

ARTICLE

Effects of corn (*Zea mays* L.) Varieties and NPK Fertilizer Combinations on Growth and Productivity

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ABSTRACT

The main goal was to evaluate the response of corn varieties to different NPK fertilizer combinations and their interaction. The presented research was conducted 2024 summer season in the Al-Hashimiyah area, Babil City, Iraq. Fertilizer combination was used rate of F₁ (50 kg N + 20K+15P kg ha⁻¹), and F₂ (65 kg N + 35K +20P kg ha⁻¹) and F₀ (control), with three corn varieties (*Zea Mays L*) Furat (FU), Maha (MA) and Gadiz (GA). The F₂ was significantly superior to the other level of F₁ and F₀. The GA variety was significantly better than MA and FU varieties. For GA variety, the plant height (PH), leaf area (LA), chlorophyll index in leaves (CIL), grains number (GNR), Ear length, grain yield(GY)and biological yield (BY), were 165.34 cm 541.88 cm², 45.76 SPAD, 470.2 grains ear⁻¹, 27.2cm ,5.698 t ha⁻¹ and 17.200 t ha⁻¹respectively, The interaction among fertilizer combination F₂ × GA variety present noteworthy execution versus other interactions, caused the best results were 172.58 cm,653.85cm², 51.42 SPAD, 578.6 grain ear⁻¹,28.9 cm , 7.85t ha⁻¹ and 18.064 t ha⁻¹ respectively.

Keywords: Corn; Fertilizer Combinations; Local Corn Varieties; Growth Characteristics; Productivity

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INTRODUCTION

The corn (*Zea mays* L.) is third place after wheat and barley crops in terms of cultivated area and production (Alsharifi *et al.*, 2024), and it is called the king of crops because of its economic importance, at the level of nutrition, pharmaceutical and chemical industries (Alaamer *et al.*, 2023a). Corn is grown on large areas of Iraq, and its cultivation is concentrated in Najaf, Karbala, Wasit, Babil and Baghdad. The yellow corn crop needs high temperatures and abundant water (Alaamer *et al.*, 2020; Alaamer *et al.*, 2023b). The increase in nitrogen fertilizer levels led to an increase in crop growth and productivity (Alsharif *et al.*, 2021a). The phosphorus is an essential macronutrient for corn growth and productivity because of its fundamental role in energy transfer, photosynthesis, nucleic acid synthesis, and membrane formation. Adequate phosphorus availability promotes early root development and enhances the establishment and growth of corn plants, thereby improving their ability to absorb water and other essential nutrients (Chen *et al.*, 2024).

Phosphorus contributes to reproductive development, including flowering, grains formation, and grain filling, which are critical determinants of final grain yield. Therefore, an adequate and balanced supply of P, in combination with (N) and (K), is essential for supporting optimal vegetative growth, reproductive development, and productivity of corn.

The combined application of NPK fertilizers may also promote balanced nutrient availability and improve nutrient-use

efficiency by reducing nutritional limitations associated with the deficiency of individual macronutrients (Luo *et al.*, 2024).

Nitrogen (N) and potassium (K) are two of the most yield-limiting macronutrients in corn cultivation. Nitrogen is the fundamental building block of chlorophyll, amino acids, proteins, driving photosynthetic capacity and biomass accumulation. Recent research continues to underscore its paramount importance. The Kaleri *et al.* (2025) demonstrated that optimal N fertilization significantly enhances the photosynthetic rate and activities of key nitrogen-metabolizing enzymes, directly correlating with increased kernel number and weight (Rajput *et al.*, 2023), that modern agronomic strategies, including split applications and the use of controlled-release fertilizers, are crucial for synchronizing N availability with crop demand, thereby boosting yield while mitigating ecological harm (Manzoor *et al.*, 2025).

