Egypt. J. Agron. **Vol. 44**, No. 2-3, pp. 131-161 (2022)

Egyptian Journal of Agronomy
http://agro.journals.ekb.eg/

Response of Flowering Traits to Water Stress in Yellow Maize (*Zea mays* L.) Using Line × Tester Analysis

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MAIZE (*Zea mays* L.) is the third-most significant cereal grain in Egypt, although it is susceptible to water stress, which results in substantial losses in both productivity and quality. A set of 100 S1-lines along with their top-crosses using two testers were evaluated under normal and water stress conditions. We used line × tester to evaluate general (GCA) and specific (SCA) combining ability effects for Days to 50% anthesis, Days to 50% silking, and Anthesis silking interval. Results of line × tester analysis showed highly significant differences among parents, crosses vs parents under normal and water stress condition. Both lines and testers showed significant and non-significant differences. Finally, line × tester analysis showed significant differences for Days to 50% anthesis and non-significant differences for Days to 50% silking under normal and water stress condition while, anthesis silking interval trait showed non-significant differences under normal condition and significant differences under water stress condition. Broad sense heritability values for the aforementioned traits were higher under water stress compared to those under normal condition. The high values of broad sense heritability make the selection process easier for the plant breeder and more accurate as the phenotype reflects its genotype. Our findings suggested that dominance genes predominately regulate the aforementioned traits. In conclusion, these S1-lines could be promising as a base for developing early- maturity and drought tolerant hybrids. This will help avoiding water stress events during growing season.

Keywords: General and specific combining ability, Heritability, line × tester, Maize, Water stress.

Introduction

After wheat and rice, *Zea mays* L. is one of the most significant cereal crops in the world (Reddy et al., 2012). It serves as both human nourishment and animal feed. In 2020 season, the harvested area in the world was 243,275,654 Ha producing 1,423,229,473 MT. The harvested area in Egypt was 1,458,881 ha producing 7,500,000 MT (FAOSTAT, 2017). By using enhanced agronomic approaches to obtain varieties with higher qualitative and quantitative features and resilience to abiotic challenges, maize output can be boosted to satisfy the ever-increasing demand (Ali et al., 2014). A critical issue, drought significantly reduces crop productivity and quality. By developing hybrids that are drought-tolerant and adapted to arid conditions, like those found in the freshly reclaimed areas, drought damage may be lessened. Early maturing maize hybrids are necessary for productive farming in regions with short growing seasons. Anthesis-silking interval (ASI) is a crucial secondary trait that assisted selection of maize for drought tolerance (Ziyomo & Bernardo, 2012). A significant decrease in ASI and barrenness, also a rise in the number of ears per plant, stay green, and harvest index, were found to be linked to selection for greater drought tolerance

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Received 11/08/2022; Accepted 09/11/2022
DOI: 10.21608/AGRO.2022.155493.1331

(Banziger et al., 2002; Al-Naggar et al., 2011). Selection for short ASI and improved drought resistance has boosted tolerance to anthesis-imposed shadow (Edmeades et al., 1992). Under drought stress, there were significant correlations between ASI, ears per plant and for maize grain yield (Monneveux et al., 2006; Al- Naggar et al., 2004). Combining ability is a potent tool that has been widely used to find the best combiner parents in a series of its crosses and that offers details on the type and strength of gene actions (Uddin et al., 2008). General combining ability (GCA) and specific combining ability are the two components of combining ability (SCA). First, GCA refers to the average performance of parents across a set of crosses, whereas SCA refers to situations in which particular combinations perform somewhat better or worse than would be predicted based on the average performance of parents (Hundera, 2017). Therefore, both components of combining ability provide breeders with useful estimations that help them choose the optimal parent pairings for their breeding programs. General combing ability (GCA) effect was observed to imply that some lines under normal and drought stress conditions seem to be good general combiners for improving hybrid yield and yield components (Khattab et al., 2011). Emyhum (2013) said that for all traits, specific combining ability variance was more significant than general combining ability variance, showing that dominance variance dominated the control of these characters. Ertiro et al. (2017) found that drought stress enhanced the anthesis-silking interval (ASI) while decreasing grain yield (GY) and plant height (PH). According to Abrha et al. (2013), genotypes had a substantial impact on mean squares for days to 50% anthesis and silking. In addition, for days to 50% anthesis and days to 50% silking, 1000-grain weight, and grain yield, there were substantial mean square changes because to line GCA. El-Hosary & Elgammaal (2013) found that mean squares due to crosses (C) inbred lines (L), testers (T) and line x tester (LxT) were significant for days to 50% anthesis, days to 50% silking,100-grain weight and grain yield per plant as well as for the combined analysis. Emyhum (2013) found that some inbred line showed significant GCA effects for days to 50% anthesis, days to 50% silking and 100-grain weight additional to, some test cross hybrids showed significant SCA effects days to 50% silking. One of the drought-tolerant traits suggested for inclusion in a drought breeding program is the anthesis-silking interval by Banziger et al. (2000). In addition, Kambe et al. (2013) found that the analysis of variance for combining ability data showed that mean squares resulting from lines, testers, and line-testers were significant for days to 50% anthesis, and days to 50% silking. This indicated that both additive and non-additive gene effects were important in the genetic expression of most of the studied traits. In addition, according to Tajwar & Chakraborty (2013), grain yield, days to 50% anthesis, days to 50% silking, ear diameter, and study of combining ability effects demonstrated significant gca effects. El-Hosary (2014) reported that σ^2_{sca} played the central role in determining inheritance for days to 50 % anthesis and 100-grain weight revealing that the largest part of the total genetic variability associated with these traits result of non-additive gene action. According to Dhasarathan et al. (2015), for days to 50% anthesis and plant height, the mean squares of SCA were greater than those of GCA, indicating that non-additive gene action predominates in the regulation of both traits. Continuation, Erdal et al. (2015) found that Significant differences were detected between genotypes for number of days to 50% anthesis, anthesis-silking interval and grain yield. In addition, Bisen et al. (2017) reported that the analysis of variance for combining ability revealed significant mean squares due to GCA and SCA for days to 50% anthesis, days to 50 % silking and grain yield per plant. Samanci et al. (1998) found that the highest heritability values were 0.58, 0.47 and 0.53 for plant height, ear height and days to tasseling, respectively. Al-Naggar et al. (2016a) reported that in normal condition, the anthesis-silking interval and days to 50% anthesis showed the highest values of broad sense heritability estimate 90% and the lowest values of broad sense heritability estimate 46 %, respectively, under water stressed environments. Heritability was found to be higher in stressed situations for the trait's days to 50% anthesis, days to 50% silking, and grain yield/ha. A useful technique for estimating combining ability, gene action, male and female, and helping to choose attractive parents and crosses is the line × tester mating approach (Hundera, 2017). line × tester analysis is a crucial technique performed at random to assess the inbred lines (Amin et al., 2014). Plant breeders frequently employ the line x tester analysis method (Ali, 2013). The goals of the present study were to: 1) Clarification the effect of water stress for Days to 50% anthesis, Days to 50% silking and Anthesis silking interval in 100 S1 selected lines, 2) appreciation genetic variances and heritability and 3) Utilizing two testers, SC162 and TWC352, conduct line tester analysis and

estimate general and specific combining ability for these lines.

Materials and Methods

Growing condition

This study was acomplished during the seasons 2018and 2019 In a Farm at Assiut University to study the effect of water stress on flowering traits, line × tester analysis and combining ability in maize utilizing 100 S1-lines.

In spring 2018, maize population (IY376, imported from India 1969) was sown, 300 vigorous and disease-free plants were chosen before silking, and self-pollinated. After harvest, 100 selfed ears (S1's) which had adequate grains were selected. Selected Selected S1ears were individually shelled and each S1-line was divided into four equal parts. In late summer 2018, top-crosses were created for S1-lines utilizing two testers, single cross 162 (SC162) and three-way cross 352 (TWC352). In season 2019, 100 S1-lines and their top-crosses with SC162 and TWC 352 testers (302 genotype entry) were evaluated at Assiut University farm Station under normal condition (add every 10 days) and water stress condition (irrigated every 20 days after 2nd irrig.) utilizing simple lattice design (10 × 10) with three replications. One row, 3 meters long, and 70 cm between rows composed the experimental plot, sowing was in hills spaced 30 cm apart. Seedlings were thinned at one plant/hill before the first irrigation. 120kg nitrogen/fed was used as the fertilizer application rate before the first and second irrigations. Throughout the season, other cultural practices continued as usual.

Traits studied

For the following characters, data were recorded based on the plot:

1) Days to 50% anthesis (DA) as number of days from planting until 50% of the plants showed their anthesis.
2) Days to 50% silking (DS) as number of days from planting until 50% of plants showed their silks.
3) Anthesis silking interval (ASI), computed as the differences between days to 50% anthesis and silking.

Statistical analysis

R software was used to conduct statistical analysis. (version 3.6.1) using package AGRICOLAE (De Mendiburu, 2014).

Line (L) × tester (T) analysis was performed utilizing the method described by Kempthorne (1957). General (GCA) and specific (SCA) combining ability effects were calculated for Days to 50% anthesis, Days to 50% silking and Anthesis silking interval. The following was the statistical model that was used to determine the various effects:

$$Y_{ijk} = \mu + \rho_k + l_i + t_j + (l \times t)_j + \varepsilon_{ijk}$$

where: Y_{ijk} = the value of a character measured on ith × jth progeny in kth replication, μ is the general mean, ρ_k effect of kth replication, l_i is the effect of the ith line, t_j is the effect of the jth tester, $(l \times t)_{ij}$ is the interaction effect of the cross between ith line and jth tester and ε_{ijk} is the error term associated with each observation. Due to the lack of homogeneity of variances according to Bartlett's test (Bartlett, 1937). combined analysis of both normal and water stress conditions was not carried out.

The combing ability ratio (CAR) was utilized, in the current research, to expect the gene action as per Baker (1978) using the following equation:

$$CAR = 2\sigma^2_{GCA} (2\sigma^2_{GCA} + \sigma^2_{SCA})$$

where: σ^2_{GCA} and σ^2_{SCA} are the GCA and SCA variances, respectively.

According to Singh & Chaudhary (1985), the heritability in broad sense (hb) for these traits was calculated using the following formula:

$$h_b = \frac{\sigma^2 g}{\sigma^2 p}$$

where:

$\sigma^2 g$ = genetic variance, and $\sigma^2 p$ = phenotypic variance.

Results and Discussion

Line × Tester analysis

One hundred S1-lines were crossed with two testers (SC162 and TWC352) resulted in 200 top-crosses. The lines, testers and top-crosses were evaluated under normal and water stress condition to identify the best drought-tolerant crosses based on the early flowering days, which could one day be used to create hybrids that are drought-tolerant. Analysis of variance for the studied traits under normal and water stress condition are showed in

Table 1. Under normal condition, the results showed significant differences for Days to 50% anthesis, Anthesis silking interval and Days to 50% silking for parents and parents vs crosses. In addition, the crosses showed significant differences for Days to 50% anthesis and Days to 50% silking. Anthesis silking interval showed non-significant differences. For lines, significant differences add only for Days to 50% silking and revealed non-significant differences for Days to 50% anthesis and Anthesis silking interval. For testers, significant differences were found in Days to 50% anthesis and Days to 50% silking and non-significant differences is found in Anthesis silking interval Finally, line × tester showed non-significant differences for all traits studied except days to 50% anthesis. The higher estimates of variance owing to specific combining abilities were seen in the bigger contributions of lines tester interaction than testers for these studied traits. In this context, our results were consistent with those found by Akula et al. (2018).

Results exhibited significant differences under water stress condition for Days to 50% anthesis, Days to 50% silking and Anthesis silking interval for parents, crosses and parents vs crosses. For lines, both of Days to 50% anthesis and Anthesis silking interval showed non-significant differences; whereas, Days to 50% silking exhibited significant differences. For testers, significant differences were found in both studied traits for Days to 50% anthesis, Days to 50% silking but, Anthesis silking interval exhibited non-significant differences. Finally, for line × tester, all examined traits showed significant differences except Days to 50% silking. The higher estimates of variance owing to specific combining abilities were seen in the bigger contributions of lines tester interaction than testers for these examined traits, in this regard, Akula et al. (2018) reported similar results.

Mean performance

Mean performance of 100 S1-lines for days to 50 % anthesis evaluated under normal condition are presented in Table 2. Data exhibited that there were four S1-lines took less than 60 days to 50% anthesis**,** while the most of S1-lines took more than 60 days to %50 anthesis. For the testers, TWC352 was earlier in anthesis date than SC162. Mean performances for days to 50 % anthesis of 200 top-crosses under normal condition are presented in Table 3. Results showed that all the top-crosses involving TWC352 were earlier in anthesis date than those involving SC162. The cross combinations including S1-lines 51, 53, 80, 88 × SC162 and S1-line 90 × SC162; additional to S1-line 17 × TWC352 and S1-line 88× TWC352 were earlier compared to the other top-crosses. These findings suggest that there were numerous lines that could be exploited in next breeding projects since they have acquired advantageous earliness alleles.

