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Evaluation of Combining Ability in Maize Hybrids Using Line X Tester Model Under Well-Watered and Water-Deficit Conditions

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Abstract

Thirty top crosses of maize (ten inbred lines x three testers) were tested under full irrigation and water deficit circumstances. To evaluate the combining ability of several traits in maize, these crosses were set in an RCBD design with three replications along with two checks (SC 2031 and SC 128) in both environments. Desirable mean values for 50% silking were detected for the crosses L25xM8 under normal irrigation and L21xM8 under water deficit. The most desirable mean values for grain yield plant^{-1} were obtained for the cross L29xM8 followed by L23xM4 under normal irrigation and L26xM4 under water stresss. For all examined traits, non-additive was more important than additive in all environments. The tester T1 (M4) was the best for days to 50% silking, chlorophyll content, and grain yield, while the line L2 exhibited the best GCA effects for 100 kernel weight and grain yield. The highest significant and negative SCA effects for days to 50% were detected for the crosses L25xM8 under normal irrigation and combined data. For grain yield, the cross L28x M4 gave the best SCA effects under E1 and L29x M8 under E2 and combined analysis. The most desirable heterosis for grain yield relative to both checks was obtained for the cross L23xM4 in the combined analysis. Also, the cross L26xM4 expressed desirable heterosis for most traits under both environments. The cross L29xM8 recorded the best heterosis values for days to 50% silking, 100-kernel weight, and grain yield under normal irrigation.

Key words: Maize, Combining ability, heterosis, water deficit.

Introduction

Plant breeders all over the world use the line x tester analysis approach to obtain accurate data on combining ability effects of various parents and their hybrids. Numerous researchers have utilized this approach extensively with maize, and it is still being employed in quantitative genetic studies with maize (**Sharma *et al*., 2004**). To offer information on the grouping of materials into various heterotic patterns and to assess the type of gene action involved in the expression of yield and traits related to yield, we can use this method. General combining ability (GCA) and specific combining ability (SCA), two expressions created using the concept of combining ability, are highly useful genetic factors for breeding programs. The genetic mechanisms governing quantitative features are revealed through the study of combining ability, which also enables us to choose ideal parents for continued development or use in hybrid combinations for commercial purposes. While SCA measures non-additive gene action, GCA provides a decent indication of additive gene activation. Numerous researchers noted the significance of nonadditive gene action is responsible for grain production and other characteristics. Among them are **Sedhom *et al*. (2012), Youstina *et al*. (2016), Emam and Mohamed (2021), Adewale *et al* (2023) and El Naggar *et al*. (2023).** However, the importance of additive gene action was reported by other researchers (**Sedhom *et al*., 2021; and Yadesa *et al*., 2022**).

The most significant abiotic restriction that destabilizes maize grain production is drought stress (**Bänziger *et al*., 2000**). According to **Romo *et al*. (2001),** drought causes physiological and biochemical changes in maize, including a decrease in photosynthesis and alterations in gene expression. All stages of plant growth are impacted by drought, but the effects are most severe during flowering and subsequent grain filling (**Bolanos and Edmeades, 1996**). If the dryness persists throughout grain filling, impacted ears have fewer kernels and continue to be poorly filled. These factors make the development of drought-tolerant cultivars seem to be the most effective way to handle drought stress.

Therefore, this work was done to estimate both types of combining ability and heterosis for grain yield and other important traits under well-watered and water deficit.

Materials and Methods

The plant materials for this investigation included ten new inbred lines and three testers. The parental inbred lines L21, L22, and L23 were developed from Giza 2 (synthetic variety), while parents L24, L28, L29, and L30 were isolated from Pioneer (Fatah). Cairo 1 (synthetic variety) was the origin of the three lines L25, L26, and L27. The three studied testers were T1 (developed from Giza 2), T2 (isolated from Pioneer, Taba), and T3, CIMMYT14 (introduced from CIMMYT). The parents and the testers were planted together in 2022 late summer season in a line x tester model on different planting dates to overcome differences in flowering time. At the end of the initial growing season, thirty top crosses were obtained. During the 2023 season, thirty top crosses as well as two checks (S.C. 2031 and S.C. 128) were evaluated in two different experiments. The first experiment was allocated to normal irrigation every 12 days (E1), while the second experiment was subjected to water stress conditions where irrigation was done every 21 days (E2). In both experiments, RCBD design was used with three replications. Each plot consists of a single, 6-meter-long ridge, with ridges 70 cm apart and plants spaced 25 cm apart. The maize crop area received the required nitrogen fertilization, pest control, and other cultural practices. Days to 50% silking, chlorophyll content, No. of row ear^{-1}, No. of grains row^{-1}, 100 kernel weight and grain yield plant^{-1} were evaluated.

Statistical analysis was done for each separate experiment and combined analysis was performed whenever homogeneity was detected according to **Steel *et al*., (1997).** Both types of combining ability were calculated following the approach of **Kempthorne (1957).**

Standard heterosis relative to S.C. 2031 and S.C. 128 was estimated for all traits under normal irrigation and water deficit as follows:

The relative increase(heterosis) = $\frac{\text{F1 - Check variety}}{\text{Check variety}} \text{X} 100$

The values of L.S.D values were computed according to the following formulae:

L.S.D. for heterosis relative to check variety = t x $\sqrt{\frac{2MSe}{r}}$

Where:

t refers to and the tabulated t value at a stated level of probability, and

r refers to number of replications.

Results & Discussion

Analysis of variance and mean performance

Table 1 shows information from the statistical analysis of the six studied traits under normal watering and water deficit as well as combined data. The characters in the study reacted somewhat differently in well-watering and water-deficit situations, as indicated by the significance of the mean squares due to environments for all attributes. The mean values of days to 50% silking under drought stress were higher than those of regular irrigation, even though the mean values of all evaluated features under normal irrigation surpassed those of stress environment (Table 2). Such outcomes were expected because dryness throughout the growing season harms maize plant growth. Similar results are reported by **Vinodhana and Gansan (2017), Hayati and Sutoyo (2019) and El Naggar, *et al*. (2023)**. Apart from the number of grains row^{-1} under combined analysis, significant mean squares arising from crossings, lines, testers, and line x tester were detected for all features in all contexts (Table 1). This result means that the tested genotypes possessed great variability regarding the studied traits. Significant mean squares arising from the interaction of crosses, testers, and line x testers with the environment were also obtained for days to 50% silking. For, chlorophyll content, the interaction between crosses, lines and testers with environment was significant. Whereas, significant mean squares due to the interaction between crosses and testers were obtained for No. of rows ear^{-1}, and No. of grains row^{-1}. For 100 kernel weight and grain yield plant^{-1}, mean squares resulting from the interaction of crosses, lines, and line x tester with the environment were found. Such results revealed that the behavior of the studied maize genotypes varied from normal irrigation to drought stress conditions. Several investigators reported a great deal of variability among maize entries. Among those are **Sedhom *et al*. (2021), Belay (2022) and Yadesa *et al*. (2022).**

Data on the performance of all studied traits under normal watering and drought stress are presented in Table 2. Under well watered, drought stress, and combined data, respectively, 11, 1, and 8 top crosses were significantly better than the check hybrids for days to 50% silking. The most effective crosses at the time were L25xM8 (with normal irrigation), L21xM8 (under drought stress), L21xM4, L21xM8, and L21xCIMMYT14 (under combined data). Regarding chlorophyll content, eight, five and nine crosses had a significant increase over the best check for the respective cases. However, the best crosses were L29xM8, L23xM4 and L27xM4 under normal irrigation, water deficit and combined data, respectively. For No. of rows ear^{-1}, six, four and six crosses exhibited desirable mean values as compared to the best check under E1, E2, and combined data, respectively. However, the best crosses for No. of rows ear^{-1} were L29xM8 (under normal irrigation), and L29xCIMMYT14 (under drought stress and combined data). Concerning No. of grains row^{-1}, three crosses under normal irrigation (L23xM4, L26xM4 and L29xM8), one cross under drought stress (L26xM4), and two crosses under combined data (L23xM4 and L26xM4) expressed significant desirable mean values as compared to the check hybrids. However, the best mean values for this trait were detected for the cross L26xM4 under all environments. For 100 kernel weight, five, five, and three crosses expressed significant desirable mean values under normal irrigation, drought stress and combined data, respectively. However, the most desirable mean values were obtained for the crosses L28xM4 (under normal condition), L26xM4 (under stress condition and combined data). Regarding grain yield plant^{-1}, four, three and four top crosses exhibited significant and desirable mean values as compared to the checks under normal irrigation, drought stress and combined analysis, respectively. However, the best mean values for this trait were obtained for the cross L29xM8 (266.40 g) followed by L23xM4 (264.07 g) then L28xM4 (263.67 g) under normal irrigation. Under drought stress the best mean values for grain yield plant^{-1} were detected for the cross L26xM4 (261.33 g) followed by L23xM4 (260.00 g). Under combined analysis, the cross L23xM4 (262.03 g) gave the best mean value for this trait followed by the cross L26xM4 (261.77 g) (Table 2).

