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FIELD PERFORMANCE OF MAIZE SYNTHETIC CULTIVARS UNDER THE INFLUENCE OF MINERAL AND ORGANIC FERTILIZER COMBINATIONS

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SUMMARY

The promising study aimed to determine the most suitable synthetic cultivar of maize (*Zea mays* L.) under varied effects of mineral fertilizer combinations (nitrogen, phosphate, and potassium) and organic manures. A maize field experiment materialized in the 2022 crop season in the experimental fields of Ibn-Al-Bitar Preparatory Vocational School, District Al-Hussainiya, Holy Kerbala Governorate, Iraq. Employing the randomized complete block design (RCBD) with a split-plot arrangement helped set the experiment. In the main plots, the six combinations of mineral and organic fertilizers used comprised a) 160N + $100P_2O_5$ + $40K_2O$ kg ha^{-1}, b) 160N + $100P_2O_5$ + $40K_2O$ + 4 t ha^{-1} of organic fertilizer, c) 160N + $100P_2O_5$ + $40K_2O$ kg ha^{-1} + 8 t ha^{-1} of organic fertilizer, d) 320N + $200P_2O_5$ + $80K_2O$ kg ha^{-1}, e) 320N + $200P_2O_5$ + $80K_2O$ kg ha^{-1} + 4 t ha^{-1} of organic fertilizer, and f) 320N+$200P_2O_5$+$80K_2O$ kg ha^{-1} + 8 tons ha^{-1} organic fertilizer. The six maize synthetic cultivars in the subplots were Fajr-1, Maha, 5018, Sumer, Sarah, and Baghdad-3. The total uptake of nitrogen and phosphorus showed a significant interaction between fertilization levels and maize cultivars. The maize synthetic cultivar 5018 achieved the highest interaction at the sixth fertilizer level, with nitrogen and phosphorus uptake of 348.33 and 69.50 kg ha^{-1}, respectively. The maize cultivar Baghdad-3 at the sixth fertilizer level achieved the maximum interaction for potassium uptake, grains per ear, biological, and grain yields (213.43 kg ha^{-1}, 777.50 grains per ear, 20,949 kg ha^{-1}, and 9,674 kg ha^{-1}, respectively). However, this interaction was not significantly different from the interaction of the same synthetic cultivar with the fifth fertilizer level for the traits, viz., grains per ear, biological, and grain yields.

Keywords: Maize (*Zea mays* L.), synthetic cultivars, organic manures, mineral fertilizers, potassium uptake, biological and grain yield, biochemical traits

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Key findings: The maize cultivar Baghdad-3, with the sixth level of fertilizer combination, achieved the highest interaction for total uptake of potassium, grains per ear, biological yield, and grain yield. However, this interaction did not differ significantly from the interaction of the same cultivar with the fifth fertilizer level for the grains per ear, biological, and grains yield.

INTRODUCTION

The maize crop, considered one of the economic crops due to its multiple uses, has its vegetative parts, a desirable fodder for animals, with the grains used in bread flour after mixing them with wheat flour. Its grains can also become concentrated feed for livestock because it contains carbohydrates (81%), protein (6.10%), oils (6.4%), ash (2%), and some other vital and macro-minerals, such as sodium, potassium, and phosphorus. In addition, maize grains contain vitamins B1, B2, and E, and from its grains extracting the finest type of oil and starch come in large quantities, and the stalks can serve to make paper (Al-Asadi and Muhamed, 2023; Zaki and Ahmed, 2023).

Maize, an industrial food grain crop, has immense economic importance due to its high nutritional values, use in many nutritional fields, and, most notably, human consumption in preparing several food products and producing animal feed in various forms. Plant breeders and agronomists have worked a lot to increase the maize yield per unit area through several means, and the most vital is the use of high-yielding genotypes, including synthetic and hybrid cultivars (Al-Nasrawi, 2015; Yu *et al.*, 2023).

