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Relationships Between Seedling Growth Rate and Yield of Maize Cultivars Under Normal and Water Stress Conditions

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Abstract
Effects of water stress on root and leaf growth rates and their relationships with yield under normal and water stress conditions were examined at the Greenhouse and Research Field of Faculty of Agriculture, Kerman University, Iran, using seven maize cultivars including SC-404, SC-704, BC-666, TC-647, DC-370, Jeta and Kordona. During a period of 14 days, water stress at -0.4 MPa was imposed by application of PEG-6000 to the seedlings. The root and leaf growth were measured every day. Leaf and root growth rates were expressed as the slope of the line fitted to the data of length and time. Results showed that water stress inhibited root and shoot growth in all cultivars. Differences were found among cultivars in terms of root and leaf growth rates. Differences were greater under normal compared with water stress condition. In a field experiment during 2007- 2008 growing season, yield performances of the same cultivars were measured under water stress and normal conditions. Correlation coefficients of yield with root (0.54), (0.10) and leaf (0.79), (0.32), (0.91), (0.63) growth rates were stronger under normal compared with water stress condition. Higher grain yield (mean of 10 plants per plot) of cultivars with higher growth rates under normal condition may be attributed to the higher growth rates at the early stages of growth. It could be also indicated that the higher growth rate ability of cultivars decreases when they are exposed to water stress condition.

Keywords: Corn, Growth rate, Water stress, Yield

Introduction

Water stress adversely affects crop growth and yield in many regions of the world. (Teulat *et al.* 1997). Maintaining high water status plays an important role in tolerance to water stress and in yield stability of crop plants (Teulat *et al*. 1997). Different mechanisms such as developed root systems are involved in maintaining plant water status at high levels and plant normal growth and functioning depends on the amount of water supplied by the root system. Under water stress condition, reduced root and shoot growth in maize (Kolarovic *et al*. 2006) and also root growth in wheat (Blum *et al*. 1988, Galle *et* *al*. 2002 and Akmal and Hirasawa 2004) were reported. Water stress was also shown to decrease root and shoot dry weight in wheat (Kerepesi and Galiba 2000), root and stem dry weight in soybean (Michalek and Browski 2005) and root weight in maize (Chammacho and Caraballo 1994, Ogawa *et al.* 2005, Grzesiak *et al*. 2007), rice (Cui *et al*. 2008) and triticale (Grzesiak *et al*. 2007). Water stress reduced relative growth rate of adventitious roots in maize and millet (Blum 1986) and elongation rate of roots in maize (Ogawa *et al*. 2006). Root length and number of roots were shown to decrease under water stressed environment in maize (Ogawa *et al.* 2005) and rice (Cui *et al*. 2008). Leaf growth rate and number of leaves which are considered as stress tolerance indicators were reduced under water stress condition (Ingram and Bartels 1996, Veselov *et al*. 2002). As the level of water stress increased, leaf growth rate in barley, maize and rice (Lu and Neumman 1998) and leaf area in maize (Sobrado 1986) were shown to be decreased. Leaf wilting was also reported in maize under severe water stress conditions (Lu *et al*. 2007).

Maize is usually grown in loamy soils in some parts of central region of Iran. Seedlings are, therefore, exposed to short term water stress as these types of soil often can not maintain the soil water content high enough to supply the required amount of water for normal growth of seedlings. Leaf rolling, usually observed by farmers, is, perhaps, the result of water stress as disappears right after irrigation. Maize hybrids with higher growth rates, particularly under water stress condition, may have advantages, because this could help them to stand vigorously at earlier stages of growth. The aims of this study were: i) to compare root and leaf growth rates of maize cultivars at the seedling growth stage under normal and water stress condition imposed by PEG solutions and ii) to evaluate the yield performance of cultivars under the same stress conditions and iii) to investigate the relationship between seedling growth rate and grain yield.

