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Effect of Different fertilizers on Growth, Yield and Yield Components for two genotypes of Maize (*Zea mays* L.) in Calcareous Soil.

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ABSTRACT

The experiment was conducted to assess the effect of different type of fertilizers on growth, yield and yield components of maize plant, conducted at Qlyasan Agricultural Research Farm in Sulaimani governorate, Iraq. The study was conducted during the summer growing season in (2024). Experimental treatments have been organized and experiment was laid out in a randomized completely block design with three replicates. The treatments included seven levels of different fertilizers. 150 kg N ha-1, 150 kg P_2O_5 ha^{-1}, 100 kg K ha^{-1}, Organic fertilizer of cattle manure (10 *M*g ha^{-1}), Nano NPK (20:20:20) (0.4 g L^{-1}) and NPK (20:20:20) chemical fertilizer (150 kg ha^{-1}), and two genotypes of maize (Fajer and Medium). The results showed that the effect was significant at ($P \leq 0.05$) on the growth criteria of a maize plant. The experiment shows the effect of fertilizers in parameters, such as: Vegetative growth, Reproductive growth, Grain, and Yield parameters. Compared to Control, Urea is a very effective fertilizer for Vegetative and Reproductive growth, in plant height (183.01, leaf number (17.91), leaf area (446.32), spike length (22.37), row spike^{-1} (19.00), and spike diameter (5.02), compared to Control's (159.98), (12.87), (356.00), (18.13), (13.67), and (4.22) respectively. Finally, in Grain and Yield parameters, Urea has a greater effect compared to control in Number of grain rows^{-1} (48.17), Number of grain spikes^{-1} (915.67), 100 grain weight g (29.43), Biological yield (*M*g ha^{-1}) (30.65), Grain yield (*M*g ha^{-1}) (14.20), and Harvest index % (46.74), compared to Control's (32.67), (446.0), (22.98), (21.87), (5.38), and (24.94) respectively.

***Keywords*:** Maize, Organic fertilizer, Nano NPK, chemical fertilizer, Urea**.**

INTRODUCTION

Maize (*Zea mays* L.) is a cereal crop of significant global economic importance [1]. Therefore, Maize is the world's third most significant cereal crop after rice and wheat [2][3][4]. With roughly 72% carbohydrate, 10.4% proteins, and 4.5% fats, minerals, and non-cholesterol oil, maize has excellent nutritional value [5]. Since the Iraqi Kurdistan region is semi-arid, the focusing is on producing field crops and farmers are advised to cultivate vegetables and grain crops. In recent years, maize farming in the Kurdistan region of Iraq has received increased attention. The Kurdistan region's agricultural area is approximately 1824 hectares, with an average production of 5138 kg ha^{-1} [6]. However, low-quality seed and uneven nutrient delivery limit the yield potential of maize in poorer nations [2]. To achieve its nutritional needs, though, it needs the best fertilization possible [1][7]. Mineral fertilizers are typically used by farmers to boost maize yields, endangering the environment. The use of synthetic fertilizers in agricultural fields has increased, partly due to a decrease in land area per capita and deteriorating soil quality. However, preserving agricultural productivity and enhancing soil fertility cannot be achieved sustainably with the use of synthetic fertilizers alone. Furthermore, using too many mineral fertilizers might have negative effects on the ecosystem [8][9]. Therefore, alternative preparations are sought in modern agriculture to reduce the amount of agrochemicals application. One such alternative is the use of organic fertilizers are biodegradable substances that boost plant production, enhance the number of helpful soil microorganisms, and offer substitute sources of nutrients that plants require [10][11]. For increase soil fertility and soil health, research on the use of organic fertilizers in agricultural soils has drawn a lot of interest [12][13][14]. An other option is to apply nano-fertilizers, which can lessen losses from chemical fertilizers and assist regulate nutrient leakage into the soil [15]. Nanomaterials and agricultural canvasses as Nano fertilizers have pledged to meet the targets for sustainable agriculture and worldwide food production. Nano fertilizers may be the best way to address the lack of macro and micronutrients by improving the quality of Utilizing nutrients and resolving ongoing eutrophication issues [16]. When sprayed on leaves or applied through ground treatments, nano fertilizers contribute to plant nutrition. They differ from conventional fertilizer particles in that they are more soluble and active [17]. The plant requires a variety of nutrients, including major and minor elements at the nanoscale, which enables their application in a wide range of crops [18]. The goal of this study was therefore to understand how various fertilizer types affected maize production in Kurdistan soil using (Triple Super Phosphate, Potassium Sulfate, Urea, Organic Fertilizer (Cattle Manure), Nano NPK and chemical fertilizer NPK)

