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Responses of Various Corn Cultivars under Supplementary Irrigation Management

Marjan Zohrabi*, Ebrahim Amiri* and Parisa Shahinrokhsar**
**Department of Agriculture, Lahijan Branch, Islamic Azad University, Lahijan, IRAN*
***Agricultural Research, Education and Extension Organization. Gilan, IRAN*

(Corresponding author: Ebrahim Amiri)
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ABSTRACT: This project was executed in a split-plot experiment using the randomized complete block design with four replications in the research field at the Gilan Agriculture and Natural Resources Research Center to evaluate the effects of various irrigation regimes on three single cross hybrids in corn. The major factor was the irrigation treatment (one irrigation before flowering, one irrigation at flowering and one at seed filling stages, no irrigation or rainfed farming), and the minor factor the cultivars (the single cross hybrids 704, 260, and 400). The three irrigation regimes and the three cultivars had significantly different effects on seed yield at the 5% and 1% probability levels, respectively. Comparing the means of irrigation regimes showed the maximum yield (6580 kg/ha) belonged to the treatment of irrigation at flowering and at seed filling stages and the minimum (4888 kg/ha) to the treatment of irrigation before flowering. Irrigation at flowering and seed filling stages increased yield and yield components, while the hybrid SC704 was the suitable cultivar under water stress conditions.

Keywords: Corn, seed yield, two irrigations, no irrigation, hybrid

INTRODUCTION

Corn is a main cereal in humid and sub-humid tropical regions, but it can also be grown in cold areas due to its high adaptability (Ulger *et al.,* 1997). Corn has deep roots and also good ability to absorb nutrients and, therefore, does not require very fertile soils. It can be grown in various soils but deep soils with average texture, good drainage, and high water retention capability are best for its cultivation. Droughts mainly occur during the flowering stage of corn, and drought stress is one of the main factors reducing corn production in regions with limited water resources. Drought is also one the major dangers facing successful corn production in Iran and other less developed countries. Droughts happen when a combination of physical and environmental factors create drought stress for plants (Sarmadnia and Koochaki, 2002). Azari Nasrabadi (1999) stated that, under irrigation conditions, phenological characteristics such as those of leaves, stem diameter, plant height, and number of seeds per row of corncob, could be important indices in selecting corn hybrids with high yields. Rashidi (2005) studied the effects of drought stress on various growth stages of corn and concluded that drought stress during vegetative growth affected seed yield the least while it influenced seed yield the most during reproductive growth. Curran and Posch (2000) reported that a good forage crop should have a large dry matter yield, a high level of energy content, and a low fiber percentage to be fermented desirably in silos and to be stored. These characteristics, except for protein content, are better in corn compared to other forage crops. Panda *et al.* (2004) conducted an experiment to study the effects of five irrigation treatments on corn, and evaluated moisture distribution in soil profile using a neutron probe. They found that soil water depletion should not exceed 45% of available soil moisture at any growth stage of corn. Based on results of an experiment carried out by Doorenbas and Kassam (1979), maximum corn seed yield was achieved after about 60% of available soil water was depleted. Stockle and James simulated four strategies of under-irrigation on forage corn yield and concluded that a slight reduction in irrigation resulted in higher yields and economic advantages compared to full irrigation. In a study conducted in Zimbabwe, it was shown that reducing the total volume of irrigation water in corn by 59%, and increasing area under its cultivation by using the saved water, would increase total corn production by 68% (English and Raja, 1996). Purpose of the research is (i) To minimize drought stress through increasing the amount of irrigation in order to obtain maximum seed yield (ii) To assess responses of various corn cultivars to irrigation treatments.

MATERIALS AND METHODS

This project was executed in the experimental field at the Gilan Agriculture and Natural Resources Research Center, with latitude of 37°11" north and longitude of 49? 38" east, and altitude of -7, situated in Rasht in the cropping year 2013.

Three single cross hybrids in corn were planted in split plots using the randomized complete block design with 4 replications. The three major factors were the irrigation treatments (one irrigation before flowering, one irrigation at flowering and one at seed filling stages, and no irrigation or rainfed farming). The minor factors were the cultivar treatments (single cross hybrids 704, 206, and 400, which are late-maturing, intermediate-maturing, and early-maturing cultivars, respectively). Each plot had an area of 9m2 and contained 5 cultivation rows each 2 m long, with 75 cm between adjacent lines and 20 cm between plants on each row. Three seeds were sown in each hill, and thinning was performed at the 5-7 leaf stage leaving one plant in each hill. There was a 1-meter border between plots and between treatments. Based on water depletion, and according to the mentioned treatments, the required volume of water for the soil to reach the FC level was calculated and the needed water for each plot was measured using a volumetric counter. Moreover, soil water content before and after irrigations were determined using the gravimetric method: samples were taken from the area of root expansion, and were weighed and then dried in an oven at 110 C° for 24 hours. Depth of irrigation water required to raise soil water at the depth of rooting to field capacity (FC) was determined for each irrigation treatment using the following relation:

