Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

Maize Hybrids Production for Direct Consumption by Three –Way Crosses

Kamal A. Kazem* , Nadhum. Y. Abed
Department of Field Crops, College of Agricultural Engineering Sciences, University of Baghdad.

ABSTRACT

This study was aimed to produce and evaluate 30 triple cross hybrids generated by crossing ten single hybrids with five genetically diverse inbred lines. A field experiment was conducted using five inbred lines of maize: (1) NADH 102, (2) NASA 2022, (3) NAEL 2022, (4) NA 9928 E, and (5) NADH 2006. In the first spring season 2022, the genetic materials used by half-diallel crosses program to produce (10) single crosses. In the fall season, parental inbred lines and single crosses were subjected to a triple hybridization program. The results of this study revealed significant differences among the genotypes, of triple hybrid (2×5) ×3 produced the highest yield per unit area for both seasons at 23.41 and 23.55 tons ha^{-1}. But did not significantly differ from the triple hybrids (1×3) ×2, (2×3) ×4, and (2×4) ×1, which yielded 22.19, 22.82, and 20.88 tons ha^{-1}, respectively. The superiority of the triple hybrid (2×5) ×3 could be attributed to its higher, increased number of kernel row per ear, resulting in a higher weight of ears, which reached 556.5 and 553.4 gm for both seasons, as well as the highest yield per individual plant, reaching 439.2 and 441.5 grams.

Key words: Grain yield, single hybrids, Spring and fall season, *Zea mays* L.

Received: 16/1/2024, Accepted: 24/4/2024, Published: 30/6/2026

INTRODUCTION

Studies were conducte to maize (*Zea mays L.*) by Shull (1910)(43) on the effect of hybridization on the grain yield of maize. He demonstrated that the yield increased by 40% in the first generation as a result of using diallel crosses for inbred lines to produce single cross hybrids. The primary objectives of plant breeders are either to increase grain yield, eliminate specific defects, or breed for a particular purpose, as noted by (Saleh & Salmand, 2005). Maize is known for its ease of hybridization, which has attracted the attention of plant breeders since ancient times. Numerous experiments have been conducted to transfer pollen grains from male to female plants, as they are monoecious cross-pollinated plants. Due to its versatility, yellow maize is used directly or indirectly in human food, as its grains contain carbohydrates, proteins, oil, as well as some minerals and vitamins, making it highly nutritious, Maize cultivation in Iraq remains below the required level despite the spread hybrids, and synthetic varieties. The average yield of this crop is low compared to global production, possibly because Iraqi farmers are accustomed to cultivating open-pollinated varieties, and did not rely on single or triple hybrids due to the difficulty of importing them and the poor technical capabilities of soil and crop management practices. Therefore, it is necessary to focus on breeding and improving this crop to achieve a significant increases in grain yield and improve its quality through the implementation of breeding and improvement programs (Elsahookie & Dawood, 2021). The difficulty in obtaining pure and superior lines and their ability to combine when crossed with other lines, also a challenge faced by plant breeders. Therefore, multiplying superior triple hybrids with productive and genetic traits, as well as their adaptability to environmental conditions, has become one of the important tasks for plant breeders .The difficulty in producing hybrids or varieties stems from the challenge of obtaining parents, especially in-

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

bred lines, and the subsequent changes to those strains. It is essential to determine their combining ability with other strains and their suitability for producing high-yielding hybrids through various breeding systems, (Elsahookie & Dawood, 2021). This study was aimed to production three –way hybrids and evalution the crosses.

MATERIALS AND METHODS

Field experiment: A field experiment was conducted using five inbred lines of maize (Table 1): (1) NADH 102, (2) NASA 2022, (3) NAEL 2022, (4) NA 9928 E, and (5) NADH 2006, developed at the College of Agricultural Engineering Sciences. These inbred lines included yellow-orange, white, sugary, red, and purple, respectively.. The lines were crossed by half-diallel crosses program according to Griffing's (Griffing,1956).) method during the spring season of 2022 to produce ten single hybrids. During the fall season of the same year, the parental lines and single hybrids were entered into a triple hybridization program according to Cockerham and Rawling's (Rawlings and Cocker ham,1962) method, resulting in 30 triple hybrids, following the equation C=P(P-1)(P-2)/2. Each triple hybrid was expressed with three numbers inside parentheses (representing single hybrids), indicating the two lines as grandparents, while the number outside the parentheses indicated the inbreds as a parent, to obtain 30 triple hybrids.

Field managements: The field experiments were conducted at 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 managements, including plowing, harrowing, leveling, and partitioning, were carried out according to the study requirements and the seasons. Additionally, all agricultural practices such as irrigation, hoeing, weeding, were conducted according to recommendations, Fertilization was done with triple superphosphate fertilizer (46% P_2O_5) at a rate of 200 kg P_2O_5ha-1 in one batch before planting, and nitrogen fertilizer 350 kg N ha^{-1} in the form of urea (46% N) in three batches, the first two weeks after germination, the second in the elongation stage, and the third at the beginning of the flowering stage (Saleh and Salmand,2005).

First and second season (spring and fall 2022): In the first and second seasons (spring and fall 2022), seeds of the mentioned five inbred lines were sown in plots with a length of 5 meters and a spacing of 0.75 meters between rows, with plant spaced of 0.25 meters apart, totaling ten rows per inbred, on March 20, 2022, for the purpose of conducting half-diallel crossing between the inbred lines to obtain ten single hybrids according to Griffing's method (Griffing,1956). equation S=P (P-1)/2. In the fall season of the same year, the parental lines and single hybrids were entered into a triple crossing program according to Cockerham and Rawling's (1962) method, resulting in 30 triple hybrids following the equation C=P(P-1)(P-2)/2. Each triple hybrid was expressed with three numbers inside parentheses (representing individual hybrids), indicating the two inbred as grandparents, while the number outside the parentheses indicated the inbred as a parent. When the plants reached the flowering stage, the female ears were bagged with paper bags before silk emergence to ensure the desired pollination and prevent open pollination between the lines. Similarly, the male tassels of the five inbred were bagged with paper bags one day before the start of pollination between the inbred lines. Pollen grains were collected and used to pollinate the ready female ears of genotypes to receive the pollen grains. This process continued until all required crossing between the inbred lines and single hybrids were completed. Additionally, self-pollination was performed for the five inbred lines to increase their seed stock for planting in the subsequent seasons.

Third and fourth season (spring and fall 2023): In the third and fourth seasons (spring and fall 2023), first and second comparative experiments were conducted. Seeds of the 30 triple hybrids were planted on March 20, 2023, and July 20, 2023. The planting was applied using a Randomized Complete Block Design (RCBD) with four replications. The planting was on furrows 0.75 meters apart, with plant spacing of 0.25 meters, and with an average of three seeds per hole, which were later thinned to one plant per hole two weeks after germina-

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

tion. All agricultural managements for soil and crop management, including plowing, harrowing, leveling, irrigation, hoeing, weeding, and controlling weeds, were carried out as mentioned earlier. Statistical analysis was performed for each trait using Analysis of Variance (ANOVA) of Randomized Complete Block Design (RCBD). The significance of the differences was tested using the F-test at a significance level of 0.05. Mean comparisons were conducted using the Least Significant Difference (LSD) test at a significance level of 0.05 for all means.

RESULTS AND DISCUSSION

Number of days from seeding to 75% tasseling (day): The results in Table (1) indicate that the trait of the number of days to tasseling was significantly affected for both the spring and fall seasons. The result shows that the hybrids differed significantly in achieving 75% tasseling in the spring season. The hybrid (1×3)×2 exhibited the earliest tasseling, with a number of days (56.00 days) followed by hybrids (1×5) ×4, (3×4) ×5, and (3×5) ×4, each with a number of days at 57.50 days. The last triple hybrid to reach tasseling in the spring season was the hybrid (2×4) ×5, with a number of days (63.50 days) which did not significantly differed from the hybrid (1×4) ×2, with a number of days (63.00 days). In the fall season, the result shows that the triple hybrid (1×4) ×5 was the earliest in tasseling, with a number of days at 45.25 days, which did not differed significantly from hybrids (1×2) ×5, (2×3) ×5, (3×5) ×4, and (4×5) ×1, with number of days at 45.75, 46.00, 45.50, and 45.75 days, respectively. However, the last hybrid to reach 75% tasseling in the fall season was the hybrid (3×4) ×1, with a number of days at 55.50 days, which did not differed significantly from the hybrid (2×5) × 1, with a number of days (55.00 days). The variations in the tasseling among hybrids' is attributed to the genotypes differences in morphological traits and their responsiveness to environmental factors such as temperature and photoperiod, leading to differences in the number of days required to tasseling. These results are consistent with findings by Hadi and Hassan (2021), as well as Almousawi and Hassan (2020), indicating significant differences among triple hybrids in reaching tasseling.

