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المجلة العراقية لبحوث السوق
وحماية المستهلك

STUDY OF SOME GROWTH CRITERIA OF SINGLE CROSSES AND ITS PARENT OF MAIZE IN THE SPRING AND FALL SEASON

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ABSTRACT

A field experiment was conducted using five in bred lines of maize: NADH 102, NASA 2022, NAEL 2022, NA 9928 E, and NADH 2006, (numberd 1,2,3,4,5 respectively) In the first season of spring 2022, a half-diallel Crossing program was employed to obtain (10) single crossing hybrids. Subsequently, the parents and single cross hybrids were planted in two comparison experiment in the fields of the College of Agricultural Engineering Sciences - University of Baghdad / Jadriyah during the spring and fall seasons of 2023, following a RCBD design with four replications. To study the traits days to silking, ear height, leaf area index (LAI), ear length, days to physiological maturity (DTM), crop growth rate (CGR), ear weight, total dry matter (TDM), yield per unit area, and harvest index (HI). The results of the study showed significant differences between the genotypes, parent 1 recorded the highest yield per unit area, at 15.45 and 15.86 tons ha^{-1} for both seasons due to its superiority in CGR (6.32 and 6.54 g plant^{-1} day^{-1}) for both seasons, as well as the highest ear weight (356.8 and 366.0 g) and highest TDM (594.8 and 628.4 g), with no significant difference with parent 3, with yield per unit area of 13.86 and 14.95 tons ha^{-1} for the two seasons, respectively. Due to its superiority in LAI, ear weight, and HI. Among the hybrids, the single cross hybrid (4×2) excelled with the highest yield, at 22.8 and 24.0 tons ha^{-1} due to its superiority in ear height (136.7 and 130.3) and highest TDM (697.0 and 672.8 g) for the two consecutive seasons. There is no significant difference between hybrid (2×4), and hybrid (1×5) with a yield of 22.7 and 23.1tons ha^{-1} for the two seasons, respectively, due to its early silking, DTM, and HI. We suggest studying single cross hybrids at different planting dates to demonstrate their ability to adapt to the Iraqi climate and test them under stress conditions such as drought and salinity.

Keywords: Crop Growth Rate, Harvest Index (HI‹) half diallel crossing, Yield potential,

[*] **This article is taken from the doctoral dissertation of the first researcher**.

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دراسة بعض معايير النمو لتضريبات فردية وابائها من الذرة الصفراء في الفصل الربيعي والخريفي

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الخلاصة

تم اجراء تجربة حقلية باستعمال خمس سلالات نقية من الذرة الصفراء وهي NADH 102 وNASA 2022 و NAEL 2022 وNA9928 وNADH 2006 (رقمت1 و2و3 و4 و 5 بالتتابع), في الموسم الاول ربيع 2022 ادخلت في برنامج تهجين تبادلي نصفي للحصول على (10) هجن فردية, ثم زرعت الآباء والهجن الفردية في تجربتي مقارنة في حقول كلية علوم الهندسة الزراعية – جامعة بغداد / الجادرية خلال الموسمين ربيع وخريف 2023 وفق تصميم RCBD بأربعة مكررات، لدراسة صفات عدد ايام التزهير الانثوي وارتفاع العرنوص ودليل مساحة الاوراق (LAI) وطول العرنوص وعدد أيام النضج الفسلجي (DTM) ومعدل نمو المحصول (CGR) ووزن العرانيص والوزن الجاف (TDM) وحاصل وحدة المساحة ودليل الحصاد (HI). اظهرت نتائج الدراسة وجود فروقات معنوية بين التراكيب الوراثية وسجل الأب 1 أعلى حاصل لوحدة المساحة بلغ 15.45 و 15.86 طن هـ$^{-1}$ للموسمين بسبب تفوقه بأعلىCGR (6.32 و6.54 غم نبات $^{-1}$ يوم$^{-1}$) للموسمين، واعلى وزن للعرنوص (356.8 و366.0غم) واعلى TDM(594.8 و628.4 غم) ولم يختلف عنه معنوياً الأب 3 بحاصل بلغ 13.86 و14.95 طن هـ$^{-1}$ للموسمين بالتتابع, بسبب تفوقه بأعلى LAI ووزن العرانيص وHI. ومن الهجن تفوق الهجين الفردي (4×2) بأعلى حاصل بلغ 22.8 و24.0 طن هـ$^{-1}$ بسبب تفوقه باعلى ارتفاع للعرنوص (136.7 و130.3) و اعلى TDM (697.0 و672.8غم) للموسمين بالتتابع، ولم يختلف عنه معنوياً الهجين (5×1) بحاصل بلغ 22.7 و23.1 طن هـ$^{-1}$ للموسمين بالتتابع, بسبب تبكيره بالتتزهير، وDTM وHI. نقترح دراسة الهجن الفردية عند مواعيد زراعة مختلفة لبيان قدرتها على التكيف البيئي لمناخ العراق، واختبارها تحت شدود لا حيوية كالجفاف والملوحة.