It is worth noting that the crosses L23xM4, L26xM4, L28xM4, and L29xM8 are prospective in maize breeding programs since they expressed the most desirable mean value for grain yield of maize.

Combining ability

Results in Table 1 show the mean squares of both combining abilities for all traits under Both environments and their combined analysis. It is clear that for all attributes, mean squares resulting from SCA were more significant than those resulting from GCA, demonstrating the predominance of non-additive gene action in regulating these traits. Moreover, the interaction effects between SCA with environment were much higher than those of GCA with the environment meaning that GCA was more changeable than SCA as a result of environmental fluctuations. The significant role of non-additive gene action in controlling such traits were previously reported by several investigators (**Emam and Mohamed, 2021; Neveen *et al*., 2021; Sedhom *et al*., 2021; Adewaker *et al*., 2023; and El Naggar *et al*., 2023**).

Table 3 and Figures (1-6) provide the effects of GCA for all examined attributes under normal irrigation, drought stress, as well as combined analyses. The tester T1(M4) seemed to be the best general combiner for days to 50%, chlorophyll content and grain yield plant-1 under normal irrigation, drought stress and combined data as well as 100 kernel weight under stress conditions. This tester (M4) exhibited the highest significant and desirable GCA effects for the previous traits under all environmental conditions (Table 3 and Figures (1-6). The tester T2(M8) expressed the highest and significant GCA effects for 100 kernel weight under normal irrigation. Whereas, the tester T3 (CIMMYT14) seemed to be the best combiner for No. of rows ear^{-1} under normal watering, water deficit and combined data as well as No. of grains row^{-1} under normal treatment. The line L21 expressed the highest negatively significant GCA effects for days to 50% silking recording -4.14, -2.90 and -3.52 under E1, E2 and combined data, respectively (Table 3 and Fig 1). Line L23 seemed to be the best general combiner for chlorophyll content in the combined analysis (3.64) and No. of grains row^{-1} under stress condition (3.61) and combined data (2.73) (Table 3, Fig 2&3). Line L25 exhibited the highest significant and positive GCA effects for chlorophyll content in recording 3.55 in the combined analysis. The parent L26 seemed to be the best general combiner for 100 kernel weight and grain yield plant^{-1} recording 1.68, 2.93, and 23.1; and 16.08, 254.8, and 20.44 under normal irrigation, drought stress, and combined data, respectively (Table 3 and Figs 5&6). Parent L28 expressed the most desirable GCA for No. of rows ear^{-1} under stress conditions and combined analysis. Under normal watering, Line L29 appeared to be the best combiner for No. of rows ear^{-1} and No. of grains row^{-1}, recording 1.07 and 2.08, respectively. Also, Line L30 exhibited the best GCA effects for chlorophyll content recording 1.05 under stress conditions (Table 3 and Fig 2).

Data in Table 4 show the effects of SCA for all traits under E1, E2, and combined data. The most desirable SCA effects for days to 50% silking were detected for the crosses L25xM8 under normal irrigation (-4.67**), and combined data (-2.09**) and the cross L21xM8 (-2.63**) under E2 environment. When it came to chlorophyll content, the top cross L27xM4 showed the highest significant and favorable SCA impacts, with values of 4.98**, 5.87**, and 5.42**, respectively, under well-watered, drought stress, and combined data. For No. of rows ear^{-1}, the most desirable SCA effects were detected for the crosses L29xM5 (1.54**) under normal irrigation and L27xCIMMYT14 (1.42** and 1.08** under stress conditions and combined data, respectively). Concerning the No. of grains row^{-1}, the top crosses L28xM4 produced the highest significant SCA effects under normal irrigation and combined data, recording 4.35** and 3.10**, respectively. None of the studied crosses expressed desirable SCA for No. of grains row^{-1} under drought stress conditions. For 100 kernel weight, the crosses L27xM8 (2.67**) under well-watered conditions and L21xM8 (2.82**) under water shortage and combined data (2.13**) showed the most favorable

SCA effects. For grain yield plant^{-1}, the cross L28xM4 expressed the highest significant SCA effects under normal irrigation (27.34**) followed by the cross L29xM8 (27.16**). The cross L29xM8 exhibited the most desirable SCA for grain yield plant^{-1} under drought stress and combined data recording 37.47** and 32.31** respectively. The cross L26xM4 ranked the second best or this trait under water deficit, while the cross L28xM4 occupied the second rank followed by the cross L23xM4 under combined analysis.

These findings led to the conclusion that the crossings L23xM4, L26xM4, L28xM4, and L29xM8 expressed the most desirable SCA effects for grain yield plant^{-1} and the majority of its contributing traits, making them promising and suitable for use in future maize breeding programmes.

Table 1. Analysis of variance for days to 50% silking, chlorophyll content, No. of rows ear^{-1}, No. of kernels row^{-1}, 100 kernel weight and grain yield plant^{-1} under normal irrigation and drought stress as well as combined data.

S.O.V	df		Days to 50% silking			Chlorophyll content			No. of rows ear^{-1}			No. of grains row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
	S	C	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Environment (E)		1			156.80**			544.62**			22.60**			737.38**			355.61**			22151.17**
Rep	2		2.54	6.14		14.04	17.87		0.35	0.66		1.82	7.11		7.54	4.13		75.84	55.03	
Rep/E		4			4.34			15.96			0.51			4.47			5.84			65.44
Crosses	29	29	27.53**	14.01**	36.11**	63.97**	64.46**	107.51**	3.06**	4.22**	6.35**	27.50**	19.92**	35.15**	19.23**	20.33**	29.75**	1450.21**	2238.54**	3251.50**
Lines	9	9	34.45**	17.25**	47.27**	110.32**	86.35**	164.96**	5.23**	5.58**	9.90**	25.76**	32.42**	51.39**	27.07**	43.12**	57.24**	1289.64**	2697.50**	3447.95**
Testers	2	2	127.14**	74.54**	189.07**	138.52**	187.84**	251.01**	9.19**	23.96**	30.72**	26.9*	23.81*	0.06	32.48**	13.43**	38.29**	1243.98*	1111.60*	2340.43**
Lines x testers	18	18	13.01**	5.67*	13.54**	32.51**	39.81**	62.85**	1.30**	1.35*	1.87**	28.45**	13.24*	30.94**	13.84**	9.70**	15.05**	1553.41**	2134.28**	3254.50**
Crosses x E		29			5.43**			20.92*			0.93*			12.27*			9.81**			437.25*
Line x E		9			4.42			31.70*			0.91			6.79			12.95**			539.19*
Testers x E		2			12.62**			75.36**			2.43*			50.65**			7.62			15.15
Line x Testers x E		18			5.14*			9.48			0.78			10.75			8.49**			433.18*
Error	58	116	2.45	2.55	2.50	13.01	13.32	13.17	0.53	0.65	0.59	6.40	7.15	6.77	4.75	2.62	3.68	275.42	225.32	250.37
CV%			2.88	2.79	2.84	8.31	9.21	8.74	5.38	6.37	5.87	6.88	8.15	7.49	6.15	5.24	5.75	8.56	7.65	8.17
variance GCA			0.27	0.16	0.21	0.59	0.46	0.42	0.03	0.05	0.04	-0.02	0.12	0.04	0.10	0.20	0.14	-1.93	1.95	0.03
variance SCA			3.52	1.04	1.84	6.50	8.83	8.28	0.25	0.24	0.21	7.35	2.03	4.03	3.03	2.36	1.90	426.00	636.32	500.69
GCA/ SCA			0.08	0.15	0.11	0.09	0.05	0.05	0.12	0.21	0.19	0.00	0.06	0.01	0.03	0.08	0.07	0.00	0.00	0.00
GCA x E					0.17			2.26			0.05			0.92			0.09			8.00
SCA x E					2.72			7.05			0.28			5.35			3.49			561.63

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

Table 2. Mean performance of crosses and check varieties for days to 50% silking, chlorophyll content, No. of rows ear^{-1}, No. of kernel row^{-1}, 100 kernel weight, and grain yield plant^{-1} under normal irrigation and drought stress as well as combined data.