The maize breeders also worked to improve the quality of the crop, which is crucial because of its economic and commercial values. Indeed, attempts by plant breeders have succeeded in producing cultivars and strains of maize that are rich in the percentage of oil and protein in the grains (Al-Burki *et al*., 2021). Maize grain yield and essential amino acids can bear enhancement through hybridization and further selection for the genetic potential in the temperate, tropical, and sub-tropical exotic maize germplasm in sub-tropical breeding programs (Nyoni *et al*., 2023).

However, the maize crop suffers from significant production fluctuations, especially in Iraq. The instability in productivity calls for a search for possible means to enhance production considerably and its nutritional qualities by applying soil and crop service operations and selecting promising maize genotypes in various advanced approaches. In Iraq, most soils suffer from a declining organic matter content, and increasing production requires using agricultural methods that raise the yield by adding organic fertilizers. Organic fertilizer is a cornerstone needing foundation to enhance soil fertility and production and reduce environmental pollution as an essential factor in determining the productivity level per unit area (Nenova *et al.*, 2019).

The importance of mineral fertilizers also increases soil conditions that lack organic matter and some basic macro- and micro-elements. Therefore, the focus has progressed in recent years on sustainable agricultural practices that enhance the growth of corn plants, and one of these practices is using organic manures, which involves the use of animal wastes (Al-Jobouri *et al*., 2018). Animal waste fertilization is characteristic of most of the macro- and micronutrients necessary for the growth and development of crop plants. Based on the above facts, the presented research transpired to study the effects of different combinations of mineral and organic fertilizers on the biochemical and yield-related parameters of the yellow corn crop.

MATERIALS AND METHODS

The presented maize experiment materialized in the 2022 crop season in a randomized complete block design (RCBD) with a split-plot arrangement, two factors, and three replications. The main plots consisted of six combinations of mineral and organic fertilizer applications, i.e., a) 160N + $100P_2O_5$ + $40K_2O$ kg ha^{-1}, b) 160N + $100P_2O_5$ + $40K_2O$ + 4 t ha^{-1} of organic fertilizer, c) 160N + $100P_20_5$ + $40K_2O$ kg ha^{-1} + 8 t ha^{-1} of organic fertilizer, d) 320N + $200P_2O_5$ + $80K_2O$ kg ha^{-1}, e) 320N + $200P_2O_5$ + $80K_2O$ kg ha^{-1} + 4 t ha^{-1} of organic fertilizer, and f) 320N + $200P_2O_5$ + $80K_2O$ kg ha^{-1} + 8 t ha^{-1} organic fertilizer. The organic fertilizer was from cow and poultry waste in a ratio of 3:1, respectively (Al-Abdi, 2011). Growing six maize synthetic cultivars in the subplots used Fajr-1, Maha, 5018, Sumer, Sarah, and Baghdad-3. The maize sowing in the experimental units had an area of 3 m^2 × 3 m^2 for each experimental unit. The distance was 75 cm apart and 25 cm between hills, with a distance of 1.5 m between main plots.

Data recorded and statistical analysis

In all the maize subplots and replication, data recording ensued on the following parameters, i.e., total uptake of nitrogen, phosphorus, and potassium (kg ha^{-1}), ears per plant, grains per ear, 500-grain weight (g), biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), and harvest index (%). All the analyzed data underwent the analysis of variance (ANOVA) according to the RCBD with a split-plot arrangement (Steel and Torrie, 1980). The means comparison and separation used the least significant differences ($LSD_{0.05}$) test.

RESULTS AND DISCUSSION

Nitrogen uptake (kg ha^{-1})

The highest averages of nitrogen uptake emerged at the sixth fertilizer level and the lowest at the first level (343.62 and 218.66 kg ha^{-1}, respectively) (Table 1). These results were consistent with past studies, which revealed that nitrogen content enhanced by a significant percentage exceeding 50% in maize grains when fertilizing with an increased nitrogen fertilizer (Nenova *et al*., 2019). Nitrogen is integral in various compounds necessary for plant growth, including chlorophyll and many enzymes. Anas *et al.* (2020) and Peng *et al.* (2023) also authenticated that the corn plant responds sensitively to the fertilization process, which affects the accumulation of total nitrogen in the maize and other crop plants.

