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Article

Estimation of Combining Ability of Growth and Yield and Its Components of Maize under Salicylic Acid Concentrations

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Abstract

An experiment was carried out in the fields of Al-Hamidhyia research station - College of Agriculture / Anbar University to study the concentrations of salicylic acid (0, 200 and 400 mg L^{-1}) and fifteen genotypes (5 lines + 10 hybrids) of maize using a randomized complete block design according to split plots arrangement at three replications, the main plots included spraying of salicylic acid concentrations, while the subplots include maize genotypes (inbreds and hybrids) in order to produce hybrids (superior) by introducing a group of inbreds and reciprocal hybrids of maize within half diallel reciprocal crosses program. The results showed that Zm 6inbred was significantly superior and gave the highest general combining ability of grain yield (5.77 and 9.65) for both seasons due to its superiority in the number of rows per ear and weight of 300 grains (0.27 and 1.48), respectively in the spring season, and early flowering in the autumn season. Also, the spraying of salicylic acid at 400 mgL^{-1} was significantly superior in all studied traits for both seasons, with non-significant differences with the spraying of salicylic acid at 200 mgL^{-1}.The effect of hybrids' specific combining ability (SCA) significantly affected the studied traits. The BK116×ABS6 hybrid had the highest specific effect on the early female flowering (-2.76). In contrast, the Zm6×BK104 hybrid with control treatment had the highest specific effect on the weight of 300 grains and grain yield (13.84 and 50.12), respectively, in the spring season, while the BK104×Inb27 hybrid with the spraying of salicylic acid at a 400 mgL^{-1}had the highest effect of the specific combining ability (72.11) in the autumn season. We recommend spraying salicylic acid at 200 mg L^{-1} and using superior inbreds and hybrids in general and specific combining ability in both seasons.

Keywords: Inbred line, hybrid, SA, SCA, GCA.

Introduction

Maize is an important cereal crop that is characterized by the ease of hybridization and production, which helped the spread of its cultivation to alleviate the global food crisis[1] .Improvement the grain yield of crops such as

maize is a major aim for plant breeders, who are in constant search for genetic materials with superior field performance.It is necessary to an increase the productivity of crops, agricultural area and transform some desert lands into productive land in order to face global challenges such as the rise of the standard of living and increasing the population[2] .Combining ability is defined as the ability of inbred to transfer its good traits to its hybrids resulting from its mating or combining with another inbred by giving it a high grain yield in the F1Individualsresulting from mating.Combiningability test is considered a basic test for inbredsstrengthening and its purpose is to renew the ability of the inbreds to produce economic hybrids with high yield and required traits[3,4] .indicated that the knowing the behavior of the inbreds and their performance in crosses enables the researcher to produce promising hybrids and cultivars.Salicylic acid is one of the phenolic compounds and it is one of the important plant hormones that lead to the regulation of ion uptake, hormonal balance, the speed of cell division, flowering induction, stomata movement and photosynthesis.It is a colorless and odorless crystalline powder, its density is 1.44 gcm^3 and melting point is 159 ºC, and its boiling point is 211 ºC, so it is slightly soluble in water, but it dissolves wellin polar organic solvents[5] .The effect of the exogenous application of salicylic acid on the plant depends on several factors; including the concentration used, plant type, plant growth stage and the method of application.Also, it helps the plant to resist diseases and insect, which facilitates the absorption of water and nutrients by the roots[6] .In addition to, it helps stimulate cells to biosynthesis of chlorophyll in the leaves[7] .This study aims to produce superior hybrids by introducing a group of maize inbredswithin half diallelreciprocalcrosses programand their evaluating by estimating the effects and variances of GCA and SCA, grain yield and its components, in addition to determining the best hybrid among the reciprocalhybrids as well as knowing the effect of spraying of salicylic acid on the GCA and SCA for grain yield and its components.

Materials and Methods

Five inbreds of maize were used and entered within a half-diallel reciprocal crosses program according to the second method of [8].

