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# EVALUATION OF SOME MAIZE-TEOSINTE HYBRIDS AND THEIR PARENTS UNDER WATER STRESS CONDITIONS

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**ABSTRACT:** The study was carried out to evaluate some maize-teosinte hybrids under water stress conditions, seven parent genotypes *i.e*., maize (S.C. 130, S.C. 168, T.W.C. 321 and T.W.C. 352) as female and teosinte (Gemmeiza 3, Gemmeiza 4 and Sakha 1) were used as male. Genotypes were crossed using by line × tester mating design to produce 12 $F_1$ crosses. Tested genotypes, *i.e.*, seven parents (four maize and three teosinte) as well as their 12 F1 crosses were evaluated under three irrigation regimes *i.e.*, irrigation every 12 (normal), every 18 (moderate) and every 24 days (stress regime). Mean performance and combining ability (general and specific). For tested genotypes (growth characters and forage production, physiological parameters, chemical composition in forage plants, grains yield and its components of maize as well as water use efficiency/ fad and drought tolerance indices. Results cleared that, analysis of variance was highly significant among the tested genotypes (parents and crosses) for most characters studied under the three irrigation regimes. The three teosinte parents were superior to the four maize parents in most growth characters and forage productivity under the three irrigation regimes. Moreover, teosinte parents Gemmeiza 3 ($T_1$) and maize parent S.C. 130 ($L_1$) produced the highest values of most characters as well as forage productivity. In addition, all 12 tested crosses had the highest values of most measured traits that were higher than that obtained by their parents (maize or teosinte). S.C. 130 x Gemmeiza 3 ($L_1$ x $T_1$) cross which gave the highest values under the three irrigation regimes. Exposing the tested seven parents (four maize and three teosinte) and their crosses to drought stress by increasing irrigation intervals from 12 to 18 and 24 days caused a gradual decrease in their most characters as well as fresh and dry forage yields/ fad. Maize genotype S.C. 130 ($L_1$) and teosinte genotype Gemmeiza 3 ($T_1$) exhibited highly significant (useful) GCA effect for most characters studied as well as fresh and dry forage yields/ fad generally in all tested irrigation regimes. Crosses ($L_1$ x $T_1$, $L_4$ x $T_3$) exhibited the highest significant positive desirable SCA effect for all studied as well as fresh and dry forage yields fad$^{-1}$ (under the three irrigation regimes). GCA/SCA variance for all traits studied were less than unity under all irrigation treatments. The data showed generally that water use efficiency (WUE) of the three tested teosinte parents was superior to the four tested maize parents under the three irrigation regimes. The highest values of WUE for teosinte parents were obtained by Gemmeiza 4 ($T_2$) genotype, while for the maize parents were obtained by SC130 ($L_1$) genotype at the three irrigation regimes. All 12 $F_1$ crosses (maize x teosinte) significantly surpassed their parents in WUE under three irrigation regimes. The highest values of WUE were obtained by crosses ($L_1$x $T_1$), ($L_2$ x $T_1$), ($L_4$ x $T_3$), ($L_3$ x $T_3$) and ($L_3$ x $T_2$) in descending order when they were irrigated every 24 days (stress regime). All tested teosinte parent genotypes are generally considered more tolerant to drought stress than all tested maize parent genotypes under moderate irrigation regime. Moreover, teosinte Gemmeiza 3 ($T_1$) genotype was superior in the drought tolerant under stress irrigation regime. Crosses ($L_1$ x $T_1$), ($L_1$ x $T_2$), ($L_2$ x $T_1$), ($L_3$ x $T_3$) and ($L_4$ x $T_3$) exhibited the lowest values of drought tolerance indices (TOL, RYR % and DSI) when they were grown under the stress irrigation conditions, indicating that those crosses were found to be the best crosses (maize x teosinte) to drought tolerance in this study.

**Keywords**: Maize, Teosinte, Drought, Crosses, Hybrids, Irrigation Regimes, Line × Tester, Combining Ability.

## INTRODUCTION

The production of forages insufficient quantity and quality throughout the year. So, Now-adays many attempts in Egypt are doing for increasing the forage quantity and quality production, especially in summer season, where the area of fresh forage crops is very limited. Great efforts have been done for increasing forage yield quantity and quality per unit area. Maize x teosinte hybrids (maizinte) could provide and answer to overcoming the problem of insufficient quantity and quality production of summer forages. Chaudhuri and Prasad (1969), raised the successful hybrids between maize and teosinte with considerable of heterosis was observed, where Teosinte (*zea Mexicana L.* 2n=20) belongs to *Poaceae* is considered the most closely related to maize (*zea mays L.* 2n= 20) and an expected new forage crop in Egypt. Maize × teosinte hybrid (maizinte) has been of considerable interest to both maize and teosinte breeders. Hybridization between maize and teosinte was started in early thirty's in India (khan 1957). The F1 hybrids possessed the characters that contributed toward higher forage yield. Hybrid had somewhat longer vegetative period than maize but, were much earlier than teosinte in flowering habit and had a profuse number of cobs plant$^{-1}$. Hybrids grew quicker than either their parents and on average had 2-3 tillers plant$^{-1}$ and consequently more leaves plant$^{-1}$ than maize. The information about "maizente" has been given by several authors (Abdel-Aty *et al*., 2013; Hatab, 2014; Sakr, 2017; Mousa *et al*., 2017 and Bendary *et al*., 2022).

Water is the most important factor which is essential for growth of plant and ultimately enhance yield of crops. Water stress is abiotic stress factor that adversely affects crop growth and productivity by changing the morphological, physiological and biochemical processes of plant (Al-ashkar *et al.*, 2016 and Barutculer *et al*. 2016).

Line x tester analysis developed by Kempthorne 1957 is a breeding strategy for predicting general combining ability (GCA) of parents and selecting suitable parents and crosses with high specific combining ability (SCA). Also, provides information regarding genetic mechanisms controlling important quantitative traits (Yildirim and Cakir, 1986; Rashid *et al.*, 2007; Aslam *et al.,* 2014).

Knowledge of general and specific combining abilities and gene actions helps to decide breeding method to choose desirable genotypes. Salgotra *et al.* (2009). Malik *et al.* (2014) stated that general combining ability is attributed to additive type of gene effects, while specific combining ability is attributed to non-additive type of gene actions.

## MATERIALS AND METHODS

The present study was carried out in the Experimental Farm at EL-Gemmeiza Agriculture Research Station (ARC), El-Gharbia Governorate, Egypt, during 2018 and 2019 summer seasons. Seven different genotypes (four female and three males) belonging to different species of *Zea* were used in the present study. Four maize hybrids belong to *Zea mays* (S.C. 130- S.C. 168- T.W.C. 321- T.W.C. 352) were used as female parents (lines), while three teosinte genotypes were belonged to *zea mexicana* (*Euchlaena mexicana*) were used as males (testers). The four females and three males were crossed according to (line × tester) mating design to produce 12 $F_1$ crosses. In 2018 season, the parents representing of the three teosinte genotypes (Testers*) i. e.,* Gemmeiza 3, Gemmeiza 4 and Sakha 1 were sown on the 3rd June while those of four maize hybrids (Lines) were sown on two dates; July 25th and 31th. The kernels of the four maize and three teosinte genotypes were obtained from maize and forage research sections, respectively, agriculture research center (ARC) ministry of agriculture. All recommended cultural practices were applied. At the flowering stage, crosses were made between lines and testers using (lines × tester) design. In 2019 summer season, three field experiments were conducted to evaluate the seven parents and 12 $F_1$ crosses under three irrigation regimes *i.e.*, irrigation every 12 (3481.11m$^3$), 18 (2752.07m$^3$) and 24 days

($2444.99m^3$). Each experiment was arranged in a randomized complete plot design with three replicates. Each entry was grown in 4 rows, 4 meters long and 80 cm apart. Kernels were planted in hill 35 cm apart on 15th June. Irrigation was stopped for the three irrigation regimes at (90 DAS) to reach grain maturity of maize (110 DAS) and teosinte and crosses (maize × teosinte (120 DAS).

Water requirement for the three irrigation regimes was determined using submerged flow orifice with fixed dimension to convey and measure the irrigation water applied according method described by Michael (1978).

## Studied traits

At silage stage (100 DAS), the following parameters were measured:

**Growth characters** *i.e*., Plant height (cm), Numbers of tillers and leaves plant$^{-1}$, Leaves area plant-1 ($cm^2$), Stem fresh and dry weights plant-1(g), Leaves fresh and dry weights plant-1(g), Ears fresh and dry weights plant$^{-1}$ (g) and Fresh and dry forage yields fad$^{-1}$ (ton)

**Physiological parameters**: Total chlorophyll, Proline concentration, Peroxidase Enzyme, Osmotic pressure, Total and relative water content.

**Chemical composition:** Crude protein %, Carbohydrate content % and Ash content%.

**Grains yield and its components**: At harvest, (maize at 110 DAS , teosinte and crosses at 120 DAS), samples of ten plants were taken to determine the following traits (number of ears plant$^{-1}$, number of kernels ear$^{-1}$, 100- kernel weight (g), kernels weight ear$^{-1}$ and grain yield plant$^{-1}$).

## Analysis of variance

Line × tester analysis as proposed by Kempthorne (1957) used to was used in portioning the genetic variation of the $F_1$ crosses due to lines, testers and their crosses and provides information about general and specific combining ability for parents and crosses.

## Drought tolerance efficiency

The following drought tolerance indices have been performed to identify drought tolerance efficiency of genotypes considering fresh forage yield fad$^{-1}$ at the three irrigation regimes.

1. **Water use efficiency (kg / $m^3$ water)**

It was calculated using the following Equation (Michael, 1978)

Water use efficiency = fresh yield (kg/ fad) / total applied water (m3/fad).

2. **Drought susceptibility index (DSI)**

It was calculated using the following equation according to according to Fischer and Maurer (1978):

$$DSI = (1 - Y_{s\,/}\ Y_P)\ /D$$

3. **Tolerance index (TOL)**

It was calculated using the following equation according to Hossain *et al.* (1990).

$$TOL = YP - YS$$

4. **Relative yield reduction % (RYR)**

It was calculated according to Golestani and Assad (1998) using the following formula

$$(RYR\%) = 1 - (Ys / Yp)\ x100$$

Where: Ys = performance of genotype under drought stress.

YP = performance of genotype under normal irrigation

# RESULTS AND DISCUSSION

## 1- Growth characters and forage production

The analysis of variance of the tested genotypes (four maize as lines, three teosintes as testers and their 12 crosses) under irrigation regimes, *i.e*, irrigation every12 days (normal), 18 days (moderate) and 24 days (stress) are presented in Table (1) for growth characters and forage production fad$^{-1}$.

The data of mean squares for tested genotypes were highly significant for all studied growth characters (plant height, numbers of tillers plant$^{-1}$ and leaves plant$^{-1}$, leaves area plant$^{-1}$ and fresh and dry weights of stems plant$^{-1}$,

**Table (1): Analysis of variance for growth characters and forage production $fad^{-1}$ of seven parental genotypes (four maize lines and three teosinte testers) and their 12 $F_1$ crosses under three irrigation regimes (at 100 days after sowing (DAS)).**

| S.O.V. | df | Plant height (cm) | | | No. of tillers $plant^{-1}$ | | | No. of leaves $plant^{-1}$ | | | Leaves area $plant^{-1}$ ($cm^2$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **Rep.** | **2** | 78.65 | 24.44 | 0.33 | 0.12 | 0.16 | 0.54* | 38.53 | 3.21 | 7.58 | 12110274.11 | 7816885.12 | 867218.50 |
| **genotypes** | **18** | 4998.20** | 4990.90** | 5077.10** | 5.62** | 4.94** | 3.53** | 2279.17** | 1910.41** | 4998.20** | 778700779.03** | 501309537.04** | 313275328.57** |
| **Parents** | **6** | 2665.10** | 2484.97** | 2503.32** | 13.83** | 13.00** | 9.63** | 4256.52** | 3649.08** | 2665.10** | 249477959.36** | 132013671.17** | 83677521.46** |
| **Crosses** | **11** | 608.25** | 582.27** | 618.72** | 0.81** | 0.75** | 0.41** | 148.51** | 83.60** | 95.30** | 176860791.79** | 47060796.62** | 110444728.71** |
| **Parents *vs.* crosses** | **1** | 67286.26** | 68521.46** | 69561.93** | 9.39** | 2.62** | 1.14** | 13852.28** | 11573.34** | 9266.69** | 10574277556.62** | 7713820876.84** | 3921998769.79** |
| **Lines** | **3** | 1018.92** | 966.55** | 1324.63** | 1.93** | 1.85** | 0.63** | 208.96** | 109.85** | 224.62** | 295152377.33** | 57655411.93** | 176857136.93** |
| **Testers** | **2** | 1125.58** | 827.86** | 403.11* | 0.11 | 0.11 | 0.19 | 11.86 | 13.44 | 2.53 | 9559816.80 | 1090076.56 | 27269761.62** |
| **Lines × tester** | **6** | 230.47** | 308.27** | 337.63** | 0.48* | 0.41 | 0.38* | 163.82** | 93.85** | 61.56** | 173481990.69** | 57087062.31** | 104963513.63** |
| **Error** | **36** | **48.70** | **60.92** | **81.03** | **0.20** | **0.21** | **0.14** | **17.73** | **8.77** | **7.26** | **9495898.1700** | **9440915.6667** | **2941331.97** |
| **$\sigma^2$GCA** | | 16.296 | 25.123 | 25.092 | 0.014 | 0.015 | 0.001 | -0.661 | -0.442 | 1.455 | 145752.205 | -432505.579 | 236444.572 |
| **$\sigma^2$SCA** | | 60.589 | 37.370 | 132.801 | 0.095 | 0.065 | 0.081 | 48.698 | 28.362 | 18.100 | 54662030.838 | 15882048.882 | 34007393.885 |
| **GCA/ SCA** | | 0.269 | 0.672 | 0.189 | 0.149 | 0.227 | 0.018 | -0.014 | -0.016 | 0.080 | 0.003 | -0.027 | 0.007 |
| | **df** | **Stem fresh weight $plant^{-1}$(g)** | | | **Leaves fresh weight $plant^{-1}$(g)** | | | **Ears fresh weight $plant^{-1}$(g)** | | | **Fresh forage yield $fad^{-1}$ (ton)** | | |
| **Rep.** | **2** | 10058.27 | 6343.18 | 8885.99 | 2817.84 | 739.18 | 1884.14 | 5024.11 | 599.72 | 7091.65 | 30.59 | 10.76 | 10.66 |
| **genotypes** | **18** | 3158344.56** | 2819431.92** | 2570457.21** | 891987.41** | 827666.05** | 692374.18** | 446266.14** | 429189.97** | 376691.08** | 6938.83** | 6319.88** | 5549.05** |
| **Parents** | **6** | 1592337.11** | 1479862.75** | 967270.73** | 728264.72** | 741635.58** | 682938.22** | 30207.13** | 22792.63** | 19262.46** | 3150.80** | 3056.54** | 2315.04** |
| **Crosses** | **11** | 197485.38** | 104016.62** | 325813.29** | 21309.13** | 22113.33** | 15512.27** | 49153.30** | 68206.57** | 59647.15** | 318.97** | 229.70** | 450.49** |
| **Parents vs. crosses** | **1** | 45123840.23** | 40726415.24** | 36880659.20** | 11451784.55 ** | 10204928.84** | 8194471.01** | 7310861.39** | 6838391.50** | 6008745.99** | 102485.41** | 92891.95** | 81037.26** |
| **Lines** | **3** | 24641.51* | 15898.69 | 77499.19** | 42956.03** | 29586.45** | 28497.01** | 38520.24** | 48031.95** | 23086.33** | 140.89** | 66.01** | 120.35** |
| **Testers** | **2** | 412838.78** | 159747.78** | 431639.94** | 6483.66 | 1941.54 | 6222.64 | 68517.38** | 31687.83** | 14008.50* | 433.19** | 165.13** | 392.36** |
| **Lines × tester** | **6** | 212122.84** | 129498.54** | 414694.79** | 15427.51** | 25100.70** | 12116.44** | 48015.13** | 90466.79** | 93140.44** | 369.94** | 333.06** | 634.94** |
| **Error** | **36** | **7331.03** | **21763.28** | **9869.17** | **3831.69** | **989.99** | **2809.6** | **8309.18** | **2902.74** | **3863.80** | **14.9733** | **14.1318** | **13.6186** |
| **σ2GC** | | -631.420 | -1099.220 | -3834.104 | 253.717 | -128.867 | 146.439 | 49.097 | -960.245 | -1444.702 | -2.199 | -4.943 | -7.948 |
| **σ2 SCA** | | 68263.937 | 35911.752 | 134941.875 | 3865.272 | 8036.903 | 3102.450 | 13235.318 | 29188.018 | 29753.091 | 118.195 | 144.548 | 207.261 |
| **GCA/ SCA** | | -0.009 | -0.031 | -0.028 | 0.066 | -0.016 | 0.047 | 0.004 | -0.033 | -0.049 | -0.019 | -0.034 | -0.038 |
| | **df** | **Stem dry weight $plant^{-1}$(g)** | | | **Leaves dry weight $plant^{-1}$(g)** | | | **Ears dry weight $plant^{-1}$(g)** | | | **Dry forage yield $fad^{-1}$ (ton)** | | |
| **Rep.** | **2** | 149.70 | 310.23 | 2276.32 | 379.91 | 1100.98 | 245.40 | 759.77 | 395.95 | 216.13 | 0.51 | 0.86 | 3.64 |
| **genotypes** | **18** | 254984.60** | 211489.59** | 179904.72** | 189297.22** | 156155.60** | 118096.27** | 48397.27** | 27618.83** | 12125.43** | 791.23** | 612.64** | 459.49** |
| **Parents** | **6** | 85907.31** | 68997.36** | 65008.43** | 163681.35** | 163757.93** | 118965.28** | 1500.75* | 1641.64** | 1994.49** | 324.10** | 294.08** | 239.32** |
| **Crosses** | **11** | 21518.78** | 12920.05** | 15083.50** | 10826.58** | 13041.24** | 11439.00** | 18934.76** | 10512.85** | 3433.22** | 74.12** | 59.79** | 45.94** |
| **Parents *vs.* crosses** | **1** | 3837572.40** | 3250707.93** | 2682315.75** | 2306169.52** | 1684799.60** | 1286112.06** | 653863.94** | 371647.89** | 168525.53** | 11482.19** | 8605.34** | 6329.65** |
| **Lines** | **3** | 8458.04** | 5883.74** | 15074.94** | 11264.56** | 16403.37** | 12054.28** | 21346.10** | 12346.57** | 3660.42** | 63.56** | 58.69** | 42.38** |
| **Testers** | **2** | 7870.67** | 16829.84** | 19821.31** | 9129.93** | 17.51 | 10563.64** | 17726.74** | 3773.39** | 4576.12** | 7.20* | 23.68** | 58.82** |
| **Lines × tester** | **6** | 32598.53** | 15134.95** | 13508.52** | 11173.13** | 15701.41** | 11423.16** | 18131.77** | 11842.47** | 2938.64** | 101.71** | 72.38** | 43.42** |
| **Error** | **36** | **1125.73** | **800.15** | **1596.82** | **1049.07** | **733.78** | **537.74** | **570.86** | **205.27** | **268.25** | **1.8840** | **1.2951** | **1.2550** |
| **$\sigma^2$GCA** | | -477.950 | -95.544 | 67.941 | -14.949 | -114.753 | 0.684 | 34.639 | -57.356 | 21.335 | -1.190 | -0.543 | 0.109 |
| **$\sigma^2$SCA** | | 10490.933 | 4778.266 | 3970.567 | 3374.685 | 4989.211 | 3628.473 | 5853.634 | 3879.066 | 890.130 | 33.275 | 23.694 | 14.055 |
| **GCA/ SCA** | | -0.046 | -0.020 | 0.017 | -0.004 | -0.023 | 0.000 | 0.006 | -0.015 | 0.024 | -0.036 | -0.023 | 0.008 |

leaves and ears plant$^{-1}$ as well as forage production (fresh and dry yields fad$^{-1}$). These results were common in under the three irrigation regimes. Moreover, the data of mean squares for parents, crosses and parents *vs.* crosses, lines (maize), testers (teosinte) and lines × testers (crosses) were highly significant for all studied growth characters and forage yield under any of the studied irrigation regimes. However, the mean squares of testers were not significant for numbers of tillers and leaves plant$^{-1}$ and leaves fresh weight plant$^{-1}$ (under the three irrigation regimes) as well as leaves area plant$^{-1}$ (under normal and moderate) and leaves dry weight plant$^{-1}$ (under moderate regime). In this respect, many researchers found a significant variation among genotypes of maize, teosinte and their hybrids under any of irrigation regimes for some growth characters (Abdel- Aty *et al.*, 2013) and Ghazy, 2016) and for forage yield (Sakr and Ghazy, 2010).

