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Response of Introduced Egyptian Maize Varieties to Varying Plant Densities in the Middle and Western Regions of Iraq.

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ABSTRACT: This study was conducted to evaluate the growth performance of several imported Egyptian maize varieties (four varieties: TW-78E, TW-345E, IY-355E, IY-207E) compared to two local varieties (Baghdad 3I and Al MahaI), under the influence of three different plant densities (60, 70, and 80 thousand plants ha⁻¹), in two different agricultural environments in Iraq: the middle region (Baghdad) and the western region (Anbar), during the fall season of 2024. The experiment was designed using a Randomized Complete Block Design (RCBD) with a split-plot arrangement of three replications, where the main plots included the plant densities and the subplots included the varieties. Aggregative analysis was then performed on the two experimental locations. The most important findings of the study are: The Baghdad location significantly outperformed the Anbar location in all studied traits (days to tassling and silking, plant height, ear height, number of green leaves, and leaf area). Plants in Baghdad reached the tassling and silking earlier (54.70 ,57.52 days) compared to Anbar (71.37 , 75.11 days). The highest average plant height and ear height was recorded in Baghdad (215.09 cm,125.18) compared to Anbar (146.55 cm,71.52). Increasing plant density from 60.000 to 80.000 plants h-1 delayed tassling and silking. The density of 80.000 plants h-1 recorded the highest average plant height (182.22 cm), which was not significantly different from that of 70.000 plants h-1. The density of 70.000 plants h-1 recorded the highest average number of green leaves (13.767 leaves). The Egyptian variety IY-207E was the fastest to reach the tassling and silking (59.56 ,64.17 days). The Egyptian variety TW-345E recorded the highest average plant height, ear height, number of leaves and leaf area (189.62 cm,103.53 cm,13.989 leaves and 5252 cm²) sequentially.

Best response to the triple interaction (location × plant density × variety) was observed in variety IY-207E at a density of 70.000 plants ha⁻¹ at the Baghdad location. It reached early tassling in 51 days and early silking in 54 days. It also recorded the highest average leaf area (6759 cm²) at a density of 80,000 plants ha⁻¹ at the Baghdad location.

INTRODUCTION

Maize (*Zea mays* L.) is one of the world's most important field crops, ranking third after wheat and rice in nutritional and economic importance. It is widely used in animal feed production and the food and starch industries. It is also a primary source of carbohydrates and energy for both human and animal consumption. Despite the increasing areas cultivated with maize in Iraq in recent years, local production is still below the required level, largely due to reliance on limited varieties and the failure to expand the introduction of new genetic combinations with high efficiency in growth and production. Especially those produced in diverse environments, such as Egyptian varieties, which possess genetic variations that may contribute to improved agricultural performance under Iraqi environmental conditions (Mirza and Hadi,2024). The introduction of different genetic

combinations, whether varieties, hybrids, or inbred lines, and the expansion of the crop's genetic base, is one of the most important breeding programs aimed at improving traits. Introducing new varieties that are superior in their productive and genetic characteristics, as well as their ability to adapt to environmental conditions, has become one of the breeder's most important tasks. When comparing the performance of genotypes under different environmental conditions, we find a difference in performance; it thrives in one environment but not in another. This is due to the influence of genetic-environmental interaction (Hadi *et al.* 2018, Kazem & Hassan, 2021). Plant density is also one of the important agricultural factors that directly affect vegetative growth characteristics and yield components. The variation in the number of plants planted per unit area is reflected in the plant's ability to utilize light, nutrients, and water, and thus affects the plant's vegetative structure and productivity. Geographical location and environmental variation between regions are also a crucial factor in determining the success or failure of imported varieties, due to differences in soil and weather conditions between one location and another (Allard and Bradshaw, 1964, and Hadi and Wuhaib, 2015). Al-Majmiei (2009) indicated significant differences between genotypes in the number of days from planting to reach 50% tassling and silking. The shortest period was 68.00 and 75.00 days, respectively, for the Masarra variety in Tikrit. However, at the Ishaqi location, the Abaa 5012 variety exhibited the shortest silking period of 64.67 days. The Buhouth 106 variety outperformed the others in both Tikrit and Ishaqi location in plant height, reaching 173.78 and 203.93 cm, respectively. Kanoosh (2011), in a study evaluating some genotypes of maize at different planting dates in two location (Al-Qubba and Telkaif) in Nineveh Governorate, indicated that the results of the aggregative analysis of plant traits from both locations showed that the mean squares of the varieties and their binary interactions with Plant densities $\times$ location, were significant for all traits except the number of rows per ear. Plants at the Telkaif location showed a significant advantage in height over those at the Qubba location, with average heights of 220.6 and 191.9 cm respectively. Amanah (2021) stated that plant density significantly affects tassling, silking, as the lower plant density (70.000 plants ha^{-1}) reached 75% tassling and silking earlier, taking 53.97 and 57.67 days respectively, compared to the higher plant density (90.000 plants ha^{-1}), which took 58.68 and 61.68 days to reach 75% tassling and silking respectively. Zeleke *et al.* (2018) found significant differences in plant height and ear height with different plant densities when they studied maize under three plant densities (44444, 66666 and 88888 plants ha^{-1}). The high density (88888 plants ha^{-1}) gave the highest plant and ear heights of 245.25 and 136.59 cm respectively, compared to the low density (44444 plants ha^{-1}), whose plant and ear heights reached 233.04 and 122.81 cm respectively. The results of Mahmood *et al.* (2017) showed a significant effect of plant density on the number of leaves per plant, as the density of 66.666 plants ha^{-1} resulted in the highest average number of leaves at 13.23 leaves per plant ha^{-1} , compared to the density of 53.333 plants ha^{-1} , which resulted in the lowest average number of leaves at 12.90 leaves per plant ha^{-1} . Al-Lhebee (2022) indicated significant differences between genotypes in plant height, with the Al-Maha genotype having the highest plant height at 211.25 cm, compared to the DKC6315 genotype, which resulted in the lowest average plant height at 203.55 cm. However, his study did not show significant differences between genotypes in ear height. Alfatlawy *et al.* (2022) found no significant difference in plant height between the genotypes. Al-Khafaji (2023) demonstrated a significant effect of genotypes on both plant and ear height. The genotype Fajr1 resulted in the highest average plant and ear heights, at 216.2 and 140.8 cm, respectively, compared to the Zia4 $\times$ Zia2 hybrid, which resulted in the lowest average plant and ear heights, at 187.4 and 101.3 cm, respectively. From this standpoint, this study came with the aim of evaluating the growth performance of several introduced Egyptian varieties compared to two local varieties of maize under three different plant densities in two different agricultural environments (Baghdad and Anbar), through the study of five basic growth traits: plant height, ear height, stem diameter, number of leaves, and leaf area, in order to determine the best varieties and plant densities that can be adopted under Iraqi environmental conditions.