Number of days from seeding to 75% silking (days): Data in Table (1) shows that the triple hybrid (3×5) ×1 silking 75% in the spring season earliest, with the least number of days, at 59.00 days, significantly differed from the other hybrids, followed by the hybrid (1×2) ×3 at 75% silking in 60.50 days, which did not differed significantly from the triple hybrids (1×2) ×4, (1×3) ×5, (1×5) ×4, (3×4) ×5, and (3×5) ×4, with number of days (61.50, 61.50, 61.00, 61.50, and 60.50 days), respectively. However, the hybrid (1×4) ×2 was delayed, taking more days to silking, at 67.50 days, which did not differed significantly from the hybrids (1×5) ×3, (2×3) ×1, and (2×4) ×3. In the fall season, the triple hybrid (3×5) ×2 reached 75% silking earliest, with the lowest number of days, (50.50 days), which did not differed significantly from the hybrid (1×2) × 5, with 51.50 days. However, the triple hybrid (3×4) ×1 was delayed in silking, 61.75 days, which did not differed significantly from the hybrid (2×5) ×1, which took 61.25 days. These results are consistent with those of Hamood (2019) and Hamdi (2021).

Plant height (cm): The differences in plant height varied among the triple hybrids in both seasons. Hybrid (1×5) ×2 had the highest mean plant height, (207.33 cm), which did not differed significantly from hybrid (1×2) ×4, with an mean height of 195.83 cm. The latter did not differed significantly from hybrids (1×4) ×3, (2×4) ×5, (2×5) ×1, (2×5) ×3, (3×4) ×1, and (3×5) ×4. The lowest mean height, 135.50 cm, was recorded by hybrid (4×5) ×1, which did not differed significantly from hybrids (1×4) ×5, (1×5) ×3, (1×5) ×4, and (2×4) ×3, with plant heights of 145.33, 137.41, 147.58, and 147.25 cm, respectively, in the spring season. In the fall season, hybrid (1×4) ×3 had the highest mean height, at 213.70 cm, which did not differed significantly from hybrids (1×2) ×4, (1×5) ×2, (2×4) ×1, and (3×4) ×1, with heights of 210.6, 205.6, 206.4, and 198.1 cm, respectively. Hybrid (4×5) ×1 produced the lowest mean plant height for the trait, at 151.9 cm, which did not differ significantly from hybrids (1×4) ×5, (1×5) ×3, (2×3) ×5, (2×4) ×3, (3×5) ×2, and (4×5) ×3, with

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

heights of 161.1, 161.1, 164.1, 158.5, 164.7, and 155.0 cm, respectively. The variation in plant height could be attributed to differences in the genetic nature of each genotype, as well as physiological activity within each hybrid. Additionally, differences in environmental conditions and the duration of growth, along with each genetic combination's ability to efficiently utilize growth factors, contribute to the variation in plant height. This aligns with the findings of Kazem and Hassan (2021).

Ear height (cm): In the spring season, hybrid (2×5) ×3 exhibited the highest ear height, at 143.91 cm (Table 1). It did not differed significantly from hybrids (1×2) ×4, (1×4) ×3, (1×5) ×2, (2×5) ×1, and (3×4) ×1, with heights of 141.66, 132.16, 137.50, 139.49, and 135.08 cm, respectively. The lowest mean ear height was produced by hybrid (1×4) ×5, at 85.58 cm, which did not differed significantly from hybrids (1×3) ×4, (2×3) ×5, (2×4) ×3, (3×5) ×2, and (4×5) ×1, with heights of 93.91, 99.00, 86.16, 100.08, and 95.75 cm, respectively. In the fall season, the three-way hybrid (1×5) ×2 was distinguished with highest ear height, of 150.58 cm, which did not differed significantly from hybrid (1×2) ×5, with a height of 150.41 cm. The lowest ear height was produced by hybrid 1×(5×4), at 89.00 cm, which did not differed significantly from hybrids (1×3) ×4, (1×4) ×5, (1×5) ×3, (2×4) ×3, (3×5) ×1, (3×5) ×2, (4×5) ×2, and (4×5) ×3, with heights of 100.91, 96.49, 100.79, 91.91, 98.62, 95.20, 101.12, and 95.49 cm, respectively. The variation in ear height could be attributed to differences in the genetic combination of the triple hybrids.

Table 1. The mean number of days to tasseling and silking, plant height, and ear height for triple hybrids of maize for the spring and fall seasons of 2023

Triple hybrids	Tasseling		Silking		Plant height		Ear height	
p1 p2 p3	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
(1×2) ×3	58.00	46.75	60.50	52.00	173.00	177.7	114.33	109.66
(1×2) ×4	58.25	50.50	61.50	57.50	195.83	210.6	141.66	130.12
(1×2) ×5	62.00	45.75	66.00	51.50	166.83	177.8	108.08	150.41
(1×3) ×2	56.00	48.75	60.50	54.50	180.83	185.3	117.24	108.24
(1×3) ×4	60.00	47.25	63.50	54.25	161.92	169.3	93.91	100.91
(1×3) ×5	58.00	49.50	61.50	55.00	167.42	171.4	121.83	107.29
(1×4) ×2	63.00	48.50	67.50	55.50	164.16	184.3	111.58	109.95
(1×4) ×3	59.25	52.25	63.50	56.50	185.25	213.7	132.16	130.16
(1×4) ×5	62.00	45.25	64.50	52.50	145.33	161.9	85.58	96.49
(1×5) ×2	61.00	51.00	65.00	60.50	207.33	205.6	137.50	150.58
(1×5) ×3	62.00	48.00	66.50	53.75	137.41	161.1	100.66	100.79
(1×5) ×4	57.50	48.25	61.00	53.75	147.58	171.9	105.16	109.41
(2×3) ×1	62.50	51.50	66.50	56.50	170.66	170.9	117.25	121.16
(2×3) ×4	59.50	50.75	62.00	57.75	180.58	187.4	125.83	133.70
(2×3) ×5	61.00	46.00	66.00	52.00	155.41	164.1	99.00	101.41
(2×4) ×1	58.50	52.00	62.00	57.50	172.66	206.4	117.33	129.20
(2×4) ×3	61.50	48.00	67.00	52.00	147.25	158.5	86.16	91.91
(2×4) ×5	63.50	47.50	65.00	52.50	185.17	186.5	127.00	118.58
(2×5) ×1	61.50	55.00	63.75	61.25	193.08	195.3	139.49	136.20
(2×5) ×3	60.00	53.00	64.00	59.75	192.33	194.8	143.91	126.54
(2×5) ×4	62.50	52.50	65.50	57.50	159.83	187.7	105.08	108.70
(3×4) ×1	60.50	55.50	63.50	61.75	194.58	198.1	135.08	120.54
(3×4) ×2	60.50	50.25	63.50	58.00	176.75	185.6	127.58	115.41
(3×4) ×5	57.50	50.50	61.50	57.50	164.00	175.2	120.83	115.79
(3×5) ×1	60.50	49.50	59.00	54.75	165.50	169.4	116.25	98.62
(3×5) ×2	61.50	45.50	64.50	50.50	150.92	164.7	100.08	95.20
(3×5) ×4	57.50	46.50	60.50	51.75	185.33	187.2	122.16	109.50
(4×5) ×1	61.00	45.75	64.50	51.75	135.50	151.9	95.75	89.00
(4×5) ×2	62.00	50.00	65.50	55.00	170.83	172.5	125.41	101.12
(4×5) ×3	61.50	48.50	64.50	55.50	148.83	155.0	102.00	95.49
LSD	0.92	1.07	1.27	1.12	12.07	16.45	15.05	12.34