Inbred name	Source
BK 116	Locally derived Buhooth 106
Zm 6	Locally derived
ABS 6	Locally derived
BK 104	Locally derived Buhooth 106
In-27	Locally derived

Table 1: The inbreds used and their sources.

The experiment was conducted in fields of Al-Hamidhyia research station - College of Agriculture / Anbar University, north of the Ramadi distinct, which is located at latitude 33° 27' 10.8" N and longitude 43° 23' 2.4" E in the spring and autumn seasons of 2021. Soil management was carried out. DAP fertilizer was added with an average of 300 Kg ha^{-1} before the planting. In comparison, the nitrogen fertilizer was added with an average of 300 kg ha^{-1} at two equal doses, the first when the plant reached a height of 30 cm and the second before the emergence of male inflorescences. Crop management was carried out as needed, and the plants were harvested after the appearance of maturity signs.

The split plots arrangement according to randomized complete blocks design at three replications was used, the concentrations of salicylic acid (0, 200 and 400)

mg L^{-1} were included in the main plots, while the subplots were included the genotypes, as the seeds of single hybrids and parental inbreds were planted in the spring and autumn seasons 2021. Therefore, the number of genotypes that entered each experiment was 15 (10 derived hybrids + 5 parental inbreds).

Combining ability analysis

According to the analysis of variance and based on the presence of significant differences between the genotypes, the data obtained from 5 inbreds and 10 single hybrids resulting from half diallel reciprocal crosses between parents were analyzed according to the fixed model and the second method of analysis[8] to estimate the GCA for parents and SCA for hybrids according to the following mathematical model:

$$\mathbf{Y_{ijk} = \mu + \hat{g}_i + \hat{g}_j + \hat{S}_{ij} + R_k + e_{ijk}}$$

The standard error of the difference between the effect of GCA for parents and SCA for any two hybrids that shared at least one parent was estimated as follows:

$$\mathbf{SE\ (S_{ij}\text{-}S_{ik})} = \sqrt{\frac{2(p+1)ms\bar{e}}{p+2}}$$

$$\mathbf{SE\ (g_i\text{-}g_j)} = \sqrt{\frac{2ms\bar{e}}{p+2}}$$

Studied traits

1. Number of days to 50% female flowering (day): It was calculated from planting until each experimental unit's silk emergence in 50% of the plants.

2. leaf area (cm^2): It was calculated from the following equation[3] :

Leaf area (cm^2) = (Leaf length under the leaf of the prominent ear) ^{2}× 0.75

3. Number of rows per ear

4. Weight of 300 grains (g): 300 grains were calculated and weighed, then the final weight was corrected based on the optimum moisture content (15.5%).

5. Plant grain yield (g): It was calculated as an average of the grain yield of five plants for each experimental unit.

2.3. Statistical analysis

Statistical analysis was conducted using a randomized complete block design (RCBD) according to split plots arrangement. The means were compared using the least significant difference (LSD) at a 5% probability level.

Results and Discussion

General combining ability (GCA)

Number of days to 50% female flowering (day)

It is clear from the results in Table 2 that there was a significant difference between the parents in the values of the GCA effects in all concentrations of salicylic acid in the spring season, as the 3 inbred with a concentration of 200 mg L^{-1} gave a negative and significant effect in inheritability of the number of days to 50% female flowering (-0.62), while in the concentration of 400 mg L^{-1}, the 1 inbred gave a highest negative and significant effect in inheritability of this trait (-0.69), so these inbreds had a significant contribution to transferring the early flowering trait to their offspring through the combining their genes with other

inbred. In comparison, the 4 and 5 inbreds with a concentration of 200 mg L^{-1} gave (0.31 and 0.52), respectively, and the 5 inbreds with a concentration of 400 mg L^{-1} positively affected the GCE (0.99). This means these inbreds significantly contributed to transferring the delayed flowering traits to their offspring.