الكلمات المفتاحية : معدل نمو المحصول، دليل الحصاد، التضريب التبادلي النصفي، الحاصل الكامن.

INTRODUCTION

The studies conducted by Shull and East were among the first to investigate the effect of hybridization on the yield of maize. They showed that the yield could be increased by 40% in the first generation by using diallel hybridization to produce single cross hybrids. The main goals of plant breeders are to increase crop yield, remove a specific defect from it, or breed it for a specific purpose **(Sedgley, 1991).** Maize is a crop that is easy to hybridize, so plant breeders have focused on this crop by conducting numerous experiments to transfer pollen from male to female plants, as it is a monoecious cross-pollinating plant. The importance of maize is due to its multiple uses. It is used directly or indirectly in human food through its many industrial applications. Its grains contain carbohydrates, protein, oil, and some minerals and vitamins, which makes it a food of high nutritional value.

The cultivation of maize in Iraq is still below the desired level, despite the spread of the cultivation of single, triple cross hybrids and synthetic varieties. The mean production yield of this crop is low compared to global production. This could be due to the fact that the Iraqi farmer is accustomed to cultivating open-pollinated and synthetic varieties and not relying on the cultivation of single cross hybrids due to the difficulty of importing them and the weakness of soil and crop management's techniques, in addition to the weak government orientation towards the agricultural reality. Therefore, it is necessary to pay attention to the breeding and

improvement of this crop to achieve a significant increase in grain yield and improve its quality through the implementation of breeding and improvement programs for this crop.

The difficulty of obtaining pure and superior inbred lines in terms of yield and their combining ability when crossed with others is inbreds or difficulty facing plant breeders. Therefore, the crossing of single cross hybrids that are superior in their productive and genetic traits and their ability to adapt to environmental conditions has become one of the most important tasks of plant breeders.

This study aims to develop and test single cross hybrids resulting from the crossing of five genetically diverse inbred lines, with the purpose of initiating a breeding program to develop one or more hybrids with high productivity and good qualitative traits under local conditions in Iraq.

MATERIALS AND METHODS

A field experiment was conducted using five inbred of maize: These inbred lines are yellow-orange, white, sugary, red, and purple, respectively. They were obtained from the College of Agricultural Engineering Sciences / Department of Field Crops. The inbred lines were entered into a half-diallel crossing program using **(Griffing, 1956)** Method 2 during the spring season of 2022 to obtain ten single cross hybrids.

Field managements

The experiments were conducted in the fields of the College of Agricultural Engineering Sciences, University of Baghdad - Jadriyah, over four consecutive growing seasons, spring and fall of 2022 and 2023. All agricultural operations, including plowing, leveling, and partitioning according to the study requirements and seasons, were carried out. Additionally, all agricultural activities such as irrigation, weeding, fertilizing.