Materials and Methods

a) Seedling experiment: In order to compare seedling root and leaf growth rates under water stress and normal conditions, an experiment was carried out under controlled condition in the Faculty of Agriculture, Kerman University, using seven maize cultivars of SC-404, SC-704, BC-666, TC-647, DC-370, Jeta and Kordona (Table 9). After germination, seedlings were grown four days in a hydroponic medium to make possible non-destructive sampling, especially root measurements. PVC tubes (160mm diameter) were divided longitudinally, closed at both ends, and tested for any leakage of water before starting the experiment. To provide oxygen for root respiration, an air pump was connected to a net of pips with porous ceramic heads fixed at the bottom of the half tubes. Uniform seeds in terms of size, weight, and shape were selected for sowing. Selected seeds, however, were weighted up to four decimal digits before sowing. Rootlets of pre-germinated seeds were carefully passed through the holes made on Styrofoam plates (with 10mm thickness) and were fixed so that the growing coleoptile was directed upward and seminal roots downward. The plates were then floated on the surface of full strength Hoagland nutrient solutions with a pH adjusted to 6.5 (Table 10). Seeds were pretreated with a fungicide (Vitawax) before sowing. The half tubes were fixed on greenhouse benches and

filled with sufficient amount of solution. There were no symptoms of nutrient deficiency in plants during growth. The experimental design was split-plot based on randomized complete blocks with four replications. Water stress and normal conditions were arranged in whole half tubes as main plots and nine plants of each cultivar on Styrofoam plates as sub-plots. Water stress was imposed by application of PEG solution to the related tubes (158g PEG per litter). Seeds were planted in three rows per plate. The rows were spaced three cm apart with three seeds per row. Four days after seedling emergence, PEG-6000 stock solution was applied to the main plots until the solution water potential was reached to -0.4MPa (Michel and Kaufmann 1973). The calculated amount of PEG-6000 solution was applied gradually at one hour intervals so that the solution water potential was decreased by -0.1MPa (Lu and Neumman 1998). Air temperature ranged from 25 to 33˚C during the day and 18 to 23˚C during the night time. Humidity ranged from 40 to 55%. Light intensity was kept constant at 1400molm^{-1}s^{-1} during the day time. Root and leaf lengths were measured every day during a period of 14 days after sowing using a transparent ruler. Care was taken to avoid any damage to the seedlings during measurements. Seedlings were returned back to their place after each measurement. All measurements in a day were made within one hour.

Data were subjected to analysis of covariance taking the initial seed weight as covariate. Since there was no significant effect of seed weight on seedling characteristics, analysis of variance was performed, without considering covariate, and means were compared using Duncan's multiple range tests. Linear regression analysis was performed on root and leaf length data as dependent and time as independent variables. Slopes of the regressed lines were considered as the root and leaf growth rates. The regression coefficients were then compared using t- test (Steel and Torrie 1980).

In each plot three leaf samples were taken from middle parts of the second leaf. Samples were weighted immediately (W_1) and incubated under darkness over a wet sponge for four hours. Leaf saturated weight was then measured after removing the excess water from leaf samples by a tissue paper (W_2). Samples were oven dried at 80˚C for 24 hrs and again were weighted (W_3). The relative water content (RWC) of a sample was then computed as follows:

$$RWC = \frac{W_1 - W_3}{W_2 - W_3} \times 100$$

Finally, seedlings were removed, divided into root and shoot parts, and oven dried. Root and shoot dry weights were then determined.

b) Field experiment

The same cultivars were grown in the experimental field of Shahid Bahonar University of Kerman on May 2008 under normal (irrigation at seven-day intervals) and water stress (irrigation at 15-day intervals) conditions. Again, the experiment was arranged in a split plot design based on three randomized complete blocks, with irrigation intervals and cultivars in main plots and sub-plots, respectively. In each plot, there were four rows, 70cm apart and 20cm space between the plants. Plots were supplied with sufficient amount of N-P-K fertilizers and were hand-weeded during the growth period. Plants in one square meter of the central rows in each plot were harvested at physiological maturity and their grain yield was recorded. Data were subjected to analysis of variance. Cultivar means were compared using Duncan's multiple range tests.

Results

a) Root growth: The effect of water stress was highly significant on root length of seedlings, two days after application of PEG solutions (Table1). Cultivar effect on root and leaf lengths during the growth period was also highly significant. Cultivar by stress interaction was only significant on root length after ten days (Table1). At the end of the experiment, Jeta showed the highest root length (15.62cm) and TC-647 the lowest root length (10.44cm) among cultivars (Table 2).

b) Leaf growth: Lengths of the first and second true leaves were significantly affected by water stress after two days (Table1). Growth of the first and second leaves, 5 to 10 and 11 to 14 days after sowing, respectively, were significantly affected by water stress. Leaves were, generally, significantly affected by cultivar during the growth period (Table1). At the end of the experiment, Jeta and SC-404 showed the highest growth of the first leaf with 9.89 and 9.82 cm, respectively, while TC-647 with 7.22 cm showed the lowest growth (Table 3). In the case of second leaf, the highest and the lowest growth were recorded for SC-404 with 13.36 cm and TC-647 with 7.31 cm, respectively (Table 3).

