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Evaluation of Maize (Zea mays L.) Genotypes for Salt Tolerance

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Abstract

The current study was carried out to screen 45 different maize (*Zea mays* L.) genotypes (23 inbred lines and 22 hybrids) against salt tolerance by evaluating germination percentage, vigor index and growth as well as yield and yield components. The greenhouse and filed experiments were conducted in Mashhad, Iran in 2009, using completely randomized design (CRD) and complete randomized block design (RCBD), respectively. Different salinity levels (1, 4, 8 and 12 dsm^{-1}) were used in the greenhouse experiments, whereas field experiment was conducted on a saline soil (5.9 dsm^{-1}). In both experiments, irrigation was performed using saline water too. Days to anthesis, days to silking, anthesis-silking interval (ASI), days to physiological maturity, plant height, ear height, leaves number per plant, leaves number above ear, yield components and yield were measured from the field experiment. Germinating was deferred by 8 and 12 dsm^{-1} salinity levels, however the seedlings of all genotypes remained alive up to 12 dsm^{-1} salinity level. Plant height, ear height, days to anthesis, yield and yield components affected by salinity at the field experiment. Results showed that maize hybrids were more tolerated to salinity compared with inbred lines. Among the hybrids, the highest yields were produced by KE72012/1-12 × K2331(7.772 ton/ha), KSC500 and ZP434, respectively. The lowest grain yield (2.89 ton ha^{-1}) was obtained from hybrid ETH-M82. The highest (1.72 ton ha^{-1}) and lowest (0.279 ton ha^{-1}) grain yield in inbred lines was produced by KE72012/1-12 and OH43/1-42, respectively.

Key words : Anthesis, Silking, Plant height, Yield components

INTRODUCTION

The exact amount of saline lands is not reported, however FAO has estimated that globally, 19.5% of irrigated lands are salt-affected; and out of (1500 million/ha) cultivated lands in arid region, (32 million/ ha), (2.1%) are suffering from salinity [1]. In Iran, soil and water salinity, is a significant problem in arid and semi-arid lands [2]. Crop production has been affected by salinity in the United States of America, North Africa, Pakistan, Iran, Iraq and Egypt. In these countries, precipitation amount is not enough to rinse salt from the soil which result in salt accumulation. Salinization by irrigation water is a process whereby soluble salts from the irrigation water accumulate in the soil due to inadequate leaching, high water tables and high evaporation rates. Soil salinity affects plants directly through osmotic effects, which limit the ability of the plants to absorb water from the soil solution. Specific ions and any alteration in soil physical and chemical properties might have long-term detrimental effects on crop production [3]. Salinity levels, higher than crop tolerance threshold, may reduce crop yield [4]. Preventing plant cell from ion uptake will prevent them from toxicity but will result in lower water absorption too [5-6]. Salinity is one of the most significant abiotic factors limiting crop productivity [7-8]. The ability of seeds to germinate at high salt concentrations in the soil is crucial for the survival of many plant species [9]. Salt tolerance depends on different plant growth stage as well as fertilization application. Delayed germination rate, wilting, growth prohibition, marginal leaf necrosis, especially in old leaves, defoliation and leaf chlorosis, restricted growth, root injuries and plant death are all consequence of salt stress [10]. Maize, a plant with a C_4 metabolism, is also classified as moderately sensitive to salinity [11],[12] have reported that in barley and maize, potassium content was increased by low salinity while higher salinity level was resulted in lower potassium concentration in plant cells. [13] declared that the addition of sodium chloride led to a reduction in potassium content in different plant parts. In addition, higher sodium in the media caused a reduction in potassium uptake and also affect distribution of potassium within plant parts. On the other hand, potassium retaining capability of plant cells is a key factor for salinity tolerance [14],[15] investigated the effect of salinity on survival and biomass production of 16 plants belonged to Poaceae family. They found that tall fescue (*Festucaarundinacea*) was the most tolerant species while sorghum and maize were ranked as 5th and 6th tolerant crops. Maize tolerance to the salinity may increase during growing season considering water salinity level [16],[16] reported that tolerance threshold of 16 maize cultivars was 10 dsm^{-1} at germination stage while it increased at maturity stage. They showed a 10% reduction in grain yield per each dsm^{-1} increase in salinity, at salinities higher than 5.5 dsm^{-1}. [17] investigated the effect of different salinity levels on maize growth and yield. They declared that maize was tolerate to salinities ranged between 1-10 dsm^{-1} at germination stage. The electrical conductivity of soil was enhanced three folds, after 18 times of irrigation, which resulted in yield shortage. [18], studied the effect of salinity on yield of 12 different inbred lines in the Philippine. The highest tolerance observed for pi-21 and pi-31 due to the higher concentration of nitrate reductase. In a research, [19], investigated the effect of salinity on yield of 27 maize hybrids using stress sensitivity and tolerance indices. Biplot analysis showed that BC504, OSSK373, G-3337, G-54190, KSC301, KSC250 and NS540 were salt tolerant hybrids observing grain yield. KSC350, BC282, BC354, OSSK444, G-54185, KSC260 and ZP341 produced a high yield at both control and saline conditions. BC572, G-54193, KSC340, KSC500, ZP434 and BC418 produced a high yield at control condition but had a low yield at saline situation.