MATERIALS AND METHODS

Two experiments were carried out at two locations: the first, the middle Region (Baghdad), in the fields belonging to the College of Agricultural Engineering Sciences - University of Baghdad, and the second, the Western Region (Anbar) in Karma, for the fall season of 2024, to evaluate the performance of Egyptian varieties under different plant densities in different locations in Iraqi environment.

Table (1): Names and symbols of maize varieties used in the study and their source.

Variety number	Variety symbols	Pedigree
1	Baghdad 3 I	Ministry of Agriculture – Department of Agricultural Research(Abu Ghraib -Iraq)
2	Al-Maha I	
3	TW-78E	Egyptian Ministry of Agriculture – Agricultural Research Center – Crops Research Institute – Maize Research Department(Cairo -Egypt)
4	TW-345E	
5	IY-355E	
6	IY-207E	

Experiment Factors, Design and Arrangement

The study included two factors: the first was three plant densities (60, 70 and 80 thousand plants ha⁻¹), and the second was six varieties of maize, four of which were introduced (TW-78E, TW-345E, IY-355E, IY-207E) and two local varieties (Baghdad 3 I and Al-Maha I). The experiment was designed using a Complete Block Design (RCBD) with a split-plots arrangement in three replications, where the main plots included plant densities and the secondary plots included varieties.

Soil analysis and Weather forecast (temperature and relative humidity)

A soil sample was taken before planting at a depth of 30 cm for both locations and was analyzed at the Central Laboratory for Soil, Water and Plant Analysis – Consulting Office of the College of Agricultural Engineering Sciences – University of Baghdad. The results were as shown in Table 1. The climatic conditions for the period from 1/7 to 1/12, during which the experimental plants passed, were also obtained from the General Authority for Meteorology and Seismic Monitoring(table 3).

Table (2): Some chemical and physical properties of the experimental soil before planting.

Anbar			Baghdad		
unit of measurement	Value	The measured attribute	unit of measurement	Value	The measured attribute
ds m ⁻¹	1.6	Electrical conductivity EC 1:1	ds m ⁻¹	1.3	Electrical conductivityEC 1:1
-----	7.26	PH 1:1	-----	7.12	PH 1:1
mg/kg ⁻¹ soil	13	Available nitrogen (N)	mg/kg ⁻¹ soil	15	Available nitrogen (N)
	6.18	Available phosphorus P		5.17	Available phosphorus P
	137.02	Available potassium K		117.89	Available potassium K
gm kg ⁻¹	3.2	Organic soil material	gm kg ⁻¹	4.5	organic soil material
	312	Carbonate minerals		235	Carbonate minerals
milliequivalent to ⁻¹ liter	6.31	Dissolved calciumCa ⁺²	milliequivalent to ⁻¹ liter	6.14	Dissolved calcium Ca ⁺²
	5.00	Dissolved magnesium(Mg ⁺²)		3.12	Dissolved magnesium(Mg ⁺²)