First season (Spring 2022)

The seeds of the mentioned five inbred lines were sown directly in furrows with a length of 5 meters, spaced at 0.75 meters apart, and between plants of 0.25 meters. Each inbred line was planted in ten furrows on March 20, 2022, for the purpose of conducting half-diallel crosses between the inbred lines (Table 2) and obtaining ten single cross hybrids following Griffing's (1956) second method, S=P(P-1)/2. When the plants reached the tasseling stage, the female inflorescence were covered with paper bags before silk emergence to facilitate the desired pollination and prevent open pollination between the inbred lines. Similarly, the male tassels of the five inbred lines were covered with paper bags one day before the start of the cross-pollination process between the inbred lines. Then, pollen grains from ready male tassels were collected and used to pollinate the female inflorescence of the five inbred lines to receive pollen grains. This process continued until all the required crosses between the inbred were completed. Additionally, self-pollination was performed for the five inbred lines for seed multiplication purposes for planting in subsequent seasons.

Second and third season (Spring 2023)

The first and second comparison experiments were conducted in the spring and fall seasons (2023). Single cross hybrid seeds and inbred lines (15 genotype combinations) were planted on March 15, 2023, and July 15, 2023, respectively, using a randomized complete block design with four replication . Planting was done in furrows with a spacing of 0.75 meters between furrows, and between plants 0.25 meters. Initially, three seeds were sown per hole and later thinned to one plant per hole two weeks after germination. All soil and crop management operations, including plowing, harrowing, leveling, irrigation, weeding, and weed control, were conducted as previously mentioned. The traits studied included the number of days to silking, ear height, leaf area index (LAI), ear length, days to physiological maturity (DTM), crop growth rate (CGR), ear weight, total dry weight (TDM), yield per unit area, and harvest index (HI).

Statistical analysis

Statistical analysis was performed for each trait using analysis of variance (ANOVA) with a randomized complete block design (RCBD). Significance was tested using the F-test at a significance level of 0.05. Arithmetic means were compared using the least significant difference (LSD) test at a significance level of 0.05 for all means using GenStat 2014 software. Steel and. (**Steel & Torrie,1980)**.

RESULTS AND DISCUSSION

Number of days from planting to 75% silking (days)

The results indicate a significant effect for number of days to 75 % silking for both seasons (Table 1). inbred line 5 exhibited the earliest onset silking, with durations of 60.25 and 53.00 days for the respective spring and fall seasons. This preceded the flowering onset of inbred lines 1, 2, and 3 by margins of 5.25, 5.75, and 6.25 days, respectively. In contrast, inbred line 4 experienced a delay of 14.25 days compared to inbred line 5 during the spring season. While in the fall season, inbred lines 1, 2, and 3 were delayed by 5.75, 3, and 8 days respectively compared to inbred line 5. Additionally, inbred line 4 was delayed by 17 days compared to inbred line 5 in the fall season.

The single cross hybrid ((1×5) outperformed its parent (parent 5), flowering earlier at 60 days. There was no significant difference between this hybrid and the single cross hybrids (2×5), (3×5), and (1×4) . However, the latest single cross hybrid to reach 75% tassling was the hybrid (1×3), taking 68.00 days, followed by hybrids(1×2) and (2×3) at 65.5 and 64.00 days, respectively, in the spring season. In the autumn season, the single cross hybrid (1×5) was also the earliest to flower, taking 51.00 days, with no significant difference from the hybrid (3×5). While, the single cross hybrid (3×4) was delayed at 62.00 days. to reach 75%silking, with no significant difference from the hybrid (2×5), which took 60.50 days. The reason for the difference in the time to reach silking stage between single cross hybrid plants and their parents is that the genotypes vary among themselves according to the morphological traits and their degree of influence by temperature and photoperiod, which leads to a difference in the number of days required to reach silking. This finding is consistent with the conclusions reached by **Hassan *et al.*, (2019); Kazem, (2020); Hadi *et al.*, (2019a).**

Table (1): Number of days to 75% silking for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	65.50 58.75	65.50 58.00	68.50 54.25	60.50 55.50	60.00 51.00
2		66.00 56.00	64.00 54.75	61.50 57.25	60.00 60.50
3			66.50 61.00	61.50 62.00	60.25 52.50
4				74.50 70.00	62.50 58.50
5					60.25 53.00
LSD 5%	0.72 3.03				

Ear height (cm)

The results reveal significant differences among parents and their single cross hybrids in both seasons (Table 2). inbred line 4 exhibited the highest mean ear height, at 138.50 cm, while the lowest mean ear height was recorded for inbred line 5 at of 50.33 and 61.71 cm for the two experimental seasons, respectively. In the fall season, inbred line 1 surpassed with the highest mean ear height of 99.66 cm, which did not significantly differ from inbred line 4with mean of 99.58 cm.

