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Full Length Research Paper

The effect of different sowing patterns and deficit irrigation management on yield and agronomic characteristics of sweet corn

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Water stress restricts crop yields in both the arid and semi-arid zones of the world. The responses of sweet corn (*Zea mays*) to irrigation frequency and sowing patterns were studied in the field from December 2005 to December 2006. This research was laid out in split plot, with water quantity as main plot and sowing patterns as subplot in three replications. The treatments consisted of two irrigation times (6 and 10 days) and six levels of planting patterns (full irrigation in single row, changeable alternative irrigation in single row, full irrigation in double row, changeable alternative irrigation in double row, fixed alternative irrigation in single row and fixed alternative irrigation in double row pattern). The results show that, both biomass and stem fresh weight was affected by irrigation regimes, with normal irrigation treatments accounting for the highest. The effect of sowing patterns on all measured traits were significant at 1% level with the exception of plant height, ear depth, number of seeds/ear row and number of seeds/row. The results further demonstrate that water consumption in alternative furrow irrigation trait was worthwhile (35%) in contrast with control treatment. Although, the degree of decline in yield when compared with the control group was 3.4 and 5.2%, respectively, it was not statistically significant. The practice of alternative furrow irrigation may be recommended as a suitable farming method in northern Iran due to the benefits associated with it in terms of weeds reduction and providing soil ventilation.

Key words: Deficit irrigation, double row, furrows irrigation, planting pattern, sweet corn.

INTRODUCTION

Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Plants adapt to water deficits by many different mechanisms including changes in morphology, altered patterns of development as well as a range of physiological and biochemical processes. The general response of plants to salinity is obvious in their growth reduction (Romero et al., 2001; Ghoulam et al., 2002). Water scarcity and low quality of soil and water resources are factors associated with loss of production in arid and semi arid regions. In this condition, application of deficit irrigation is the most important alternative for decreasing detrimental effects arising from water shortage. However, producers should pay particular attention to selecting the appropriate species to meet their need (Qureshi et al., 2007). Various irrigation strategies have been adopted by farmers in the arid and semi-arid regions, but none have proved to be sufficient to achieve the required return for production of sweet corn. Information is therefore, required on the growth and yield responses of sweet corn to variable water inputs. More studies are also needed to have a better understanding of planting management of the crop. Hence, the objective of this study was to determine the effects of irrigation treatments on the growth, yield and water use efficiency

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(WUE) of sweet corn on an alluvial soil in a semiarid environment.

MATERIALS AND METHODS

A field experiment was conducted in 2006 at Gorgan Agricultural Research Centre, Northern Iran. The experiment was laid out in a randomized complete block design arranged in split plot with water quantity as main plot and water sowing patterns as subplot in three replications (Figure 1). The experiment consisted of 12 treatments outlined as follows: two levels of irrigation water [I1 = normal irrigation (every 6 days as control), I2 = irrigation stress (every 10 days)] and six levels of planting patterns (P1 = full irrigation in single row, P2= changeable alternative irrigation in single row, P3= full irrigation in double row, P3 = changeable alternative irrigation in double row, P5= fixed alternative irrigation in single row and P6= fixed alternative irrigation in double row). The amount of water required for the irrigation of each treatment was calculated using the following equation as outlined by Muhammad et al. (2008):

V = SMD×A

Where, V = volume of water to be applied (mm); A = plot area = πr^2.

SMD = (θ_{FC} - θ_i) D × Bd /100:

Where, SMD = sSoil moisture deficit; θ_{FC} = gravimetric soil moisture content at field capacity (%), θ_i = soil moisture content before irrigation in percent by volume; D = rooting depth (cm); Bd = bulk density (in this soil 1.5 g cm^{-3}).