The results in Table 3 show that there was a significant difference between the parents in the values of the GCA effects in the concentrations of 200 and 400 mg L^{-1}in the autumn season, as the 1 inbred with a concentration of 200 mg L^{-1} gave a negative and significant effect in inheritability of the number of days to 50% female flowering (-0.36), while the 2 inbreds with a concentration of 400 mg L^{-1} it gave a highest negative and significant effect inheritability of this trait (0.60-). Thus, these inbreds significantly contributed to transferring the early flowering trait to their offspring by combining their genes with other inbreds. In contrast, the 3 and 5 inbreds with a concentration of 200 mg L^{-1} and the 5 inbreds with a concentration of 400 mg L^{-1} had a positive and significant effect on the GCA (0.80); this means that these inbreds had a significant contribution to transferring the delay flowering to their offspring. These results are in agreement with [9,10,11], who obtained the positive and negative significant values for the effects of GCA on female flowering.

.Leaf area (cm^2)

The results in Table 2 indicate that there was a significant difference between inbreds in the values of the GCA effects of the leaf area in the spring season, as 1 inbred with control treatment (0 mg L^{-1}) recorded a highest positive and significant effect (178.52). Also, the 5 inbreds with a concentration of 400 mg L^{-1} recorded a positive and significant effect of GCA (165.15). This indicates that the two inbreds (1 and 5) contributed to the inheritability of this trait by increasing the leaf area. The 5 inbreds recorded a negative and significant effect of the GCA (-258.25) towards reducing the leaf area.

Regarding the autumn season, the results in Table 3 show that the 3 inbreds achieved the highest positive and significant effect with concentrations of 200 and 400 mg L^{-1}, which amounted to 180.80 and 198.09, respectively. The 4 inbred with the control treatment achieved a positive and insignificant effect (130.29). However, some inbreds achieved a negative and insignificant effect of the GCA of this trait, as the 5 inbred with the concentration of 400 mg L^{-1} achieved a negative and insignificant effect (-338.96).

Number of rows per ear

The results in Table 2 show that the values of inbreds differed in the effect of the GCA in the spring season, as the 3 inbreds with concentrations of 0 and 400 mg L^{-1} gave positive and significant effects (0.31 and 0.30) respectively, as this inbred was a significant contribution to inheritability of this trait towards increasing the number of rows per ear. Also, the 2 inbred with a 200 mg L^{-1} gave a positive and significant effect of (0.27). In contrast, the 1 inbred with a concentration of 400 mg L^{-1} gave a negative value of GCA (-0.48). This means that his inbred significantly contributed to this trait's inheritability towards reducing the number of rows per ear. The results in Table 3 show the values of the effect of the GCA in the autumn season, as the 3 inbred 3 with concentrations of 0 and 400 mg Achieved a positive and significant effect (0.60 and 0.49), as the concentration of 200 mgL^{-1}wasn't significant effect on all inbreds in this trait. In contrast, the 4 inbred with a concentration of 400 mg Achieved the highest negative and significant effect (-0.45).

Weight of 300 grains (g)

The results in Table 2 reveal that the 4 inbreds with 0 and 200 mg L^{-1} showed the GCA's highest positive and significant effect (1.51 and 1.69), respectively. The 2 inbred with the concentration of 400 mg Showed a positive and significant effect (1.48). In contrast, the 3 inbreds with a concentration of 400 showed a negative and significant effect in the spring season, which indicates that the inbreds showed a positive and significant effect contributed to improving the trait and transferring it to their hybrids towards the weight of the grain due to the high non-additive gene action. The results in Table 3 show the effects of the GCA on inbreds in the autumn season, as the 4 inbreds with concentrations of 200 and 400 mg Gave positive and significant effects of GCA (3.41 and 3.34), respectively, followed by the 5 inbred with control treatment (3.34). In contrast, the 3 inbred with the control treatment gave a negative and significant value (-4.68).