The single cross hybrid (2×4) displayed the highest mean for both seasons, with heights of 136.67 and 130.29 cm, respectively. It did not significantly differ from the single cross hybrid (4×3), which had ear heights of 126.08 and 126.12 cm for the two seasons, respectively. The lowest mean ear height was observed for the hybrid (3×5)in both seasons, with heights of 74cm and 86.75 cm, respectively, which did not significantly differ from the hybrid (1×5), yielding mean heights of 87.42 and 89.33 cm for the two seasons, respectively. The variation in ear height between the parents and their single cross hybrids is attributed to differences in genetic performance due to genetic factors in addition to variations in the plant height. This finding is supported by **Kazem, (2020); Hadi *et al.*, (2021); Hassan *et a.*, (2018); Al-Mousawi &Hassan, (2020).**

Table (2): Ear height (cm) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	91.83 99.66	114.00 128.91	96.75 108.75	119.00 114.79	87.42 89.33
2		73.83 72.75	112.16 108.62	136.67 130.29	96.66 93.95
3			84.33 83.12	126.08 126.12	74.00 86.75
4				138.50 99.58	105.25 105.45
5					50.33 61.71
LSD 5%	14.32				
	10.97				

Leaf Area index (LAI)

Leaf area index (LAI) is a key trait that directly or indirectly affects yield through its association with other yield components. This is because LAI is the primary source of dry matter deposited in grains through photosynthesis. The results of Table (3) showed significant differences between the among parents and single cross hybrids, as parent 3 outperformed with the highest mean trait value of 2.81 and did not significantly differ from parents 1 and 4, with mean of 2.61 and 2.67, respectively. While, the lowest mean was for parent 5 at 1.31 in the first season (spring). In the second season (fall), parent 4 surpassed with the highest mean of 3.77, while parent 5 again exhibited the lowest mean trait value of 1.85.

The variability among the parents was reflected in their single cross hybrids. In the spring season, the single cross hybrid (1×4) outperformed with the highest mean leaf area index of 3.05 and did not significantly differ from hybrids (4×3) and (5×4), as their mean leaf area index was 2.85 for each. While, the hybrid(3×5) exhibited the lowest at 2.06 and did not significantly differ from the hybrid (1×3) with an mean of 2.20. In the fall season, the hybrid (2×4) the highest mean at 3.46 and did not significantly differ from the hybrid (1×2) with an mean of 3.34, the latter of which did not significantly differ from the hybrid (1×4).The single cross hybrid (2×3) recorded the lowest mean at 2.35 and did not significantly differ from hybrids (1×5) and (2×5) with mean of 2.41 and 2.46, respectively.

The variation in leaf area index between the parents and their single cross hybrids may be attributed to differences in leaf area (data from another study), aligning with findings by**. Kazem & Hassan, (2020); Abd *et al.*, (2017a); Hadi *et al.*, (2023a).**

Table (3): Leaf area index for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	2.61 2.86	2.50 3.34	2.20 2.81	3.05 3.14	2.55 2.41
2		2.20 2.33	2.77 2.35	2.79 3.46	2.83 2.46
3			2.81 2.87	2.85 2.95	2.06 2.81
4				2.67 3.77	2.85 2.73
5					1.31 1.85
LSD 5%	0.22				
	0.20				

Ear length (cm)

Results of Table (4) indicate significant differences among parents and their single cross hybrids. Parent 4 surpassed with the highest ear length for both seasons at 16.75 and 18.25 cm, respectively. It did not significantly differ from the first parent with ear lengths of 16.33 and 17.54 cm for the two seasons, respectively. Parent 2 exhibited the lowest ear length at 11.41 cm, which did not significantly differ from parent 5, with an ear length of 12.33 cm for the spring season and possessing the lowest in the fall season at 12.92 cm.