$$d = (\theta_{FC} - \theta_i) \times A_s \times D_z$$

In the above relation, θ_i and θ_{FC} are soil moisture before irrigation and soil moisture at field capacity, respectively, Pb soil bulk density (g/cm^3), Pw specific gravity of water (g/cm^3), Dx and root depth (mm). Urea, potassium sulfate, and concentrated superphosphate were applied at 184, 75, and 46 kg/ha, respectively. The K and P fertilizes together with 1/3 of urea were disked into the soil before planting. The rest of urea was added to the soil as a top-dressing at the 6-7 leaf stage. The studied parameters were stem diameter, number of plant/m^2, number of cobs per m^2, and seed yield. ANOVA and comparison of the means of the treatments were performed at the 1 and 5% probability levels using SAS 9.1 and Duncan's test. Excel 2003 was employed to draw the diagrams.

RESULTS AND DISCUSSION

A. Stem diameter

Based on results of ANOVA regarding stem diameter, the effects of various levels of irrigation and of cultivars and their mutual effects on stem length were not significantly different. Pandy *et al.* (2000) stated that applying drought stress at various growth stages of corn generally reduced seed yield, number of seeds/cob, 1000-seed weight, stem diameter, and plant height.

B. Number of seeds/m^2

The effects of the various hybrids and the mutual effects of irrigation and cultivars on number of plants /m^2 were significant at the 5% probability level. Comparison of the means of cultivars under various irrigation conditions showed that the hybrids exhibited different responses: SC704 had the maximum number of plants/m^2 while SC206 had the minimum. Moreover, comparing the means of the mutual effects of the various irrigation regimes and cultivars on the number of plants/m^2 indicated the 11V3 and 12V2 treatments had the largest and the 11V2 treatment the smallest number of plants/ m^2.

C. Number of cobs/m^2

The ANOVA table shows the effects of various irrigation regimes, and the mutual effects of irrigation regimes and cultivars, on number of cobs/ m^2 were significant at the 5% probability level. The effects of the three irrigation regimes on number of cobs/ m^2 were significantly different at the 5% probability level. Based on comparison of the means of various irrigation regimes, the maximum number of cobs/ m^2 (7.94) was that of irrigation at flowering and at seed filling stages and the minimum (6.35) that of irrigation before flowering. Moreover, comparison of the means of the mutual effects of various irrigation regimes and cultivars on number of cobs/ m^2 indicates the 12V2 treatment had the largest number (9) and the 11V2 treatment the smallest number (5.32) of cobs/m2. The minimum number of cobs/ m^2 was observed in the treatment of irrigation before flowering because the low soil water potential at the seed filling stage reduced the total dry weight of cobs compared to the other two irrigation treatments. Results indicate that the number of cobs/ m^2 in the treatment of no irrigation was higher compared to the treatment in which irrigation was carried out before flowering. Rafiei *et al.* (2002) also stated that drought stress had a negative effect on growth and development of reproductive organs leading to reductions in yield components including number of cobs per unit area, number of seeds per row in each cob, 1000-seed weight and, finally, in seed yield.

D. Leaf area index

The effects of various levels of irrigation, of the different hybrids, and their mutual effects on leaf area index (LAI) were significant at the 5, 1, and 1% probability levels, respectively. The highest LAI (3.11) belonged to the treatment of irrigation at flowering and at seed filling stages and the lowest (2.36) to the treatment of no irrigation. Comparison of the means shows that the SC704 hybrid had the maximum (3.76) and the SC400 hybrid the minimum LAI (1.34). Moreover, the mutual effects of various irrigation regimes and cultivars on LAI indicate that the highest LAE (4.70) belonged to the 12V3 treatment and the lowest (1.62) to the 12V1 treatment. The SC704 hybrid had lower LAI in the treatment of no irrigation. Insufficient available water during plant growth reduces LAI and slows down crop growth rate significantly.

Table 1: Variance analysis of yield and yield component of corn.