Genotype	Days to 50% silking (day)			Chlorophyll content (SPDA)			No. of rows ear^{-1}			No. of grains row^{-1}			100 kernel weight (g)			Grain yield plant^{-1} (g)		
	Nor	Stres	Com	Nor	Stres	Com	Nor	Stres	Com	Nor	Stres	Com	Nor	Stres	Com	Nor	Stres	Com
L21 x M4	53.67	58.33	56.00	41.10	40.00	40.55	13.67	11.00	12.33	34.33	30.00	32.17	32.00	31.67	31.83	190.6	154.3	172.5
L21 x M8	55.33	56.67	56.00	43.00	41.00	42.00	12.67	12.00	12.33	35.67	34.67	35.17	36.67	36.33	36.50	223.3	212.6	218.0
L21 x CIMMYT14	54.33	57.67	56.00	42.90	42.80	42.85	14.37	14.27	14.32	42.60	33.87	38.23	34.33	32.33	33.33	230.3	213.0	221.6
L22 x M4	57.00	59.00	58.00	54.70	49.97	52.33	14.93	12.93	13.93	36.13	31.39	33.76	36.67	33.00	34.83	209.4	159.0	184.2
L22 x M8	61.33	63.33	62.33	47.47	41.57	44.52	14.53	11.93	13.23	39.67	34.60	37.13	37.00	30.67	33.83	241.0	168.6	204.8
L22 x CIMMYT14	59.33	60.67	60.00	51.03	48.27	49.65	15.27	15.00	15.13	39.07	31.73	35.40	32.33	30.33	31.33	205.4	193.6	199.5
L23 x M4	57.00	59.00	58.00	55.07	53.37	54.22	15.30	13.47	14.38	44.33	41.60	42.97	41.00	39.67	40.33	264.0	260.0	262.0
L23 x M8	62.33	63.67	63.00	48.67	45.00	46.83	13.40	12.67	13.03	37.67	37.33	37.50	35.33	35.00	35.17	200.0	191.6	195.8
L23 x CIMMYT14	61.33	62.00	61.67	51.50	50.93	51.22	14.50	14.47	14.48	41.47	37.53	39.50	38.00	37.33	37.67	236.3	235.3	235.8
L24 x M4	55.00	60.67	57.83	44.03	40.67	42.35	13.07	12.40	12.73	41.60	37.00	39.30	37.67	32.67	35.17	239.9	215.6	227.8
L24 x M8	63.00	64.33	63.67	43.93	37.40	40.67	12.45	11.67	12.06	38.80	34.93	36.87	38.67	32.33	35.50	197.2	178.0	187.6
L24 x CIMMYT14	62.00	62.33	62.17	43.73	43.33	43.53	13.60	13.27	13.43	41.53	38.07	39.80	38.67	33.00	35.83	236.4	214.0	225.2
L25 x M4	56.33	58.67	57.50	51.03	41.67	46.35	14.00	13.87	13.93	33.47	33.33	33.40	38.33	37.67	38.00	233.0	208.6	220.8
L25 x M8	53.33	62.33	57.83	53.63	38.33	45.98	13.60	12.80	13.20	39.27	33.00	36.13	41.00	39.33	40.17	223.9	206.6	215.3
L25 x CIMMYT14	59.00	59.33	59.17	52.53	49.17	50.85	14.53	14.50	14.52	35.80	33.20	34.50	36.67	35.00	35.83	212.0	203.6	207.8
L26 x M4	54.33	58.33	56.33	53.67	53.33	53.50	14.33	14.00	14.17	43.67	42.67	43.17	41.00	40.00	40.50	262.2	261.3	261.7
L26 x M8	58.00	58.67	58.33	51.33	43.33	47.33	13.37	13.17	13.27	35.00	34.00	34.50	38.00	36.67	37.33	224.7	210.0	217.3
L26 x CIMMYT14	59.67	60.00	59.83	43.57	43.33	43.45	14.87	14.70	14.78	39.20	33.40	36.30	38.67	36.33	37.50	242.4	217.6	230.0
L27 x M4	56.00	57.67	56.83	53.97	53.00	53.48	14.40	13.73	14.07	35.27	34.47	34.87	35.33	34.67	35.00	212.8	198.3	205.6
L27 x M8	62.33	63.33	62.83	45.03	42.70	43.87	12.93	12.40	12.67	38.00	37.00	37.50	39.33	33.00	36.17	213.3	212.3	212.8
L27 x CIMMYT14	59.33	59.67	59.50	40.87	39.00	39.93	14.18	14.13	14.16	37.27	29.93	33.60	32.67	32.00	32.33	192.4	152.3	172.3
L28 x M4	55.67	58.00	56.83	54.30	49.63	51.97	16.27	16.20	16.23	41.27	35.13	38.20	41.33	33.33	37.33	263.6	239.0	251.3
L28 x M8	62.33	63.33	62.83	44.37	43.60	43.98	14.43	13.67	14.05	31.77	31.33	31.55	38.67	37.67	38.17	194.3	192.3	193.3
L28 x CIMMYT14	59.33	59.67	59.50	46.80	45.77	46.28	15.33	14.57	14.95	40.00	31.27	35.63	36.67	35.67	36.17	228.7	194.0	211.3
L29 x M4	59.33	61.00	60.17	52.90	43.07	47.98	14.00	13.90	13.95	38.13	37.47	37.80	37.33	36.00	36.67	243.7	203.3	223.5
L29 x M8	62.67	63.00	62.83	55.33	45.73	50.53	16.33	13.87	15.10	44.67	37.00	40.83	42.00	32.00	37.00	266.4	249.3	257.8
L29 x CIMMYT14	58.67	59.00	58.83	47.20	46.93	47.07	15.90	15.33	15.62	39.60	32.00	35.80	37.33	34.00	35.67	217.4	189.3	203.4
L30 x M4	59.00	60.67	59.83	51.40	51.33	51.37	15.20	14.53	14.87	36.93	36.00	36.47	37.33	35.00	36.17	225.0	217.6	221.3
L30 x M8	63.00	63.33	63.17	50.40	48.00	49.20	13.47	13.33	13.40	42.93	34.87	38.90	37.67	35.00	36.33	253.2	205.6	229.4
L30 x CIMMYT14	57.67	60.00	58.83	50.07	48.93	49.50	15.27	15.13	15.20	40.20	34.60	37.40	38.67	34.33	36.50	227.6	188.3	207.9
SC 2031	62.00	62.67	62.33	46.50	46.40	46.45	14.00	13.93	13.97	39.67	39.00	39.33	37.00	36.00	36.50	233.0	232.3	232.6
SC 128	59.33	59.67	59.50	46.00	45.90	45.95	14.20	14.00	14.10	39.73	37.53	38.63	36.33	35.67	36.00	230.6	230.0	230.3
Mean	58.72	60.50	59.61	48.69	45.42	47.05	14.32	13.65	13.99	38.90	35.00	36.95	37.49	34.80	36.15	227.3	206.5	216.9
LSD 5%	2.32	2.31	1.63	5.56	3.77	3.83	1.07	0.84	0.79	3.58	2.69	2.60	3.15	1.76	2.00	24.26	15.29	16.16
LSD 1%	3.08	3.08	2.18	7.41	5.02	5.05	1.43	1.11	1.05	4.77	3.58	3.42	4.20	2.35	2.64	32.30	20.36	21.31

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

Table 3. General combining ability effects for days to 50% silking, chlorophyll content, No. of rows ear^{-1}, No. of kernels row^{-1}, 100 kernel weight and grain yield plant^{-1} under normal irrigation and drought stress as well as combined data.