	3.42	Dissolved sodium (Na ⁺)			2.21	Dissolved sodium (Na ⁺)	
	0.90	Soluble potassiumK			0.82	Soluble potassium K	
	1.5	Soluble bicarbonate HCO3			1.2	Soluble bicarbonate HCO3	
	10.15	Dissolved chlorine (Cl ⁻)			9.00	Dissolved chlorine (Cl ⁻)	
	4.35	Soluble sulfatesSO4-2			2.8	Soluble sulfatesSO4-2	
	Nill	CarbonatesCO3			Nill	CarbonatesCO3	
-----	Silt loam	Soil texture			Sandy loam	Soil texture	
gm kg ⁻¹ soil	472	sand	Soil separators	gm kg ⁻¹ soil	572	sand	Soil separators
	28	clay			88	clay	
	500	silt			340	silt	

Table 3. Percentage of relative humidity, maximum and minimum temperatures, and their averages monthly for Baghdad and Anbar locations for the fall season 2024

	Baghdad				Anbar			
period	relative humidity	Minimum temperature	Maximum temperature	average temperature	relative humidity	Minimum temperature	Maximum temperature	average temperature
1-31/July	18.3	20.5	45.86	33.18	19.74	31.04	44.71	37.87
1-31/August	23	27.73	44.94	36.34	20.24	30.84	44.74	37.79
1-30/September	26.88	24.39	41.11	32.75	26.64	26.84	39.92	33.38
1-31/October	29.18	17.22	33.27	25.25	27.51	18.71	32.05	25.38
1-30/November	64.103	11.214	23.67	17.44	61.53	13.20	22.72	17.96
1-31/December	58.96	4.487	18.66	11.57	56.12	7.22	17.88	12.55

. Land preparation and soil and crop management operations

The land was prepared for cultivation at the two experimental locations (Baghdad and Anbar) by carrying out all necessary agricultural operations, including plowing, harrowing, and leveling. Fertilization was then performed with a single application of 240 kg hectare⁻¹ of NPK compound fertilizer before planting. Additionally, 360 kg hectare⁻¹ of urea (46% nitrogen) was applied in two applications: the first during the elongation stage and the second at the beginning of the flowering stage. The land was divided into 54 plots, each representing an experimental unit. Each plot measured (2 × 3) m² and contained four rows of maize .. The spacing between rows was 75 cm, and the spacing between plants was 16 cm for a plant density of 80,000 plants

hectare-1, 19 cm for a plant density of 70,000 plants hectare-1 and 22 cm for a plant density of 60,000 plants hectare-1. Planting date for the Baghdad location: 25-7-2024, and for the Anbar location: 26-7-2024. The seeds were sown at a rate of 2-3 seeds per hole, and the plants were thinned. Weeding was carried out manually several times during the growing season, and irrigation was done whenever needed. Preventive control was carried out against the stem borer insect using granular diazinon with a concentration of 10% at a rate of 4 kg/h in two applications, the first when the plant was about 25 cm high and the second 15 days after the first application.

Traits studied

Plant height: measurements were taken for five plants per experimental unit at random using a graduated ruler, starting from the soil surface and ending at the base of the flag leaf, as described by Elsahookie and Daoud (2021).

Height of the main ear (cm): The height of the upper ear of five plants per experimental unit was randomly measured using a graduated wooden ruler from the soil surface to the node of the upper ear (Elsahookie, 1990).

Stem diameter (cm): The stem diameter from the middle of five plants taken randomly for each experimental unit was measured by the vernier (Elsahookie and Daoud 2021).

Number of leaves (plant leaf - 1): The number of effective plant leaves at the anthesis stage was calculated for five random plants per experimental unit (Elsahookie and Daoud, 2021).

Leaf area (m²): The length of the leaf under the main ear leaf (L_b) was measured for five plants, randomly selected for each experimental unit, and the leaf area was estimated using the formula established by Elsahookie (1985), which are as follows:

- Green area for plants with 10-12 effective leaves = Long square (L^2b) $\times$ 0.64

- Green area for plants with 13-15 effective leaves = Long square (L^2b) $\times$ 0.75

Statistical Analysis

Statistical analysis was performed on all studied traits using Excel and Genstat software according to the RCBD design within the arrangement of the split plots for the Baghdad and Anbar locations. Then the aggregative analysis of the locations was performed and the means were compared according to the least significant difference (LSD) at a probability level of 0.05 Steel and Torrie. (1980).

RESULTS AND DISCUSSION

Number of days from planting to 50% tassling

The aggregative analysis data for the Baghdad and Anbar locations indicate Plants at the Baghdad location reached tassling earlier than those at the Anbar location, taking 54.70 days, a difference of 16.67 days compared to the Anbar location, where plants took 71.37 days to reach tassling (Table 4). This is most likely attributed to the difference in temperature and relative humidity between the two locations, which coincided with plant growth and the time it took to reach tassling (Table 3).