c) Seedling dry matter: Water stress and cultivar effects on seedling dry weight were significant. Generally seedling dry matter was lower under stress as compared with non-stress condition (Table1). The highest and the lowest root dry matter were observed in SC-404 and TC-647 with 0.033 and 0.014g, respectively. In the case of leaf dry matter, the highest and the lowest values belonged to SC-404 (TC-647 with 0.095 and 0.034g, respectively) (Table 7).

d) Leaf relative water content: Water stress significantly decreased leaf RWC and it was 6.9% lower under water stress compared with normal condition. However, cultivar effect on RWC was not significant (Table1). The highest and the lowest values of RWC were found in Jeta (93.8%) and SC-404 (91.3%), respectively (Table 7).

e) Seedling growth rate: Under normal condition, root growth rate was significantly different among cultivars. However, the differences disappeared under water stress condition (Table 5). Generally, Jeta with 1.49 and DC-370 with 0.65cmday^{-1} showed the highest growth rates under normal and water stress conditions, respectively. On the other hand, TC-647 showed the lowest root growth rate under both normal and water stress conditions with 0.84 and 0.36cmday^{-1}, respectively (Table 4) (Figure 1).

The highest growth rate of the first true leaf was also found in Jeta (2.01cmday^{-1}), while the lowest rate was obtained in DC-370 (1.18cmday^{-1}). Under water stress condition SC-404 showed the highest and TC-647 showed the lowest growth rates with 0.96 and 0.54cmday^{-1}, respectively (Table 4) (Figure 1). Under normal condition, Jeta with 2.09 and TC-647 with 1.40cmday^{-1} showed the highest and the lowest growth rates of the second leaf, respectively. However, under water stress condition, SC-404 and Kordona with 0.96 and BC-666 with 0.37cmday^{-1} showed the highest and the lowest values, respectively (Table 4) (Figure 1).

Table 4. Root and first and second leaf growth rates of maize cultivars under normal and water stress condition

Cultivar		Water stress	Normal
SC404	Root	Y=0.56X+4.133	Y=1.10X+1.40
	First leaf	Y=0.96X-0.99	Y=1.56X-4.20
	Second leaf	Y=0.96X-4.23	Y=1.92X-9.58
SC-704	Root	Y=0.45X+3.26	Y=.0.98X+2.26
	First leaf	Y=0.61X-0.33	Y=1.44X-3.43
	Second leaf	Y=0.71X-5.00	Y=1.74X-10.18
BC-666	Root	Y=0.52X+3.99	Y=1.06X+1.95
	First leaf	Y=0.71X+0.42	Y=1.40X-3.22
	Second leaf	Y=0.37X+0.81	Y=1.66X-7.99
TC-647	Root	Y=0.36X+2.44	Y=0.84X+2.06
	First leaf	Y=0.54X-0.81	Y=1.32X-3.58
	Second leaf	Y=0.53X-4.52	Y=1.40X-7.66
DC-370	Root	Y=0.65X+3.33	Y=1.25X+2.02
	First leaf	Y=0.75X+0.62	Y=1.183X-1.44
	Second leaf	Y=0.46X+1.75	Y=1.69X-7.45
Jeta	Root	Y=0.50X+3.73	Y=1.41X+1.86
	First leaf	Y=0.76X-0.81	Y=2.01X-6.76
	Second leaf	Y=0.77X-4.68	Y=2.09X-12.0
Kordona	Root	Y =0.51X+3.76	Y=1.37X+0.97
	First leaf	Y=0.87X-1.02	Y=1.6X-4.73
	Second leaf	Y=0.96X-4.23	Y=1.82X-10.63

Leaf growth rates of cultivars were more variable under water stress condition than under normal condition. The differences between cultivars in terms of the second leaf growth rate were also significant. The differences were again greater under stress compared with the normal condition.