TABLE 1. Mean squares of line × tester analysis for Days to 50% anthesis, Days to 50% silking and Anthesis silking interval under normal and water stress conditions

Source	DF	MS					
		Normal condition			water stress condition		
		DA	DS	ASI	DA	DS	ASI
Replications	2	3.58^{NS}	6.61^{NS}	0.47^{NS}	21.37^{**}	30.31^{**}	2.99^{NS}
Genotypes	301	34.98^{**}	60.27^{**}	6.99^{**}	41.64^{**}	64.07^{**}	5.48^{**}
Parents	101	29.87^{**}	48.85^{**}	8.70^{**}	19.96^{**}	30.15^{**}	5.48^{**}
Parents vs. Crosses	1	6.90^{**}	6.46^{**}	1.39^{NS}	8.12^{**}	8.05^{**}	1.94^{**}
Crosses	199	6139.90^{**}	11920.91^{**}	950.21^{**}	8899.39^{**}	14638.58^{**}	710.40^{**}
Lines	99	7.582^{NS}	7.98^{**}	1.18^{NS}	7.65^{NS}	9.08^{*}	1.64^{NS}
Testers	1	29.93^{*}	46.48^{**}	1.82^{NS}	206.51^{**}	205.34^{**}	17×10^{-4NS}
Lines × Testers	99	5.97^{**}	4.53^{NS}	1.59^{NS}	6.60^{**}	5.02^{NS}	2.25^{**}
Error	602	2.85	4.19	1.40	2.66	4.34	1.28
Contribution of lines		54.72	61.48	42.38	46.83	56.15	42.17
Contribution of tester		2.18	3.62	0.66	12.77	12.82	4×10^{-4}
Contribution of line×tester		43.10	34.90	56.97	40.40	31.03	57.83

*, ** Significant at levels of probability of 0.05 and 0.01, respectively.

DA= days to 50%anthesis (d), DS= days to 50%silking (d), ASI= Anthesis-silking interval (d).

TABLE 2. Means (M) and their standard errors (SE) of days to 50% anthesis (d) for parents (S1-lines and two testers) under normal condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	62.67±1.67	35	70.67±0.33	69	68.00±0.58
2	59.33±0.33	36	67.67±0.67	70	65.67±0.33
3	63.67±1.20	37	63.00±0.00	71	67.33±0.33
4	64.33±0.88	38	66.00±0.58	72	60.67±1.76
5	62.00±1.15	39	63.00±1.53	73	63.33±0.67
6	65.00±0.58	40	62.67±0.67	74	65.33±1.20
7	66.00±1.15	41	63.33±0.67	75	72.00±0.58
8	62.00±0.58	42	62.67±0.33	76	69.00±1.53
9	63.67±1.20	43	63.00±0.58	77	67.33±0.67
10	60.67±0.33	44	66.33±0.33	78	64.33±0.67
11	60.67±1.20	45	62.33±0.88	79	63.67±0.67
12	70.33±1.20	46	62.33±0.33	80	66.00±0.58
13	65.67±1.33	47	64.00±1.53	81	65.67±1.33
14	68.00±1.00	48	66.33±0.88	82	63.00±0.58
15	64.67±1.45	49	67.00±0.58	83	69.67±0.33
16	62.00±1.53	50	64.67±0.88	84	66.67±0.67
17	67.00±0.58	51	63.00±0.00	85	66.67±0.33
18	66.00±1.00	52	70.00±1.00	86	64.33±0.88
19	70.00±1.00	53	61.33±1.33	87	64.67±1.20
20	59.33±0.88	54	62.67±0.33	88	60.67±1.67
21	64.00±0.58	55	64.00±1.00	89	67.00±1.15
22	67.67±0.88	56	65.33±1.20	90	61.33±0.67
23	66.67±0.33	57	63.67±0.33	91	64.00±0.58
24	63.33±1.33	58	67.67±0.88	92	62.67±1.76
25	67.00±0.58	59	68.33±1.33	93	67.00±0.58
26	62.67±0.33	60	67.00±1.00	94	64.00±0.58
27	64.00±0.58	61	64.67±0.67	95	67.00±0.00
28	63.00±0.00	62	64.00±0.00	96	63.67±0.33
29	57.00±0.00	63	61.00±1.00	97	71.00±0.58
30	59.67±0.67	64	70.67±2.40	98	60.33±1.20
31	65.67±0.88	65	63.00±0.58	99	68.67±0.67
32	63.33±0.88	66	64.33±0.88	100	62.00±2.52
33	65.33±1.45	67	72.00±0.58	SC162	61.67±1.45
34	61.00±1.15	68	60.33±0.88	TWC352	55.00±0.58
F value for testers	5.01*		RLSD for lines	NS	

*, ** and NS means significant at levels of probability of 0.05, 0.01and not significant, respectively.

TABLE 3. Means (M) and their standard errors (SE) of days to 50% anthesis for add top-crosses (T1= SC162 and T2=TWC352) under normal condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	59.33±0.88	59.33±0.67	35	60.33±0.33	59.33±1.33	69	62.00±0.58	59.67±0.88
2	59.67±1.45	56.67±0.33	36	59.33±1.20	60.67±0.88	70	59.67±1.45	59.67±0.67
3	59.33±1.20	57.67±0.67	37	57.00±1.53	58.00±0.00	71	62.00±2.08	61.33±1.67
4	60.33±0.88	58.33±0.33	38	59.67±1.76	60.33±0.33	72	58.00±0.58	58.67±0.88
5	58.33±0.33	57.33±0.33	39	60.00±2.00	60.33±1.20	73	61.00±1.00	59.67±0.33
6	60.33±0.67	57.67±0.33	40	58.67±0.88	60.67±1.20	74	63.00±0.58	61.00±1.15
7	61.00±0.58	59.67±0.33	41	58.33±1.86	60.33±0.33	75	61.00±2.08	60.67±0.88
8	58.33±0.88	57.67±0.33	42	58.33±0.88	57.00±0.58	76	59.67±0.88	59.00±1.00
9	59.00±1.00	59.67±0.33	43	57.00±0.00	59.33±0.33	77	59.33±0.67	60.33±0.33
10	59.00±1.53	57.00±1.00	44	59.67±0.88	59.67±0.67	78	59.33±0.67	58.00±1.00
11	59.00±1.53	57.67±1.45	45	60.33±1.45	60.00±1.15	79	57.00±0.00	60.33±0.67
12	61.00±1.00	57.33±0.33	46	57.67±0.67	59.33±0.33	80	55.67±1.67	56.33±0.33
13	60.67±0.67	57.67±0.33	47	57.33±0.33	60.00±1.53	81	60.67±0.88	59.00±0.58
14	59.67±0.33	57.67±0.33	48	57.33±0.33	60.00±0.58	82	57.00±0.00	59.67±0.33
15	60.00±0.00	56.67±0.33	49	58.67±0.33	61.33±1.20	83	61.00±0.58	60.67±0.67
16	59.67±1.76	57.67±0.33	50	61.33±0.88	59.33±0.88	84	59.00±0.58	61.67±1.20
17	58.00±2.00	56.00±1.15	51	56.67±0.33	58.33±0.33	85	58.33±0.88	61.00±2.08
18	60.67±0.33	57.67±0.33	52	60.67±1.20	59.67±0.88	86	58.33±0.33	58.33±0.33
19	62.00±1.53	58.00±0.58	53	56.67±0.33	60.33±0.88	87	60.33±0.88	60.33±0.67
20	58.67±1.33	56.00±1.15	54	58.33±0.67	59.00±1.00	88	56.67±0.33	55.00±0.58
21	60.00±0.58	57.00±0.58	55	57.33±0.67	60.00±1.00	89	57.33±0.33	57.33±0.33
22	60.00±1.73	59.00±1.15	56	60.33±0.33	60.33±1.86	90	56.67±1.45	58.00±1.00
23	59.67±0.88	57.67±0.67	57	57.33±0.88	59.67±0.33	91	59.33±0.67	60.33±0.33
24	59.33±1.20	57.33±2.03	58	59.67±0.33	58.33±0.88	92	59.00±0.58	59.67±0.88
25	60.00±2.08	58.00±0.58	59	59.00±1.15	59.00±0.58	93	60.00±1.53	60.67±1.20
26	59.33±0.33	58.00±0.58	60	58.00±0.58	59.00±1.00	94	60.33±0.33	58.00±0.00
27	62.00±1.00	57.33±0.88	61	60.00±0.58	59.33±0.67	95	61.67±0.88	59.00±0.58
28	62.00±1.53	57.00±0.58	62	57.33±0.33	58.00±1.00	96	61.67±0.88	60.00±1.00
29	60.00±0.00	56.00±1.00	63	59.00±1.00	59.67±0.33	97	59.67±1.45	61.33±2.33
30	57.67±1.20	59.67±0.33	64	60.00±1.00	59.67±0.88	98	63.00±3.00	60.67±0.33
31	57.33±0.88	59.67±0.33	65	57.33±0.33	58.67±1.76	99	59.00±1.15	58.33±0.88
32	58.67±0.67	59.33±0.88	66	59.00±0.58	59.33±0.33	100	61.00±1.15	57.00±0.00
33	59.67±0.33	61.33±0.67	67	59.00±1.00	60.33±1.45			
34	59.67±0.88	55.67±0.88	68	59.67±0.33	57.33±0.88			
Top-crosses means			SC162	59.33		TWC352	58.89	
RLSD for line× testers		3.30						

Under water stress condition, the mean performance of 100 S1-lines for days to 50% anthesis are shown in Table 4. Data displayed that there were three S1-lines took less than 60 days to 50% anthesis**,** while the most of S1-lines took more than 60 days to 50% anthesis. For the testers, TWC352 was earlier in anthesis date than SC162.Under water stress condition the mean performance of 200 top-crosses for days to 50% anthesis are presented in Table 5. Results showed that all top crosses involving TWC352 were earlier in anthesis date than those involving SC162. The cross combinations including S1-line 37 ×SC162 and S1-line 80 ×SC162; additional to S1-lines 17, 26 ×TWC352 and S1-line 88×TWC352 were earlier in anthesis date compared to the other top-crosses. The result of this study is in conformity with the findings of Abrha et al. (2013).

Mean performance of 100 S1-lines for days to 50% silking evaluated under normal condition are presented in Table 6. Data showed that S1-lines 29 and 30 were earlier compared to the other S1-lines to 50% silking. For the testers, TWC352 was earlier in silking date than SC162. Mean performances for days to 50% silking of 200 top-crosses under normal condition are presented in Table 7. Results showed that all the top-crosses involving TWC352 were earlier in silking date than those involving SC162. The cross combinations including S1-lines 51, 80 × SC162 and S1-line 88 × SC162; additional to S1-lines 20, 29 × TWC352 and S1-line 88× TWC352 were earlier in silking date compared to the other top-crosses. These findings suggest that there were numerous lines that could be exploited in next breeding projects since they have acquired advantageous earliness alleles.

Under water stress condition, the mean performance of 100 S1-lines for days to 50% silking are shown in Table 8. Data displayed that S1-lines 29 and 80 were earlier compared to the other S1-lines for 50% silking. For the testers, TWC352 was earlier in silking date than SC162.Under water stress condition the mean performance of 200 top-crosses for days to 50 % silking are presented in Table 9. Results showed that all top crosses involving TWC352 were earlier in silking date than those involving SC162. The cross combinations including S1-lines 31, 37, 40, 45, 46, 51, 55, 62, 66, 80 ×SC162 and S1-line 88 ×SC162; additional to S1-lines 11, 20, 88 ×TWC352 and S1-line 100 ×TWC352 were earlier in silking date compared to the other top-crosses. The outcome of this study is in conformity with the findings of Ilyas et al. (2019).

Mean performance of 100 S1-lines for anthesis-silking interval evaluated under normal condition are presented in Table 10. Data exhibited that S1-lines 89 and 93 had longer ASI compared to the other S1-lines. While, S1-lines 7, 10, 16, 23, 30, 38, 40, 42, 44, 46, 55, 65 and 94 had shorter ASI compared to the other S1-lines. For the testers, SC162 has shorter anthesis-silking interval than TWC352. Mean performances for anthesis-silking interval of the 200 top-crosses under normal condition are presented in Table 11. Results showed that the top-crosses involving TWC352 had shorter anthesis-silking interval than those involving SC162. The cross combinations including S1-lines 43, 54, 64, 65, 79× SC162 and S1-line 98 × SC162; additional to S1-line 7 × TWC352 and S1-line 100× TWC352 had longer ASI compared to the other top-crosses. While, the cross combinations including S1-lines 2, 8, 10, 21, 22, 27, 32, 45, 52, 56, 66, 69, 73, 76, 86, 91, 92, 94, 97, and 100 × SC162; additional to S1-lines 1, 6, 33, 35, 36, 39, 43, 47, 49, 50, 51, 52, 55, 56, 65, 70, 75, 76, 82, 86, 87, 97, 98 and 99 × TWC352 had shorter ASI compared to the other top-crosses.

