

Five years of collaboration work with ICARDA/APRP in Al-Jouf area in Saudi Arabia

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Introduction

The Kingdom of Saudi Arabia (KSA) has a large land area of the Arabian Peninsula. It covers an area of about 2.25 million square kilometers, which occupies about four-fifth of the Arabian Peninsula. This area is extending between latitudes 16° – 32° north and longitudes 34° – 56° east. More than 70% of the total land area can be classified as a range lands. Grazing is therefore the largest single land use type in KSA.

During recent decades there has been rapid economic development and a large population increase with corresponding increase in pressure on natural resources. The population of domestic animals has also dramatically increased. Now a day, Nomads practice free grazing. Each herder has the right to graze his herds in any range site and at any particular time and duration he likes. There are no restrictions on the size and movement of herds, which make animal population increased gradually. The result is that range condition became extremely very poor and deteriorated. Overgrazing is the main problem of the rangeland in addition to the harshest climate that the country has.

The government has recognized the important of maintaining the kingdom's natural resources. Government established specialized departments for natural resources, conservation and management. The government also established the Range and Animal Development Research Center (RADRC) in the northern of Saudi Arabia in order to supply the scientific information on which improvement and proper management of the rangeland should based.

Arabian Peninsula Regional program (ICARDA) has contributed in rehabilitation rangeland in Saudi Arabia by establishing three experiments in Al-Jouf region northern of Saudi Arabia. These experiments started during phase I and continue to phase II. Those experiments are as follows:

Transplanting of native shrubs under natural condition with supplementary irrigation. The goal of this experiment was to evaluate re-vegetation of degraded rangeland with native rangeland shrubs. Shrubs survival was more than 95% during the first three years and seeds were produced. Survival, however, drops to less than 50% in year 2001 due to the continuously drought for two years.

Comparison of two different methods of rangeland reseeding. The goal of this experiment is to compare two cultural methods (contour furrowing and pitting) for providing better seed bed and increase water infiltration and herbage yields. The drought have negative effect on this experiment and reduced survival to less than 1%. The first two experiment were successfully completed and the results were presented in the regional meeting in Dubai, 2000. Summaries of the results of these two experiments are:

Native range shrubs adapted to low water requirements.

A few amount of water at the planting time is sufficient to establish range shrubs.

Species that are naturally distributed in the area adapted better with transplanting methods.

Re-vegetation of perennial species on rangeland often requires reseeding.

The third experiment water use efficiency of currently used and indigenous forage (*Medicago sativa*, rhodes grass blue panic) and their mixture did not succeed due to poor germination and too many grasses that completely covered the shrubs.

During phase II the third experiment was replaced with a new experiment with an objective of comparing water use efficiency of currently used forage *Medicago sativa* (*Medicago sativa*) and local range shrubs *Atriplex leucoclada*. A progress report including layout of the experiment were presented in ICARDA meeting in Dubai, 2000. The final report of this experiment will be presented in this meeting. This report will also included a future working plan for range rehabilitation at Saudi Arabia.

Water use efficiency of *Medicago sativa* (*Medicago sativa*) and *Atriplex leuoclada*:

The goal of this experiment was to compare water use efficiency between *Medicago sativa* (*Medicago sativa*) and *Atriplex leuoclada*. It is also aimed to have enough information on *Atriplex leuoclada* such as irrigation requirements and harvesting procedure. The experiment was divided into four level of irrigation under central irrigation pivot (Central pivot speed 20 m/h, 40 m/h, 60 m/h, and 80 m/h). Each level include eight blocks (10*10 m); four blocks *Medicago sativa* and four *Atriplex*. Four replications were used. Experiment started on spring 1999. The amount of water applied under each speed was calculated in table 1.

