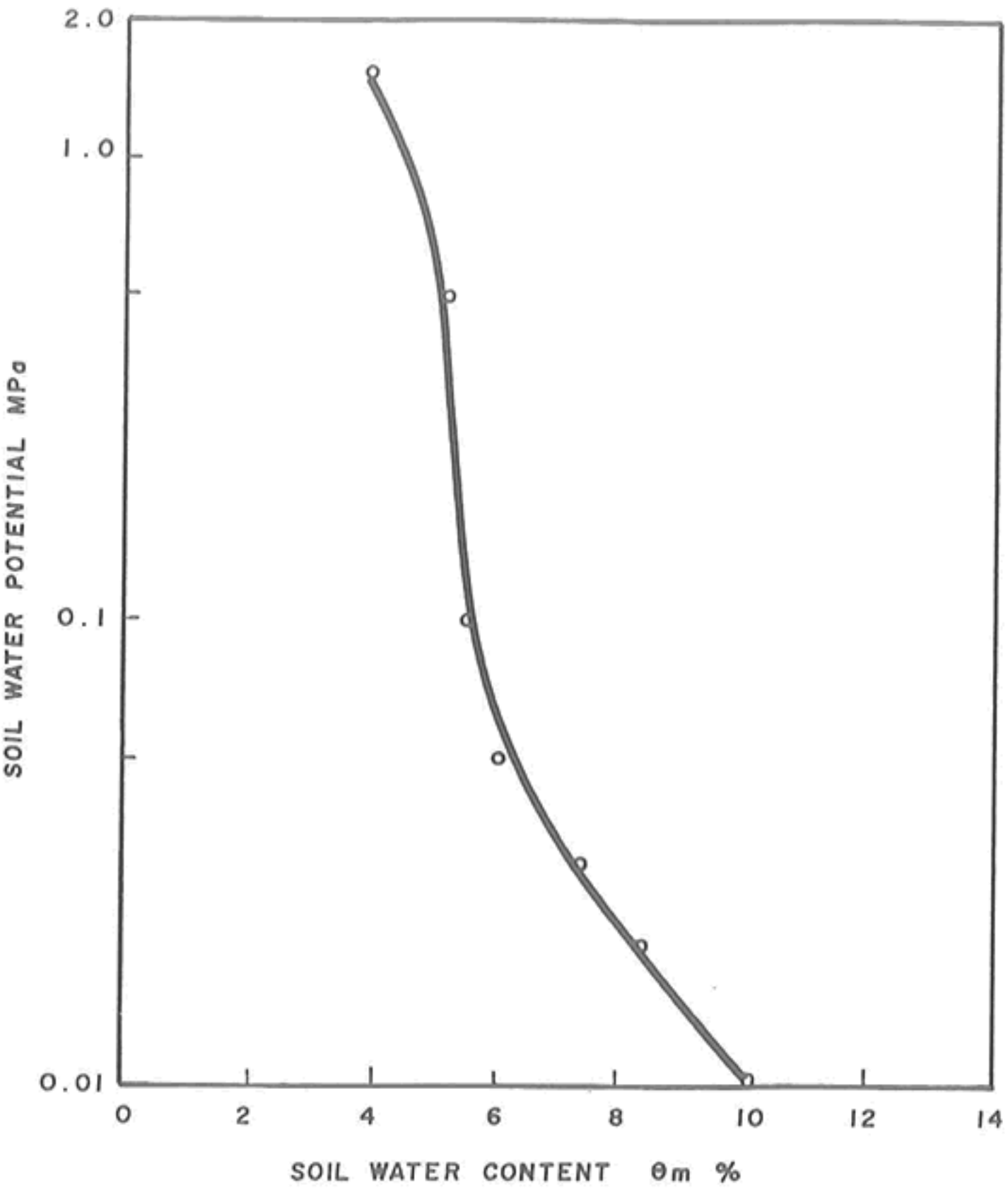

Fig. 1. Soil water status as an indicator for irrigation

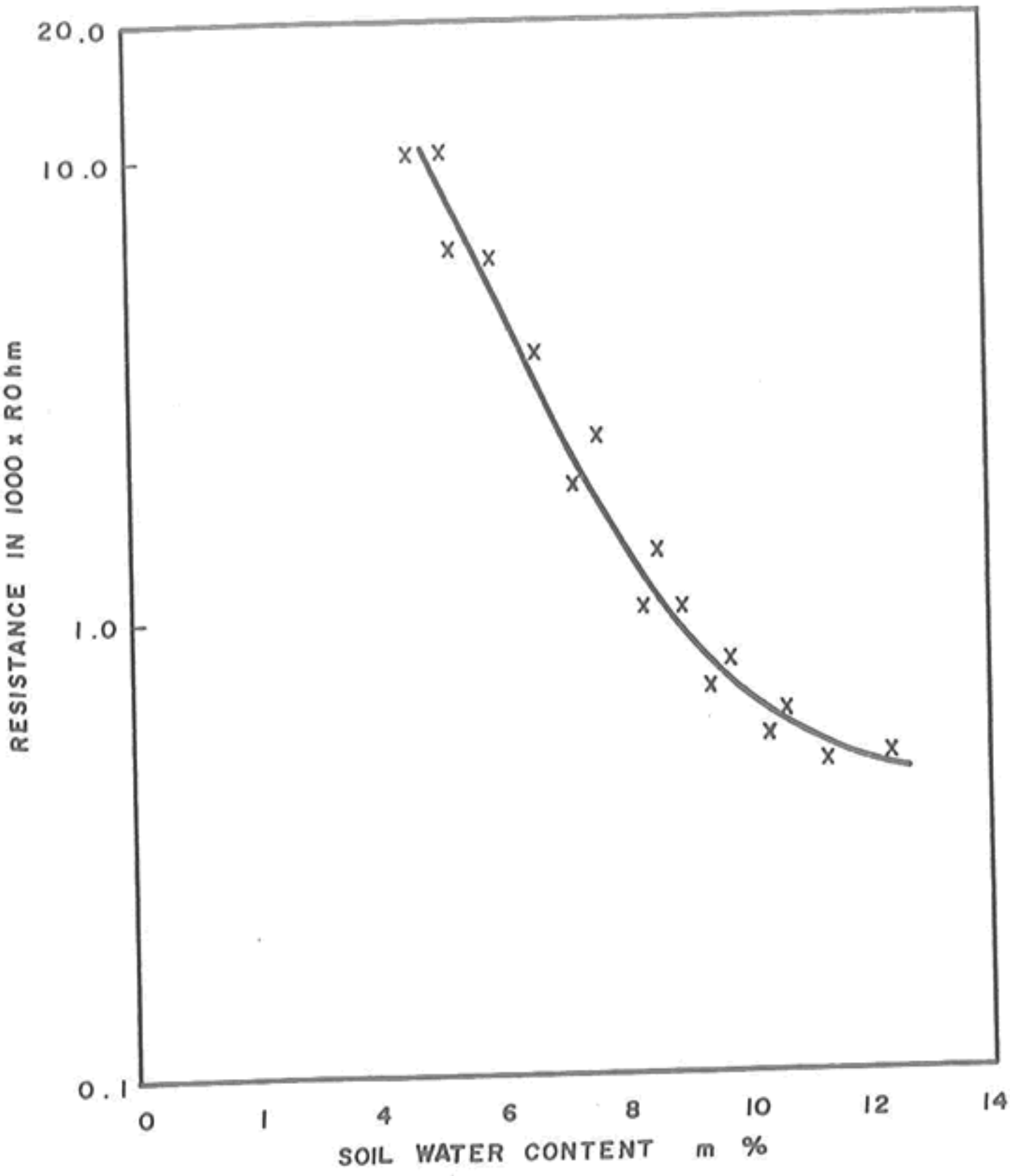

Fig. 2. Mean resistance of the Boyoucos meter of the plots

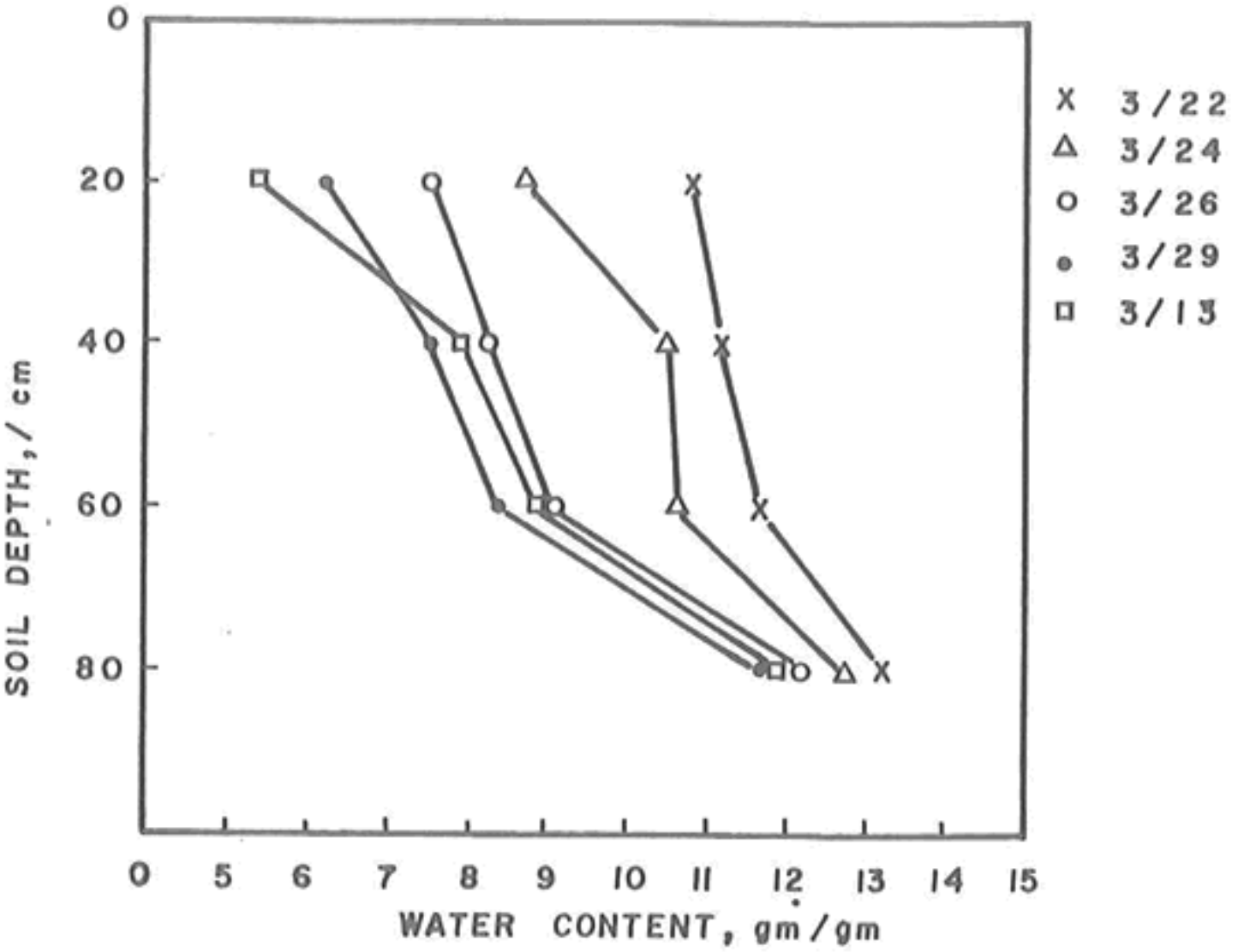

Fig. 3. Water contents distribution for the wet soil profile

from the top 80 cm of the profile for each cycle of irrigation. Based on the water balance equation I= ET + Dr + ΘE - ΘB where I is irrigation, ET is evapotranspiration, Dr is drainage, OE is the soil water content expressed as a depth of water at the end of the irrigation cycle and ΘB at the beginning of the irrigation cycle. The total amount of water consumed by the crop for the period from 3/20 to 4/1/1986 was 51.8 mm. Thus the leaching fraction for the wet regime is : LF=1.82/7.0 equal to 26%. According to the tables presented by Ayers and Westoct (1976), the LF of 26% for the water used in the experiment might not be enough to get a maximum yield of the crops.

The results showed that the response of corn yield to total water applied is not clear and this might be attributed to deficit of irrigation since the leaching fraction was 26% only for the highest treatment. The amount of water used was not enough to ensure a high production of corn yield using saline water with EC= 5.5 dS/m. That was also reflected upon the medium regime where the LF was 18%. Musick and Dusek (1980) evaluated corn yield response to water and developed functional relationship between yield and evapotranspiration. They concluded that limited irrigation of corn involved unacceptable high risks and should not be practiced in the high evaporation demand climate in the southern high plains of U.S.A. Extrapolation of these to the present trial may lead to conclude that higher amounts of water are needed for satisfactory corn yield to be obtained under the prevailing soil, water quality and ambient temperature conditions.