The application of fertilizers may influence the mobility and availability of potentially toxic contaminants in soil–plant systems, particularly through changes in soil acidity (Asante-Badu *et al.*, 2020; Singh *et al.*, 2022). Therefore, understanding the response of different maize varieties to varying fertilizer levels is essential for optimizing nutrient management, improving plant growth and productivity, and identifying fertilizer–variety combinations that promote sustainable maize production under the prevailing soil conditions (Zhang *et al.*, 2025). NPK fertilizers can increase the cadmium and nickel contents of soil and corn, with the increases being the highest for roots and the lowest for cobs and kernels. The effects of varying NPK fertilization levels and corn varieties had been investigated on plant nutrient status, reporting that NPK fertilization enhanced nutrient uptake, particularly zinc accumulation (Abu-El-Fotoh *et al.*, 2025). Furthermore, nitrogen fertilization and increasing potassium application rates were associated with higher zinc concentrations in plant tissues.

Potassium (K) is a soil nutrient critical for sustaining soil ecosystems and supporting crop growth and development (Zone *et al.*, 2020). Recent investigations into have broadened their focus from crop production to encompass its environmental impact, particularly concerning soil emissions, is an important component of Biofertilization Technology and has been widely endorsed as a promising solution to address the dual challenges of food security and climate change in agroecosystems (Kareem *et al.*, 2021). Understanding the performance and response of different corn varieties under varying fertilization levels is essential for identifying appropriate nutrient management strategies and improving crop growth and productivity. Evaluating the interaction between fertilization levels and corn varieties can provide valuable information regarding varietal differences in nutrient utilization and their contribution to improved crop performance, growth, and development of organs during the growing period from planting to harvest, which will lead to a positive increase in the crop yield of these varieties (Mohammed *et al.*, 2022; Mueen *et al.*, 2025). Increasing grain productivity and improving its quality is achieved by selecting varieties that give the highest yield to ensure food security in line with the increasing population (Anang *et al.*, 2022; Kodua *et al.*, 2022; Hussein *et al.*, 2026). Crop productivity increases through the adoption of improved varieties IMV, as these varieties prove effective in improving agricultural performance and efficiency, ultimately contributing to improved livelihoods for farmers, increased profits, and enhanced food security (Mdoda *et al.*, 2025; Alaamer *et al.*, 2026). Most farmers suffer from limited resources, so the focus is on special measures for soil and crop management by selecting the variety that gives the highest productivity under the growing conditions.

The amount and balance of fertilizer applied are among the most important factors influencing modern agricultural production, as adequate nutrient supply plays a critical role in promoting crop growth, improving nutrient-use efficiency, and increasing yield. Optimizing fertilizer application is therefore essential for achieving high productivity while ensuring efficient utilization of applied nutrients. Accordingly, the current study aimed to evaluate the effects of different fertilizer application levels on the growth characteristics and productivity of different maize varieties and to identify the most effective fertilizer level for each variety.

MATERIALS AND METHODS

Study site

Al-Hashimiyah City, the district center of Babylon Governorate, is situated in the Middle Euphrates region, approximately 130 km south of Baghdad. Known for its fertile agricultural lands, the area is renowned for its orchards and cultivation of strategic crops such as wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and corn (*Zea mays* L.)

Field soil preparation

Prior to planting, soil samples were collected from nine randomly selected locations (0-20 cm depth) with three replicates each for comprehensive physicochemical analysis. The sampling area was determined based on experimental requirements, with results presented in Table 1.

Table (1) Analysis of soil physical and chemical characteristics

Depth	Texture %			
0-20 (cm)	Clay	Silt	Sand	
	659	188	153	Clay
	Soil physical properties			
	Pb (Mg m ⁻³)	TSP (%)	SPR (Kpa)	
	1.23	53.58	1555.09	field capacity %
	1.27	52.07	1668.81	33.12
	1.32	50.18	1625.45	32.43
VA	1.27	52.07	1616.45	
0-20	Soil chemical properties			
	E.C (ds\cm ³)	HP	True Density (Mg.m-3)	
	2.34	7.42	2.55	
	Soluble cation meq\l			
	Na	K	Ca+Mg	
	8.21	12.16	55.15	
	O.C (%)	CEC Meq\100 g)	CaCo3 (%)	O.M (%)
	0.55	31.88	4	0.65