Plant grain yield (g)

It is clear from Table 2 the importance of additive and non-additive genetic influences in plant grain yield. As for the spring season, the 2 inbred with concentrations of 0, 200 and 400 mg Showed a positive and significant effect of the GCA (5.41, 5.77 and 4.72), respectively, while some inbreds showed a negative and significant effect, which indicates that the inbred that showed the positive and significant effect contributed to improving the trait and transferring it to their hybrids towards increasing the plant grain yield due to the high due to the high additive gene action. In contrast, the inbreds that gave the negative and significant effect cannot improve the trait. As for the autumn season, the results in Table 3 reveal that the 3 inbred with control treatment and 4 inbred with concentrations of 200 and 400 mg L^{-1} gave positive and significant effects of GCA (5.56, 4.77 and 5.47), respectively, while some inbreds showed the negative and significant effect significantly the 1 inbred with control treatment which gave -7.49, which indicates that the inbreds that showed the positive and significant effect contributed to improving the trait and transferring it to their hybrids towards increasing the plant grain yield due to the high additive gene action. In contrast, the inbreds that showed the negative and significant effect cannot improve the trait.

Parents	Number of days to 50% female flow-ering (day)	Leaf area (cm^2)	Number of rows per ear	Weight of 300 grains (g)	Plant grain yield (g)
1	0.12	-138.39	-0.37	0.79	0.30-
	-0.09	-78.86	-0.34	1.23	2.43-
	-0.69	-63.75	-0.48	0.36	1.50-
2	0.33	91.65	0.28	-0.67	5.41
	-0.12	78.40	0.27	-0.18	5.77
	0.0001	-150.67	-0.01	1.48	4.72
3	-0.72	178.52	0.31	-1.83	0.91-
	-0.62	17.09	0.10	-2.38	1.68-
	-0.37	-29.34	0.30	-2.85	0.94-
4	-0.04	126.45	-0.07	1.51	1.81-
	0.31	-6.17	-0.11	1.69	0.11
	0.06	78.61	-0.02	0.97	1.33

5	0.30	-258.25	-0.15	0.20	2.39-
	0.52	-10.46	0.08	-0.35	1.76-
	0.99	165.15	0.22	0.03	3.60-
SE(gi^-gj^)	0.30	27.01	0.15	0.46	3.90
SE(gi^-gj^)	0.19	106.07	0.17	1.08	4.45
SE(gi^-gj^)	0.21	47.37	0.18	0.82	4.23

Table 2: The GCA values of parents of the studied traits of maize by the effect of 0 (upper), 200 (middle) and 400 mg L^{-1} of salicylic acid in the spring season 2021.

Parents	Number of days to 50% female flowering (day)	Leaf area (cm^2)	Number of rows per ear	Weight of 300 grains (g)	Plant grain yield (g)
1	-0.39	-1.46	-0.25	-0.35	6.23-
	-0.36	19.20	-0.15	-1.26	7.50-
	0.01	113.60	0.07	-2.09	3.83-
2	-0.26	-19.55	-0.07	-1.55	9.65
	-0.16	99.21	0.12	-1.55	9.13
	-0.60	84.99	-0.07	-0.71	3.46
3	0.50	38.13	0.60	-4.68	10.55-
	0.31	180.80	0.23	-3.75	10.14-
	-0.29	198.09	0.49	-3.64	5.17-
4	0.34	130.29	-0.08	3.25	2.31-
	-0.04	-106.51	-0.07	3.41	1.48-
	0.07	-57.71	-0.45	3.34	2.06
5	-0.18	-147.41	-0.18	3.34	9.44
	0.26	-192.71	-0.13	3.15	9.99
	0.80	-338.96	-0.03	3.10	3.48
SE(gi^-gj^)	0.47	72.53	0.22	1.07	1.31
SE(gi^-gj^)	0.17	83.34	0.25	0.82	2.06
SE(gi^-gj^)	0.19	101.84	0.17	0.69	1.85

Table 3: The SCA values of parents of the studied traits of maize by the effect of 0 (upper), 200 (middle) and 400 mg L^{-1} of salicylic acid in the spring season 2021.