MATERIALS AND METHODS

During the summer growing season (7 July 2024 to 30 October 2024 which equal to 116 days), the experiment was carried out at Qlyasan Agricultural Research Farm (45° 21' 29" E, 35° 34' 36" N 757m above sea level) in Sulaimani governorate - Iraq, as shown in (Figure 1), to assess how different fertilizer types affect maize (*Zea mays* L.) yield and yield components cv. Medium and Fajer, grown under calcareous soil. Two genotypes of maize (G_1= Fajer and G_2= Medium) and various fertilizers are used in the experiment. Urea 150 kgN ha^{-1} F_2, Triple Super Phosphate 150 kgP_2O_5 ha^{-1} F_3, Potassium Sulfate (50% K) 100 kgK ha^{-1} F_4, Organic Fertilizer (Cattle Manure 10 *M*g ha^{-1}) F_5, Nano NPK (20 20 20) (Khazra Nano chelated) 0.4 g L^{-1} F_6 and chemical compound fertilizer NPK 200 kg ha^{-1} (20 20 20) was utilized F_7.

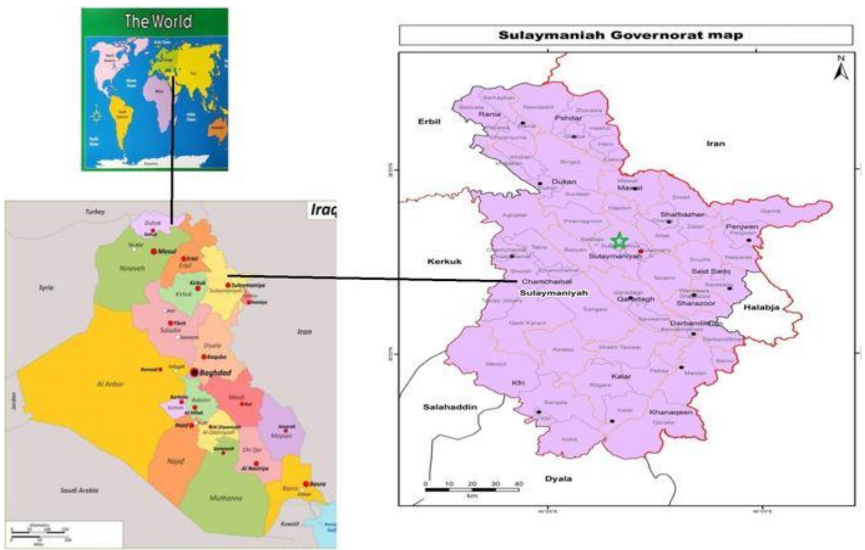

Figure 1 Location of study area.

In order to achieve a mean density of 52500 plants ha^{-1}. The experiment was carried out on a $365m^2$ area (10m × 36.5m) in 14 experimental units with three replicates. Each experimental unit had an area of $4m^2$ (2 × 2) m, and each experimental plot had three rows of two (m) length, with a distance of 0.75m between them and 0.30m within the individual plant rows. The experimental units were spaced 0.5m apart, and the blocks were separated by 1m. In this experiment, experimental treatments have been arranged using the compete (R.C.B.D).