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

Number of leaves (leaf plant^{-1}): The results of Table (2) indicate significant differences between the triple hybrids in leaf number plant-1. We notice that the hybrid (1×5) ×2 showed the highest mean of 14.17 leaves plant^{-1}, and did not differed significantly from the hybrids (1×2) ×4, (2×4) ×1, (2×4) ×5, (2×5) × 1, (2×5) ×3, and (3×4) ×2, with leaf numbers of 13.49, 13.66, 13.08, 13.25, 14.00, and 13.25 respectively. The lowest leaf count was 10.16 leaves plant^{-1} for both hybrids (2×3) ×5 and (2×4) ×3, which did not differed significantly from the hybrids (1×4) ×5, (1×5) ×3, (2×5) ×4, (3×5) ×1, and (3×5) ×2, with mean leaf numbers of 10.66, 10.58, 11.25, 10.66, and 11.16 respectively. In the fall season, the highest mean was 14.25 leaves plant^{-1} for the hybrid (1×5) ×2, which did not differed significantly from the hybrids (1×2) ×4, (1×4) ×3, and (2×4) ×1 with leaves numbered of 13.70, 13.54, and 13.66 respectively. Whereas, the lowest mean was 10.33 for the hybrid (2×4) ×3, which did not differed significantly from the hybrids (1×4) ×5, (1×5) ×3, and (2×3) ×5 with leaves number of 10.83, 11.21, and 10.87 respectively. The leaves number is a hereditary trait affected by environmental conditions. We notice that the triple hybrids that excelled in leaves number took longer to reach 75% tasseling and silking (Table 1). This indicates a longer vegetative growth stage, leading to taller plant and ear heights (Table 1), resulting in an increase in the number of nodes and internodes, hence an increase in the number of plant leaves. These results are consistent with Hashim (2017)

Leaf area (cm²): Results in Table (2) indicate significant differences between the triple hybrids in leaf area, with the hybrid (1×2) ×4 showed the highest mean of 5808 cm² in the spring season. It did not differed significantly from the hybrids (1×2) ×5, (1×5) ×2, (2×3) ×1, (2×4) ×1, (2×4) ×5, (2×5) ×1, and (3×5) ×4, with leaf areas of 5615, 5315, 5753, 5366, 5447, 5606, and 5550 cm², respectively. The lowest mean was produced by the hybrid (1×5) ×3 at 3621 cm², significantly differed from other triple hybrids. In the fall season, the hybrid (1×4) ×3 produced the highest mean leaf area of 6588 cm², not differing significantly from the hybrids (1×2) ×4, (1×5) ×2, (2×4) ×1, (2×5) ×4, and (3×4) ×1, which had leaf areas of 6326, 6308, 6212, 6200, and 6177 cm², respectively. The lowest means for leaf area were for the hybrid (2×4) ×3 at 3811 cm², not significantly differed from the hybrid (1×5) ×3 with a leaf area of 4302 cm². The significant differences in leaf area between the triple hybrids could be attributed to their genetic nature, the duration of plant growth, and height, which lead to increased cell division and consequently an increase in leaf area. These results are consistent with those of Al-luhaibi (2022)

Leaf area index (LAI): Significant differences were observed among the triple hybrids in leaf area index (LAI). In the spring season, the hybrid (1×2) ×4 exhibited the highest mean LAI at 3.10 and did not differed significantly from the hybrids (1×2) ×5, (2×3) ×1, (2×4) ×1, (2×4) ×5, (2×5) ×1, and (3×5) ×4, which had LAI values of 2.99, 3.07, 2.86, 2.91, 2.99, and 2.96, respectively. The lowest mean LAI value was produced by the hybrid (1×5) ×3 at 1.93. In the fall season, the hybrid (1×4) ×3 distinguished with the highest LAI value of 3.51 and did not differ significantly from the hybrids (1×2) ×4, (1×5) ×2, (2×3) ×4, (2×4) ×1, (2×5) ×4, and (3×4) ×1, which had LAI values of 3.37, 3.36, 3.11, 3.31, 3.31, and 3.30, respectively. The hybrid (2×4) ×3 had the lowest LAI value with an mean of 2.03. Significant differences in leaf area lead to significant differences in LAI, which depend on the genetic or hereditary nature of each specific genotype, especially the plant height trait. This finding aligns with the results of Al-Badrani (2020) and Hadi and Hassan (2021),

Physiological maturity (days): Results in Table (2) indicate that the number of days from planting to 95% physiological maturity differed significantly among the triple hybrids. The trihybrid (1×4) ×5 reached physiological maturity in the lowest number of days, at 90.50 days, significantly different from the other hybrids except the (1×2) ×5 hybrid, which took 91.25 days did not differed significantly. The hybrid (1×5) ×4 took the longest time to reach physiological maturity, at 104.00 days, did not differed significantly from the hybrid (1×2) ×4, which took 103.50 days to reach maturity in the spring season. In the fall

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

season, the hybrid (4×5) ×1 reached physiological maturity earliest, taking 94.50 days, and did not differed significantly from the hybrids (1×4) ×5 and (2×3) ×5, which took 95.25 and 95.00 days, respectively. However, the (1×5) ×4 hybrid was delayed by a difference of 14.5 days compared to the earliest hybrid and differed significantly from the closest hybrid to it, the (2×4) ×1 hybrid, which took 106.75 days to reach physiological maturity. The variation of genotypes (triple hybrids) affected the duration of growth, resulting in differences in the time required to reach 95% physiological maturity. Additionally, triple hybrids that flowered earliest (Table 1) reached physiological maturity before the rest of the hybrids. This aligns with the findings Al-Mousawi, and Hassan (2020).

Table 2. The mean number of leaves, leaf area, leaf area index, and days to 95% physiological maturity for triple hybrids of maize for the spring and fall seasons of 2023

Triple hybrids p1 p2 p3	Leaf number		Leaf area (cm^2)		Leaf area index		Days to maturity	
	Sprin	Fall	Spring	Fall	Spring	Fall	Spring	Fall
(1×2) ×3	11.33	13.04	5076	5283	2.71	2.82	96.00	97.00
(1×2) ×4	13.49	13.70	5808	6326	3.10	3.37	103.50	106.00
(1×2) ×5	12.83	12.54	5615	5431	2.99	2.90	91.25	95.75
(1×3) ×2	11.83	13.17	4612	5482	2.46	2.92	101.00	104.75
(1×3) ×4	11.33	11.79	4874	5044	2.60	2.69	93.25	96.00
(1×3) ×5	11.99	12.16	5199	4943	2.77	2.64	102.25	106.00
(1×4) ×2	12.91	13.29	5208	5594	2.78	2.98	95.50	97.75
(1×4) ×3	12.08	13.54	5256	6588	2.80	3.51	99.00	103.25
(1×4) ×5	10.66	10.83	4356	4431	2.32	2.36	90.50	95.25
(1×5) ×2	14.17	14.25	5315	6308	2.83	3.36	100.50	105.50
(1×5) ×3	10.58	11.21	3621	4302	1.93	2.29	93.25	96.75
(1×5) ×4	11.75	11.66	5067	5522	2.70	2.95	104.00	109.00
(2×3) ×1	12.33	12.28	5753	5537	3.07	2.95	96.50	97.75
(2×3) ×4	12.58	12.75	5219	5821	2.78	3.11	100.75	104.00
(2×3) ×5	10.16	10.87	4346	4683	2.32	2.50	101.25	95.00
(2×4) ×1	13.66	13.66	5366	6212	2.86	3.31	93.75	106.75
(2×4) ×3	10.16	10.33	4757	3811	2.54	2.03	93.25	95.75
(2×4) ×5	13.08	11.33	5447	4741	2.91	2.53	99.25	102.75
(2×5) ×1	13.25	12.88	5606	5174	2.99	2.76	101.50	105.50
(2×5) ×3	14.00	13.29	5106	5549	2.72	2.96	101.75	104.75
(2×5) ×4	11.25	12.21	5263	6200	2.81	3.31	98.00	102.25
(3×4) ×1	13.00	12.95	5161	6177	2.75	3.30	100.50	106.25
(3×4) ×2	13.25	13.12	4876	5387	2.60	2.87	97.50	103.25
(3×4) ×5	12.75	12.79	4591	5884	2.45	3.14	96.50	100.25
(3×5) ×1	10.66	11.87	4439	4967	2.37	2.65	95.00	96.50
(3×5) ×2	11.16	11.54	4457	4568	2.38	2.44	95.75	96.00
(3×5) ×4	12.66	11.66	5550	4727	2.96	2.52	99.5	99.25
(4×5) ×1	11.50	11.45	4583	4583	2.45	2.45	93.50	94.500
(4×5) ×2	11.42	12.12	4693	4876	2.50	2.60	99.50	101.25
(4×5) ×3	11.41	11.83	4677	4855	2.49	2.59	100.50	102.25
LSD	1.17	0.95	516	612.4	0.28	0.33	1.16	0.88