Specific combining ability (SCA)

Number of days for 50% female flowering (day)

The results in Table 4 show the presence of non-additive effects of genes in controlling the heritability of female flowering in the spring and autumn seasons. There were effects of the SCA of single hybrids in the spring season. The 2×1 hybrid recorded the negative and significant values(-1.67, -2.17 and - 2.03), as it was the earliest female flowering when spraying salicylic acid at a 0, 200 and 400 mg L^{-1}, respectively, also, of the 3 × 1 hybrid was superior and recorded a negative and significant value(-2.76), as it was the earliest flowering when spraying of salicylic acid at a 200 mgL^{-1}. In contrast, the 4 × 3 hybrid recorded 0.67, 1.66 and 1.63, as it was the most delayed female flowering when spraying salicylic at 0, 200 and 400 mg L^{-1}, respectively. The results in Table 5 reveal the effect of SCA on single hybrids in the autumn season, as the hybrid 3×2 gave

negative and significant values (-1.92, -3.26 and -2.18), as was the earliest male flowering when spraying of salicylic acid at a 0, 200 and 400 mg L^{-1}respectively, while the 5×1 hybrid gave non-significant values (-0.11, 0.89 and -0.03), as it was the most delayed of female flowering when spraying of salicylic acid at 0, 200 and 400 mg L^{-1}respectively.

Leaf area (cm^2)

The results in Table 4 show that there were significant differences between the mean of the squares of the SCA for all concentrations of salicylic acid and highly significant for the control treatment and the concentration of 400 mg L^{-1}in the spring season, which indicates the presence of non-additive effects of genes in controlling on the inheritability of the leaf area for two seasons, as the 2×1 hybrid gave the lowest negative and significant values of SCA (-2.41, -2.20 and -2.64) were the earliest of male flowering for the spraying of salicylic acid at 0, 200 and 400 mg L^{-1} respectively, as well as the 3×1 hybrid had a lowest negative and significant SCA (-2.52). It was the earliest flowering for control treatment, while the hybrid gave 0.75, 1.12 and 1.78, and it was the most delayed male flowering for spraying salicylic acid at 0, 200 and 400 mg L^{-1}, respectively. The results in Table 5 show the effect of the SCA of single hybrids in the autumn season. The 4×1 hybrid with spraying of salicylic acid at 0 and 200 mg L^{-1}gavethe positive and significant values of SCA (586.61 and 711.32), respectively, while the 5 × 3 hybrid with a concentration of 400 mg L^{-1} was superior (950.14), whereas the 3 × 2, 2 × 1, and 5 × 4 hybrids gave the negative and non-significant values of SCA (-176.85, -93.25 and 216.52) with spraying of salicylic acid at a 0, 200 and 400 mg L^{-1}respectively. The positive and negative values of the effect of SCA show that the average trait in these crosses was higher or lower than the average performance of his parents for the same trait, which shows that this trait is under the influence of the dominant gene.

Number of rows per ear

The values of the hybrids significantly differed in the effect of the SCA in the spring season (Table 4), as the 5×4 hybrid achieved a positive and significant effect at a concentration of salicylic acid 0, 200 and 400 mg L^{-1} amounted to 1.54, 1.40 and 0.94 respectively. In contrast, the 4×2 hybrid achieved a negative and non-significant SCA value of -1.00.

Weight of 300 grains (g)

The results in Tables 4 and 5 reveal significant differences between the mean squares of the SCA for all salicylic concentrations for both seasons. The 4×2 was superior and gave a positive value of the specific effects for all concentrations of salicylic acid (0, 200 and 400 mg L^{-1}), amounting to 7.13, 6.90 and 6.84, respectively, in the spring season, which indicates the large size of the participation of these hybrids in the inheritability of an increase the weight of grain by additive gene action, offset by the participation of the 5×3 hybrid in reducing the percentage of heritability of this trait to reduce the weight of grain which gave the lowest value towards the decrease (-8.21 and -8.60)with concentrations of salicylic acid 200 and 400 mg L^{-1}. Also, the hybrids showed different effects of the SCA in the autumn season (Table 5). The 2×1 hybrid was superior and gave a positive value of the specific effects with concentrations of salicylic acid 0 and 400 mgL^{-1} amounted to 13.20 and 13.50, respectively, followed by the 4×2 hybrid with the concentration of salicylic acid 200 mgL-1 (11.72).