Under water stress condition, the mean performance of 100 S1-lines for anthesis-silking interval are shown in Table 12. Data displayed that S1-lines 13, 47 and 79 had longer ASI compared to the other S1-lines. While, S1-lines 10, 22, 23, 31, 41, 65, 76, 80, 92 and 99 had shorter ASI compared to the other S1-lines. For the testers, SC162 has shorter anthesis-silking interval than TWC352.Under water stress condition, the mean performance of the 200 top-crosses for anthesis-silking interval are presented in Table 13. Results showed that the top-crosses involving TWC352 had longer anthesis-silking interval than those involving SC162. The cross combinations including S1-lines 4, 52, 59, 67, 74 × SC162 and S1-line 87 × SC162; additional to S1-lines 7, 10, 17, 26, 79 × TWC352 and S1-line 95× TWC352 had longer ASI compared to the other top-crosses. While, the cross combinations including S1-lines 1, 66 and 76 × SC162; additional to S1-lines 38, 56, 64, 67, 82 and 84 × TWC352 had shorter ASI compared to the other top-crosses. These results not applicable with Bekele & Rao (2014). High yielding hybrids and a shorter anthesis-silking interval both worked well in the selection of tolerant hybrids. (Mhike et al., 2012). On the other

hand, wider ASI under stress, which normally has a large negative association with GY in stress conditions, may help to partially explain the high yield drop under stress environments (Westgate, 1997; Beyene et al., 2013). Prior to or during flowering, drought stress slows silk elongation but has little to no impact on pollen shed. Indirect selection to reduce ASI has thus proven to be a successful strategy for choosing genotypes with better synchronization of male and female blooming under stress.

Estimates of general combining ability (GCA) effects

Appreciation of general combining ability for both normal and water stress conditions for these studied traits are presented in Tables 14–16. Under normal condition, estimates of GCA effects for days to 50% anthesis, Table 14 revealed that out of studied 100 S1-lines in line × tester cross, showed that S1-lines 80 and 88 possessed negative (desirable) and significant GCA effects for DA toward earliness with values of –3.11 and –3.28, respectively; Conversely, S1-lines 74 and 98 displayed positive (undesirable) and significant GCA effects for DA towards lateness with values of 2.89 and 2.72, respectively. For the testers, T2 was the best general combiner in contrast; T1 was poor general combiner for days to 50% anthesis. However, under water stress condition, estimates of GCA effects for days to 50% anthesis, Table 14 revealed that out of studied 100 S1-lines in line × tester cross, Similarly, S1-lines 80 and 88 showed negative (desirable) and significant effects of GCA under water stress with values of –2.70 and –3.03, respectively. However, S1-lines 75 and 83 displayed positive (undesirable) and significant GCA effects for DA towards lateness with values of 3.47 and 1.97, respectively. For the testers, T2 was the best general combiner in contrast; T1 was poor general combiner for days to 50% anthesis. The negative value implies that the inbred lines are good combiners as it indicates the tendency of earliness and the reverse is true for those with positive GCA effects. The present outcomes are in general agreement with the results Bello & Olaoye (2009).

Estimate of GCA effects for days to 50% silking under normal condition, Table 15 showed that S1-lines 80 and 88 showed negative (desirable) and significant GCA effects with value of –2.43 and –3.26, respectively. Conversely, S1-lines 74 and 98 displayed positive (undesirable) and significant GCA effects for DS lateness with the same value of 3.08 followed by S1-line 83 with an effect of GCA of 2.43. For the testers, T2 was the best general combiner in contrast; T1 was poor general combiner for days to 50% silking. However, under water stress condition, estimates of GCA effects for days to 50% silking, Table 15 revealed that out of studied 100 S1-lines in line × tester cross, Similarly, S1-lines 80 and 88 showed negative and significant effects of GCA under water stress with values of – 2.29 and – 3.13, respectively. However, S1-lines 75 and 83 displayed positive and significant GCA effects for DA towards lateness with values of 3.04 and 2.71, respectively. For the testers, T2 was the best general combiner in contrast; T1 was poor general combiner for days to 50% silking. The negative value implies that the inbred lines are good combiners as it indicates the tendency of earliness and the reverse is true for those with positive GCA effects. The present outcomes are in general agreement with the results Bello & Olaoye (2009).

Appreciation of GCA effects for anthesis-silking interval under normal condition, Table 16 showed that only S1-line 76 showed negative and significant GCA effects with value of –0.98. Conversely, S1-lines 7 and 54 displayed positive and significant GCA effects for ASI towards lateness with the same value of 1.02. For the testers, showed any significant effects for anthesis-silking interval. However, under water stress condition, estimates of GCA effects for anthesis-silking interval, Table 16 revealed that S1-lines 45 and 66 showed negative and significant effects of GCA under water stress with the same values of –0.93, followed by S1-line 76 with an effect of GCA of –1.10. However, both S1-lines 4 and 95 displayed positive and significant GCA effects for ASI towards with the same values of 1.24, both S1-lines 7 and 54 displayed positive and significant GCA effects for ASI towards with the same values of 1.41. For the testers, none of them showed any significant effects for anthesis-silking interval. In this study negative GCA effects are desirable for anthesis-silking interval. Similarly, for days to 50% tasselling, days to 50% silking, and anthesis-silking interval, reported significant positive and negative GCA impacts are desired. Positive GCA impacts are preferred for the other traits. For early maturity and lodging resistance, the minimum days to 50% tasselling, days to 50% silking, and plant height are required (Umar et al., 2014).

TABLE 4. Means (M) and their standard errors (SE) of days to 50% anthesis for parents (S1- lines and two testers) under water stress condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	64.67±1.33	35	63.00±1.15	69	67.00±3.79
2	62.33±0.88	36	65.67±0.33	70	61.67±1.76
3	64.00±0.58	37	65.00±1.00	71	66.00±2.31
4	68.33±1.86	38	66.00±0.58	72	60.33±1.86
5	63.67±1.20	39	63.33±2.33	73	60.67±1.20
6	63.33±0.88	40	62.67±1.20	74	64.33±1.76
7	65.33±0.33	41	60.33±0.88	75	70.00±2.00
8	63.67±0.33	42	63.33±0.67	76	69.33±0.88
9	63.33±1.45	43	60.33±0.33	77	66.67±0.33
10	61.33±0.88	44	66.33±0.33	78	64.33±1.20
11	61.67±0.88	45	62.33±1.20	79	66.33±0.33
12	67.00±0.58	46	62.67±0.67	80	59.00±0.58
13	62.67±1.33	47	64.00±1.53	81	63.67±1.45
14	65.00±1.15	48	65.33±0.88	82	61.67±1.20
15	65.33±0.33	49	66.33±0.33	83	66.33±0.88
16	63.00±1.15	50	68.00±2.08	84	64.00±1.53
17	63.67±0.67	51	64.00±1.73	85	66.00±1.73
18	61.33±1.67	52	68.00±1.53	86	63.67±1.67
19	65.33±1.20	53	63.67±0.67	87	66.33±0.33
20	62.67±1.67	54	64.00±1.53	88	61.33±0.33
21	64.00±0.58	55	65.33±0.67	89	64.67±1.20
22	62.00±1.00	56	65.00±2.08	90	60.00±0.58
23	62.33±0.88	57	63.67±0.67	91	66.33±0.88
24	64.00±1.15	58	66.67±0.33	92	61.33±0.33
25	67.00±1.53	59	62.33±0.67	93	68.33±0.88
26	63.67±1.76	60	65.00±0.58	94	63.67±1.20
27	63.67±0.33	61	63.33±0.33	95	65.33±0.88
28	64.00±0.00	62	61.33±0.33	96	64.33±0.67
29	57.00±0.00	63	64.33±0.88	97	69.00±1.15
30	63.67±0.67	64	71.33±0.33	98	64.33±0.33
31	59.67±0.88	65	63.33±1.20	99	66.00±2.08
32	64.33±0.88	66	63.67±0.33	100	62.67±0.88
33	65.00±0.58	67	65.00±0.58	SC162	58.67±0.88
34	63.00±0.58	68	62.67±1.20	TWC352	55.33±0.88
F value for testers	31.30**		RLSD for lines	NS	

*, ** and NS means significant at levels of probability of 0.05, 0.01 and not significant, respectively.

TABLE 5. Means (M) and their standard errors (SE) of days to 50% anthesis for add top-crosses (T1= SC162 and T2=TWC352) under water stress condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	57.67±0.67	55.67±1.45	35	59.33±0.33	58.00±0.00	69	59.00±0.58	58.33±0.67
2	58.33±1.33	56.00±0.58	36	57.67±0.67	59.00±1.00	70	57.33±0.88	56.00±0.58
3	58.33±0.33	56.67±0.33	37	55.00±0.58	57.33±0.67	71	59.33±0.88	59.00±0.58
4	60.33±0.33	57.00±0.00	38	58.67±0.33	58.67±0.33	72	56.00±0.00	55.33±0.33
5	56.67±0.33	56.67±0.33	39	58.33±1.33	58.00±0.58	73	58.00±1.15	57.33±0.67
6	58.33±0.67	55.00±1.53	40	56.00±0.00	57.00±0.58	74	59.00±0.58	58.33±0.33
7	60.33±1.86	54.33±1.45	41	57.00±0.00	59.33±0.88	75	61.67±0.88	60.00±1.00
8	58.00±0.58	56.67±0.67	42	57.67±0.88	55.33±0.67	76	58.33±0.33	57.00±1.00
9	60.00±0.58	58.33±1.33	43	56.67±0.33	57.33±0.88	77	58.33±0.67	58.67±0.67
10	57.33±0.88	53.33±2.33	44	56.67±0.33	57.67±0.67	78	58.67±0.67	57.33±0.67
11	58.33±0.33	53.67±0.88	45	56.33±0.33	58.67±0.88	79	57.33±0.88	59.67±0.67
12	58.67±0.88	54.00±1.53	46	56.33±0.67	57.33±0.33	80	55.33±0.33	54.00±0.00
13	59.33±0.33	55.67±0.67	47	57.00±0.58	57.33±0.88	81	58.00±0.58	58.00±0.00
14	59.33±2.03	58.00±2.08	48	57.00±0.00	58.33±1.45	82	58.00±1.00	58.67±0.33
15	58.00±0.00	54.00±1.00	49	58.33±1.33	58.00±0.58	83	60.00±0.58	58.67±0.33
16	59.67±0.33	55.33±0.88	50	59.67±0.67	57.67±0.33	84	58.33±1.45	58.33±0.33
17	57.33±1.33	52.67±1.86	51	56.00±1.00	57.00±0.58	85	57.00±0.58	59.33±0.67
18	58.00±1.15	57.00±0.58	52	60.00±1.53	57.67±0.33	86	57.00±0.58	57.67±0.33
19	59.00±0.58	56.67±0.33	53	57.33±0.88	58.00±0.58	87	59.33±0.67	58.33±0.33
20	59.33±1.20	53.33±0.67	54	57.00±0.00	58.00±0.00	88	56.00±0.00	52.67±0.67
21	58.00±0.00	56.67±0.33	55	56.00±0.58	58.00±0.00	89	56.33±0.67	55.33±0.33
22	57.67±1.20	55.00±1.00	56	59.00±0.58	58.67±0.67	90	57.00±1.00	55.33±0.88
23	59.00±1.00	57.33±0.33	57	57.33±0.88	57.00±0.00	91	57.00±0.00	59.67±0.88
24	57.67±0.33	53.33±0.67	58	57.67±0.88	57.33±0.33	92	58.33±1.45	56.67±0.33
25	59.33±1.20	55.00±1.00	59	57.33±0.88	57.00±0.00	93	59.33±0.88	57.33±0.33
26	58.00±0.58	53.00±0.00	60	58.00±0.58	58.00±1.53	94	58.67±0.33	55.67±0.88
27	60.67±1.20	55.67±0.88	61	57.00±0.00	56.67±0.33	95	60.00±0.58	54.67±1.45
28	58.33±0.33	53.33±1.33	62	56.00±0.00	55.33±1.20	96	58.67±0.33	57.00±1.00
29	58.33±0.67	53.67±0.88	63	56.67±0.33	57.33±0.88	97	59.00±2.00	57.33±0.88
30	56.33±0.88	56.33±0.67	64	58.33±0.33	58.00±0.58	98	57.33±0.33	58.00±0.58
31	56.33±0.33	56.33±0.67	65	56.67±1.20	57.67±0.33	99	58.67±0.88	57.33±0.67
32	57.00±0.00	58.00±0.00	66	56.67±0.33	57.33±0.67	100	58.00±0.58	53.67±1.20
33	58.00±0.58	58.33±0.88	67	58.33±0.88	59.67±0.88			
34	57.33±0.33	55.00±0.58	68	57.33±0.88	56.33±1.20			
Top-crosses means			SC162	57.95		TWC352	56.78	
RLSD for line× testers		3						