Understanding the properties of inbred lines could be useful in predicting hybrids' characteristics. The objective of this study was to evaluate the effect of salinity on germination, yield and yield components of different maize genotypes (inbred lines and hybrids) to introduce the most tolerant genotypes to be used in future breeding programs.

MATERIALS AND METHODS

Greenhouse experiment

The greenhouse experiment was carried out in a greenhouse situated at Torogh Agricultural Research Station of Mashhad, Iran. As there were four levels of salinity (1, 4, 8 and 12 dsm^{-1}) maize genotypes (Table 1) were evaluated using four separate completely randomized design (CRD) with three replicates. Maize seeds were in plastic pots filled with sandy soil (135 pots for each salinity level). The pots were irrigated with saline water. Water volume for each pot was 150 ml per each irrigation round. Greenhouse temperature was set at 25 and 15°C for day and night, respectively. Germinated seeds (with a 1-2 mm radicle) were counted every day after 7 to 10 days. Germination percentage (GP) was calculated using the following formula [20].

The samples oven dried at 80°C for 48 hours and weighted by digital scale. Vigor index was estimated according to [21].

Field experiment

A randomized complete block design (RCBD) with three replicates was used to screen the maize genotypes in a field experiment. The field was located in Abbas-Abad rural area near Mashhad, Iran 2009. The electrical conductivity of saturated soil-past extract and irrigation water were measured 5.85 and 5.9 dsm^{-1}, respectively. The 43 maize genotypes were manually sown in experimental plots with 3 m length and 20 cm row distance. Plant density was 85,000 and 75,000 for mid and late maturity genotypes. The number of established plants per plot, anthesis date, silking stage, anthesis-silking interval (ASI), date of physiological maturity was recorded for each genotype. Plant and ear height were measured on 10 random plants for each genotype. Plant number and ear number recorded in each plot and grain yield estimated at 14% relative humidity. Yield components (ear length and diameter, kernel depth, thousand kernel weight, kernel per row, row per ear and total kernel number per each ear) were measured on 10 random ears for each genotype. Analysis of variance was carried out using Minitab and MST established plantAT-C. Means were compared by Duncan's multiple range test at 0.05 significance levels.

Table 1: Different maize genotypes used in the study

No.	Inbred line	No.	Hybrid
1	K3640/5	1	KSC108
2	K1263/2-1	2	KSC260
3	K722	3	KSC301
4	K19	4	KSC302
5	K18	5	KSC400*
6	KE72012/1-12	6	KSC500
7	K615.1	7	KSC604
8	K2816	8	KSC700
9	K1264/5-1	9	KSC704
10	K2331*	10	TWC603
11	K3651/1	11	DC370
12	S61	12	ZP434*
13	TVA926	13	ETH-M82
14	K1263/1	14	K74/1 × MO17
15	K1728/8	15	K1264/1 × KE72012/1-12
16	K166A	16	L105 × K74/1
17	SL12	17	B73 × K74/1
18	A188	18	L105 × K19
19	L105	19	B73 × K19
20	OH43/1-42	20	K2816 × K1264.1
21	B73	21	K1264/1 × TVA926
22	MO17	22	KE72012/1-12 × K2331
23	K1264/1		