The table 4 also shows that increasing the plant density from 60,000 to 80,000 plants ha⁻¹ delayed tassling. Plants grown at the third density took 63.61 days to reach tassling, not significantly different from the second density. This is attributed to the fact that the increased number of plants per square meter led to increased shading and a delay in tassling. The aggregative analysis data for the Baghdad and Anbar locations indicate a significant difference between the genotypes. The Egyptian variety IY_207E reached tassling earlier, in 59.56 days, followed by the Egyptian variety TW_78E. Tassling period was 62.28 days, not significantly different from the Egyptian variety IY_355E. However, the Iraqi variety Al-Maha I was delayed in reaching tassling by 65.44 days, 5.88 days later than the Egyptian variety IY_207E. This is attributed to the difference between the Iraqi and Egyptian genotypes in their requirements for temperature and relative humidity according to their acclimatized environment. These results confirm the findings of Al-Majmeci (2009) Kanoosh (2011) and Hadi and Amana (2021). Table 4 shows a significant interaction between the two study factors: location and plant density. The Baghdad location showed the best response at a plant density of 70,000 plants per hectare, with its plants reaching tassling in 54.50 days, not significantly different from the plant densities of 60,000 and 80,000 plants per hectare. In contrast, the Anbar location at a density of 70,000 plants per hectare was delayed in reaching tassling by 72.28 days, not significantly different from the density of 80,000 plants

per hectare.⁻¹ The response of the varieties in the Baghdad and Anbar locations was similar, and no significant interaction was found between the two study factors regarding the number of days to tassling.

The response of the varieties varied according to plant density. Some varieties were delayed in reaching tassling at the second plant density, and then raised earlier, such as the Baghdad 3 I, TW-78E, and IY-207E varieties. Other varieties remained stable, such as the Egyptian IY-355E and the Iraqi Al-Maha I varieties. The best response was observed in the Egyptian IY-207E variety at a plant density of 70.000 plants per hectare, taking 57.83 days, while the lowest response was observed in the Iraqi Al-Maha I variety at both densities of 70.000 and 80.000 plants per hectare, taking 66.17 days. The data in Table 3 showed that the response of the varieties differed according to the location and plant density. The best response to the triple interaction was for the (Baghdad location $\times$ density of 70,000 plants per hectare $\times$ the variety IY-207E), as it reached tassling earlier, taking 51 days, and did not differ significantly from the plant density of 70,000 plants per hectare for the same variety and location. Meanwhile, the lowest response to the triple interaction was for the Anbar location at the third density for the Iraqi Maha variety, which took 74.67 days to reach tassling and did not differ significantly from the Baghdad variety at the same density.

Number of days from planting to 50% silking

Table 5 shows a significant interaction between the two study factors: location and plant density. The Baghdad location showed the best response at a plant density of 70,000 plants per hectare, with its plants reaching tassling in 54.50 days, not significantly different from the plant densities of 60,000 and 80,000 plants per hectare. In contrast, the Anbar location at a density of 70,000 plants per hectare was delayed in reaching tassling by 72.28 days, not significantly different from the density of 80,000 plants per hectare.⁻¹ The response of the varieties in the Baghdad and Anbar locations was similar, and no significant interaction was found between the two study factors regarding the number of days to tassling.

The response of the varieties varied according to plant density. Some varieties were delayed in reaching tassling at the second plant density, and then raised earlier, such as the Baghdad 3 I, TW-78E, and IY-207E varieties. Other varieties remained stable, such as the Egyptian IY-355E and the Iraqi Al-Maha I varieties. The best response was observed in the Egyptian IY-207E variety at a plant density of 70.000 plants per hectare, taking 57.83 days, while the lowest response was observed in the Iraqi Al-Maha I variety at both densities of 70.000 and 80.000 plants per hectare, taking 66.17 days. The data in Table 3 showed that the response of the varieties differed according to the location and plant density. The best response to the triple interaction was for the (Baghdad location $\times$ density of 70,000 plants per hectare $\times$ the variety IY-207E), as it reached tassling earlier, taking 51 days, and did not differ significantly from the plant density of 70,000 plants per hectare for the same variety and location. Meanwhile, the lowest response to the triple interaction was for the Anbar location at the third density for the Iraqi Maha variety, which took 74.67 days to reach tassling and did not differ significantly from the Baghdad variety at the same density.

The data in the same table showed significant differences between the varieties under study, as the Egyptian variety Iy207E reached silking earlier by 64.17 days and did not differ significantly from the 78-Tw variety, while the Iraqi variety Al MahaI was delayed in reaching silking by 67.78 days and did not differ significantly from the Baghdad 3 and 345-Tw varieties. The reason for this is attributed to The difference between varieties in the number of days from planting to silking is due to the genetic nature of the varieties and its adaptation to the environment.