GCA/SCA variance for all growth traits studied were less than unity under all irrigation treatments. Such results suggests that inheritance of these traits was mainly controlled by non-additive gene effects (Sakr *et al.*, 2009 and Ghazy, 2016).

Mean performance of variance of the tested genotypes for growth characters and forage production were presented in Table (2). Data showed that increasing irrigation intervals from 12 to 18 or 24 days significantly and gradually decreased all growth characters studied, *i.e,* plant height, number of tillers plant$^{-1}$, number of leaves plant$^{-1}$, leaves area plant$^{-1}$ and fresh and dry weights of stem, leaves and ears plant$^{-1}$ as well as forage production (fresh and dry forage yields fad$^{-1}$). This means that exposing either maize and teosinte plants or their crosses to drought condition caused an injury and reduction in the growth characters and consequently the forage production fad$^{-1}$. The highest reduction (minimum values) was obtained when the plants were irrigated every 24 days (stress condition). The data showed that the tested crosses were superior to their parents in most growth characters and forage production fad$^{-1}$ under the three tested irrigation regimes. Also, the data indicated that the means of teosinte parents had higher values than those of maize parents for all growth characters studied as well as fresh and dry forage yields fad$^{-1}$ and the highest values of parents were recorded by genotypes S.C. 130 and Gemmeiza 4 for the same traits under the three tested irrigation regimes. Sakr and Ghazy (2010) and Mousa *et al.* (2017) found variation among teosinte and maize in their growth and forage production.

The superiority of cross ($L_1$ × $T_1$) in the abovementioned characters may be due to the exceeding of their maize parent (S.C. 130) in those characters under all experienced irrigation regimes as previously discussed. In this respect, Ghazy (2016) and Habeba (2019) found variation among the crosses of (maize × teosinte) in their growth characters and Nanavati *et al.* (2016) and Fayed *et al.* (2020) in fresh and dry forage production/ unite

## General Combining Ability: (GCA)

Estimation of GCA effects for individual parents *i.e.* maize (lines) and teosinte (testers) for growth characters and forage production were shown in Table (3) under the studied three irrigation regimes. Generally data showed that a positive high values of GCA effects which might be of interest for most studied traits Maize genotype (S.C. 130) showed high significant positive GCA effect for plant height, number of tillers and leaves plant$^{-1}$, leaves area plant$^{-1}$, leaves and ears fresh weight plant$^{-1}$ and leaves, stem and ears dry weight plant$^{-1}$ as well as fresh and dry forage yields fad$^{-1}$ as compared with the other maize parents during the three regimes. This indicate that such maize parents found to be a good combiner for growth developing and forage productivity. Teosinte genotype (Gemmeiza 3). for plant height, stem and ears fresh weight plant$^{-1}$, leaves, stem and ears dry weight plant$^{-1}$ as well as fresh and dry forage yields fad$^{-1}$ under one or more of tested irrigation regimes. This indicate that such genotype seemed to be best combiner for those traits. On the other hand, there were no significant among testers for numbers of tillers and leaves plant$^{-1}$, leaves area plant$^{-1}$. From these results, it can be

**Table (2): Mean performance for growth characters and forage production $fad^{-1}$ of the seven parental genotypes (four maize lines and three teosinte testers) and their 12 $F_1$ crosses under three irrigation regimes (at 100 DAS).**

| Genotypes | Plant height (cm) | | | No. of tillers $plant^{-1}$ | | | No. of leaves $plant^{-1}$ | | | Leaves area $plant^{-1}$ ($cm^2$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 265.67 h | 250.00 j | 212.00 f | 1.00 f | 1.00 e | 1.00 g | 14.00 i | 13.66 j | 13.33 g | 6014.3 e | 5336.1 g | 3929.4 i |
| **S.C. 168 ($L_2$)** | 237.67 i | 217.00 l | 194.33 g | 1.00 f | 1.00 e | 1.00 g | 14.00 i | 13.33 j | 13.33 g | 3628.0 e | 3502.4 g | 2424.0 i |
| **T.W.C. 321 ($L_3$)** | 223.33 j | 216.67 l | 210.33 f | 1.00 f | 1.00 e | 1.00 g | 13.66 i | 13.33 j | 12.33 g | 3848.7 e | 3353.1g | 2035.0 i |
| **T.W.C. 352 ($L_4$)** | 245.33 i | 230.00 k | 220.00 f | 1.00 f | 1.00 e | 1.00 g | 13.33 i | 13.00 j | 12.66 g | 5146.1 e | 4678.6 g | 2930.9 i |
| **Mean maize (L)** | **243.00** | **228.42** | **209.17** | **1.00** | **1.00** | **1.00** | **13.75** | **13.33** | **12.67** | **4659.3** | **4217.6** | **2829.8** |
| **Gemmeiza ($T_1$)** | 290.67 g | 277.33hi | 267.67 d | 5.33 a | 5.00 a | 4.33 ab | 85.66 ab | 77.66 bc | 74.33 a | 21821.9 d | 13370.2 f | 10099.0h |
| **Gemmeiza 4 ($T_2$)** | 303.33 f | 285.00 h | 262.33 de | 5.00 a | 5.00 a | 4.67 a | 86.66 ab | 82.66 a | 76.00 a | 23427.5 d | 19539.5 e | 14737.7 g |
| **Sakha 1 ($T_3$)** | 283.33 g | 270.00 i | 251.67 e | 4.66 ab | 4.66 a | 4.00 b | 80.00 b-e | 75.00 cde | 72.66 ab | 19257.0 d | 1547.0 ef | 12135.6 gh |
| **Mean teosinte (T)** | **292.44** | **277.44** | **260.56** | **5.00** | **4.89** | **4.33** | **84.11** | **78.44** | **74.33** | **21502.1** | **16085.6** | **12324.1** |
| **Mean parent (L&T)** | **264.19** | **249.43** | **231.19** | **2.71** | **2.67** | **2.43** | **43.90** | **41.24** | **39.10** | **11877.6** | **7332.4** | **6898.8** |
| **$L_1 \times T_1$** | 358.67 a | 348.67 a | 331.67 a | 4.67 ab | 4.33 ab | 3.33 c | 92.00 a | 80.66 ab | 75.66 a | 57401.8 a | 41288.1 a | 36523.4 a |
| **$L_1 \times T_2$** | 352.00 ab | 342.67 ab | 324.33 a | 4.00 bc | 3.66 bc | 3.00 cd | 81.66 bcd | 77.00 bcd | 72.00 abc | 49669.5 b | 37690.00 b | 31528.4 b |
| **$L_1 \times T_3$** | 324.33 e | 319.00 c-f | 308.33 b | 3.66 cd | 3.33 cd | 3.00 cd | 73.33 e-h | 69.66 fg | 68.33 bcd | 37460.5 c | 31010.25 cd | 23680.8 cd |
| **$L_2 \times T_1$** | 341.33 bcd | 323.00 cde | 307.00 b | 3.00 de | 2.66 d | 2.66 de | 69.00 h | 67.33 ghi | 59.00 f | 35436.1 c | 29954.35 cd | 20501.3 ef |
| **$L_2 \times T_2$** | 324.67 e | 315.33 d-g | 291.67 c | 2.66 e | 2.66 d | 2.66 de | 71.33 fgh | 66.66 ghi | 61.33 ef | 36291.5 c | 32193.5 cd | 20733.00 e |
| **$L_2 \times T_3$** | 326.00 e | 307.67 fg | 295.33 bc | 3.33 cde | 3.00 cd | 2.66 de | 71.33 fgh | 69.33 fgh | 61.33 ef | 34203.4 c | 31552.2 cd | 20891.6 de |
| **$L_3 \times T_1$** | 326.33 e | 311.33 efg | 307.33 b | 3.33 cde | 3.00 cd | 2.33 ef | 70.66 gh | 64.00 i | 60.00 f | 36376. 8 c | 29084.2 d | 21237.1 de |
| **$L_3 \times T_2$** | 333.00 de | 330.00 bc | 276.67 d | 4.000 bc | 3.33cd | 3.00 cd | 78.66 cde | 72.33 def | 67.66 cd | 38726.5 c | 34216.0 bc | 19859.0 ef |
| **$L_3 \times T_3$** | 308.67 f | 305.33 g | 299.67 bc | 3.66 cd | 2.666 d | 2.33 ef | 78.00 c-f | 71.33 efg | 61.00 ef | 35616. 7 c | 31485.6 cd | 24811.6 c |
| **$L_4 \times T_1$** | 349.67 abc | 306.67 fg | 302.00 bc | 3.66 cd | 2.66 d | 2.00 f | 76.00 d-g | 68.66 f-i | 65.33 de | 35010.5 c | 32171.4 cd | 19153.8 ef |
| **$L_4 \times T_2$** | 339.67 cd | 328.00 cd | 296.67 bc | 3.33 cde | 3.00cd | 2.66 de | 68.66 h | 64.66 hi | 62.00 ef | 35323.6 c | 30808.4 cd | 17778.6 f |
| **$L_4 \times T_3$** | 340.67 bcd | 318.00 c-g | 302.67 bc | 3.33 cde | 3.00 cd | 3.00 cd | 84.00 bc | 77.66 bc | 72.66 ab | 49846.5 b | 39588.6 a | 32441.00 b |
| **Mean crosses** | **335.42** | **321.31** | **303.61** | **3.56** | **3.11** | **2.72** | **76.22** | **70.78** | **65.53** | **40113.6** | **33420.2** | **24094.9** |
| **Overall means** | **309.18** | **294.82** | **276.93** | **3.25** | **2.95** | **2.61** | **64.32** | **59.89** | **55.79** | **29710. 9** | **23808.9** | **17759.5** |
| **L.S.D 0.05** | **11.55** | **12.92** | **14.90** | **0.73** | **0.76** | **0.61** | **6.97** | **4.90** | **4.46** | **5102.8** | **5088.0** | **2839.9** |
| **L. S. D 0.01** | **15.49** | **17.33** | **19.98** | **0.98** | **1.02** | **0.82** | **9.34** | **6.57** | **5.98** | **6842.4** | **6822.6** | **3808.1** |

Table (2): Cont.

| Genotypes | Stem Fresh weight $plant^{-1}$(g) | | | Leaves Fresh weight $plant^{-1}$(g) | | | Ears Fresh weight $plant^{-1}$(g) | | | Fresh Forage yield $fad^{-1}$(ton) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 726.56 i | 667.64 g | 587.38 i | 263.79 g | 239.31 h | 168.60 e | 454.66 gh | 371.54 hij | 334.09 hij | 36.125 i | 31.963 h | 27.252 h |
| **S.C. 168 ($L_2$)** | 617.66 ij | 552.96 g | 544.02 i | 224.86 g | 212.84 h | 185.51 e | 430.00 gh | 356.25 ij | 315.65 ij | 31.813 ij | 28.051 hi | 26.130 h |
| **T.W.C. 321 ($L_3$)** | 564.01 j | 531.49 g | 479.26 i | 220.42 g | 202.16 h | 158.31 e | 278.65 i | 259.72 k | 235.78 j | 26.577 j | 24.546 i | 21.834 h |
| **T.W.C. 352 ($L_4$)** | 659.56 ij | 650.40 g | 580.97 i | 256.29 g | 190.62 h | 177.51 e | 323.66 hi | 288.69 jk | 233.46 j | 30.990 ij | 28.531 hi | 24.799 h |
| **Mean maize (L)** | **641.98** | **600.63** | **547.91** | **241.34** | **211.24** | **172.49** | **371.75** | **319.05** | **279.75** | **31.376** | **28.273** | **24.799** |
| **Gemmeiza 3 ($T_1$)** | 2027.35 g | 1916.84 ef | 1593.00 h | 1109.05 f | 1090.66 g | 1033.03 d | 483.70 g | 448.36 gh | 428.90 h | 89.427 g | 86.396 g | 77.373 g |
| **Gemmeiza 4 ($T_2$)** | 2163.57 g | 2037.43 e | 1657.33 h | 1242.06 e | 1218.65 f | 1112.78 d | 580.43 g | 503.55 g | 431.13 h | 97.651 f | 93.991 f | 80.031 g |
| **Sakha 1 ($T_3$)** | 1764.83 h | 1752.80 f | 1570.89 h | 1126.92 f | 1104.42 g | 1045.48 d | 441.17 gh | 427.00 ghi | 340.46 hi | 86.323 h | 82.106 g | 72.921 g |
| **Mean teosinte (T)** | **1984.25** | **1902.36** | **1607.07** | **1159.34** | **1137.91** | **1063.76** | **501.77** | **459.64** | **400.16** | **91.134** | **87.498** | **76.775** |
| **Mean parent (L&T)** | **1217.24** | **1158.51** | **1001.84** | **634.77** | **608.38** | **554.46** | **427.47** | **379.30** | **331.35** | **56.987** | **53.655** | **47.191** |
| $L_1 \times T_1$ | 3657.72 a | 3372.85 a | 3295.40 a | 1760.81 a | 1669.51 a | 1461.22 a | 1412.22 a | 1381.52 a | 1276.31 a | 170.769 a | 163.097 a | 153.323 a |
| $L_1 \times T_2$ | 2708.30 f | 2701.87 d | 2518.87def | 1622.97 b | 1579.28 b | 1461.15 a | 1231.58 bc | 1127.96 d | 990.90 de | 139.071 e | 133.629 de | 124.278 e |
| $L_1 \times T_3$ | 2950.01 de | 2694.89 d | 2290.65 g | 1616.26 b | 1457.33cd | 1333.86 b | 1104.09 c-f | 1076.15 de | 937.38 def | 141.75 de | 129.909 e | 114.047 f |
| $L_2 \times T_1$ | 3430.83 b | 3201.90ab | 3153.52 b | 1564.77 bc | 1417.48de | 1355.27 b | 1335.46 ab | 1284.60 b | 1128.32 bc | 158.277 b | 150.598 b | 140.928 b |
| $L_2 \times T_2$ | 2874.00 e | 2693.05 d | 2511.97 def | 1499.76 cd | 1439.26cd | 1304.20 b | 1062.61def | 1030.66 e | 847.78 fg | 135.909 e | 129.074 e | 116.759 f |
| $L_2 \times T_3$ | 3020.53 d | 2948.52 c | 2562.25 de | 1560.94 bc | 1476.38 c | 1204.78 c | 980.44 f | 890.60 f | 891.27 ef | 139.048 e | 132.188 de | 116.459 f |
| $L_3 \times T_1$ | 2983.63 de | 2906.26cd | 2596.83 d | 1476.30 cd | 1430.94 cd | 1289.79 bc | 1030.10 ef | 870.27 f | 783.40 g | 137.251 e | 129.386 e | 116.751 f |
| $L_3 \times T_2$ | 3044.14 cd | 2961.66bc | 2553.77 de | 1548.56 bcd | 1540.59 b | 1361.25 b | 1226.85 bc | 1164.86 cd | 1106.73 bc | 145.489cd | 140.078 bc | 125.544de |
| $L_3 \times T_3$ | 3037.06 d | 2963.57bc | 2820.71 c | 1558.87 bc | 1462.89 cd | 1367.93 b | 1065.31def | 1032.66 e | 1028.68cd | 141.531de | 135.683cd | 130.433cd |
| $L_4 \times T_1$ | 2944.07 de | 2768.34cd | 2356.49 fg | 1447.10 d | 1366.74 e | 1310.15 b | 1205.00bcd | 1083 01 de | 969.87 de | 139.904de | 129.652 de | 115.913 f |
| $L_4 \times T_2$ | 2909.39 de | 2888.97cd | 2424.97efg | 1495.29 cd | 1422.20 d | 1285.98 bc | 1156.77cde | 1001.65 e | 939.56 def | 139.036 e | 132.022 de | 116.453 f |
| $L_4 \times T_3$ | 3181.17 c | 2928.13cd | 2846.98 c | 1616.08 b | 1563.94 b | 1350.21 b | 1228.45 bc | 1224.04 bc | 1152.92 b | 150.642c | 142.903 b | 133.753 c |
| **Mean crosses** | **3061.74** | **2910.84** | **2669.38** | **1563.98** | **1485.55** | **1340.49** | **1169.91** | **1097.35** | **1004.44** | **144.891** | **137.351** | **125.387** |
| **Overall means** | **2382.19** | **2265.24** | **2055.02** | **1221.64** | **1162.38** | **1050.90** | **896.38** | **832.81** | **756.46** | **112.505** | **106.516** | **96.578** |
| **L.S.D 0.05** | **141.78** | **244.28** | **81.11** | **102.50** | **52.10** | **87.77** | **150.94** | **89.21** | **102.93** | **6.407** | **6.224** | **6.110** |
| **L. S. D 0.01** | **190.11** | **327.55** | **220.57** | **137.44** | **69.86** | **117.69** | **202.39** | **119.62** | **138.01** | **8.592** | **8.347** | **8.194** |