Ear length (cm): Results in Table (3) indicated significant differences in plants ear length. The triple hybrid (1×5) ×2 exhibited the highest ear length, at 18.79 cm, and did not differed significantly from the hybrids (1×2) × 4, (1×3) ×5, (2×4) ×1, (2×5) ×1, and (3×4) ×2, with ear lengths of 17.58, 17.87, 17.41, 17.24, and 17.08 cm, respectively. While, the lowest ear length was produced for the (1×5) ×3 hybrid, which 12.91 cm, which did not differed significantly from four other triple hybrids, (1×4) ×2, (1×4) ×5, (3×5) ×2, and (4×5) ×1, with ear lengths of 14.66, 13.74, 13.87, and 14.12 cm, respectively, in the spring season. In the fall season, the highest mean ear length was 18.83 cm for the (2×5) ×1 hybrid, which did not differed significantly from the hybrids (1×2) ×3, (1×2) ×4, (1×3) ×2, (1×3) ×5, (1×5) ×2, (2×5) ×3, and (3×4) ×5. The hybrid (1×5) ×3 produced the lowest mean ear length at 14.21 cm, differed significantly from the closest hybrid to it, the (1×5) ×4 hybrid, which had

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

an ear length of 15.46 cm. The superior performance of the triple hybrids (1×5) ×2 and (2×5) ×1 in both the spring and fall seasons in the ear length could be attributed to their good plant height and ear height, in addition to a higher number of leaves (Tables 1 and 2). This leads to reduced shading percentage for the ears due to their sparse distribution on the stem length, resulting in increased photosynthetic efficiency and accumulation of dry matter, ultimately leading to increased ear length. These results align with the findings of Al-Amiri (2021) and Okab and Abed (2023),

Rows per ear: Number of rows per ear is one of the highly heritable components of maize yield (19). The results from Table (3) indicate significant differences among the genotypes (triple hybrids) for the number of rows per ear. The triple hybrid (1×2) ×3 exhibited the highest mean of 17.83 rows ear^{-1} and did not differed significantly from hybrids (1×2) ×4, (1×3) ×4, (1×5) ×2, (1×5) ×3, (1×5) ×4, (2×3) ×1, (2×3) ×4, (2×3) ×5, (2×4) ×3, (2×4) ×5, (3×4) ×5, and (3×5) ×2. Conversely, the triple hybrids (1×2) ×5, (2×5) ×1, and (4×5) ×2 were characterized by the lowest mean of 13.66 rows ear^{-1} for each. In the fall season, the highest mean was 17.41 rows per ear for the (1×5) ×2 hybrid, and most triple hybrids did not differed significantly from it in the number of rows ear^{-1}. The lowest mean value was produced for the (4×5) ×2 hybrid at 14.33 rows ear^{-1}. The number of rows ear^{-1} is a heritable trait in maize. Significant differences among hybrids result from variations in the genetic makeup of each hybrid. The superiority of the (1×5) ×2 hybrid could be attributed to its superiority in several traits, including taller plant and ear height, higher leaf count, and longer ear length (Tables 1, 2, and 3). These findings align with those of Abdel-Hamid et al. (2021) and Hadi *et al*., (2021).

Kernels per row: The results from Table (3) indicate that the triple hybrid (2×5) ×3 exhibited the highest mean for kernels per row in the spring season, at 36.16 kernels row^{-1}. It did not differed significantly from the triple hybrids (1×4) ×3, (2×3) ×4, and (3×5) ×1, which had mean values of 34.08, 34.49, and 35.74 kernels row^{-1}, respectively. Conversely, the triple hybrid (1×5) ×3 had the lowest mean at 24.08 kernels row^{-1}, differing significantly from the means of the other hybrids except for (1×4) ×2, (1×4) ×5, and (3×5) ×2, which had mean values of 25.50, 24.24, and 25.66 kernels row^{-1}, respectively. In the fall season, the triple hybrid (1×4) ×3 outperformed others with the highest mean of 35.16 kernels row^{-1}. Which did not differed significantly from the triple hybrids (1×2) ×3, (1×2) ×4, and (3×5) × 1, which had mean values of 34.08, 34.41, and 33.83 kernels row^{-1}, respectively. The lowest mean for kernels row^{-1} was produced for the (1×4) ×5 triple hybrid at 26.41 kernels row^{-1}, and it did not differ significantly from the triple hybrids (1×4) ×2, (1×5) ×3, (2×3) ×4, (3×4) ×2, (3×4) ×5, and (3×5) ×4, which had mean values of 28.66, 26.99, 28.58, 26.91, 27.66, and 27.41 kernels row^{-1}, respectively. These results align with findings from Allaw (2022), and Hassan et al. (2018).

Number of kernels per ear: The results in Table (3) indicate significant differences among the hybrids in terms of kernels per ear, which is one of the primary components of plant yield. The hybrid (2×3) ×4 showed superiority with a mean of 595.1 kernels ear^{-1}, but did not diffed significantly from the means of hybrids (1×2) ×3, (1×2) ×4, (2×3) ×5 and (3×4) ×5, which produced 575.0, 554.7, 559.3, and 552.3 kernels ear^{-1}, respectively. The lowest value was observed for the hybrid (1×4) ×5 at 359.9 kernels ear^{-1}, which did not differed significantly from hybrids (1×2) ×5, (1×4) ×2, (1×5) ×3, (2×5) ×1, (3×4) ×2, and (3×5) ×4, with kernel counts of 397.7, 396.3, 383.3, 400.7, 414.0, and 382.7 kernels ear^{-1}, respectively, in the spring season. In the fall season, the triple hybrid (1×2) ×3 achieved the highest mean for kernels per ear at 576.9 kernels ear^{-1}, which did not differed significantly from hybrids (1×2) ×4, (1×4) ×3, (1×5) ×2, and (3×5) ×1, which produced means of 572.5, 572.9, 555.7, and 556.8 kernels ear^{-1}, respectively. Conversely, the lowest means.