f) Yield and yield components: Water stress significantly affected yield and its components. Cultivar effect on grain yield and its components was also significant (Table 6). The highest and the lowest grain yields were found in Jeta (with 6.17t/ha) and TC-647 (with 2.36 t/ha), respectively (Table 7). There was no interaction between watering condition and cultivar for grain yield (Table 6). The highest grain numbers were found in SC-704 (524.64), Jeta (515.27) and the lowest in TC-647 (267.5). Furthermore, the highest values of 1000 grain weight were found in SC-404 (169.03g) and Jeta (160.57g) and the lowest values in TC-647 (with 120.94g) (Table 7).

g) Correlations: Significant correlation coefficients were found between root and leaf growth rates. Generally, correlations under normal condition were stronger than water stress condition. Positive correlation coefficients were found between root growth rate and grain yield, though they were not significant at 5% probability level. However, the correlations were stronger under normal compared to water stress condition. Correlations of the first and the second leaf growth rates with yield were significant only under the normal condition. The correlation in the case of the second leaf was stronger than

Table 5. Calculated t-student values used for the comparison of maize seedlings growth rates under normal and water stress conditions

			SC-404	SC-704	BC-666	TC-647	DC-370	Jeta
SC-704	Root	Normal	2.69*					
		Stress	1.28^{ns}					
	First leaf	Normal	1.94^{ns}					
		Stress	18.99**					
	Second leaf	Normal	2.44^{ns}					
		Stress	7.03**					
BC-666	Root	Normal	0.93^{ns}	-1.68^{ns}				
		Stress	0.39^{ns}	-0.86^{ns}				
	First leaf	Normal	1.88^{ns}	-0.03^{ns}				
		Stress	13.07**	-7.76**				
	Second leaf	Normal	4.08*	1.29^{ns}				
		Stress	24.07**	12.08**				
TC-647	Root	Normal	6.14**	2.75*	4.74**			
		Stress	2.53*	1.32^{ns}	2.10*			
	First leaf	Normal	2.94*	1.14^{ns}	1.16^{ns}			
		Stress	14.71**	2.71*	6.75**			
	Second leaf	Normal	7.52**	4.88**	4.13*			
		Stress	13.17**	5.06**	-6.65**			
DC-370	Root	Normal	-3.45**	-5.34**	-3.95**	-8.56**		
		Stress	-0.97^{ns}	-2.54*	-1.42^{ns}	-4.20**		
	First leaf	Normal	5.06**	3.46**	3.41**	2.14^{ns}		
		Stress	9.17**	-7.74**	-2.05^{ns}	-7.40**		
	Second leaf	Normal	3.78*	0.94^{ns}	-0.44^{ns}	-7.52**		
		Stress	19.60**	8.75**	-6.37**	3.01*		
Jeta	Root	Normal	-7.42**	-8.67**	-7.54**	-12.11**	-3.51**	
		Stress	0.72^{ns}	-0.54^{ns}	0.318^{ns}	-1.81^{ns}	1.83^{ns}	
	First leaf	Normal	-3.78**	-5.46**	-5.38**	-6.19**	-7.79**	
		Stress	8.21**	-8.10**	-2.70**	-7.75**	-0.63^{ns}	
	Second leaf	Normal	-2.24^{ns}	-4.36*	-5.92**	-8.88**	-5.69**	
		Stress	5.55**	-1.79^{ns}	-16.06**	-7.36**	-12.12**	
Kordona	Root	Normal	-8.22**	-9.17**	-8.02**	-13.45*	-3.11**	1.15^{ns}
		Stress	0.60^{ns}	-0.66^{ns}	0.20^{ns}	-11.93^{ns}	1.69^{ns}	-0.11^{ns}
	First leaf	Normal	3.64**	-12.66**	-7.49**	-11.00**	-4.85^{ns}	-4.10**
		Stress	-0.41^{ns}	-2.33*	-2.26^{ns}	-3.29*	-5.33**	3.39**
	Second leaf	Normal	1.27^{ns}	-1.07^{ns}	-2.44^{ns}	-5.84**	-2.12^{ns}	3.28*
		Stress	3.82*	-1.95^{ns}	-11.65**	-6.28**	-9.15**	-0.52^{ns}

*, **: Significant at 5 and 1% probability level, respectively. ns: Non-significant.