TABLE 6. Means (M) and their standard errors (SE) of days to 50% silking for parents (S1-lines and two testers) under normal condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	66.33±2.33	35	75.67±1.45	69	72.33±0.33
2	65.00±1.00	36	71.67±0.88	70	71.00±0.58
3	68.00±2.08	37	68.67±0.88	71	72.00±0.58
4	70.00±1.53	38	69.00±1.00	72	64.33±0.88
5	67.00±1.53	39	67.33±2.85	73	68.67±0.67
6	71.33±0.88	40	65.67±0.33	74	70.33±1.76
7	69.00±1.15	41	67.00±0.58	75	79.00±0.00
8	66.67±1.45	42	66.00±0.58	76	73.00±1.73
9	69.33±1.20	43	68.67±0.88	77	74.67±1.20
10	64.00±1.00	44	69.67±0.33	78	70.67±0.33
11	64.67±1.67	45	67.33±0.88	79	71.33±1.33
12	77.33±1.20	46	65.67±0.33	80	70.33±0.88
13	71.00±2.08	47	70.00±2.52	81	69.67±0.88
14	75.33±1.45	48	76.33±1.20	82	68.33±0.88
15	69.00±2.31	49	74.00±0.58	83	77.33±0.67
16	65.00±1.53	50	68.67±0.88	84	76.33±1.20
17	71.00±1.00	51	70.00±0.58	85	75.33±0.88
18	71.00±0.58	52	74.00±1.53	86	70.00±1.15
19	77.33±0.33	53	65.33±1.86	87	70.00±1.15
20	64.33±1.45	54	70.67±0.88	88	64.33±1.86
21	70.00±0.58	55	67.33±0.88	89	78.00±0.58
22	71.67±0.88	56	69.67±1.86	90	65.67±0.67
23	70.00±1.00	57	67.33±1.33	91	69.33±1.86
24	69.67±1.76	58	71.33±0.88	92	66.33±2.85
25	72.00±0.58	59	76.67±1.45	93	77.33±0.33
26	68.67±0.88	60	71.67±0.67	94	67.33±0.88
27	70.67±0.33	61	69.67±0.33	95	73.33±0.88
28	68.33±0.88	62	70.00±0.58	96	66.33±0.33
29	61.67±0.88	63	66.33±2.4	97	76.67±0.67
30	63.00±1.00	64	75.33±2.67	98	65.67±1.86
31	70.67±1.76	65	66.00±0.58	99	73.00±1.00
32	67.00±0.58	66	69.33±1.20	100	68.00±4.04
33	69.33±1.86	67	78.33±0.33	SC162	64.67±2.03
34	65.67±0.88	68	65.33±0.67	TWC352	58.33±0.33
F value for testers	10.26**	RLSD for lines	3.14		

*,** and NS means significant at levels of probability of 0.05, 0.01 and not significant, respectively.

TABLE 7. Means (M) and their standard errors (SE) of days to 50% silking for top-crosses (T1= SC162 and T2=TWC352) under normal condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	62.00±1.00	61.67±0.88	35	64.33±0.33	61.67±1.67	69	64.00±0.58	63.33±1.45
2	62.00±1.15	59.33±0.33	36	62.33±1.20	62.67±0.88	70	63.67±0.33	62.00±0.58
3	63.00±0.58	61.00±0.58	37	60.33±1.45	60.67±0.67	71	64.67±2.73	63.67±1.86
4	63.33±0.67	61.67±0.88	38	63.00±1.15	63.00±0.58	72	60.67±0.67	62.67±0.67
5	61.00±0.58	60.00±0.58	39	63.00±2.08	62.67±1.45	73	63.33±0.88	62.67±0.33
6	63.33±0.33	60.00±0.58	40	62.00±0.58	63.33±0.88	74	66.33±1.20	64.00±1.15
7	64.00±0.00	64.67±1.20	41	61.00±1.53	63.00±0.58	75	65.00±1.53	63.00±1.15
8	60.67±0.67	60.67±0.88	42	61.00±0.58	59.67±0.67	76	61.67±0.88	61.00±1.00
9	62.67±0.33	63.00±1.53	43	62.33±0.88	61.67±0.33	77	62.00±1.00	63.00±0.58
10	61.33±1.33	60.33±1.33	44	62.67±0.67	62.33±1.20	78	62.67±0.88	60.67±1.20
11	62.33±1.20	60.33±1.45	45	62.33±1.45	62.67±1.20	79	61.33±0.33	63.67±0.33
12	64.00±1.15	60.33±0.33	46	61.33±1.45	62.33±0.67	80	60.00±1.53	59.33±0.88
13	63.33±0.33	61.33±0.88	47	60.00±0.00	62.33±1.86	81	63.33±0.67	62.67±0.88
14	63.00±0.58	62.00±1.15	48	61.00±0.58	62.67±0.88	82	60.33±0.33	61.67±0.88
15	62.67±0.33	59.67±0.33	49	62.00±0.58	63.67±1.33	83	65.00±0.58	64.00±0.00
16	62.67±1.20	61.00±0.58	50	64.33±0.88	61.67±1.20	84	61.67±0.67	64.33±1.45
17	60.67±1.67	59.67±1.33	51	59.67±0.33	60.33±0.33	85	62.33±0.33	64.33±2.03
18	63.33±0.33	60.67±0.33	52	63.00±1.15	62.00±1.00	86	60.33±0.33	60.67±0.33
19	64.67±1.45	60.67±1.20	53	60.00±1.15	63.00±1.00	87	63.33±0.88	62.67±0.88
20	61.33±0.67	59.00±1.15	54	63.67±1.20	61.67±0.88	88	59.67±0.33	58.00±0.58
21	62.00±0.58	59.67±0.33	55	60.00±0.00	62.33±1.45	89	60.33±0.88	60.00±0.00
22	62.00±1.73	61.67±1.20	56	62.67±0.33	62.33±1.86	90	60.33±0.88	60.67±0.88
23	62.00±1.00	61.67±0.67	57	61.00±1.00	62.67±0.88	91	61.67±0.33	63.00±1.00
24	62.00±1.53	60.00±2.08	58	62.67±0.88	61.67±1.20	92	61.00±0.58	62.67±1.33
25	63.00±2.31	60.67±1.20	59	62.67±1.45	61.67±0.88	93	62.67±0.88	64.33±0.88
26	62.00±0.58	61.33±0.33	60	62.00±0.58	61.67±1.33	94	62.67±0.33	61.67±1.20
27	64.33±1.20	61.33±0.88	61	62.67±0.67	62.00±1.00	95	64.00±0.58	62.67±0.88
28	65.00±2.00	61.00±1.00	62	60.33±0.33	62.00±1.15	96	64.33±0.67	63.33±1.20
29	63.33±0.33	59.00±1.15	63	63.00±0.58	62.33±0.33	97	62.00±1.53	63.33±2.33
30	61.67±0.88	63.00±0.58	64	65.33±0.67	62.33±0.33	98	67.33±5.33	63.00±0.58
31	60.67±1.67	62.33±0.67	65	61.67±1.20	61.00±1.53	99	61.67±1.33	60.33±0.88
32	61.00±0.58	62.00±1.53	66	61.33±0.88	63.00±0.58	100	63.33±1.45	61.67±0.67
33	62.67±0.67	63.67±0.88	67	61.67±0.88	64.00±1.53			
34	62.00±1.00	60.00±1.53	68	63.00±1.00	61.00±0.58			
Top-crosses means			SC162	62.37		TWC352	61.81	
RLSD for line× testers		-						

TABLE 8. Means (M) and their standard errors (SE) of days to 50% silking for parents (S1-lines and two testers) under water stress condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	68.67±1.33	35	67.33±0.67	69	71.33±4.33
2	67.00±1.15	36	71.67±0.33	70	66.33±2.03
3	70.33±0.67	37	72.33±0.67	71	71.00±2.65
4	75.00±2.00	38	71.00±0.58	72	65.00±2.52
5	69.67±1.86	39	67.67±2.60	73	66.67±0.67
6	68.33±1.67	40	67.00±1.53	74	69.67±1.86
7	70.67±0.33	41	64.00±1.00	75	75.00±2.65
8	69.00±1.00	42	68.67±0.33	76	73.00±1.00
9	70.00±2.08	43	66.67±1.20	77	72.33±0.33
10	65.00±1.15	44	71.00±0.58	78	70.00±1.73
11	66.00±1.73	45	68.33±1.67	79	76.67±0.88
12	71.67±0.88	46	67.67±1.20	80	62.33±0.67
13	71.33±0.88	47	72.67±0.67	81	68.00±2.08
14	70.33±1.20	48	72.00±1.15	82	66.67±1.76
15	72.67±1.20	49	74.33±0.33	83	72.00±0.58
16	69.33±1.76	50	72.33±2.60	84	70.00±1.73
17	69.33±1.86	51	70.67±1.86	85	73.67±2.19
18	67.67±1.45	52	72.67±0.67	86	69.00±2.00
19	71.67±0.88	53	68.00±0.58	87	72.67±0.33
20	67.33±1.86	54	71.67±0.88	88	65.67±0.88
21	69.33±1.45	55	71.33±0.88	89	69.33±1.86
22	65.67±1.67	56	69.67±2.96	90	64.67±1.20
23	66.00±0.58	57	69.67±1.76	91	72.33±1.45
24	68.67±1.33	58	71.33±0.67	92	65.00±0.58
25	71.00±1.53	59	68.67±0.33	93	73.33±0.33
26	71.00±2.65	60	70.00±0.58	94	72.00±1.53
27	71.00±0.58	61	68.33±0.67	95	71.00±0.58
28	71.33±0.88	62	68.67±0.67	96	68.33±0.88
29	61.33±0.33	63	69.67±1.45	97	75.67±2.33
30	70.00±2.08	64	77.00±0.58	98	71.33±1.45
31	63.33±0.67	65	66.67±1.45	99	69.67±2.40
32	69.33±1.20	66	69.00±1.00	100	67.33±1.76
33	72.00±1.00	67	71.00±0.00	SC162	62.00±0.58
34	67.33±0.88	68	69.33±1.67	TWC352	59.33±0.33
F value for testers	40.92**		RLSD for lines	3.14	

*, ** and NS means significant at levels of probability of 0.05, 0.01 and not significant, respectively.

TABLE 9. Means (M) and their standard errors (SE) of days to 50% silking for top-crosses (T1= SC162 and T2=TWC352) under water stress condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	59.67±0.67	59.33±0.67	35	63.67±0.88	61.00±0.00	69	63.00±1.73	61.67±0.67
2	61.67±1.45	59.33±0.33	36	61.67±0.67	62.00±1.00	70	61.67±1.45	60.00±0.58
3	61.33±0.67	60.67±0.88	37	59.00±0.58	60.33±0.33	71	62.33±0.88	61.67±0.67
4	65.33±0.33	61.67±0.33	38	62.67±0.88	61.00±0.58	72	59.67±0.33	59.00±0.58
5	60.00±0.58	60.67±1.20	39	62.67±2.67	61.00±0.58	73	62.33±2.03	60.67±0.88
6	61.33±0.67	58.67±0.88	40	59.00±0.00	60.00±0.58	74	64.33±0.67	61.00±0.58
7	64.00±2.65	60.67±0.88	41	60.00±0.58	62.33±0.88	75	65.33±1.20	62.67±0.88
8	61.67±0.33	60.33±1.33	42	60.67±0.88	58.67±0.88	76	60.33±0.33	60.00±0.00
9	63.67±1.20	62.67±0.67	43	60.67±0.67	60.33±1.33	77	62.00±1.15	61.33±0.88
10	60.33±1.86	58.67±1.76	44	60.00±0.58	60.33±0.33	78	62.67±0.88	60.33±0.67
11	62.00±1.15	57.67±0.88	45	59.00±0.00	61.33±0.88	79	61.00±1.15	65.00±0.58
12	61.67±1.45	58.67±1.45	46	59.33±0.33	60.00±0.00	80	59.00±0.00	58.33±0.33
13	63.67±0.33	59.33±0.33	47	60.33±0.33	60.67±0.67	81	62.33±0.88	61.67±1.20
14	63.33±2.33	62.33±2.40	48	60.67±0.88	61.67±1.67	82	61.67±1.33	61.00±0.00
15	60.67±0.33	58.67±0.33	49	62.00±2.52	61.67±0.88	83	64.67±0.88	62.67±0.67
16	62.33±0.33	59.67±0.67	50	64.33±1.45	60.33±0.33	84	62.00±2.08	60.67±0.33
17	60.00±1.15	58.00±1.00	51	59.33±0.67	61.33±0.33	85	61.00±0.58	63.33±0.88
18	61.00±1.53	60.33±0.88	52	65.33±2.60	60.67±0.33	86	59.67±0.33	60.67±0.33
19	62.00±1.15	59.67±0.33	53	60.33±0.88	61.00±0.58	87	64.67±2.33	61.00±0.00
20	63.00±1.15	57.67±0.33	54	63.67±0.33	61.33±0.33	88	59.00±0.00	56.67±0.67
21	60.33±0.33	60.33±0.88	55	59.00±0.00	61.00±0.58	89	59.00±0.58	59.67±0.33
22	60.33±1.33	58.33±0.88	56	63.67±0.88	60.67±0.88	90	59.67±1.20	59.00±1.00
23	62.00±1.53	61.00±1.00	57	61.67±1.45	60.00±0.00	91	60.67±0.67	63.33±0.88
24	60.33±0.67	58.33±0.33	58	61.00±1.15	60.33±0.33	92	63.00±1.53	61.00±0.00
25	62.67±1.86	59.00±1.53	59	62.33±2.03	60.33±0.33	93	63.00±1.53	61.33±0.67
26	61.67±0.33	58.33±0.33	60	61.00±1.15	61.33±1.86	94	62.33±1.20	59.00±0.58
27	64.00±1.53	60.33±0.88	61	60.67±0.88	60.67±0.88	95	64.33±1.45	60.00±1.53
28	61.00±0.58	58.00±2.08	62	59.33±0.33	59.67±0.88	96	62.67±1.20	60.67±0.33
29	62.00±1.53	58.33±1.20	63	60.67±0.88	61.33±1.20	97	62.33±3.33	61.00±1.00
30	59.67±0.67	59.33±0.67	64	62.00±1.53	60.33±0.33	98	60.00±0.58	61.00±0.58
31	59.33±0.33	60.33±0.88	65	59.67±1.20	60.33±0.33	99	62.33±1.67	61.33±1.45
32	61.67±0.33	61.33±0.33	66	59.00±0.00	60.33±0.67	100	60.67±0.33	57.67±0.67
33	62.33±0.88	61.33±0.88	67	63.33±1.45	62.00±1.15			
34	60.67±0.33	58.67±0.33	68	61.33±1.86	60.00±0.58			
Top-crosses means			SC162	61.54		TWC352	60.37	
RLSD for line× testers	-							