**Table (2): Cont.**

| Genotypes | Stem dry weight plant$^{-1}$(g) | | | Leaves dry weight plant$^{-1}$(g) | | | Ears dry weight plant$^{-1}$(g) | | | Dry Forage yield fad $^{-1}$ (ton) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 237.64 g | 225.37 f | 210.96 h | 166.82 i | 157.42 h | 138.02 f | 243.23 g | 234.48 e | 224.59 g | 16.192 i | 15.432 h | 14.33 j |
| **S.C. 168 ($L_2$)** | 221.57 g | 205.85 fg | 178.32 h | 148.23 i | 134.46 h | 128.54 f | 227.33 g | 218.36 e | 212.70 g | 14.929 ij | 13.967 h | 12.98 j |
| **T.W.C. 321 ($L_3$)** | 187.77 g | 170.04 g | 165.58 h | 137.42 i | 127.82 h | 115.01 f | 182.51 h | 169.29 f | 153.94 h | 12.692 j | 11.679 i | 10.86 k |
| **T.W.C. 352 ($L_4$)** | 223.29 g | 215.17 fg | 202.55 h | 159.00 i | 147.86 h | 134.82 f | 213.39 gh | 225.34 e | 221.76 g | 14.892 ij | 14.709 h | 13.97 j |
| **Mean maize (L)** | **217.57** | **204.11** | **189.36** | **152.87** | **141.89** | **129.10** | **216.62** | **211.87** | **203.25** | **14.676** | **13.947** | **13.035** |
| **Gemmeiza 3 ($T_1$)** | 510.85 f | 466.96 e | 449.88 g | 552.63 h | 550.76 g | 446.31 e | 227.66 g | 215.25 e | 209.25 g | 32.279 h | 30.824 g | 27.63 i |
| **Gemmeiza 4 ($T_2$)** | 554.21 f | 498.20 e | 480.64 g | 611.50 fg | 613.74 e | 559.36 cd | 249.15 g | 236.38 e | 228.26 g | 35.372 g | 33.708 f | 31.70 h |
| **Sakha 1 ($T_3$)** | 531.07 f | 491.27 e | 457.86 g | 600.52 gh | 5667.10 fg | 482.78 e | 236.70 g | 233.69 e | 222.45 g | 34.207 gh | 32.302 fg | 29.07 i |
| **Mean teosinte (T)** | **532.05** | **485.48** | **462.80** | **588.22** | **577.20** | **496.15** | **237.84** | **228.44** | **219.99** | **33.952** | **32.278** | **29.467** |
| **Mean parent (L&T)** | **352.35** | **324.70** | **306.55** | **339.45** | **328.45** | **286.41** | **225.71** | **218.97** | **210.42** | **22.9384** | **21.803** | **20.077** |
| $L_1 \times T_1$ | 1077.39 a | 947.20 a | 882.62 a | 849.95 a | 792.05 a | 718.51 a | 599.79 a | 492.78 a | 374.59 a | 63.079 a | 55.801 a | 49.393 a |
| $L_1 \times T_2$ | 964.57 b | 852.29 bc | 825.70 abc | 827.99 ab | 784.20 a | 673.68 b | 541.73 b | 452.44 b | 365.07 ab | 58.358 b | 52.223 b | 46.611 b |
| $L_1 \times T_3$ | 759.50 e | 765.03 d | 740.30 de | 747.28 de | 632.01 e | 552.74 cd | 380.80 ef | 350.86 cd | 288.7 e | 47.190 f | 43.698 de | 39.543 ef |
| $L_2 \times T_1$ | 903.46 c | 895.05 b | 833.14 ab | 733.94 de | 722.64 b | 665.00 b | 524.36 b | 457.67 b | 342.90 bc | 54.044 c | 51.884 b | 46.026 b |
| $L_2 \times T_2$ | 908.54 c | 831.99 c | 754.63 de | 738.20 de | 676.95 cd | 585.51 c | 354.40 f | 339.52 d | 284.47 ef | 50.029 de | 46.212 c | 40.615 de |
| $L_2 \times T_3$ | 856.31 cd | 740.58 d | 642.68 f | 774.13 cd | 681.03 bc | 531.97 d | 365.41 ef | 357.22 cd | 257.36 f | 49.896 de | 44.471 cde | 35.800 g |
| $L_3 \times T_1$ | 842.20 d | 839.08 c | 748.01 de | 661.20 f | 611.31 ef | 571.53 c | 394.16 de | 341.13 d | 331.64 cd | 47.439 f | 44.788 cde | 41.279 de |
| $L_3 \times T_2$ | 900.79 c | 744.76 d | 711.33 e | 772.23 cde | 634.43 de | 561.92 cd | 382.17 ef | 343.83 d | 309.98 de | 51.380 d | 43.075 e | 39.581 def |
| $L_3 \times T_3$ | 858.44 cd | 824.27 c | 764.96 cde | 777.41 bcd | 652.79 cde | 549.64 cd | 427.20 cd | 339.08 d | 342.24 bc | 51.577 d | 45.404 cd | 41.421 d |
| $L_4 \times T_1$ | 805.22 de | 770.50 d | 748.89 de | 657.81 f | 618.37 e | 564.05 cd | 453.78 c | 335.70 d | 327.84 cd | 47.921 ef | 43.114 e | 41.019 de |
| $L_4 \times T_2$ | 837.69 d | 756.37 d | 643.54 f | 719.45 e | 643.65 cde | 548.85 cd | 434.47 c | 371.96 c | 318.39 cd | 49.790 de | 44.300 de | 37.769 f |
| $L_4 \times T_3$ | 968.85 b | 870.04 bc | 779.21 bcd | 817.63 abc | 768.89 a | 650.25 b | 518.64 b | 454.19 b | 334.53 cd | 57.628 b | 52.328 b | 44.100 c |
| **Mean crosses** | **890.25** | **819.77** | **756.25** | **756.44** | **684.86** | **597.81** | **447.75** | **386.37** | **323.15** | **52.360** | **47.274** | **41.929** |
| **Overall means** | **692.08** | **637.37** | **590.57** | **602.81** | **553.56** | **483.08** | **365.94** | **324.70** | **281.62** | **41.520** | **37.890** | **33.879** |
| **L.S.D 0.05** | **55.55** | **46.84** | **66.17** | **53.63** | **44.85** | **38.39** | **39.56** | **23.72** | **27.12** | **2.722** | **1.884** | **1.855** |
| **L. S. D 0.01** | **74.48** | **62.8** | **88.72** | **71.91** | **60.13** | **51.47** | **53.04** | **31.8** | **36.36** | **3.047** | **2.526** | **2.487** |

**Table (3): Estimates of general combining ability (GCA) effects of seven parent genotypes (four maize lines and three teosintes testers) for growth character and forage productionfad$^{-1}$ under three irrigation regimes (at 100 DAS).**

| Genotypes | Plant height (cm) | | | Number of tillers plant$^{-1}$ | | | Number of leaves plant$^{-1}$ | | | Leaves area plant$^{-1}$(cm$^2$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Maize (lines)** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **S.C. 130 ($L_1$)** | 9.58** | 15.47** | 17.83** | 0.56** | 0.67** | 0.39** | 6.11** | 5.00** | 6.47** | 8063.76** | 3242.56** | 6482.62** |
| **S.C. 168 ($L_2$)** | -4.75* | -5.97* | -5.61 | -0.56** | -0.33* | -0.06 | -5.67** | -3.00** | -4.97** | -4803.22** | -2186.85* | -3386.29** |
| **T.W.C. 321 ($L_3$)** | -12.75** | -5.75* | -9.06** | 0.11 | -0.11 | -0.17 | -0.44 | -1.56 | -2.64** | -3207.22** | -1824.91 | -2125.85** |
| **T.W.C. 352 ($L_4$)** | 7.92** | -3.75 | -3.17 | -0.11 | -0.22 | -0.17 | 0.00 | -0.44 | 1.14 | -53.32 | 769.20 | -970.48 |
| **L.S.D 0.05** | **4.72** | **5.28** | **6.09** | **0.30** | **0.31** | **0.25** | **2.85** | **2.00** | **1.82** | **2083.22** | **2077.18** | **1159.41** |
| **L.S.D 0.01** | **6.33** | **7.08** | **8.16** | **0.40** | **0.42** | **0.33** | **3.82** | **2.68** | **2.44** | **2793.40** | **2785.30** | **1554.67** |
| **Teosinte (testers)** | | | | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 8.58** | 1.11 | 6.56* | 0.11 | 0.06 | -0.14 | 0.69 | -0.61 | -0.53 | 942.76 | -295.73 | 258.96 |
| **Gemmeiza 4 ($T_2$)** | 1.92 | 7.69** | -4.44 | -0.06 | 0.06 | 0.11 | -1.14 | -0.61 | 0.22 | -110.76 | 306.76 | -1620.18** |
| **Sakha 1 ($T_3$)** | -10.50** | -8.81** | -2.11 | -0.06 | -0.11 | 0.03 | 0.44 | 1.22 | 0.31 | -832.00 | -11.03 | 1361.22** |
| **L.S.D 0.05** | **4.09** | **4.57** | **5.27** | **0.26** | **0.27** | **0.22** | **2.47** | **1.73** | **1.58** | **1804.12** | **1798.89** | **1004.08** |
| **L.S.D 0.01** | **5.48** | **6.13** | **7.07** | **0.35** | **0.36** | **0.29** | **3.31** | **2.32** | **2.12** | **2419.16** | **2412.14** | **1346.38** |
| **Maize (lines)** | **Stem fresh weight plant$^{-1}$(g)** | | | **Leaves fresh weight plant$^{-1}$(g)** | | | **Ears fresh weight plant$^{-1}$(g)** | | | **Fresh Forage yield fad $^{-1}$ (ton)** | | |
| **S.C. 130 ($L_1$)** | 43.61 | -20.96 | 65.62 | 102.70** | 83.16** | 78.27** | 79.39* | 97.86** | 63.79** | 5.64** | 4.00** | 5.19** |
| **S.C. 168 ($L_2$)** | 46.72 | 36.99 | 73.21* | -22.15 | -41.17** | -52.40** | -43.74 | -28.73 | -48.64* | -0.48 | -0.82 | -0.70 |
| **T.W.C. 321 ($L_3$)** | -40.13 | 33.00 | -12.27 | -36.06 | -7.41 | -0.83 | -62.49* | -74.69** | -31.50 | -3.47* | -1.23 | -1.11 |
| **T.W.C. 352 ($L_4$)** | -50.20 | -49.02 | -126.56** | -44.49* | -34.59** | -25.04 | 26.83 | 5.55 | 16.35 | -1.70 | -1.95 | -3.38** |
| **L.S.D 0.05** | **57.88** | **99.73** | **67.16** | **41.85** | **21.27** | **35.83** | **61.62** | **36.42** | **42.02** | **2.62** | **2.54** | **2.49** |
| **L.S.D 0.01** | **77.62** | **133.73** | **90.05** | **56.11** | **28.52** | **48.05** | **82.63** | **48.84** | **56.35** | **3.51** | **3.41** | **3.35** |
| **Teosinte (testers)** | | | | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 192.33** | 126.50** | 206.20** | -1.73 | -14.38 | 13.58 | 75.79** | 57.50** | 35.06 | 6.66** | 4.24** | 6.37** |
| **Gemmeiza 4 ($T_2$)** | -177.78** | -99.45* | -166.98** | -22.33 | 9.79 | 12.71 | -0.45 | -16.06 | -33.19 | -5.01** | -2.64* | -4.69** |
| **Sakha 1 ($T_3$)** | -14.54 | -27.06 | -39.23 | 24.06 | 4.59 | -26.29 | -75.34** | -41.44* | -1.87 | -1.65 | -1.60 | -1.68 |
| **L.S.D 0.05** | **50.13** | **86.37** | **58.16** | **36.24** | **18.42** | **31.03** | **53.37** | **31.54** | **36.39** | **2.27** | **2.20** | **2.16** |
| **L.S.D 0.01** | **67.22** | **115.81** | **77.99** | **48.59** | **24.70** | **41.61** | **71.56** | **42.30** | **48.80** | **3.04** | **2.95** | **2.90** |
| **Maize (lines)** | **Stem dry weight plant$^{-1}$(g)** | | | **Leaves dry weight plant$^{-1}$(g)** | | | **Ears dry weight plant$^{-1}$(g)** | | | **Dry Forage yield fad $^{-1}$ (ton)** | | |
| **S.C. 130 ($L_1$)** | 43.57** | 35.07** | 59.96** | 51.97** | 51.23** | 50.50** | 58.37** | 45.67** | 19.64** | 3.85** | 3.30** | 3.25** |
| **S.C. 168 ($L_2$)** | -0.81 | 2.78 | -12.77 | -7.68 | 8.68 | -3.64 | -33.02** | -1.56 | -28.23** | -1.04* | 0.25 | -1.12** |
| **T.W.C. 321 ($L_3$)** | -23.10* | -17.06 | -14.82 | -19.49 | -52.02** | -36.78** | -46.57** | -45.02** | 4.81 | -2.23** | -2.85** | -1.17** |
| **T.W.C. 352 ($L_4$)** | -19.66 | -20.79* | -32.37* | -24.80* | -7.89 | -10.09 | 21.22* | 0.92 | 3.77 | -0.58 | -0.69 | -0.97* |
| **L.S.D 0.05** | **22.68** | **19.12** | **27.01** | **21.90** | **18.31** | **15.68** | **16.15** | **9.69** | **11.07** | **0.93** | **0.77** | **0.76** |
| **L.S.D 0.01** | **30.41** | **25.64** | **36.22** | **29.36** | **24.56** | **21.02** | **21.66** | **12.99** | **14.85** | **1.24** | **1.03** | **1.02** |
| **Teosinte (testers)** | | | | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 16.82 | 43.19** | 46.91** | -30.71** | 1.23 | 31.97** | 44.28** | 20.46** | 21.10** | 0.76 | 1.62** | 2.50** |
| **Gemmeiza 4 ($T_2$)** | 12.65 | -23.41** | -22.45 | 8.03 | -0.05 | -5.31 | -9.55** | -9.43* | -3.66 | 0.03 | -0.82* | -0.79* |
| **Sakha 1 ($T_3$)** | -29.47** | -19.78* | -24.46* | 22.67* | -1.18 | -26.65** | -4.73** | -11.03* | -17.44** | -0.79 | -0.80* | -1.71** |
| **L.S.D 0.05** | **19.64** | **16.56** | **23.40** | **18.96** | **15.86** | **13.58** | **13.99** | **8.39** | **9.59** | **0.80** | **0.67** | **0.66** |
| **L.S.D 0.01** | **26.34** | **22.21** | **31.37** | **25.43** | **21.27** | **18.20** | **18.76** | **11.25** | **12.86** | **1.08** | **0.89** | **0.88** |

concluded that S.C. 130 maize parent ($L_1$) and Gemmeiza three teosinte parent ($T_1$) exhibited favorable general combining ability effect for most traits studied herein. This means that those genotypes could be used as donors in program to improve the growth characters and forage productivity of maize and teosinte under any tested irrigation regimes. Rady (2007), Sakr and Ghazy (2010), Meseka *et al.*, (2011), Abd El-Zaher (2016) and Shaibu *et al.* (2021) they found positive GCA in some maize and teosinte genotypes in some growth characters and forage productivity.

## Specific Combining Ability: (SCA)

Estimates of the (SCA) effects of the 12 crosses between four maize parents (lines) and three teosinte parents (testers) under the three tested irrigation regimes for growth characters, fresh and dry forage yields fad$^{-1}$ were presented in Table (4). There are highly significant positive SCA effects in the plant height of crosses $L_3 \times T_2$ (under normal irrigation regime), $L_1 \times T_1$ and $L_4 \times T_3$ (under moderate irrigation regime) and $L_1 \times T_2$ (under stress irrigation regime). These crosses also exhibited significant desirable heterosis for this trait under various irrigation regimes as previously discussed. Moreover, Cross $L_1 \times T_1$ had the highest significant positive SCA effects for number of leaves plant$^{-1}$ and leaves dry weight (under normal), leaves and ears fresh weight plant$^{-1}$ (under moderate and stress, respectively) and stem fresh weight plant$^{-1}$, as well as fresh forage yield fad$^{-1}$(under normal, moderate and stress irrigation regimes). The cross $L_4 \times T_3$ exhibited highest significant positive desirable SCA effect for ears fresh weight plant$^{-1}$ (under moderate), ears dry weight plant$^{-1}$(under normal and moderate), number and dry weight of leaves (under moderate and stress), leaves area plant$^{-1}$, stem dry weight plant$^{-1}$ and dry forage yield fad$^{-1}$ (under the three irrigation regimes). Also, cross ($L_3 \times T_3$) showed good SCA effect for ears dry weight/ plant (under stress irrigation regime). In this concern, Sakr and Ghazy (2010), Abdel-Aty *et al.* (2013), Hatab (2014), Ghazy (2016), Habeba (2019) and Shaibu *et al.* (2021) found highly significant positive SCA effects in maize × teosinte crosses in some growth characters and forage productivity.

From these results, it could be concluded generally that the crosses namely $L_1 \times T_1$, and $L_4 \times T_3$ could be considered the best combination, since these crosses recorded the highest significant positive SCA for most growth traits and productivity under different environmental conditions of irrigation stress.

## 2- Physiological parameters

Data in Table (5) observed that the mean squares of lines (maize) were significant for total chlorophyll, peroxidase enzyme and osmotic pressure (under the three irrigation regimes), proline content (under normal regime) and relative water content (under normal and stress regimes). However, the mean squares of lines were no significant for total water content in the three regimes. Moreover, the data showed that testers mean squares were significant for peroxidase enzyme and osmotic pressure (under three irrigation regimes), total chlorophyll, proline content and relative water content (under moderate and stress regimes). However, mean squares of testers for total water content % failed to reach the 5 % level of significance. The mean squares of lines × testers were significant for total chlorophyll, proline content, peroxidase enzyme and osmotic pressure (under three irrigation regimes), for total water content (under normal regime) and for relative water content (under stress regime).

GCA/SCA variance for the physiological traits were less than unity under any of the three tested irrigation regimes.

Data in Table (6) showed that increasing irrigation intervals from 12 (normal) to 18 (moderate) and 24 (stress regime) consistently decreased the mean values of each tested parents (maize and teosinte) and their crosses in total chlorophyll, peroxidase enzyme and osmotic pressure, but caused an increase in the values of proline content. On the contrary, the values of total and relative water contents for the tested genotypes were fluctuated from irrigation regime to another.