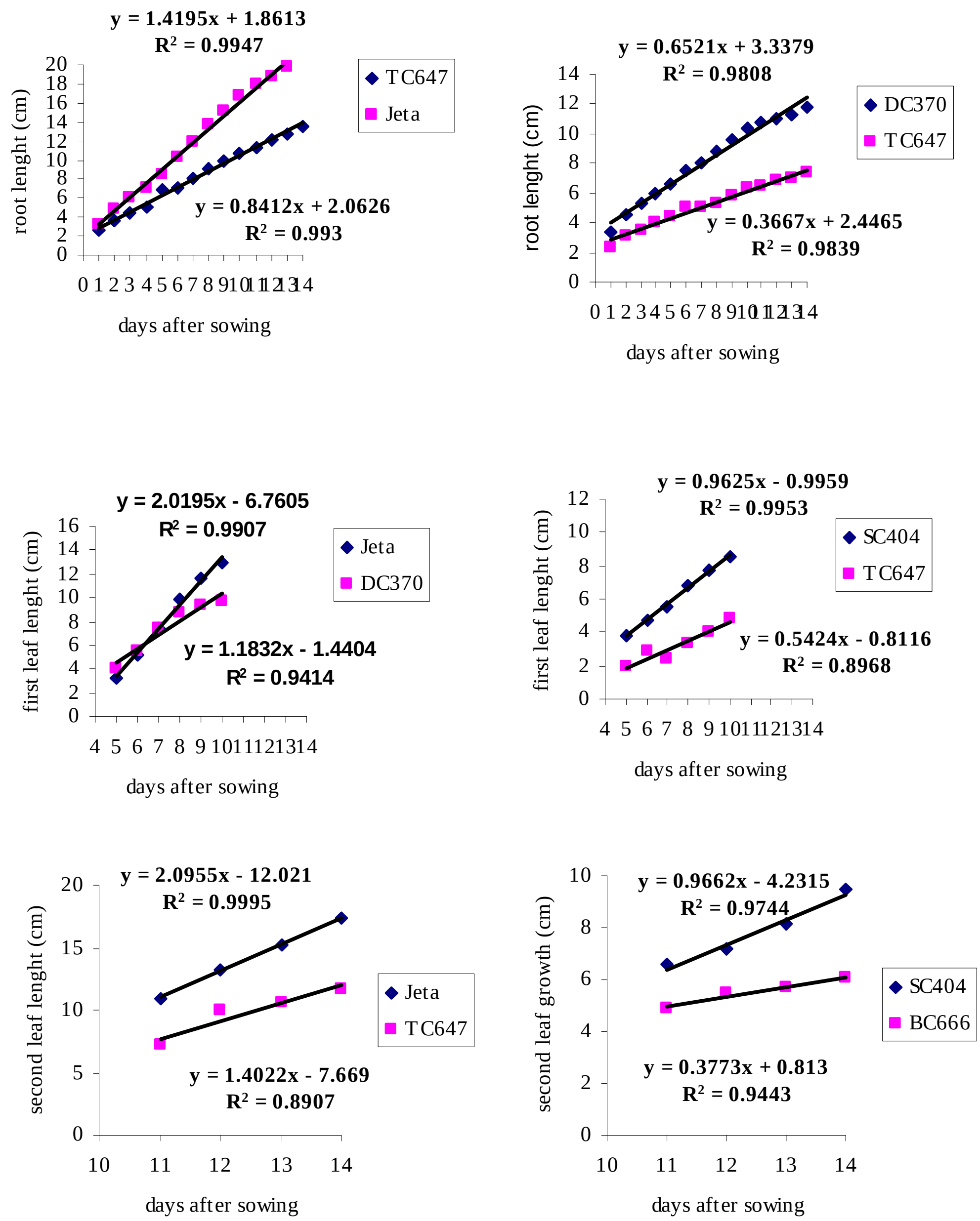

Figure 1. Linear regression lines showing the highest and the lowest growth rates of roots, first leaf and second leaf of maize seedlings grown under normal (left) and water stress (right) conditions

the case of the first leaf. On the other hand, mean seedling growth rate (roots and leaves) was significantly correlated with grain yield under normal condition (Table 8).

Discussion

This study showed the decline of root and leaf growth under water stress conditions. Retardation of growth under low water availability, was also reported by other workers in maize root (Vamerali *et al*. 2003, -Fan and Neumann 2004, Ogawa *et al*. 2006 and Kolarovic *et al*. 2006), leaf (Douglas and Paleg 1981, Sobrado 1986 and Lu and Neumann 1998) and other crop plants (Mian *et al*. 1993, Matsuura *et al*. 2000, Radhouane, 2007 and Aydi *et al*. 2008). It has been shown that water stress decreases the cell division and elongation rates and as a result decreases the growth rate of plants (Choi *et al*. 2000). Lower rates of cell division and cell elongation may be the cause of lower growth of roots and shoots under water stress condition. It was shown that leaf water potential decreases in water stressed plants due to decrease in leaf turgor pressure and as a result leaf elongation rate decreases (Hsiao 1973). Cell wall elasticity also decreases under water stress condition due to hormonal and hydraulic signals (Nilson and Orcut 1996). This in turn may reduce the final size of the cells (Nilson and Orcut 1996).