After applying fertilizers, 150 kgN ha^{-1} of urea 46% N was added and split into two equal halves. The first dosage was added at the planting stage, and the second dose was applied 40 days after the planting stage. At the planting stage, 150 kgP_2O_5 ha^{-1} of triple superphosphate (TSP) and 100-kilogram K ha^{-1} of potassium sulphate were administered. Organic fertilizer incorporated into the soil in the 15 days before planting on (23th June 2024), with one level of cattle manure (10 *M*g ha^{-1}), Nano NPK (20 20 20) (0.4 g L^{-1}), some chemical characteristics of the cattle manure as show in Table 1. The nano fertilizer is sprayed on the plants' vegetative system in two batches. The first batch is applied on August 15, 2024, forty days after planting, and the second is applied on September 9, 2024, twenty-five days later, using Khazra Nano chelated, obtained from Sodour Ahrar Shargh Knowledge-based Company / Iran - Tehran and NPK (20 20 20) chemical fertilizer (150 kg ha^{-1}) at planting.

Table (1): Some chemical characteristics of the cattle manure

Properties	cattle manure	unit
pH	7.3	
EC at 25ºC	8.3	dS m^{-1}
OM	525.4	g kg^{-1}
Total P (P_2O_5)	4.87	g kg^{-1}

Total K (K_2O)	7.89	g kg^{-1}
Total N	14.57	g kg^{-1}
Total Organic Carbon	304.76	g kg^{-1}
C/N ratio	20.92	
Water content	68.5	g kg^{-1}

Prior to planting, soil samples were collected from 0–40cm below the soil utilized in the field tests. After being allowed to air dry and passing through a 2mm screen, the soil samples were stored in plastic bottles until analysis. The soil's primary physical and chemical characteristics are laid out in (Table 2).

Table 2. Chemical and physical analysis of the field experiment soil

Micronutrients available form mg kg^{-1}	Fe	2.18
	Zn	0.55
	Cu	2.97
	Mn	8.86
Soluble ions mmol L^{-1}	Ca^{2+}	1.99
	Mg^{2+}	0.91
	Na^{+}	0.39
	K^{+}	0.14
	HCO_3^{-}	2.51
	SO_4^{2-}	0.709
Particle Size Distribution(PSD) g kg^{-1}	Sand	62.18
	Silt	599.26
	Clay	338.56
Textural Class	Silty clay loam	
Bulk density *M*g m^{-3}	1.40	
pH	7.32	
EC dS m^{-1} At 25 °C	0.34	
Organic matter (OM) g kg^{-1}	18.89	
Total $CaCO_3$ equivalent g kg^{-1}	218.88	

The following physiological parameters were recorded: At each plot three plants were tagged, and every metric related to vegetative and reproductive growth was noted. Plant height was measured from the base to the top leaf when it was completely opened. At the silking stage, the average height of three plants was measured and recorded in centimeters. The total number of green leaves produced by each of the three randomly selected plants was tallied. and their average number of green leaves per plant was determined. At the 50% milking stage, the leaf area per plant, the length and width of each leaf, and the total number of leaves on three plants per net plot were measured. The leaf area was calculated by multiplying the leaf length by the maximum leaf width, modified by a correction factor of 0.75 (0.75 X leaf length X maximum leaf width) [19].

$$\textbf{Maximum Length(cm) X Maximum width of leaf (cm) X 0.75 equals Leafarea (LA)}$$

After cleaning the randomly chosen spikes, the number of rows in each spike was manually tallied. The number of rows per spike was then calculated as the average number of rows of the chosen spikes. Grain was separated from the spikes and the row, and the number of grains was then manually counted.

When the crop reached the mature physiological stage—the point at which plants exhibit maturity symptoms—it was harvested on October 30, 2024. From each treatment that had previously been signed, three plants were picked, and the spikes were detached from the plants. The plants were rinsed three times with distilled water after being cleansed with tap water to get rid of dust. They were then left to air dry in a dry cabinet room at 70 °C until their weight remained the same. The total dry matter weight of the plants was then recorded. The plants were then cut into tiny pieces to allow for full drying, and they were oven-dried at 70 °C until their weight remained constant. For each plant, the oven-dry weight of the dry matter was measured and reported in grams. After drying the spikes, the corn grain was shelled and dried until it had 15% moisture. Every harvested area's dried maize grains were weighed. Each experimental unit (4 m^2) had its grain weight calculated, and the yield was reported in *M*g ha^{-1}. The net weight of 100 seeds (g) was calculated by counting and weighing a small sample of seeds chosen at random from each experimental unit's grain production. Wasonga et al. (2008) used the following formula to calculate kernel yield (*M*g ha^{-1}) [20]:

Plant density × grain yield kgplant^{-1} = kernel yield (*M*g ha^{-1}).