The distance between furrows was 75 cm and the space among bush's on the furrow double row arrangement was 20 cm. Soil pH, Ca, Mg, Na, electrical conductivity (EC), cation exchange capacity (CEC), organic carbon (OC), field capacity (FC) and permanent welting point (PWP) were measured before and after the completion of the experiment. Data were analyzed using SAS by the proc. GLM procedure.

RESULTS AND DISCUSSION

The results show that, deficit irrigation affects total biomass, stem fresh weight and ear length. The planting pattern was found to affect the ear height, plant height, total biomass, ear length, grain weight, husked fresh weight, ear cob weight and ear weight of the sweet corn (Table 1). Also, the results show that ear height, grain weight and ear weight, husked fresh weight, stem fresh weight, leaf fresh weight, cob weight and stem diameter effects under planting patterns and deficit irrigation and with changing planting pattern from single row to double row, above the studied parameters increased (Tables 1 and 2). When irrigation was delayed from normal to four days stress, the yields and yield components were found to decrease (Table 3). Biomass and ear weight are two important parameters in sweet corn. The best time for harvesting ear is between the doughing and milking stages to properly conserve the green shrub used as forage. The interaction effects elucidated further yields and yield components obtained from the control treatment, with the highest biomass and ear yield produced on double row normal irrigation treatment with 34.01 and 9.456 ton ha^{-1}, respectively. It can be concluded that, the use of double row planting pattern and changing arrangement of water consumption will be decreased due to shading and decrease amount of evaporate. Therefore, WUE will be increased (Table 3). Similar results were reported by Graterol et al. (1993) and Shazhong et al. (2000).

Crop productivity in semiarid environments largely depends on water availability. Growth and dry matter accumulation of sweet corn decreased as soil water deficits developed. Rosenthal et al. (1987) reports ad-verse effects on stem height, cumulative leaf area, leaf area indices and biomass production of sorghum as soil water deficits developed. Water deficits also affected total number of leaves, rates of individual leaf emergence from the whorl, leaf extension and senescence of sorghum (Arkin et al., 1983). All of these components are significant in determining the leaf surface area for assimilate production and transpiration. Data from this study show that sweet corn yield was significantly increased (9456 $kgha^{-1}$) with light and more frequent irrigation (six-days full irrigation in double row). Similar results were obtained by Abdel (1982) for the same crop grown on salt-affected soils in the same region. In this study, the WUEs obtained for the lightly and frequently watered sweet corn plants were higher than those reported by Abdel (1982) for the same variety in northern Sudan. Although, larger volumes of water were used in this investigation than in the two previous studies, the higher WUEs obtained here may have been due to the enhancement of dry matter yields by irrigation. Plants adapt to water deficits by many different mechanisms including changes in morphology, altered patterns of development as well as a range of physiological and biochemical processes (Sinaki et al., 2004). Optimum use of agricultural water requires field research, which considers legal and water use patterns in each region. In order to reach this objective, field data such as crop yield, different levels of irrigation, water and irrigation management is necessary. Deficit irrigation is an effective method for alleviation of drought impacts on crop yield. It also save considerable amount of water without significant effect on crop yields (Macon et al., 2002). The impact of different sorghum density on stresses under good water quality produced similar trend to the impact of salinity under low density (Ould Ahmed et al., 2007). Water potential, relative water content, root and shoot growth declined with the severity of the water deficit (Sinaki et al., 2004).

Study of crop response to water stress, planting arrangement and long-term effects of distributing water in soil profile are necessary. The heavily and infrequently watered sweet corn plants were found to reduce dry matter, LAIs and biomass accumulation. This, nevertheless, was found to increase WUEs. It is therefore, recommended that in semiarid environments (saving water is very crucial or important), sweet corn should be watered heavily and infrequently to get high WUEs (6.58).