The soil was prepared by plowing using a Chisel plow and the tiller was set to a depth of 20 cm to stir the soil, the soil was smoothed using double disc combs, and leveled using leveling equipment arranged. The experiment was arranged as a split-plot design within a randomized complete block design (RCBD), with three replications. Maize varieties were assiGNRd to the main plots, while fertilizer application levels were assiGNRd to the subplots. Within each replication, the maize varieties were randomly allocated to the main plots. Each main plot was then divided into subplots, and the different fertilizer levels were randomly assiGNRd to these subplots independently within each main plot. Thus, each replication contained all combinations of maize varieties and fertilizer levels, with the randomization procedure applied separately at the main-plot and subplot level, with 27 experimental units measuring 3x3.5 m², with a distance of 75 cm between the experimental units and 1 m between the blocks. 20 cm was between planting holes. A locally developed fertilizer application machine is used to apply a triple phosphate fertilizer at a rate of 140 kg ha⁻¹ at a time and to a depth of 8 cm before planting (Alsharifi *et al.*, 2021b).

The planter type sowing machine, was set at 100 kg ha⁻¹ for the FU variety then the same process was repeated for the MA and GA varieties, corn planting commenced on July 15, and the crop was harvested on Dec 5. This arrangement allowed the effects of maize variety, fertilizer level, and their interaction on growth characteristics and productivity to be statistically evaluated.

The experiment includes two factors

- i) The first factor comprising of three different corn varieties include; Furat (FU), Maha (MA) and Gadiz (GA).
- ii) Added fertilizers, the experiment tested three nitrogen (N: 0, 50, and 65 kg N•ha⁻¹) and three potassium (K: 0, 20, and 35 kg K•ha⁻¹) and three phosphorus (0, 15, and 20 kg ha⁻¹) levels in a factorial combination, denoted as F₀ (control), F₁ (50 kg N + 20K+15P kg ha⁻¹), and F₂ (65 kg N + 35K +20P kg ha⁻¹)

Vegetative growth characteristics

1. Plant height (cm)

It was measured after the plant reached the flowering stage (100%), using an Invar split measurements were taken from the soil surface to the flag leaf base for ten randomly selected plants from the midlines for each experimental unit, with three replicates (Alaamer *et al.*, 2023a).

2. Leaf area (cm²)

It was calculated according to the Eq.3, approved by Shathar *et al.* (2024).

$$L_A = FL \times FW \times 0.74$$

Where: L_A = Leaf area cm², FL; Leaf length cm, FW; Leaf width cm.

3. Ear length

It's measured using an Invar tape measure, according to method (Alwan *et al.*, 2019; Mohammed *et al.*, 2022).

4. Chlorophyll index in leaves (SPAD)

It was calculated using a manual digital scaling device SPAD-502-meter and awarding to the method by (Mohammed *et al.*, 2022; Alaamer *et al.*, 2023b).

Yield characteristics

1. Grains number in the ear (grain ear⁻¹)

After the plant reached physiological maturity, ten ears were taken from the midlines for each experimental unit (three replicates) and placed in husking and counting machine (Satak type), (Aljibouri *et al.*, 2022).

2. Grains Yield (t ha⁻¹)

It was calculated using the equation mentioned by (Shtewy *et al.*, 2020).

$$GY = GP \times PD$$

Where: GY = Grain yield (t•ha⁻¹), GP = Grain weight per plant (kg•plant⁻¹), PD = Plant density (plants•ha⁻¹)

3. Biological yield (t ha⁻¹)

It was calculated after drying the sample in the oven at 70 °C until the weight stabilized using the equation below.

$$BY = PDW + PD$$

Where; BY=biological yield (t ha⁻¹), PDW=plant dry weight (Ton), and PD= plant density (ha⁻¹)

Statistical Analysis:

The experimental data were statistically analyzed using GenStat, 18th Edition (VSN International). The experiment was arranged as a split-plot design within a randomized complete block design (RCBD). Analysis of variance (ANOVA) was performed according to the appropriate split-plot model, with the corresponding error terms used to test the effects of the main plots, subplots, and their interaction. When significant differences were detected, treatment means were compared using the Least Significant Difference (LSD) test at a significance level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Vegetative growth characteristics