A better conversion of dry matter to grain production is indicated by a higher harvest index. Nowadays, a large number of workers compute the harvest index for grain harvests as a percentage, as follows: **Harvest index (%) is equal to (Kernel yield / Biological yield) × 100**

The ExcelSTAT (2022) Package conducted an analysis of variance (ANOVA) on the data, and the Duncan Multiple Range Test (DMRT) was used to analyze the differences at the 5% significant level.

Results and discussion

VEGETATIVE GROWTH PARAMETERS

Table (3) shows the significant influence of fertilizer types, cultivars, and their interactions on the Plant height (cm). The type of fertilizers affected plant height significantly; the results showed that the highest plant height (183.01 cm) was obtained from the application of urea fertilizer while the lowest plant height (159.98 cm) was produced from control treatment. Additionally, significant differences between genotypes were recorded in same parameter in the plant height (cm). The maximum plant height mean value (174.58 cm) was recorded for the Fajer genotype. In contrast, the minimum value (167.61 cm) was obtained for the Medium genotype. Fajer surpassed Medium genotype by 4.16 %. The interaction between fertilizers and maize genotypes in (Table3) revealed that (urea x Medium) and (Control x Medium) exhibited the highest (185.46 cm) and the lowest (157.51 cm) values for the plant height, respectively.
Table (3) clarified that fertilizer treatments significantly affected the Leaf number (leaf plant^{-1}), the highest value (17.91) was recorded from (urea treatment), in comparing with treatment (12.87). The results indicated the role of nutrients, especially Nitrogen, phosphorus, and potassium, in the growth of maize, since the mentioned different fertilizers are the sources for the three essential nutrients; for this reason, they caused an increase in leaf number. Additionally, significant differences between genotypes were recorded in same parameter in the leaf number. The highest mean value which was (15.33 leaf plant^{-1}) was recorded for the Fajer genotype. In contrast, Medium genotype recorded the lowest values (14.78 leaf plant^{-1}). This may be relative to the different genetic properties of the studied genotypes and phenotypic effects. Fajer surpassed Medium genotype resulting by 3.72 %. The interaction between fertilizer types and genotypes has a significant effect on the traits studied. The highest values (18.26 leaf plant^{-1}) were recorded for (urea x Fajer). The lowest value (11.11 leaf plant^{-1}) from (Organic fertilizer x Fajer).
As shown in table (3), fertilizers significantly affected the leaf area (cm^2). The application of urea fertilizer produced the greatest mean value (446.32 cm^2) when compared to the control treatment, which produced the mean value (356.00 cm^2). Similarly, it was noticed that the genotypes had a significant effect on leaf area (cm^2). The maximum mean value (403.51 cm^2) was recorded for Fajer genotype and the lowest value (354.53 cm^2) was observed for Medium genotype. As with most investigated indicators, the capsule weight plant^{-1} was affected by all the two-factor interactions. The maximum mean value of leaf area (cm^2) (458.84 cm^2) was obtained from interaction treatment (Chemical NPK x Fajer), and the lowest value (261.39 cm^2) was recorded from (Organic fertilizer x Medium) interaction treatments.

Table (3) Effect of fertilizer treatments, genotypes, and their interactions on vegetative growth parameters of maize.