**Table (4): Estimates of specific combining ability effects (SCA) of 12 crosses (four maize × three teosinte) for growth characters and forage productionfad$^{-1}$ under three irrigation regimes (at 100 DAS).**

| Crosses | Plant height (cm) | | | No. of tillers plant$^{-1}$ | | | No. of leaves plant$^{-1}$ | | | Leaves area plant$^{-1}$ (cm$^{2}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| $L_1 \times T_1$ | 5.08 | 10.78* | -3.67 | 0.44 | 0.50 | 0.36 | 8.97** | 5.50** | 4.19* | 8281.76** | 4921.04** | 5686.91** |
| $L_1 \times T_2$ | 5.08 | -1.81 | 14.67** | -0.06 | -0.17 | -0.22 | -0.47 | 1.83 | -0.22 | 1602.99 | 720.45 | 2571.04* |
| $L_1 \times T_3$ | -10.17* | -8.97 | -11.00* | -0.39 | -0.33 | -0.14 | -9.44** | -7.33** | -3.97* | -9884.75** | -5641.49** | -8257.95** |
| $L_2 \times T_1$ | 2.08 | 6.56 | 2.44 | -0.11 | -0.17 | 0.14 | -2.25 | 0.17 | -1.03 | -816.97 | -983.28 | -466.31 |
| $L_2 \times T_2$ | -7.92 | -7.69 | -1.89 | -0.28 | -0.17 | -0.11 | 1.92 | -0.50 | 0.56 | 1091.89 | 653.37 | 1644.52 |
| $L_2 \times T_3$ | 5.83 | 1.14 | -0.56 | 0.39 | 0.33 | -0.03 | 0.33 | 0.33 | 0.47 | -274.92 | 329.91 | -1178.21 |
| $L_3 \times T_1$ | -4.92 | -5.33 | 6.22 | -0.44 | -0.06 | -0.08 | -5.81* | -4.61* | -2.36 | -1472.31 | -2215.27 | -990.96 |
| $L_3 \times T_2$ | 8.42* | 6.75 | -13.44* | 0.39 | 0.28 | 0.33 | 4.03 | 3.72* | 4.56** | 1930.95 | 2313.96 | -489.89 |
| $L_3 \times T_3$ | -3.50 | -1.42 | 7.22 | 0.06 | -0.22 | -0.25 | 1.78 | 0.89 | -2.19 | -458.65 | -98.70 | 1480.86 |
| $L_4 \times T_1$ | -2.25 | -12.00* | -5.00 | 0.11 | -0.28 | -0.42 | -0.92 | -1.06 | -0.81 | -5992.49** | -1722.49 | -4229.63** |
| $L_4 \times T_2$ | -5.58 | 2.75 | 0.67 | -0.06 | 0.06 | 0.00 | -6.42* | -5.06** | -4.89** | -4625.83* | -3687.79* | -3725.67** |
| $L_4 \times T_3$ | 7.83 | 9.25* | 4.33 | -0.06 | 0.22 | 0.42 | 7.33** | 6.11** | 5.69** | 10618.32** | 5410.28** | 7955.30** |
| **L.S.D 0.05** | **8.17** | **9.14** | **10.54** | **0.52** | **0.54** | **0.43** | **4.93** | **3.47** | **3.16** | **3608.24** | **3597.78** | **2008.17** |
| **L.S.D 0.01** | **10.96** | **12.25** | **14.13** | **0.70** | **0.73** | **0.58** | **6.61** | **4.65** | **4.23** | **4838.31** | **4824.29** | **2692.76** |
| | **Stem Fresh weight plant$^{-1}$ (g)** | | | **Leaves Fresh weight plant$^{-1}$ (g)** | | | **Ears Fresh weight plant$^{-1}$ (g)** | | | **Fresh Forage yield fad$^{-1}$ (ton)** | | |
| $L_1 \times T_1$ | 360.05** | 256.48** | 454.27** | 95.86* | 115.18** | 28.72 | 87.14 | 128.81** | 173.12** | 13.58** | 12.51** | 16.40** |
| $L_1 \times T_2$ | -219.27** | -88.55 | -49.15 | -21.38 | 0.79 | 29.89 | -17.27 | -51.18 | -44.14 | -6.45** | -3.47 | -1.58 |
| $L_1 \times T_3$ | -140.79** | -167.93 | -405.12** | -74.48* | -115.97** | -58.61 | -69.87 | -77.62* | -128.98** | -7.13** | -9.04** | -14.82** |
| $L_2 \times T_1$ | 130.05* | 127.57 | 204.74** | 24.68 | -12.51 | 53.60 | 133.50* | 158.48** | 137.47** | 7.21** | 6.84** | 9.90** |
| $L_2 \times T_2$ | -56.67 | -155.33 | -63.64 | -19.73 | -14.90 | 3.41 | -63.10 | -21.89 | -74.82* | -3.49 | -4.80* | -3.38 |
| $L_2 \times T_3$ | -73.37 | 27.76 | -141.10 | -4.95 | 27.42 | -57.01 | -70.40 | -136.58** | -62.65 | -3.72 | -2.04 | -6.52** |
| $L_3 \times T_1$ | -230.30** | -164.08 | -266.48** | -49.88 | -32.82 | -63.45* | -153.11** | -209.90** | -224.60** | -10.83** | -10.17** | -13.86** |
| $L_3 \times T_2$ | 200.31** | 117.28 | 63.65 | 42.98 | 52.66** | 8.88 | 119.88* | 158.27** | 166.98** | 9.08** | 8.21** | 5.99** |
| $L_3 \times T_3$ | 29.99 | 46.79 | 202.83** | 6.90 | -19.84 | 54.56 | 33.22 | 51.63 | 57.62 | 1.75 | 1.96 | 7.88** |
| $L_4 \times T_1$ | -259.80** | -219.98* | -392.53** | -70.66 | -69.84** | -18.88 | -67.53 | -77.39* | -85.98* | -9.95** | -9.18** | -12.43** |
| $L_4 \times T_2$ | 75.63 | 126.60 | 49.14 | -1.87 | -38.55* | -42.18 | -39.51 | -85.19** | -48.03 | 0.86 | 0.07 | -1.03 |
| $L_4 \times T_3$ | 184.17** | 93.37 | 343.39** | 72.53* | 108.39** | 61.06 | 107.04* | 162.58** | 134.01** | 9.09** | 9.11** | 13.46** |
| **L.S.D 0.05** | **100.26** | **172.74** | **116.32** | **72.48** | **36.84** | **62.07** | **106.73** | **63.09** | **72.78** | **4.53** | **4.40** | **4.32** |
| **L.S.D 0.01** | **134.43** | **231.63** | **155.98** | **97.19** | **49.40** | **83.22** | **143.12** | **84.59** | **97.60** | **6.08** | **5.90** | **5.79** |
| | **Stem Dry weight plant$^{-1}$ (g)** | | | **Leaves Dry weight plant$^{-1}$ (g)** | | | **Ears Dry weight plant$^{-1}$ (g)** | | | **Dry Forage yield fad$^{-1}$ (ton)** | | |
| $L_1 \times T_1$ | 126.75** | 49.17** | 19.50 | 72.26** | 54.73** | 38.23** | 45.40** | 40.30** | 10.70 | 6.11** | 3.60** | 1.71* |
| $L_1 \times T_2$ | 18.10 | 20.86 | 31.95 | 11.55 | 48.16** | 30.68* | 55.17** | 29.84** | 25.95** | 2.12* | 2.47** | 2.21** |
| $L_1 \times T_3$ | -144.85** | -70.03** | -51.44* | -83.80** | -102.90** | -68.92** | -100.58** | -70.14** | -36.65** | -8.23** | -6.08** | -3.93** |
| $L_2 \times T_1$ | -2.80 | 29.32 | 42.74 | 15.89 | 27.87 | 38.87** | 65.36** | 52.41** | 26.89** | 1.96* | 2.74** | 2.71** |
| $L_2 \times T_2$ | 6.45 | 32.86 | 33.60 | -18.59 | -16.54 | -3.34 | -40.77** | -35.86** | -6.78 | -1.32 | -0.49 | 0.59 |
| $L_2 \times T_3$ | -3.65 | -62.18** | -76.34** | 2.70 | -11.33 | -35.54* | -24.58 | -16.56 | -20.11* | -0.64 | -2.25** | -3.30** |
| $L_3 \times T_1$ | -41.77* | -6.82 | -40.34 | -45.04* | -22.77 | -21.47 | -51.30** | -20.67* | -17.41 | -3.45** | -1.26 | -1.98** |
| $L_3 \times T_2$ | 21.00 | -34.53* | -7.65 | 27.25 | 1.64 | 6.20 | 0.54 | 11.91 | -14.31 | 1.22 | -0.52 | -0.39 |
| $L_3 \times T_3$ | 20.77 | 41.35* | 47.99* | 17.79 | 21.13 | 15.26 | 50.76** | 8.76 | 31.72** | 2.23** | 1.78* | 2.37** |
| $L_4 \times T_1$ | -82.19** | -71.67** | -21.90 | -43.11* | -59.83** | -55.64** | -59.46** | -72.04** | -20.18* | -4.62** | -5.09** | -2.44** |
| $L_4 \times T_2$ | -45.55* | -19.19 | -57.89* | -20.21 | -33.27* | -33.55* | -14.94 | -5.90 | -4.86 | -2.02* | -1.46* | -2.41** |
| $L_4 \times T_3$ | 127.73** | 90.86** | 79.79** | 63.32** | 93.10** | 89.19** | 74.41** | 77.94** | 25.05* | 6.64** | 6.55** | 4.85** |
| **L.S.D 0.05** | **39.29** | **33.12** | **46.79** | **37.93** | **31.72** | **27.15** | **27.98** | **16.78** | **19.18** | **1.61** | **1.33** | **1.31** |
| **L.S.D 0.01** | **52.68** | **44.41** | **62.74** | **50.85** | **42.53** | **36.41** | **37.51** | **22.50** | **25.72** | **2.16** | **1.79** | **1.76** |

**Table (6): Mean performance for physiological characters of seven parental genotypes (four maize lines and three teosinte testers) and their 12 $F_1$ crosses under three irrigation regimes (at 100 DAS)**

| Genotypes | Total chlorophyll ( SPAD) | | | Proline content (µg/g ) | | | Peroxidase enzyme ($min^{-1}g^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 (L1)** | 45.13 e-h | 43.00 fg | 42.03 de | 0.517 de | 0.622 bcd | 0.730 bcd | 1.799 a | 1.746 a | 1.623 a |
| **S.C. 168 (L2)** | 38.46 lm | 37.53 i | 36.70 ij | 0.448 f | 0.451 j | 0.628 fg | 1.66 bc | 1.633 cd | 1.566 b |
| **T.W.C. 321 (L3)** | 37.73 m | 35.03 k | 33.93 k | 0.510 de | 0.529 i | 0.563 h | 1.540 d-g | 1.516 fg | 1.456 |
| **T.W.c. 352 (L4)** | 42.26 h-k | 41.10 h | 38.03 hi | 0.442 f | 0.557 hi | 0.626 fg | 1.790 a | 1.706 ab | 1.573 b |
| **Mean maize (L)** | **40.90** | **39.17** | **37.68** | **0.479** | **0.540** | **0.637** | **1.697** | **1.650** | **1.555** |
| **Gemmeiza 3 (T1)** | 39.23 klm | 33.36 l | 32.03 l | 0.550 cd | 0.573 gh | 0.570 h | 1.426 hij | 1.386 ejk | 1.373 gh |
| **Gemmeiza 4 (T2)** | 41.63 ijk | 36.90 ij | 36.53 j | 0.629 a | 0.663 bcd | 0.725 cd | 1.496 f-j | 1.453 hi | 1.416 ef |
| **Sakha 1 (T3)** | 41.13 jkl | 35.73 jk | 34.66 k | 0.614 a | 0.640 c-f | 0.870 a | 1.455 g-j | 1.420 ij | 1.390 fg |
| **Mean teosinte (T)** | **40.67** | **35.33** | **34.41** | **0.598** | **0.625** | **0.722** | **1.459** | **1.420** | **1.393** |
| **Mean parent (L&T)** | **40.80** | **37.52** | **36.28** | **0.530** | **0.576** | **0.673** | **1.595** | **1.551** | **1.485** |
| $L_1 \times T_1$ | 55.10 a | 53.83 a | 50.16 a | 0.633 a | 0.720 a | 0.783 b | 1.750 ab | 1.690 b | 1.563 bc |
| $L_1 \times T_2$ | 52.46 ab | 51.80 b | 49.13 ab | 0.595 abc | 0.651 b-e | 0.668 ef | 1.686 bc | 1.603 cde | 1.540 bcd |
| $L_1 \times T_3$ | 48.50 cd | 48.36 c | 46.20 c | 0.516 de | 0.575 gh | 0.685 de | 1.406 j | 1.380jk | 1.323 i |
| $L_2 \times T_1$ | 51.26 bc | 47.76 cd | 43.13 d | 0.514 de | 0.650 b-e | 0.746 bc | 1.666 bc | 1.653 bc | 1.506 d |
| $L_2 \times T_2$ | 47.53 def | 44.26 e | 41.26 ef | 0.556 bcd | 0.677 bc | 0.728 bcd | 1.526 d-h | 1.476 gh | 1.423 ef |
| $L_2 \times T_3$ | 44.46f-i | 42.40 g | 39.20 gh | 0.547 de | 0.588 gh | 0.612 gh | 1.423 ij | 1.370 jk | 1.333 hi |
| $L_3 \times T_1$ | 43.36 g-j | 40.50 h | 39.83 g | 0.501 e | 0.635 def | 0.730 bcd | 1.623 cd | 1.556 ef | 1.513 d |
| $L_3 \times T_2$ | 45.16 e-h | 42.76 fg | 37.20 ij | 0.597 abc | 0.608 fg | 0.690 de | 1.520 e-i | 1.416 ij | 1.406 fg |
| $L_3 \times T_3$ | 48.30 cde | 46.56 d | 43.13 d | 0.596 abc | 0.613 efg | 0.713 cde | 1.441 g-j | 1.420 ij | 1.370 gh |
| $L_4 \times T_1$ | 44.53 f-i | 41.13 h | 40.13 fg | 0.616 a | 0.690 ab | 0.737 bcd | 1.596 c-f | 1.516 fg | 1.430 ef |
| $L_4 \times T_2$ | 46.36 d-g | 43.70 ef | 41.20 ef | 0.537 de | 0.587 gh | 0.690 de | 1.396 j | 1.343 k | 1.306 i |
| $L_4 \times T_3$ | 51.46 bc | 50.90 b | 47.93 b | 0.603 ab | 0.659 bcd | 0.754 bc | 1.615 cde | 1.596 de | 1.523 cd |
| **Mean crosses** | **48.25** | **46.17** | **43.21** | **0.568** | **0.638** | **0.711** | **1.554** | **1.502** | **1.436** |
| **Overall means** | **45.50** | **42.98** | **40.66** | **0.562** | **0.624** | **0.699** | **1.550** | **1.500** | **1.438** |
| **L.S.D 0.05** | **3.19** | **1.20** | **1.35** | **0.047** | **0.041** | **0.055** | **0.100** | **0.053** | **0.042** |
| **L. S. D 0.01** | **4.27** | **1.60** | **1.81** | **0.063** | **0.055** | **0.074** | **0.134** | **0.071** | **0.056** |

**Table (6): Cont.**

| Genotypes | Osmotic pressure (bar) | | | Total water content % | | | Relative water content % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 4.68 a | 4.582 a | 4.16 b | 57.83 efg | 75.35 ab | 57.27 def | 60.53c-g | 42.64 def | 53.91 bcd |
| **S.C. 168 ($L_2$)** | 4.16 c | 4.081 bc | 4.05 bc | 76.00 ab | 72.83 abc | 70.33 abc | 50.71 fg | 40.57 ef | 50.83 cd |
| **T.W.C. 321 ($L_3$)** | 3.87 cd | 3.792 de | 3.68 d | 49.97 h | 52.76 f | 57.52 def | 51.46 fg | 36.70 f | 42.02 d |
| **T.W.c. 352 ($L_4$)** | 4.60 ab | 4.160 b | 4.13 b | 56.13 fgh | 72.24 abcd | 49.69 ef | 50.00 g | 40.24 ef | 51.39 cd |
| **Mean maize (L)** | **4.33** | **4.15** | **4.01** | **59.98** | **68.30** | **58.70** | **53.18** | **40.04** | **49.54** |
| **Gemmeiza 3 ($T_1$)** | 3.84 cd | 3.739 e | 3.63 e | 51.18 gh | 71.03 abcd | 77.48 a | 57.18 d-g | 57.00 bcde | 57.70 a-d |
| **Gemmeiza 4 ($T_2$)** | 4.16 c | 4.029 bcd | 3.95 cd | 70.85 abc | 64.64 bcde | 71.23 abc | 55.52 efg | 60.47 bcd | 57.87 a-d |
| **Sakha 1 ($T_3$)** | 4.10 c | 4.002 bcde | 3.89 cd | 66.97 cd | 62.37 cdef | 59.56 cde | 60.26 c-g | 50.02 cdef | 54.91 bcd |
| **Mean teosinte (T)** | **4.04** | **3.92** | **3.83** | **63.00** | **66.01** | **69.42** | **57.65** | **55.83** | **56.83** |
| **Mean parent (L&T)** | **4.21** | **4.06** | **3.93** | **61.28** | **67.32** | **63.30** | **55.09** | **46.81** | **52.66** |
| $L_1 \times T_1$ | 4.87 a | 4.50 a | 4.47 a | 61.82 def | 69.09 b-e | 68.66 a-d | 82.13 a | 65.69 abc | 79.50 a |
| $L_1 \times T_2$ | 4.66 a | 4.06 a | 4.34 a | 64.33 cde | 69.00 b-e | 49.29 ef | 71.94 a-d | 67.82 abc | 71.20 abc |
| $L_1 \times T_3$ | 3.42 ef | 3.31 f | 3.18 fg | 65.16 cd | 59.86 ef | 74.08 a | 63.69 b-g | 66.31 abc | 67.58 abc |
| $L_2 \times T_1$ | 4.21 bc | 4.08 bc | 3.97 cd | 70.51 bc | 72.29 a-d | 71.58 ab | 81.26 a | 79.95 a | 77.62 a |
| $L_2 \times T_2$ | 3.42 ef | 3.29 f | 3.24 fg | 65.64 cd | 69.36 b-e | 69.96 abc | 69.19 a-e | 62.51 abc | 58.35 a-d |
| $L_2 \times T_3$ | 3.29 f | 3.23 f | 3.21 fg | 58.11 efg | 70.82 a-e | 53.57 ef | 60.64 c-g | 68.99 ab | 64.51 abc |
| $L_3 \times T_1$ | 3.81 cde | 3.81 cde | 3.63 e | 77.82 a | 68.10 b-e | 61.05 b-e | 71.57 a-d | 63.23 abc | 61.19 a-d |
| $L_3 \times T_2$ | 3.16 f | 3.16 f | 3.16 g | 75.94 ab | 81.35 a | 46.88 f | 76.57 ab | 71.44 ab | 61.02 a-d |
| $L_3 \times T_3$ | 3.55 def | 3.37 f | 3.32 f | 76.78 ab | 61.44 def | 66.12 a-d | 73.57 abc | 69.54 ab | 73.24 ab |
| $L_4 \times T_1$ | 3.29 f | 3.21 f | 3.16 g | 70.17 bc | 73.00 abc | 71.11 abc | 65.19 b-f | 63.29 abc | 61.71 a-d |
| $L_4 \times T_2$ | 3.55 def | 3.29 f | 3.26 fg | 67.37 cd | 70.86 a-e | 60.66 b-e | 65.66 b-f | 63.29 abc | 73.53 ab |
| $L_4 \times T_3$ | 4.18 c | 4.02 bcd | 3.92 cd | 70.79 bc | 70.21 b-e | 73.31 a | 77.91 ab | 79.95 a | 79.74 a |
| **Mean crosses** | **3.79** | **3.62** | **3.49** | **68.70** | **69.62** | **63.86** | **71.61** | **68.50** | **69.10** |
| **Overall means** | **3.94** | **3.78** | **3.66** | **65.97** | **68.77** | **63.65** | **65.53** | **60.51** | **63.04** |
| **L.S.D 0.05** | **0.416** | **0.288** | **0.152** | **6.98** | **11.015** | **11.93** | **14.95** | **18.70** | **21.80** |
| **L. S. D 0.01** | **0.558** | **0.386** | **0.204** | **9.36** | **14.77** | **16.00** | **20.04** | **25.07** | **29.23** |

Data of parents means (maize and teosinte) and their crosses, showed that the means of all tested crosses ware superior to their parents in total chlorophyll, proline content, total and relative water contents under the three irrigation regimes. However, the means of the two parents exceeded their crosses in peroxidase enzyme and osmotic pressure under the three irrigation regimes. Similar results were obtained by Niazi *et al.* (2015) who found that mean of crosses (maize × teosinte) had total chlorophyll more than their parents.