Genotype	Days to 50% silking			Chlorophyll content			No. of rows ear^{-1}			No. of grains row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Testers																		
T1 (M4)	-2.26**	-1.32**	-1.79**	2.37**	2.23**	2.30**	0.18	-0.03	0.08	-0.76	0.70	-0.03	0.26	0.63*	0.44	7.42*	6.87*	7.14**
T2 (M8)	1.78**	1.74**	1.76**	-0.53	-2.71**	-1.62**	-0.62**	-0.88**	-0.75**	-0.30	0.31	0.00	0.89*	0.07	0.48	-3.29	-2.13	-2.71
T3 CIMMYT14	0.48	-0.42	0.03	-1.83**	0.47	-0.68	0.44**	0.91**	0.67**	1.06*	-1.00*	0.03	-1.14**	-0.70*	-0.92**	-4.13	-4.73	-4.43
L.S.D. (gi) 5%	0.57	0.58	0.39	1.32	1.33	0.92	0.27	0.29	0.19	0.92	0.98	0.63	0.80	0.59	0.52	5.88	5.49	4.53
L.S.D. (gi) 1%	0.76	0.78	0.52	1.75	1.77	1.22	0.35	0.39	0.25	1.23	1.30	0.84	1.06	0.79	0.70	7.82	7.30	6.03
L.S.D. (gi-gj) 5%	0.81	0.82	0.56	1.86	1.89	1.30	0.38	0.42	0.27	1.31	1.38	0.89	1.13	0.84	0.74	8.31	7.76	6.41
L.S.D. (gi-gj) 1%	1.08	1.10	0.74	2.48	2.51	1.73	0.50	0.55	0.35	1.74	1.84	1.18	1.50	1.11	0.99	11.06	10.32	8.53
Lines																		
L21	-4.14**	-2.90**	-3.52**	-6.52**	-4.11**	-5.31**	-0.77**	-1.21**	-0.99**	-1.08	-1.72	-1.40*	-3.21**	-1.29*	-2.25**	-12.28*	-11.53*	-11.90**
L22	0.63	0.54	0.59	2.22	1.23	1.72*	0.57*	-0.34	0.12	-0.32	-1.99*	-1.16*	-2.21**	-3.40**	-2.81**	-8.39	-31.09**	-19.74**
L23	1.63**	1.10*	1.37**	2.89*	4.39**	3.64**	0.06	-0.10	-0.02	1.85*	3.61**	2.73**	0.57	2.60**	1.58**	6.41	24.13**	15.27**
L24	1.41**	1.99**	1.70**	-4.95**	-4.91**	-4.93**	-1.30**	-1.19**	-1.24**	2.03*	2.10*	2.07**	0.79	-2.07**	-0.64	-2.52	-2.31	-2.42
L25	-2.37**	-0.34	-1.36**	3.55**	-2.32	0.62	-0.29	0.09	-0.10	-2.43**	-1.39	-1.91**	1.12	2.60**	1.86**	-4.05	1.47	-1.29
L26	-1.26*	-1.46**	-1.36**	0.67	1.29	0.98	-0.15	0.33	0.09	-0.83	0.61	-0.11	1.68*	2.93**	2.31**	16.08**	24.80**	20.44**
L27	0.63	-0.23	0.20	-2.23	-0.47	-1.35	-0.50*	-0.21	-0.35*	-1.77*	-0.76	-1.27*	-1.77*	-1.51**	-1.64**	-20.85**	-17.20**	-19.03**
L28	0.52	-0.12	0.20	-0.36	0.96	0.30	1.01**	1.18**	1.09**	-0.93	-1.99*	-1.46*	1.34	0.82	1.08*	1.86	3.58	2.72
L29	1.63**	0.54	1.09**	2.96*	-0.13	1.42	1.07**	0.74**	0.90**	2.08*	0.92	1.50*	1.34	-0.73	0.31	15.48**	9.13	12.31**
L30	1.30*	0.88	1.09**	1.77	4.05**	2.91**	0.31	0.70*	0.50**	1.41	0.59	1.00	0.34	0.04	0.19	8.26	-0.98	3.64
L.S.D. (gi) 5%	1.04	1.06	0.72	2.41	2.44	1.68	0.49	0.54	0.34	1.69	1.78	1.15	1.45	1.08	0.96	10.73	10.02	8.28
L.S.D. (gi) 1%	1.39	1.42	0.96	3.20	3.24	2.23	0.65	0.71	0.46	2.25	2.37	1.53	1.94	1.44	1.27	14.28	13.33	11.01
L.S.D. (gi-gj) 5%	1.48	1.51	1.02	3.40	3.44	2.37	0.69	0.76	0.49	2.39	2.52	1.63	2.06	1.53	1.35	15.18	14.16	11.70
L.S.D. (gi-gj) 1%	1.97	2.00	1.35	4.53	4.58	3.15	0.92	1.01	0.65	3.18	3.36	2.16	2.74	2.03	1.80	20.20	18.85	15.57

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

Table 4. Specific combining ability effects for days to 50% silking, chlorophyll content, No. of rows ear^{-1}, No. of kernels row^{-1}, 100 kernel weight and grain yield plant^{-1} under normal irrigation and drought stress as well as combined data.

Genotype	Days to 50% silking			Chlorophyll content			No. of rows ear^{-1}			No. of grains row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
	Nor mal	Stres s	Com b	Nor mal	Stress	Com b	Norm al	Stress	Comb	Norm al	Stre ss	Comb	Nor mal	Stres s	Com b	Norm al	Stres s	Com b
L21 x M4	1.48	2.10*	1.79*	-3.60	-3.50	-	-0.08	-	-0.74*	-2.44	-	-	-	-	-	-	-	-
L21 x M8	-0.89	-	-	1.20	2.44	1.82	-0.28	0.46	0.09	-1.56	1.51	-0.03	1.44	2.82*	2.13	11.85	21.47	16.66
L21 x	-0.59	0.53	-0.03	2.40	1.06	1.73	0.36	0.94*	0.65*	4.01*	2.03	3.02*	1.14	-0.41	0.37	19.68*	24.40	22.04
L22 x M4	0.03	-0.68	-0.32	1.27	1.14	1.20	-0.16	-0.33	-0.24	-1.40	-	-1.64	1.08	1.03	1.06	-16.62	-	-
L22 x M8	0.33	0.59	0.46	-3.07	-2.33	-2.70	0.24	-0.48	-0.12	1.68	1.72	1.70	0.78	-0.73	0.02	25.69*	-2.98	11.36
L22 x	-0.37	0.09	-0.14	1.80	1.19	1.50	-0.09	0.80	0.36	-0.28	0.16	-0.06	-1.86	-0.30	-1.08	-9.07	24.62	7.77
L23 x M4	-0.97	-1.23	-1.10	0.96	1.37	1.16	0.72	-0.04	0.34	2.56	0.79	1.68	2.63*	1.70	2.17	23.18*	24.13	23.66
L23 x M8	0.33	0.37	0.35	-2.54	-2.06	-2.30	-0.38	0.01	-0.18	-2.50	-	-1.83	-	-	-	-	-	-
L23 x	0.63	0.87	0.75	1.59	0.69	1.14	-0.34	0.03	-0.16	-0.06	0.36	0.15	1.03	0.70	0.87	6.99	11.07	9.03
L24 x M4	-	-0.46	-	-2.23	-2.03	-2.13	-0.15	-0.02	-0.08	1.71	-	0.68	-0.92	-0.63	-0.78	7.98	6.24	7.11
L24 x M8	1.22	0.14	0.68	0.57	-0.36	0.10	0.03	0.10	0.07	-1.54	-	-1.79	-0.56	-0.40	-0.48	-	-	-
L24 x	1.52	0.31	0.92	1.66	2.39	2.03	0.12	-0.08	0.02	-0.17	2.40	1.12	1.48	1.03	1.26	16.06	16.18	16.12
L25 x M4	2.37*	-0.12	1.12	-3.73	-3.62	-	-0.22	0.17	-0.03	-1.95	-	-1.25	-0.59	-0.30	-0.44	2.65	-4.53	-0.94
L25 x M8	-	0.48	-	1.77	-2.02	-0.12	0.18	-0.04	0.07	3.39*	-	1.45	1.44	1.93*	1.69	4.23	2.47	3.35
L25 x	2.30*	-0.36	0.97	1.96	5.64*	3.80*	0.05	-0.13	-0.04	-1.44	1.03	-0.21	-0.86	-1.63	-1.24	-6.87	2.07	-2.40
L26 x M4	-0.74	0.66	-0.04	1.78	4.44*	3.11*	-0.03	0.07	0.02	2.11	2.26	2.19*	1.52	1.70	1.61	11.65	24.80	18.22
L26 x M8	-1.11	-	-	2.35	-0.63	0.86	-0.20	0.09	-0.06	-2.48	-	-1.98	-2.11	-1.07	-1.59	-15.11	-	-
L26 x	1.86*	1.42	1.64*	-4.12	-3.81	-	0.24	-0.16	0.04	0.36	-	-0.21	0.59	-0.63	-0.02	3.46	-7.27	-1.90
L27 x M4	-0.97	-1.23	-1.10	4.98*	5.87*	5.42*	0.38	0.34	0.36	-0.82	-	-0.42	-0.70	0.81	0.06	-0.75	3.80	1.52
L27 x M8	1.33	1.37	1.35*	-1.05	0.51	-0.27	-0.28	-0.14	-0.21	1.46	2.89	2.17*	2.67*	-0.29	1.19	10.43	26.80	18.61
L27 x	-0.37	-0.13	-0.25	-3.92	-	-	-0.10	-0.20	-0.15	-0.64	-	-1.75	-1.97	-0.52	-1.24	-9.67	-	-
L28 x M4	-1.19	-1.01	-1.10	3.45	1.07	2.26	0.74	1.42*	1.08*	4.35*	1.86	3.10*	2.19	-	-0.33	27.34*	23.69	25.51
L28 x M8	1.44	1.26	1.35*	-3.59	-0.03	-1.81	-0.29	-0.26	-0.28	-	-	-	-1.11	2.04*	0.47	-	-	-
L28 x	-0.26	-0.24	-0.25	0.14	-1.04	-0.45	-0.45	-1.15*	-	1.26	-	0.48	-1.08	0.81	-0.13	3.95	-9.71	-2.88
L29 x M4	1.37	1.32	1.34*	-1.28	-4.41*	-2.84	-	-0.44	-	-1.80	1.28	-0.26	-1.81	1.37	-0.22	-6.22	-	-
L29 x M8	0.67	0.26	0.46	4.06	3.19	3.63*	1.54*	0.38	0.96*	3.95*	1.20	2.57*	2.22	-	0.08	27.16*	37.47	32.31
L29 x	-	-1.58	-	-2.78	1.21	-0.78	0.05	0.06	0.05	-2.15	-	-2.32*	-0.41	0.70	0.14	-	-	-
L30 x M4	1.37	0.66	1.01	-1.59	-0.32	-0.95	0.38	0.23	0.30	-2.33	0.15	-1.09	-0.81	-0.41	-0.61	-17.66	6.91	-5.38
L30 x M8	1.33	0.26	0.79	0.31	1.28	0.80	-0.56	-0.12	-0.34	3.21*	-	1.31	-1.11	0.16	-0.48	21.25*	3.91	12.58
L30 x	-	-0.91	-	1.28	-0.96	0.16	0.18	-0.11	0.04	-0.88	0.45	-0.22	1.92	0.26	1.09	-3.58	-	-7.20