Fertilizer treatments	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect
	G1	G2		G1	G2		G1	G2	
	Plant height (cm)			Leaf number (leaf plant^{-1})			Leaf area (cm^2)		
Control	162.45^{ef}	157.51^{f}	159.98^{c}	12.97^{d}	12.77^{d}	12.87^{cd}	370.61^{bc}	341.39^{c}	356.00^{bc}
Urea	180.55^{ab}	185.46^{a}	183.01^{a}	18.26^{a}	17.57^{ab}	17.91^{a}	441.88^{ab}	450.75^{ab}	446.32^{a}
Triple Super Phosphate	177.56^{bc}	165.69^{de}	171.62^{b}	16.63^{b}	16.56^{b}	16.60^{b}	398.68^{abc}	330.03^{cd}	364.36^{bc}
Potassium sulfate	176.90^{bc}	168.26^{de}	172.58^{b}	16.68^{b}	15.11^{c}	15.90^{b}	346.81^{c}	319.43^{cd}	333.12^{c}
Organic fertilizer	170.30^{cd}	167.34^{de}	168.82^{b}	11.11^{e}	14.03^{cd}	12.57^{d}	375.17^{bc}	261.39^{d}	318.28^{c}
Nano NPK	176.00^{bc}	161.97^{ef}	168.99^{b}	14.55^{c}	12.97^{d}	13.76^{c}	432.60^{ab}	347.46^{c}	390.03^{b}
Chemical NPK	178.29^{ab}	167.03^{de}	172.66^{b}	17.11^{ab}	14.47^{c}	15.79^{b}	458.84^{a}	431.24^{ab}	445.04^{a}
Genotypes effect	174.58^{a}	167.61^{b}		15.33^{a}	14.78^{b}		403.51^{a}	354.53^{b}	

REPRODUCTIVE GROWTH PARAMETERS

The effects of fertilization on the reproductive growth parameters of maize (Table 4) were not homogeneous when compared to the treatment without fertilization. Urea fertilizer, Triple Super Phosphate, chemical NPK and Nano NPK significantly increased the spikes length (22.37, 20.11, 20.73 and 19.18 cm) respectively, while potassium sulfate and organic fertilizer had no significant effect on the spike's length (17.02 and 17.80) cm respectively. Additionally, significant differences between genotypes were recorded in the spike's length. The highest mean value which was (20.17cm) was recorded for the Fajer genotype. In contrast, Medium genotype recorded the lowest values (18.50cm). Fajer surpassed Medium genotype by 9.03%. Experimental treatments interaction between fertilizer types and genotypes significantly affected the spikes length cm as compared to the Control treatment (Table4). The highest value of spikes length (23.21cm) was recorded from (urea x Fajer) treatment. On the other hand, the lowest value of the same trait (16.57 cm) was recorded by (Organic fertilizer x Medium) treatment. This outcome may occur from the application of chemical and nano NPK, which enhances the physicochemical characteristics of the soil and increases the availability of key nutrients, hence improving conditions for the production of maize crops. According to Table4 data, fertilizer treatments considerably raised the number of rows spikes^{-1} when compared to the Control. Urea had the greatest number of rows spikes^{-1} (19.00). Conversely, the Control treatment had the lowest value (13.67). More photosynthetic activity and additional nutrients from organic or inorganic sources for plant development up to spike formation may be the cause of the increase in the number of rows spikes^{-1}. Data presented in Table4 show the effect of different genotypes of maize on the No. of rows spikes^{-1} of maize. Medium genotype gave the highest value of No. of rows spikes^{-1} (15.76). Fajer genotype had the lowest value of 15.52 rows spikes^{-1}. It is noticed clearly that the Medium genotype surpassed Fajer genotype resulting in 1.56 %. Significant differences in No. of rows spikes^{-1} due to interaction between fertilizer types and genotypes were observed (Table4). The maximum No. of rows spikes^{-1} (19.33) was recorded by the (urea x Medium) treatment. On the other hand, the lowest No. of rows spikes^{-1} (13.33) was recorded by (Control x Fajer).

Table (4). Effect of fertilizer treatments, genotypes, and their interactions on reproductive growth parameters of maize.