Table 1: Depth of water under each speed

Central Pivot Speed	Applied Depth of Water (mm)
20 m/h	15.4
40 m/h	8.6
60 m/h	6.0
80 m/h	4.4

The results show that *Medicago sativa* was at the highest productivity with high moisture content (20 m/h). The productivity reaches 2738 kg at 20/hr speed in the first year while its reduced to 1185 kg at 80 m/hr speed. Productivity of *Medicago sativa* reduced as long as the amount of water reduced (Table 2). Productivity of *Atriplex*, however, increases while the amount of water decrease until 6mm depth of water (60 m/h speed of central pivot) then decreased (Table 3). Productivity of *Atriplex* increased from 1450 kg/ha at 20 m/hr speed to 1950 kg/ha at 60m/hr speed (6mm) but reduced again to 800kg/ha at 80 m/hr speed. Productivity of *Medicago sativa* increased with cut while *Atriplex* productivity decreased with more cuts. *Medicago sativa* makes 13 cuts in two years while *Atriplex* makes only 5 cuts. Table 2 shows the productivity of *Medicago sativa* in three years in different central pivot speed. It is clear from the table that *Medicago sativa* productivity increased with cuts until the 9th cut then decreased.

Paragraph one show the productivity of the two plants within three years. Table 3 shows the productivity of *Atriplex* in three years. It is clear from the table than *Atriplex* increased while the moisture content decreased until 6 mm then decreased again.

Chemical content shows slit different between the two species. Table 4 shows the chemical content in the two species

In conclusion we can say that water use efficiency of *Atriplex leuoclada* is much higher than *Medicago sativa*. *Atriplex* can be cut for several times but its productivity reduced with more cuts. *Atriplex leuoclada* alone can not be enough diet for animal feed, but some other range species it can replaced *Medicago sativa*.

Table 2: Productivity of *Medicago sativa* in different central pivot speed

Speed M/hr	Cuts												
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th	9 th	10 th	11 th	12 th	13 th
20 m/hr	90.3	84.5	92	105	145	140	157	153	134	145	98	99	47
40 m/hr	37	42.5	44	64	91	115	77	50	41	55	61	67	47
60 m/hr	13.5	29.3	42	54	82	108	72	41	34.4	28	14	21	20
80 m/hr	7.5	26.5	44	46	62	99	108	50	30	24	7	14	12.4
mean	37	46	56	67	95	116	104	74	239	63	45	50	32

Table 3: Productivity of *Atriplex leuoclada* in different pivot speed:

SpeedM/hr	Cuts				
	1 st	2 nd	3 rd	4 th	5 th
20 m/hr	75	83	16	92	150
40 m/hr	136	42	37	128	136
60 m/hr	86	69	80	207	90
80 m/hr	36	35	25	148	10
mean	83	57	40	144	97

Productivity of *Medicago sativa* and *Atriplex leucoclada*

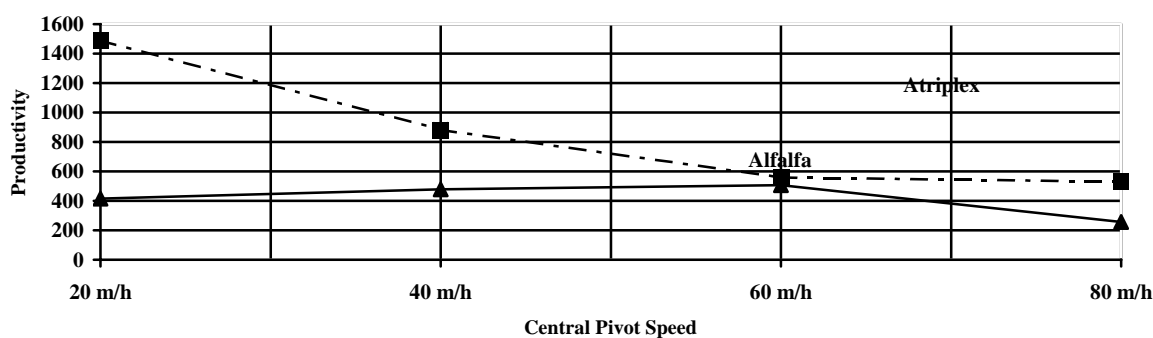


Table 4: Chemical content of *Medicago sativa* and *Atriplex leucoclada*:

Plant	%						
	Total Protein	Crudeprotein	Ash	Ether Extract	Nitrogen(NFE)	Calcium	Phosphorous
<i>Medicago sativa</i>	14.8	27.3	8.6	4.3	45	1.53	0.25
<i>Atriplex leucoclada</i>	13.10	23.07	21.3	0.96	40.9	1.28	0.38

*Data of *Medicago sativa* was taken from Goh, 1981. While data of *Atriplex* was taken from Mirreh 1990.