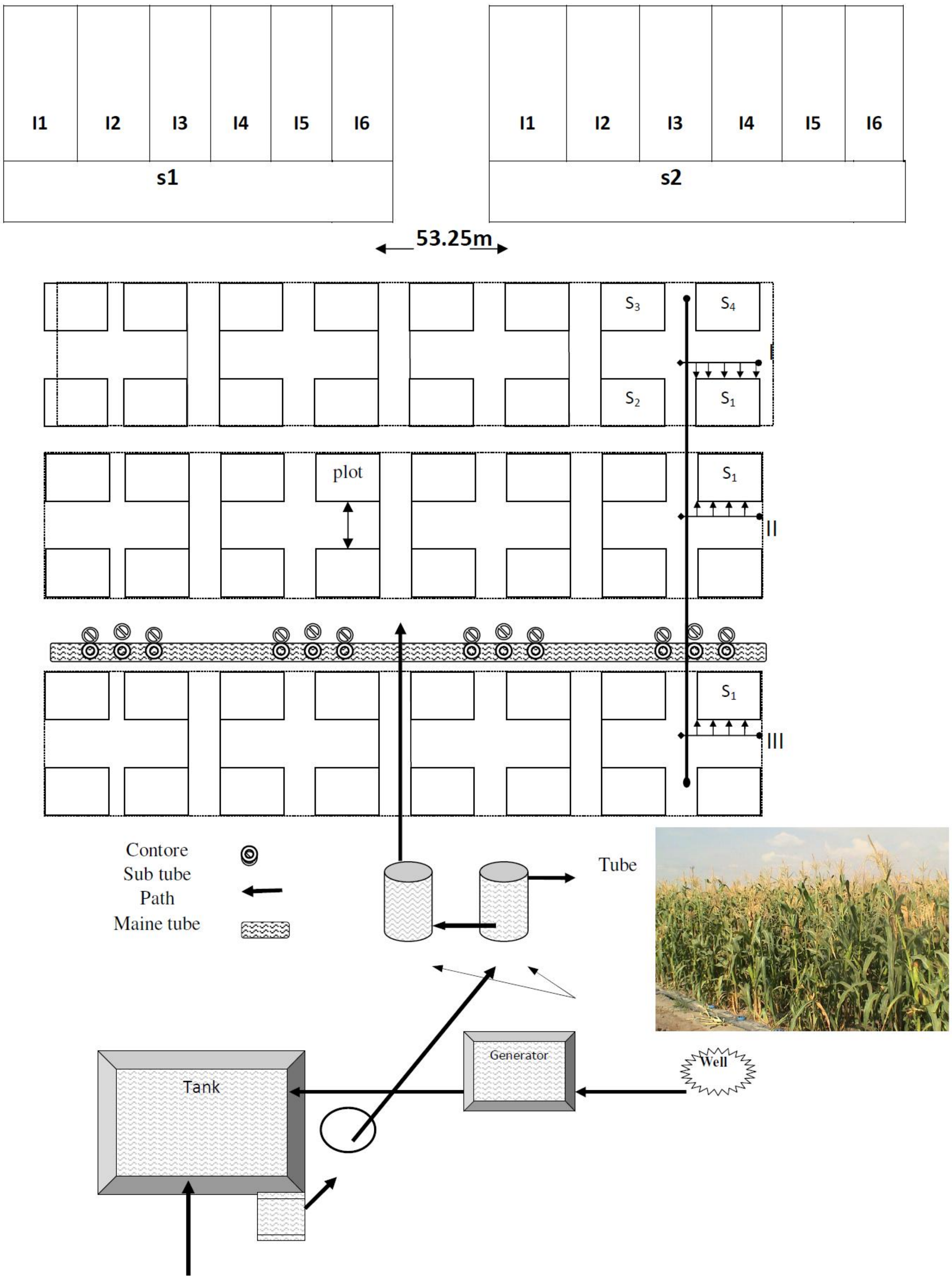

Figure 1. Plan and practice flowchart at the field.

Table 1. ANOVA of mean square for sowing patterns and deficit irrigation management on yield and some agronomic characteristics of sweet corn.