Table 2, and 3 results showed that there is a highly significant effect of both the fertilizer combination factors and the varieties of local corn on the plant vegetative growth characteristics. The averages of this characteristic differed according to the fertilizer combination, as the F2 gave the highest vegetative growth averages of 170.87cm, 622.25 cm², and 46.11SPAD respectively, compared to the F1 and F0, which gave undesirable results for this study. The improvement in vegetative growth characteristics can be attributed to the role of fertilizer application in supplying essential nutrients required for various physiological processes. Adequate nutrient availability enhances cell division and expansion, chlorophyll synthesis, and photosynthetic efficiency, thereby promoting overall vegetative growth and plant development (Alaamer *et al.*, 2023a). As for the corn varieties, the GA variety achieved the highest averages, reaching 165.34 cm, 541.88 cm², and 45.76 SPAD, respectively, as compared to FU and MA which gave undesirable results for this study. This was due to the genetic composition for the selected variety and its. Accordingly, the superior performance of the selected variety suggests that it was better adapted to the environmental and agronomic conditions of the present experiment, whereas FU and MA may require different management conditions or may possess a lower genetic capacity to respond positively to the fertilizer treatments applied (Mohammed *et al.*, 2022). Suitability to withstand the cultivation conditions by giving the highest growth rates, that the interaction among fertilizer combination F2 and the GA variety caused the best results for this study. The level of the vegetative growth characteristics at different conditions is show in Figure 1 for fertilizer combination and corn varieties.

Yield properties

Table 2and 4 results showed that there is a highly significant effect of both the fertilizer combination factors and the varieties of local corn on the yield characteristics. The averages of this characteristic differed according to the fertilizer combination, as the F2 gave the highest yield averages of 493.7 grains ear⁻¹, 26.8 cm 5.364 tha⁻¹and, 17.345 t ha⁻¹, respectively, compared to the F1 and F0, which gave undesirable results for this study.

Table (2) Analysis of variance (ANOVA) showing calculated F-statistics for the studied maize traits.

Source	df	plant height	Leaf area	Chlorophyll index in leaves	Grains number in the ear	Ear length	Grain yield	biological yield
C.v = Varieties	2	106.92**	698.12**	409.70**	150.30**	346.57**	246.92**	50.92**
Experimental error-V	4	0.88732	1.88693	0.27382	0.18374	0.10702	0.47718	0.07519
fertilizer combination	2	822.83**	3627.60**	247.79**	174.19**	724.11**	231.47**	146.09**
C.v*F	4	5.09*	509.85**	120.54**	9.74*	1.90 ^{N.S}	42.44**	3.94 ^{N.S}
Experimental error-C.v*F	12	0.13851	1.38984	0.05126	0.30121	0.23122	0.13162	0.061601

C.v = Varieties, F= fertilizer combination. ** Significant at 0.01 level. * Significant at 0.05 level

This is due to the spread of roots over wide distances, and the largest possible amount absorption from available nutrients with the soil moisture abundance, which was positively reflected in the yield characteristics (Kareem *et al.*, 2021). Overall, the pronounced response of grain yield to fertilizer application was supported by improvements in the measured growth characteristics and yield components. The results indicate that the most effective fertilizer treatment enhanced nutrient availability, stimulated vegetative development, increased the capacity for photosynthesis and

assimilate production, and improved the formation of yield components, ultimately resulting in higher grain yield. Therefore, the grain-yield response represents the integrated outcome of improved plant growth and reproductive development under an adequate and balanced nutrient supply (Alsharifi *et al.*, 2025). As for the corn varieties, the GA variety achieved the highest averages, reaching 470.2 grains ear⁻¹, 27.2cm, 5.698 t ha⁻¹, and 17.200 t ha⁻¹, respectively, as compared to FU and MA which gave undesirable results for this study. This was due to the genetic composition for the selected variety and its (Zhang *et al.*, 2023). Suitability to withstand the cultivation conditions by giving the highest growth rates, that the interaction among fertilizer combination F2 and the GA variety caused the best results for this study. The level of the vegetative growth characteristics at different conditions is show in Figure 2 for fertilizer combination and corn varieties.