Table 5 shows that plant density varied across different locations. The best response was observed at the Baghdad location with a plant density of 70.000 plants h⁻¹, where the plants took 57.11 days to reach silking. This did not differ significantly from the plant density of 60.000 and 80.000 plants per hectare. The lowest response was observed at the Anbar location with a plant density of 70.000 plants h⁻¹, where it took 76.06 days to reach silking

Table 4. Aggregative analysis of the number of days to tassling of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Locations	Plant density (1000plant hectare ⁻¹)	varieties						locations $\times$ plant density
		Baghdad 3I	Al- MahaI	TW- 78E	T W - 34 5E	IY - 35 5E	IY - 20 7 E	

Baghdad	60	56.67	54.67	53	56	55	52		54.56
	70	54.33	58	54.67	54.67	54.33	51		54.5
	80	55	57.67	52.67	57	56.7	51.33		55.06
Anbar	60	69.33	73.33	69.67	67	68.7	70		69.67
	70	77.33	74.33	73	72	72.33	64.7		72.28
	80	74.33	74.67	70.67	75	70	68.33		72.17
L.S.D (0.05)		Location ×Plant Density × Varieties= 3.33							0.453
Locations	varieties							Locations means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-35E	IY-207E			
Baghdad	55.33	56.78	53.44	55.89	55.33	51.44		54.7	
Anbar	73.67	74.11	71.11	71.33	70.33	67.67		71.37	
L.S.D (0.05)	Location × Varieties= N.S							1.435	
Plant density (1000plant hectare-1	Varieties							Plant density means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-35E	IY-207E			
60	63	64	61.33	61.5	61.83	61		62.11	
70	65.83	66.17	63.83	63.33	63.33	57.83		63.39	
80	64.67	66.17	61.67	66	63.33	59.83		63.61	

L.S.D (0.05)	Plant Density $\times$ Varieties= 2.272						0.756
Varieties means	64.5	65.44	62.28	63.61	62.83	59.56	
L.S.D 0.05	1.47						

. This did not differ significantly from the plant density of 80.000 plants hectare⁻¹ at the same location. The response of the varieties at the Baghdad and Anbar locations was similar, and no significant interaction was observed (Table5).

The response of the varieties varied according to plant density. The direction was to delay silking in the two Iraqi varieties, Baghdad 3 and ALMaha, and the two Egyptian varieties, TW-345E and TW-78E, with increasing plant density from 60.000 to 70.000 plants h⁻¹. The Egyptian variety IY-355 behaved differently, as it was delayed with increasing plant density to 70.000 plants h⁻¹, then decreased at a density of 80.000 plants h⁻¹. The Egyptian variety IY-207E behaved in the opposite direction . The best response was interaction of the plant density of 70.000 plants h⁻¹ with the Egyptian variety IY-207E, as it took 61.83 days to reach silking. In contrast, the interaction of the second density with the Iraqi variety ALMahaI was even later, with a delay of 68.33 days to reach silking. Table 3 shows that the response of varieties varied according to location and plant density. The best response to the triple interaction at the Baghdad location, at a plant density of 70.000 plants ha⁻¹, was observed in the Egyptian variety IY-207E, which reached silking earlier, taking 54 days. It performed similarly at densities of 60.000 and 80.000 plants ha⁻¹ at the same location. In contrast, the Iraqi variety Baghdad 3 was delayed at the second density (70.000 plants ha⁻¹) at the Anbar location, taking 79 days to reach silking. This did not differ significantly from the Iraqi variety Al Maha and the two Egyptian varieties TW_78E and IY_355E at the same density and location.

Plant Height (cm)

The results in table 6 indicate significant differences in plant height for each of the locations , plant densities, varieties, binary interactions, and triple interactions. The Baghdad location significantly outperformed the Anbar location, an average plant height of 215.09 cm, a 46.76% increase compared to the Anbar location, where plants reached an average height of 146.55 cm . The significant difference in plant height between the two locations is attributed to differences in soil composition (table,2), particularly in the content of nitrogen, phosphorus, potassium, and organic matter, as well as genetic factors related to gene expression (variation in physiological performance) in response to changes in environmental conditions such as soil type, temperature, relative humidity, and light intensity(table,3) . This agree with the findings of Balem et al. (2014), Hamood(2019), Kazem (2020), and Naes (2023), who also noted significant variations in plant height between locations, indicating... The difference in the environmental impact of the locations on the performance of the genotypes leads to the existence of genetic and geographical divergence between the Egyptian and Iraqi varieties.

Table 6 of the aggregate analysis shows that there are significant differences between plant densities. The plant height increased with increasing plant density from 6 to 8 plants m⁻². The plant height reached 182.22 cm in the high density (80.000 plants ha⁻¹), and did not differ significantly from the second density (70.000 plants ha⁻¹), while the density of 60.000 plants ha⁻¹ gave the lowest average for the trait. The same table also indicates differences between varieties. The Egyptian variety TW345E exhibited the highest average plant height at 189.62 cm, while the Baghdad 3I variety showed the lowest at 177.33 cm, not significantly different from Al Maha and the two Egyptian varieties TW-78E and IY207E. These differences are attributed to variations in their genetic nature. The interaction between plant locations and densities was significant. The best response for plant height was observed at the Baghdad location with a plant density of 80.000 plants h⁻¹, reaching 219.73 cm. Conversely, the lowest response for plant height at the same density was observed at the Anbar location, reaching 144.71 cm.The response of the varieties differed significantly with varying plant densities.