Table 1 shows the significant effect between the maize varieties, with the Baghdad3 variety having the highest mean nitrogen uptake, amounting to 309.83 kg ha^{-1}, and the Sumer variety recorded the lowest mean, amounting to 277.96 kg ha^{-1}. The value of the total uptake of nitrogen varies from one cultivar to another and according to the genetic makeup, as the ability to withdraw nutrients from the soil depends on the availability of those nutrients and the genetic ability present in the root hairs of those plants (Yang *et al.,* 2019; Abdul Mohsin and Farhood, 2023).

Table 1. Effect of maize cultivars, fertilization levels, and their interaction on the uptake of nitrogen.

Cultivars / Fertilizer combinations	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (kg ha^{-1})
First fertilizer level	204.49	218.65	234.29	212.63	205.25	236.68	218.66
Second fertilizer level	242.52	229.41	247.91	218.39	222.68	260.21	236.85
Third fertilizer level	297.13	266.92	307.28	256.29	274.48	310.61	285.45
Fourth fertilizer level	324.50	334.34	367.59	316.60	322.13	361.67	337.81
Fifth fertilizer level	331.13	334.27	330.67	326.21	327.83	343.82	332.32
Sixth fertilizer level	347.19	346.60	348.33	337.65	335.92	346.00	343.62
Means (kg ha^{-1})	291.16	288.36	306.01	277.96	281.38	309.83	

$LSD_{0.05}$ Cultivars = 2.98, Fertilizer levels = 4.18, Cultivars ×Fertilizer = 7.64

The interaction effects of fertilizer combinations and maize cultivars enunciated significant differences in the nitrogen uptake by the cultivars under study (Table 1). The highest accumulation of nitrogen (348.33 kg ha^{-1}) was visible with the interaction cultivar 5018 and the sixth fertilizer level, whereas the lowest (204.49 kg ha^{-1}) was with maize cultivar Fajr-1 at the first fertilizer level. The organic fertilizers increase the value of the total nitrogen uptake depending upon the genotypes and their ability. However, the decrease in total nitrogen uptake in some high-yielding genotypes can also refer to the tendency of the leaves of those plants to stay green at maturity (Mang *et al*., 2023).

Phosphorus uptake (kg ha^{-1})

The availability of phosphorus to crop plants depends on several factors, including the availability of organic material and nutrients, which the plants can absorb through soil fertilization. In maize plants, the phosphorus uptake significantly increased with increased application of the fifth combination of inorganic and organic fertilizers (Table 2). However, the lowest uptake for the said macro-component was at the first level and the highest at the sixth fertilizer level (46.32 and 60.35 kg ha^{-1}, respectively). These results were valid due to the available large quantities of phosphorus in fertilizers and the synergism of the presence of nitrogen and ammonia in organic fertilizers, helping the availability and absorption of phosphorus from the soil by the maize plants. Such outcome also has confirmation from previous studies in maize under different levels of mineral fertilization (Nenova *et al.*, 2019).

The order of maize cultivar means for the phosphorus uptake was as follows: Sumer < Sarah < Fajr-1 < Maha < Baghdad-3 < 5018 (Table 2). In general, most crop plants work to increase the root-to-stem ratio and increase the soil-root interface through various means. Nutrient transfer from the plant to the root helps raise the branching of the roots in the surface soil and enhances the density and length of the root hairs. In addition, the length of the lateral root, in turn, helps pull nutrients and storage in grains, and this mechanism depends on the genetic makeup and the potential of the genotypes in the wheat-maize system (Xin *et al.*, 2017).

In the case of the interaction means, the highest significant interaction for the phosphorus was prominent at the sixth fertilizer level with the maize cultivar 5018 (69.50 kg ha^{-1}) (Table 2). These findings also depend on the genetic makeup of the promising maize genotypes and the phosphorus level found in the soil (Saleh, 2013). In addition, it also varies upon the abundance of nitrogen, as the availability of nitrogen enhances root growth and increases their surface area for absorption, plus promoting the escalation of microorganisms to decompose organic materials. Moreover, the liberating phosphorus from its compounds becomes ready for absorption, and similar results came from past studies on maize genotypes with the application of classic and stabilized nitrogen fertilizers (Szulc *et al.*, 2023).