Table 3. The mean of ear length, rows ear^{-1}, kernel row^{-1}, and kernel ear^{-1} for triple hybrids of maize for the spring and fall seasons of 2023

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

Triple hybrids	Ear length (cm)		Rows ear^{-1}		kernel row^{-1}		kernel ear^{-1}	
p1 p2 p3	Sprin	Fall	Spring	Fall	Spring	Fall	Spring	Fall
(1×2) ×3	16.16	17.79	17.83	16.91	32.16	34.08	575.0	576.9
(1×2) ×4	17.58	18.12	16.50	16.75	33.33	34.41	554.7	572.5
(1×2) ×5	16.29	17.29	13.66	14.91	28.75	30.83	397.7	462.4
(1×3) ×2	16.75	17.79	15.17	15.75	30.58	32.74	464.3	513.0
(1×3) ×4	15.45	17.08	16.16	15.91	29.75	30.41	481.0	486.2
(1×3) ×5	17.87	18.62	15.17	15.41	31.74	30.83	480.9	479.1
(1×4) ×2	14.66	17.08	15.50	16.58	25.50	28.66	396.3	475.7
(1×4) ×3	16.25	17.66	14.83	16.33	34.08	35.16	503.6	572.9
(1×4) ×5	13.74	16.08	15.00	15.58	24.24	26.41	359.9	410.8
(1×5) ×2	18.79	18.71	16.50	17.41	32.16	31.83	532.9	555.7
(1×5) ×3	12.91	14.21	15.83	14.49	24.08	26.99	383.3	387.6
(1×5) ×4	15.87	15.46	15.83	16.75	31.66	31.66	501.4	530.6
(2×3) ×1	15.33	16.67	17.00	16.75	31.58	31.58	535.8	531.0
(2×3) ×4	16.75	16.96	17.33	16.33	34.49	28.58	595.1	462.3
(2×3) ×5	14.79	17.04	16.17	15.83	28.91	31.49	468.7	495.7
(2×4) ×1	17.41	17.42	15.00	15.91	32.08	30.99	480.7	493.6
(2×4) ×3	16.04	17.04	17.08	15.58	28.66	28.99	491.2	451.4
(2×4) ×5	15.00	16.17	16.16	16.16	31.00	30.91	500.6	503.5
(2×5) ×1	17.24	18.83	13.66	14.75	29.33	31.58	400.7	464.0
(2×5) ×3	16.66	18.25	15.50	16.49	36.16	29.24	559.3	488.1
(2×5) ×4	16.00	16.66	14.58	14.41	30.16	28.91	438.1	412.4
(3×4) ×1	16.66	17.50	15.33	16.33	30.16	29.99	462.6	493.1
(3×4) ×2	17.08	17.71	14.33	15.08	28.74	26.91	414.0	410.4
(3×4) ×5	16.50	17.91	16.33	15.41	33.91	27.66	552.3	425.5
(3×5) ×1	16.00	16.96	15.00	16.41	35.74	33.83	532.8	556.8
(3×5) ×2	13.87	16.12	17.00	17.25	25.66	28.83	436.6	498.8
(3×5) ×4	15.66	16.75	14.16	17.00	27.08	27.41	382.7	467.5
(4×5) ×1	14.12	16.62	15.16	16.75	27.08	29.25	414.9	492.7
(4×5) ×2	16.16	17.42	13.66	14.33	31.91	30.50	436.8	436.2
(4×5) ×3	15.49	16.92	15.50	16.83	31.66	30.16	489.3	502.5
LSD	1.83	1.06	2.19	2.61	2.25	2.37	54.2	45.6

Number of ears per plant: The number of ears per plant is one of the yield components. Table (4), shows that there were no significant differences among the hybrids in the spring season. However, in the fall season, significant differences were observed among the hybrids. The hybrid (2×5) ×1 produced the highest mean (1.650 ears plant^{-1}), although did not differed significantly from most of the triple hybrids (1×2) ×3, (1×2) ×4, (1×3) ×2, (1×3) ×4, (1×4) ×5, (1×5) ×2, (1×5) ×3, (2×3) ×1, (2×3) ×4, (2×3) ×5, (2×4) ×1, (2×4) ×3, (2×4) ×5, (3×4) ×1, (3×4) ×5, (3×5) ×1, (3×5) ×2, (3×5) ×4, (4×5) ×1, (4×5) ×2, and (4×5) ×3. The lowest mean was 1.225 ears plant^{-1} for the triple hybrid (1×3) ×5, which did not differed significantly from other hybrids such as (1×2) ×5, (1×3) ×4, (1×4) ×2, (1×4) ×3, (1×4) ×5, (1×5) ×3, (1×5) ×4, (2×4) ×1, (3×4) ×2, (3×4) ×5, (3×5) ×1, and (3×5) ×4. The reason for the superiority of the hybrid (2×5) ×1 could be attributed to its longer ears (Table 3). These results are consistent with those found by Hadi and Hassan (2018), who found significant differences among genotypes in the number of ears plant^{-1}.

Weight of 100 kernels: Significant differences were observed among the triple hybrids for the produced 100-kernels weight. The triple hybrid (1×3) ×2 the highest mean of 24.96 grams. It did not differed significantly from the means of the hybrids (1×2) ×5, (2×5) × 1, and (3×4) ×2, which were 23.93, 23.72, and 23.72 grams, respectively. The lowest mean was produced by the triple hybrid (1×5) × 3 in both seasons, with values of 17.55 and 18.14 grams, respectively. It did not differed significantly from the hybrids (1×4) ×2, (2×3) ×1, (2×4) ×3, (2×4) ×5, and (4×5) ×1, which had 18.20, 19.05, 19.59, 19.50 grams, respectively, in the spring season. In the fall season, the weight of 100 kernels for the triple hybrids increased compared to the spring season. The highest mean was 24.17 grams, achieved by

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

the hybrid (1×2) ×5, which did not differed significantly from the hybrids (1×3) ×2, (2×5) ×1, (2×5) ×4, (3×4) ×1, and (3×4) ×2, with means of 24.14, 23.67, 22.86, 22.86, and 24.00 grams, respectively. Similarly, the hybrids (1×2) ×3, (1×3) ×4, (1×4) ×2, (2×3) ×1, (2×4) ×3, (2×4) ×5, and (4×5) ×1 did not differed significantly from the hybrid (1×5) ×3, which produced the lowest means (17.55 and 18.14 grams) for both seasons. The reason for the superiority of the triple hybrid (1×3) ×2 could be attributed to its shorter number of days to reach tasseling (Table 1), allowing sufficient time for the accumulation of assimilates in the source and directing them to the sink represented by the kernels, thus increasing their weight. Additionally, genetic factors responsible for differences in kernel size could contribute to this. These findings align with those of, Al-Mohammady (2022), and Hadi et al. (2019), who found significant differences among genotypes in kernel weight.

dry matter weight (grams): The results in Table (4) indicate significant differences among the triple hybrids for the plant dry weight, with the highest values produced by the triple hybrid (1×5) ×2 in both seasons, at 795.7 and 823.0 grams, respectively. This triple hybrid differed significantly from all other hybrids and from the closest triple hybrid to it in weight, which was the triple hybrid (1×4) ×3 at 704.8 grams in the spring season. The lowest mean was produced by the triple hybrid (1×4) ×5 at 361.4 grams, which did not differed significantly from the triple hybrids (1×5) ×3, (3×5) ×2, (3×5) ×4, (4×5) ×1, and (4×5) ×3, with means of 361.7, 407.2, 443.1, 424.2, and 432.4 grams, respectively. In the fall season, the same triple hybrid (1×4) ×5 also gave the lowest means at 369.1 grams, which did not differed significantly from the triple hybrids (1×5) ×3, (3×5) ×2, and (3×5) ×4, with means of 400.3, 407.2, and 437.1 grams, respectively. The significant differences among the hybrids in dry matter weight and the superiority of the triple hybrid (1×5) ×2 in dry matter weight could be attributed to its higher plant and ear height (Table 1). Additionally, it had the highest leaf count (14.17 and 14.25 leaves plant^{-1}) in both the spring and fall seasons (Table 2). Moreover, it had the highest ear length and number of rows (Table 3), leading to increased accumulation of dry matter. These findings are consistent with those of Abd-Alwahed (2022).