Table 5. Aggregative analysis of the number of days to silking of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Locations	Plant density (1000plant hectare ⁻¹)	varieties						location s × plant density
		Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E	
Baghdad	60	58.33	57.00	57.00	59.00	56.33	56.33	57.33
	70	56.33	60.00	57.33	57.00	57.67	54.00	57.11
	80	57.67	59.67	57.33	59.67	58.00	56.33	58.11
Anbar	60	72.67	75.67	67.67	73.33	75.33	75.00	73.28
	70	79.00	76.67	77.33	75.67	78.00	69.67	76.06
	80	77.67	77.67	76.33	75.67	75.00	73.67	76.00
L.S.D (0.05)= 1.328		Location ×Plant Density × Varieties= 3.319						1.328
Locations	varieties						Locations means	
	Baghdad 3I	Al-MahaI	TW- 78E	TW-345E	IY-355E	IY- 207E		
Baghdad	57.44	58.89	57.22	58.67	57.33	55.56	57.52	
Anbar	76.44	76.67	73.78	74.89	76.11	72.78	75.11	
L.S.D (0.05)	Location × Varieties= ns						1.005	
Plant density (1000plant hectare-1	Varieties						Plant density means	
	Baghdad 3I	Al-MahaI	TW- 78E	TW-345E	IY-355E	IY- 207E		
60	65.50	66.33	62.33	66.17	65.83	65.67	65.31	
70	67.67	68.33	67.33	66.50	67.83	61.83	66.58	
80	67.67	68.67	66.83	67.67	66.50	65.00	67.06	
L.S.D (0.05)	Plant Density × Varieties= 2.345						0.979	
Varieties means	66.94	67.78	65.50	66.78	66.72	64.17		
L.S.D (0.05)	1.386							

Some varieties increased with increasing plant density up to 70,000 plants ha⁻¹, then decreased at 80,000 plants ha⁻¹. Others decreased at the second density and increased at the third. The response of varieties TW345 and IY355 was generally upward, reaching high density. The best response for plant height was observed in variety TW-345 at high plant density, reaching 193.7 cm, while the lowest response was 171.57 cm for the Iraqi variety Al Maha (Table, 6). The same table showed a significant triple interaction, as the Egyptian variety TW-345 outperformed the 80,000 plant density ha⁻¹ at the Baghdad location by giving the

highest average plant height of 226.40 cm, without a significant difference from the IY-355 variety at the same location and density mentioned, as it gave an average of the trait of 224.87 cm, and from the IY-207 variety, which gave 223 cm at the 70.000 plant density ha^{-1} at the same location. Meanwhile, the Egyptian variety TW-78E recorded the lowest average plant height of 137.20 cm, which did not differ significantly from the other varieties except for the TW-345E variety at the Anbar location at the density 80.000 plant ha^{-1} .

Table 6. Aggregative analysis of the plant height (cm) of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Ear Height(cm)

Table7 indicates significant differences in ear height based on location, plant density, genotype, and the binary interaction between location and density. The other interactions did not show a significant effect.

The Baghdad location significantly outperformed the Anbar location, yielding an average ear height of 125.18 cm, a 75.03% increase compared to the Anbar location, where plants yielded an average ear height of 71.52 cm. The superiority of the Baghdad location in ear height is attributed to its superiority in overall plant height (Table 6).

The aggregative analysis in Table 7 reveals significant differences between plant densities. Ear height increased by 6.51 cm with

Locations	Plant density (1000plant hectare ⁻¹	varieties						locations × plant density
		Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E	
Baghdad	60	207.13	195.07	210.80	222.87	216.33	209.07	210.21
	70	201.73	217.67	214.73	216.33	218.53	223.00	215.33
	80	220.27	212.80	214.60	226.40	224.87	219.47	219.73
Anbar	60	149.00	148.07	144.40	151.33	140.67	144.47	146.32
	70	144.53	150.53	152.93	159.80	141.67	142.27	148.62
	80	141.33	143.87	137.20	161.00	145.40	139.47	144.71
L.S.D (0.05)		Location ×Plant Density × Varieties= 8.405						5.179
Locations	varieties						Locations means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E		
Baghdad	209.71	208.51	213.38	221.87	219.91	219.91	215.09	
Anbar	144.96	147.49	144.84	157.38	142.58	142.07	146.55	
L.S.D (0.05)	Location × Varieties= 5.478						4.696	
Plant density (1000plant hectare-1	Varieties						Plant density means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E		
60	178.07	171.57	177.60	187.10	178.50	176.77	178.27	
70	173.13	184.10	183.83	188.07	180.10	182.63	181.98	
80	180.80	178.33	175.90	193.70	185.13	179.47	182.22	
L.S.D (0.05)	Plant Density × Varieties= 5.670						3.210	
Varieties means	177.33	178.00	179.11	189.62	181.24	179.62		
L.S.D (0.05)	3.123							