The Genotypes that tagged with (*) didn't cultivate at greenhouse

RESULTS

Greenhouse experiment

Statistical analysis indicated that there was significant difference between genotypes in terms of germination percentage (GP), dry weight and vigor index (p<0.01), however there was no significant difference between salinity levels in terms of GP (Fig 1). Although GP reduced at 8 and 12 dsm^{-1} salinity levels, all genotypes (hybrids and inbred lines) showed salt tolerance at germination stage. [22], reported the same results on sorghum plants. The results were in agreement with [23-16-17]. [24] reported that biomass of salt sensitive plants significantly reduced as salt concentration increased. Seedling dry weight and vigor index (Fig 2) decreased at 8 and 12 dsm^{-1} salinity levels. The variation between genotypes in respect of germination percentage, dry weight and vigor index is presented in (Table 2) [25].

DISCUSSION

Field experiment

There was a significant difference between genotypes in terms of days to maturity, days to anthesis and days to silking as well as anthesis-silking interval. The longest (129 days) and shortest (108 days) maturity period belonged to TWC603 and KSC108 hybrids, respectively. Furthermore, among inbred lines, the longest (133 days) and shortest (107 days), maturity period belonged to K166A and S61, respectively. [26], reported that salt stress results in longer ASI in maize hybrids.

The increase in ASI results in yield shortage. The ZP434 hybrid had a 3.33 days ASI and yielded 7.22 ton ha^{-1} grain while K2816 inbred line had a 12.33 days ASI and yielded 0.69 ton ha^{-1}.

There were significant differences among the genotypes in terms of morphological traits, yield and yield components (Table 4 to 6). Among hybrids, the maximum (166.7 cm) and minimum (110.5 cm) plant height values were related to B73×K19 and ETH-M82, whereas among inbred lines, the maximum (105.8 cm) and minimum (65.27 cm) plant height values were observed from MO17 and K1263/1, respectively (Table 3). There was also significant correlation between plant height and ear height (r^2= 0.903**). In addition, grain yield was significantly correlated with plant height (r^2= 0.826**) and ear height (r^2= 0.771**) (Table 7). The maximum ear height with 84.47cm was related to B73×K19, whereas among inbred lines, the maximum (47.77 cm) and minimum (19.73cm) ear height values were observed from

Table 2: Variation between Maize genotypes in terms of germination percentage, Plantlet dry weight a vigor index