Fertilizer treatments	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect
	G1	G2		G1	G2		G1	G2	
	Spikes length cm			rows/spikes			Spikes diameter cm		
Control	18.97^{def}	17.30^{ef}	18.13^{cd}	13.33^{f}	14.00^{ef}	13.67^{e}	4.43^{cdef}	4.00^{fg}	4.22^{c}
Urea	23.21^{a}	21.53^{abc}	22.37^{a}	18.67^{ab}	19.33^{a}	19.00^{a}	5.10^{a}	4.93^{ab}	5.02^{a}
Triple Super Phosphate	22.45^{ab}	17.77^{ef}	20.11^{b}	15.33^{de}	16.33^{cd}	15.83^{c}	5.07^{a}	4.13^{efg}	4.60^{b}
Potassium sulfate	17.13^{ef}	16.90^{ef}	17.02^{d}	14.33^{ef}	14.67^{def}	14.50^{de}	4.87^{abc}	3.70^{g}	4.28^{c}
Organic fertilizer	19.03^{def}	16.57^{f}	17.80^{cd}	14.00^{ef}	14.33^{ef}	14.17^{de}	4.60^{bcd}	3.77^{g}	4.18^{c}
Nano NPK	19.47^{cde}	18.90^{def}	19.18^{bc}	15.33^{de}	14.67^{def}	15.00^{cd}	4.57^{bcde}	4.03^{fg}	4.30^{c}
Chemical NPK	20.96^{abcd}	20.50^{bcd}	20.73^{b}	17.67^{bc}	17.00^{c}	17.33^{b}	5.10^{a}	4.37^{def}	4.73^{ab}
Genotypes effect	20.17^{a}	18.50^{b}		15.52^{a}	15.76^{a}		4.82^{a}	4.13^{b}	

The effect of various studied treatments on Spikes diameter cm was presented in Table4. Significant increment of the studied parameter was obtained mostly due to the application of urea, Triple Super Phosphate and Chemical NPK fertilizers (5.02, 4.60 and 4.73 cm) respectively, while potassium sulfate, organic fertilizer and Nano NPK had no significant effect on the Spikes diameter cm (4.28, 4.18 and 4.30 cm) respectively, compared to the control (4.22 cm). Additionally, significant differences between genotypes were recorded in the same parameter. The maximum mean value (4.82 cm) was recorded for the Fajer genotype. In contrast, the minimum value (4.13 cm) was obtained for the Medium genotype. Fajer surpassed Medium genotype resulting in 16.71 % in the Spikes diameter cm. Significant differences in Spikes diameter cm due to interaction between fertilizer types and genotypes were observed (Table 4). The maximum Spikes diameter cm (5.10 cm) was recorded by the (urea x Fajer) and (Chemical NPK x Fajer) treatments. On the other hand, the lowest Spikes diameter cm (3.70 cm) was recorded by (Potassium sulfate x Medium).

GRAIN PARAMETERS

According to Table 5, there were notable variations in how maize responded to the various fertilizer treatments' effects on the grain parameters under investigation. The number of rows of grains is a significant factor that affects the economic yield. According to the data in Table (5), the number of grains per row increased significantly as a result of the various fertilizer treatments. The highest number of grains row^{-1} (48.17) was recorded from urea. On the other hand, the lowest value (32.67) was recorded by Control treatment. More photosynthetic activity and additional nutrients from organic or inorganic sources for plant development could be the cause of the increase in the number of grains per row. There were notable variations in the number of grains per row as a result of the various maize genotypes (Table 5). The maximum No. of grains row^{-1} (40.00) was recorded by the Fajer genotype. On the other hand, the lowest No. of grains row^{-1} (38.14) was recorded by Medium genotype. It is noticed clearly that the Fajer genotype surpasses Medium genotype resulting in 4.88 %. Significant differences in Number of grains row^{-1} due to interaction between fertilizer types and genotypes were observed. The maximum No. of grains row^{-1} (49.33) was recorded by the (urea x Medium) treatment. On the other hand, the lowest No. of grains row^{-1} (31.00) was recorded by (Control x Medium).

Data in Table5 represents the response of Number of grain spikes^{-1} of maize to different fertilizer treatments. The highest Number of grain spikes^{-1} (915.67) was recorded from urea. On the other hand, the lowest value (446.0) was recorded by Control treatment. Significant differences in Number of grain spikes^{-1} due to different genotypes of maize were observed (Table 5). The maximum Number of grain spikes^{-1} (628.57) was recorded by the Fajer genotype and the lowest value (611.05) was recorded by Medium genotype. It is noticed clearly that the Fajer genotype surpassed Medium genotype by 2.87 % and significant differences due to interaction between fertilizer types and genotypes were observed in Number of grains spikes^{-1} the maximum value (954.0) was recorded by the (urea x Medium) treatment and the lowest value (434.0) was recorded by (Control x Medium).