Future Working Plan for APRP

During recent decades there has been rapid economic development and a large population increase with corresponding increase in pressure on natural resources in Saudi Arabia. The population of domestic animals has also dramatically increased. Now a day, Nomads practice free grazing. Each herder has the right to graze his herds in any range site and at any particular time and duration he likes. There are no restrictions on the size and movement of herds, which make animal population increased gradually. The result is that range condition became extremely very poor and deteriorated. Overgrazing is the main problem of the rangeland in addition to the harshest climate that KSA has.

The proposal for the future working plan as I think is the plan-animal interaction. We should focussed on the animals as the main factors of using range land. The overall objective of this project is to provide technical management packages for sustainable animal production with rangeland rehabilitation in Saudi Arabia. That is can be reached by identify promising forage and fodder species for rangeland rehabilitation and fodder production in different region of Saudi Arabia, to conserve promising and fodder species, and findout the chose the right number and type of animals in each range area. Materials and methods can be discussed later. But we can established this experiment at Al-jouf area after we select the grazing area and calculated the carrying capacity of the choosed area. Then put the exact number and type of animals and taking the results every two days. At then we will be able to have enough information on plant-animal

Performance, Productivity and Water Use Efficiency of Five Indigenous Forage Grasses under Central Saudi Arabia Environmental Conditions

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Abstract

Exotic forage species such as alfalfa (*Medicago sativa*) and Rhodes grass (*Chloris gayana*) are being grown in Arabian Peninsula region to accommodate the shortfall of forage from rangeland. These species, however, require large volumes of irrigation water, mainly ground water. This has compounded the problems of desertification by lowering the ground water levels and raising salinity levels that has led to reduced potential productivity of agricultural land, and in severe cases to the abandoning of the cultivated land.

ICARDA-Arabian Peninsula Regional Program Phase I, was successfully launched in 1997 (1997-2000) to deal with the harsh environment of AP countries. Four themes were selected by the participating countries to be the main focus for the program. These were: (i) rangeland, shrubs, irrigated forages and livestock, (ii) protected agriculture, (iii) an abiotic stress and (iv) on farm water use and irrigation management

Utilizing the adapted genetic variation of indigenous forage species, seed multiplication and rehabilitation of degraded rangelands is the main strategy of the rangeland component of the program. During phase I, germplasm collection missions were conducted in various countries of the Peninsula (UAE and Oman), along with the development of herbaria, databases and enclosures. Seeds of priority species were multiplied and evaluation for water use efficiency and nutritive values are determined. Initial data show that such desert forages use less water than the introduced forages and has an acceptable nutritive value.

The purpose of this research activity is collecting more data on the water use efficiency of five indigenous forage grasses

Objectives

To compare the water use efficiency of five indigenous grass species: Labeid (*Cenchrus ciliaris*); Thomam (*Panicum turgidum*); Themoma (*pennisetium Divism*); Sabat (*Stipagrostis Ciliata* and/or *Stipagrostis Drarii*) and Dakhna (*Coelachyrum piercei*) and one exotic species: Rhodes grass (*Chloris gayana*), under the environmental conditions of the Central Saudi Arabia.

Experimental site: Riyadh, National Agriculture and Water Research Center of the Ministry of Agriculture and Water, Saudi Arabia., Date of commencement of study: April 2002, Expected date of completion: April 2003, Research supervisors: A. Alshankiti, A. Alhamdan, A. Habib, A. Aljouiead, A.E. Osman, A. Al Ajmi

Introduction

In the Arabian Peninsula, the main fodder crops are alfalfa (*Medicago sativa*) and Rhodes grass (*Chloris gayana*). These species do not occur naturally and are not adapted to the prevailing harsh conditions of drought, temperature and salinity. They require vast quantities of water (up to 48 000 m³/ha/year) often derived from nonrenewable ground water sources (Guide for Crop Irrigation in the Kingdom of Saudi Arabia, 1988). Apart from being unsustainable, production of these forages has resulted in many countries of Arabian Peninsula in abandoning of forage cultivated lands, due to problems of salinity and shortage of water.