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

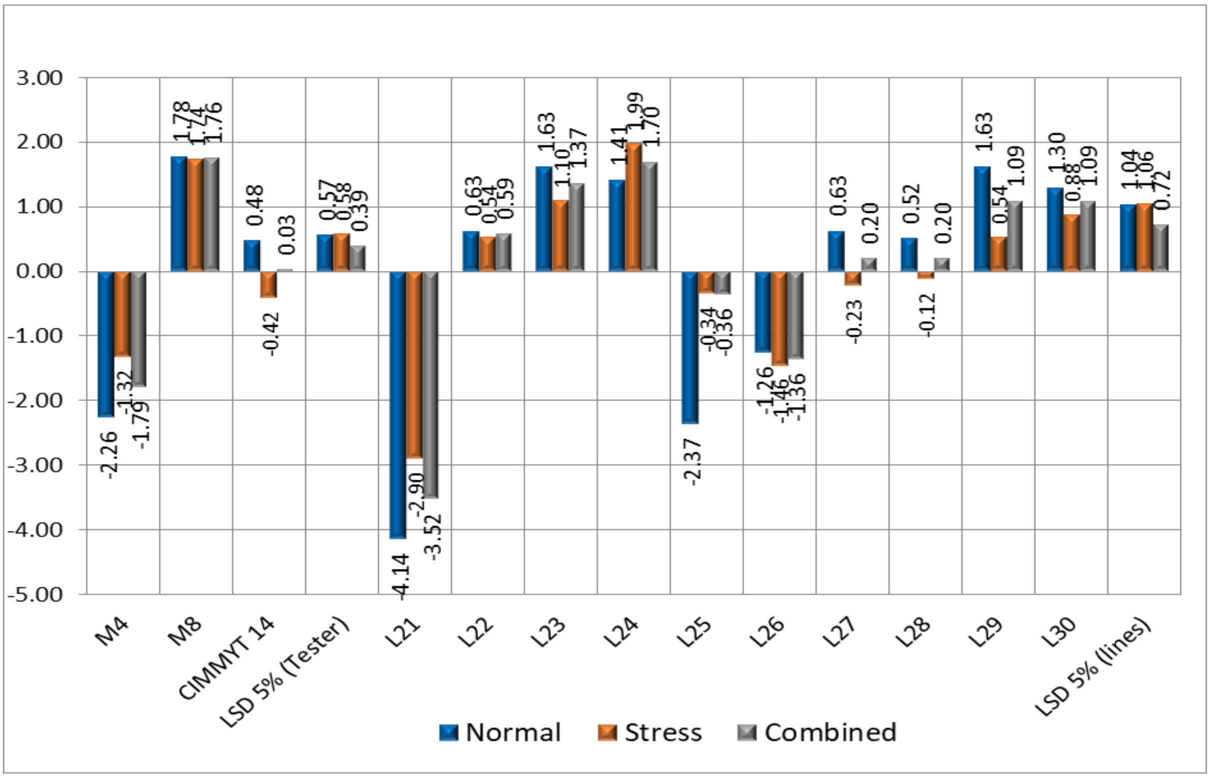


Fig. (1): GCA effects for days to 50% silking under normal irrigation and drought stress as well as combined data.

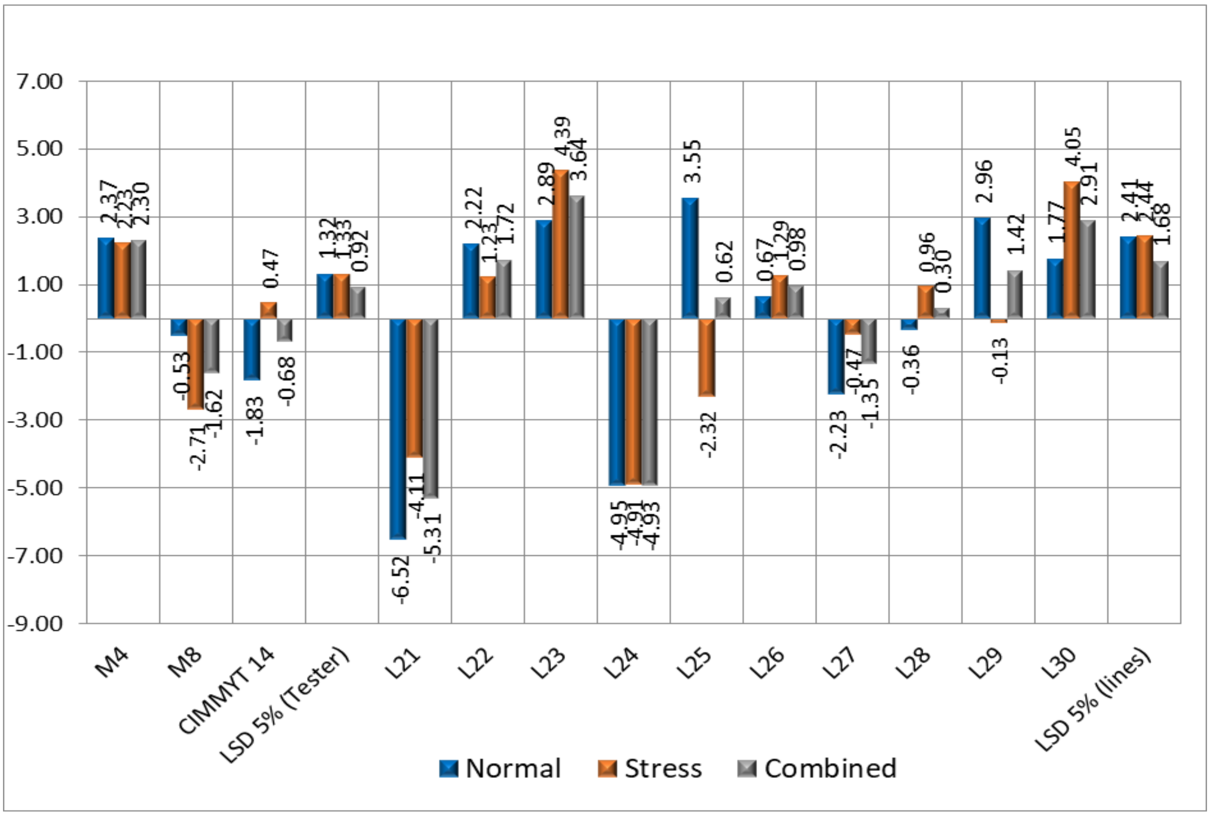
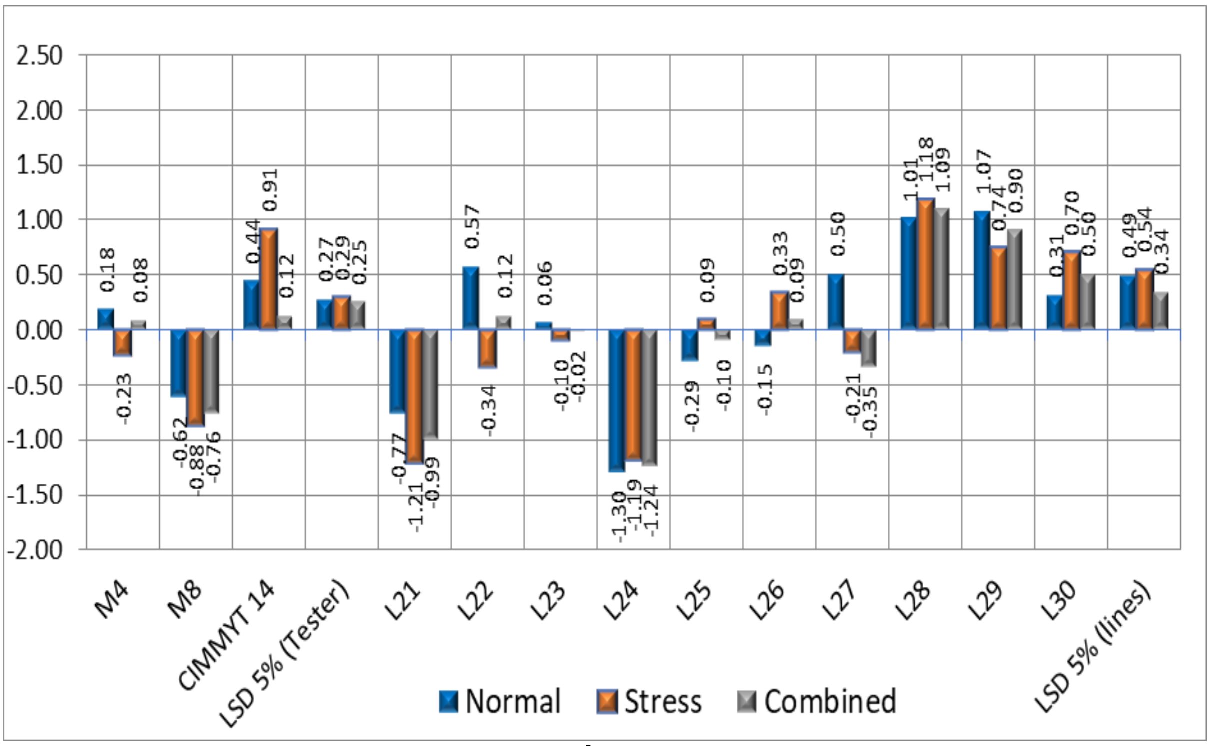
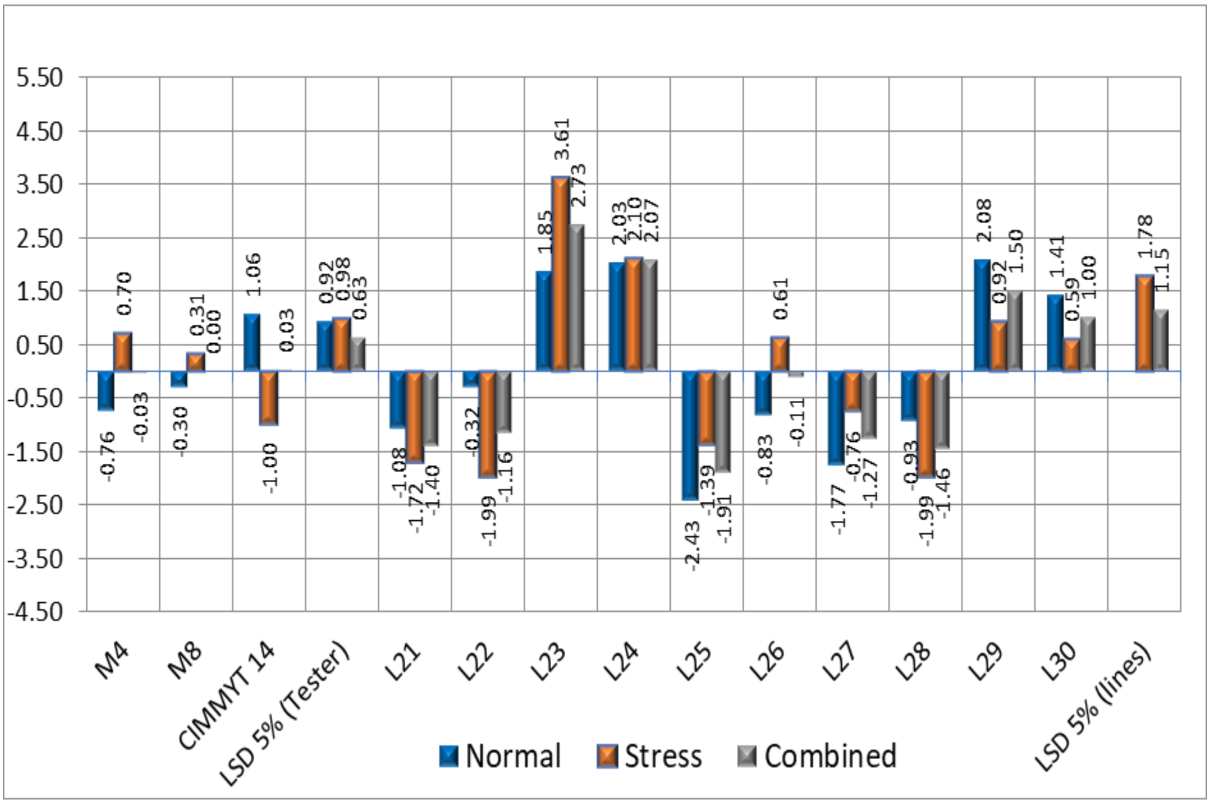