Plant grain yield (g)

The results in Table 4 show the presence of genes' non-additive effects in controlling the inheritability of the plant grain yield in the spring and autumn seasons. The estimation of the SCA in the spring season was affected. The hybrids significantly differed, as the 4×2 hybrid recorded a positive and significant effect towards increasing plant yield (50.12, 43.86 and 43.66) for spraying salicylic acid at 0, 200 and 400 mg, respectively. In contrast, the 4×3 hybrid with the control treatment recorded the lowest adverse significant specific effects (10.34-). In contrast, the 5×3 hybrid with spraying of salicylic acid at 200 and 400 mg L^{-1} had non-significant effects (3.01 and 1.84).

The results in Table 5 show the effects of estimating the SCA for the autumn season. The hybrids significantly differed, as the 5×4 hybrid recorded a positive and significant effect towards increasing plant grain yield (64.39, 61.77 and 72.11) for spraying salicylic acid at 0 and, 200 and 400 mg, respectively. In contrast, the 4×1 hybrid with control treatment had non-significant effects of SCA (4.73). In comparison, the 5×2 hybrid with the spraying of salicylic acid at 400 mg L^{-1} had significant adverse effects towards the decrease of plant grain yield (-23.12).

Hybrids	Number of days to 50% female flow-ering (day)	Leaf area (cm^2)	Number of rows per ear	Weight of 300 grains (g)	Plant grain yield (g)
2×1	-1.67	139.07	0.17	-4.00	8.25
	-2.17	-93.25	0.57	-5.96	16.64
	-2.03	502.05	-0.19	-6.20	14.87
1×3	-0.90	29.20	0.11	6.39	35.55
	-2.76	228.05	0.81	6.16	34.49
	-2.33	346.05	0.13	6.89	30.83
4×1	-1.17	586.61	0.19	1.94	24.47
	-0.10	711.32	0.57	7.50	30.46
	0.67	647.76	0.22	3.16	24.13
5×1	-0.18	475.31	0.10	11.75	43.03
	0.01	380.27	0.23	12.47	43.38
	-0.03	260.22	0.20	11.27	41.00
3×2	-1.22	-176.85	0.88	1.67	40.61
	-1.62	172.11	0.86	0.88	37.58
	-0.03	397.30	0.38	4.86	32.91
4×2	-0.50	89.22	-1.00	13.84	50.12
	0.27	198.05	-0.70	13.03	43.86
	-0.47	356.68	-0.41	12.10	43.66
5×2	0.54	217.59	0.22	-0.50	23.64
	0.38	109.00	-0.32	7.21	29.56
	-0.40	502.81	-0.01	4.58	41.69
4×3	0.67	64.35	-0.45	-2.85	-10.34
	1.66	480.36	0.11	-2.46	3.94
	1.63	792.34	0.37	-2.38	28.70

5×3	-1.00	283.39	0.68	-0.94	7.47
	-1.78	387.98	0.34	-8.21	3.01
	0.96	950.14	0.05	-8.60	1.84
5×4	-1.01	-164.53	1.54	-2.39	43.33
	-1.21	352.92	1.40	0.47	39.52
	0.52	216.52	0.94	2.55	36.56
SE(gi^-gj^)	0.74	66.16	0.38	1.88	9.55
SE(gi^-gj^)	0.97	259.81	0.43	2.65	10.90
SE(gi^-gj^)	0.73	116.04	0.45	2.03	10.38

Table 4: The GCA values of hybrids of the studied traits of maize by the effect of 0 (upper), 200 (middle) and 400 mg L^{-1} of salicylic acid in spring 2021.