Wheat Experiment

The irrigation regime (quantity and frequency) had a very highly significant effect on mean plant height at heading, 1000 seed weight, seed yield and biological yield of wheat in the two seasons (Table 2). The results indicate that the wet regime gave significantly taller plants and heavier seeds and thus resulted in significantly greater seed and biological yields than medium and dry regimes. It seems that the infrequent irrigations of dry regime subjected the crop to higher water and osmotic stresses which may be responsible for the present growth and yield depressions.

Figure 4 illustrates the relationship between total water used in the experiment and crop production. The figure shows quite clearly that the high water applied (wet regime) gave the highest yield. The relationship between water used in the experiment and yield was described by a linear relationship .

Some research workers indicated that yield was reported to be linearly related to evapotranspiration in many crops (Hanks, 1974; English, 1981). While the relationship between yield and gross water use should be curvilinear, where water use is low the two functions should track rather closely. In this experiment, the gross water use was 978 mm in 1987/88 season for the wet regime which was much lower than the estimated total water for the Dirab area using surface irrigation. Mustafa et al. (1989) estimated gross water requirements for wheat in the

Table (2) Effect of irrgation level on mean plant height, 1000 grain weight,grain yield and biological yield of wheat.

Irrigation level	Plant height(cm)	100 Grain weight(g)	Grain yield (t/ha)	Biological yield (t/ha)
		1986/87 Season		
wet	90.83±0.43	41.88±5.11	6.58±1.03	16.0±1.88
med	85.33±1.08	36.88±5.82	4.80±0.70	14.7±1.27
dry	82.83±5.06	33.37±6.41	3.60±0.53	12.5±1.96
$LSD_{0.05}$	3.52	6.81	0.92	2.02
		1987/88 Season		
wet	94.83±1.67	41.25±1.75	6.78±0.32	20.53±1.4
med	76.17±1.03	38.28±0.74	5.62±0.67	17.28±1.8
dry	68.67±4.53	36.67±0.92	3.87±0.97	12.73±1.8
$LSD_{0.05}$	3.35	1.43	0.83	1.99