Table (3) Effect of the interaction between varieties and fertilizer combination on vegetative growth characteristics

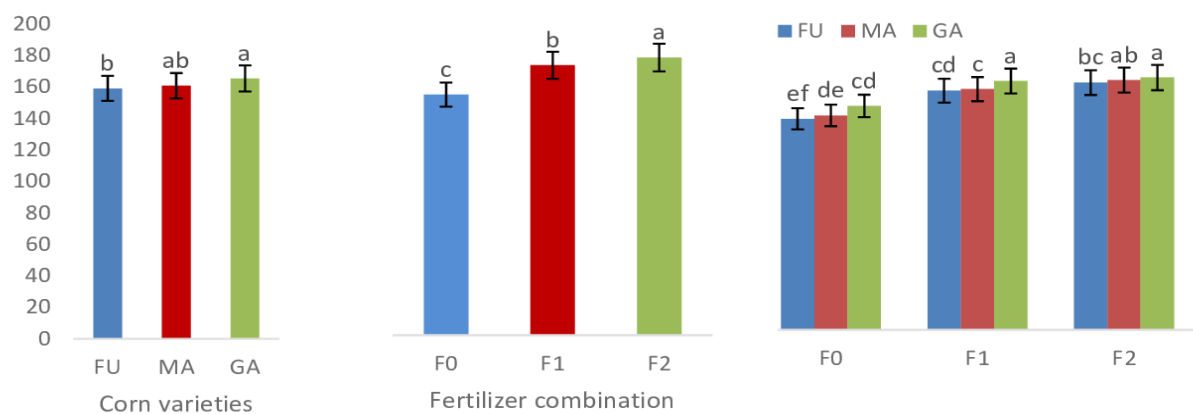
Varieties	F Kg ha ⁻¹	Ph in cm	LA in cm ²	CIL as SPAD
FU	F ₀	144.40	345.22	35.26
	F ₁	163.63	512.18	38.63
	F ₂	169.17	588.75	42.34
MA	F ₀	146.71	351.76	38.76
	F ₁	164.70	606.66	41.22
	F ₂	170.84	624.15	44.58
GA	F ₀	153.22	355.79	40.14
	F ₁	170.23	616.01	45.70
	F ₂	172.58	653.85	51.42
V	FU	159.07	482.05	38.74
	MA	160.75	527.52	41.52
	GA	165.34	541.88	45.76
F	F ₀	148.11	350.92	38.05
	F ₁	166.19	578.28	41.85
	F ₂	170.87	622.25	46.11
LSD _(0.05)	V	1.233	1.789	0.684
	F	1.645	1.869	0.578
	V*F	1.984	2.784	0.763

V=Varieties; MA=Maha variety; FU=Furat variety; GA= Gadiz variety; F=fertilizer combination; PH=Plant height; LA=Leaf area; CIL=Chlorophyll index in leaves

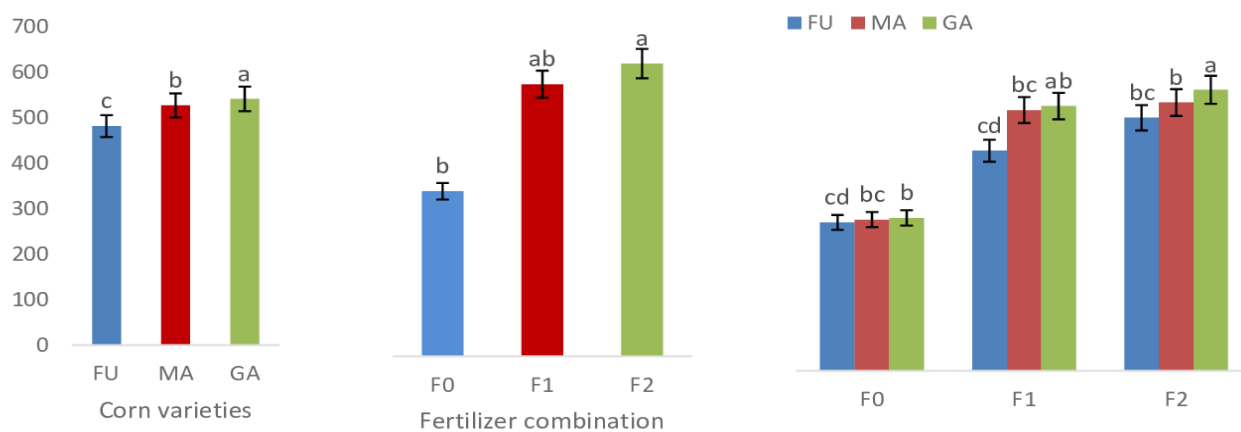
Table (4) Effect of the interaction between varieties and fertilizer combination on yield characteristics