The means of maize genotypes was superior to the means of teosinte genotypes in the total chlorophyll, parents in the proline content, total and relative water contents under most tested irrigation regimes. Maize parent (S.C. 130) had the highest values of total chlorophyll, proline content, peroxidase enzyme and osmotic pressure under the three irrigation regimes. Moreover, S.C168 genotype had the highest values of total water content under normal and stress regimes. However, no significant variation was detected among the tested maize genotypes for relative water content under the three irrigation regimes. Teosinte parent (Gemmeiza 4) surpassed the other genotypes in the values of total chlorophyll, proline content and osmotic pressure under the three irrigation regimes, peroxidase enzyme under moderate and stress regimes and total water content under normal regime. However, Gemmeiza 3 was superior to the other genotypes in total water content under stress regime. Reversely, the differences among tested teosinte genotypes were not significant for relative water content under all tested irrigation regimes.

In Comparison among the 12 crosses (maize × teosinte), the data showed that the cross ($L_1$ × $T_1$) was considered the best cross where it gave the highest values of total chlorophyll, proline content, peroxidase enzyme and osmotic pressure under the three irrigation regimes. Moreover, the greatest values of total water content were obtained by cross $L_3$ × $T_1$ under normal, cross $L_3$ × $T_2$ under moderate and cross $L_1$ × $T_3$ under stress regime. However, the best values of relative water content were recorded by $L_1$ × $T_1$ under normal as well as cross $L_4$ × $T_3$ under moderate and stress regime. From these results, it can be suggested that crosses $L_1$ × $T_1$ and $L_4$ × $T_3$ were generally superior to the other crosses in the most physiological characters and this in turn increased its growth characters and forage production as previously shown in Table (2). In this concern, Niazi *et al*. (2015) and Kumar *et al.* (2020) found variation among the crosses (maize × teosinte) in total chlorophyll.

## General Combining Ability effects: (GCA)

Concerning maize parental genotypes (lines), data in Table (7) indicated that maize genotype S.C. 130 had the highest significant positive GCA effect for total chlorophyll, peroxidase enzyme and osmotic pressure under the three irrigation regimes, respectively. However, T.W.C. 321 genotype had the highest significant positive GCA effect for total water content under normal regime. On the other hand, the other maize genotypes (lines) had no significant positive for GCA for the rest of physiological characters (proline content and relative water contents) under the irrigation regimes. With regard to teosinte parent genotypes (testers), data showed that Gemmeiza three genotype had the highest significant positive values of GCA for peroxidase enzyme, osmotic pressure under the three irrigation regimes, as well as proline content under moderate and stress regimes, respectively and total water content under stress regime. On the other hand, Sakha1 genotype had the highest significant positive values of GCA for total chlorophyll under moderate and stress regimes, respectively. Reversely, there were no significant positive differences in GCA among the other tested teosinte genotypes in relative water content under all irrigation regimes.

From these results, it might be concluded that maize parent S.C. 130 ($L_1$) and teosinte parent Gemmeiza 3 ($T_1$) exhibited favorable general combining ability effect for most physiological studied traits. This means that those genotypes could be used as donors in breeding program to improve physiological traits of maize and teosinte genotypes under any of the tested irrigation regimes. Consequently, increase growth characters and forage productivity.

**Table (7): Estimates of general combining ability (GCA) effects of seven parental genotypes (four maize lines and three teosinte testers) for physiological characters under three irrigation regimes (at 100 DAS).**

| Genotypes | Total chlorophyll (SPAD) | | | Proline content (µg/g) | | | Peroxidase enzyme ($min^{-1}g^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Maize (Lines)** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **S.C. 130 ($L_1$)** | 3.92** | 5.17** | 5.29** | 0.01 | 0.01 | 0.0004 | 0.06** | 0.06** | 0.04** |
| **S.C. 168 ($L_2$)** | -0.49 | -1.36** | -2.01** | -0.03** | 0.00 | -0.0156 | -0.02 | 0.00 | -0.02 |
| **T.W.C. 321 ($L_3$)** | -2.64** | -2.89** | -3.16** | 0.00 | -0.02* | -0.0004 | -0.03 | -0.04** | -0.01 |
| **T.W.c. 352 ($L_4$)** | -0.79 | -0.92** | -0.12 | 0.02 | 0.01 | 0.0155 | -0.02 | -0.02 | -0.02 |
| **L.S.D 0.05** | **1.30** | **0.49** | **0.55** | **0.02** | **0.02** | **0.02** | **0.04** | **0.02** | **0.02** |
| **L.S.D 0.01** | **1.75** | **0.66** | **0.74** | **0.03** | **0.02** | **0.03** | **0.06** | **0.03** | **0.02** |
| **Teosinte (Tester )** | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 0.32 | -0.36 | 0.11 | -0.002 | 0.04** | 0.04** | 0.10** | 0.10** | 0.07** |
| **Gemmeiza 4 ($T_2$)** | -0.26 | -0.53* | -1.01** | 0.004 | -0.01 | -0.02 | -0.02 | -0.04** | -0.02* |
| **Sakha 1 ($T_3$)** | -0.06 | 0.89** | 0.91** | -0.002 | -0.03** | -0.02* | -0.08** | -0.06** | -0.05** |
| **L.S.D 0.05** | **1.13** | **0.43** | **0.48** | **0.02** | **0.01** | **0.02** | **0.04** | **0.02** | **0.02** |
| **L.S.D 0.01** | **1.51** | **0.57** | **0.64** | **0.02** | **0.02** | **0.03** | **0.05** | **0.03** | **0.02** |
| **Maize (Lines)** | **Osmotic pressure (bar)** | | | **Total water content %** | | | **Relative water content %** | | |
| **S.C. 130 ($L_1$)** | 0.53** | 0.48** | 0.43** | -4.93** | -3.63 | 0.15 | 0.98 | -1.99 | 3.74 |
| **S.C. 168 ($L_2$)** | -0.14 | -0.12* | -0.10** | -3.95** | 1.21 | 1.18 | -1.25 | 1.89 | -2.19 |
| **T.W.C. 321 ($L_3$)** | -0.28** | -0.21** | -0.20** | 8.14** | 0.68 | -5.84* | 2.30 | -0.52 | -3.87 |
| **T.W.c. 352 ($L_4$)** | -0.11 | -0.15* | -0.13** | 0.74 | 1.74 | 4.51 | -2.03 | 0.62 | 2.31 |
| **L.S.D 0.05** | **0.17** | **0.12** | **0.06** | **2.86** | **4.57** | **4.84** | **5.78** | **7.71** | **8.08** |
| **L.S.D 0.01** | **0.23** | **0.16** | **0.08** | **3.84** | **6.13** | **6.49** | **7.75** | **10.34** | **10.83** |
| **Teosinte (Tester )** | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 0.26** | 0.27** | 0.24** | 1.38 | 1.01 | 4.25* | 3.43 | -0.55 | 1.49 |
| **Gemmeiza 4 ($T_2$)** | -0.09 | -0.10 | -0.07** | -0.38 | 3.03 | -7.16** | -0.77 | -2.04 | -2.99 |
| **Sakha 1 ($T_3$)** | -0.17* | -0.17** | -0.16** | -0.99 | -4.04* | 2.91 | -2.66 | 2.59 | 1.50 |
| **L.S.D 0.05** | **0.15** | **0.10** | **0.05** | **2.48** | **3.96** | **4.19** | **5.01** | **6.68** | **6.99** |
| **L.S.D 0.01** | **0.20** | **0.14** | **0.07** | **3.33** | **5.31** | **5.62** | **6.71** | **8.96** | **9.38** |

## Specific Combining Ability: (SCA)

Estimates of the SCA effects of the 12 crosses data in Table (8) showed that cross $L_4 \times T_3$ had the highest significant positive SCA effects for total chlorophyll, peroxidase enzyme and osmotic pressure under the three irrigation regimes. On the other hand, the highest significant positive SCA effect for proline content were obtained by cross $L_1 \times T_1$ under normal and cross $L_2 \times T_2$ under moderate regime. Moreover, cross $L_2 \times T_2$ had also, the highest significant positive SCA effects for total water content under stress regime. From these results, it might be concluded that the crosses $L_4 \times T_3$, $L_1 \times T_1$ and $L_2 \times T_2$ might be considered the best combination, since these crosses recorded the highest significant positive SCA for most studied physiological traits under different conditions of irrigation.

## 3- Chemical composition

The analysis of variance for chemical composition (protein%, carbohydrates% and ash%) in the whole plants of the tested genotypes (four maize (lines), three teosintes (testers) and their 12 crosses under three irrigation regimes were presented in Table (9). Results showed that mean squares of genotypes for all chemical traits were mostly highly significant under any of the three irrigation regimes. Moreover, the mean squares of parents were highly significant for carbohydrate% under normal, and ash% under stress. In addition, the mean squares of crosses were highly significant for ash% and protein% under the three irrigation regimes. Also, carbohydrate% under normal and moderate irrigation regimes. However, the mean squares of Parents *vs.* crosses were highly significant for protein % and carbohydrate % under the three irrigation regimes but for ash % under normal. Results also showed that lines mean squares were highly significant for protein% and ash% under all irrigation regimes but for carbohydrate% under normal. Moreover, testers mean squares were highly significant for protein% (under stress) and ash% (under normal and moderate regimes). However, lines × testers mean squares were highly significant for protein % (under moderate and stress), carbohydrate % (under normal and moderate) and ash % (under the three irrigation regimes). On the contrary, the rest of chemical composition under irrigation regimes, the mean squares were not significant.

The GCA/SCA variance ratio were less than unity for all chemical characters under the three studied irrigation regimes with exception protein% under normal irrigation regime.

Mean performance of chemical composition traits (protein %, carbohydrates % and ash %) for the tested parental genotypes (four maize and three teosinte) and their 12 crosses under three irrigation regimes were presented in Table (10). Data showed that prolonging irrigation intervals from 12 (normal) to 24 days (stress) gradually decreased the values of protein, carbohydrates and ash % of the tested genotype and their crosses. El-Gedwy *et al.* (2020) found that decreasing the amount of irrigation caused a reduction in protein %. Also, Barutçular *et al.* (2016) reached similar results in maize grain in ash %.

The data showed that maize parent (S.C. 130) mostly had the highest values of carbohydrates% (under the three irrigation regimes), ash% (under moderate and stress regimes) and protein % (under stress regime). Moreover, teosinte parent (Gemmeiza 4) was superior in the values of carbohydrates % (under normal and stress irrigation regimes) than the other parents. However, insignificant variation were detected among the other tested maize and teosinte parents for the rest of chemical analysis under the other irrigation regimes. Hatab (2014), Mousa *et al.* (2017) and Sakr (2017) who found a significant differences among maize and teosinte genotypes in the protein and ash contents.

With regarded to the comparison among the tested crosses and their parents (maize or teosinte) data showed that the mean of all crosses surpassed the mean of their parents in protein% and carbohydrate % in the three irrigation regimes. Also, ash % in normal regime gave similar result. The cross ($L_1 \times T_1$) was considered the best hybrid regarding chemical composition traits, since it produced the highest

**Table (8): Estimates of specific combining ability effects (SCA) of 12 crosses (four maize × three teosinte) for Physiological characters under three irrigation regimes (at 100DAS).**

| Crosses | Total chlorophyll ( SPAD) | | | Proline content (µg/g ) | | | Peroxidase enzyme ($min^{-1}g^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| $L_1 \times T_1$ | 2.61* | 2.86** | 1.56** | 0.05** | 0.04* | 0.03 | 0.03 | 0.03 | 0.02 |
| $L_1 \times T_2$ | 0.99 | 1.00* | 1.64** | 0.01 | 0.01 | -0.03 | 0.09* | 0.09** | 0.08** |
| $L_1 \times T_3$ | -3.60** | -3.86** | -3.21** | -0.06** | -0.04** | -0.01 | -0.12** | -0.12** | -0.10** |
| $L_2 \times T_1$ | 3.19** | 3.31** | 1.83** | -0.02 | -0.02 | 0.01 | 0.02 | 0.05** | 0.02 |
| $L_2 \times T_2$ | 0.03 | -0.01 | 1.08* | 0.01 | 0.05** | 0.05* | 0.01 | 0.02 | 0.02 |
| $L_2 \times T_3$ | -3.23** | -3.30** | -2.91** | 0.01 | -0.02 | -0.06** | -0.03 | -0.07** | -0.04* |
| $L_3 \times T_1$ | -2.56* | -2.42** | -0.33 | -0.06** | -0.02 | -0.02 | -0.01 | -0.01 | 0.02 |
| $L_3 \times T_2$ | -0.19 | 0.02 | -1.84** | 0.03 | 0.00 | -0.004 | 0.01 | -0.01 | -0.01 |
| $L_3 \times T_3$ | 2.75* | 2.40** | 2.17** | 0.03* | 0.02 | 0.02 | 0.00 | 0.02 | -0.01 |
| $L_4 \times T_1$ | -3.24** | -3.75** | -3.06** | 0.03 | 0.01 | -0.03 | -0.04 | -0.07** | -0.06** |
| $L_4 \times T_2$ | -0.83 | -1.01* | -0.88 | -0.05** | -0.05** | -0.02 | -0.12** | -0.10** | -0.10** |
| $L_4 \times T_3$ | 4.08** | 4.76** | 3.94** | 0.02 | 0.04** | 0.05* | 0.16** | 0.17** | 0.15** |
| **L.S.D 0.05** | **2.26** | **0.85** | **0.96** | **0.03** | **0.03** | **0.04** | **0.07** | **0.04** | **0.03** |
| **L.S.D 0.01** | **3.03** | **1.14** | **1.28** | **0.04** | **0.04** | **0.05** | **0.10** | **0.05** | **0.04** |
| | Osmotic pressure (bar) | | | Total water content % | | | Relative water content % | | |
| $L_1 \times T_1$ | 0.29 | 0.20 | 0.24** | -3.33 | 2.10 | 0.41 | 6.12 | -0.37 | 5.25 |
| $L_1 \times T_2$ | 0.43** | 0.46** | 0.42** | 0.94 | -0.01 | -7.56 | 0.12 | 3.25 | 1.43 |
| $L_1 \times T_3$ | -0.72** | -0.65** | -0.65** | 2.39 | -2.09 | 7.16 | -6.24 | -2.89 | -6.68 |
| $L_2 \times T_1$ | 0.31* | 0.27** | 0.26** | 4.38 | 0.46 | 2.30 | 7.47 | 10.02 | 9.30 |
| $L_2 \times T_2$ | -0.13 | -0.15 | -0.16** | 1.27 | -4.49 | 12.08** | -0.40 | -5.93 | -5.49 |
| $L_2 \times T_3$ | -0.18 | -0.13 | -0.10 | -5.65* | 4.03 | -14.38** | -7.07 | -4.08 | -3.82 |
| $L_3 \times T_1$ | 0.05 | 0.10 | 0.03 | -0.40 | -3.20 | -1.21 | -5.76 | -4.29 | -5.45 |
| $L_3 \times T_2$ | -0.26 | -0.19 | -0.14* | -0.53 | 8.02* | -3.98 | 3.44 | 5.41 | -1.14 |
| $L_3 \times T_3$ | 0.22 | 0.09 | 0.11* | 0.93 | -4.82 | 5.19 | 2.33 | -1.12 | 6.59 |
| $L_4 \times T_1$ | -0.65** | -0.57** | -0.53** | -0.65 | 0.64 | -1.49 | -7.82 | -5.36 | -9.10 |
| $L_4 \times T_2$ | -0.04 | -0.12 | -0.11* | -1.69 | -3.52 | -0.54 | -3.16 | -2.73 | 5.19 |
| $L_4 \times T_3$ | 0.68** | 0.69** | 0.64** | 2.34 | 2.88 | 2.03 | 10.98* | 8.09 | 3.91 |
| **L.S.D 0.05** | **0.29** | **0.20** | **0.11** | **4.96** | **7.92** | **8.39** | **10.01** | **13.36** | **13.99** |
| **L.S.D 0.01** | **0.40** | **0.27** | **0.15** | **6.65** | **10.62** | **11.25** | **13.43** | **17.91** | **18.76** |

**Table (9): Analysis of variance of chemical characters in whole plant for seven parental genotypes (four maize as lines and three teosinte as testers) and their 12 $F_1$ crosses under three irrigation regimes at (100 DAS).**

| S.O.V. | df | Protein % | | | Carbohydrates % | | | Ash % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **Rep.** | **2** | 0.29 | 0.02 | 0.04 | 0.09 | 2.56 | 16.45 | 0.17 | 0.02 | 0.03 |
| **genotypes** | **18** | 2.32** | 0.89** | 0.76** | 6.25** | 6.89** | 24.96 | 0.33** | 0.76** | 0.77** |
| **Parents** | **6** | 0.17 | 0.14 | 0.14 | 3.42** | 2.77 | 42.15* | 0.12 | 0.23* | 0.30** |
| **Crosses** | **11** | 0.85** | 0.45** | 0.50** | 2.31** | 5.64** | 4.39 | 0.41** | 1.11** | 1.10** |
| **Parents *vs.* crosses** | **1** | 31.50** | 10.20** | 7.31** | 66.49** | 45.33** | 148.03** | 0.64** | 0.18 | 0.07 |
| **Lines** | **3** | 2.61** | 0.63** | 0.59** | 2.60** | 3.83 | 1.99 | 0.37** | 1.15** | 1.73** |
| **Testers** | **2** | 0.07 | 0.27 | 0.39** | 0.22 | 6.85* | 8.04 | 0.51** | 2.27** | 0.38* |
| **Lines × tester** | **6** | 0.22 | 0.42** | 0.49** | 2.87** | 6.15** | 4.38 | 0.40** | 0.70** | 1.02** |
| **Error** | **36** | **0.20** | **0.12** | **0.06** | **0.24** | **1.82** | **15.61** | **0.06** | **0.07** | **0.09** |
| **$\sigma^2$GCA** | | 0.027 | 0.001 | 0.0005 | -0.024 | -0.022 | 0.001 | 0.001 | 0.017 | 0.003 |
| **$\sigma^2$ SCA** | | 0.007 | 0.102 | 0.142 | 0.876 | 1.444 | -3.743 | 0.113 | 0.210 | 0.310 |
| **GCA/ SCA** | | 3.949 | 0.012 | 0.003 | -0.027 | -0.015 | 0.000 | 0.005 | 0.083 | 0.011 |