It is known that indigenous species are capable of surviving with less water than most introduced species such as Rhodes grass and alfalfa. However, unlike the latter, the productivity of the indigenous species as a function of the amount of water is not fully known. Results from a line source experiment at Dhaid (Sharjah), UAE, during 1999, comparing the water use efficiency of Rhodes grass with two indigenous forages (*Coelachyrum piercei* and *Cinchrus ciliaris*) was not conclusive. However, The values of WUE reported for the latter two species elsewhere (include UAE) are as good or even better than that of Rhodes grass (John Peacock, personal communication). A review of available research publications did not show such trials had been tried in Saudi Arabia.

In this study, five indigenous grasses (: *Labeid* (*Cenchrus ciliaris*); *Thomam* (*Panicum turgidum*); *Themoma* (*pennisetium Divism*); *Sabat* (*Stipagrostis Ciliata* and/or *Stipagrostis Drarii*) and *Dakhna* (*Coelachyrum piercei*) and an exotic species: Rhodes grass (*Chloris gayana*) will be compared for their productivity and water use efficiency. The study will also assess the performance of the different species under different levels of irrigation and repeated cutting.

Materials and Methods

Five indigenous grass species and one exotic forage (see above) will be compared for their productivity under three irrigation treatments, (the amount of water applied will depend on the season (see Table 1).

Table 1: The amount of irrigation water to be applied during different seasons

Irrigation level	Winter (N,D,J,F)	Summer (M,J,J,A)	Spring/Fall (M, A, S, O)
I	15 minutes/ Day	45 minutes/ Day	30 minutes/ Day
II	15 minutes/ 2 Days	45 minutes/ 2 Days	30 minutes/ 2 Days
III	15 minutes/ 4 Days	45 minutes/ 4 Days	30 minutes/ 4 Days

The irrigation chart can be shown as follows for the different irrigation treatments:

Table 2: Irrigation schedule shown for three weeks from the beginning of the experiment.

Weeks	Irrigation. Level	Sat.	Sun.	Mon.	Tue.	Wed.	Thur.	Fri.
W ₁	I	X	X	X	X	X	X	X
	II	X		X		X		X
	III	X				X		
W ₂	I	X	X	X	X	X	X	X
	II		X		X		X	
	III		X				X	
W ₃	I	X	X	X	X	X	X	X
	II	X		X		X		X
	III			X				X

The irrigation system will be drip irrigation, with 50 cm between the drip nozzles, and 50 cm between the drip lines. The irrigation treatments will be laid out as the main plot treatments.

Six grass species (the sub-plot treatments), will be randomly distributed within each main plot treatment. Each species will occupy a plot size of 2.5 m x 2.75 m in each main plot treatment. There will be a boarder of one meter between sub-plots and three meters between the main plots treatments. Each plot will have six drip lines (the outer most are boarder lines). Plots will receive the same irrigation schedule: 15. 45 or 30 minutes' irrigation daily, depending on the season (see Table 1), until all grasses are established.

Data collection

After establishment, grasses will be cut down to the same height (10-cm). This will mark the beginning of the experiment. Thereafter the plots will be irrigated according to schedule (Table 2), and harvested at interval of 4-6 weeks to ground level. Harvested forages (2m x 2m in the middle of sub-plot) will be weighed, and sub-samples taken for oven drying. The dried material will be weighed and stored. Sub-samples from the dried material will be used for chemical analysis (CP, NDF, ADF and Ash). The data will be statistically analyzed for split-plot design under randomized complete block.

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The grasses under study were: *Labeid* (*Cenchrus ciliaris*); and *Dakhna* (*Coelachyrum piercei*) brought from UAE. *Thomam* (*Panicum turgidum*); *Themom* (*Pennisetium Divism*); *Sabat* (*Stipagrostis Ciliata* and/or *Stipagrostis Drarii*) collected on March, 2002 from Central Saudi Arabia.

