EVALUATION OF SOME MAIZE HYBRIDS FOR WATER STRESS TOLERANCE

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Abstract

A field experiment was carried out at Mallawy Research Station, Field Crops Res. Inst, Agric. Res. Center, Egypt in 2010 and 2011 seasons to study the effect of water deficit at different physiological growth stages on growth and yield of maize hybrids. Twenty hybrids, i.e. (SC 10, SC 122, SC 123, SC 124, SC 128, SC 129, SC 162, SC 164, SC 166, SC 167, SC 168, SC 173, TWC 310, TWC 311, TWC 314, TWC 320, TWC 321, TWC 324, TWC 329, and TWC 352), and four water stress treatments i.e. skipping the third and fourth irrigations, skipping the fifth and sixth irrigations, skipping the seventh irrigation, and the control, (regular irrigation). Statistical design was randomize complete blocks arranged in incomplete blocks with four replications nested within blocks (water stress treatments), and hybrids were randomly distributed within water stress treatments (blocks). Results of 2010 revealed that skipping 3rd and 4th irrigations and, skipping the 7th irrigation significantly reduced number of days from planting to 50% tasseling and silking, In 2011 skipping irrigation treatments did not significantly affect tasseling and silking, and plant and ear heights. But in 2010, data presented showed that water deficit treatments i.e. (skipping irrigations 3rd and 4th, 5th and 6th irrigations and 7th irrigation) at different reproductive growth stages significantly reduced plant and ear heights compared with the control (regular irrigation), and skipping irrigation 7 was associated with the highest ear length, and number of kernel per row in both growing seasons. In contrast, skipping irrigation 3rd and 4th lead to the shortest ear length and number of kernels per row in the two growing seasons 2010 and 2011. Application of regular irrigation significantly produced the highest grain yield (34.58 and 37.4 ard fed-1), while the lowest grain yield was linked to skipping irrigations 3 and 4 . Three way cross 310 was the earliest hybrid for number of days to 50% tasseling and silking in both growing seasons. But TWC 329 recorded the latest in terms of tasseling and silking in the first and second season. TWC 321 and SC 10 had the tallest plant and ear heights, but TWC 352 was the shortest hybrid in both growing seasons. Moreover, the tallest and the shortest ear length were recorded for SC 162 and TWC 352 in both growing seasons, respectively. Single cross 129 had the highest grain yield followed by SC 10 in both growing seasons. In contrast, TWC 329 and TWC 352 recorded the lowest grain yield in both seasons. SC 129 and SC 10 were the most tolerant hybrids in terms of agronomic traits when skipping irrigation happened at 3rd and 4th , and 5th and 6th irrigations.

Keywords: Maize hybrids, Skipping irrigation.

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INTRODUCTION

Water availability is considered one of the most limiting factors to increase crop yields. Drought stress is one of the most important environmental stresses affecting agricultural productivity worldwide and can result in considerable yield reductions. Irrigated agriculture is under pressure to cut down the amount of water use for crop production and at the same time to produce more crops with less water by achieving the objective of more crops per drop of water. Water stress results in less evapotranspiration in plants due to closure of the stomata decreased biomass production (Smith et al, 2002). When the water stress is severe or occurs at the critical growth stages of a crop, the reduction in yield may be so high that the benefit and returns for water will be reduced. The subjects of deficit irrigation and the effect of moisture stress on crop production are widely reported in literatures (Jensen. 1968, Hargreaves, 1975, Doorenbos and Kassan, 1979, English et al., 1990, Howell 1990, English and Raja, 1996, and FAO, 2002). The effect of deficit irrigation for the same crop may vary with location as it very much depends on climate, which dictates the evaporative demand and soil type, which dictates the available water for plant uptake. Previous reports showed that stress during tasseling or silking was most harmful and stress during grain filling was more drastic than that during the vegetative growth stage (Grant et al 1989), Further studies demonstrated that stress during early vegetative growth was more drastic than that during the grain filling growth stage (Ahmed- Amal, and Mekki 2005), Additional data indicated that water stress during pre or post silking reduced grain yield by 9 and 10% compared with the conventional irrigation, respectively (EL-Sheikh 1994). (Vicente et al 1999) reported that the reduction in grain yield was 70% and 90% in intermediate water stress and severe water stress, respectively with grain yield fluctuating between 0.30 and 2.41 t ha-1 in severe stress. Normal irrigation and number of cobs per plant were reduced by 50% in severe stress. Moreover, the reduction in plant height was found to be 36 cm in severe stress.