Ear weight (g): The weight of ear is one of the main components of maize yield, and the results of Table (4) show significant differences among the triple hybrids. In the spring season, the hybrid (2×5) ×3 gave the highest mean weight, reaching 556.5 g. However, it did not differed significantly from hybrids (1×2) ×4, (1×5) ×2, (2×3) ×4, and (2×4) ×1, which produced plant mean of 471.5, 509.2, 530.8, and 499.3 g, respectively. Plants of hybrid (1×5) ×3 produced the lowest mean for both seasons, at 255.2 and 287.5 g, respectively, and did not differed significantly from hybrids (1×2) ×5, (1×3) ×4, (1×4) ×2, (1×4) ×5, (3×5) ×2, (3×5) ×4, and (4×5) ×1. In the fall season, the same genotype (2×5) ×3 achieved the highest value at 553.4 g, and did not differed significantly from three other hybrids: (1×5) ×2, (2×3) ×4, and (2×4) ×1, with means of 527.5, 520.9, and 523.7 g, respectively. Likewise, hybrids (1×2) ×5, (1×3) ×4, (2×3) ×5, (3×4) ×2, (3×5) ×2, (3×5) ×4, (4×5) ×1, (4×5) ×2, and (4×5) ×3 did not differed significantly from the lowest triple hybrid (1×5) ×3. The superiority of some triple hybrids in ear weight, especially hybrid (2×5) ×3, is attributed to its superiority in ear length and number of rows per ear (Table 3), as found by Al-Amili (2023), and Hassan and Hadi (2022).

Table 4. The mean of ear plant^{-1}, weight of 100 kernels, dry matter weight, and ear weight of triple hybrids of maize for the spring and fall seasons of 2023

Triple hybrids	Ear plant^{-1}	Weight of 100	Dry matter weight	Ears weight (g)

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

p1	p2	p3	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
(1×2) ×3			1.247	1.450	19.75	18.67	559.8	580.3	425.2	445.0
(1×2) ×4			1.247	1.500	21.02	22.68	667.8	651.0	471.5	454.2
(1×2) ×5			1.082	1.300	23.93	24.17	470.7	478.2	329.8	338.3
(1×3) ×2			1.165	1.500	24.96	24.14	589.9	564.7	417.5	389.7
(1×3) ×4			1.082	1.375	20.24	19.45	450.9	440.5	314.7	304.8
(1×3) ×5			1.082	1.225	21.96	22.67	572.9	551.9	393.2	369.5
(1×4) ×2			1.330	1.300	18.20	18.56	456.9	487.2	331.1	357.9
(1×4) ×3			1.247	1.275	20.72	21.01	704.8	739.2	448.3	411.2
(1×4) ×5			1.083	1.350	20.37	20.67	361.4	369.1	268.4	269.9
(1×5) ×2			1.330	1.625	21.36	21.50	795.7	823.0	509.2	527.5
(1×5) ×3			1.165	1.375	17.55	18.14	361.7	400.3	255.2	287.5
(1×5) ×4			1.165	1.300	20.97	21.21	556.8	578.6	415.8	431.9
(2×3) ×1			1.247	1.575	19.05	18.75	499.6	492.9	381.3	377.1
(2×3) ×4			1.330	1.575	21.31	21.56	661.2	653.0	530.8	520.9
(2×3) ×5			1.247	1.575	19.93	20.62	468.0	456.1	367.2	355.4
(2×4) ×1			1.247	1.375	21.88	21.23	685.7	711.1	499.3	523.7
(2×4) ×3			1.000	1.450	19.11	18.51	452.3	478.1	351.1	373.8
(2×4) ×5			1.247	1.575	19.59	19.15	539.4	536.3	425.9	420.0
(2×5) ×1			1.330	1.650	23.72	23.67	614.6	662.1	404.8	451.9
(2×5) ×3			1.330	1.525	19.93	19.82	695.7	693.5	556.5	553.4
(2×5) ×4			1.330	1.450	22.56	22.86	590.9	616.2	435.6	459.7
(3×4) ×1			1.165	1.450	22.62	22.86	561.6	529.6	402.9	375.3
(3×4) ×2			1.247	1.300	23.72	24.00	613.7	631.5	376.2	350.0
(3×4) ×5			1.165	1.375	20.48	21.18	573.6	545.3	400.7	366.7
(3×5) ×1			1.330	1.375	21.99	21.82	602.5	589.6	439.2	424.7
(3×5) ×2			1.247	1.450	21.08	20.49	407.2	407.2	301.6	300.1
(3×5) ×4			1.247	1.375	21.47	22.17	443.1	437.1	325.3	318.0
(4×5) ×1			1.165	1.525	19.50	19.56	424.2	448.0	325.1	329.0
(4×5) ×2			1.247	1.500	21.26	21.05	498.6	464.6	374.8	343.3
(4×5) ×3			1.083	1.525	21.23	21.38	432.4	445.1	355.9	354.4
LSD			n.s	0.34	2.18	1.58	83.9	68.96	85.7	68.23

Growth crop rate (GCR): Significant differences were observed among the triple cross hybrids in the growth crop rate, with the triple hybrid (1×5) ×2 distinguished by the highest mean growth crop rate for both seasons, at 7.92 and 7.80 g plant^{-1} day^{-1} respectively. But did not differed significantly from hybrids (1×4) ×3 and (2×4) ×1, with means of 7.12 and 7.31 g plant^{-1} day^{-1}, respectively, in the spring season. The lowest means were produced by the hybrid (1×5) ×3 at 3.88 g plant^{-1} day^{-1} and did not differed significantly from hybrids (1×4) ×5, (2×3) ×5, (3×5) ×2, (3×5) ×4, (4×5) ×1, and (4×5) ×3. The lowest growth rate in the fall season was also 3.88 g plant^{-1} day^{-1}, for the hybrid (1×4) ×5, which did not differed significantly from hybrids (1×5) ×3, (3×5) ×2, (3×5) ×4, and (4×5) ×3, with mean growth rates of 4.14, 4.24, 4.40, and 4.35 g plant^{-1} day^{-1} respectively. The superiority of the triple hybrid (1×5) ×2 in growth rate is attributed to its higher plant and ear height (Table 1), higher leaf number (Table 2), and ear length and row number (Table 3), all contributing to its highest dry matter weight for both seasons, at 795.7 and 823.0 g (Table 4). This result is consistent with those who found that genotypes with high growth rates have higher total dry matter weight, such as Ziyad et al. (2018), and Hadi et al. (2019).

Plant yield (g): Results in Table (5) reveal a significant differences among the triple hybrids in the trait of individual plant yield are observed for both seasons. In the first season (spring), the hybrid (2×5) ×3 achieved the highest mean plant yield for both seasons at 439.2 and 441.5 g, respectively. But did not differed significantly from hybrids (1×3) ×2, (2×3) ×4, and (2×4) ×1 for both spring and fall seasons. While, the lowest mean was produced by the hybrid (1×4) ×5 in both seasons, at 200.6 and 221.8 g, respectively. However, it did not differed significantly from 10 other triple hybrids: (1×2) ×5, (1×3) ×4, (1×3) ×5, (1×4) ×2, (1×5) ×3, (3×4) ×2, (3×5) ×2, (3×5) ×4, (4×5) ×1, and (4×5) ×2, in addition to the hybrid (4×5) ×3 in the fall season. The superiority of the triple hybrid (2×5) ×3 in plant

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

yield is attributed to its higher ear height (Table 1) and higher number of rows per ear (Table 3), resulting in a higher ear weight for both seasons, at 556.5 and 553.4 g (Table 4). This result is consistent with findings by Al-Najmawi (2023), Hadi et al. (2023), and Hassan et al. (2019).

Table 5. The mean of Growth Crop rate, plant yield, yield per unit area, and harvest index of triple hybrids of maize for the spring and fall seasons of 2023.