increasing plant density from 60.000 to 70.000 plants h⁻¹, and did not differ significantly from the third density (80.000 plants per hectare). The same table indicates the difference between the varieties, as the Egyptian variety TW_345 recorded the highest ear height of 103.53 cm and did not differ significantly from IY_355, which gave an ear height of 102.33 cm, while the Baghdad 3 genotype gave the lowest average for the trait of 94.50 and did not differ significantly from the Iraqi variety Al Maha and the Egyptian varieties IY_207E and TW_78E. Table 4 shows a significant interaction between plant location and plant density for ear height. The best response was observed at the Baghdad location for plant densities of 70.000 and 80.000 plants h⁻¹, where the ear height reached 128.23 cm. The lowest response was observed at the Anbar location for a density of 80.000 plants h⁻¹, at

68.13 cm, and this did not differ significantly from the first two densities at the same location. The table also shows no significant effect of the remaining binary or the triple interactions of the study factors.

Number of green leaves plant⁻¹

The results in table 8 indicate significant differences in the number of leaves for each location, plant density, and varieties, while the binary and triple interactions showed no significant differences. Table 8 shows significant differences between the Baghdad and Anbar locations for the number of leaves per plant. The Baghdad location significantly outperformed the Anbar location, leaves number an average of 14.093 leaves, which is 13.093% higher than the Anbar location, where plants had an average of 12.833 leaves. The results of the combined analysis in Table 5 show significant differences between plant densities. The second plant density resulted in the highest average leaves number, reaching 13.767 leaves, while the lowest average in plant density was 60.000 plants h⁻¹, with 13.278 leaves. The same table also indicates differences between varieties. Variety TW-345 had the highest leaf count at 13.989 leaves, not significantly different from the Egyptian varieties IY-355E and TW-78E. The Iraqi variety Baghdad 3I had the lowest average leaf number at 13 leaves, not significantly different from the Iraqi variety Al Maha and the Egyptian variety IY-207E. The results in Table 8 also show that the binary and triple

interactions of the study factors were not significant in determining the leaves number.

Leaf Area(cm²)

The Baghdad location significantly outperformed the Anbar location, yielding an average leaf area of 6277 cm², while the Anbar location yielded an average leaf area of 3509 cm² (Table 9). The same table shows no significant difference in plant density.

Table 6 indicates the difference between genotypes. The Egyptian variety TW-345 recorded the highest average leaf area at 5252 cm², followed by the Egyptian variety IY-355 at 4944 cm², which did not differ significantly from the Egyptian varieties IY-207 and TW-78. The Iraqi varieties Baghdad 3 and Al-Maha recorded the lowest average leaf area. Table 6 shows that the binary interaction between plant density and location decreases as plant density increases from 60.000 to 70.000 plants h⁻¹ at the Baghdad location, where the highest average leaf area was recorded at a density of 80.000 plants h⁻¹ (6394 cm²), while the lowest average leaf area was recorded at the same density in Anbar (3437 cm²). The Egyptian variety IY-207 outperformed other Egyptian varieties, giving the highest average leaf area of 6533 cm² at the Baghdad location, and did not differ significantly from all other Egyptian varieties. However, the same variety recorded the lowest average leaf area at the Anbar location (3198 cm²). The response of the varieties varied significantly with increasing plant density. Some varieties showed increased growth up to 70.000 plants h⁻¹, then decreased at 80.000 plants h⁻¹. Others decreased at the second density and increased at the third. The response of varieties TW_345E and IY-207E was generally upward, reaching the highest density. The best response for leaf area of the TW345 E variety at high plant density was 5324 cm² (Table 9). The same table showed a significant triple interaction, where the Egyptian variety IY-207E and the third density at the Baghdad location exhibited the highest average leaf area, reaching 6759 cm². This did not differ significantly from the second density of the same variety or from other Egyptian varieties at the same density.

Table 7. Aggregative analysis of the ear height (cm) of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Locations	Plant density (1000 plant hectare ⁻¹)	varieties						locations × plant density
		Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E	
Baghdad	60	118.33	109.53	119.00	127.73	125.13	114.73	119.08
	70	118.87	129.07	124.80	129.00	138.39	128.73	128.23
	80	127.20	124.67	125.53	133.20	129.27	129.53	128.23