Genotype	Germination (%)	Genotype	Plantlet dry weight (g)	Genotype	Vigor index
ETH-M82	80 A	B73	8.238 A	B73	750.6 A
ZP434	76AB	K1264/1 × TVA926	7.850 A	K1264/1 × TVA926	669.0 AB
KSC500	75AB	KSC260	6.938 B	KSC260	646.6 B
KSC260	75AB	OH43/1-42	6.287 BC	K74/1 × MO17	540.6 C
K74/1 × MO17	74AB	KSC704	5.867 CD	OH43/1-42	534.0 CD
A188	73AB	K74/1 × MO17	5.838 CD	KSC704	521.5 CDE
K1264/1 × KE72012/1-12	73AB	K1264/1 × KE72012/1-12	5.700 CD	K1264/1 × KE72012/1-12	521.4 CDE
B73	73AB	B73 × K74/1	5.600 CD	KSC500	515.0 CDE
L105 × K74/1	72ABC	KSC500	5.463 CDE	B73 × K74/1	504.9 CDE
MO17	72.52BCD	S61	5.050 DEF	S61	435.3 DEF
KSC700	72.52BCD	K19	4.625 EFG	ZP434	429.6 EF
K2816 × K1263/1	68.52 BCDE	KSC400	4.538 EFG	ETH-M82	401.3 FG
KSC400	68.52 BCDE	KSC700	4.525 EFG	MO17	398.1 FG
KE72012/1-12	68.52 BCDE	ZP434	4.500 EFGH	K18	396.5 FG
TVA926	67.52BCDEF	K1263/1	4.475 EFGH	KE72012/1-12	388.9 FG
S61	67BCDEF	MO17	4.450 EFGH	TVA926	380.6 FGH
OH43/1-42	63.52 CDEFG	TVA926	4.425 FGH	KSC700	359.1 FGHI
K18	61.52 DEFG	KE72012/1-12	4.238 FGHI	K19	352.3 FGHI
KSC604	61 EFG	K18	4.238 FGHI	K18	335.3 FGHIJ
K3651/1	60.52 EFGH	L105	4.225 FGHI	K722	325.4 GHIJK
K19	60 EFGHI	K722	4.188 FGHIJ	K615/1	312.5 GHIJKL
KSC704	59 FGHI	DC370	4.013 FGHIJK	DC370	308.8 GHIJKL
K722	58 GHIJ	ETH-M82	3.913 GHIJKL	K1263/2-1	308.8 GHIJKL
TWC603	56.52 GHIJ	K1263/2-1	3.826 GHIJKLM	TWC603	272.4 IJKLMN
K1263/2-1	56.52 GHIJ	K1264/5-1	3.612 GHIJKLM	A188	272.3 IJKLMN
K2816	55 GHIJK	TWC603	3.612 HIJKLM	L105	270.6 IJKLMN
K615/1	52 HIJK	K1263/1	3.350 IJKLM	K1264/5-1	240.1 JKLMNO
KSC302	51.52 IJK	B73 × K19	4.500 EFGH	K2816	228.2 KLMNO
B73 × K19	50 JKL	KSC302	3.338 IJKLM	K3651/1	226.2 KLMNO
K1728/8	49.52 JKL	L105 × K19	3.313 IJKLM	KSC302	222.2 KLMNO
K1264/5-1	47.52 KLM	K2816	3.188 JKLM	L105 × K19	218.8 LMNO
L105	43 LMN	L105 × K74/1	3.150 KLM	K1728/8	182.5 MNOP
L105 × K74/1	40.52 MNO	A188	2.963 LM	L105 × K74/1	176.9 NOPQ
K3640/5	38 NOP	K1264/1	2.950 LM	K1263/1	173.1 NOPQ
L105 × K19	38 NOP	K3651/1	2.900 LMN	L105 × K19	170.8 NOPQ
K1263/1	38 NOP	K1728/8	2.850 MN	K1264/1	138.3 OPQ
K1264/1	34.5 OPQ	K2816 × K1264/1	2.000 NO	K3640/5	91.88 PQR
KE72012/1-12 × K2331	32 PQ	KE7012/1-12 × K2331	1.800 O	B73 × K19	81.00 QR
K2816 × K1264/1	28 Q	K3640/5	1.763 O	KE72012/1-12 × K2331	76.25 QR
KSC108	16.5 R	KSC604	1.513 O	KSC108	19.19 R
KSC604	11 RS	KSC301	1.350 O	KSC604	5.963 R
KSC301	7.5 S	KSC108	1.225 O	KSC301	5.873 R

There is no significant differences between data with the same letters in each row

Table 3: Variation between maize genotypes in terms of plant height and ear height