Planting date: 01-05-2002

Harvesting date: 24-8-02002

Irrigation: A drip irrigation system was used, and all plots were irrigated equally three times a week for 40 min @118 liter/plot.

Observations: Emergence was partial for all grasses except Rhodes. Table (1) shows the emergence status as of 25-5-2002. Where: S1= *Dakhna*, S2= *Labeid*, S3= *Thomam*, S4= *Sabat*, S5= *Themom*, S6= *Rhodas*

Table 3: Soil Analysis

Sample #	Depth (cm)	EC (1:1) dsm ⁻¹	Ca Co ₃ %	K ppm	P ppm	Texture Class
1	30	2.76	38.70	231	10	SL
2	60	3.30	35.54	223	9	SL
3	30	2.52	21.72	187	8	SL
4	60	4.20	38.31	135	6	SL
5	30	0.56	39.88	53.40	3	SL
6	60	1.46	40.67	47	7	SL

Table 4: Water Analysis

Element	ppm
Ca	156
Mg	145
Na	354
K	11
B	.46
Cl	674
TDS	3240
pH	7.04
EC	4.5 dsm ⁻¹

Table 5: Plants emergence (total number of plants/rep.) as of 25-5-02

Rep	S1-Dakhma	S2-Labied	S3-Thomam	S4-Sabat	S5-Themom	S6-Rhodas
A1	7	4	1	x	26	108
A2	18	x	4	1	18	108
A3	15	3	4	1	35	108
A4	40	7	9	2	79	324

The low emergence has resulted in low plant population per plots as showed in table (2).

Table 6: Plants Population (total number of plants/rep) as of 29-7-02

Rep	S1-Dakhma	S2-Labied	S3-Thomam	S4-Sabat	S5-Themom	S6-Rhodas
A1	7	4	1	x	26	108
A2	18	x	4	x	18	108
A3	15	3	4	x	35	108
G. Total	40	7	9	x	79	324

As of 25-5-02, all species has emerged after sewing, though emergence percentage/plot differ between species. Sabat shows the lowest emergence between species.

As of 29-7-02 Sabat did not stand the harsh summer and wilted out. Themom shows the highest emergence percentage and have survived the summer noticeably followed by Dakhna.

Discussion and conclusion

Farming practices for these indigenous species had not been documented. Thus, all observations recorded during this trial are of a valuable reference.

Planting date of early summer did not seem to be appropriate and the low emergence could be attributed to such planting time and/or to seed quality.

Though these grasses species have been known for their drought resistance, non-has been documented regarding their salinity tolerance.

In this trial, in addition to harsh summer temperature, soil salinity, irrigation methodology, water salinity might have attributed to the low emergence.

Seeds have been collected from this trial to replant the incomplete plots (gap filing) and to further investigate a different planting date (early September is suggested).

The Response of Wheat Cultivars to Deficit Irrigation in Central Region of Saudi Arabia

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Abstract

Three field experiments were carried out at NAWRC in Riyadh in 1997/98, 1998/99 and 1999/2000 season to study the responses of the new wheat cultivars and the well known cultivar in Saudi Arabia Yecora rojo (*Triticum aestivum* L. Thell) to irrigation amounts. Factorial experiments of three amount of irrigation: normal evapotranspiration (ET), 0.8 of ET and 0.6 of ET and six cultivars were laid out as Completely Randomized Design with three replications. Grain yield was insignificantly greater (about 2.8%) in the normal ET treatments than in the intermediate irrigation, while more reduction in water supply declined the yield 9%. Therefore, the intermediate irrigation around $5500 \text{ m}^3 \text{ h}^{-1}$ could be recommended to obtain high yield. Increasing irrigation more than $5500 \text{ m}^3 \text{ h}^{-1}$ may increase grain yield slightly, but it also increased the risk of lodging. The new recommended cultivars (Sahel 1, Jomaiza 3, Sodos 6, Sodos 7, Sakha 8) do not seem to be well adapted to drought more than Yecora rojo.