**Table (10): Mean performance of chemical characters in whole plant for seven parent genotypes (four maize as lines and three teosinte as testers) and their 12 $F_1$ crosses) under three irrigation regimes (at 100 DAS)**

| Genotypes | Protein % | | | Carbohydrates % | | | Ash % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 8.591 ef | 8.223 e-h | 8.036 efg | 33.385 c-f | 32.056 a-d | 29.600 j | 9.510 efg | 9.223 cde | 9.073 bc |
| **S.C. 168 ($L_2$)** | 8.453 f | 8.003 gh | 7.523 h | 31.633 h | 30.736 def | 29.470 j | 9.390 fg | 9.150 def | 8.253 e-h |
| **T.W.C. 321 ($L_3$)** | 8.170 f | 7.736 h | 7.483 h | 30.380 i | 29.600 ef | 28.726 k | 9.106 gh | 8.633 gh | 8.180 fgh |
| **T.W.c. 352 ($L_4$)** | 8.476 f | 8.168 fgh | 7.800 fgh | 32.200 gh | 31.496 bcde | 29.413 j | 9.393 fg | 9.193 cde | 8.762 cd |
| **Mean maize (L)** | **8.423** | **8.033** | **7.711** | **31.900** | **30.972** | **29.302** | **9.350** | **9.050** | **8.567** |
| **Gemmeiza 3 ($T_1$)** | 7.880 f | 7.793 h | 7.716 gh | 30.386 i | 26.695 ef | 28.280 k | 9.303 fg | 9.233 cde | 8.610 c-f |
| **Gemmeiza 4 ($T_2$)** | 8.269 f | 8.273 d-h | 8.036 efg | 32.213 gh | 31.713 b-e | 30.853 gh | 9.696 b-f | 9.543 a-d | 8.806 cd |
| **Sakha 1 ($T_3$)** | 8.206 f | 8.200 e-h | 7.803 fgh | 31.606 h | 31.006 c-f | 30.340 i | 9.603 def | 9.326 b-e | 8.676 cde |
| **Mean teosinte (T)** | **8.118** | **8.089** | **7.852** | **31.402** | **29.805** | **29.824** | **9.534** | **9.367** | **8.697** |
| **Mean parent (L&T)** | **8.292** | **8.057** | **7.771** | **31.686** | **30.472** | **29.526** | **9.429** | **9.186** | **8.623** |
| $L_1 \times T_1$ | 10.910 a | 9.630 a | 9.503 a | 35.550 a | 34.23 a | 33.323 a | 10.116 a | 9.960 a | 9.623 a |
| $L_1 \times T_2$ | 10.800 ab | 9.503 a | 9.046 b | 35.376 a | 33.715 ab | 32.733 b | 10.026 ab | 9.700 ab | 9.593 a |
| $L_1 \times T_3$ | 10.106 bc | 8.762 b-e | 8.125 d-g | 33.211 def | 32.646 a-d | 30.465 hi | 9.536 ef | 8.733 fgh | 8.366 d-g |
| $L_2 \times T_1$ | 9.693 cd | 9.178 ab | 8.501 cd | 34.843 bcd | 33.560 ab | 32.680 bc | 10.016 abc | 9.556 a-d | 8.736 cde |
| $L_2 \times T_2$ | 9.550 cd | 9.213 ab | 8.478 cd | 32.986 efg | 32.370 a-d | 31.550 e | 9.606 def | 8.980 efg | 8.810 cd |
| $L_2 \times T_3$ | 9.494 cd | 8.458 d-g | 8.036 efg | 34.400 b | 31.510 b-e | 29.450 j | 9.396 fg | 8.533 gh | 8.336 d-g |
| $L_3 \times T_1$ | 9.746 cd | 8.786 bcd | 8.390 cde | 32.900 fg | 32.685 a-d | 31.496 ef | 9.973 a-d | 9.366 b-e | 8.626 c-f |
| $L_3 \times T_2$ | 9.606 cd | 8.796 bcd | 8.521 cd | 33.246 c-f | 29.203 f | 30.905 gh | 8.816 h | 8.393 hi | 8.006 gh |
| $L_3 \times T_3$ | 9.960 cd | 8.750 b-e | 8.437 cde | 34.440 b | 34.150 a | 31.100 fg | 9.400 fg | 8.073 i | 7.783 h |
| $L_4 \times T_1$ | 9.330 de | 8.580 c-f | 8.190 def | 33.843 bcd | 33.136 abc | 32.070 d | 9.4400 efg | 9.376 b-e | 8.430 d-g |
| $L_4 \times T_2$ | 9.293cde | 8.461 d-g | 8.296 cde | 33.730 b-e | 32.400 a-d | 29.710 j | 9.616 c-f | 8.543 gh | 8.490 d-g |
| $L_4 \times T_3$ | 9.522 cd | 9.08 abc | 8.629 c | 33.385 c-f | 33.386 ab | 32.246 cd | 9.833 a-e | 9.636 abc | 9.516 ab |
| **Mean crosses** | **9.834** | **8.933** | **8.513** | **33.993** | **32.749** | **31.477** | **9.648** | **9.071** | **8.693** |
| **Overall means** | **9.266** | **8.610** | **8.239** | **33.143** | **31.910** | **30.758** | **9.567** | **9.113** | **8.667** |
| **L.S.D 0.05** | **0.746** | **0.563** | **0.412** | **0.817** | **2.231** | **0.448** | **0.403** | **0.448** | **0.487** |
| **L. S. D 0.01** | **1.000** | **0.755** | **0.552** | **1.096** | **2.992** | **0.601** | **0.540** | **0.601** | **0.653** |

significant values of protein%, carbohydrates% and ash% under the three irrigation regimes. In this concern, Niazi *et al.* (2015) and Nanavati *et al.* (2016) found variation among maize and teosinte as well as their crosses in protein %, Flint-Garcia *et al.* (2009) in carbohydrate % and Hatab (2014) and Mousa *et al.* (2017) in ash %.

## General Combining Ability (GCA)

Estimation of GCA of protein, carbohydrate and ash % for the tested seven parent genotypes (four maize and three teosinte) were presented in Table (11). Data indicated that maize genotype S.C. 130 had the highest significant positive GCA effect for protein and ash % under all irrigation regimes, while carbohydrate content under normal irrigation regime. With regard to teosinte parents (testers), data showed that the tester (Gemmeiza 3) had the highest significant positive values of GCA for ash % under normal and under moderate irrigation regimes. Reversely, there were no significant positive differences for GCA among the other tested teosinte parents (testers) in protein, carbohydrate and ash % under all different irrigation regimes.

## Specific Combining Ability effects (SCA)

Estimates of SCA effects of 12 crosses for chemical composition traits (protein %, carbohydrate % and ash %) were presented in Table (12). Data cleared that the highest significant positive values of SCA effect for protein % were obtained by cross ($L_4 \times T_3$) at moderate regime and cross ($L_1 \times T_1$) at stress regime. However, there were no significant positive effect among the other crosses for SCA in chemical composition traits studied under any irrigation regime. As for carbohydrate %, the results showed that the cross $L_3 \times T_3$ had the highest and largest significant positive values of SCA under most irrigation regimes. Data of ash % indicated that the maximum values of significant positive SCA effect were presented by cross ($L_3 \times T_1$) under normal regime and cross ($L_4 \times T_3$) under moderate and stress regimes, as compared to the other tested crosses. However, there were insignificant values of SCA for most of other crosses in this trait under the three irrigation regimes.

## 4- Grain yield and its components

The analysis of variance of grain yield plant$^{-1}$ and its components for the tested genotypes cleared that data of mean squares for tested genotypes, parents and parents *vs.* crosses were found to be highly significant for all grain yield plant$^{-1}$ studied (no. of ears plant$^{-1}$, no. of kernels ear$^{-1}$, kernels weight ear$^{-1}$ and 100-kernel weight) in the three tested irrigation regimes were presented in Table (13). The mean squares of crosses were highly significant for no. of ears plant$^{-1}$ and grains yield plant$^{-1}$ under the three irrigation regimes as well as 100-kernel weight under normal and moderate irrigation regimes. However, the mean squares of crosses were not significant for the number and weight of kernels ear$^{-1}$ in the three irrigation regimes. The mean squares for lines (maize), testers (teosinte) and lines × testers (crosses) were highly significant in the number of ears plant$^{-1}$ and grain yield plant$^{-1}$ under the three irrigation regimes, while but for (line × testers) for 100-kernel weight under normal and moderate irrigation regimes. Reversely, the mean squares of lines, testers and their crosses were not significant for no. and weight of kernels ear$^{-1}$ under the three irrigation regimes. GCA/SCA variance for all grain yield traits studied were less than unity under all irrigation treatments.

Mean performance of grain yield plant$^{-1}$ and its components (number of ears plant$^{-1}$, number of kernel ear$^{-1}$, kernels weight ear$^{-1}$ and 100-kernel weight) for the tested parental genotypes and their 12 crosses in under the three tested irrigation regime were presented in Table (14). Data showed that values of grain yield plant$^{-1}$ and its components for the different tested genotypes were gradually decreased with increasing irrigation intervals from 12 to 18 or 24 days. This means that exposing either maize and teosinte plants or their crosses to drought conditions caused an inhibition and reduction in the grain yield components. Similar results were obtained by Badu-Apraku *et al.* (2018) and Ali and Abdelaal (2020). With regard to the means of the

**Table (11): Estimates of general combining ability (GCA) effects of seven parent genotypes (four maize as lines and three teosinte as testers) for chemical characters in whole plant under three irrigation regimes at /(100 DAS).**

| Genotypes | Protein % | | | Carbohydrates % | | | Ash % | | |
|---|---|---|---|---|---|---|---|---|---|
| **Maize (lines)** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **S.C. 130 ($L_1$)** | 0.77** | 0.36** | 0.38** | 0.79** | 0.78 | 0.70 | 0.24** | 0.39** | 0.50** |
| **S.C. 168 ($L_2$)** | -0.26 | 0.02 | -0.17* | -0.12 | -0.27 | -0.25 | 0.03 | -0.05 | -0.07 |
| **T.W.C. 321 ($L_3$)** | -0.06 | -0.16 | -0.06 | -0.40* | -0.74 | -0.31 | -0.25** | -0.46** | -0.55** |
| **T.W.c. 352 ($L_4$)** | -0.45** | -0.23 | -0.14 | -0.27 | 0.23 | -0.14 | -0.02 | 0.11 | 0.12 |
| **L.S.D 0.05** | **0.30** | **0.23** | **0.17** | **0.33** | **0.91** | **2.67** | **0.16** | **0.18** | **0.20** |
| **L.S.D 0.01** | **0.41** | **0.31** | **0.23** | **0.45** | **1.22** | **3.58** | **0.22** | **0.25** | **0.27** |
| **Teosinte (testers)** | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 0.09 | 0.11 | 0.13 | 0.16 | 0.65 | 0.92 | 0.24** | 0.49** | 0.16 |
| **Gemmeiza 4 ($T_2$)** | -0.02 | 0.06 | 0.07 | -0.09 | -0.83* | -0.25 | -0.13 | -0.17* | 0.03 |
| **Sakha 1 ($T_3$)** | -0.06 | -0.17 | -0.21** | -0.07 | 0.17 | -0.66 | -0.11 | -0.33** | -0.19* |
| **L.S.D 0.05** | **0.26** | **0.20** | **0.15** | **0.29** | **0.79** | **2.31** | **0.14** | **0.16** | **0.17** |
| **L.S.D 0.01** | **0.35** | **0.27** | **0.20** | **0.39** | **1.06** | **3.10** | **0.19** | **0.21** | **0.23** |

**Table (12): Estimates of specific combining ability effects (SCA) of crosses (four maize × three teosintes) for chemical characters in whole plant under three irrigation regimes at (100 DAS).**

| Crosses | Protein % | | | Carbohydrates % | | | Ash % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| $L_1 \times T_1$ | 0.22 | 0.22 | 0.48** | 0.68* | 0.05 | 0.23 | -0.02 | 0.00 | 0.27 |
| $L_1 \times T_2$ | 0.22 | 0.14 | 0.08 | 0.75* | 1.01 | 0.81 | 0.27 | 0.40* | 0.37* |
| $L_1 \times T_3$ | -0.44 | -0.37 | -0.56** | -1.43** | -1.06 | -1.05 | -0.25 | -0.40* | -0.64** |
| $L_2 \times T_1$ | 0.03 | 0.12 | 0.03 | 0.07 | 0.43 | 0.54 | 0.10 | 0.04 | -0.05 |
| $L_2 \times T_2$ | -0.01 | 0.20 | 0.07 | -0.73* | 0.72 | 0.58 | 0.07 | 0.12 | 0.15 |
| $L_2 \times T_3$ | -0.02 | -0.32 | -0.10 | 0.66* | -1.14 | -1.11 | -0.17 | -0.16 | -0.10 |
| $L_3 \times T_1$ | -0.11 | -0.10 | -0.19 | -0.79** | 0.02 | -0.59 | 0.34* | 0.26 | 0.33 |
| $L_3 \times T_2$ | -0.14 | -0.04 | 0.00 | -0.19 | -1.98* | -0.01 | -0.45** | -0.05 | -0.16 |
| $L_3 \times T_3$ | 0.25 | 0.14 | 0.19 | 0.98** | 1.96* | 0.59 | 0.11 | -0.21 | -0.16 |
| $L_4 \times T_1$ | -0.14 | -0.24 | -0.32* | 0.03 | -0.49 | -0.19 | -0.43** | -0.30 | -0.54** |
| $L_4 \times T_2$ | -0.07 | -0.31 | -0.15 | 0.17 | 0.25 | -1.38 | 0.12 | -0.48** | -0.35* |
| $L_4 \times T_3$ | 0.20 | 0.55** | 0.46** | -0.20 | 0.24 | 1.57 | 0.31* | 0.78** | 0.90** |
| **L.S.D 0.05** | **0.53** | **0.40** | **0.29** | **0.58** | **1.58** | **4.63** | **0.29** | **0.32** | **0.34** |
| **L.S.D 0.01** | **0.71** | **0.53** | **0.39** | **0.77** | **2.12** | **6.20** | **0.38** | **0.42** | **0.46** |

**Table (13): Analysis of variance of grain yield plant$^{-1}$ and its components for seven parent genotypes (four maize lines and three teosinte testers) and their 12 $F_1$ crosses under three irrigation regimes.**

| S.O.V. | df | No. of ears plant$^{-1}$ | | | No. of kernel Ear$^{-1}$ | | | 100-kernel weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **Rep.** | **2** | 14.37 | 8.75 | 7.86 | 284.96 | 206.89 | 29.60 | 0.61 | 0.17 | 0.63 |
| **Genotypes** | **18** | 3965.59** | 3008.83** | 2193.79** | 105165.09** | 84377.01** | 62782.42** | 172.63** | 176.77** | 126.96** |
| **Parents** | **6** | 5809.32** | 4264.78** | 3806.63** | 180505.43** | 146108.78** | 108637.08** | 283.49** | 303.04** | 205.16** |
| **Crosses** | **11** | 1247.02** | 786.80** | 380.43** | 22.44 | 17.88 | 21.89 | 2.00* | 1.72** | 0.71 |
| **Parents *vs.* crosses** | **1** | 22807.54** | 19915.46** | 12463.58** | 809692.08** | 641936.84** | 478020.32** | 1384.33** | 1344.63** | 1046.44** |
| **Lines** | **3** | 796.63** | 674.18** | 525.73** | 34.59 | 24.07 | 26.10 | 0.15 | 0.77 | 0.39 |
| **Testers** | **2** | 2007.03** | 1064.58** | 363.58** | 7.44 | 13.58 | 16.33 | 1.80 | 0.09 | 0.54 |
| **Lines × tester** | **6** | 1218.88** | 750.51** | 313.40** | 21.37 | 16.21 | 21.63 | 3.00** | 2.74** | 0.93 |
| **Error** | **36** | **24.79** | **21.07** | **16.34** | **150.98** | **243.69** | **172.00** | **0.81** | **0.46** | **0.73** |
| **$\sigma^2$GCA** | | 1.214 | 1.565 | 2.892 | 0.046 | 0.072 | 0.011 | -0.043 | -0.044 | -0.009 |
| **$\sigma^2$ SCA** | | 398.028 | 243.147 | 99.019 | -43.204 | -75.826 | -50.125 | 0.730 | 0.758 | -12.165 |
| **GCA/ SCA** | | 0.003 | 0.006 | 0.029 | -0.001 | -0.001 | 0.000 | -0.059 | -0.058 | 0.001 |

| S.O.V. | df | kernels weight ear$^{-1}$ (g) | | | grains weight plant$^{-1}$ (g) | | |
|---|---|---|---|---|---|---|---|
| | | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **Rep.** | **2** | 0.05 | 1.77 | 101.50 | 253.22 | 214.51 | 59.18 |
| **Genotypes** | **18** | 10118.85** | 7729.50** | 3520.15** | 19775.59** | 11858.37** | 4189.25** |
| **Parents** | **6** | 17198.10** | 13271.40** | 6022.73** | 26042.96** | 15501.30** | 4334.12** |
| **Crosses** | **11** | 0.57 | 0.43 | 2.50 | 16138.54** | 9296.53** | 3354.31** |
| **Parents *vs.* crosses** | **1** | 78944.41** | 59497.89** | 27198.70** | 22178.89** | 18181.09** | 12504.45** |
| **Lines** | **3** | 0.26 | 0.14 | 2.94 | 12384.02** | 8551.07** | 2245.58** |
| **Testers** | **2** | 0.24 | 0.83 | 1.89 | 37830.96** | 23392.01** | 9917.67** |
| **Lines × tester** | **6** | 0.85 | 0.44 | 2.49 | 10785.00** | 4970.76** | 1720.89** |
| **Error** | **36** | **2.5957** | **1.7926** | **165.12** | **277.5350** | **69.0877** | **45.91** |
| **$\sigma^2$GCA** | | -0.01171 | -0.00049 | 0.00052 | 230.937 | 186.602 | 70.461 |
| **$\sigma^2$ SCA** | | -0.58325 | -0.45117 | -54.20779 | 3502.487 | 1633.890 | 558.327 |
| **GCA/ SCA** | | 0.02008 | 0.00108 | -0.00001 | 0.066 | 0.114 | 0.126 |