Fig. (2): GCA effects for chlorophyll content under normal irrigation and drought stress as well as combined data.



2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
M4
M8
CIMMYT 14
LSD 5% (Tester)
L21
L22
L23
L24
L25
L26
L27
L28
L29
L30
LSD 5% (lines)
Normal
Stress
Combined

data.



5.50
4.50
3.50
2.50
1.50
0.50
-0.50
-1.50
-2.50
-3.50
-4.50
M4
M8
CIMMYT 14
LSD 5% (Tester)
L21
L22
L23
L24
L25
L26
L27
L28
L29
L30
LSD 5% (lines)
Normal
Stress
Combined

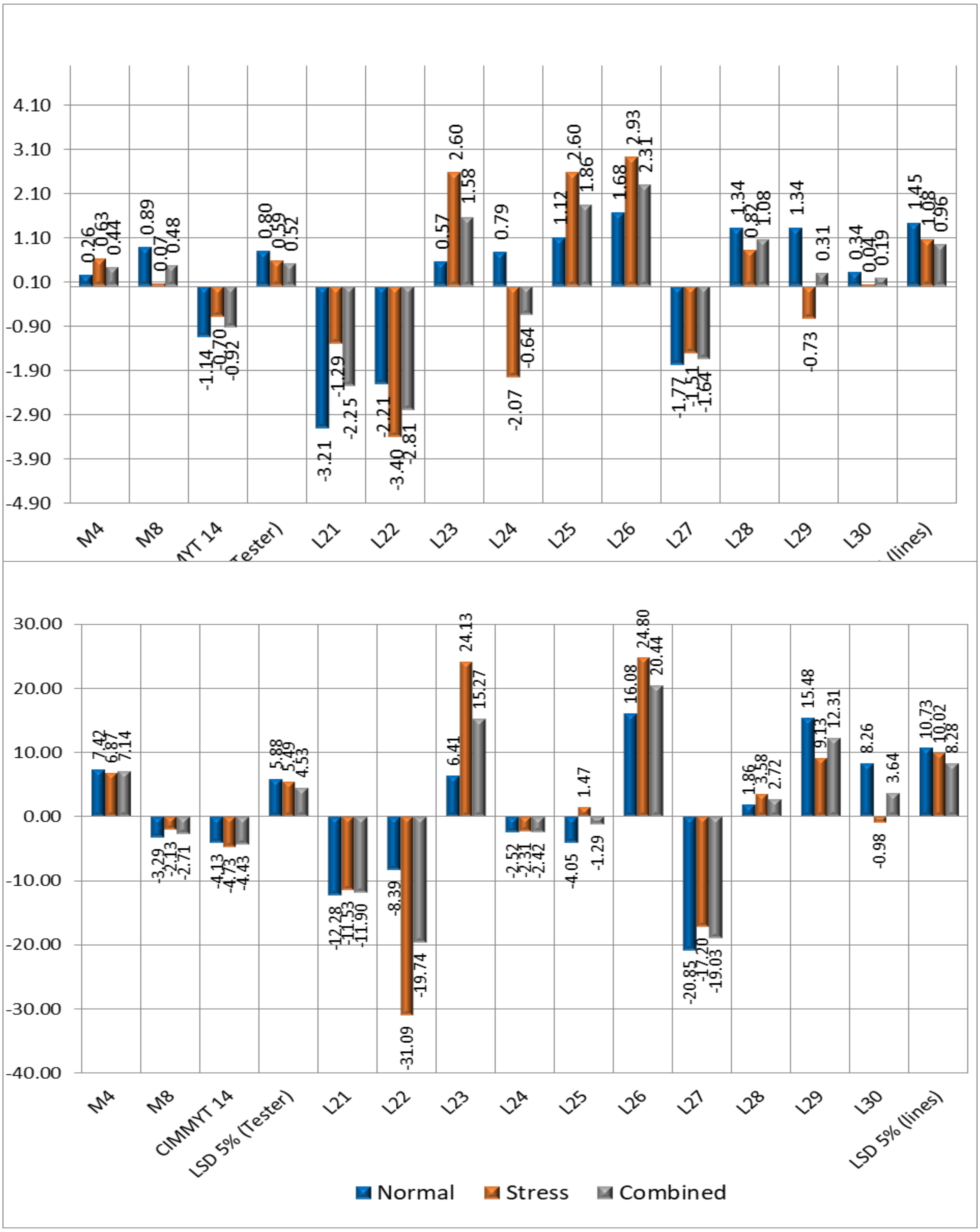


Fig. (6): GCA effects for grain yield plant-1 under normal irrigation and drought stress as well as combined data.

Heterosis

Data on Tables 5 and 6 show standard heterosis relative to SC 2031 and SC 128 for all studied traits under both environments and their combined analysis. For days to 50% silking, 21, 16, and 20 crosses exhibited desirable heterotic effects relative to SC 2031 as well as 11, 1, and 6 crosses relative to SC 128 under both environments and combined analysis, respectively. Moreover, the best heterosis for this trait was detected for the crosses L25xM8 recording -13.98** relative to SC 2031 and -10.11** relative to SC 128 under normal irrigation. Under water deficit, the cross L21xM8 gave the best heterotic values relative to SC 2031 (-9.57**) and SC 128 (-5.03*). Under combined data, the crosses L21xM4, M21xM8, and M21xCIMMYT14 expressed the best heterotic effects relative to both checks (Table 5).