The single cross hybrid (1×4) outperformed with the highest ear length for both seasons, at 18.75 and 20.25 cm, respectively, and did not significantly differ from the single cross hybrid (3×4) in the spring season with an mean ear length of 18.45 cm, nor from hybrids (1×2) and (2×4) in the fall season with mean ear lengths of 19.17cm and 19.33 cm, respectively. The lowest ear length was observed for the single cross hybrid (3×5)for both experimental seasons, at 13.08cm and 14.46 cm, respectively. The superiority of parent 4 in ear length can be attributed to its superiority in ear height (138.50cm and 99.66 cm) for both seasons, as well as its superiority in leaf area index (2.67 and 3.77) for both seasons. Similarly, the superiority of the single cross hybrid (1×4) can be attributed to its superiority in ear height and leaf area index, aligning with the findings of **Abed *et al.*, (2017b); Al-Najmawi, (2023); Al-Aimri, (2021).**

Table (4): Ear length (cm) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	16.33 17.54	17.33 19.17	13.96 16.58	18.75 20.25	16.96 17.25
2		11.41 13.12	15.67 17.37	17.75 18.75	14.87 16.75
3			14.66 15.46	18.45 19.33	13.08 14.46
4				16.75 18.25	15.83 17.58
5					12.33 16.96
LSD 5%	1.37 1.10				

Days to physiological maturity (DTM)

Results from Table (5) indicate significant differences of days from planting to 95% physiological maturity among the genotypes (parents and their single cross hybrids). In the spring season, parent 5 exhibited the earliest days to reach physiological maturity, with 88.50 days, followed by parent 3, which took 92.25 days. During both experimental seasons, parent 4 exhibited delayed physiological maturity compared to the other parents, requiring 103 and 115 days to reach this stage, respectively**.** In the season, parent 5 also showed the earliest days to reach physiological maturity at 93.00 days.

The hybrid (1×5) displayed the fewest days to reach physiological maturity at 90.50 days and did not significantly differ from the hybrid (2×5), which delayed by one day. However, the hybrid (1×4) required the most days to reach physiological maturity at 104.50 days and did not significantly differ from the hybrid (4×2), which lagged behind by one day, both in the spring season. In the fall season, the hybrid (2×5) exhibited the fewest days to reach physiological maturity at 93.00 days, while the hybrid (1×4) took the most days at 107.50 days, delayed by 3.5, 4.25, and 5 days compared to the hybrids (2×4), (3×4), and (4×5), respectively. The superiority of parent 5 and the hybrid derived from it (1×5) can be attributed to their being the earliest in reaching silking , with 60.25 and 53.00 days for parent 5 in both seasons and 60.00 and 51.00 days for the hybrid derived from it (1×5) These results agreed with the findings **of Hadi *et al.*, (2019b); Hassan *et a.*, (2018); Hassan & Hadi (2022); Al-Baidhani, (2022).**

Table (5): Days to physiological maturity for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	94.00 95.25	94.00 96.00	94.00 96.50	104.50 107.50	90.50 94.50
2		93.75 94.25	93.25 95.50	103.50 104.00	91.50 93.00
3			92.25 94.50	100.00 103.25	93.50 96.25
4				103.25 115.00	102.75 102.50
5					88.50 93.00
LSD 5%	1.08 1.40				

Crop Growth Rate (CGR)

The results from Table 6 indicate significant differences between inbred lines and diallel hybrids in crop growth rate. The first inbred line outperformed with the highest mean crop growth rate(CGR) in the two seasons at 6.32 and 6.54 g plant^{-1} day^{-1}, respectively, which was significantly different from the other parents. The lowest growth rate was recorded by parent 5 in both seasons, at 2.70 and 3.00 g plant^{-1} day^{-1}, which did not significantly differ from parent 2, whose mean growth rate was 2.96 and 3.67 g plant^{-1} day^{-1} for the two seasons.