Reduced values of root and shoot dry matter under water stress condition was reported in soybean (Michalek and Browski 2005), maize (Ogawa *et al.* 2006) and wheat (Kerepesi and Galiba 2000). Water stress also reported to reduce stem dry matter in sensitive cultivars compared to the tolerant genotypes (Turkan, *et al.* 2005). In wheat, barley and bean, shoot dry matter was decreased under water stress condition (Samia 2008). Reduced shoot dry matter was also reported in maize (Chammacho and Caraballo 1994), and bean (Alyari *et al.* 2001). Reduced dry matter may be attributed to lower activities of photosynthetic enzymes under water stress condition (Abdalla and El-Khoshiban, 2007). Higher levels of triglycerides and sterylesters are shown in maize leaves under water stress environments (Douglas and Paleg 1981).

Higher RWC in water stressed plants may be the result of lower rates of water loss due to stomatal closure and more developed root systems (Valentovic *et al*. 2006). Lower levels of RWC have been reported in maize (Valentovic *et al*. 2006) and triticale (Kayden and Yagmur, 2008) when confronted with water stress.

Lower growth rates of leaves compared to the roots may be due to higher levels of water stress imposed on them. Since roots are in direct contact with solution, they may be exposed to lower levels of water stress. This may cause the roots to have higher growth rates. However, since roots have to penetrate into soil in the field, they may not show the same response as they did under hydro culture condition. Smith (1990) concluded that the difference between root and shoot growth under normal and water stress condition could be the result of accumulation of indigenous hormones and osmotic adjustment. In the water stress environment, the regular arrangement of microtubules in the cell walls changes and the level of ABA increases which limits cell growth (Lu *et. al*. 2007). On the other hand, higher concentration of osmolites such as proline in the roots may cause the root cells to keep their turgor pressures at higher levels which in turn may cause the roots to growth more rapidly. It has been reported that ABA synthesized in root apical meristem in response to water stress causes high concentration of proline in elongation zone of roots (Mohammadkhani and Heidari 2008).

Reduced grain yield under water stress condition in maize has been reported by many researches (Zinselmei *et al*. 1995, Cakir 2004). Decrease in maize grain yield has been attributed to smaller and lower grains per ear which is the result of lower seed set under low tissue water content and lower translocation rate of assimilates. Reduction of the duration of grain filling period is also reported to be another reason for lower grain yield under water stress situation (Zinselmeier *et al*. 1995, Nesmith and Ritchie 1992). Water stress also advances anthesis soon before eggs are ready to accept them which in turn results in lower seed set and yield (Cakir 2004).

Grain yield was poorly correlated with root and leaf growth rates under water stress condition. Correlations were, however, stronger under normal condition and in the case of the second leaf growth rate were significant at 1% level of probability. Positive correlation between growth characteristics and yield has been found in some crop plants such as wheat (Mian *et al*. 1993) and pea (Ogbonnaya *et al*. 2003) under normal condition. It may be concluded that genotypic potential of cultivars in the water stress environment is limited so that their differences reduce under such condition and in turn results in weaker correlation coefficient under water stress condition. This may be considered as a turning point in the plant life cycle which is accompanied by accelerating investment rate in growth substances for later growth and yield. More studies are needed to confirm this at later growth stages.

Crop establishment in silt-loam soils which loose their water content in the sowing depth soon after irrigation is difficult. Water stress may even become more severe due to the retardation of irrigation. Cultivars with higher growth rate at early growth stages may be able to develop their root systems into deeper soil layers in order to avoid the detrimental effects of soil surface drying. More studies are needed to confirm the results in a wider range of soils and water stress conditions.