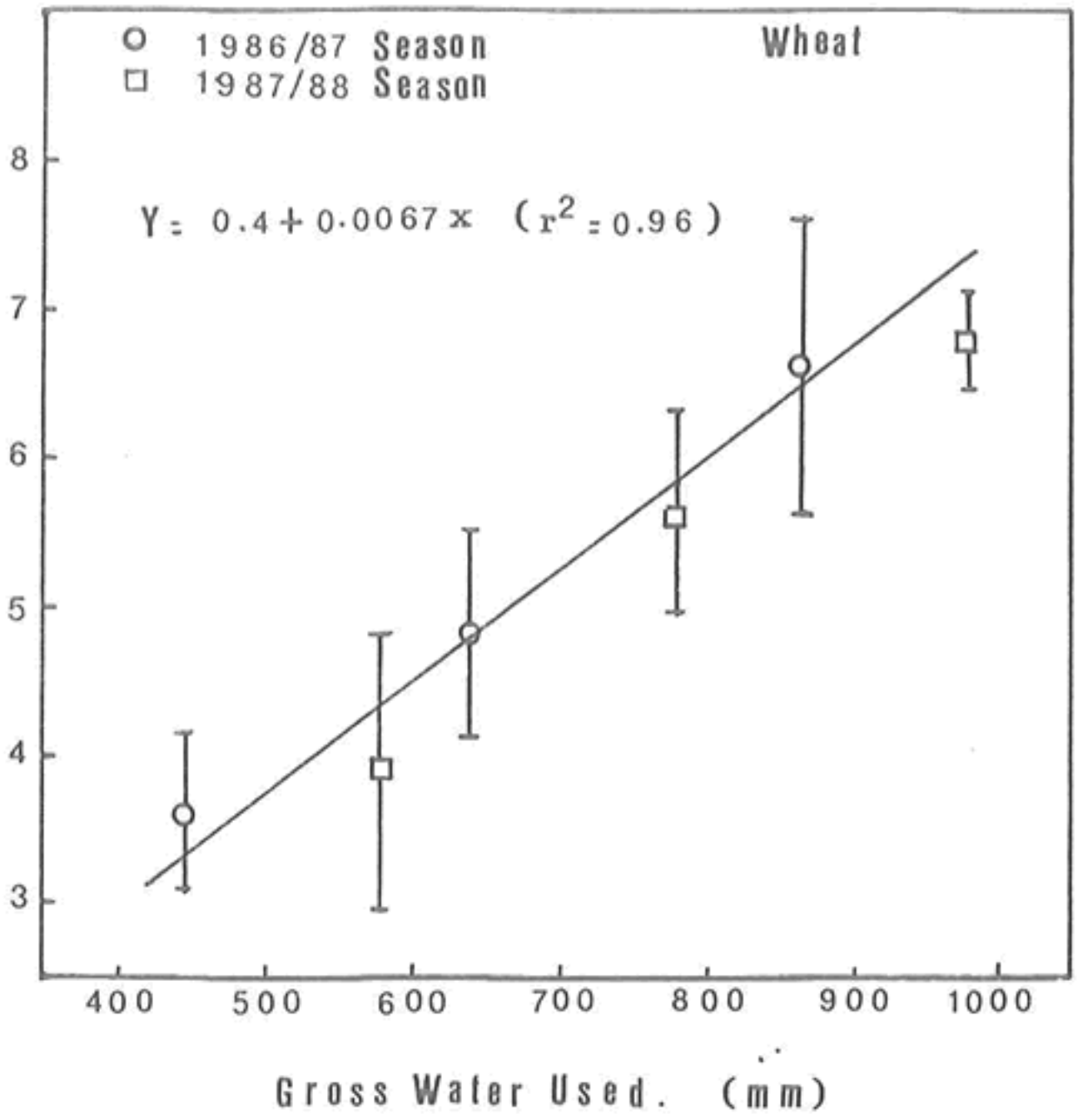

Fig. 4. Relationship between total water use and crop production

same area using surface irrigation with EC of irrigation water of 5 dS/m as 1343 mm. Thus the total amount of irrigation water was not enough to get the maximum yield which may result in straight linear relationship between yield and water used rather than curvilinear relationship as reported by other researchers (English et al., 1985).

Table 3 shows the effect of irrigation regime on the water use efficiency. The dry regime resulted in highest water use efficiency in 1986/87 season, while the medium regime resulted in the highest water use efficiency in 1987/88 season. However, the highest yield record for the wet regime was 6.78 tonne/ha, while the gross water used was 978 mm during 1987/88 season.

Table 3. Effect of irrigation regime on water use efficiency of corn and wheat.

Irrigation regime 1987/88	corn 1985	Total yield 1986	Wheat grain yield 1986/87	
		Kg/ha.	cm	
Wet	39.07	56.80	76.1	69.33
Med.	50.61	77.12	74.6	72.30
Dry	53.30	81.03	86.7	77.99

It can be concluded that the corn may not tolerate irrigation deficit and saline water quality,

on the other hand, the wheat recorded a high yield of 6.78 tonne/ha under some water stress when grown in the central region of Saudi Arabia.

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مجلة الامارات للعلوم الزراعية (١٩٩٠) ، ٢ : ٨٠-٩٦

تأثير مستويات الرى على انتاجية محصولى الذرة والقمح

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ملخص

أجريت دراسة حقلية على مدى اربع سنوات من موسم ١٩٨٦/٨٥ حتى موسم ١٩٨٨/٨٧م حول تأثير مستويات الرى على نمو وانتاج كل من الذرة والقمح حيث زرع كل محصول لمدة موسمين متتالين على ثلاث مستويات لماء الرى : رطب (يتم الرى عندما يصل الماء الميسر ٨٠٪) متوسط الرطوبة (يتم الرى عندما يصل الماء الميسر الى ٥٠٪) وجاف (يتم الرى عندما يصل الماء الميسر الى ٣٠٪). بالنسبة لعينات الذرة كانت كمية الماء المضافة فى التربة سبعة سنتيمترات وذلك لمستويات الرى الثلاثة ، بينما كانت هذه الكمية خمسة سنتيمترات بالنسبة لمحصول القمح . وقد استخدمت مكعبات الجبس لتحديد ميعاد الرى فى كل مستوى من مستويات الرى المختلفه. واجريت التجربة بستة مكررات لكل معاملة.

لقد وجد فى تجربة الذرة عدم وجود اختلافات فى الانتاج بين مستويات الرى الثلاثة المستخدمة وكان المحصول فى كل المعاملات اقل بكثير من معدلات الانتاج الاقتصادى حيث لم يتحمل النبات نقص الماء. بينما فى تجربة القمح اعطى مستوى الرى العالى زيادة معنوية فى طول النبات وانتاجية المحصول .

كلمات مفتاحية : ذرة ، قمح ، مستويات رى ، الانتاجية ، المملكة العربية السعودية .