The single cross hybrids hybrid (5×1) exhibited the highest mean growth rate at 6.90 g plant^{-1} day^{-1} and did not significantly differ from hybrids (1×2), (1×4), and (2×4), which had growth rates of 6.83, 6.39, and 6.74 g plant^{-1} day^{-1}, respectively, followed by the hybrid (3×4) with an mean crop growth rate of 6.14 g g plant^{-1} day^{-1} in the spring season. The lowest crop growth rate for both seasons was in hybrid (3×5) at 4.21 g plant^{-1} day^{-1} for both, which did not significantly differ from hybrid (5×4). The highest growth rate in the fall season was in hybrid (1×2) at 6.82 g plant^{-1} day^{-1}, which did not significantly differ from hybrids (1×4) and (1×5), with mean trait values of 6.26 and 6.72 g plant^{-1} day^{-1}, respectively. The superiority of hybrid (1×5) in growth rate could be attributed to its early silking by 60.00 and 51.00 days for both seasons (Table 1), as well as its early physiological maturity (Table 5). These results were aligned with the findings of **Al-Mohammady, (2022); Al-Najmawi, (2023); Wuhaib *et al.*, (2018); Al-Maliki & Abed, (2019).**

Table (6): Crop Growth Rate (CGR) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons of 2023.

Parents	1	2	3	4	5
1	6.32 6.54	6.83 6.82	5.57 5.35	6.39 6.26	6.90 6.72
2		2.96 3.67	5.19 5.03	6.74 5.77	5.09 4.89
3			4.58 4.86	6.14 5.71	4.21 4.21
4				4.60 4.39	4.51 4.67
5					2.70 93.00
LSD 5%	1.08				
	1.40				

Ear Weight (g)

The results from Table 7 indicate significant differences between the genotypes (inbred lines and single cross hybrids) in ear weight. The first parent had the highest mean value for the trait in both seasons, with a mean of 356.80g and 366.03 g, respectively. This was significantly different from the other parents, with the exception of parent 3, which had a mean of 300.80 and 327.53 g for the two seasons, respectively. The difference between the first parent and parent 3 was not statistically significant. The lowest mean 147.22 g for parent 2 in the first season, not significantly different from parents 4 and 5, whose ear weights were 175.33 and 159.50 g, respectively, for both seasons. In the fall season, the lowest mean was recorded for parent 4 at 190.59 g, not significantly different from parents 2 and 5 with mean of 191.28 and 199.38 g, respectively.

The single cross hybrid (2×4) exhibited the highest mean ear weight at 561.94 g in the first season, not significantly different from hybrids (1×4) and (1×5) with ear weights of 512.91gm and 507.00 g, respectively. The hybrid (3×5) recorded the lowest mean for the trait at 242.80 and 254.36 g for both seasons, not significantly different from hybrids (2×5) and (4×5). In the fall season, hybrid (1×4) had the highest mean at 514.83 g, not significantly different from hybrid (1×5) with an mean of 514.31 g.

The superiority of the first parent in this trait can be attributed to its higher crop growth rate, at 6.32 and 6.54 g plant^{-1} day^{-1} (Table 6). Similarly, the superiority of hybrid (2×4) in the spring season is due to its higher ear height of 136.67 cm (Table 2), while the superiority of hybrids (1×4) and(1×5) in the fall season is attributed to their superiority in several traits such as silking, leaf area index, ear length, ear weight, and crop growth rate (Tables 1, 3, 4, 5, and 6), .Theses results agreed with the findings of **Hadi *et al.*, (2023b); Wuhaib *et al.*, (2017); Khalaf & Hassan, (2022).**

Table (7): Ear Weight (g) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	356.80 366.03	423.60 399.45	368.33 351.90	512.91 514.83	512.91 514.83
2		147.22 199.38	339.53 335.86	561.94 462.40	561.94 462.40
3			300.80 327.53	423.40 397.68	423.40 397.68
4				175.33 190.59	175.33 190.59
5					159.50 191.28
LSD 5%	69.57 67.48				