Table 2. Effect of maize cultivars, fertilization levels, and their interaction on the uptake of phosphorus.

Cultivars / Fertilizer combinations	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (kg ha^{-1})
First fertilizer level	42.00	45.23	50.33	43.54	46.10	50.70	46.32
Second fertilizer level	56.39	57.83	63.13	46.84	47.05	58.46	54.95
Third fertilizer level	58.51	59.13	64.09	47.43	53.52	64.67	57.89
Fourth fertilizer level	62.18	62.95	66.89	47.27	48.01	68.32	59.27
Fifth fertilizer level	61.72	62.53	66.60	47.99	48.65	53.33	56.80
Sixth fertilizer level	63.08	64.82	69.50	51.19	50.81	62.70	60.35
Means (kg ha^{-1})	57.31	58.75	63.42	47.38	49.02	59.70	

$LSD_{0.05}$ Cultivars = 1.95, Fertilizer levels = 2.24, Cultivars × Fertilizer = 4.79

Potassium uptake (kg ha^{-1})

Results revealed that the means for the potassium uptake bore an increase proportional to increasing fertilizer levels (Table 3). The boost in organic carbon has an essential effect on the macro exchange of potassium and other positive ions, which leads to their availability, withdrawal, and collection by crop plants. These results were analogous to past findings based on the effect of potassium fertilization and foliar feeding with iron on nutrient absorption of white corn (*Sorghum bicolor* L.) (Khalifa and Sahel, 2020) and maize (Mang *et al.*, 2023).

The highest mean for the total potassium uptake reached 190.81 kg ha^{-1} in the maize cultivar Baghdad-3 (Table 3). The results also exhibited the significant and the highest interaction of cultivar Baghdad-3 grown with the sixth fertilizer level (213.43 kg ha^{-1}). The ability to accumulate potassium may depend on the genetic makeup of the genotypes and the type and amount of fertilization applied to the maize crop (Hussain *et al.,* 2007).

Ears per plant (ear plant^{-1})

The outcomes enunciated the nonsignificant effect of the different fertilization levels on the number of ears per plant (Table 4). These results also agree with obtained past findings by studying the impact of spring maize cultivars and fertilization levels on growth and yield-related traits (Al-Nasiri *et al.,* 2016). Comparing the means for the number of ears of the cultivars under the experiment provided a significant difference. The cultivar Baghdad-3 gave the highest mean for ears per plant (1.31 ear plant^{-1}), while cultivar Fajr-1 owned the lowest value for the said trait (1.11 ear plant^{-1}). Al-Mufarji (2023) reported significant differences in the number of ears per plant based on the genetic makeup of the maize genotypes.

Table 3. Effect of maize cultivars, fertilization levels, and their interaction on the uptake of potassium.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (kg ha^{-1})
First fertilizer level	145.99	154.57	159.56	152.88	148.51	162.12	153.94
Second fertilizer level	156.89	161.57	167.26	154.80	156.13	159.67	159.39
Third fertilizer level	174.91	177.71	173.85	172.69	177.64	190.63	177.90
Fourth fertilizer level	194.26	200.29	213.03	195.37	190.82	212.17	200.99
Fifth fertilizer level	199.02	209.31	201.06	195.23	199.93	206.82	201.89
Sixth fertilizer level	196.57	207.42	207.39	197.24	195.41	213.43	202.91
Means (kg ha^{-1})	177.94	185.15	187.02	178.04	178.07	190.81	

$LSD_{0.05}$ Cultivars = 2.65, Fertilizer levels = 2.09, Cultivars × Fertilizer = 6.21

Table 4. Effect of maize cultivars, fertilization levels, and their interaction on the ears per plant.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (ear plant^{-1})
First fertilizer level	1.13	1.23	1.13	1.10	1.10	1.26	1.16
Second fertilizer level	1.06	1.20	1.10	1.13	1.16	1.30	1.16
Third fertilizer level	1.10	1.20	1.13	1.13	1.13	1.30	1.16
Fourth fertilizer level	1.13	1.23	1.13	1.13	1.13	1.30	1.17
Fifth fertilizer level	1.10	1.20	1.16	1.13	1.26	1.33	1.20
Sixth fertilizer level	1.13	1.23	1.23	1.20	1.23	1.36	1.23
Means (ear plant^{-1})	1.11	1.21	1.15	1.13	1.17	1.31	

$LSD_{0.05}$ Cultivars = 0.05, Fertilizer levels = N.S., Cultivars × Fertilizer = N.S.