plant height (cm)		Ear height (cm)	
Hybrid	Inbred line	Hybrid	Inbred line
B73 × k19 = 166.7 A	MO17 = 105.8 A	B73 × K19 = 84.47 A	L105 = 47.77 A
B73 × k74/1 = 157.5 AB	B73 = 103.3 AB	B73 × K74/1 = 74.20 AB	SL12 = 40.83 AB
L105 × k74/1 = 157.1 AB	KE72012/1-12 = 103.1 AB	KSC704 = 73.10 AB	B73 = 40.27 AB
KSC301 = 156.4 AB	K19 = 101.1 AB	L105 × K74/1 = 71.10 BC	K19 = 40.17 AB
KSC704 = 155.6 AB	K1264/1 = 97.77 AB	L105 × K19 = 68.60 BCD	K722 = 38.33 ABC
KSC604 = 155.6 AB	OH43/1-42 = 97.23 ABC	KSC604 = 67.40 BCDE	K615/1 = 36.97 ABC
KSC260 = 153.0 ABC	A188 = 96.10 ABC	KSC700 = 66.37 BCDEF	K1264/5-1 = 36.10 ABC
Ke72012/1 × k2331 = 146.9 BCD	K1264/5-1 = 96.10 ABC	KSC400 = 63.33 BCDEFG	OH43/1-42 = 36.10 ABC
K1264/1 ×KE72012 /1-12= 146.6 BCD	K722 = 94.70 ABCD	KSC500 = 62.77 BCDEFG	K1264/1 = 35.87 ABC
L105 x k19= 145.8 BCD	K166A = 94.70 ABCD	KSC260 = 62.50 BCDEFG	MO17 = 34.17 ABCD
K1264/1 ×TVA926 = 144.7 BCD	L105 = 93.33 ABCD	ZP434 = 59.17 CDEFGH	K18 = 34.17 ABCD
KSC500 = 141.4 BCDE	K18 =92.23 ABCDE	KSC301 = 59.13 CDEFGH	K3640.5 = 33.60 ABCD
KSC700 = 139.7 BCDE	K615/1 =92.23 ABCDE	K1264/1 × TVA926= 58.33 CDEFGHI	K2816 = 32.47 BCD
KSC400 = 137.8 CDE	K2816 = 91.10 ABCDE	TWC603 = 56.93 DEFGHIJ	KE72012/1-12 = 31.13 BCD
K74.1 × MO17 = 135.4 CDEF	SL12 =89.93 ABCDE	K74/1 X MO17 = 56.40 DEFGHIJ	K3651/1 = 30.87 BCD
ZP434 = 132.8 DEF	K3640/5 =86.40 ABCDEF	KE72012 X K2331 = 54.43 EFGHIJ	K166A = 30.80 BCD
TWC603 = 131.7 DEF	K3651/1 = 86.10 BCDEF	DC370 = 52.50 FGHIJ	K1263/1 = 26.67 BCD
KSC108 = 130.4 DEF	S61 = 85.27 BCDEF	K1264/1 × KE72012=50.57 GHIJK	K1728.8 = 26.37 BCD
DC370 = 125.3 EFG	K1728/8 = 78.03 CDEFG	K2816 × K1264/1 = 48.03 HIJKL	S61 = 26.13 BCD
KSC302 = 124.7 EFG	TVA926 = 75.53 DEFG	KSC302 = 45.00 IJKL	K1263/2-1 = 25.77 BCD
K2816 × K1264/1 = 119.7 FG	K1263/2-1 = 74.03 EFG	KSC108 = 43.27 JKL	A188 = 25.57 BCD
KSC403 = 111.1 G	K2331 = 69.87 FG	KSC403 = 38.87 KL	TVA926 = 23.90 CD
ETH-M82 = 110.5 G	K1263/1 = 65.27 G	ETH-M82 = 35.27 L	K2331 = 19.73 D

There is no significant differences between data with the same letters in each row

Table 4: Variation between maize genotypes in terms of kernel depth and thousand kernel weight

Kernel depth (mm)		thousand kernel weight (g)	
Hybrid	Inbred line	Hybrid	Inbred line
K1264/1 × KE72012 = 10.72 A	K1263/2-1 = 8.967 A	KSC704 = 261.7 A	B73 = 209.3 A
KSC500 = 10.50 A	Mo17 = 8.500 AB	TWC603 = 257.2 AB	MO17 = 208.1 AB
K74/1 X MO17 = 10.35 A	B73 = 8.200 ABC	KSC700 = 255.5 ABC	K1264/5-1 = 184.0 ABC
KSC700 = 9.900 AB	K1264/1 = 8.000 ABC	B73 × K19 = 250.4 ABC	SL12 = 178.4 ABC
KSC260 = 9.800 AB	Sl12 = 8.000 ABC	B73 × K174.1 = 250.0 ABC	K2816 = 174.0 ABC
KE72012 X K2331 = 9.717 AB	A188 = 7.950 ABC	ZP434 = 244.9 ABC	KE72012/1-12 = 173.7 ABC
KSC108 = 9.700 AB	K166A = 7.683 ABC	KSC260 = 243.3 ABC	K722 = 171.6 ABCD
KSC704 = 9.683 AB	K1264/5-1 =7.417 ABC	L105 × K74/1 = 234.0 ABC	K615.1= 169.6 ABCD
B73 × K74/1 = 9.683 AB	K1263/1 = 7.267 ABC	K74/1 × MO17 = 233.7 ABC	K1263/1 = 165.5 ABCDE
KSC302 = 9.533 AB	TVA926 = 7.083 ABC	L105 × K19 = 230.1 ABC	K1264/1 = 162.0 ABCDE
B73 × K19 = 9.367 AB	K3640/5 = 7.017 ABC	KE72012 × K2331 = 228.0 ABCD	OH43/1-42 =160.5 ABCDE
KSC400 = 9.317 AB	K19 = 6.683 ABC	KSC500 = 227.1 ABCD	K3651/1 =160.4 ABCDE
TWC603 = 9.283 AB	K722 = 6.300 ABC	KSC604 = 225.1 ABCD	A188 =156.0 ABCDE
KSC301 = 8.733 AB	K615/1 =6.217 BC	K1264/1 × TVA926= 220.1 ABCD	K3640/5 = 155.5 ABCDE
L105 × K19 = 8.717 AB	K2331 = 6.183 BC	DC370 = 218.9 ABCD	L105 = 154.9 ABCDE
L105 × K74/1 = 8.333 ABC	K2816 = 6.167 BC	ETH-M82 = 215.1 ABCD	S61 = 154.0 ABCDE
K1264.1 × TVA926 = 8.200 ABC	L105 = 6.133 BC	KSC301 =207.9 ABCD	K19 =150.9 ABCDE
DC370= 8.150 ABC	K1728/8 = 6.083 BC	K1264/1× KE72012= 202.9 ABCD	K1263/2-1 = 144.7 BCDEF
ZP434= 8.100 ABC	K3651/1 =6.067 BC	K2816 × K1264/1 = 187.1 ABCD	TVA926 = 130.9CDEF
KSC604 =7.933 ABC	OH43/1-42 = 6.000 BC	KSC302 = 175.6 BCD	K166A = 122.1CDEF
KSC403 = 7.267 BC	KE72012/1-12 = 5.683 C	KSC400 = 174.0 BCD	K2331 =108.8 DEF
K2816 × k1264/1 = 7.183 BC	S61 = 5.667 C	KSC403 = 172.7 CD	K1728.8 = 103.1 EF
ETH-M82 = 5.883 C	K18 = 5.500 C	KSC108 = 147.9 D	K18 = 86.67 F