Table (5). Effect of fertilizer treatments, genotypes, and their interactions on grain parameters of maize.

Fertilizer treatments	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect
	G1	G2		G1	G2		G1	G2	
	Number of grain /rows			Number of grain /spikes			100 grain weight g		
Control	34.33^{de}	31.00^{e}	32.67^{e}	458.0^{gh}	434.0^{h}	446.0^{f}	22.75^{h}	23.21^{gh}	22.98^{d}
Urea	47.00^{ab}	49.33^{a}	48.17^{a}	877.33^{a}	954.0^{a}	915.67^{a}	27.80^{bcd}	31.07^{a}	29.43^{a}
Triple Super Phosphate	43.00^{c}	36.67^{d}	39.83^{c}	658.67^{cd}	599.0^{def}	628.83^{c}	25.87^{def}	26.88^{cdef}	26.38^{bc}
Potassium sulfate	35.67^{d}	36.00^{d}	35.83^{d}	510.67^{fgh}	529.67^{fgh}	520.17^{de}	26.90^{cdef}	25.75^{def}	26.33^{bc}
Organic fertilizer	35.33^{d}	35.00^{d}	35.17^{de}	494.0^{gh}	501.0^{gh}	497.50^{ef}	25.55^{ef}	24.96^{fg}	25.26^{c}
Nano NPK	40.67^{c}	36.33^{d}	38.50^{c}	624.0^{de}	533.33^{efg}	578.67^{cd}	27.17^{cde}	27.67^{bcde}	27.42^{b}
Chemical NPK	44.00^{bc}	42.67^{c}	43.33^{b}	777.33^{b}	726.33^{bc}	751.83^{b}	29.60^{ab}	28.85^{bc}	29.22^{a}
Genotypes effect	40.00^{a}	38.14^{b}		628.57^{a}	611.05^{a}		26.52^{a}	26.91^{a}	

Applying different fertilizer treatments significantly affected the weight of 100 grains (g), table (5) demonstrate the application of urea and chemical NPK outperformed the other treatments the highest value of 100 grains (g) (29.43g) was recorded from urea and the lowest value (22.98g) was recorded by Control treatment. The same data shows that the genotypes of maize are not significant from one another, the Fajer genotype exhibited the lowest value (26.52g), whereas the Medium genotype generated the largest average weight of 100 grains (26.91) g. It is noticed that the Medium genotype surpassed Fajer genotype resulting in 1.47%. Significant differences due to interaction between fertilizer types and genotypes were observed in quantity of 100 grains (g) the maximum value (31.07g) was recorded by the (urea x Medium) treatment and the lowest value (22.75g) was recorded by (Control x Fajer).

YIELD PARAMETERS

The effects of various fertilizer treatments on yield parameters are displayed in Table (6). A significant effect of different fertilizers (urea, nano NPK and chemical NPK) was recorded for biological yield (*M*g ha^{-1}). The urea, nano NPK and chemical NPK gave the greatest biological yield (30.65, 29.04 and 30.06 *M*g ha^{-1}) respectively, while the lowest value was recorded by Control treatment (21.87 *M*g ha^{-1}). No significant difference in biological yield *M*g ha^{-1} was recorded for the different genotypes of maize (Table 6). The maximum biological yield (27.82 *M*g ha^{-1}) was recorded by the Medium genotype and the lowest value (26.55 *M*g ha^{-1}) was recorded by Fajer genotype. Significant differences due to interaction between fertilizer types and genotypes were observed in biological yield, the maximum value (32.94 *M*g ha^{-1}) was recorded by the (urea x Medium) treatment and the lowest value (21.29 *M*g ha^{-1}) was recorded by (Control x Medium).