Grains per ear (grain ear^{-1})

A significant difference appeared among the different fertilizer combinations for the grains per ear (Table 5). The highest average emerged with the sixth fertilizer level (708.9 grain ear^{-1}), and the lowest average resulted from the first fertilizer level (516.2 grain ear^{-1}). Al-Nasrawi (2015) also revealed that the availability of macro- and micro-nutrients and mineral elements positively affects the number of grains per ear, and their decrease causes a decline in the level of metabolic material reaching the ear grains themselves in maize crops. Yu *et al.* (2023) mentioned that reduced fertilization during the differentiation period of the growing buds and its transition from the vegetative to the reproductive phase reduces the number of grains per ear in maize plants. This increase was due to high fertilizer levels and available nutrients, raising the number of fertilized ovaries in the ear seed rows. It then causes the activation of silking cell divisions in the upper extremities of the ear, thus enlarging the emergence of the ear and fertilizing the ovaries in that area with pollen grains, significantly enhancing the number of grains per ear in maize genotypes (Cirilo *et al*., 2009).

Maize cultivars revealed significant differences in the number of grains per ear, and the highest mean for the said trait was evident in the cultivar Baghdad-3 (669.4 grains per ear) (Table 5). The number of grains in the ear depends on the maize genotypes and their genetic makeup, which can produce a specific number of grains per ear, and the same phenomenon attained support from Al-Mufarji (2023).

The number of grains per ear also had influences from the interaction of fertilizer combinations with the maize synthetic cultivars (Table 5). The highest interaction effect appeared in the cultivar Baghdad-3 at the sixth fertilizer level (777.50 grains in the ear). A relationship between the type and quantity of fertilizer in increasing the number of grains per ear also depended on the genetic makeup of the cultivars, as confirmed by the study of Masood *et al.* (2011), who mentioned that the number of grains per ear relied on the genetic makeup of the cultivars and growth factors, including fertilization levels.

The 500-grain weight (g)

The latest study revealed significant fertilization effects on the 500-grain weight (Table 6). The highest mean value for the said trait occurred at the sixth fertilizer level, with the lowest at the first fertilizer level (146.56 and 125.00 g, respectively). The promising results were also consistent with previous studies, including the study of Al-Nasrawi (2015), which proved that fertilization levels significantly affected the grain size and weight.

By comparing the maize cultivars for average 500-grain weight, the recent study exhibited highly significant differences among the maize genotypes for the said trait (Table 6). However, the highest average for 500-grain weight resulted in the maize cultivar Baghdad-3 (141.00 g), while the lowest in the cultivar Sumer (131.11 g). It confirms a significant effect of the cultivars on the 500-grain weight. Ahmed *et al.* (2007) also authenticated that the 500-grain weight depends on the genetic makeup of the cultivars. Grain weight is one of

Table 5. Effect of maize cultivars, fertilization levels, and their interaction on the grains per ear.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (grain ear^{-1})
First fertilizer level	504.0	530.8	536.4	491.5	479.5	554.8	516.2
Second fertilizer level	520.0	558.9	546.2	520.7	516.9	574.9	539.6
Third fertilizer level	528.4	554.5	558.0	531.3	517.1	568.5	543.0
Fourth fertilizer level	640.9	674.5	753.2	663.5	641.7	765.9	690.0
Fifth fertilizer level	650.7	709.0	770.9	677.8	666.8	774.7	708.3
Sixth fertilizer level	683.1	682.3	736.5	694.9	678.9	777.5	708.9
Means (grain ear^{-1})	587.0	618.3	650.2	596.6	583.5	669.4	