TABLE 10. Means (M) and their standard errors (SE) of anthesis-silking interval for parents (S_1- lines and two testers) under normal condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	3.67±0.67	35	5.00±1.15	69	4.33±0.33
2	5.67±1.33	36	4.00±0.58	70	5.33±0.88
3	4.33±0.88	37	5.67±0.88	71	4.67±0.67
4	5.67±0.88	38	3.00±0.58	72	3.67±0.88
5	5.00±0.58	39	4.33±1.33	73	5.33±0.67
6	6.33±0.88	40	3.00±0.58	74	5.00±0.58
7	3.00±0.00	41	3.67±0.33	75	7.00±0.58
8	4.67±0.88	42	3.33±0.33	76	4.00±0.58
9	5.67±0.67	43	5.67±0.33	77	7.33±0.88
10	3.33±0.88	44	3.33±0.33	78	6.33±0.88
11	4.00±0.58	45	5.00±0.58	79	7.67±0.67
12	7.00±0.58	46	3.33±0.33	80	4.33±0.33
13	5.33±1.45	47	6.00±1.15	81	4.00±0.58
14	7.33±0.67	48	10.00±0.58	82	5.33±0.33
15	4.33±0.88	49	7.00±0.58	83	7.67±0.33
16	3.00±0.00	50	4.00±0.58	84	9.67±0.88
17	4.00±0.58	51	7.00±0.58	85	8.67±0.88
18	5.00±0.58	52	4.00±0.58	86	5.67±0.88
19	7.33±0.88	53	4.00±0.58	87	5.33±0.88
20	5.00±1.00	54	8.00±1.00	88	3.67±0.33
21	6.00±1.15	55	3.33±0.33	89	11.00±1.00
22	4.00±0.00	56	4.33±0.88	90	4.33±0.67
23	3.33±0.67	57	3.67±1.20	91	5.33±2.33
24	6.33±0.67	58	3.67±0.33	92	3.67±1.20
25	5.00±0.58	59	8.33±0.88	93	10.33±0.67
26	6.00±0.58	60	4.67±0.88	94	3.33±0.33
27	6.67±0.67	61	5.00±0.58	95	6.33±0.88
28	5.33±0.88	62	6.00±0.58	96	2.67±0.33
29	4.67±0.88	63	5.33±1.45	97	5.67±0.88
30	3.33±0.33	64	4.67±0.67	98	5.33±0.88
31	5.00±1.00	65	3.00±0.00	99	4.33±0.33
32	3.67±0.33	66	5.00±0.58	100	6.00±1.53
33	4.00±0.58	67	6.33±0.33	SC162	3.00±0.58
34	4.67±0.88	68	5.00±1.00	TWC352	3.33±0.33
F value for testers		1.14^{NS}	RLSD for lines		NS

*, ** and NS means significant at levels of probability of 0.05, 0.01 and not significant, respectively.

TABLE 11. Means (M) and their standard errors (SE) of anthesis-silking interval for top-crosses (T1= SC162 and T2=TWC352) under normal condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	2.67±0.67	2.33±0.33	35	4.00±0.00	2.33±0.33	69	2.00±0.00	3.67±0.67
2	2.33±0.33	2.67±0.33	36	3.00±0.00	2.00±0.00	70	4.00±1.15	2.33±0.33
3	3.67±0.67	3.33±0.33	37	3.33±0.67	2.67±0.67	71	2.67±0.67	2.33±0.33
4	3.00±0.58	3.33±0.67	38	3.33±0.67	2.67±0.33	72	2.67±0.33	4.00±0.58
5	2.67±0.67	2.67±0.33	39	3.00±0.58	2.33±0.33	73	2.33±0.33	3.00±0.58
6	3.00±0.58	2.33±0.33	40	3.33±0.88	2.67±0.67	74	3.33±0.88	3.00±0.00
7	3.00±0.58	5.00±1.15	41	2.67±0.67	2.67±0.67	75	4.00±1.15	2.33±0.33
8	2.33±0.33	3.00±0.58	42	2.67±0.33	2.67±0.33	76	2.00±0.00	2.00±0.00
9	3.67±1.20	3.33±1.45	43	5.33±0.88	2.33±0.67	77	2.67±0.33	2.67±0.67
10	2.33±0.33	3.33±0.33	44	3.00±0.58	2.67±1.20	78	3.33±0.33	2.67±0.33
11	3.33±1.33	2.67±0.33	45	2.00±0.00	2.67±0.33	79	4.33±0.33	3.33±0.88
12	3.00±0.58	3.00±0.00	46	3.67±0.88	3.00±0.58	80	4.33±0.33	3.00±0.58
13	2.67±0.33	3.67±1.20	47	2.67±0.33	2.33±0.33	81	2.67±0.33	3.67±0.33
14	3.33±0.88	4.33±0.88	48	3.67±0.33	2.67±0.67	82	3.33±0.33	2.00±0.58
15	2.67±0.33	3.00±0.58	49	3.33±0.88	2.33±0.33	83	4.00±1.00	3.33±0.67
16	3.00±1.00	3.33±0.33	50	3.00±0.00	2.33±0.33	84	2.67±0.33	2.67±0.33
17	2.67±0.33	3.67±0.67	51	3.00±0.00	2.00±0.00	85	4.00±1.15	3.33±0.33
18	2.67±0.33	3.00±0.58	52	2.33±0.33	2.33±0.33	86	2.00±0.00	2.33±0.33
19	2.67±0.33	2.67±0.67	53	3.33±0.88	2.67±0.67	87	3.00±0.58	2.33±0.33
20	2.67±0.67	3.00±0.00	54	5.33±1.20	2.67±0.33	88	3.00±0.58	3.00±0.58
21	2.00±0.00	2.67±0.67	55	2.67±0.67	2.33±0.67	89	3.00±1.15	2.67±0.33
22	2.00±0.00	2.67±0.33	56	2.33±0.33	2.00±0.00	90	3.67±0.67	2.67±0.67
23	2.33±0.33	4.00±1.15	57	3.67±0.33	3.00±1.00	91	2.33±0.33	2.67±0.67
24	2.67±0.67	2.67±0.33	58	3.00±0.58	3.33±0.33	92	2.00±0.00	3.00±0.58
25	3.00±0.58	2.67±0.67	59	3.67±0.33	2.67±0.33	93	2.67±0.67	3.67±0.33
26	2.67±0.33	3.33±0.33	60	4.00±1.00	2.67±0.33	94	2.33±0.33	3.67±1.20
27	2.33±0.33	4.00±0.00	61	2.67±0.33	2.67±0.33	95	2.33±0.33	3.67±0.33
28	3.00±0.58	4.00±1.15	62	3.00±0.00	4.00±0.58	96	2.67±0.33	3.33±0.33
29	3.33±0.33	3.00±0.58	63	4.00±1.15	2.67±0.33	97	2.33±0.33	2.00±0.00
30	4.00±1.15	3.33±0.33	64	5.33±0.88	2.67±0.67	98	4.33±2.33	2.33±0.33
31	3.33±0.88	2.67±0.33	65	4.33±1.33	2.33±0.33	99	2.67±0.67	2.00±0.00
32	2.33±0.33	2.67±0.67	66	2.33±0.33	3.67±0.88	100	2.33±0.33	4.67±0.67
33	3.00±0.58	2.33±0.33	67	2.67±0.33	3.67±0.33			
34	2.33±0.33	4.33±0.88	68	3.33±0.67	3.67±0.67			
Top-crosses means			SC162	3.04		TWC352	2.93	
RLSD for line× testers		-						

TABLE 12. Means (M) and their standard errors (SE) of anthesis-silking interval for parents (S1-lines and two testers) under water stress condition

S1-line	M±SE	S1-line	M±SE	S1-line	M±SE
1	4.00±0.00	35	4.33±1.33	69	4.33±0.67
2	4.67±0.33	36	6.00±0.00	70	4.67±0.33
3	6.33±0.88	37	7.33±0.33	71	5.00±0.58
4	6.67±0.33	38	5.00±0.00	72	4.67±0.88
5	6.00±1.15	39	4.33±0.33	73	6.00±0.58
6	5.00±1.15	40	4.33±0.33	74	5.33±0.33
7	5.33±0.33	41	3.67±0.33	75	5.00±1.00
8	5.33±0.67	42	5.33±0.33	76	3.67±0.33
9	6.67±0.88	43	6.33±0.88	77	5.67±0.33
10	3.67±0.33	44	4.67±0.67	78	5.67±1.20
11	4.33±0.88	45	6.00±0.58	79	10.33±0.88
12	4.67±0.88	46	5.00±0.58	80	3.33±0.33
13	8.67±0.88	47	8.67±0.88	81	4.33±0.67
14	5.33±0.33	48	6.67±0.33	82	5.00±1.00
15	7.33±0.88	49	8.00±0.58	83	5.67±0.67
16	6.33±0.67	50	4.33±0.88	84	6.00±0.58
17	5.67±1.20	51	6.67±0.67	85	7.67±0.88
18	6.33±0.67	52	4.67±0.88	86	5.33±0.33
19	6.33±0.67	53	4.33±0.33	87	6.33±0.33
20	4.67±0.33	54	7.67±0.88	88	4.33±0.67
21	5.33±0.88	55	6.00±1.00	89	4.67±0.88
22	3.67±0.67	56	4.67±0.88	90	4.67±0.67
23	3.67±0.67	57	6.00±1.15	91	6.00±1.00
24	4.67±0.67	58	4.67±0.88	92	3.67±0.33
25	4.00±0.00	59	6.33±0.88	93	5.00±0.58
26	7.33±0.88	60	5.00±0.00	94	8.33±0.67
27	7.33±0.67	61	5.00±1.00	95	5.67±0.33
28	7.33±0.88	62	7.33±0.88	96	4.00±0.58
29	4.33±0.33	63	5.33±0.67	97	6.67±1.45
30	6.33±1.67	64	5.67±0.33	98	7.00±1.15
31	3.67±0.33	65	3.33±0.33	99	3.67±0.33
32	5.00±0.58	66	5.33±0.67	100	4.46±1.20
33	7.00±1.15	67	6.00±0.58	SC162	3.33±0.33
34	4.33±0.33	68	6.67±1.20	TWC352	4.00±0.58
F value for testers		0.001^{NS}	RLSD for lines		NS

*, ** and NS means significant at levels of probability of 0.05, 0.01 and not significant, respectively.