Source of variation	DF	Plant height	Ear diameter	Husked fresh wt.	Stem fresh weight	Leaf fresh weight	Number of leaves	Ear cob weigh
Replication	2	101.67ns	998.31ns	219617.1 ns	3648162.9*	385868.6ns	23706562500ns	340647387ns
Irrigation regime	1	5.84ns	118.774ns	6136.1ns	122012645.3**	6725204.5ns	189062500 ns	8190186.068ns
Error	2	82.50	1.621	121754.4	4743320.4	470115.7	1314062500*	1906746.683
Planting pattern	5	86.49**	6.708ns	316870.2**	17384324.3	1038367.4ns	2676562500	688097.994**
Irrigation r.×Planting p.	5	52.05*	14.812ns	1244094.3**	38123554.6**	421826.4**	3256562500	987850.227*
Error(E)	20	14.27	4.479	178190.275	7431220.5	944826.4	761562500	381067.076
CV (%)		6.89	5.57	18.30	22.03	22.41	3.86	27.12

Source of variation	DF	Ear height	Number of kernel in row	Number of row in ear	Ear length	Stem diameter	Biomass weight	Total ear weight	Ear grain weight
Replication	2	1178.77ns	0.15ns	3.25 ns	7.05ns	810.45ns	30771433.5ns	1683808.7ns	273163.0ns
Irr.Re.	1	40.32ns	2.99ns	7.22ns	21.26**	72.50ns	232561507.1*	23248306.9ns	1840363.5ns
Error	2	660.49	9.69	3.36	1.04	14.55	6978230.7	7865499.3	1631111.9
P. P.	5	263.16**	12.47ns	0.39ns	11.20**	7.87ns	74543476.3**	4720618.5**	998188.6**
Irr.Re.× P. P.	5	138.33*	6.95ns	1.49ns	6.85ns	15.55*	39643978.2ns	4492461.6**	6883190.0*
Error(E)	20	54.02	8.41	0.72	2.22	5.82	18096446.9	906907.0	192955.0
CV (%)		5.23	12.40	6.33	11.47	9.98	16.89	13.43	21.79

Irr. Re. = Irrigation regime; P. P. = planting pattern. ns,* and **respectively are; non significant, significant at 5% level and significant at 1% level table.

Table 2. Mean comparison of the some agronomic characteristics of sweet corn on deferent sowing patterns and deficit irrigation.

Treatment	Plant height (cm)	Ear height (mm)	Husked fresh weight (kg/h)	Stem fresh weigh t(kg/h)	Leaf fresh weight (kg/h)	Stem diameter (mm)	Ear cob weight (kg/h)	Total ear weight (kg/h)	Ear grain weight (kg/h)
Gim × irrigation re Planting pattern									
6-day full irrigation in single rows	140.3bcd	53.5bcd	10590cd	2258abc	38.55bc	23.5bc	2785abc	8519ab	2680ab
6-day changeable alternative irrigation in single rows	136.3cd	49.5cd	19810a	2730a	36.67bcd	19.87c	2672abc	8259abc	2448abc
6-day full irrigation in double row	151.5ab	58.17ab	1678ab	2643ab	37.27bcd	22.87bc	3019ab	9456a	2876a
6-day changeable alternative irrigation in double row	134.7cd	54.33bcd	13540bc	2204cd	35.04cd	23.25bc	2103bcd	7181bc	1628cd
6-day fix alternative irrigation in double row	154.7c	64.9a	14080bc	2668cd	35.67cd	23.21bc	3804a	7208bcd	1848bcd
6-day fix alternative irrigation in single row	131.7d	51.5bcd	10480cd	1888bcd	33.94d	23.87bc	2164bcd	6739bcd	1974bcd

Table 2. Contd.