$LSD_{0.05}$ Cultivars = 8.06, Fertilizer levels = 7.90, Cultivars × Fertilizer = 19.32

Table 6. Effect of maize cultivars, fertilization levels, and their interaction on the 500-grain weight.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (g)
First fertilizer level	125.67	127.33	120.67	120.33	125.00	131.00	125.00
Second fertilizer level	134.33	136.33	134.67	130.00	131.00	132.33	133.11
Third fertilizer level	135.33	135.67	139.00	133.00	136.00	143.67	137.11
Fourth fertilizer level	138.33	145.67	147.00	133.67	136.67	145.33	141.11
Fifth fertilizer level	137.33	143.67	146.67	130.67	134.33	142.67	139.22
Sixth fertilizer level	144.00	150.67	155.00	139.00	139.67	151.00	146.56
Means (g)	135.83	139.89	140.50	131.11	133.78	141.00	
$LSD_{0.05}$ Cultivars = 1.26, Fertilizer levels = 1.39, Cultivars ×Fertilizer = 3.09							

Table 7. Effect of maize cultivars, fertilization levels, and their interaction on the biological yield.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (kg ha^{-1})
First fertilizer level	14228	15486	15513	14645	14669	15715	15043
Second fertilizer level	15458	15544	15656	15115	15158	16613	15591
Third fertilizer level	16389	18208	18617	18226	18094	18875	18068
Fourth fertilizer level	19128	19807	20262	19159	19236	20861	19742
Fifth fertilizer level	19280	19778	20309	19191	19285	20894	19789
Sixth fertilizer level	19812	20037	20833	19623	19285	20949	20090
Means (kg ha^{-1})	17382	18143	18532	17660	17621	18985	
$LSD_{0.05}$ Cultivars = 100.80, Fertilizer levels = 158.10, Cultivars × Fertilizer = 266.40							

the quantitative characteristics inherited from generation to generation, managed by polygenes; however, it may gain influences from various factors, such as growth, cultivation method, soil fertility, and environmental stresses.

The results indicated that the interaction between fertilizer levels and maize cultivars substantially influenced the seed index (Table 6). The highest interaction effect was notable at the sixth fertilizer level with the maize cultivar 5018 (155.00 g), and the lowest interaction was between the first fertilizer level and the cultivar Sumer (120.33 g). The decrease in grain weight may be due to a decline in the accumulation of dry matter during the grain-filling stage, which also depends on the genotypic and environmental factors related to the levels of nutrition and irrigation. The grain formation, size, and growth rely on the plant's reproductive stage, environmental conditions related to temperature and fertilization, and genotypic factors related to the maize cultivars. These results were consistent with past studies of Al-Halafi and Al-Tamimi (2017) in studying the response of synthetic varieties of yellow corn to mineral, organic, and biological fertilizers.

Biological yield (kg ha^{-1})

The outcomes showed that fertilizer combinations considerably affected the biological yield in maize genotypes (Table 7). The highest average biological yield was with the sixth fertilizer level (20,090 kg ha^{-1}), while the lowest was with the first fertilizer level (15,043 kg ha^{-1}). It may be because of fertilization processes contributing to the plant's growth and its reflection in the increase in the shoot, augmenting the grain mass of the plant because of the increased accumulation of carbon metabolism products, thus an increase in the biological yield weight (Shiferaw *et al.*, 2018).

The maize cultivars also revealed a significant effect on the biological yield, and the highest mean for the said trait appeared in the maize cultivar Baghdad-3, with the lowest for the cultivar Fajr-1 (18.985 and 17.382 kg ha^{-1}, respectively). Kubba and Esti (2012) also confirmed a remarkable effect of the genetic makeup of the maize genotypes on the biological yield, and some cultivars can ably increase biomass, hence increasing the biological yield.