Concerning Chlorophyll content, significant and positive heterotic effects were detected for nine, three and four crosses relative to SCA and nine, three, and five relative to SC 128 under full irrigation, water deficit, and combined data, respectively. However, the most desirable heterotic effects for this trait were obtained for the cross L29xM8 recording 19.00** relative to SC 2031 and 20.2*** relative to Sc 128 under normal irrigation. Under drought stress, the best heterotic values were detected for the cross L23xM4 relative to SC 2031 (15.01*) and Sc 128 (16.27**).

For No. of rows ear^{-1}, 8, 3 and 5 crosses expressed significant and positive heterotic values relative to SC 2031 under E1, E2 and combined data. The respective values relative to SC 128 were detected for five, three and three crosses. The topcross L29xM8 was the best under full irrigation and L28xM4 under water deficit and combined data relative to both checks.

Regarding No. of grains row^{-1}, three, one, and two crosses expressed significant and positive heterotic values relative to SC 2031 and three, two, and two crosses relative to SC 128 under full irrigation, water deficit and combined data, respectively. The best heterosis for this trait was obtained for the crosses L29xM8 under normal irrigation relative to Sc 2031 (12.61**) and SC 128 (12.42**), and the cross L26 x M4 recording 9.40* and 9.75* relative to SC 2031; and 13.68** and 11.73* relative to SC 128 under drought stress and combined data, respectively.

Concerning 100 kernel weight, 5, 3 and 2 crosses exhibited significant and positive heterotic values relative to SC 2031 and 5, 3 and 3 crosses under E1, E2, and combined data, respectively. The best values were detected for the cross L29xM8 relative to both checks under normal irrigation. Under drought stress conditions and combined data, the best values were obtained for the cross L26xM4 relative to both checks.

For grain yield plant^{-1}, significant and positive heterotic effects were obtained in four, two, and three crosses relative to SC 2031, and four, two, and three crosses relative to SC 128 under E1, E2, and combined over them, respectively. However, the most desirable heterotic values were detected for the cross L29xM8 relative to SC 2031 (14.33**) and SC 128 (15.49**) under normal irrigation. Under drought stress, the best heterotic values were obtained for the cross L26xM4 recording 12.48* relative to SC 2031 and 1362* relative to SC 128. Under combined analysis, the best heterosis was detected for the cross L23xM4 relative to SC 2031 (12.62*) and Sc 128 (13.76*). **Youstina *et al.* (2017), *Patil et al*. (2020), El-Hosary (2020), Yadesa et al. (2022), and El Naggar *et al*. (2023)** all came to similar conclusions.

In conclusion, the studied top crosses L2xM4, L26xM4, L28xM4, and L29xM8 were promising and prospective and would be used in future maize breeding program since they had the highest mean values and the most desirable heterotic effects relative to both checks for grain yield plant-1 and most of its related attributes.

Table 5. Standard heterosis for days to 50% silking, chlorophyll content, and No. of rows ear^{-1} relative to S.C. 2031 and S.C. 128 under normal irrigation, drought stress as well as combined data.

c	Days to 50% silking						Chlorophyll content						No. of rows ear^{-1}					
	Relative to S.C. 2031			Relative to S.C. 128			Relative to S.C. 2031			Relative to S.C. 128			Relative to S.C. 2031			Relative to S.C. 128		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
L21 x M4	-	-	-	-	-2.23	-	-	-	-	-	-	-11.75	-2.38	-	-	-3.76	-	-
L21 x M8	-	-	-	-	-	-	-7.53	-	-9.58	-6.52	-	-8.60	-	-	-	-	-	-
L21 x	-	-	-	-	-3.35	-	-7.74	-7.76	-7.75	-6.74	-6.75	-6.75	2.62	2.39	2.51	1.17	1.90	1.54
L22 x M4	-	-	-	-	-1.12	-2.52	17.63	7.69	12.67	18.91	8.86	13.89	6.67	-7.18	-0.24	5.16	-7.62	-1.18
L22 x M8	-1.08	1.06	0.00	3.37	6.15*	4.76*	2.08	-	-4.16	3.19	-9.44	-3.12	3.81	-	-5.25	2.35	-	-6.15
L22 x	-	-3.19	-	0.00	1.68	0.84	9.75	4.02	6.89	10.94	5.16	8.05	9.05*	7.66	8.35*	7.51	7.14	7.33
L23 x M4	-	-	-	-	-1.12	-2.52	18.42	15.01	16.72	19.71	16.27	17.99	9.29*	-3.35	2.98	7.75*	-3.81	2.01
L23 x M8	0.54	1.60	1.07	5.06*	6.70*	5.88*	4.66	-3.02	0.83	5.80	-1.96	1.92	-4.29	-	-6.68	-5.63	-	-7.57
L23 x	-1.08	-1.06	-1.07	3.37	3.91*	3.64	10.75	9.77	10.26	11.96	10.97	11.46	3.57	3.83	3.70	2.11	3.33	2.72
L24 x M4	-	-3.19	-	-	1.68	-2.80	-5.30	-	-8.83	-4.28	-	-7.83	-6.67	-	-	-7.98*	-	-
L24 x M8	1.61	2.66	2.14	6.18*	7.82*	7.00*	-5.52	-	-	-4.49	-	-11.50	-	-	-	-	-	-
L24 x	0.00	-0.53	-0.27	4.49*	4.47*	4.48*	-5.95	-6.61	-6.28	-4.93	-5.59	-5.26	-2.86	-4.78	-3.82	-4.23	-5.24	-4.73
L25 x M4	-	-	-	-	-1.68	-3.36	9.75	-	-0.22	10.94	-9.22	0.87	0.00	-0.48	-0.24	-1.41	-0.95	-1.18
L25 x M8	-	-0.53	-	-	4.47*	-2.80	15.34	-	-1.00	16.59	-	0.07	-2.86	-	-5.49	-4.23	-	-6.38
L25 x	-	-	-	-0.56	-0.56	-0.56	12.97	5.96	9.47	14.20	7.12	10.66	3.81	4.07	3.94	2.35	3.57	2.96
L26 x M4	-	-	-	-	-2.23	-	15.41	14.94	15.18	16.67	16.19	16.43	2.38	0.48	1.43	0.94	0.00	0.47
L26 x M8	-	-	-	-2.25	-1.68	-1.96	10.39	-6.61	1.90	11.59	-5.59	3.01	-4.52	-5.50	-5.01	-5.87	-5.95	-5.91
L26 x	-	-	-	0.56	0.56	0.56	-6.31	-6.61	-6.46	-5.29	-5.59	-5.44	6.19	5.50	5.85	4.69	5.00	4.85
L27 x M4	-	-	-	-	-3.35	-	16.06	14.22	15.14	17.32	15.47	16.39	2.86	-1.44	0.72	1.41	-1.90	-0.24
L27 x M8	0.54	1.06	0.80	5.06*	6.15*	5.60*	-3.15	-7.97	-5.56	-2.10	-6.97	-4.53	-7.62	-	-	-8.92*	-	-
L27 x	-	-	-	0.00	0.00	0.00	-	-	-	-	-	-	1.29	1.44	1.36	-0.14	0.95	0.40
L28 x M4	-	-	-	-	-2.79	-	16.77	6.97	11.88	18.04	8.13	13.09	16.19	16.27	16.23	14.55	15.71	15.13
L28 x M8	0.54	1.06	0.80	5.06*	6.15*	5.60*	-4.59	-6.03	-5.31	-3.55	-5.01	-4.28	3.10	-1.91	0.60	1.64	-2.38	-0.35
L28 x	-	-	-	0.00	0.00	0.00	0.65	-1.36	-0.36	1.74	-0.29	0.73	9.52*	4.55	7.04	7.98*	4.05	6.03
L29 x M4	-	-2.66	-3.48	0.00	2.23	1.12	13.76	-7.18	3.30	15.00	-6.17	4.43	0.00	-0.24	-0.12	-1.41	-0.71	-1.06
L29 x M8	1.08	0.53	0.80	5.62*	5.59*	5.60*	19.00	-1.44	8.79	20.29	-0.36	9.97	16.67	-0.48	8.11*	15.02	-0.95	7.09
L29 x	-	-	-	-1.12	-1.12	-1.12	1.51	1.15	1.33	2.61	2.25	2.43	13.57	10.05	11.81	11.97	9.52*	10.76
L30 x M4	-	-3.19	-	-0.56	1.68	0.56	10.54	10.63	10.58	11.74	11.84	11.79	8.57*	4.31	6.44	7.04	3.81	5.44
L30 x M8	1.61	1.06	1.34	6.18*	6.15*	6.16*	8.39	3.45	5.92	9.57	4.58	7.07	-3.81	-4.31	-4.06	-5.16	-4.76	-4.96
L30 x	-	-	-	-2.81	0.56	-1.12	7.67	5.46	6.57	8.84	6.61	7.73	9.05*	8.61*	8.83*	7.51	8.10*	7.80*