There is no significant differences between data with the same letters in each row

Table 5: Variation between maize genotypes in terms of kernel per row and row per ear

Kernel per row		Row per ear	
Hybrid	**Inbred line**	**Hybrid**	**Inbred line**
KSC400 = 39.07 A	L105 = 28.57A	B73 X K74/1 = 18.23 A	B73 = 16.33A
ZP434 = 37.80 A	MO17 =28.00 A	KSC500 = 17.47 AB	K2331 = 15.73 AB
KSC302 = 36.23 A	K1264.1 = 21.67 AB	K1264/1 X KE72012 =17.30 ABC	K18 = 15.33ABC
L105 X K19 = 35.90 ABC	K2816 = 21.57 AB	KE72012 X K2331 = 17.27 ABC	L105 = 15.23 ABC
KSC704 = 35.73 ABC	SL12= 21.20 AB	KSC301 = 16.90 ABCD	K166A =14.53 ABCD
L105 X K74/1 = 35.23 ABC	K19 = 21.00 ABC	KSC302 = 16.60 ABCDE	K1728/8 = 14.53ABCD
KSC500 = 34.80 ABCD	KE72012/1-12 = 20.63 ABC	K74.1 X MO17 = 16.47ABCDEF	K3640/5 = 14.10 ABCD
K74.1 X MO17 = 34.60 ABCD	K18 = 19.67 ABC	KSC700 = 16.43 ABCDEF	K2816 = 14.07 ABCD
KSC260 = 34.47 ABCDE	K166A = 18.70 ABC	L105 X K74/1 = 16.33 ABCDEF	OH43/1-42 = 12.40 ABCD
K2816 X K1264/1 = 34.33 ABCDE	K3651/1 = 17.43 BC	KSC260 = 15.87ABCDEFG	K3651/1 = 12.37ABCD
KSC700 = 33.77 ABCDE	B73 = 15.07 BC	K1264/1 X TVA926 =15.83 ABCDEFG	K19 = 12.33 ABCD
TWC603 = 32.87 ABCDEF	K1263/1 = 14.93 BC	KSC108 = 15.77 ABCDEFG	K1264/5-1 = 12.20 ABCD
B73 X K19 = 32.07 ABCDEF	K722 = 14.90 BC	KSC604 = 15.73 ABCDEFG	SL12 =12.10 ABCD
K1264.1 X TVA926 = 31.43 ABCDEF	K2331 = 14.47 BC	KSC400 = 15.30 BCDEFG	K722 = 11.87 ABCD
KE72012/1 X K2331= 31.40 ABCDEF	A188 = 14.03 BC	L105 X K19 = 14.83 BCDEFGH	TVA926 = 11.80 ABCD
K1264/1 X KE72012=30.80 ABCDEF	K1728/8 = 13.67 BC	TWC603 = 14.70 CDEFGH	KE72012/1-12 = 11.77 ABCD
KSC108 = 26.93 BCDEFG	K615.1 =13.27 BC	K2816 X K1264/1= 14.40 DEFGH	S61 = 11.67 ABCD
KSC301 = 26.53 CDEFG	S61= 12.87 BC	B73 X K19 = 14.40 DEFGH	K1264/1 = 11.33ABCD
DC370 = 25.50 DEFG	TVA926 = 12.80 BC	KSC704 = 14.13 EFGH	A188 = 10.87 BCD
KSC403 =25.27 EFG	K1263/2-1 =12.73 BC	KSC403 = 13.90 FGH	K1263/1 = 10.77BCD
B73 X K74/1 = 25.23 EFG	K3640.5 = 12.70 BC	ZP434 = 13.53 GH	K1263/2-1 = 10.70 BCD
KSC604= 24.20 FG	K1264/5-1 =12.33 BC	DC370 = 13.40 GH	K615/1 = 10.53 CD
ETH-M82 = 20.30 G	OH43/1-42 = 10.33C	ETH-M82= 12.27H	MO17 = 10.00 D