The biological yield also varies depending on the genetic makeup of the maize cultivars and the available nutrients. Accordingly, the interaction between fertilizer levels and the maize cultivars under study proved significant (Table 7). The highest interaction was distinct between the sixth fertilizer level and the cultivar Baghdad-3 (20,949 kg ha^{-1}) and the lowest at the first fertilizer level with cultivar Fajr-1 (14,228 kg ha^{-1}). The findings of Lomer *et al.* (2012) also indicated a mutual interaction between the maize cultivar and the amount of nitrogen fertilizer used, which always varied for biological yield with the different maize cultivars grown even with the same fertilizer level. Ali *et al.* (2011) reported that organic and inorganic fertilizer combinations' interactions with maize genotypes have a noteworthy relationship with biological yield.

Grain yield (kg ha^{-1})

Grain yield is the final product and valuable trait affected by the fertilization process and has management from various growth and yield components (Wahib, 2001). Fertilizer levels are one of the chief growth factors significantly affecting this trait, and the sixth fertilizers combination was visible with the highest average grain yield (9,048 kg ha^{-1}), while the lowest mean was with the first fertilizer level (5,505 kg ha^{-1}) (Table 8). The reason for this is that the fertilization process leads to a supply of nutrients to the plants, which, in turn, increases the ability to assimilate carbon, supporting the processes of manufacturing proteins and carbohydrates, ultimately leading to an increase in the total grain yield (Matongera *et al*., 2023).

Maize cultivars also showed differences in grain yield, and the maximum average grain yield appeared in the cultivar Baghdad-3 (8,141 kg ha^{-1}), while the lowest was in the cultivar Sarah (7,208 kg ha^{-1}) (Table 8). The superiority of the cultivar Baghdad-3 in grain yield is due to the superiority of this cultivar in most of the yield components, as reflected positively in increasing the total grain yield, which depends on the genetic makeup of the genotypes under study. Otung (2014) reported an effect of synthetic cultivars on grain yield, with the grain yield varying from one cultivar to another. The promising results also agreed with many previous studies, including the study of Amanullah *et al*. (2021), who mentioned that biofertilizers with organic and inorganic phosphorus sources improve the dry matter partitioning and grain yield of hybrid maize.

The results also revealed the significant interaction between the fertilizer levels and the maize cultivars under study for grain yield (Table 8). The highest interaction effect manifested from the cultivar Baghdad 3 grown with the sixth fertilizer level (9,674 kg ha^{-1}), and the lowest was in the cultivar Sumer with the first fertilizer level (5,166 kg ha^{-1}). Its reason was due to the fertilization process and available nutrients, which boost the efficiency of the photosynthesis process, thus storing energy as carbohydrates, fats, and proteins in

Table 8. Effect of maize cultivars, fertilization levels, and their interaction on the grain yield.

Fertilizer combinations \ Cultivars	Fajr-1	Maha	5018	Sumer	Sarah	Baghdad-3	Means (kg ha^{-1})
First fertilizer level	5407	5546	5738	5166	5373	5798	5505
Second fertilizer level	5621	5669	5967	5312	5437	6149	5693
Third fertilizer level	7542	0756	7889	7614	7178	8212	7666
Fourth fertilizer level	8516	8809	9048	8389	8370	9438	8762
Fifth fertilizer level	8959	8968	9395	8553	8483	9577	8989
Sixth fertilizer level	9074	9221	9439	8473	8408	9674	9048
Means (kg ha^{-1})	7520	7629	7913	7251	7208	8141	

$LSD_{0.05}$ Cultivars = 41.94, Fertilizer levels = 53.93, Cultivars × Fertilizer = 105.31

the grains. It then increases grain yield. The grain yield also sustained influences from the genetic makeup of the maize cultivars. The superiority of the interaction between Baghdad 3 and the sixth fertilizer level in achieving the maximum grain yield was due to its superiority in the total potassium uptake, the number of ears, grains per ear, and the biological yield (Tables 3 and 7). These results agreed with the findings of Aslam *et al.* (2015), who also assessed the genetic components for different traits in maize (*Zea mays* L.).

CONCLUSIONS

The nature of the genetic makeup of the cultivated maize cultivars and the type and quantity of fertilizers used are the prime factors influencing the yield-related traits and, eventually, grain yield in maize. The pertinent study confirmed that the synthetic maize cultivar Baghdad-3 and the fifth fertilizer combination achieved the highest productivity and savings on fertilizers.

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