10-day irrigation in single rows	141.2abcd	56.27bc	13170bc	2668ab	37.65bcd	28.78a	2218bcd	7644bcd	2273abcd
10-day changeable alternative irrigation in single row	128.5d	48.67d	7112d	1301d	38.74bc	27.30ab	1045b	3533e	818.7e
10-day irrigation in double row	141.7abcd	58.11ab	1288ab	2588ab	40.46ab	27.00ab	1795cb	6947bcd	2171abcd
10-day changeable alternative irrigation in double row	147.7abcd	58.67ab	11220cd	2589ab	38.11bc	23.17ab	2082bcd	6559cd	1537de
10-day fix alternative irrigation in double row	142.4abcd	52.5bcd	10010cd	1483ab	43.32a	23.35bc	1742cd	6379d	2214abcd
10-day fix alternative irrigation in single row	135cd	53.4bcd	8902cd	2037ab	40.65ab	24.01bc	1913bcd	6657cd	1726cd
LSD (5%)	12.52	6.435	4643	719	3.605	4.111	1051	1622	748.2

Treatment	Total biomass weight (kg/h)	Ear length (cm)
On time irrigation(6-day)	27730a	13.77a
Irrigation with 4-day interval(10-day)	22640b	12.33b
LSD (5%)	622.6	0.2412
Planting pattern		
Full irrigation in single rows	26250abc	11.66b
Changeable alternative irrigation in single rows	21420bc	12.83b
Full irrigation in double rows	30190a	13.13b
Changeable alternative irrigation in double row	26740ab	11.74b
Fixed alternative irrigation in single row	25680abc	13.22b
Fixed alternative irrigation in double row	20810c	15.42b
LSD (5%)	5133	1.713

Means followed by the same letter in each column are not significantly different at 5% level by LSD's.

Table 3. Effect of irrigation frequency on yield, total amount of water applied and water use efficiency (WUE).

Irrigation schedule	Days after treatment								Biomass (tonh^{-1})	Total amount of water applied (m^3)	WUE (%)
	6	13	19	25	31	37	43	49			
Liter water											
I1P1	0.4	0.42	0.52	0.68	0.75	0.95	0.9	0.8	24.78	5.42	4.57
I1P2	0.4	0.43	0.55	0.71	0.84	0.95	0.92	0.85	27.62	4.65	5.93
I1P3	0.4	0.42	0.54	0.7	0.79	0.95	0.94	0.84	34.01	5.57	6.10
I1P4	0.4	0.43	0.53	0.69	0.77	0.96	0.91	0.81	28.44	4.50	6.32
I1P5	0.4	0.41	0.52	0.68	0.75	0.95	0.89	0.8	28.97	4.40	6.58
I1P6	0.4	0.42	0.54	0.68	0.75	0.95	0.9	0.82	22.53	4.46	5.05

Table 3. Contd.

Days after treatment	10	21	31	41	51			
I2P1	0.6	0.93	1.22	1.28	0.99	27.72	5.02	5.52
I2P2	0.6	0.88	0.92	0.94	0.89	15.23	4.23	3.60
I2P3	0.6	0.92	1.12	1.17	0.99	26.37	4.80	5.49
I2P4	0.6	0.86	0.90	0.92	0.89	25.04	4.17	6.00
I2P5	0.6	0.84	0.90	0.92	0.87	22.39	3.94	6.41
I2P6	0.6	0.90	1.15	1.22	0.93	19.10	4.01	4.76

I1= Normal irrigation (6 days as control); I2 = four days stress in irrigation; P1= full irrigation in single row pattern; P2 = changeable alternative irrigation in single row pattern; P3 = full irrigation in double row pattern; P4 = changeable alternative irrigation in double row pattern; P5 = fixed alternative irrigation in single row pattern; P6 = fixed alternative irrigation in double row pattern.