TABLE 13. Means (M) and their standard errors (SE) of anthesis-silking interval for top-crosses (T1= SC162 and T2=TWC352) under water stress condition

S1-line	T1	T2	S1-line	T1	T2	S1-line	T1	T2
	M±SE	M±SE		M±SE	M±SE		M±SE	M±SE
1	2.00±0.00	3.67±0.88	35	4.33±0.67	3.00±0.00	69	4.00±1.15	3.33±0.67
2	3.33±0.88	3.33±0.33	36	4.00±0.00	3.00±0.00	70	4.33±0.67	4.00±0.00
3	3.00±0.58	4.00±0.58	37	4.00±0.00	3.00±0.58	71	3.00±0.00	2.67±0.33
4	5.00±0.58	4.67±0.33	38	4.00±0.58	2.33±0.33	72	3.67±0.33	3.67±0.67
5	3.33±0.67	4.00±1.00	39	4.33±1.33	3.00±0.00	73	4.33±0.88	3.33±0.33
6	3.00±0.00	3.67±0.67	40	3.00±0.00	3.00±0.58	74	5.33±0.33	2.67±0.33
7	3.67±0.88	6.33±0.67	41	3.00±0.58	3.00±0.58	75	3.67±0.33	2.67±0.33
8	3.67±0.67	3.67±0.67	42	3.00±0.00	3.33±0.33	76	2.00±0.00	3.00±1.00
9	3.67±0.88	4.33±0.67	43	4.00±0.58	3.00±0.58	77	3.67±0.67	2.67±0.33
10	3.00±1.00	5.33±0.88	44	3.33±0.33	2.67±0.33	78	4.00±0.58	3.00±0.00
11	3.67±0.88	4.00±0.00	45	2.67±0.33	2.67±0.33	79	3.67±0.33	5.33±0.88
12	3.00±0.58	4.67±0.67	46	3.00±1.00	2.67±0.33	80	3.67±0.33	4.33±0.33
13	4.33±0.33	3.67±0.33	47	3.33±0.88	3.33±0.33	81	4.33±0.67	3.67±1.20
14	4.00±0.58	4.33±0.33	48	3.67±0.88	3.33±0.67	82	3.67±0.33	2.33±0.33
15	2.67±0.33	4.67±0.67	49	3.67±1.20	3.67±0.67	83	4.67±0.67	4.00±0.58
16	2.67±0.33	4.33±0.33	50	4.67±0.88	2.67±0.33	84	3.67±0.67	2.33±0.33
17	2.67±0.67	5.33±0.88	51	3.33±0.33	4.33±0.33	85	4.00±0.58	4.00±0.58
18	3.00±0.58	3.33±0.33	52	5.33±1.20	3.00±0.00	86	2.67±0.67	3.00±0.58
19	3.00±0.58	3.00±0.00	53	3.00±0.00	3.00±0.00	87	5.33±1.67	2.67±0.33
20	3.67±0.33	4.33±0.33	54	6.67±0.33	3.33±0.33	88	3.00±0.00	4.00±0.00
21	2.33±0.33	3.67±0.67	55	3.00±0.58	3.00±0.58	89	2.67±0.33	4.33±0.33
22	2.67±0.33	3.33±0.33	56	4.67±0.67	2.00±0.58	90	2.67±0.33	3.67±0.67
23	3.00±0.58	3.67±1.20	57	4.33±0.67	3.00±0.00	91	3.67±0.67	3.67±0.33
24	2.67±0.33	5.00±0.58	58	3.33±0.33	3.00±0.00	92	4.67±0.33	4.33±0.33
25	3.33±0.88	4.00±0.58	59	5.00±1.15	3.33±0.33	93	3.67±1.20	4.00±0.58
26	3.67±0.67	5.33±0.33	60	3.00±0.58	3.33±0.33	94	3.67±0.88	3.33±0.33
27	3.33±0.33	4.67±0.33	61	3.67±0.88	4.00±0.58	95	4.33±0.88	5.33±0.33
28	2.67±0.33	4.67±0.88	62	3.33±0.33	4.33±0.33	96	4.00±1.00	3.67±0.67
29	3.67±0.88	4.67±0.33	63	4.00±1.15	4.00±1.00	97	3.33±1.33	3.67±0.33
30	3.33±0.33	3.00±0.00	64	3.67±1.20	2.33±0.33	98	2.67±0.67	3.00±0.58
31	3.00±0.00	4.00±0.58	65	3.00±0.00	2.67±0.33	99	3.67±0.88	4.00±1.00
32	4.67±0.33	3.33±0.33	66	2.33±0.33	3.00±0.00	100	2.67±0.33	4.00±0.58
33	4.33±0.33	3.00±0.58	67	5.00±0.58	2.33±0.33			
34	3.33±0.33	3.67±0.33	68	4.00±1.15	3.67±0.67			
Top-crosses means			SC162	3.59		TWC352	3.60	
RLSD for line× testers		2.47						

TABLE 14. General combining ability effects (GCA) for days to 50% anthesis for 100 S1-lines and the two testers (SC162 and TWC352) under normal and water stress conditions

S1-lines/ testers	DAN	DAS	S1-lines/ testers	DAN	DAS	S1-lines/ testers	DAN	DAS
1	0.22	-0.70	35	0.72	1.30	69	1.72*	1.30
2	-0.94	-0.20	36	0.89	0.97	70	0.56	-0.70
3	-0.61	0.14	37	-1.61*	-1.20	71	2.56**	1.80**
4	0.22	1.30	38	0.89	1.30	72	-0.78	-1.70*
5	-1.28	-0.70	39	1.06	0.80	73	1.22	0.30
6	-0.11	-0.70	40	0.56	-0.86	74	2.89**	1.30
7	1.22	-0.03	41	0.22	0.80	75	1.72*	3.47**
8	-1.11	-0.03	42	-1.44*	-0.86	76	0.22	0.30
9	0.22	1.80**	43	-0.94	-0.36	77	0.72	1.14
10	-1.11	-2.03**	44	0.56	-0.20	78	-0.44	0.64
11	-0.78	-1.36*	45	1.06	0.14	79	-0.44	1.14
12	0.06	-1.03	46	-0.61	-0.53	80	-3.11**	-2.70**
13	0.06	0.14	47	-0.44	-0.20	81	0.72	0.64
14	-0.44	1.30	48	-0.44	0.30	82	-0.78	0.97
15	-0.78	-1.36*	49	0.89	0.80	83	1.72*	1.97**
16	-0.44	0.14	50	1.22	1.30	84	1.22	0.97
17	-2.11*	-2.36**	51	-1.61*	-0.86	85	0.56	0.80
18	0.06	0.14	52	1.06	1.47*	86	-0.78	-0.03
19	0.89	0.47	53	-0.61	0.30	87	1.22	1.47*
20	-1.78*	-1.03	54	-0.44	0.14	88	-3.28**	-3.03**
21	-0.61	-0.03	55	-0.44	-0.36	89	-1.78*	-1.53*
22	0.39	-1.03	56	1.22	1.47*	90	-1.78*	-1.20
23	-0.44	0.80	57	-0.61	-0.20	91	0.72	0.97
24	-0.78	-1.86**	58	-0.11	0.14	92	0.22	0.14
25	-0.11	-0.20	59	-0.11	-0.20	93	1.22	0.97
26	-0.44	-1.86**	60	-0.61	0.64	94	0.06	-0.20
27	0.56	0.80	61	0.56	-0.53	95	1.22	-0.03
28	0.39	-1.53*	62	-1.44*	-1.70*	96	1.72*	0.47
29	-1.11	-1.36*	63	0.22	-0.36	97	1.39*	0.80
30	-0.44	-1.03	64	0.72	0.80	98	2.72**	0.30
31	-0.61	-1.03	65	-1.11	-0.20	99	-0.44	0.64
32	-0.11	0.14	66	0.06	-0.36	100	-0.11	-1.53*
33	1.39*	0.80	67	0.56	1.64*	T1(SC 162)	0.22*	0.59**
34	-1.44*	-1.20	68	-0.61	-0.53	T2(TWC352)	-0.22*	-0.59**
S.E. (gca for line)	0.69	0.67				S.E. (gca for tester)	0.10	0.09
S.E. (gi - gj) line	0.97	0.94				S.E. (gi - gj) tester	0.14	0.13

DAN = days to 50% anthesis under normal condition, DAS= days to 50% anthesis under water stress condition.

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

TABLE 15. General combining ability effects (GCA) for days to 50% silking for 100 S1-lines and the two testers (SC162 and TWC352) under normal and water stress conditions

S1-lines / testers	DSN	DSS	S1-lines / testers	DSN	DSS	S1-lines / testers	DSN	DSS
1	-0.26	-1.46	35	0.91	1.38	69	1.58	1.38
2	-1.43	-0.46	36	0.41	0.88	70	0.74	-0.13
3	-0.09	0.04	37	-1.59	-1.29	71	2.08*	1.04
4	0.41	2.54**	38	0.91	0.88	72	-0.43	-1.63
5	-1.59	-0.63	39	0.74	0.88	73	0.91	0.54
6	-0.43	-0.96	40	0.58	-1.46	74	3.08**	1.71*
7	2.24**	1.38	41	-0.09	0.21	75	1.91*	3.04**
8	-1.43	0.04	42	-1.76*	-1.29	76	-0.76	-0.79
9	0.74	2.21**	43	-0.09	-0.46	77	0.41	0.71
10	-1.26	-1.46	44	0.41	-0.79	78	-0.43	0.54
11	-0.76	-1.13	45	0.41	-0.79	79	0.41	2.04*
12	0.08	-0.79	46	-0.26	-1.29	80	-2.43**	-2.29*
13	0.24	0.54	47	-0.93	-0.46	81	0.91	1.04
14	0.41	1.88*	48	-0.26	0.21	82	-1.09	0.38
15	-0.93	-1.29	49	0.74	0.88	83	2.41**	2.71**
16	-0.26	0.04	50	0.91	1.38	84	0.91	0.38
17	-1.93*	-1.96*	51	-2.09*	-0.63	85	1.24	1.21
18	-0.09	-0.29	52	0.41	2.04*	86	-1.59	-0.79
19	0.58	-0.13	53	-0.59	-0.29	87	0.91	1.88*
20	-1.93*	-0.63	54	0.58	1.54	88	-3.26**	-3.13**
21	-1.26	-0.63	55	-0.93	-0.96	89	-1.93*	-1.63
22	-0.26	-1.63	56	0.41	1.21	90	-1.59	-1.63
23	-0.26	0.54	57	-0.26	-0.13	91	0.24	1.04
24	-1.09	-1.63	58	0.08	-0.29	92	-0.26	1.04
25	-0.26	-0.13	59	0.08	0.38	93	1.41	1.21
26	-0.43	-0.96	60	-0.26	0.21	94	0.08	-0.29
27	0.74	1.21	61	0.24	-0.29	95	1.24	1.21
28	0.91	-1.46	62	-0.93	-1.46	96	1.74*	0.71
29	-0.93	-0.79	63	0.58	0.04	97	0.58	0.71
30	0.24	-1.46	64	1.74*	0.21	98	3.08**	-0.46
31	-0.59	-1.13	65	-0.76	-0.96	99	-1.09	0.88
32	-0.59	0.54	66	0.08	-1.29	100	0.41	-1.79**
33	1.08	0.88	67	0.74	1.71*	T1(SC 162)	0.28*	0.59**
34	-1.09	-1.29	68	-0.09	-0.29	T2(TWC352)	-0.28*	-0.59**
S.E. (gca for line)	0.84	0.85				S.E. (gca for tester)	0.12	0.12
S.E. (gi - gj) line	1.18	1.20				S.E. (gi - gj) tester	0.17	0.17

DSN = days to 50% silking under normal condition, DSS = days to 50% silking under water stress condition.

*, ** Significant at levels of probability of 0.05 and 0.01, respectively.

TABLE 16. General combining ability effects (GCA) for anthesis-silking interval for 100 S1-lines and the two testers (SC162 and TWC352) under normal and water stress conditions

S1-lines / testers	ASIN	ASIS	S1-lines / testers	ASIN	ASIS	S1-lines / testers	ASIN	ASIS
1	-0.48	-0.76	35	0.19	0.07	69	-0.15	0.07
2	-0.48	-0.26	36	-0.48	-0.10	70	0.19	0.57
3	0.52	-0.10	37	0.02	-0.10	71	-0.48	-0.76
4	0.19	1.24**	38	0.02	-0.43	72	0.35	0.07
5	-0.32	0.07	39	-0.32	0.07	73	-0.32	0.24
6	-0.32	-0.26	40	0.02	-0.60	74	0.19	0.41
7	1.02*	1.41**	41	-0.32	-0.60	75	0.19	-0.43
8	-0.32	0.07	42	-0.32	-0.43	76	-0.98*	-1.10*
9	0.52	0.41	43	0.85	-0.10	77	-0.32	-0.43
10	-0.15	0.57	44	-0.15	-0.60	78	0.02	-0.10
11	0.02	0.24	45	-0.65	-0.93*	79	0.85	0.91*
12	0.02	0.24	46	0.35	-0.76	80	0.69	0.41
13	0.19	0.41	47	-0.48	-0.26	81	0.19	0.41
14	0.85	0.57	48	0.19	-0.10	82	-0.32	-0.60
15	-0.15	0.07	49	-0.15	0.07	83	0.69	0.74
16	0.19	-0.10	50	-0.32	0.07	84	-0.32	-0.60
17	0.19	0.41	51	-0.48	0.24	85	0.69	0.41
18	-0.15	-0.43	52	-0.65	0.57	86	-0.82	-0.76
19	-0.32	-0.60	53	0.02	-0.60	87	-0.32	0.41
20	-0.15	0.41	54	1.02*	1.41**	88	0.02	-0.10
21	-0.65	-0.60	55	-0.48	-0.60	89	-0.15	-0.10
22	-0.65	-0.60	56	-0.82	-0.26	90	0.19	-0.43
23	0.19	-0.26	57	0.35	0.07	91	-0.48	0.07
24	-0.32	0.24	58	0.19	-0.43	92	-0.48	0.91*
25	-0.15	0.07	59	0.19	0.57	93	0.19	0.24
26	0.02	0.91*	60	0.35	-0.43	94	0.02	-0.10
27	0.19	0.41	61	-0.32	0.24	95	0.02	1.24**
28	0.52	0.07	62	0.52	0.24	96	0.02	0.24
29	0.19	0.57	63	0.35	0.41	97	-0.82	-0.10
30	0.69	-0.43	64	1.02*	-0.60	98	0.35	-0.76
31	0.02	-0.10	65	0.35	-0.76	99	-0.65	0.24
32	-0.48	0.41	66	0.02	-0.93*	100	0.52	-0.26
33	-0.32	0.07	67	0.19	0.07	T1(SC 162)	0.06	0.00
34	0.35	-0.10	68	0.52	0.24	T2(TWC352)	-0.06	0.00
S.E. (gca for line)	0.48	0.46				S.E. (gca for tester)	0.07	0.07
S.E. (gi - gj) line	0.68	0.66				S.E. (gi - gj) tester	0.10	0.09

ASIN = Anthesis-silking interval under normal condition, ASIS = Anthesis-silking interval under water stress condition.