Introduction

Saudi Arabia suffers sever water shortage due to limited water resources and increase irrigated agriculture. Irrigation water constitutes about 90% of the national water consumption, with irrigated wheat area being the largest in the country. Selecting the best adapted cultivars to drought and determining the proper amount of irrigation for wheat are extremely important for sustainable development and conservation of water resources. The purpose of the field experiments described here was to compare the responses of the new cultivars and the well known cultivar in Saudi Arabia Yecora rojo to irrigation amounts.

Material and methods

Field experiments were carried out at NAWARC in Riyadh in 1997/8, 1998/9 and 1999/2000 seasons. Six wheat cultivars were selected for the study. Yecora rojo was chosen as it has been used for high production in Saudi Arabia since mid eighties (Sliman and Ghandorah 1992). For comparing with Yecora rojo, the new Egyptian cultivars Sahel 1, Jomaiza 3, Sodos 6, Sodos 7, Sakha 8 were chosen as well adapted to drought as recently recommended by Ministry of Agriculture, Riyadh, Saudi Arabia.

Factorial experiments of six cultivars with three amount of irrigation were laid out as Completely Randomized Design with three replications. The soil was loam sandy. Seeds were sown at a rate of 140 kg h^{-1} on 1 December. Plot size was 3 m by 2m. Fertilizers were applied at recommended rate ($250, 200, 100 \text{ kg h}^{-1} \text{ y}^{-1}$ N: P: K).

There were three irrigation water application treatments for the whole season based on Guide for Crop Irrigation Requirements by the ministry of Agriculture and water (Al-Zeid et al 1988). The first irrigated treatment was watered at evapotranspiration level which, while the second and third treatments were watered at 0.8 and 0.6 of evapotranspiration, respectively. In the case of rain fall, the water application was reduced by the amount of rain fall for that particular period. The amount of irrigation for the first treatment was: 41, 100, 133, 220 and 186 mm for December, January, February, March and April, respectively. Accordingly, the total annual irrigation was: $6800, 5500$ and 4100 m^3 for the first, second and third treatment, respectively.

Tow samples of 1 m^2 were taken from each plot excluding the half meter surround. The plants were cut as closely to the ground level as possible, and plant height, spike length, Number of spikelet in spike and weight of 1000 kernels were measured. Total dry weight (biomass) and grain weight were recoded after oven-drying at 95°C for 48 hours.

Data were subject to analysis of variance using SAS statistical package (SAS Institute Inc., Cary, Nc, USA) to test differences in the characteristic measured due to cultivar, irrigation, season and their interactions. Least Significant differences (LSD 0.05) were calculated in order to compare means of different cultivar and irrigation treatments.

Results

1997/98 experiment: All the characters used here were significantly affected by cultivar (Table 1). In contrary, the different amount of irrigation applied here had no significant effects on the parameters, except kernel weight which was decreased by increased water supply. However, grain yield was increased by increasing water supply from 5.0 t h⁻¹ at the W3 treatment to 5.4 and 5.6 t h⁻¹ at the W2 and W1 treatment (Table 6). Sahel 1, Sakha and Yecora rojo produced the highest grain yield (about 6.1 t h⁻¹), while Sodos 6 gave the lowest yield (4.3 t h⁻¹) (Table 3). Yecora rojo was by far the shortest cultivar (63 cm), while Jomaiza 3 was the highest (103 cm).

1998/99 experiment: The respond of cultivar to irrigation followed the same pattern to that of the first season (Table 4). An exception, was grain yield which did not differ significantly between cultivars. Grain yield ranged from 4.57 t h⁻¹ at the normal ET treatment to 4.46 t h⁻¹ at the W2 treatment, and this was not significant (Table 6). The result presented the first and second season showed that kernel weight was the most affected characters by the water treatment.