Water stress is one of the major problems affecting crops production, including corn, in many parts of Egypt. Maize crop may experience reductions of grain yields when subjected to water deficit during the critical period of crop cycle from tasseling stage to initiation of grain filling. In maize, grain yield reduction caused by water stress ranges from 10 to 76% depending on the severity and stage of occurrence (Bolaòos and Edmeades 1993). Water stress at silking, tasselling, and grain filling has been reported to be more drastic on grain yield in maize than stress during vegetative phase (Grant et al., 1989). Water stress, or more generally, limited water availability is the main factor limiting crop production (Seghatoleslami et al., 2008, Golbashy et al 2010).

The objective of this study was to test water stress tolerance of maize hybrids as affected by water deficit at different physiological growth stages.

MATERIALS AND METHODS

A field experiment was carried out at Mallawy Res. Stn. in Egypt in 2010 and 2011 to study the effect of water deficit at different physiological growth stages on growth and yield of some maize hybrids. Treatments were four water stresses and twenty hybrids. Water deficit treatments, were skipping irrigations 3rd and 4th (at flowering stage), skipping irrigations 5th and 6th (at filling stage), skipping irrigation the 7th (before harvest), and the control. Hybrids were (SC 10, SC 122, SC 123, SC 124, SC 128, SC 129, SC 162, SC 164, SC 166, SC 167, SC 168, SC 173, TWC 310, TWC 311, TWC 314, TWC 320, TWC 321, TWC 324, TWC 329, and TWC 352). Statistical design was randomize complete blocks arranged in incomplete blocks with four replications nested within blocks (water stress treatments), and hybrids were randomly distributed within water stress treatments (blocks). Wheat was the previous crop in both seasons. A side dress application of 30 kg P_2O_5 and 24 kg K_2O fed^{-1} were applied for all plots. Plot size was two rows, 70 cm in width, 6 m in length and 25 cm between hills. Two to three kernels of hybrid were planted per hill, then thinned to one plant/hill at thinning. Nitrogen fertilizer (120 Kg fed^{-1}) was applied in the form of ammonium nitrate (33.5%) and split into two equal doses, where the first was applied by the first irrigation and the second was added by the second irrigation. Recorded data were,

1- Number of days from planting to 50% tasseling.
2- Number of days from planting to 50% silking.
3- Plant height (cm) measured from ground surface to the base of tassel node.
4- Ear height (cm) measured from ground surface to the node of the topmost ear.
5- Ear length and number of kernels row^{-1}.
6- Grain yield in ardab $faddan^{-1}$ (ard fad^{-1}) adjusted to 15.5 % grain moisture.

Recorded data were statistically analyzed, according (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Effect of skipping irrigations:

Effect of skipping irrigation on flowering date, plant and ear heights, grain yield and yield components in 2010 and 2011 growing seasons is presented in Table (1). Skipping irrigation 7, and skipping irrigation 3 and 4,

significantly reduced number of days from planting to 50% tasseling or silking in 2010, but all skipping irrigation did not significantly affect tasseling or silking in 2011. In this regard, Song et al. (1998) showed that water stress led to slower pollen and filament development and decreased filament fertility. Similar results were recorded by Batanouny et al. (1991), Grant et al (1989), Ahmed and Mekki (2005), and El-Sheikh (1994). Results also showed that plant and ear heights were not significantly affected by skipping irrigations in 2011. In 2010, results showed that subjecting maize plants to water deficits conditions i.e. (skipping the 3rd and 4th irrigation, the 5th and 6th irrigation, and the 7th irrigation), which represent different physiological growth stages significantly reduced plant and ear heights compared with the control. The depression in these growth parameters as a result of water deficit may be attributed to the loss of turgor which affects the rate of cell division and enlargement. Skipping irrigation treatments control (Normal irrigation), and skipping 7th irrigation were coupled with the highest ear length, and number of kernels row^{-1}, in 2010 and 2011 growing seasons. Whereas skipping of the 3rd and 4th irrigations was associated with lowest ear length and number of kernels row^{-1} in 2010 and 2011.

Table 1. Effect of skipping irrigations on number of days to 50 % tasseling, 50 % silking, plant height, and ear height in Mallawy in 2010, and 2011 seasons.