*, ** Significant at levels of probability of 0.05 and 0.01, respectively.

Estimation of specific combining ability (SCA)

Estimate of specific combining ability for both normal and water stress conditions for these studied traits are presented in Tables 17–22. In details, under normal condition, estimate of SCA effects for days to 50% anthesis (Table 17) both negative and positive significant estimates were found among the top-crosses. Top-crosses including S1-line 53 ×SC162 and S1-line 28 ×TWC352 were good specific combiners, whereas, top-cross, including S1-line 53 ×TWC352 and S1-line 28 ×SC162 were poor specific combiners. Under water stress condition, estimate of SCA effects for days to 50% anthesis (Table 18), both negative and positive and significant estimates of SCA effects were found among the top-crosses. Top-crosses including S1-line 91 ×SC162, S1-line 7 ×TWC352 and S1-line 20 ×TWC352 were good specific combiners, however, the top-crosses including S1-line 91 ×TWC352, S1-line 7 ×SC162 and S1-line 20×SC162 were poor specific combiners. Abrha et al. (2013) found significant positive and negative SCA effects for days to 50% anthesis.

None of the top-crosses showed any significant effects for days to 50% silking under both normal and water stress conditions (Tables 19–20). In contrast, Akula (2018) found significant positive and negative SCA effects in maize for days to 50% silking.

Under normal condition, appreciation of SCA effects for anthesis-silking interval Table (21) both negative and positive significant estimate were detected among the top-crosses. Top-crosses including S1-line 43 ×TWC352 was good specific combiners, whereas, the top-cross including S1-line 43 ×SC162 was poor specific combiners. Under water stress condition, estimates of SCA effects for anthesis-silking interval (Table 22) both negative and positive and significant estimate of SCA effects were detected among the top-crosses. Top-crosses including S1-line 7 ×SC162, S1-line 17 ×SC162 and S1-line 54 ×TWC352 were good specific combiners, however, the top-crosses including S1-line 7 ×TWC352, S1-line 17×TWC352 and S1-line 54 ×SC162 were poor specific combiners. Umar et al. (2014) reported significant positive and negative SCA effects for anthesis-silking interval.

Heritability in broad sense along with variances for both GCA and SCA are shown in Table 23. Under normal condition, heritability in broad sense was lower than under water stress condition for these traits studied. The high values of broad sense heritability make the selection process easier for breeder of plants and more accurate as the phenotype reflect its genotypes. The lowest value was recorded for days to 50% silking (0.0807) which indicate that the environment plays a big role in this trait which make the selection process is complicated. Similar results, Worku (2005) revealed a decline in heritability under stressed environments, as opposed to Al-Naggar et al. (2016b) found that heritability was increased in stressful environments.

Under normal condition and water stress condition, specific combining ability variance was important than general combining ability variance for these traits indicating preponderance of dominance variance in controlling these characters. For the previous traits the combining ability ration (CAR) values were lower than unity which mean that the preponderance of dominance variance controlling these characters. Slightly different results were reported by Emyhum (2013), who found that variance due to SCA was more important than variance due to GCA for days to 50%anthesis, days to 50% silking and anthesis-silking interval.

Conclusion

The current study revealed that S1-lines 80 and 88 are good combiners for both days to 50% anthesis and days to 50% silking based on GCA. For the top-crosses, results showed that all the top-crosses involving TWC352 were earlier in anthesis and silking date than those involving SC162.

Under normal condition, heritability in broad sense was lower than under water stress condition for these traits studied. The high values of broad sense heritability make the selection process easier for the plant breeder and more accurate as the phenotype reflect it's genotypes. In conditions of water stress, heritability in a broad sense revealed a high estimate for these traits. Furthermore, we came to the conclusion that the dominant gene predominately controls the attributes under study Finally, these S1-lines show promise in producing inbred lines that are drought-tolerant based on the early flowering days, which could one day be used to create hybrids that are drought-tolerant.

TABLE 17. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) for days to 50%anthesis under normal condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	-0.22	0.22	35	0.28	-0.28	69	0.94	-0.94
2	1.28	-1.28	36	-0.89	0.89	70	-0.22	0.22
3	0.61	-0.61	37	-0.72	0.72	71	0.11	-0.11
4	0.78	-0.78	38	-0.56	0.56	72	-0.56	0.56
5	0.28	-0.28	39	-0.39	0.39	73	0.44	-0.44
6	1.11	-1.11	40	-1.22	1.22	74	0.78	-0.78
7	0.44	-0.44	41	-1.22	1.22	75	-0.06	0.06
8	0.11	-0.11	42	0.44	-0.44	76	0.11	-0.11
9	-0.56	0.56	43	-1.39	1.39	77	-0.72	0.72
10	0.78	-0.78	44	-0.22	0.22	78	0.44	-0.44
11	0.44	-0.44	45	-0.06	0.06	79	-1.89	1.89
12	1.61	-1.61	46	-1.06	1.06	80	-0.56	0.56
13	1.28	-1.28	47	-1.56	1.56	81	0.61	-0.61
14	0.78	-0.78	48	-1.56	1.56	82	-1.56	1.56
15	1.44	-1.44	49	-1.56	1.56	83	-0.06	0.06
16	0.78	-0.78	50	0.78	-0.78	84	-1.56	1.56
17	0.78	-0.78	51	-1.06	1.06	85	-1.56	1.56
18	1.28	-1.28	52	0.28	-0.28	86	-0.22	0.22
19	1.78	-1.78	53	-2.06*	2.06*	87	-0.22	0.22
20	1.11	-1.11	54	-0.56	0.56	88	0.61	-0.61
21	1.28	-1.28	55	-1.56	1.56	89	-0.22	0.22
22	0.28	-0.28	56	-0.22	0.22	90	-0.89	0.89
23	0.78	-0.78	57	-1.39	1.39	91	-0.72	0.72
24	0.78	-0.78	58	0.44	-0.44	92	-0.56	0.56
25	0.78	-0.78	59	-0.22	0.22	93	-0.56	0.56
26	0.44	-0.44	60	-0.72	0.72	94	0.94	-0.94
27	2.11*	-2.11*	61	0.11	-0.11	95	1.11	-1.11
28	2.28*	-2.28*	62	-0.56	0.56	96	0.61	-0.61
29	1.78	-1.78	63	-0.56	0.56	97	-1.06	1.06
30	-1.22	1.22	64	-0.06	0.06	98	0.94	-0.94
31	-1.39	1.39	65	-0.89	0.89	99	0.11	-0.11
32	-0.56	0.56	66	-0.39	0.39	100	1.78	-1.78
33	-1.06	1.06	67	-0.89	0.89			
34	1.78	-1.78	68	0.94	-0.94			
S.E. (SCA effect)		0.97			S.E. (sij - skl) tester		1.38	

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

S.E. (sij - skl) tester = standard error of difference in tester

TABLE 18. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) for days to 50%anthesis under water stress condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	0.41	-0.41	35	0.08	-0.08	69	-0.25	0.25
2	0.58	-0.58	36	-1.25	1.25	70	0.08	-0.08
3	0.25	-0.25	37	-1.75	1.75	71	-0.42	0.42
4	1.08	-1.08	38	-0.59	0.59	72	-0.25	0.25
5	-0.59	0.59	39	-0.42	0.42	73	-0.25	0.25
6	1.08	-1.08	40	-1.09	1.09	74	-0.25	0.25
7	2.41*	-2.41*	41	-1.75	1.75	75	0.25	-0.25
8	0.08	-0.08	42	0.58	-0.58	76	0.08	-0.08
9	0.25	-0.25	43	-0.92	0.92	77	-0.75	0.75
10	1.41	-1.41	44	-1.09	1.09	78	0.08	-0.08
11	1.75	-1.75	45	-1.75	1.75	79	-1.75	1.75
12	1.75	-1.75	46	-1.09	1.09	80	0.08	-0.08
13	1.25	-1.25	47	-0.75	0.75	81	-0.59	0.59
14	0.08	-0.08	48	-1.25	1.25	82	-0.92	0.92
15	1.41	-1.41	49	-0.42	0.42	83	0.08	-0.08
16	1.58	-1.58	50	0.41	-0.41	84	-0.59	0.59
17	1.75	-1.75	51	-1.09	1.09	85	-1.75	1.75
18	-0.09	0.09	52	0.58	-0.58	86	-0.92	0.92
19	0.58	-0.58	53	-0.92	0.92	87	-0.09	0.09
20	2.41*	-2.41*	54	-1.09	1.09	88	1.08	-1.08
21	0.08	-0.08	55	-1.59	1.59	89	-0.09	0.09
22	0.75	-0.75	56	-0.42	0.42	90	0.25	-0.25
23	0.25	-0.25	57	-0.42	0.42	91	-1.92*	1.92*
24	1.58	-1.58	58	-0.42	0.42	92	0.25	-0.25
25	1.58	-1.58	59	-0.42	0.42	93	0.41	-0.41
26	1.91*	-1.91*	60	-0.59	0.59	94	0.91	-0.91
27	1.91*	-1.91*	61	-0.42	0.42	95	2.08*	-2.08*
28	1.91*	-1.91*	62	-0.25	0.25	96	0.25	-0.25
29	1.75	-1.75	63	-0.92	0.92	97	0.25	-0.25
30	-0.59	0.59	64	-0.42	0.42	98	-0.92	0.92
31	-0.59	0.59	65	-1.09	1.09	99	0.08	-0.08
32	-1.09	1.09	66	-0.92	0.92	100	1.58	-1.58
33	-0.75	0.75	67	-1.25	1.25			
34	0.58	-0.58	68	-0.09	0.09			
S.E. (SCA effect)		0.94			S.E.(sij - skl)tester		1.33	

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

S.E. (sij - skl) tester = standard error of difference in tester

TABLE 19. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) for days to 50% silking under normal condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	-0.11	0.11	35	1.06	-1.06	69	0.06	-0.06
2	1.06	-1.06	36	-0.45	0.45	70	0.56	-0.56
3	0.72	-0.72	37	-0.45	0.45	71	0.22	-0.22
4	0.56	-0.56	38	-0.28	0.28	72	-1.28	1.28
5	0.22	-0.22	39	-0.11	0.11	73	0.06	-0.06
6	1.39	-1.39	40	-0.95	0.95	74	0.89	-0.89
7	-0.61	0.61	41	-1.28	1.28	75	0.72	-0.72
8	-0.28	0.28	42	0.39	-0.39	76	0.06	-0.06
9	-0.45	0.45	43	0.06	-0.06	77	-0.78	0.78
10	0.22	-0.22	44	-0.11	0.11	78	0.72	-0.72
11	0.72	-0.72	45	-0.45	0.45	79	-1.45	1.45
12	1.56	-1.56	46	-0.78	0.78	80	0.06	-0.06
13	0.72	-0.72	47	-1.45	1.45	81	0.06	-0.06
14	0.22	-0.22	48	-1.11	1.11	82	-0.95	0.95
15	1.22	-1.22	49	-1.11	1.11	83	0.22	-0.22
16	0.56	-0.56	50	1.06	-1.06	84	-1.61	1.61
17	0.22	-0.22	51	-0.61	0.61	85	-1.28	1.28
18	1.06	-1.06	52	0.22	-0.22	86	-0.45	0.45
19	1.72	-1.72	53	-1.78	1.78	87	0.06	-0.06
20	0.89	-0.89	54	0.72	-0.72	88	0.56	-0.56
21	0.89	-0.89	55	-1.45	1.45	89	-0.11	0.11
22	-0.11	0.11	56	-0.11	0.11	90	-0.45	0.45
23	-0.11	0.11	57	-1.11	1.11	91	-0.95	0.95
24	0.72	-0.72	58	0.22	-0.22	92	-1.11	1.11
25	0.89	-0.89	59	0.22	-0.22	93	-1.11	1.11
26	0.06	-0.06	60	-0.11	0.11	94	0.22	-0.22
27	1.22	-1.22	61	0.06	-0.06	95	0.39	-0.39
28	1.72	-1.72	62	-1.11	1.11	96	0.22	-0.22
29	1.89	-1.89	63	0.06	-0.06	97	-0.95	0.95
30	-0.95	0.95	64	1.22	-1.22	98	1.89	-1.89
31	-1.11	1.11	65	0.06	-0.06	99	0.39	-0.39
32	-0.78	0.78	66	-1.11	1.11	100	0.56	-0.56
33	-0.78	0.78	67	-1.45	1.45			
34	0.72	-0.72	68	0.72	-0.72			
S.E. (SCA effect)		1.18			S.E. (sij - skl) tester		1.67	

*, ** Significant at levels of probability of 0.05 and 0.01, respectively.