There is no significant differences between data with the same letters in each row

Table 6: Variation between maize genotypes in terms of grain yield

Hybrids	grain yield (ton/ha)	Inbred lines	grain yield (ton/ha)
KE72012/1-12 × K2331	= 7.772 A	KE72012/1-12	= 1.722 A
KSC500	= 7.661 A	K3640/5	= 1.469 AB
ZP434	= 7.223 AB	K19	= 1.408 AB
KSC260	= 7.067 AB	SL12	= 1.137 BC
K74/1 × MO17	= 6.937 AB	B73	= 1.095 BCD
K1264/1 × KE72012/1-12	= 6.697ABC	K2331	= 1.055 BCDE
KSC700	= 6.684 ABC	K3651/1	= 1.018 BCDEF
L105 × K19	= 6.619 ABC	S61	= 0.9802 BCDEF
B73 × K19	= 6.247 ABCD	K1263/2-1	= 0.8665 CDEFG
KSC704	= 6.027ABCDE	K1728/8	= 0.8189 CDEFGH
L105 × K74/1	= 6.026 ABCDE	K1263/1	= 0.7992 CDEFGH
KSC302	= 5.521 ABCDEF	K1264/5-1	= 0.7064 CDEFGHI
KSC301	=5.310 ABCDEF	K2816	= 0.6950 CDEFGHI
B73 × K74/1	=5.310 ABCDEF	L105	= 0.6123 DEFGHI
TWC603	=5.158 ABCDEF	K166A	= 0.5822 EFGHI
KSC400	= 4.876 ABCDEF	K615/1	= 0.5570 EFGHI
K2816× K1264/1	=4.164BCDEF	MO17	= 0.5317 FGHI
K1264/1×TVA926	=4.091BCDEF	A188	= 0.4521 GHI
KSC108	= 3.671 CDEF	TVA926	= 0.4521 GHI
KSC604	= 3.306 DEF	K1264/1	= 0.3761 GHI
DC370	= 2.916 EF	K722	= 0.3547 GHI
ETH-M24	= 2.894 F	K18	= 0.3132 HI
		OH43/1-42	= 0.2798 I

There are no significant differences between data with the same letters in each row

L105 and K2331, respectively (Table 3). [27] reported that these growth inhibition is partially due to the metabolic costs associated with an attempt to adapt the plant to salinity. The cell expansion process depends on the hydraulic conductivity of the water uptake pathway, uptake of solutes to maintain osmotic potentials, and the yielding of the surrounding cell walls [28-29].

The longest (18.67 cm) and shortest (11.43 cm) ears were produced by L105×K19 and DC370, respectively. Moreover, ear length significantly correlated with kernel per row (r^2= 0.83**)(table 7). There was significant difference among genotypes in terms of kernel depth.Kernel depth was deeper in control treatment compared with stress treatments(Table 4).