The Total Dry Matter (TDM)

Results, as presented in Table (8), indicated significant differences among the inbred lines and single cross hybrids in total dry weight for both spring and fall seasons. The inbred line 1 excelled with the highest mean dry weight for both experimental seasons at 594.8 and 628.4 grams, respectively, while the lowest mean was for both seasons inbred line 5 at 239.0 and 279.0 grams, respectively. There was no significant difference from the inbred line 2, with an mean of 277.1 and 346.0 grams for both seasons, respectively.

The single cross hybrid (2×4) showed the highest mean dry weight in the spring season at 697.0 grams and did not differ significantly from hybrids (1×2) and (1×4), with mean of 642.5 and 667.2 grams, respectively. The lowest mean dry weight for both seasons for hybrid (3×5) was 393.4 and 404.6 grams, respectively, and did not significantly differ from hybrid (4×5) in the spring season, with an mean of 463.3 grams. In the fall season, the highest mean dry weight was recorded for hybrid (1×4) at 672.8 grams, and there was no significant difference from the single cross hybrids (1×2), (1×5), and (2×4).

The reason for the superiority of the parent 1 in this trait is its superiority in the highest growth rate at 6.32 and 6.54 grams plant^{-1} day^{-1} for both seasons (Table 6), and the highest ear weight of 356.80 and 366.03 grams (Table 7). The reason for the superiority of single cross hybrid (2×4) in the spring season is its superiority in the highest ear height and the highest ear weight (Tables 2 and 7). The reason for the superiority of single cross hybrid (1×4) in the fall season is its superiority in ear length, at 20.25 cm (Table 4), which is consistent with findings by **Hadi & Hassan, (2021); Ali & Kadhm, (2023); Brto & Hadi, (2023);** who found significant differences between parents and their single cross hybrids in the trait of dry weight.

Table (8): The Total Dry Matter (TDM) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons of 2023**.**

Parents	1	2	3	4	5
1	594.8 628.4	642.5 649.9	523.3 516.1	667.2 672.8	624.2 634.4
2		277.1 346.0	483.2 480.1	697.0 600.4	465.5 455.1
3			422.3 459.0	613.5 589.5	393.4 405.6
4				475.2 504.7	463.3 478.8
5					239.0 279.0
LSD 5%	69.12 79.01				

Yield per unit area (ton ha^{-1})

The analysis of the data presented in Table 9 indicates the presence of statistically significant differences in grain yield between the evaluated inbred lines and single cross hybrids. This was consistent across both the spring and fall seasons. The parent 1 achieved the highest mean total yield at 15.45 tons ha^{-1} for the first season and 15.86 tons ha^{-1} for the second season, significantly differing from the other parents except for parent 3, which did not significantly differ with mean of 13.86 and 14.95 tons ha^{-1} for both seasons, respectively. Parent 2 yielded the lowest mean area yield, with 4.84 tons ha^{-1}, not significantly different from parents 4 and 5 with mean of 5.32 and 6.79 tons ha^{-1}, respectively, for the spring season. In the fall season, parent 4 had the lowest area yield at 7.37 tons ha^{-1}.

It is notable from the table that in the second season, the total yield increased for all parents and hybrids compared to the first season. The single cross hybrid (2×4) achieved the highest mean total yield for both seasons at 22.79 and 24.02 tons ha^{-1}, respectively, not differing significantly from hybrids (1×4) and (1×5), which achieved mean total yields of 20.15, 21.08, 22.68, and 23.06 tons ha^{-1} for the two seasons, respectively. Hybrid (3×5) yielded the lowest mean total yield at 10.93 and 11.54 tons ha^{-1}, respectively, not differing significantly from hybrids (2×3), (2×5), and (4×5), which achieved mean yields of 13.19, 12.11, and 11.35 tons ha^{-1} for the two seasons, respectively. The reason for the superiority of the first parent in achieving the highest yield for both seasons could be attributed to its higher crop growth rate (6.31 and 6.54), as well as its higher ear weight (356.80 and 366.03) and dry matter weight (594.8 and 628.4) for both seasons (Tables 6, 7, and 8). The superiority of hybrid (2×4) in yield is due to its higher ear height for both seasons (136.67 and 130.29), higher leaf area index for the fall season (3.46), and higher ear and dry matter weight for the spring season (561.94 and 697.0) (Tables 2, 3, 7, and 8). These findings align with those of **Al-Essawi & Abed, (2020); Hadi *et al.*, (2019a); Wuhaib *et al.*, (2017); Kazem & Hassan, (2021).**