Triple hybrid	GCR		Plant yield g		Yield ton ha^{-1}		Harvest index	
p1 p2 p3	Spring	Fall	Spring	Fall	Spring	Fall	Sprig	Fall
(1×2) ×3	5.84	5.98	321.0	322.0	17.11	17.10	58.4	55.53
(1×2) ×4	6.46	6.14	364.9	369.5	19.45	19.71	55.3	57.17
(1×2) ×5	5.16	4.99	222.2	237.9	11.84	12.69	47.5	50.34
(1×3) ×2	5.84	5.39	416.3	416.6	22.19	22.22	70.4	76.10
(1×3) ×4	4.84	4.59	253.4	259.2	13.51	13.83	56.5	59.29
(1×3) ×5	5.61	5.21	253.4	273.8	13.51	14.60	44.6	49.68
(1×4) ×2	4.78	4.98	248.7	271.1	13.26	14.46	56.2	55.90
(1×4) ×3	7.12	7.16	350.5	356.2	18.68	19.00	49.9	48.23
(1×4) ×5	4.00	3.88	200.6	221.8	10.69	11.83	56.2	60.72
(1×5) ×2	7.92	7.80	322.5	341.0	17.19	18.19	40.9	41.91
(1×5) ×3	3.88	4.14	203.7	224.2	10.86	11.96	57.7	57.23
(1×5) ×4	5.35	5.31	333.8	349.2	17.79	18.62	61.4	60.34
(2×3) ×1	5.18	5.04	318.2	330.2	16.96	17.61	63.9	67.11
(2×3) ×4	6.57	6.28	428.2	421.3	22.82	22.47	66.2	64.82
(2×3) ×5	4.63	4.80	295.2	293.4	15.74	15.65	63.2	64.45
(2×4) ×1	7.31	6.66	391.7	391.0	20.88	20.85	57.8	55.03
(2×4) ×3	4.85	4.99	275.9	277.0	14.70	14.77	61.3	58.02
(2×4) ×5	5.43	5.22	339.8	327.6	18.11	17.47	62.9	61.62
(2×5) ×1	6.06	6.28	324.5	324.9	17.30	17.33	52.8	49.20
(2×5) ×3	6.84	6.62	439.2	441.5	23.41	23.55	63.0	63.76
(2×5) ×4	6.03	6.03	348.0	319.7	18.55	17.05	59.2	51.88
(3×4) ×1	5.59	4.98	288.6	289.4	15.38	15.43	51.3	55.42
(3×4) ×2	6.30	6.12	273.0	288.1	14.55	15.37	44.4	45.79
(3×4) ×5	5.95	5.44	325.2	330.7	17.33	17.64	57.5	61.17
(3×5) ×1	6.34	6.11	356.9	359.9	19.02	19.20	60.2	61.55
(3×5) ×2	4.25	4.24	232.9	247.0	12.41	13.17	58.7	61.47
(3×5) ×4	4.45	4.40	273.8	290.8	14.59	15.51	62.3	67.28
(4×5) ×1	4.54	4.74	249.3	272.1	13.29	14.51	60.5	61.85
(4×5) ×2	5.01	4.58	266.1	274.7	14.18	14.65	53.6	59.71
(4×5) ×3	4.30	4.35	275.6	250.4	14.69	13.35	58.8	56.17
LSD	0.87	0.68	73.5	60.04	3.92	3.20	n.s	14.32

Yield per unit area (tons ha^{-1}): Results in Table (5) indicate a significant differences among the triple hybrids in the yield per unit area were observed for both seasons. Since the cultivation was done at a same density for all genotypes, we find that the triple cross hybrid (2×5) ×3, which excelled in the trait of individual plant yield, also excelled in the highest unit area yield for both spring and fall seasons, with an mean of 23.41 and 23.55 ton ha^{-1} respectively. It did not differed significantly from the hybrids (1×3) ×2, (2×3) × 4, and (2×4) ×1 for both seasons, with means of 22.19, 22.82, and 20.88 ton ha^{-1} respectively for spring, and 22.22, 22.47, and 20.85 ton ha^{-1} respectively for fall. The lowest mean was also produced by the hybrid (1×4) ×5 for both seasons, with mean of 10.69 and 11.83 ton ha^{-1} respectively, and did not differed significantly from hybrids (1×2) ×5, (1×3) ×4, (1×3) ×5, (1×4) ×2, (1×5) ×3, (3×4) ×2, (3×5) ×2, (3×5) ×4, (4×5) ×1, and (4×5) ×2. It also did not differed significantly from the same hybrids in the fall season, in addition to hybrids (2×4) ×3 and (4×5) ×3. The reason for the triple hybrid (2×5) ×3 produced the highest yield per unit area is attributed to its superiority in the traits that resulted in its highest individual plant yield (Table 5). This result is consistent with those who found that genotypes vary in grain yield, Khalaf Hassan and (2022b), Hassan and Hadi (2022), Okab (2022), and Hadi et al. (2023).

Harvest Index: The results in Table (5) indicated no significant differences among the genotypes (triple hybrids) for the harvest index

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

in the spring season. However, in the fall season, there were significant differences among the hybrids. The hybrid (1×3) ×2 has the highest mean for the harvest index at 76.10%. However, it did not reach the level of significance compared to the means of hybrids (2×3) ×1, (2×3) ×4, (2×3) ×5, (2×5) ×3, and (3×5) ×4, which reached 67.11%, 64.82%, 64.45%, 63.76%, and 67.28% respectively. While, the lowest mean of 41.91% was produced by the hybrid (1×5) ×2, which did not differ significantly from almost half of the triple hybrids (12 hybrids). This finding is supported by the studies conducted by Al-Baidhani (2022).

CONFLICT OF INTEREST

The author declares that they have no conflicts of interest.

DECLARATION OF FUND

The authors declare that they have not received a fund.

REFERENCES

Abd alwahed, S. A. (2022). Evaluation of the Expression Activity of the INCW1 Gene in Maize Cultivars (*Zea mays* L.) Under Sowing Dates'. M. Sc. Thesis, Coll. of Agricultural Engineering Science, University of Baghdad. pp: 90.
http://dx.doi.org/10.21931/RB/CSS/2023.08.04.20

Abdel-Hamid, Z.; J. Abd & S. H. Hamad, (2021). Production of dual-purpose maize hybrids. Anbar Journal of Agricultural Sciences, 15 (special issue) 58-67.
https://www.google.com/searchpurpose

AL -Najmawi, D. and R.F. Abd .(2023). Genetic and Stability Indicators of Maize Genotypes at Different Fertilizer Combinations. M. Sc. Thesis, Coll. Of Agricultural Engineering Science, University of Mosul. pp: 150.

Al-Amili, M.A & R Abd.(2023). Evaluation the Performance of Three-Way Crosses of Maize Under Different Sowing Dates in Fall Season M. Sc. Thesis, Coll. of Agricultural Engineering Science, University of Baghdad. pp: 97. https://www.iasj.net/iasj/article/269308

Al-Amiri, A.M.J. (2021). Detection of Non Allelic Interaction Via Generation Mean Analysis for Factorial Hybrids Maize At Different Locations. M. Sc. Thesis, Coll. Of Agricultural Engineering Science, University of Baghdad. pp:191.
DOI 10.1088/1755-1315/910/1/012135

Al-Badrani, Q. A. Y. (2020). Study of Combining Ability, Gene Action and Heterosis in Single Cross Hybrids of Maize (*Zea mays* L.). M. Sc. Thesis, Coll. Of Agricultural Engineering Science, University of Mosul. pp: 127.

Al-Baidhani, H. H. j. (2022). Genetic and Molecular Analysis of Maturity and Flowering Time using Generation Mean Analysis of four Maize Hybrids (*Zea mays* L.). Ph.D. Dissertation, Dept. of Field Crop, Coll. Of Agricultural Engineering Science, University of Baghdad. pp:237.

Allaw, S.A.A.J. (2022). Estimated Some Genetic Parameters for Genotypes of Maize (*Zea Mays* L.) At Different Planting Dates. M. Sc. Thesis, Coll. Of Agricultural Engineering Science, University of Mosul. pp: 135.

Al-luhaibi, N. S. K. (2022). Evaluation of Introduced Genotypes of Maize Under Plant Density. M. Sc. Thesis, Coll. Of Agricultural Science, University Of Baghdad. pp: 91.

Al-Mohammady, H.S.H. (2022). Estimation of Some Genetic Parameters of Maize Using Half Diallel Cross under Different Levels of Salicylic. Ph.D. Dissertation, Coll. of Agricultural Engineering Science, University of Anbar. pp: 182
DOI:10.1088/1755-1315/904/1/012054

Al-Mousawi, S. H. & W. A. Hassan. (2020). Evaluation of the performance of triple, single crosses and their inbred of maize under two plant population. Plant Archives. 20 (1): 1705-1716. Doi/366089861.

Elsahookie, M. M. & A. A. Dawood. (2021). Genome and plant breeding. Ministry of Agriculture - Republic of Iraq. pp: 150.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. of Biol. Sci. 9: 463-493. DOI/1259 (1) 012091.