Skipping irrigations	Days to 50% tassiling		Days to 50% silking		Plant height (cm)		Ear height (cm)	
	2010	2011	2010	2011	2010	2011	2010	2011
3-4	56.1	63.0	57.0	64.4	241	248	136	140
5-6	57.4	63.1	58.4	64.4	247	252	135	145
7	55.7	62.6	56.8	63.9	249	255	138	148
control	56.1	61.5	57.1	63.4	261	256	147	149
LSD 0.05	1.0	NS	1.0	NS	8	NS	7	NS
CV %	2.3	5.3	2.2	2.3	4.4	5.0	6.4	9.0

Data presented in Table (2) show that the application of normal irrigation (control) significantly produced the highest grain yield, while the lowest grain yield was obtained by water stress at skipping the 3th and 4th irrigations in 2010 and 2011. These results are in confirmation with those of Quaranta *et al.* (1998), and Simpson (1981), who reported that the variation in yield and yield components due to water stress at different growth stages

could be ascribed to the impairment of many metabolic and physiological processes in plants.

Table 2. Effect of skipping irrigations on ear length, number of kernels row-1, and grain yield at Mallawy in 2010, and 2011 seasons.

Skipping irregations	Ear length (cm)		number of kernels row^{-1}		Grain yield (ard\fad)	
	2010	2011	2010	2011	2010	2011
3-4	16.3	20.1	35.7	39.8	25.15	25.68
5-6	19.0	21.7	39.0	43.4	28.88	30.68
7	21.0	23.4	42.2	47.6	33.77	35.87
control	21.3	23.0	42.6	45.9	34.58	37.47
LSD 0.05	0.7	0.6	1.0	1.7	1.68	2.91
CV %	4.7	4.2	3.8	7.0	9.3	8.1

Effect of hybrids:

Data in Table (3) show that significantly differences among hybrids for number of days to 50% tasseling and silking in both growing seasons were detected. Three way cross 310 was the earliest hybrid for number of days to 50% tasseling (51.2 and 56.1 days) and silking (52.2 and 57.5 days) in both seasons, respectively. Meanwhile, three way cross 329 recorded the latest hybrid for tasseling (58.9 and 65.1 days) and silking (59.8 and 66.3days) in the two seasons, respectively. The observed significant variation among hybrids might reflect partially their different genetic backgrounds. Three way cross 321 and single cross 10 showed the tallest plant height and ear height, but TWC 352 was the shortest hybrid in both seasons. Moreover, the tallest ear length was recorded for SC 162 (21.1 and 23.3 cm), and the shortest ear length was recorded for TWC 352 (16.8 and 18.9 cm) in both growing seasons.

There were significant differences among hybrids in grain yield in the first and the second seasons. The highest grain yield was obtained by SC 129 (34.58 and 36.45 ard fed^{-1}) and SC 10 (33.99 and 35.39 ard fed^{-1}) in both seasons, respectively. In contrast, TWC 329 and 352 had the lowest grain yield (26.48 and 26.22 ard fed^{-1}), in the first season and (22.40 and 22.75 ard fed^{-1}) in the second season, respectively (Table 4).

Table 3. Days to 50 % tasseling, days to 50 % silking, plant height, and ear height of the 20 hybrids averaged over water stress treatments at Mallawy in 2010 and 2011 seasons.

Hybrids	Days to 50% tassiling		Days to 50% silking		Plant height (cm)		Ear height (cm)	
	2010	2011	2010	2011	2010	2011	2010	2011
SC 10	57.9	63.5	58.9	64.8	270	268	151	158
SC 122	57.4	62.8	58.3	64.2	247	248	140	144
SC 123	56.9	63.3	57.9	64.5	253	256	139	147
SC 124	56.3	62.5	57.4	63.9	242	249	138	143
SC 128	54.6	60.7	55.6	62.2	236	251	129	135
SC 129	55.3	57.5	56.4	62.4	256	261	143	150
SC 162	57.6	63.6	58.5	64.8	258	262	143	154
SC 164	56.8	63.0	57.8	64.4	248	241	138	135
SC 166	56.3	63.1	57.3	64.4	232	245	131	138
SC 167	57.7	63.2	58.7	64.3	238	233	135	134
SC 168	56.1	62.9	57.1	64.3	231	242	131	138
SC 173	56.3	63.4	57.4	64.8	234	248	132	136
TWC 310	51.2	56.1	52.2	57.5	235	263	125	154
TWC 311	56.6	62.2	57.6	63.6	271	251	153	144
TWC 314	55.9	62.3	56.9	64.3	252	257	142	151
TWC 32o	56.2	64.3	57.2	65.6	261	264	150	156
TWC 321	57.3	64.4	58.3	65.5	271	263	153	161
TWC 324	57.5	64.8	58.5	66.1	268	264	151	154
TWC 329	58.9	65.1	59.8	66.3	260	257	143	152
TWC 352	53.8	61.8	54.8	62.9	223	231	119	126
LSD 0.05	0.9	2.3	0.9	1.0	8	9	6	9
CV %	2.3	5.3	2.2	2.3	4.4	5.0	6.4	9.0

Table 4. Ear length, number of kernels row-1, and grain yield of the 20 hybrids averaged over water stress treatments at Mallawy in 2010 and 2011 seasons.