S.O.V.	df	MS				
		Seed Yield	Number of cobs/m^2	Leaf area index	Number of seeds/m^2	Stem diameter
Replication	3	4506/20	4/36	^{ns} 0/37	0/54	12/08
[Irrigation	2	**94291/75	*7/53	*1/67	^{ns} 3/11	^{ns} 0/25
Error a	6	13628/31	0/89	0/24	1/85	7/53
Variety	2	**122826/26	^{ns} 2/29	**11/34	*5/44	^{ns} 4/24
Irrigation ×Variety	4	^{ns} 24736/90	*5/18	**1/24	*3/90	^{ns} 4/90
Error a×b	18	9142/33	1/71	0/21	1/19	3/71
CV	-	16/24	18/25	17/04	11/47	14/43

*, **, Significantly at the 5% and 1% levels of probability, respectively; ns, non significant.

Table 2. Mean comparison of yield and yield component of corn.

Treatment	Seed Yield	Leaf area index	Number of cobs/m^2	Number of seeds/m^2	Stem diameter
I_1	b 4888	AB 2/69	^{b} 6/35	^{a} 9/41	^{a} 13/19
I_2	a 6580	A 3/11	^{a} 7/94	^{a} 10/08	^{a} 13/45
I_3	a 6192	B 2/36	^{ab} 7/20	^{a} 9/08	^{a} 13/44
V_1	b 5847	C 1/84	^{a} 7/66	^{ab} 9/41	^{a} 13/86
V_2	c 4895	B 2/56	^{a} 6/85	^{b} 8/91	^{a} 12/70
V_3	a 6918	A 3/76	^{a} 6/97	^{a} 10/25	^{a} 13/51
I_1V_1	a 4432	C 1/87	^{abc} 7/00	^{abc} 9/75	^{a} 14/05
I_1V_2	a 4425	B 2/75	^{c} 5/32	^{c} 8/00	^{a} 12/41
I_1V_3	a 5807	B 3/45	^{bc} 6/75	^{a} 10/50	^{a} 13/11
I_2V_1	a 6736	C 1/62	^{ab} 8/32	^{ab} 10/00	^{a} 12/76
I_2V_2	a 5997	B 3/02	^{a} 9/00	^{a} 10/50	^{a} 12/94
I_2V_3	a 7006	A 4/70	^{bc} 6/50	^{abc} 9/75	^{a} 14/63
I_3V_1	a 6373	C 2/02	^{ab} 7/67	^{bc} 8/50	^{a} 14/77
I_3V_2	a 4265	C 1/92	^{bc} 6/25	^{bc} 8/25	^{a} 12/75
I_3V_3	a 7940	B 3/15	^{ab} 7/67	^{a} 10/50	^{a} 12/80

Mean followed by similar letters in each column, are not significant at the 5% level of probability.

Mean followed by similar letters in each column, are not significant at the 5% level of probability.

Water shortage during reproductive growth, and before pollination, influences leaf expansion and stem development, and greatly changes the quantity of materials stored in this organ. Cicchino *et al.* (2010) reported that drought stress in corn hybrids reduced pollen viability and the duration of pollination, delayed flowering, reduced plant height, decreased LAI, and, finally, reduced seed and biological yields.

E. Seed Yield

The effects of the three irrigation regimes and of the evaluated hybrids on seed yield were significant at the 5 and 1% probability levels, respectively. Comparison of the means related to various irrigation regimes indicates the maximum yield (6580 kg/ha) was achieved in the treatment of irrigation at flowering and at seed filling stages and the minimum (4888 kg/ha in the treatment of irrigation before flowering. The reason for this is that irrigation before flowering led to water shortage at the milky stage of the seed resulting in wrinkled seeds with lower final weight. This is the main factor that reduces seed yield when there is water shortage during the final growth stages. Comparison of the means of cultivars reveals that the largest seed yield (6918 kg/ha) belonged to the late maturing hybrid SC704 and the smallest to the hybrid SC260. It seems one of the reasons for the stability of the SC704 hybrid in various climates and in different years is its phenological flexibility against stresses such as drought (Enayat Gholizadeh *et al.,* 2013).

CONCLUSION

Results of mutual effects indicate that hybrids responded differently to various conditions probably because they have different rooting systems. In other words, it can be said that these hybrids respond differently to changes in methods of crop improvement or to changes in methods of improving water use. Therefore, it is recommended greater care be exercised in introducing hybrids for coping with water stress.

Based on results of this research, we can say that water stress reduced components of yield, irrigation at flowering and seed filling stages increased yield and yield components, and that the SC704 hybrid was suitable for areas facing stress resulting from water shortage because its yield components were larger in rainfed farming conditions compared to the other two hybrids.

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