Hadi B. H., W.A. Hassan & K.M. Wuhaib. (2019). The comparison of several methods for calculating the degree of heritability and calculating the number of genes in maize (*Zea mays* L.). Agronomic traits. IOP Conference Series: Earth and Environmental Science. 388(1)/012041. DOI 10.1088/1755-1315.

Hadi, B. H., W. A. Hassan & K. M. Wuhaib. (2019). Phenotypic, genotypic correlation and path coefficient for several traits of maize un-

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

der watered and water stress. Journal of Global pharma technology. 11(2): 76-86. DOI/338609099.

Hadi, B. H. & W. A. Hassan. (2021). Evaluating the performance of introduced varieties of maize (*Zea mays L.)* and estimating some genetic parameters. International Journal of Agricultural and Statistical Sci. 17(1): 85-91 . DOI/03899.2021.17.85.91.

Hadi, B.H., W. A. Hassan, N.Y. Abed, & K. M. Wuhaib. (2019). The comparison of several methods for calculating the degree of heritability and calculating the number of gene. II Yield components. International Journal of Agricultural and Statistical Sci. 15(2):789-794. DOI/338389758.

Hadi, B.H., W.A. Hassan & M.S.H. Hamdalla. (2023). Performance of some three-way cross hybrids and their parents of maize in the middle region of Iraq. IOP Conf. Series: Earth and Environmental Science 1259 (1) 012091 DOI 10.1088/1755-1315/1259/1/012091.

Hadi, B. H., W. A. Hassan & M. S. H. Hamdalla. (2021). Some genetic parameters and path coefficient of three-way crosses in maize. IOP Conference Series: Earth and Environmental Science 910 (1) 012099. DOI 10.1088/1755-1315/910/1/012099.

Hadi, B.H.; W.A Hassan; Z. K Alshugeairy, & F. F. Alogaidi (2023). Estimating genetic parameters of maize hybrids and parents under different plant densities (Combining ability for yield and some other traits for maize (*Zea mays* L.).Revista Bionatura J. 8(1).87. DOI:10.21931/RB/2023.08.01.87.

Hamdi, A. A. (2021). Assessment of Genetic Behavior by Effect of Plant Density by Using Half Diallel Cross in Maize. M. Sc. Thesis, the College of Agriculture at University of Al-Anbar. pp: 105.

Hamood, J. A. (2019). Half Diallel Crossing Among Maize Inbred Lines and Their Evaluation under Different Nitrogen Levels. Ph.D. Dissertation, Coll. Of Agricultural Engineering Science, University of Baghdad. pp: 131. https:// www .researchgate .net / publication/ 376501731.

Hassan, W.A., K. M. Wuhaib & B.H. Hadi. (2017).Heritability and genetic gain to a selective of maize under sufficient and insufficient water, nitrogen and potassium. Anbar Journal of Agricultural Scien*ces*, 15 (special issue) 156-165. https://www.iasj.net/iasj/article/129103.

Hassan W.A., B. H. Hadi & M.S.H. Hamdalla. (2019). Evaluation of maize hybrids, their inbred lines and of genetic divergence based on cluster analysis. Indian Journal of Ecology 46 Special Issue (8): 102-107. DOI/339213000.

Hassan, W.A. & B.H. Hadi. (2022). Drought and maize breeding. IOP Conference Series: Earth and Environmental Science. doi:10.1088/1755-1315/910/1/012099

Hassan, W.A., B. H. Hadi & K. M. Wuhaib. (2018). Estimation of some genetic parameters for grain yield and its components of maize under watered and water stress. International Journal of Agricultural and Statistical Sci. 14(2):553-559. DOI/330117468.

Kazem, K. A. & W. A. Hassan. (2021). Some genetic parameter for maize under different planting dates and environments' . Al-Muthanna J. For Agric Sc*i*. 8(3): 246-257. DOI/217375.

Khalaf, N.S. & W.A. Hassan. (2022b). Study of yield and its components of introduced varieties of maize under different planting densities: study of yield and its components of introduced varieties of maize under different planting densities. Iraqi Journal of Market Research and Consumer Protection, 14(1):52-64. https://jmracpc.uobaghdad.edu.iq/index

Okab, S. A. (2022). Gene Expression of Nitrogen Tolerance and its Relationship to Some Oxidative Enzymes in Maize. M. Sc. Thesis, Coll. of Agricultural Engineering Science, University of Baghdad. pp: 102. http://dx.doi.org/10.21931/RB/CSS/2023.08.01.93.

Okab, S.I. & Abed. (2023). Gene expression of a nitrogen tolerance gene ZmNR1 under the influence of different levels of nitrogen in maize. Bionatura 8(1): 1-9. DOI/ 10.21931/RB/CSS/2023.08.01.93.

Rawlings, J. O. & C. C. Cocker ham. (1962). Triallel analysis. Crop Sci. 2: 228-231.

Saleh, H.S. & I. Salmand. (2005). Posted on the Recommended Fertilizer Varieties According to the Fertilizers Available for Summer and Winter Crops. Ministry of Agri. Central Fertilizer Syntheses Sommittee. pp:541.

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

http://aesl.ces.uga.edu/publications/soil/cropsheets.pdf.

Shull, G.H. 1910 . Hybridization methods in corn breeding. Journal of Heredity. 1(2) 98-107.
https://ia600708.us.archive.org/view_archive.

Ziyad E. Abed, Russell W. Jessup, Mohammed H. E. Al-Issawi. (2018). Irrigation intervals affect dhn1 expression and some physiological parameters in stay green and non-stay-green sorghum. biochem. Cell. Arch. Vol. 18, Supplement 1, pp. 1043-1047. DOI/2868300H_1043-1047.

إنتاج هجن من الذرة الصفراء للاستهلاك المباشر باعتماد التهجين الثلاثي

كمال احمد كاظم، ناظم يونس عبد
قسم الحاصيل الحقلية، كلية علوم الهندسة الزراعية، جامعة بغداد

المستخلص

Iraqi Journal of Agricultural Sciences –2026:57(6):1666-1680
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/w7ps8875

بهدف استنباط واختبار 30 هجين ثلاثي ناتجة من تضريب عشرة هجن فردية مع خمسة سلالات نقية متباعدة وراثياً لغرض البدء بخطة للتربية لإيجاد هجين أو أكثر ذو انتاجية عالية وصفات نوعية جيدة تحت الظروف المحلية في العراق . أجريت تجربة حقلية باستعمال خمس سلالات نقية من الذرة الصفراء هي NADH 102(1) و NASA 2022(2) و NAEL 2022(3) و NA 9928 E(4) و NADH 2006(5), في الموسم الاول ربيع 2022 ادخلت في برنامج تهجين تبادلي نصفي للحصول على (10) هجن فردية, وفي الموسم الخريفي للسنة نفسها أدخلت السلالات الأبوية والهجن الفردية في برنامج تهجين ثلاثي وفق طريقة Cockerham و Rawling, للحصول على 30 هجيناً ثلاثياً وفق المعادلة C=P(P-1)(P-2)/2 . اظهرت نتائج الدراسة وجود فروقات معنوية بين التراكيب الوراثي, وتفوق الهجين الثلاثي 3×(5×2) بأعلى حاصل لوحدة المساحة وللموسمين بلغ 23.41 و23.55 طن/هـ$^{-1}$، ولم يختلف معنوياً عن الهجن الثلاثية 2×(3×1) و4×(3×2) و1×(4×2) بحاصل بلغ 22.19 و22.82 و20.88 طن/هكتار$^{-1}$ بالتتابع، ان تفوق الهجين الثلاثي 3×(5×2) يعود الى تفوقه بأعلى عدد لحبوب الصف ومن ثم تفوقه بأعلى وزن للعرانيص بلغ 556.5 و553.4 غم للموسمين واعلى حاصل للنبات الفردي بلغ 439.2 و441.5 غم.

الكلمات المفتاحية: حاصل حبوب, هجن فردية الموسم الربيعي والخريفي, الذرة الصفراء.