Hybrids	Number of days to 50% female flower-ing (day)	Leaf area (cm^2)	Number of rows per ear	Weight of 300 grains (g)	Plant grain yield (g)
2×1	-0.01	-341.2	0.80	13.2	46.3
	-0.44	-225.4	0.48	10.6	43.9
	-0.34	70.71	0.50	13.5	54.7
1×3	-1.84	-68.25	1.64	-0.21	20.9
	-1.92	105.6	1.71	1.50	20.9
	-0.56	-114.7	1.19	1.04	16.5
4×1	-1.52	857.92	-0.39	0.34	4.73
	-2.66	911.3	0.14	3.91	83.5
	-1.87	1073.1	-0.01	1.55	1.68
5×1	-0.11	1024.3	0.97	5.75	25.30
	0.89	346.50	1.13	1.93	29.06
	-0.03	295.69	0.55	-0.03	38.52
3×2	-1.92	700.16	0.20	0.98	12.42
	-3.26	387.30	1.03	0.80	12.26
	-2.18	-80.10	0.01	0.66	20.20
4×2	-0.64	-36.98	0.35	12.07	47.18
	-0.04	204.95	0.67	11.72	48.30
	0.12	-357.64	-0.23	10.67	53.80
5×2	-1.33	18.37	-0.27	-1.46	26.44
	-0.65	-347.85	0.79	-1.78	30.13
	-0.62	229.29	0.59	0.41	-23.12
4×3	-1.09	-436.68	1.53	4.75	24.05
	-0.30	-245.3	1.56	2.32	28.20
	-0.39	-88.73	1.49	3.27	30.57
5×3	-1.36	-259.98	1.57	6.58	39.29
	-1.25	17.90	0.82	6.91	43.23
	-0.62	149.2	1.03	8.84	49.30
5×4	-1.23	209.86	1.96	6.05	64.39

	-1.54	-242.79	2.06	5.43	61.77
	-1.80	247.67	2.12	6.30	72.11
SE(gi^-gj^)	1.17	177.67	0.55	2.63	5.67
SE(gi^-gj^)	1.11	204.16	0.63	2.01	5.06
SE(gi^-gj^)	0.74	249.46	0.44	1.69	4.55

Table 5: The SCA values of hybrids of the studied traits of maize by the effect of 0 (upper), 200 (middle) and 400 mg L^{-1} of salicylic acid in spring 2021.

Discussion

The growth factors of cultivars differ during the stages of plant formation, and this affects the yield, whether positively or negatively, which shows that increasing the leaf area is not always associated with an increase in the grain yield[12].

The results agree with [13,14,15,16], which indicated the importance of the additive and non-additive gene action in controlling the inheritability of the trait. Moreover, they are also in line with[17,18,19,20,21], who showed that the trait is under the influence of non-additive genes.

These results are in line with [22,23], who obtained the positive and negative general effects by the dominance and additive gene action. Otherwise, these results did not agree with [23,24], who reported that the additive gene action influences this trait. The results also agree with this. Otherwise, these results did not agree with [25,26], who noted that the environmental influence was more significant than the genetic influence on the grain yield. These data agree with [15,22], and Al-Agedi (2020), who obtained positive and negative effects of this trait. Furthermore, the results agree with[13,14], who obtained negative and positive values of GCA and SCA effects of leaf area.

The results in Table 5 show that there were significant differences in the SCA for the performance of the hybrid in the autumn season, as the 5 × 4 hybrid gave a positive and significant effect on all concentrations of salicylic acid (0, 200 and 400) mg L^{-1} which amounted to 64.39, 61.77 and 72.11 respectively, whereas the 4×1 hybrid was with control treatment recorded the lowest (4.73), which indicates the significant contribution of this hybrid to the inheritability of this trait towards the reducing the number of rows per ear. These results are similar to those of [19,22,24].

This result agrees with the results that obtained additive and non-additive genetic effects of maize grain weight and are similar to those of [15,20].

Conclusion

It can be concluded that the Zm 6 parent exceeded the number of rows per ear and weight of 300 grains for two seasons to benefit from the production of superior hybrids. Also, the BK116×ABS6 in the spring season and the Inb27×BK104 in the autumn were the best among the crosses due to a high plant grain yield (222.1 and 247.01 $plant^{-1}$), respectively. The highest grain yield for both seasons distinguished the spraying of salicylic acid at 200 mg L-1. In addition, the BK104×Inb27 hybrid with the spraying of salicylic acid at 400 mg L^{-1} was distinguished by the highest effect of SCA in the autumn season (72.11 g). Also, the inbreds and hybrids characterized by the highest yield can be invested in producing hybrids or synthetic varieties.

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