Hybrids	Ear length (cm)		number of kernels row^{-1}		Grain yield (ard\fad)	
	2010	2011	2010	2011	2010	2011
SC 10	20.4	22.5	42.0	43.7	33.99	35.39
SC 122	18.5	21.2	38.8	44.5	30.16	34.84
SC 123	18.3	19.9	38.5	43.4	32.71	32.35
SC 124	18.5	21.6	38.5	44.4	28.79	34.50
SC 128	19.9	22.6	40.6	44.2	31.55	34.57
SC 129	19.4	21.9	39.8	45.2	34.58	36.45
SC 162	21.1	23.3	41.7	45.7	31.32	35.60
SC 164	18.7	22.2	39.2	45.1	32.29	32.34
SC 166	19.7	22.4	40.1	44.1	30.10	35.53
SC 167	19.5	22.7	40.3	44.2	31.70	34.40
SC 168	19.3	22.3	40.2	44.4	29.98	32.33
SC 173	19.7	22.4	39.8	43.2	31.48	32.54
TWC 310	19.0	22.8	39.6	44.5	28.71	32.90
TWC 311	20.4	21.9	41.0	43.1	30.42	34.11
TWC 314	19.1	23.0	39.2	43.5	29.76	33.72
TWC 32o	20.7	23.0	41.2	44.7	32.23	31.16
TWC 321	20.1	21.7	40.2	43.5	29.83	30.50
TWC 324	20.2	23.1	40.4	45.8	29.61	30.09
TWC 329	19.0	21.7	39.6	43.9	26.48	22.40
TWC 352	16.8	18.9	36.9	42.8	26.22	22.75
LSD 0.05	0.64	0.65	1.06	NS	1.98	1.83
CV %	4.7	4.2	3.8	7.0	9.3	8.1

Skipping x hybrids interaction:

In this study, grain yield of maize hybrids showed different response to skipping treatments depending on the incidence of water stress. Single cross 129 and SC 10 were the most tolerant when water stress at the (3rd and 4th), and the (5th and 6th) irrigations (Table 5), but the difference among hybrids SC 10, SC 123, and SC 128 in the first season, and SC 10, SC 124, and TWC 324 in the second season was not significant. The response of genotypes to water stress intensity and time differs according to their genetic structure and adaptability. Wenzel (1999) reported that some genotypes yielded more under moisture stress than under near-ideal moisture conditions, and the grain yield was severely reduced when water stress occurred during the reproductive stage. This may be attributed to the fact that there was accelerating leaf senescence at this stage, which resulted in shortening of the seed filling period (De Souza *et al.,* 1997). Therefore, it could be concluded that there was a differential response of maize genotypes to water stress which varies with stage at which water stress occurs. The genotypes that showed wide range of adaptation and tolerance to drought, such as SC 129, SC 10, and SC 128 could be used as water stress tolerant maize hybrids.

Table 5. Effect of skipping irrigation on grain yield of maize hybrids at Mallawy in 2010, and 2011 seasons.

Hybrids	skipping irrigation, 2010				skipping irrigation , 2011			
	3-4	5-6	7	control	3-4	5-6	7	control
SC 10	27.71	31.21	37.41	39.65	28.11	34.10	39.45	39.93
SC 122	25.96	27.02	33.74	33.92	26.61	34.22	35.85	42.67
SC 123	27.89	29.81	35.34	37.82	27.34	30.62	35.37	36.07
SC 124	23.95	27.43	32.36	31.43	27.58	33.54	36.87	40.04
SC 128	29.10	28.31	36.35	32.43	26.88	31.92	40.73	38.77
SC 129	29.30	31.07	38.06	39.91	31.16	35.98	36.87	41.78
SC 162	27.23	27.53	35.76	34.75	27.66	32.92	37.77	44.04
SC 164	24.50	30.90	37.67	36.10	23.78	32.00	34.23	39.36
SC 166	23.98	28.67	33.27	34.48	27.32	33.32	39.44	42.03
SC 167	26.02	28.41	37.47	34.92	29.28	31.97	35.32	41.05
SC 168	22.49	27.33	35.01	35.09	27.10	30.60	34.69	36.95
SC 173	25.17	28.58	36.18	35.99	24.81	26.72	40.47	39.58
TWC310	23.38	28.83	29.59	33.04	26.49	31.00	36.68	42.25
TWC311	23.01	31.29	32.05	35.33	26.61	33.19	36.85	38.22
TWC314	24.94	30.63	28.76	34.72	22.82	27.98	36.26	34.93
TWC32o	25.60	31.61	36.52	35.18	23.39	27.54	36.44	32.98
TWC321	23.16	28.87	33.90	33.41	26.68c	31.73 b	37.08 a	39.42 a
TWC324	23.44	27.29	33.50	34.21	28.11	34.10	39.45	39.93
TWC329	23.21	26.86	27.96	27.89	26.61	34.22	35.85	42.67
TWC352	22.98	26.00	24.52	31.40	27.34	30.62	35.37	36.07
LSD 0.05	3.96				7.5			
CV %	9.3				8.1			