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

Table 6. Standard heterosis for No. of grains row^{-1}, 100 kernel weight and grain yield plant^{-1} relative to S.C. 2031 and S.C. 128 under normal irrigation, drought stress as well as combined data.

c	No. of grains row^{-1}						100 kernel weight						Grain yield plant^{-1}					
	Relative to S.C. 2031			Relative to S.C. 128			Relative to S.C. 2031			Relative to S.C. 128			Relative to S.C. 2031			Relative to S.C. 128		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
L21 x M4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L21 x M8	-	-	-	-	-7.64	-8.97	-0.90	0.93	0.00	0.92	1.87	1.39	-4.15	-8.46	-6.30	-3.18	-7.54	-5.35
L21 x	7.39	-	-2.80	7.21	-9.77*	-1.04	-7.21	-	-	-5.50	-9.35*	-7.41	-1.14	-8.32	-4.73	-0.14	-7.39	-3.76
L22 x M4	-8.91	-	-	-9.06*	-	-	-0.90	-8.33	-4.57	0.92	-7.48	-3.24	-	-	-	-9.19	-	-
L22 x M8	0.00	-	-5.59	-0.17	-7.82	-3.88	0.00	-	-7.31	1.83	-	-6.02	3.46	-	-	4.51	-	-
L22 x	-1.51	-	-	-1.68	-	-8.37	-	-	-	-	-	-	-	-	-	-	-	-
L23 x M4	11.76	6.67	9.24*	11.58	10.83	11.22	10.81	10.19	10.50	12.84	11.21	12.04	13.33	11.91	12.62	14.48	13.04	13.76
L23 x M8	-5.04	-4.27	-4.66	-5.20	-0.53	-2.93	-4.50	-2.78	-3.65	-2.75	-1.87	-2.31	-	-	-	-	-	-
L23 x	4.54	-3.76	0.42	4.36	0.00	2.24	2.70	3.70	3.20	4.59	4.67	4.63	1.43	1.29	1.36	2.46	2.32	2.39
L24 x M4	4.87	-5.13	-0.08	4.70	-1.42	1.73	1.80	-	-3.65	3.67	-8.41	-2.31	2.98	-7.17	-2.09	4.02	-6.23	-1.10
L24 x M8	-2.18	-	-6.27	-2.35	-6.93	-4.57	4.50	-	-2.74	6.42	-9.35*	-1.39	-	-	-	-	-	-
L24 x	4.71	-2.39	1.19	4.53	1.42	3.02	4.50	-8.33	-1.83	6.42	-7.48	-0.46	1.49	-7.89	-3.19	2.51	-6.96	-2.21
L25 x M4	-	-	-	-	-	-	3.60	4.63	4.11	5.50	5.61	5.56	0.03	-	-5.07	1.04	-9.28	-4.11
L25 x M8	-1.01	-	-8.14	-1.17	-	-6.47	10.81	9.26*	10.05	12.84	10.28	11.57	-3.89	-	-7.46	-2.92	-	-6.53
L25 x	-9.75*	-	-	-9.90*	-	-	-0.90	-2.78	-1.83	0.92	-1.87	-0.46	-9.01	-	-	-8.09	-	-9.77
L26 x M4	10.08	9.40*	9.75*	9.90*	13.68	11.73	10.81	11.11	10.96	12.84	12.15	12.50	12.53	12.48	12.51	13.67	13.62	13.65
L26 x M8	-	-	-	-	-9.41	-	2.70	1.85	2.28	4.59	2.80	3.70	-3.55	-9.61	-6.58	-2.57	-8.70	-5.63
L26 x	-1.18	-	-7.71	-1.34	-	-6.04	4.50	0.93	2.74	6.42	1.87	4.17	4.06	-6.31	-1.12	5.12	-5.36	-0.12
L27 x M4	-	-	-	-	-8.17	-	-4.50	-3.70	-4.11	-2.75	-2.80	-2.78	-8.64	-	-	-7.72	-	-
L27 x M8	-4.20	-5.13	-4.66	-4.36	-1.42	-2.93	6.31	-8.33	-0.91	8.26	-7.48	0.46	-8.44	-8.61	-8.52	-7.51	-7.68	-7.60
L27 x	-6.05	-	-	-6.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L28 x M4	4.03	-9.91*	-2.88	3.86	-6.39	-1.12	11.71	-7.41	2.28	13.76	-6.54	3.70	13.16	2.87	8.02	14.31	3.91	9.12
L28 x M8	-	-	-	-	-	-	4.50	4.63	4.57	6.42	5.61	6.02	-	-	-	-	-	-
L28 x	0.84	-	-9.41*	0.67	-	-7.77	-0.90	-0.93	-0.91	0.92	0.00	0.46	-1.83	-	-9.15	-0.84	-	-8.23
L29 x M4	-3.87	-3.93	-3.90	-4.03	-0.18	-2.16	0.90	0.00	0.46	2.75	0.93	1.85	4.61	-	-3.93	5.66	-	-2.95
L29 x M8	12.61	-5.13	3.81	12.42	-1.42	5.69	13.51	-	1.37	15.60	-	2.78	14.33	7.32	10.83	15.49	8.41	11.95
L29 x	-0.17	-	-8.98	-0.34	-	-7.33	0.90	-5.56	-2.28	2.75	-4.67	-0.93	-6.67	-	-	-5.72	-	-
L30 x M4	-6.89	-7.69	-7.29	-7.05	-4.09	-5.61	0.90	-2.78	-0.91	2.75	-1.87	0.46	-3.40	-6.31	-4.86	-2.43	-5.36	-3.89
L30 x M8	8.24	-	-1.10	8.05	-7.10	0.69	1.80	-2.78	-0.46	3.67	-1.87	0.93	8.70	-	-1.38	9.80	-	-0.38
L30 x	1.34	-	-4.92	1.17	-7.82	-3.19	4.50	-4.63	0.00	6.42	-3.74	1.39	-2.32	-	-	-1.33	-	-9.71

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

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تقييم القدرة على التآلف فى هجن الذرة الشامية باستخدام نموذج السلالة × الكشاف تحت ظروف الرى العادى ونقص الرطوبة

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تم تقييم ثلاثون هجينا قميا ناتجة من التهجين بين عشرة سلالات نقية جديدة من الذرة الشامية مع ثلاثة كشافات متميزة وذلك تحت ظروف الرى العادى والإجهاد الرطوبى. وتم تقييم هذه الهجن القمية مقارنة بهجينين من الذرة الشامية (هـ.ف 2031 ، هـ ف. 128) وذلك باستخدام تصميم قطاعات كاملة العشوائية فى ثلاثة مكررات لتقدير القدرة على التآلف وقوة الهجين لبعض الصفات الهامة من الذرة الشامية. وأظهر التحليل الإحصائى ان أفضل القيم لميعاد خروج 50% من الحريرة كانت مع الهجين L25x M8 تحت ظروف الرى العادى والهجين L21xM8 تحت ظروف الإجهاد الرطوبى. وامكن الحصول على افضل قيم لصفتى محصول الحبوب مع الهجين L29xM8 متبوعا بالهجين L23xM4 تحت ظروف الرى العادى والهجين L26xM4 تحت ظروف نقص الرطوبة. وأظهر التحليل الإحصائى ان الفعل الوراثى غير المضيف هو المسئول عن توارث جميع الصفات تحت الدراسة سواء تحت ظروف الرى العادى او الإجهاد الرطوبى او التحليل التجميعى. وكان الكشاف (M4) T1 هو الأفضل لصفات ميعاد خروج 50% من الحريرة ومحتوى الكلورفيل ومحصول الحبوب للنبات، بينما أعطت السلالة الأبوية افضل القيم للقدرة العامة على الأئتلاف لصفتى وزن 100 حبة ومحصول الحبوب للنبات. واعطى الهجين L25xM8 أفضل القيم للقدرة الخاصة على التآلف لصفة ميعاد خروج 50% من الحريرة تحت ظروف الرى العادى والتحليل التجميعى. واعطى الهجين L28xM4 افضل تاثيرات للقدرة الخاصة على التآلف لصفة محصول حبوب النبات تحت ظروف الرى العادى والهجين L29xM8 تحت ظروف الإجهاد المائى والتحليل التجميعى. وأمكن الحصول على افضل قيم لقوة الهجين لصفة محصول حبوب النبات نسبة الى كلا من هجينى المقارنة مع الهجين L23xM4 فى التحليل التجميعى. واعطى الهجين L26xM4 افضل قيم لقوة الهجين لمعظم الصفات تحت الدراسة سواء تحت ظروف الرى العادى او الجفاف. واعطى الهجين L29xM8 افضل قوة هجين لصفات ميعاد خروج 50% من الحريرة ووزن 100 حبة ومحصول الحبوب للنبات تحت ظروف الرى العادى.