**Table (14): Mean performance of grain yield plant[1] and its components for seven parent genotypes (four maize genotypes lines and three teosintes testers) and their 12 $F_1$ crosses under three irrigation regimes.**

| Genotypes | No. of ears plant$^{-1}$ | | | No. of kernels Ear$^{-1}$ | | | 100-kernel weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 2.00 f | 1.66 i | 1.33 i | 479.66 a | 430.00 b | 359.66 b | 34.36 a | 34.24 a | 27.35 b |
| **S.C. 168 ($L_2$)** | 1.66 f | 1.33 i | 1.33 i | 456.66 bc | 394.66 c | 350.66 bc | 33.05 a | 32.21 b | 29.14 a |
| **T.W.C. 321 ($L_3$)** | 1.33 f | 1.33 i | 1.33 i | 477.00 ab | 461.33 a | 401.33 a | 29.06 b | 27.44 c | 25.59 c |
| **T.W.c. 352 ($L_4$)** | 1.66 f | 1.66 i | 1.33 i | 448.30 c | 381.00 c | 331.33 c | 24.69 c | 22.62 d | 22.30 d |
| **Mean maize (L)** | **1.67** | **1.50** | **1.33** | **465.33** | **416.75** | **360.75** | **30.29** | **29.13** | **26.10** |
| **Gemmeiza 3 ($T_1$)** | 82.33 cd | 74.33 cd | 69.66 cd | 7.00 d | 6.66 d | 7.00 d | 12.99 def | 11.34 fghi | 10.51 fg |
| **Gemmeiza 4 ($T_2$)** | 91.00 b | 74.33 cd | 72.33 bc | 7.00 d | 6.66 d | 7.00 d | 1243 ef | 11.29 fghi | 10.95 efg |
| **Sakha 1 ($T_3$)** | 77.66 d | 67.00 def | 61.00 e | 6.66 d | 6.66 d | 6.66 d | 13.75 de | 12.28 ef | 11.94 e |
| **Mean teosinte (T)** | **83.67** | **71.89** | **67.67** | **6.89** | **6.67** | **6.89** | **13.06** | **11.64** | **11.14** |
| **Mean parent (L&T)** | **36.81** | **31.67** | **29.76** | **268.86** | **241.00** | **209.10** | **22.91** | **21.64** | **19.69** |
| $L_1 \times T_1$ | 120.66 a | 106.33 a | 84.66 a | 26.66 d | 24.00 d | 22.66 d | 13.14 def | 12.89 e | 11.07 efg |
| $L_1 \times T_2$ | 86.66 bc | 77.33 e | 69.33 cd | 24.00 d | 23.66 d | 21.33 d | 12.71 def | 10.56 i | 10.42 fg |
| $L_1 \times T_3$ | 66.00 e | 63.66 efg | 60.33 ef | 23.33 d | 22.66 d | 20.66 d | 12.43 ef | 12.20 efg | 11.78 ef |
| $L_2 \times T_1$ | 113.00 a | 95.00 b | 76.66 b | 20.66 d | 20.66 d | 18.33 d | 10.87 g | 10.84 i | 10.49 fg |
| $L_2 \times T_2$ | 64.33 e | 58.33 gh | 52.66 gh | 18.33 d | 18.00 d | 19.00 d | 12.56 ef | 12.40 ef | 10.48 fg |
| $L_2 \times T_3$ | 58.33 e | 55.00 h | 48.33 h | 22.00 d | 22.00 d | 18.66 d | 14.07 d | 11.09 ghi | 10.89 efg |
| $L_3 \times T_1$ | 61.00 e | 55.66 h | 52.00 gh | 17.66 d | 16.66 d | 16.00 d | 12.71 def | 11.06 hi | 11.67 efg |
| $L_3 \times T_2$ | 79.66 cd | 69.33 de | 58.66 efg | 24.00 d | 22.66 d | 22.00 d | 13.70 de | 12.09 efgh | 10.45 fg |
| $L_3 \times T_3$ | 66.33 e | 60.66 fgh | 51.66 h | 21.00 d | 20.66 d | 20.33 d | 11.96 fg | 11.99 efgh | 10.31 g |
| $L_4 \times T_1$ | 77.33 d | 68.00 def | 53.00 gh | 19.66 d | 19.00 d | 16.66 d | 12.31 efg | 11.61 fghi | 10.65 efg |
| $L_4 \times T_2$ | 61.66 e | 58.33 gh | 54.00 fgh | 19.66 d | 18.66 d | 15.66 d | 13.05 def | 11.48 fghi | 10.90 efg |
| $L_4 \times T_3$ | 84.33 bcd | 77.33 c | 63.66 efg | 24.33 d | 23.33 d | 22.66 d | 12.73 def | 10.57 i | 10.50 fg |
| **Mean crosses** | **78.28** | **70.42** | **60.42** | **21.78** | **21.00** | **19.25** | **12.69** | **11.57** | **10.80** |
| **Overall means** | **63.00** | **56.14** | **49.12** | **112.81** | **102.05** | **89.19** | **16.45** | **15.28** | **14.08** |
| **L.S.D 0.05** | **8.24** | **7.60** | **6.69** | **20.34** | **25.85** | **21.71** | **1.48** | **1.12** | **1.41** |
| **L. S. D 0.01** | **11.04** | **10.19** | **8.97** | **27.27** | **34.66** | **29.11** | **1.98** | **1.50** | **1.89** |

**Table (14): Cont.**

| Genotypes | Kernels weight ear$^{-1}$ (g) | | | Grain yield plant$^{-1}$ (g) | | |
|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress |
| **S.C. 130 ($L_1$)** | 164.80 a | 146.67 a | 86.43 ab | 311.93 b | 247.97 b | 126.55 cd |
| **S.C. 168 ($L_2$)** | 146.57 b | 126.35 b | 99.96 a | 242.99 c | 170.26 efg | 128.12 cd |
| **T.W.C. 321 ($L_3$)** | 136.59 c | 123.19 c | 70.60 b | 176.35 e | 158.32 g | 127.75 cd |
| **T.W.c. 352 ($L_4$)** | 108.36 d | 87.13 d | 73.75 b | 174.90 ef | 136.77 hi | 97.37 efg |
| **Mean maize (L)** | **139.08** | **120.84** | **82.68** | **226.55** | **178.33** | **119.95** |
| **Gemmeiza 3 ($T_1$)** | 0.93 e | 0.78 f | 0.74 c | 74.01 i | 58.71 l | 52.02 h |
| **Gemmeiza 4 ($T_2$)** | 0.87 e | 0.77 f | 0.74 c | 78.01 i | 61.82 l | 53.65 h |
| **Sakha 1 ($T_3$)** | 0.91 e | 0.83 f | 0.78 c | 72.95 i | 59.84 l | 49.51 h |
| **Mean teosinte (T)** | **0.91** | **0.79** | **0.75** | **75.09** | **60.12** | **51.73** |
| **Mean parent (L&T)** | **79.86** | **69.39** | **47.57** | **161.63** | **127.67** | **90.71** |
| $L_1 \times T_1$ | 3.38 e | 3.08 e | 2.68 c | 394.86 a | 311.82 a | 203.44 a |
| $L_1 \times T_2$ | 2.30 e | 2.16 ef | 1.70 c | 249.23 c | 186.57 cd | 143.41 b |
| $L_1 \times T_3$ | 2.52 e | 2.37 ef | 5.02 c | 182.86 de | 167.26fg | 137.04 bc |
| $L_2 \times T_1$ | 3.06 e | 2.78 ef | 2.32 c | 236.12 c | 195.71 c | 134.55 bcd |
| $L_2 \times T_2$ | 3.02 e | 2.39 ef | 1.90 c | 139.90 gh | 127.85 ij | 105.278 e |
| $L_2 \times T_3$ | 2.42 e | 2.13 ef | 1.75 c | 157.74 efg | 129.14 hij | 96.32 fg |
| $L_3 \times T_1$ | 2.89 e | 2.81 ef | 2.26 c | 129.20 h | 98.56 k | 91.62 d |
| $L_3 \times T_2$ | 2.16 e | 1.86 ef | 1.75 c | 207.34 d | 181.81 cd | 124.30 d |
| $L_3 \times T_3$ | 2.36 e | 2.05 ef | 1.73 c | 162.47 efg | 141.85 h | 100.47 ef |
| $L_4 \times T_1$ | 2.16 e | 2.17 ef | 1.88 c | 176.88 e | 140.40 hi | 92.32 fg |
| $L_4 \times T_2$ | 3.18 e | 2.83 ef | 2.19 c | 147.71 fgh | 115.92 j | 86.75 g |
| $L_4 \times T_3$ | 3.11 e | 2.29 ef | 2.22 c | 245.23 c | 179.39 def | 141.44 b |
| **Mean crosses** | **2.71** | **2.41** | **2.28** | **202.46** | **164.69** | **121.41** |
| **Overall means** | **31.14** | **27.09** | **18.97** | **187.46** | **151.05** | **110.10** |
| **L.S.D 0.05** | **2.67** | **2.22** | **21.28** | **27.59** | **13.76** | **11.22** |
| **L. S. D 0.01** | **3.58** | **2.97** | **28.53** | **36.99** | **18.46** | **15.05** |

two tested parents (maize and teosinte), data indicate that means of maize parents had higher values than teosinte parents in no. of kernels ear$^{-1}$, kernels ear weight, 100-kernel weight and grain yield plant$^{-1}$ under any of the tested irrigation regimes. However, teosinte parents surpassed maize parents in no. of ears plant$^{-1}$ under the three irrigation regimes. Concerning maize parents (lines), data indicated that S.C. 130 produced the highest number of kernels ear$^{-1}$ under normal regime,100-kernel weight, kernels weight ear$^{-1}$, grain yield plant$^{-1}$ under normal and moderate irrigation regimes. However, S.C. 168 had the best values for 100-kernel weight, kernels weight ear$^{-1}$ and grain yield plant$^{-1}$ under stress regime. On the other hand, T.W.C. 321 produced the highest number of kernels ear$^{-1}$ under moderate and stress regimes.

With regard to the teosinte parents (testers), the data revealed that Gemmeiza 4 significantly surpassed the other testers in number of ears plant$^{-1}$ and grain yield plant$^{-1}$ under the three irrigation regimes. However, Sakha 1 gave the maximum significant values of 100-kernel weight under stress regime. Similar results were obtained by Kumar *et al.* (2019) who found variation among some maize and teosinte parent genotypes.

In comparison among means of parents (maize and teosinte) and their crosses, data showed that means of parents were superior to the means of crosses in no. of kernels ear$^{-1}$, kernels weight ear. $^{-1}$ and 100-kernel weight under all irrigation regimes. However, the means of crosses were superior to the means of the two parents (maize and teosinte) in no. of ears and grain yield plant$^{-1}$ under the three regimes.

In comparison among the obtained crosses data showed that the cross ($L_1 \times T_1$) had the highest significant grains yield plant$^{-1}$ under the three regimes. Also, kernels weight ear under moderate regime. However, the highest values of 100-kernel weight were obtained by crosses ($L_2 \times T_3$) under normal, ($L_1 \times T_1$) under moderate and ($L_1 \times T_3$) under stress.

## General Combining Ability (GCA)

The estimation of (GCA) effects of seven tested parental genotypes were presented in Table (15). Maize genotype (S.C. 130) and teosinte genotype (Gemmeiza 3) had the highest significant positive GCA values for number of ears plant$^{-1}$ and grains yield plant$^{-1}$ under the three irrigation regimes. On the other hand, there were negative significant GCA effect among the tested maize genotypes and tested teosinte parents for other grain yield components in the three irrigation regimes.

## Specific Combining Ability (SCA)

Estimates of (SCA) effects for the 12 crosses in grain yield plant$^{-1}$ and its components were presented in Table (16). The highest significant positive values of SCA values were obtained by crosses ($L_2 \times T_1$) under normal and stress regimes , and by cross ($L_4 \times T_3$) under moderate regime for the number of ears plant$^{-1}$. Cross ($L_1 \times T_1$) produced the highest significant positive values of SCA values under the three irrigation regimes for grains yield plant$^{-1}$ and for 100-kernels weight cross ($L_2 \times T_3$) produced the highest significant positive values of SCA under normal regime. On the other hand, there were negative effect of SCA among the tested crosses for number and weight of kernels ear$^{-1}$ and under any irrigation regime.

## Drought tolerance efficiency

## Water use efficiency (WUE)

Data of water use efficiency of forage productivity (kg forage yield/ m$^3$ water) for the tested genotypes four maize (lines), three teosinte (testers) and their crosses as affected by three irrigation regimes. *i.e.*, irrigation every 12 days(normal), irrigation every 18 days (moderate) and 24 days (stress) were presented in Table (17). Generally data showed that water use efficiency of the three tested teosinte parents was superior to the four tested maize parents under the three irrigation regimes. Moreover, it could be noticed that the highest values of WUE.

**Table (15): Estimates of general combining ability (GCA) effect for seven parent genotypes (four maize lines and three teosinte testers) for grain yield plant$^{-1}$ and its components under three irrigation regimes.**

| Genotypes | No. of ears plant$^{-1}$ | | | No. of kernels Ear$^{-1}$ | | | 100-kernel weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Maize (lines)** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **S.C. 130 ($L_1$)** | 12.83** | 12.03** | 11.03** | 2.89 | 2.44 | 2.31 | 0.07 | 0.32 | 0.29 |
| **S.C. 168 ($L_2$)** | 0.28 | -0.97 | -1.19 | -1.44 | -0.78 | -1.58 | -0.18 | -0.12 | -0.18 |
| **T.W.C. 321 ($L_3$)** | -9.28** | -8.53** | -6.31** | -0.89 | -1.00 | 0.19 | 0.10 | 0.15 | 0.01 |
| **T.W.c. 352 ($L_4$)** | -3.83* | -2.53 | -3.53* | -0.56 | -0.67 | -0.92 | 0.01 | -0.34 | -0.12 |
| **L.S.D 0.05** | **3.37** | **3.10** | **2.73** | **8.31** | **10.55** | **8.87** | **0.61** | **0.46** | **0.58** |
| **L.S.D 0.01** | **4.51** | **4.16** | **3.66** | **11.14** | **14.15** | **11.89** | **0.81** | **0.62** | **0.78** |
| **Teosinte (Testers)** | | | | | | | | | |
| **Gemmeiza 3 ($T_1$)** | 14.72** | 10.83** | 6.17** | -0.61 | -0.92 | -0.83 | -0.43 | 0.03 | 0.17 |
| **Gemmeiza 4 ($T_2$)** | -5.19** | -4.58** | -1.75 | -0.28 | -0.25 | -0.50 | 0.32 | 0.07 | -0.24 |
| **Sakha 1 ($T_3$)** | -9.53** | -6.25** | -4.42** | 0.89 | 1.17 | 1.33 | 0.11 | -0.10 | 0.07 |
| **L.S.D 0.05** | **2.92** | **2.69** | **2.37** | **7.19** | **9.14** | **7.68** | **0.53** | **0.40** | **0.50** |
| **L.S.D 0.01** | **3.91** | **3.60** | **3.17** | **9.65** | **12.26** | **10.30** | **0.71** | **0.53** | **0.67** |

| Genotypes | Kernels weight ear$^{-1}$ (g) | | | Grain yield plant$^{-1}$ (g) | | |
|---|---|---|---|---|---|---|
| **Maize (Lines)** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **S.C. 130 (L1)** | 0.02 | 0.13 | 0.85 | 29.88** | 29.15** | 14.98** |
| **S.C. 168 (L2)** | 0.12 | 0.02 | -0.29 | -7.91 | -12.66** | -10.72** |
| **T.W.C. 321 (L3)** | -0.24 | -0.17 | -0.37 | -49.27** | -37.44** | -16.28** |
| **T.W.c. 352 (L4)** | 0.10 | 0.02 | -0.18 | 27.29** | 20.95** | 12.01** |
| **L.S.D 0.05** | **1.09** | **0.91** | **8.69** | **11.26** | **5.62** | **4.58** |
| **L.S.D 0.01** | **1.46** | **1.21** | **11.65** | **15.10** | **7.53** | **6.14** |
| **Teosinte (Testers)** | | | | | | |
| **Gemmeiza 3 (T1)** | 0.16 | 0.30 | 0.001 | 63.24** | 50.65** | 33.19** |
| **Gemmeiza 4 (T2)** | -0.05 | -0.10 | -0.40 | -43.98** | -30.35** | -17.02** |
| **Sakha 1 (T3)** | -0.11 | -0.20 | 0.40 | -19.26** | -20.30** | -16.17** |
| **L.S.D 0.05** | **0.94** | **0.78** | **7.52** | **9.75** | **4.87** | **3.97** |
| **L.S.D 0.01** | **1.26** | **1.05** | **10.09** | **13.08** | **6.53** | **5.32** |

**Table (16): Estimates of specific combining ability (SCA) of 12 crosses (four maize × three teosinte) for grain yield plant$^{-1}$ and its components under three irrigation regimes.**

| Crosses | No. Of Ears Plant$^{-1}$ | | | No. Of Kernels Ear$^{-1}$ | | | 100-Kernel Weight (G) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** | **Normal** | **Moderate** | **Stress** |
| **$L_1 \times T_1$** | 14.83** | 13.06** | 7.06** | 2.61 | 1.47 | 1.94 | 0.81 | 0.97* | -0.19 |
| **$L_1 \times T_2$** | 0.75 | -0.53 | -0.36 | -0.39 | 0.47 | 0.28 | -0.37 | -1.39** | -0.43 |
| **$L_1 \times T_3$** | -15.58** | -12.53** | -6.69** | -2.22 | -1.94 | -2.22 | -0.44 | 0.42 | 0.62 |
| **$L_2 \times T_1$** | 19.72** | 14.72** | 11.28** | 0.94 | 1.36 | 1.50 | -1.20* | -0.64 | -0.30 |
| **$L_2 \times T_2$** | -9.03** | -6.53* | -4.81* | -1.72 | -1.97 | -1.17 | -0.26 | 0.89* | 0.10 |
| **$L_2 \times T_3$** | -10.69** | -8.19** | -6.47** | 0.78 | 0.61 | -0.33 | 1.46** | -0.25 | 0.20 |
| **$L_3 \times T_1$** | -22.72** | -17.06** | -8.28** | -2.61 | -2.42 | -2.61 | 0.35 | -0.69 | 0.69 |
| **$L_3 \times T_2$** | 15.86** | 12.03** | 6.31* | 3.39 | 2.92 | 3.06 | 0.59 | 0.31 | -0.12 |
| **$L_3 \times T_3$** | 6.86* | 5.03 | 1.97 | -0.78 | -0.50 | -0.44 | -0.94 | 0.38 | -0.57 |
| **$L_4 \times T_1$** | -11.83** | -10.72** | -10.06** | -0.94 | -0.42 | -0.83 | 0.04 | 0.35 | -0.20 |
| **$L_4 \times T_2$** | -7.58* | -4.97 | -1.14 | -1.28 | -1.42 | -2.17 | 0.04 | 0.19 | 0.46 |
| **$L_4 \times T_3$** | 19.42** | 15.69** | 11.19** | 2.22 | 1.83 | 3.00 | -0.08 | -0.55 | -0.25 |
| **LSD 0.05** | **5.83** | **5.37** | **4.73** | **14.39** | **18.28** | **15.36** | **1.05** | **0.80** | **1.00** |
| **LSD 0.01** | **7.82** | **7.21** | **6.35** | **19.29** | **24.51** | **20.59** | **1.41** | **1.07** | **1.34** |