1999/2000 experiment: All variables studied her were significantly unaffected by irrigation treatment except grain yield, but there were no significant differences between the W1 and W2 treatments. Grain yield increased at the fully irrigation and intermediate (5 t h⁻¹) compare to the W3 (4.2 t h⁻¹). Sahel 1 and Yecora rojo yielded the highest grain of 5.9 and 5.6 t h⁻¹, respectively, whereas Jomaiza 3 and Sodos 7 produced the lowest yield (around 4 t h⁻¹)

Variation between season: Here, results will be presented for grain yield only. The effect of year was highly significant (Table 2). The first season produced the highest grain yield of 5.3 t h⁻¹ compare to 4.5 and 4.8 t h⁻¹ for the second and third year, respectively. Interaction of season X irrigation was significant, while the other interactions had no significant effects.

On the average of three years, yield was increased by increasing water supply from 4.57 t h⁻¹ at the W3 to 4.95 t h⁻¹ at the W2, and to 5.07 t h⁻¹ at the W1, but the difference was insignificant between the W1 and W2 treatments. The cultivar Sahel 1 produced the highest yield of 5.4 t h⁻¹, followed by Sakha 8, Yecora rojo and Sodos 6 (5.0, 4.9, 4.8 t h⁻¹ respectively), but this difference was not significant. However, Sodos 7 & Jomaiza 3 had significantly the lowest yield (4.67 and 4.47, respectively) compared to Sahel 1 (Table 7).

Discussion and conclusion

The average grain yield was insignificantly greater (about 2.8%) in the normal ET treatments than in the intermediate irrigation, while more reduction in water supply declined the yield 9%. Therefore, the intermediate irrigation around 5500 m³ h⁻¹ could be recommended to obtain high yield. This amount is relatively small for surface irrigation in central region, but similar values have been reported (Mustafa et al 1989), while values in other studies ranged between 7500 and 8500 m³ (Salih, A.M.A, and Sendil, U. 1984; Al-Zeid et al 1988, Al-Omran and Shalaby, 1992). Increasing irrigation more than 5500 m³ may increase grain yield slightly, but it also increased the risk of lodging. In Najran (southern Saudi Arabia) Al-Gobari (2000) found that the crop water requirement for wheat under sprinkler method was 5823, though the evaporation demand in Najran is higher than in Riyadh.

The variations in values of crop water requirements are expected because of the variations in the methods of estimation calculated or actual ET and the variations between seasons. Nevertheless, it appears that the frequency of irrigation and its distribution pattern play some influence on the variability of the values of ET. Reducing irrigation during tillering stage enhance root growth as recommended by the ministry of Agriculture (1985). Tamimi and Rosaise (1986) citing many studies on cereal crops indicated that mild drought during jointing stage improved the yield as a result of reducing plant height and lodging and increasing tillering. It seems that more attention should be paid to the timing and period of irrigation and how they effects the root systems and evapotranspiration.

The significant interaction of season X irrigation mean that the effects of irrigation treatment differ between seasons, which was mainly due to variation in rainfall. The insignificant effects of cultivar X irrigation interactions could indicated that the responses of cultivars to irrigation were similar at each treatment, and the high yielding cultivars kept their spire at all treatments and vice versa.

The new recommended cultivars (Sahel 1, Jomaiza 3, Sodos 6, Sodos 7, Sakha 8) did not produce higher grain yield than Yecora rojo. Accordingly, they do not seem to be well adapted to drought more

than Yecora rojo. However, stability of these cultivars under drought has to be investigated over years and locations.

Table 1: Summary of analysis of variance for plant height, spike length, number of spiklet in spike, kernel weight, biomass, grain yield of wheat varieties under different levels of irrigation with three replicates.

Source of variation	D.F.	plant height	spike length	spiklet in spike	kernel weight	biomass	grain yield
1997/98							
Irrigation (I)	2	N.S	N.S	N.S	*	N.S	N.S
Cultivar I	5	***	***	***	***	***	*
I X C	10	N.S	N.S	N.S	N.S	N.S	N.S
1998/99							
I	2	N.S	N.S	—	*	—	N.S
C	5	***	***	—	***	—	N.S
I X C	10	N.S	N.S	—	N.S	—	N.S
1999/00							
I	2	N.S	N.S	N.S	N.S	N.S	*
C	5	***	***	***	***	*	***
I X C	10	*	N.S	N.S	N.S	N.S	N.S

*, **, *** : Significant at the 0.05, 0.01 and 0.005 probability levels, respectively. N.S : Notsignificant.