Varieties	F Kg ha ⁻¹	GNR	EL	GY	BY
FU	F ₀	324.2	21.5	3.367	15.039
	F ₁	355.4	23.6	3.912	15.817
	F ₂	349.0	24.4	4.043	16.858
MA	F ₀	345.8	23.2	3.607	16.073
	F ₁	405.0	25.8	4.098	16.859
	F ₂	503.5	27.1	4.466	17.114
GA	F ₀	397.4	25.2	4.004	16.445
	F ₁	343.7	27.6	5.507	17.093
	F ₂	578.6	28.9	7.585	18.064
V	FU	359.5	23.3	3.774	15.904
	MA	418.1	25.4	4.057	16.682
	GA	470.2	27.2	5.698	17.200
F	F ₀	355.8	23.3	3.659	15.852
	F ₁	398.3	25.7	4.506	16.589
	F ₂	493.7	26.8	5.364	17.345
LSD _(0.05)	V	17.740	0.428	0.230	0.158
	F	21.010	0.459	0.330	0.241
	V*F	27.360	N.S	0.382	N.S

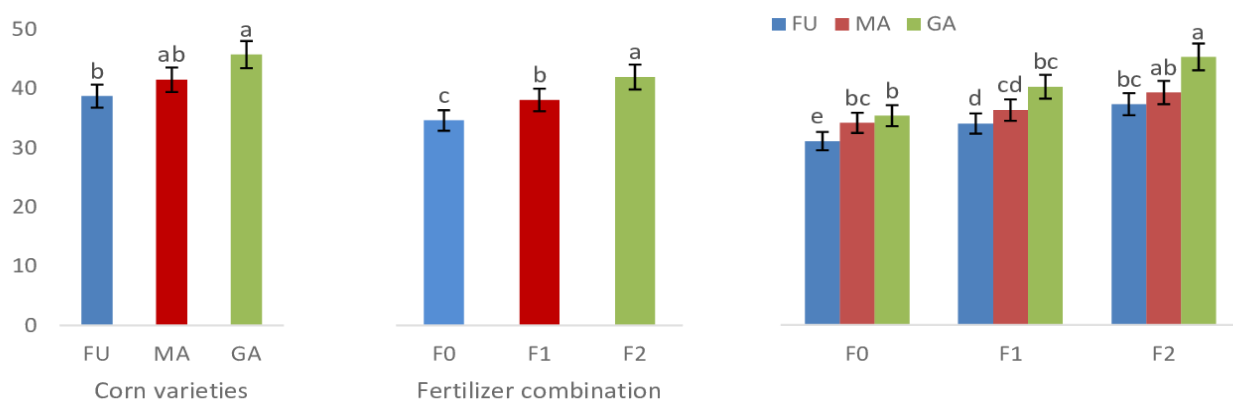
GNR= Grains number in the row; EL=Ear length; GY=Grain yield; BY=Biological yield