Table 6. Mean squares for yield and yield components under normal and water stress conditions

S.V.	df	Ear no. per plant	Grain no. per ear	1000 grain weight	Grain yield
Stress	1	0.002^{ns}	297108^{**}	22204^{*}	100.9^{*}
Error 1	2	0.002	2877	1113	2.37
Cultivar	6	0.0009	57673^{**}	1804^{*}	10.18^{**}
Interaction	6	0.001^{ns}	7048^{ns}	486.48^{ns}	1.84^{ns}
Error 2	24	0.001	3074	699.296	1.32

*,**: Significant at 5 and 1% probability level, respectively; ns: Non-significant

Table 7. Root and leaf dry matter, relative water content (RWC) at seedling growth stage, yield and yield components of maize cultivars under study

Cultivar	Root dry matter (g)	Leaf dry matter (g)	RWC (%)	Ear no. per plant	Grain no. per plant	1000 grain weight (g)	Yield (t/ha)
Sc404	0.033d	0.095C	91.3a	1a	413.14b	169.03c	5.13cde
SC704	0.019ab	0.05a	92.8ab	1.01a	524.64c	140.62abc	5.44de
BC666	0.027bcd	0.073b	92.5ab	1a	380.83b	134.23abc	3.89bc
TC647	0.014a	0.034a	91.5ab	1a	267.5a	120.94a	2.36a
DC370	0.025bd	0.075bc	93.5ab	1.03a	299.30a	155.87bc	3.41ab
Jeta	0.031cd	0.085bc	93.8b	1.01a	515.27c	160.57bc	6.17e
Kordona	0.022ab	0.075bc	93.3ab	1.01a	426.91b	132.62ab	4.23bcd

Values within each column followed by the same letter are not significantly different at 0.05 probability level according to Duncan's test

Table 8. Correlation coefficients among root, shoot and seedling growth rates and grain yield under normal and water stress conditions

		Root growth rate		First leaf growth rate		Second leaf growth rate		Seedling growth rate	
		N	S	N	S	N	S	N	S
Root growth rate	N								
	S	0.54^{ns}							
First leaf growth rate	N	0.60^{ns}	-0.12^{ns}						
	S	0.62^{ns}	0.64^{ns}	0.38^{ns}					
Second leaf growth rate	N	0.76^{*}	0.39^{ns}	0.81^{*}	0.68^{ns}				
	S	0.40^{ns}	-0.02^{ns}	0.57^{ns}	0.65^{ns}	0.62^{ns}			
Seedling growth rate	N	0.71^{ns}	0.12^{ns}	0.96^{**}	0.54^{ns}	0.94^{**}	0.62^{ns}		
	S	0.77^{*}	0.44^{ns}	0.80^{*}	0.70^{ns}	0.99^{**}	0.58^{ns}	0.93^{**}	
Grain yield	N	0.56^{ns}	0.18^{ns}	0.79^{*}	0.42^{ns}	0.91^{**}	0.47^{ns}	0.88^{**}	0.90^{**}
	S	0.28^{ns}	0.09^{ns}	0.56^{ns}	0.32^{ns}	0.76^{**}	0.63^{ns}	0.69^{ns}	0.73^{ns}

*, **: Significant at 5 and 1% probability level, respectively. ns: Non-significant

Table 9. Maize cultivars characteristics used in the experiments

Cultivar	Grain yield (t/ha)	Response to abiotic stresses	Growing length (day)	1000 grain weight (g)
SC-704	10-12	Non- tolerant to salt and drought	145-150	450
TC-647	8-9	Non- tolerant to salt and drought	115-125	440
DC-370	8-10	Relatively tolerant to salt and drought	90-110	280-420
SC-404	9-11	Relatively tolerant to salt and drought	100-115	450
BC 666	10-12	Sensitive to drought and salt stress	120-140	400
Jeta	12-15	Relatively tolerant to salt and drought	120-140	300-400
Kordona	10-12	Relatively tolerant to salt and drought	120-140	300-400

Table10. Amount of chemical compounds used for making nutrient solutions according to Hoagland

Volume of solution needed for 1 liter of nutrient solution (ml)	Molarity (mmol)	Molecular weight	Chemical compound
2	1000	115.3	NH4H2PO4
6	1000	101.11	Kno3
4	1000	236.15	Ca(NO3)2, 4H2O
1	1000	246.68	MgSO4, 7H2O
1	25	61.83	HBO3
1	50	76	KCl
1	2	287.54	ZnSO4, 7H2O
2.5	2	249.68	CuSO4, 5H20
1	2	169.02	MnSO4, H2O
1	2	162	H2MOO4
1	1000	373	NaEDTA
		278	FeSO4, 7H20

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