S.E. (sij - skl) tester = standard error of difference in tester

TABLE 20. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) for days to 50% silking under water stress condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	-0.42	0.42	35	0.75	-0.75	69	0.08	-0.08
2	0.58	-0.58	36	-0.75	0.75	70	0.25	-0.25
3	-0.25	0.25	37	-1.25	1.25	71	-0.25	0.25
4	1.25	-1.25	38	0.25	-0.25	72	-0.25	0.25
5	-0.92	0.92	39	0.25	-0.25	73	0.25	-0.25
6	0.75	-0.75	40	-1.09	1.09	74	1.08	-1.08
7	1.08	-1.08	41	-1.75	1.75	75	0.75	-0.75
8	0.08	-0.08	42	0.42	-0.42	76	-0.42	0.42
9	-0.09	0.09	43	-0.42	0.42	77	-0.25	0.25
10	0.25	-0.25	44	-0.75	0.75	78	0.58	-0.58
11	1.58	-1.58	45	-1.75	1.75	79	-2.59	2.59
12	0.92	-0.92	46	-0.92	0.92	80	-0.25	0.25
13	1.58	-1.58	47	-0.75	0.75	81	-0.25	0.25
14	-0.09	0.09	48	-1.09	1.09	82	-0.25	0.25
15	0.42	-0.42	49	-0.42	0.42	83	0.42	-0.42
16	0.75	-0.75	50	1.42	-1.42	84	0.08	-0.08
17	0.42	-0.42	51	-1.59	1.59	85	-1.75	1.75
18	-0.25	0.25	52	1.75	-1.75	86	-1.09	1.09
19	0.58	-0.58	53	-0.92	0.92	87	1.25	-1.25
20	2.08	-2.08	54	0.58	-0.58	88	0.58	-0.58
21	-0.59	0.59	55	-1.59	1.59	89	-0.92	0.92
22	0.42	-0.42	56	0.92	-0.92	90	-0.25	0.25
23	-0.09	0.09	57	0.25	-0.25	91	-1.92	1.92
24	0.42	-0.42	58	-0.25	0.25	92	0.42	-0.42
25	1.25	-1.25	59	0.42	-0.42	93	0.25	-0.25
26	1.08	-1.08	60	-0.75	0.75	94	1.08	-1.08
27	1.25	-1.25	61	-0.59	0.59	95	1.58	-1.58
28	0.92	-0.92	62	-0.75	0.75	96	0.42	-0.42
29	1.25	-1.25	63	-0.92	0.92	97	0.08	-0.08
30	-0.42	0.42	64	0.25	-0.25	98	-1.09	1.09
31	-1.09	1.09	65	-0.92	0.92	99	-0.09	0.09
32	-0.42	0.42	66	-1.25	1.25	100	0.92	-0.92
33	-0.09	0.09	67	0.08	-0.08			
34	0.42	-0.42	68	0.08	-0.08			
S.E. (SCA effect)		1.20			S.E. (sij - skl) tester		1.70	

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

TABLE 21. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) for anthesis-silking interval under normal condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	0.11	-0.11	35	0.78	-0.78	69	-0.89	0.89
2	-0.22	0.22	36	0.45	-0.45	70	0.78	-0.78
3	0.11	-0.11	37	0.28	-0.28	71	0.11	-0.11
4	-0.22	0.22	38	0.28	-0.28	72	-0.72	0.72
5	-0.06	0.06	39	0.28	-0.28	73	-0.39	0.39
6	0.28	-0.28	40	0.28	-0.28	74	0.11	-0.11
7	-1.06	1.06	41	-0.06	0.06	75	0.78	-0.78
8	-0.39	0.39	42	-0.06	0.06	76	-0.06	0.06
9	0.11	-0.11	43	1.45*	-1.45*	77	-0.06	0.06
10	-0.56	0.56	44	0.11	-0.11	78	0.28	-0.28
11	0.28	-0.28	45	-0.39	0.39	79	0.45	-0.45
12	-0.06	0.06	46	0.28	-0.28	80	0.61	-0.61
13	-0.56	0.56	47	0.11	-0.11	81	-0.56	0.56
14	-0.56	0.56	48	0.45	-0.45	82	0.61	-0.61
15	-0.22	0.22	49	0.45	-0.45	83	0.28	-0.28
16	-0.22	0.22	50	0.28	-0.28	84	-0.06	0.06
17	-0.56	0.56	51	0.45	-0.45	85	0.28	-0.28
18	-0.22	0.22	52	-0.06	0.06	86	-0.22	0.22
19	-0.06	0.06	53	0.28	-0.28	87	0.28	-0.28
20	-0.22	0.22	54	1.28	-1.28	88	-0.06	0.06
21	-0.39	0.39	55	0.11	-0.11	89	0.11	-0.11
22	-0.39	0.39	56	0.11	-0.11	90	0.45	-0.45
23	-0.89	0.89	57	0.28	-0.28	91	-0.22	0.22
24	-0.06	0.06	58	-0.22	0.22	92	-0.56	0.56
25	0.11	-0.11	59	0.45	-0.45	93	-0.56	0.56
26	-0.39	0.39	60	0.61	-0.61	94	-0.72	0.72
27	-0.89	0.89	61	-0.06	0.06	95	-0.72	0.72
28	-0.56	0.56	62	-0.56	0.56	96	-0.39	0.39
29	0.11	-0.11	63	0.61	-0.61	97	0.11	-0.11
30	0.28	-0.28	64	1.28	-1.28	98	0.95	-0.95
31	0.28	-0.28	65	0.95	-0.95	99	0.28	-0.28
32	-0.22	0.22	66	-0.72	0.72	100	-1.22	1.22
33	0.28	-0.28	67	-0.56	0.56			
34	-1.06	1.06	68	-0.22	0.22			
S.E.(SCA effect)		0.68			S.E.(sij - skl) tester		0.97	

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

S.E. (sij - skl) tester = standard error of difference in tester

TABLE 22. Estimates of specific combining ability effects for 200 f1 crosses between (T1 : SC162 and T2 : TWC352) anthesis-silking interval under water stress condition

S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352	S1-line no	S1 lines x T1:SC162	S1 lines x T2:TWC352
1	-0.83	0.83	35	0.67	-0.67	69	0.34	-0.34
2	0.00	0.00	36	0.50	-0.50	70	0.17	-0.17
3	-0.50	0.50	37	0.50	-0.50	71	0.17	-0.17
4	0.17	-0.17	38	0.84	-0.84	72	0.00	0.00
5	-0.33	0.33	39	0.67	-0.67	73	0.50	-0.50
6	-0.33	0.33	40	0.00	0.00	74	1.34*	-1.34*
7	-1.33*	1.33*	41	0.00	0.00	75	0.50	-0.50
8	0.00	0.00	42	-0.17	0.17	76	-0.50	0.50
9	-0.33	0.33	43	0.50	-0.50	77	0.50	-0.50
10	-1.17	1.17	44	0.34	-0.34	78	0.50	-0.50
11	-0.17	0.17	45	0.00	0.00	79	-0.83	0.83
12	-0.83	0.83	46	0.17	-0.17	80	-0.33	0.33
13	0.34	-0.34	47	0.00	0.00	81	0.34	-0.34
14	-0.17	0.17	48	0.17	-0.17	82	0.67	-0.67
15	-1.00	1.00	49	0.00	0.00	83	0.34	-0.34
16	-0.83	0.83	50	1.00	-1.00	84	0.67	-0.67
17	-1.33*	1.33*	51	-0.50	0.50	85	0.00	0.00
18	-0.17	0.17	52	1.17	-1.17	86	-0.17	0.17
19	0.00	0.00	53	0.00	0.00	87	1.34*	-1.34*
20	-0.33	0.33	54	1.67*	-1.67*	88	-0.50	0.50
21	-0.67	0.67	55	0.00	0.00	89	-0.83	0.83
22	-0.33	0.33	56	1.34*	-1.34*	90	-0.50	0.50
23	-0.33	0.33	57	0.67	-0.67	91	0.00	0.00
24	-1.17	1.17	58	0.17	-0.17	92	0.17	-0.17
25	-0.33	0.33	59	0.84	-0.84	93	-0.17	0.17
26	-0.83	0.83	60	-0.17	0.17	94	0.17	-0.17
27	-0.67	0.67	61	-0.17	0.17	95	-0.50	0.50
28	-1.00	1.00	62	-0.50	0.50	96	0.17	-0.17
29	-0.50	0.50	63	0.00	0.00	97	-0.17	0.17
30	0.17	-0.17	64	0.67	-0.67	98	-0.17	0.17
31	-0.50	0.50	65	0.17	-0.17	99	-0.17	0.17
32	0.67	-0.67	66	-0.33	0.33	100	-0.67	0.67
33	0.67	-0.67	67	1.34*	-1.34*			
34	-0.17	0.17	68	0.17	-0.17			
S.E.(SCA effect)		0.66			S.E.(sij - skl) tester		0.93	

*, ** significant at levels of probability of 0.05 and 0.01, respectively.

S.E. (sij - skl) tester = standard error of difference in tester.

TABLE 23. Variances of both GCA and SCA along with broad-sense heritability and combining ability ration (CAR) for studied traits under normal and water stress conditions

	Normal condition			Water stress condition		
	DA	**DS**	**ASI**	**DA**	**DS**	**ASI**
h_b	0.5293	0.0807	0.1214	0.5968	0.1392	0.4275
σ^2_{gca}	0.0020	0.0042	-0.0004	0.0033	0.0067	-0.0007
σ^2_{sca}	1.0413	0.1134	0.0652	1.3099	0.2250	0.3220
CAR	0.0038	0.0689	-0.0124	0.0050	0.0562	-0.0004

$h_{b=}$ heritability in broad-sense, σ^2gca= variances of general combining ability, σ^2sca = variances of specific combining ability, CAR = combining ability ration, DA = days to 50%anthesis, DS = days to 50% silking, ASI = anthesis-silking interval.

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استجابة صفات التزهير للإجهاد المائي في الذرة الشامية الصفراء باستخدام تحليل السلالة × الكشاف

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تعتبر الذره الشاميه ثالث أهم محاصيل الحبوب في مصر، وحيث حساسة للإجهاد المائي، الامر الذي ينتج عنه خسائر كبيرة في كل من الإنتاجية والجودة. تم تقييم مجموعة مكونة من 100 سلالة من الجيل الذاتى الاول جنبًا إلى جنب مع هجنها القمية باستخدام كشافين تحت الظروف العادية وظروف الإجهاد المائي. استخدمنا تحليل السلالة × الكشاف لتقييم القدرة العامة والخاصة على الائتلاف لعدد الأيام اللازمة لنثر حبوب اللقاح لـ 50% من النباتات، وعدد الأيام اللازمة لخروج الحريرة لـ 50% من النباتات، الفترة بين نثرحبوب اللقاح وخروج الحريرة. أظهرت نتائج تحليل السلالة × الكشاف فروق معنوية عالية بين الاباء والاباء ضد الهجن تحت ظروف الري العادي والجفاف. أظهرت كل من السلالات والكشافات اختلافات معنوية وغير معنوية. أخيرًا، أظهر تحليل تحليل السلالة × الكشاف فروقًا معنوية لعدد الأيام اللازمة لنثر حبوب اللقاح لـ 50% من النباتات واختلافات غير معنوية لعدد الأيام اللازمة لخروج الحريرة لـ 50% من النباتات تحت الظروف العادية وظروف الإجهاد المائي، بينما أظهرت الفترة بين نثرحبوب اللقاح وخروج الحريرة وجود اختلافات غير معنوية تحت الظروف العادية واختلافات معنوية تحت ظروف الإجهاد المائي. وكانت قيم درجة التوريث العامة للصفات المذكورة أعلاه أعلى تحت الإجهاد المائي مقارنة بها تحت الظروف العادية. القيم العالية لدرجة التوريث العامة تجعل عملية الانتخاب أسهل لمربي النبات وأكثر دقة حيث يعكس الشكل الظاهري تراكيبه الجينية. تشير النتائج التي توصلنا إليها إلى أن الجينات السائدة تنظم في الغالب الصفات المذكورة أعلاه. في الختام، يمكن اعتبار سلالات الجيل الذاتي الاول سلالات واعدة ويمكن استخدامها لتطوير هجن مبكرة النضج ومتحملة للجفاف، الامر الذي يساعد في تجنب الإجهاد المائي خلال موسم النمو.