Table (9): Yield per unit area (ton ha^{-1}) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons of 2023.

Parents	1	2	3	4	5
1	15.45 15.86	17.61 19.43	15.03 16.50	20.15 21.08	22.68 23.06
2		4.84 12.32	13.19 13.27	22.79 24.02	12.11 13.73
3			13.86 14.95	16.22 16.42	10.93 11.54
4				5.32 7.37	11.35 12.98
5					6.79 10.11
LSD 5%	3.04 2.47				

Harvest Index (HI)

The analysis of harvest index data presented in Table 10 revealed statistically significant differences between the genotypes. Parent 3 achieved the highest mean harvest index at 62.21, which was not statistically different from Parent 5, with mean of 53.41. Parent 4 recorded the lowest mean harvest index in both seasons, at 21.00 and 27.60, respectively. This was not statistically different from Parent 2 in the spring season. In the fall season, all parents demonstrated higher harvest indices compared to the spring season, with Parent 5 having the highest average at 68.08, which did not significantly differ from Parents 2 and 3, with mean of 66.80 and 61.16, respectively.

The single cross hybrid (1×5) achieved the highest mean harvest index at 68.50, not differing significantly from hybrid (2×4) with mean of 61.81. The lowest mean was obtained by hybrid (4×5) at 46.20, not differing significantly from the other hybrids, whose trait mean ranged from 57.00 for hybrid (4×1) to 50.31 for hybrid (3×4) in the spring season. In the fall season, hybrid (2×4) excelled with the highest mean harvest index at 76.56, not differing significantly from hybrid (1×5) at 68.09, while the lowest mean for the trait was 51.18, also for hybrid (4×5), not differing significantly from hybrids(1×2), (1×3), (2×3), (2×5),(3×4), and(3×5).

The superior performance of Parents 3 and 5 in the spring season could be attributed to their superiority in several traits such as silking, leaf area index, physiological maturity, and total yield (Tables 1, 3, and 9). These findings align with those of **Al-Amili, (2023); Al-luhaibi, (2022); Abd alwahed, (2022); Al-Badrani, (2020).**

Table (10): Harvest Index (HI) for single cross hybrids and their parental lines (diagonal values) of maize for the spring (upper values) and fall (lower values) seasons 2023.

Parents	1	2	3	4	5
1	48.80 47.82	51.21 56.15	54.00 60.33	57.00 58.87	68.50 68.09
2		32.60 66.80	51.50 52.09	61.81 76.56	49.30 56.52
3			62.21 61.16	50.31 52.07	52.00 53.24
4				21.00 27.60	46.20 51.18
5					53.41 68.08
LSD 5%	11.34				
	9.36				

CONCLUSION

The study conducted on five inbred lines of maize revealed significant genetic variability among the genotypes, with parent 1 exhibiting the highest yield per unit area attributed to its superior crop growth rate, ear weight, and total dry weight, while parent 3 also showed promising results. Among the hybrids, the single cross hybrid (2×4) stood out with exceptional performance in yield per unit area due to its superior ear height and total dry weight. The findings suggest the potential for these hybrids to contribute to maize production under varying environmental conditions in Iraq, particularly under abiotic stresses such as drought and salinity. The study recommends further investigation into the adaptability of single cross hybrids to the Iraqi climate, including testing them at different planting dates to enhance their environmental resilience and agricultural productivity.

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