LSD 0.05 For skipping x hybrid interaction are 3.96 and 7.5 in 2010 and 2011, respectively.

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تقييم بعض هجن الذره الشاميه لتحمل الإجهاد المائى

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قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

أقيمت تجربه حقليه بمحطه البحوث الزراعيه بملوى خلال موسم ٢٠١٠ وكررت فى موسم ٢٠١١ لدراسه تحمل هجن الذره للإجهاد المائى نتيجه نقص المياه خلال مراحل فسيولوجيه مختلفه. أستخدم عشرون هجينا (هـ ف ١٠، هـ ف ١٢٢، هـ ف ١٢٣، هـ ف ١٢٤، هـ ف ١٢٨، هـ ف ١٢٩، هـ ف ١٦٢، هـ ف ١٦٤، هـ ف ١٦٦، هـ ف ١٦٧، هـ ف ١٦٨، هـ ف ١٧٣، هـ ث ٣١٠، هـ ث ٣١١، هـ ث ٣١٤، هـ ث ٣٢٠، هـ ث ٣٢١، هـ ث ٣٢٤، هـ ث ٣٢٩، هـ ث ٣٥٢) كانت معاملات نقص المياه هى (حرمان الريات الثالثه والرابعه، حرمان الريات الخامسه والسادسه، حرمان الريه السابعه) بالاضافه إلى معامله المقارنه (الرى العادى). كان التصميم المستخدم قطاعات كامله العشوائيه ومرتبه فى صوره قطاعات غير كامله موزع بها معاملات الرى والمكررات كانت موزعه داخل القطاعات (معاملات الرى) والهجن موزعه عشوائيا داخل معاملات الرى .وقد أوضحت النتائج أن حرمان الريه السابعه يليه حرمان الريات الثالثه والرابعه ثم المقارنه أدى إلى نقص معنوى فى عدد الأيام من الزراعه حتى طرد ٥٠% من النباتات للنورات المذكره والمؤنثه وذلك فى الموسم الأول فقط، بينما لم يكن هناك فرق معنوى فى الموسم الثانى،وبالمثل لم يكن لمعاملات الحرمان المائى تأثير معنوى على صفتى أرتفاع النبات وأرتفاع الكوز فى الموسم الثانى بينما فى الموسم الأول كان هناك نقصا معنويا لجميع معاملات حرمان الرى مقارنة بمعاملة المقارنه . تم الحصول على أعلى قيمه لطول الكوز وعدد حبوب الصف ومحصول الحبوب بالأرب فدان عند معامله حرمان الريه السابعه وأقل قيمه مع حرمان الريات الثالثه والرابعه فى كلا الموسمين. كان هـ ث ٣١٠ ابكر الهجن فى طرد النورات المذكره والمؤنثه بينما هـ ث ٣٢٩ كان أكثر الهجن تأخرا فى التزهير. أعطى هـ ث ٣٢١، هـ ف ١٠ أعلى قيمه لإرتفاع النبات وأرتفاع ا لكوز بينما هـ ث ٣٥٢ كان أقصر الهجن واقلها فى إرتفاع الكوز فى كلا الموسمين. كان هـ ف ١٦٢ أطول الهجن فى صفه طول الكوز بينما هـ ث ٣٥٢ كان أقصر الهجن فى هذه الصفه. وبالنسبه لصفه المحصول فقد تفوق هـ ف ١٢٩ (٣٤,٥٨ و٣٦,٤٥ أردب للفدان) على باقى الهجن فى هذه الصفه يليه هـ ف ١٠ (٣٣,٩٩ و٣٥,٣٩ أردب للفدان) فى كلا الموسمين على التوالى، وعلى العكس من ذلك كان هـ ث ٣٢٩ و هـ ث ٣٥٢ أدنى الهجن محصولا(٢٦,٤٨ و ٢٦,٢٢ أردب للفدان) فى الموسم الأول و(٢٢,٤٠ ،٢٢,٧٥ أردب للفدان) فى الموسم الثانى على التوالى.