Anbar	60	70.47	67.73	71.47	75.40	75.80	66.80	71.28
	70	69.67	74.47	81.53	83.20	71.60	70.40	75.14
	80	62.47	67.73	67.73	72.67	73.27	64.93	68.13
L.S.D (0.05)		Location ×Plant Density × Varieties =NS						9.712
Locations	varieties						Locations means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E		
Baghdad	121.47	121.09	123.11	129.98	131.11	124.33	125.18	
Anbar	67.53	69.98	73.58	77.09	73.56	67.38	71.52	
L.S.D (0.05)	Location × Varieties= NS						9.887	
Plant density (1000plant hectare-1	Varieties						Plant density means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E		
60	94.49	88.63	95.23	101.57	100.47	90.77	95.18	
70	94.27	101.77	103.17	106.10	105.27	99.57	101.69	
80	94.83	96.20	96.63	102.93	101.27	97.23	98.18	
L.S.D (0.05)	Plant Density × Varieties= NS						3.479	
Varieties means	94.50	95.53	98.34	103.53	102.33	95.86		
L.S.D (0.05)	4.225							

Table 8. Aggregative analysis of the leaves number of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Locations	Plant density (1000plant hectare ⁻¹)	varieties						locations $\times$ plant density
		Baghdad 3I	Al- MahaI	TW- 78E	T W - 34 5E	IY - 35 5E	IY- 207 E	
Baghdad	60	13.533	12.933	14.333	14. 86 7	14 2. 00	13. 467	13.889
	70	13.933	14.467	14.400	14. 40 0	14 7. 33	13. 867	13.300
	80	13.200	13.667	14.533	15. 20 0	14 4. 00	13. 533	14.089

Anbar	60	12.600	11.867	13.000	13.200	12.800	12.533	12.667
	70	13.067	12.867	13.467	13.000	14.467	12.533	13.233
	80	11.667	12.667	12.267	13.267	13.067	12.667	12.600
L.S.D (0.05)		Location × Plant Density × Varieties =ns						Location × Plant Density =ns
Locations	varieties						Locations means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-35E	IY-20E		
Baghdad	13.556	13.689	14.422	14.822	14.44	13.622	14.093	
Anbar	12.444	12.467	12.911	13.156	13.44	12.578	12.833	
L.S.D (0.05)		Location × Varieties =ns						.07702
Plant density (1000plant hectare-1)	Varieties						Plant density means	
	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-35E	IY-20E		
60	13.067	12.400	13.667	14.033	13.500	13.000	13.278	
70	13.500	13.667	13.933	13.700	14.600	13.200	13.767	
80	12.433	13.167	13.400	14.233	13.733	13.100	13.344	
L.S.D (0.05)		Plant Density × Varieties =ns						0.3092

Varieties means	13.000	13.078	13.667	13.989	13 9. 44	13 1. 00	
L.S.D (0.05)	0.4728						

Table 9. Aggregative analysis of the leaves area (cm²) of introduced Egyptian varieties of maize at three plant densities in the Baghdad and Anbar locations for the fall season 2024.

Locations	Plant density (1000plant hectare ⁻¹)	varieties						locations × plant density
		Baghdad 3I	Al- MahaI	TW- 78E	T W- 345 E	IY- 355 E	IY- 207 E	
Baghdad	60	6015	5409	6693	662 7	657 8	610 8	6238
	70	5627	6066	6327	649 2	594 4	673 3	6198
	80	6159	5960	6389	642 4	667 2	675 9	6394
Anbar	60	3641	3489	3394	371 4	319 6	345 5	3482
	70	3482	4034	3688	402 9	352 5	289 9	3609
	80	3199	3359	2848	422 4	375 0	323 9	3437
L.S.D (0.05)		Location × Plant Density × Varieties = 508.2						Location × Plant Density = 198.7
Locations	varieties						Locations means	
	Baghdad 3I	Al-MahaI	TW- 78E	TW-345E	IY- 35 5E	IY - 20 7E		
Baghdad	5933	5811	6470	6514	63 98	65 33	6277	
Anbar	3441	3627	3310	3989	34 90	31 98	3509	
L.S.D (0.05)	Location × Varieties = 296.6						153.9	
	Varieties						Plant density means	

Plant density (1000plant hectare-1)	Baghdad 3I	Al-MahaI	TW-78E	TW-345E	IY-355E	IY-207E	
60	4828	4449	5044	5171	4887	4782	4860
70	4555	5050	5007	5261	4735	4816	4904
80	4679	4659	4619	5324	5211	4999	4915
L.S.D (0.05)	Plant Density $\times$ Varieties = 358.4						n.s
Varieties means	4687	4719	4860	5252	4944	4865	
L.S.D (0.05)	213.0						

CONCLUSION

The Baghdad location significantly outperformed the Anbar location in all studied growth traits (e.g., days to tassling and silk formation, plant height, ear height, number of green leaves, and leaf area). Furthermore, the optimal triple interaction (location $\times$ plant density $\times$ variety) for most traits was observed in the Egyptian variety IY-207 and the Egyptian variety TW-345, particularly at densities of 70.000 or 80.000 plants/hectare in the Baghdad location, indicating that Egyptian varieties exhibit superior performance under ideal environmental and agricultural conditions. It is recommended that the Egyptian variety TW-345 or the Egyptian variety IY-207 be adopted and cultivated at a plant density of 70,000 plants/hectare in areas with environmental conditions similar to those of the Baghdad location to achieve optimal growth traits in maize.

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