Table 2: Summary of combind analysis of variance for grain yieldof wheat varieties under different levels of irrigation with three replicates in the three seasons (1997/89, 1998/99 and 1999/00)

Source of variation	D.F.	Grain yield	L. S. D.
Season (S)	2	**	0.27
Irrigation (I)	2	*	0.27
Cultivar I	5	**	0.58
I X C	10	N.S	-
S X I	4	**	-
S X C	10	N.S	-
S X I X C	20	N.S	-

*, **, *** : Significant at the 0.05, 0.01 and 0.005 probability levels, respectively. N.S : Notsignificant.

Table 3: Grain yield (t h-1), biomass (t h-1), weight of 1000 kernels (gm) , Number of spiklet in spike, spike length (cm) and plant height (cm) of wheat varieties under different levels of irrigation with three replicates in 1997/98.

Cultivar	Grain yield	Biomass	Kernel weight	No.spiklet in spike	Spike length	Plant height
Sahel 1	6.15	9.0	43.4	21	10.8	99
Jomiaza 3	5.16	7.5	66.0	18	10.0	107
Sodos 6	4.28	5.7	54.7	19	14.9	94
Sodos 7	4.39	6.4	54.0	19	14.3	93
Sakha 8	6.09	8.5	42.1	18	9.4	93
Yecora rojo	5.98	7.2	41.8	16	9.6	62
L.S.D.	0.15	0.14	2.7	0.13	1.2	5.8

Table 4: Grain yield (t h-1), weight of 1000 kernels (gm), spike length (cm) and plant height (cm) of wheat varieties under different levels of irrigation with three replicates in 1998/99.

Cultivar	Grain yield	Kernel weight	Spike length	Plant Height
Sahel 1	4.30	43.3	9.3	84
Jomiaza 3	4.34	52.9	10.7	94
Sodos 6	4.10	44.4	13.6	89
Sodos 7	4.43	44.6	14.3	86
Sakha 8	4.76	42.2	9.0	84
Yecora rojo	5.10	40.1	10.6	71
L.S.D.	N.S.	2.5	1.1	7.5

Table 5: Grain yield (t h-1), biomass (t h-1), weight of 1000 kernels (gm) , Number of spiklet in spike, spike length (cm) and plant height (cm) of wheat varieties under different levels of irrigation with three replicates in 1999/2000.

Cultivar	Grain yield	Biomass	Kernel weight	No.spiklet in spike	Spike length	Plant height
Sahel 1	5.87	9.00	38.9	47.9	10.5	85
Jomiaza 3	3.90	7.55	57.6	39.9	10.4	85
Sodos 6	4.50	5.76	49.2	63.6	12.3	76
Sodos 7	3.97	6.39	51.1	65.3	12.9	79
Sakha 8	4.72	8.52	38.0	43.8	8.6	74
Yecora rojo	5.56	7.06	47.7	45.0	10.6	63
L.S.D.	0.96	2.63	3.0	8.9	1.5	9.3

Table 6: Means of grain yield (t h-1) for six cultivars of wheat under different irrigation levels.

Irrigation treatment	1997/98	1998/99	1999/00	Mean
Normal ET (W1)	5.60	4.57	5.04	5.07
0.8 of ET (W2)	5.35	4.46	4.99	4.93
0.6 of ET (W3)	5.01	4.52	4.21	4.58

Table 7: Effects of irrigation and cultivars on grain yield (t h-1) for wheat crop grown in Riyadh during three seasons (1997/89, 1998/99 and 1999/00).

Cultivar	Normal ET (W1)	0.8 of ET (W2)	0.6 of ET (W3)	Mean
Sahel 1	5.93	5.16	5.06	5.38
Jomiaza 3	4.85	4.43	4.12	4.47
Sodos 6	5.07	4.95	4.33	4.78
Sodos 7	4.89	4.55	4.57	4.67
Sakha 8	5.31	4.88	4.46	4.98
Yecora rojo	5.56	4.54	4.62	4.91

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