a. Plant height

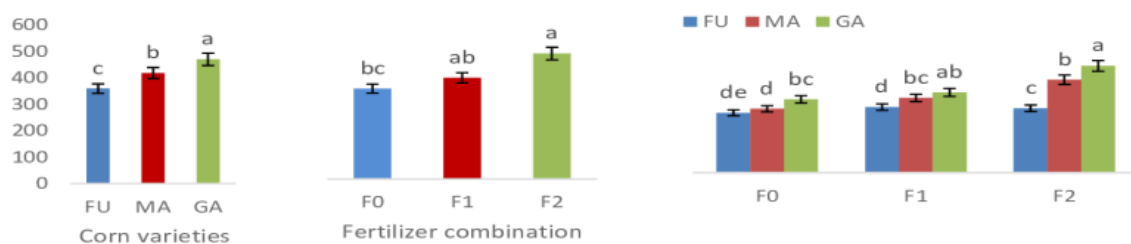


b. Leaf area

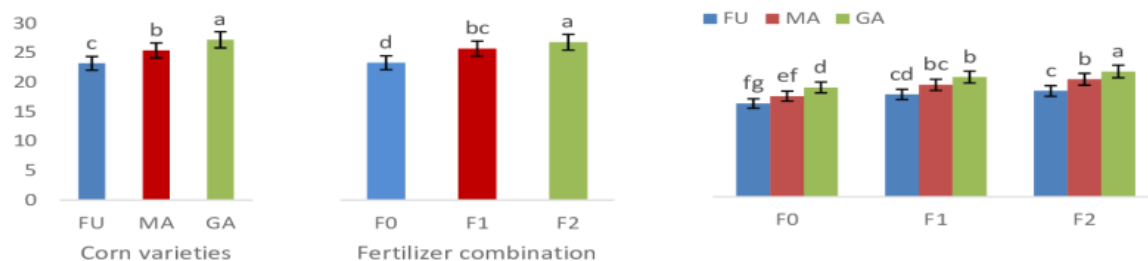


c. Chlorophyll index in leaves

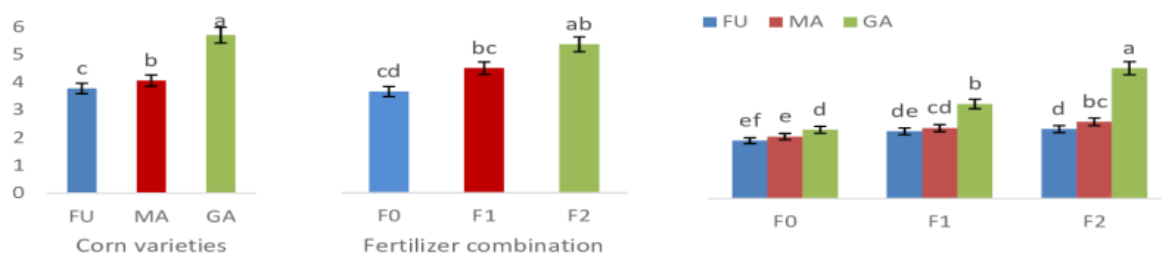
Figure (1) Effect of the varieties and fertilizer combination on vegetative growth characteristics: (a) Plant height, (b) Leaf area, and (c) Chlorophyll index in leaves.



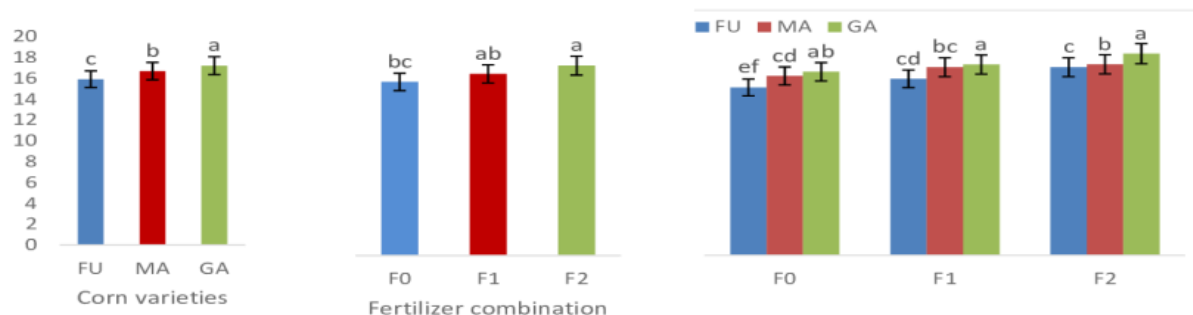
a. Grains number in the ear



b. Ear length



c. Grains yield



d. Biological yield

Figure (2) Effect of the varieties and fertilizer combination on yield characteristics: (a) grains number in the ear, (b) Ear length, (c) Grains yield (c), and (d) Biological yield.

CONCLUSIONS

Corn variety GA showed significant superiority compared to other varieties Fu and MA in the studied parameters. The fertilizer combination of F2 (65 kg N + 35K +20P kg ha⁻¹), also provided a significantly better response, the fertilizer combination of F2 (65 kg N + 35K +20P kg ha⁻¹) it achieved the best values during the growing season for corn compared to F1 (50 kg N + 20K+15P kg ha⁻¹), and F0 (control). The interaction between GA × F2 exhibited a noteworthy performance across most of the studied traits compared with the other treatment interactions, except for ear length and biological yield.

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