Table 7: Coefficient of correlation between grain yield and related traits in corn genotypes under saline conditions

Trait	Grain yield	ASI	Kernels no.	Ear lenght	Rows no.	Kernel no./row	1000-seeds weight	Kernel depth	Ear height
Plant height	0.826**	-0.093 ns	0.779**	0.793**	0.572**	0.765**	0.711**	0.579**	0.903**
Ear height	0.771**	-0.026 ns	0.739**	0.79**	0.511**	0.74**	0.715**	0.526**	
Kernel depth	0.641**	-0.152 ns	0.581**	0.444**	0.452**	0.536**	0.505**		
1000-seed eight	0.684**	0.027 ns	0.589**	0.657**	0.318**	0.62**			
Kernels no./row	0.816**	-0.202 ns	0.954**	0.83**	0.548**				
Rows no.	0.587**	-0.079 ns	0.754**	0.55**					
Ear length	0.815**	-0.149 ns	0.82**						
Kernels no.	0.836**	-0.17 *							
ASI	-0.133ns								

ns= non significant, * and ** = significant at the 5% and 1% levels respectively

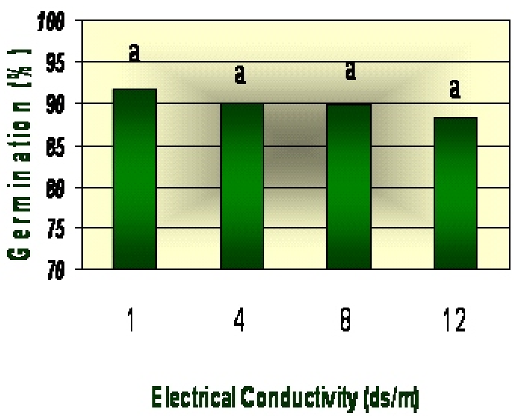

Fig 1: Effect of salt stress on maize germination percentage

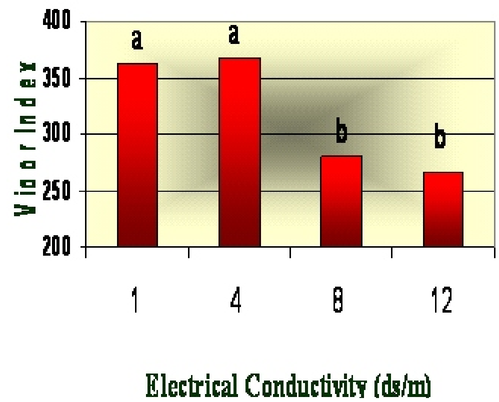

Fig 2: Effect of salt stress on vigor of maize genotypes

Kernel depth was also correlated with grain yield (r^2= 0.64 **)(Table 7). The use of mass selection for kernel depth as a means of grain yield improvement in the short term is reported by [30]. When kernels are deep and big, there are fewer kernels required per unit of corn weight [31].

The highest kernel per row in hybrids and inbred lines was belonged to KSC400 and L105 with 39.07 and 28.57, respectively. While the hybrid B73 × K74/1 and inbred line B73 had the highest rows per ear (Table 5). we estimated positive and significant correlation between kernel per row and rows no. per ear (Table 7).

Thousand kernel weight (TKW) significantly affected by genotype (Table 4). The maximum (262 g) and minimum (87 g) TKW were produced by KSC 704 and K18, respectively. Thousand kernel weight was lower in inbred lines compared with hybrids. Severe salt stress during dough and dent stages of grain fill often results in premature kernel black layer formation and thus decreases grain yield due to decreased kernel size and weight [32].

The maximum (7.77 $tonha^{-1}$) and minimum (2.89 $tonha^{-1}$) grain yield were produced by KE72012/1-12×K2331 and ETH-M82, respectively (Table 6). The highest correlation observed between grain yield and kernel per ear (r^2= 0.84**), ear length (r^2= 0.81**) and kernel per row (r^2= 0.81**)(Table 7). [33] Reported 29% reduction in yield when maize plants were irrigated continuously with saline water (EC 5.0dS m^{-1}).

CONCLUSION

Grain yield was highly correlated with plant height (r^2= 0.82**) and kernel no. per ear (r^2= 0.84**) (Table 7). The yield production of hybrids was higher than those of inbred lines at saline condition. The K364015 and K19 Inbred lines yielded 1.47 and 1.41ton ha^{-1} under salinity stress condition which is an acceptable yield for stress condition. KE72012/1-12 produced a high yield both as an inbred line and when composed with K2331, thus it is recommended as a promising inbred line for future researches.

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