**Table (16): Cont.**

| Crosses | Kernels weight ear$^{-1}$ (g) | | | Grain yield plant$^{-1}$ (g) | | |
|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Normal | Moderate | Stress |
| $L_1 \times T_1$ | 0.49 | 0.24 | -0.45 | 99.21** | 67.33** | 33.85** |
| $L_1 \times T_2$ | -0.39 | -0.28 | -1.04 | -48.53** | -35.64** | -14.10** |
| $L_1 \times T_3$ | -0.10 | 0.03 | 1.49 | -50.68** | -31.69** | -19.75** |
| $L_2 \times T_1$ | 0.07 | 0.05 | 0.33 | -8.63 | -16.11** | -0.48 |
| $L_2 \times T_2$ | 0.24 | 0.05 | 0.31 | 7.10 | 7.45 | 2.69 |
| $L_2 \times T_3$ | -0.30 | -0.10 | -0.64 | 1.53 | 8.67 | -2.21 |
| $L_3 \times T_1$ | 0.26 | 0.27 | 0.34 | -33.64** | -10.64* | -1.29 |
| $L_3 \times T_2$ | -0.26 | -0.28 | 0.24 | 19.92* | 1.66 | 3.51 |
| $L_3 \times T_3$ | 0.00 | 0.01 | -0.58 | 13.72 | 8.97 | -2.22 |
| $L_4 \times T_1$ | -0.82 | -0.56 | -0.22 | -56.94** | -40.58** | -32.08** |
| $L_4 \times T_2$ | 0.41 | 0.50 | 0.49 | 21.50* | 26.53** | 7.90 |
| $L_4 \times T_3$ | 0.41 | 0.06 | -0.28 | 35.44** | 14.05** | 24.18** |
| **LSD 0.05** | **1.89** | **1.57** | **15.05** | **19.51** | **9.73** | **7.93** |
| **LSD 0.01** | **2.53** | **2.10** | **20.18** | **26.16** | **13.05** | **10.64** |

**Table (17): Water use efficiency of fresh forage yield fad$^{-1}$ (kg forage yield /m$^3$ water) for seven parent genotypes (four maize lines and three teosinte testers) and their 12 $F_1$ crosses under three irrigation regimes.**

| Genotypes | | Irrigation regimes | | |
|---|---|---|---|---|
| | | Normal | Moderate | Stress |
| Maize (L) | S.C. 130 (L1) | 10.377 | 11.614 | 11.146 |
| | S.C. 168 (L2) | 9.139 | 10.193 | 10.687 |
| | T.W.C. 321 (L3) | 7.635 | 8.919 | 8.930 |
| | T.W.c. 35 (L4) | 8.902 | 10.367 | 10.143 |
| | **Maize mean** | **9.013** | **10.273** | **10.227** |
| Teosinte (T) | Gemmeiza 3 ($T_1$) | 25.689 | 31.393 | 31.646 |
| | Gemmeiza 4 ($T_2$) | 28.052 | 34.153 | 32.733 |
| | Sakha 1 ($T_3$) | 24.798 | 29.834 | 29.825 |
| | **Teosinte mean** | **26.179** | **31.793** | **31.401** |
| Crosses (L × T) | $L_1 \times T_1$ | 49.056 | 59.263 | 62.709 |
| | $L_1 \times T_2$ | 39.950 | 48.556 | 50.830 |
| | $L_1 \times T_3$ | 40.722 | 47.204 | 46.645 |
| | $L_2 \times T_1$ | 45.467 | 54.722 | 57.639 |
| | $L_2 \times T_2$ | 39.042 | 46.901 | 47.754 |
| | $L_2 \times T_3$ | 39.944 | 48.032 | 47.632 |
| | $L_3 \times T_1$ | 39.427 | 47.014 | 47.751 |
| | $L_3 \times T_2$ | 41.794 | 50.899 | 51.347 |
| | $L_3 \times T_3$ | 40.657 | 49.302 | 53.347 |
| | $L_4 \times T_1$ | 40.189 | 47.111 | 47.408 |
| | $L_4 \times T_2$ | 39.940 | 47.971 | 47.629 |
| | $L_4 \times T_3$ | 43.274 | 51.926 | 54.705 |
| | **Mean crosses** | **41.622** | **49.908** | **51.283** |

for testers were obtained by Gemmeiza 4 genotypes, while for maize parents were obtained by S.C. 130 genotypes under the three irrigation regimes. This meant that those parents were more efficiency in water usage than the rest parents especially under irrigated every 18 days (moderate regimes). On the other hand, it was cleared that all 12 $F_1$ hybrids obtained by crosses (maize × teosinte) significantly surpassed parents in WUE under the three irrigation regimes, indicating that all tested crosses were considered elite genotypes for growth under drought stress more than maize or teosinte genotype. The highest values of WUE were obtained by crosses ($L_1 \times T_1$) and ($L_2 \times T_1$) under stress and moderate regimes, as well as crosses ($L_4 \times T_3$), ($L_3 \times T_3$) and ($L_3 \times T_2$) in a descending order when irrigated every 24 days (stress regime), indicating that those crosses were more effective in water productivity/ $m^3$ than the rest of crosses.

## Drought tolerance indices

Table (18) showed the drought tolerance indices studied herein, *i.e.*, tolerance index (TOL), relative yield reduction % (RYR %) and drought susceptibility index (DSI) were calculated for determining the drought tolerance efficiency of the tested maize and teosinte genotypes as well as their crosses based on minimization of yield reduction under water deficit compared to normal irrigation.

As for maize parents, it could be noticed that the values of TOL were increased with prolonging the irrigation intervals from 12 to 18 or 24 days, indicating that the tested maize genotypes were more vulnerable under drought stress condition. Moreover, all tested maize genotypes had high DSI values (more than 1) under moderate and stress regime, indicating that such maize genotypes were relatively drought susceptible. In addition, S.C. maize genotypes exhibited higher fresh yield reduction % ranged from 11.521 to 24.652 % compared to 7.642 to 19.977% for T.W.C. maize genotypes under moderate and stress regimes, respectively.

From these results, it might be suggested that S.C. genotypes were more sensitive to drought stress more than the T.W.C genotype under the condition of this study. Similar results were obtained by Ali and Abdelaal (2020) who found that maize single crosses (S.C176 and S.C.178) were more susceptible to drought stress than maize three ways crosses (T.W.C 352, T.W.C 360 and T.W.C. 368).

In comparison among teosinte parents, it was found that the values of TOL were increased with increasing the irrigation intervals from 12 to 24 days. This means that a large injury and high depression in fresh forage yield $fad^{-1}$ were recorded when the plants were exposed to severe drought conditions compared to the normal irrigation regime. Moreover, it could be noted that Gemmeiza 3 genotype ($T_1$) had the lowest values of DSI as well as RYR % under moderate and stress regimes. This means that such genotype might be considered more drought tolerant because it exhibited DSI values less than unity and smaller yield reduction % under both moderate and stress drought condition compared to the other tested genotypes. However, Gemmeiza 4 ($T_2$) and Sakha 1($T_3$) genotypes had DSI values less than unity under moderate regime only, but more than unity under stress regime, indicating that such genotypes were relatively drought sensitive.

From the Abovementioned results of the two parents (maize and teosinte) it might be suggested that teosinte parents were more tolerant to drought stress condition than maize parent. Similar results were obtained by Shaibu *et al.* (2021) who highlighted the importance of transferring beneficial alleles from wild relatives of maize (*Zea diploperennis* L) for improvement of resistance or tolerance to drought in adapted maize germplasm.

Concerning the crosses (maize × teosinte), data showed that irrigation every 24 days (stress regime) caused an increase in the values of TOL and RYR % for all tested crosses compared to the irrigation every 18 days. This means that exposing plants to water deficit condition caused a harmful effect on the fresh forage production $fad^{-1}$. Moreover, it might be concluded that the least values of DSI (less than 1) were recorded

**Table (18): Drought tolerant indices (TOL, RYR and DSI) for fresh forage yield fad$^{-1}$ of the tested genotypes (four maize as lines, three teosinte as testers and their 12 $F_1$ rosses) under the irrigation sems (at 100 AS).**

| Genotypes | Fresh Forage Yield fad$^{-1}$ (ton) | | | Tolerance index (TOL) | | Relative yield reduction% (RYR) | | Drought susceptibility index (DSI) | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal | Moderate | Stress | Moderate | Stress | Moderate | Stress | Moderate | Stress |
| Maize $_{(L)}$ | | | | | | | | | |
| S.C. 130 ($L_1$) | **36.125** | **31.963** | **27.252** | 4.162 | 8.873 | 11.521 | 24.562 | 2.164 | 1.735 |
| S.C. 168 ($L_2$) | **31.813** | **28.051** | **26.130** | 3.762 | 5.683 | 11.825 | 17.864 | 2.221 | 1.262 |
| T.W.C. 321 ($L_3$) | **26.577** | **24.546** | **21.834** | 2.031 | 4.743 | 7.642 | 17.846 | 1.436 | 1.261 |
| T.W.c. 35 ($L_4$) | **30.99** | **28.531** | **24.799** | 2.459 | 6.191 | 7.935 | 19.977 | 1.491 | 1.411 |
| Teosinte $_{(T)}$ | | | | | | | | | |
| Gemmeiza 3 ($T_1$) | **89.427** | **86.396** | **77.373** | 3.031 | 12.054 | 3.389 | 13.479 | 0.637 | 0.952 |
| Gemmeiza 4 ($T_2$) | **97.651** | **93.991** | **80.031** | 3.660 | 17.620 | 3.748 | 18.044 | 0.704 | 1.275 |
| Sakha 1 ($T_3$) | **86.323** | **82.106** | **72.921** | 4.217 | 13.402 | 4.885 | 15.525 | 0.918 | 1.097 |
| Crosses $_{(L\times T)}$ | | | | | | | | | |
| $L_1 \times T_1$ | **170.769** | **163.097** | **153.323** | 7.672 | 17.446 | 4.493 | 10.216 | 0.844 | 0.722 |
| $L_1 \times T_2$ | **139.071** | **133.629** | **124.278** | 5.442 | 14.793 | 3.913 | 10.637 | 0.735 | 0.751 |
| $L_1 \times T_3$ | **141.759** | **129.909** | **114.047** | 11.850 | 27.712 | 8.359 | 19.549 | 1.570 | 1.381 |
| $L_2 \times T_1$ | **158.277** | **150.598** | **140.928** | 7.679 | 17.349 | 4.852 | 10.961 | 0.911 | 0.774 |
| $L_2 \times T_2$ | **135.909** | **129.074** | **116.759** | 6.835 | 19.150 | 5.029 | 14.090 | 0.945 | 0.995 |
| $L_2 \times T_3$ | **139.048** | **132.188** | **116.459** | 6.860 | 22.589 | 4.934 | 16.245 | 0.927 | 1.148 |
| $L_3 \times T_1$ | **137.251** | **129.386** | **116.750** | 7.865 | 20.501 | 5.730 | 14.937 | 1.076 | 1.055 |
| $L_3 \times T_2$ | **145.489** | **140.078** | **125.544** | 5.411 | 19.945 | 3.719 | 13.709 | 0.699 | 0.968 |
| $L_3 \times T_3$ | **141.531** | **135.683** | **130.433** | 5.848 | 11.098 | 4.132 | 7.841 | 0.776 | 0.554 |
| $L_4 \times T_1$ | **139.904** | **129.652** | **115.913** | 10.252 | 23.991 | 7.328 | 17.148 | 1.377 | 1.211 |
| $L_4 \times T_2$ | **139.036** | **132.020** | **116.453** | 7.016 | 22.583 | 5.046 | 16.243 | 0.948 | 1.147 |
| $L_4 \times T_3$ | **150.642** | **142.903** | **133.753** | 7.739 | 16.889 | 5.137 | 11.211 | 0.965 | 0.792 |

by crosses ($L_1 \times T_1$), ($L_1 \times T_2$), ($L_2 \times T_1$), ($L_2 \times T_2$), ($L_3 \times T_2$), ($L_3 \times T_3$) and ($L_4 \times T_3$) under moderate and stress regimes. This means that those crosses might be considered the best ones regarding drought tolerance because they exhibited DSI values less than unity and smaller forage yield reduction fad$^{-1}$ under any of the tested drought stress regimes (irrigation every 18 or 24 days). The tolerance of those crosses to drought stress might due to the high tolerance of their teosinte parents under stress condition as previously recorded. Moreover, It was noticed generally that most of those crosses had also the highest values of mean performance, SCA and heterosis % for fresh forage production fad$^{-1}$ as previously discussed.

## Conclusion

It could be concluded that the five crosses namely $L_1 \times T_1$ (S.C. 130 × Gemmeiza 3), $L_2 \times T_1$ (S.C. 168× Gemmeiza 3), $L_4 \times T_3$ (T.W.C. 352 × Sakha 1), $L_3 \times T_2$ (T.W.C. 321 × Gemmeiza 4) and $L_3 \times T_3$ (T.W.C. 321 × Sakha 1) surpassed other crosses and exhibited the maximum fresh and dry forage yield fad$^{-1}$ and recorded the least values of drought tolerance indices. So, it might be used such crosses in the forage improvement breeding program.

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# تقييم بعض هجن الذرة الشامية مع الذرة الريانة وأبائهم تحت ظروف الاجهاد المائي

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## الملخص العربي

أجريت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بالجميزة التابعة لمركز البحوث الزراعية خلال موسمي الزراعة ٢٠١٨، ٢٠١٩ حيث تم فى الموسم الزراعي الاول ٢٠١٨ زراعة ٧ تراكيب وراثية مختلفة كآباء وهي عبارة عن ٤ تراكيب وراثية من الذرة الشامية ( هـ ف ١٣٠ ، هـ ف ١٦٨ ، هـ ث ٣٢١ ، هـ ث ٣٥٢) أمهات وثلاث تراكيب وراثية من الذرة الريانة (جميزة ٣ ، جميزة ٤ ، سخا ١) آباء وتم التهجين بين الاباء والامهات لإنتاج ١٢ هجين من الجيل الاول وذلك باستخدام تصميم سلالة × كشاف. وفي الموسم الزراعي الثاني ٢٠١٩ تم تقييم كل التراكيب الوراثية المختبرة تحت ثلاث نظم رى مختلفة وهي الري كل ١٢ و ١٨ و ٢٤ يوم. هذا وقد تم استخدام تصميم القطاعات كاملة العشوائية في ثلاث مكررات فى تنفيذ وتحليل البيانات كل نظام رى علي حدة في تجربة منفصلة. وفي كل تجربة تم تقدير التباين الوراثي وتقييم كل التراكيب الوراثية المختبرة (الاباء والهجن) والقدرة العامة والخاصة علي التآلف وذلك لصفات النمو الخضرى والمحصول والصفات الفسيولوجية وصفات التحليل الكيماوي لنباتات العلف الاخضر وكذلك تقدير صفات محصول الحبوب لجميع التراكيب الوراثية كما تم تقدير كفاءة تحمل الجفاف وكفاءة استخدام المياه لجميع الاباء والهجن الناتجة .

ويمكن إيجاز أهم النتائج التي تم الحصول عليها علي النحو التالي :

١- أظهرت البيانات وجود تباين عالي المعنوية بين جميع التراكيب الوراثية المختبرة (الاباء والهجن) في جميع صفات النمو والصفات الفسيولوجية وصفات التحليل الكيماو وكذلك محصول الحبوب ومكوناته للنبات المدروسة وكذلك انتاجية الفدان من العلف الاخضر والجاف تحت نظم الري الثلاثة المختبرة.

٢- تفوقت متوسط اباء الذرة الريانة علي متوسط اباء الذرة الشامية المختبرة في جميع صفات النمو ومحصول العلف وصفات التحليل الكيماوية ومعظم الصفات الفسيولوجية، في حين تفوقت جميع اباء الذرة الشامية على أباء الذرة الريانة في محصول الحبوب للنبات ومكوناته تحت نظم الري الثلاثة المدروسة. هذا وقد اظهر صنف الذرة الريانة (جميزة ٣) وصنف الذرة الشامية (هـ ف ١٣٠) تفوقا على بقية الأباء المختبرة في هذه الصفات.

٣- تفوقت جميع الهجن المختبرة علي ابائها (الذرة الشامية والذرة الريانة) في جميع الصفات المدروسة، هذا وقد حقق الهجين ( $L_1$ x $T_1$) افضل النتائج في معظم الصفات المدروسة بالمقارنة بالهجن الاخرى المختبرة تحت جميع نظم الري الثلاثة.

٤- أدى تعريض جميع التراكيب الوراثية المختبرة (الاباء والهجن) لظروف الجفاف عن طريق زيادة فترات الري من ١٢ يوم الي ١٨ و ٢٤ يوم الي نقص تدريجي في جميع صفات النمو ومحصول العلف الاخضر والجاف للفدان في حين أدى ذلك الى زيادة في محتوى النبات من الحامض الاميني البرولين.

٥- سجل كل من التركيب الوراثي للذرة الشامية (هـ ف ١٣٠) والتركيب الوراثي للذرة الريانة (جميزة ٣) اعلى قيم معنويه موجبة للقدرة العامة على التألف لمعظم الصفات ومحصول العلف الاخضر والجاف للفدان في نظم الري الثلاثة المختبرة.

٦- اعطت الهجن ( $L_1$ x $T_1$ ) و ( $L_4$ x $T_3$ ) اعلى قيم معنوية موجبه للقدرة الخاصة على التألف لمعظم الصفات المدروسة ومحصول العلف الأخضر والجاف للفدان تحت انظمه الري الثلاثة مقارنة بباقي الهجن الاخرى المختبرة.

٧- أوضحت النتائج ان نسبة قيم القدرة العامة على التآلف الي قيم القدرة الخاصة على التآلف كانت اقل من واحد في جميع الصفات مما يشير الي ان مقدار التباين السيادى كان اكبر من التباين الاضافى .

٨- أظهرت النتائج ان أباء الذرة الريانة الثلاثة كانت متفوقة على أباء الذرة الشامية الأربعة تحت انظمة الري الثلاثة فى كفاءة استخدامها لمياه الرى وكذلك فى دلائل تحملها للجفاف.

٩- تفوقت الهجن ال١٢ بصفة عامة على آبائها في كفاءة استخدامها للمياه تحت أنظمة الري الثلاثة، هذا وتعتبر الهجن $L_1$× $T_1$ (هـ ف ١٣٠ × جميزة ٣) ، $L_2$ × $T_1$ (هـ ف ١٦٨ × جميزة ٣) ، $L_4$ × $T_3$ (هـ ث ٣٥٢ × سخا ١) ، $L_3$ × $T_2$ (هـ ث ٣٢١ × جميزة ٤) $L_3$ × $T_3$ (هـ ث ٣٢١ × سخا ١) من أفضل الهجن المختبرة حيث سجلت أعلى قيم لكفاءة استخدام المياه و أقل قيم لجميع دلائل تحمل الجفاف عند زراعتهم تحت ظروف الاجهاد المائى فى هذه الدراسة.