This is in contrast to Saeed and El-Nadi (2004) who suggested using light frequency to get high WUEs. Our result also supports the previous work of Abdel Magid (1982) who reported decreased dry matter yield of forage sorghum using infrequent irrigation. Dry matter yields found in our study were comparable to those found by Ferraris and Charles-Edwards (1986) for forage sorghum in Australia. Thus, the following recommendations are given to enhance sweet corn production with respect to water stress management: (1) competitive potential of sweet corn on the early seedling growth and growth stages should be identified; (2) relative water stress and physiological responses of sweet corn cultivars should be explained. It is worthy to note that, comprehensive monitoring of growth and physiological parameters have rarely been used to select plants with better yields in water deficit environment.

Conclusion

Overall findings show that deficit irrigation affects the growth and quantity of sweet corn. The results reveal that, water consumption in treatments with the alternative furrow irrigation was statistically significant ($p < 0.01$) when compared with the control conditions. In addition, although the degree of the decline in terms of yield in comparison to the control group was 3.4 and 5.2%, respectively, it exhibited no statistical significance. Since adoption of alternative furrow irrigation in the north of Iran tends to cause weed reduction, soil ventilation, low energy consumption, fair wear and tear of machinery and increase in WUE, this type of irrigation is recommended as a suitable method.

REFERENCES

Abdel MM (1982). Effects of irrigation interval, urea and gypsum on N, P and K uptake by forage sorghum on highly saline-sodic clay. Exp. Agric. 18(2): 177-182.

Arkin GF, Rosenthal WD, Jordan WR (1983). A sorghum leaf area model. ASAE Tech paper 83-2098. Am. Soc. Agric. Eng. St Joseph, Mich. 25 pp.

Ferraris R, Charles-Edwards DA (1986). A comparative analysis of the growth of sweet and forage sorghum crops. I. Dry matter production, phenology and morphology. Aust. J. Agric. Res. 37:495-512.

Ghoulam C, Foursy A, Fares K (2002). Effects of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. Environ. Exp. Bot., 47:39-50.

Graterol YE, Elisenhauer DE, Elmore RW (1993). Alternate-Furrow irrigaton for soybean production. Agric. Water Manage. 24(2):133-145.

Macon D (2002). Grazing for Change: Range and Watershed Management Success Stories in California. California Cattlemen's Assoc. Sacramento, CA, p. 36.

Muhammad A, Haji Kh, Ahmad H, Muhammad A, Ejaz A, Muhammad A (2008). Effec of available soil moisture depletion levels and topping treatments on growth rate total dry biomass in chickpea. J. Agric. Res. 46(3):229-243.

Ould ABA, Yamamoto T, Inoue M, Dehghanisanij H (2007). Evaluation of Sorghum Density As Affected By Two Water Quality under Drip Irrigation System. ISSN 1553-345X. Am. J. Environ. Sci. 3(4):240-245.

Qureshi AS, Qadir M, Heydari N, Turral H, Javadi A (2007). A review of management strategies for salt-prone land and water resources in Iran. International water management Institute, 30P (IWMI working paper 125) Colombo, Sri Lanka. 24 pp.

Romero AR, Soria T, Cuartero J (2001). Tomato plant-water uptake and plant-water relationships under saline growth conditions. Plant Sci., 160:265-272.

Rosenthal WD, Arkin GF, Shouse PJ, Jordan WR (1987). Water deficit effects on transportation and leaf growth. Agron. J. 79:1019-1026.

Saeed AM, El-Nadi AH (2004). Forage sorghum yield and water use efficiency under variable irrigation. Irrigation Sci., 18(2):67-71.

Shazhong K, Shi W, Zhang Z (2000). An improved water use efficiency for maize grown under regulated deficiated deficit irrigation. Field Crops Res. 67:207-214.

Sinaki JM, Nourmohammadi Gh, Maleki A (2004). Effect of water deficit on seedling, plantlets and compatible solutes of forage sorghum cv. Speed feed. 4th International Crop Science Congress. Brisbane, Australia, 26 Sep – 1 Oct 2004 | ISBN 1 920842 20 9 | www.cropscience.org.au.