The effect of different fertilizer treatments studied on grain yield (*M*g ha^{-1}) was presented in Table 6. Significant increments of the studied parameters were obtained mostly due to the application of urea and chemical NPK, compared to the Control. The urea and chemical NPK gave the greatest grain yield (14.20 and 11.52 *M*g ha^{-1}) respectively, while the lowest value was recorded by control (5.38 *M*g ha^{-1}). No significant difference in grain yield *M*g ha^{-1} was recorded for the different genotypes of maize. The Medium genotype recorded (8.82 *M*g ha^{-1}) and the Fajr genotype recorded (8.87 *M*g ha^{-1}). Moreover, positive effects due to the interaction between fertilizer types application and maize genotypes were observed in grain yield (*M*g ha^{-1}) parameter, the maximum value (15.57 *M*g ha^{-1}) was recorded by the (urea x Medium) treatment and the lowest value (5.29 *M*g ha^{-1}) was recorded by (Control x Medium). It is generally that grain yield was affected by yield attributing components like weight and diameter of spikes, number of grains per spikes and per row and weight of 100 grains.

This effect reflected on the harvest index %, which increased significantly with applying different fertilizer treatments urea, Triple Super Phosphate, Potassium sulfate, Nano NPK and Chemical NPK, the mean values were (46.74, 33.02, 27.69, 29.27 and 38.60 %) respectively, compared with that obtained from Control which was (24.94 %), but not significantly with applying Organic fertilizer (25.35 %), compared with Control. Regarding the effect of genotypes of maize, not significant differences were obtained, the higher mean harvest index % was (33.16 %), recorded by Fajer genotype, compared with that obtained at Medium genotype which was (31.30 %). There were notable variations in the interaction between fertilizer types and genotypes, according to the interaction effect of that combination. The harvest index in this study was varied in all treatments ranged from (24.36 to 48.14) % the highest value of harvest index percentage was recorded from (urea x Medium), while the lowest value of harvest index percentage was observed in (Control x Fajer).

Table (6) Effect of fertilizer treatments, genotypes, and their interactions on yield parameters of maize

Fertilizer treatments	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers effect	Genotypes of Maize		Fertilizers Effect
	G1	G2		G1	G2		G1	G2	
	Biological yield (*M*g ha^{-1})			Grain yield (*M*g ha^{-1})			Harvest index %		
Control	22.45^{cd}	21.29^{d}	21.87^{d}	5.46^{g}	5.29^{g}	5.38^{e}	24.36^{e}	25.52^{de}	24.94^{d}
Urea	28.35^{ab}	32.94^{a}	30.65^{a}	12.84^{b}	15.57^{a}	14.20^{a}	45.34^{a}	48.14^{a}	46.74^{a}
Triple Super Phosphate	25.88^{bcd}	27.25^{abc}	26.57^{bc}	8.95^{d}	8.45^{de}	8.70^{c}	34.88^{bcd}	31.16^{cde}	33.02^{bc}
Potassium sulfate	25.55^{bcd}	26.45^{bcd}	26.00^{c}	7.21^{ef}	7.17^{ef}	7.19^{d}	28.22^{cde}	27.17^{cde}	27.69^{cd}
Organic fertilizer	26.11^{bcd}	26.09^{bcd}	26.10^{c}	6.62^{fg}	6.56^{fg}	6.59^{d}	25.51^{de}	25.19^{de}	25.35^{d}
Nano NPK	28.09^{abc}	29.98^{ab}	29.04^{abc}	8.93^{d}	7.74^{def}	8.33^{c}	32.64^{bcde}	25.89^{de}	29.27^{cd}
Chemical NPK	29.40^{ab}	30.72^{ab}	30.06^{ab}	12.08^{bc}	10.96^{c}	11.52^{b}	41.17^{ab}	36.04^{bc}	38.60^{b}
Genotypes effect	26.55^{a}	27.82^{a}		8.87^{a}	8.82^{a}		33.16^{a}	31.30^{a}	

During data collection, it is found that Urea fertilizer has the greatest effect on most parameters throughout the tables (3,4,5 and 6), which are, Vegetative Growth, Reproductive Growth, Grain and Yield. All Parameters that Urea has great effects in include: (Plant Height, Leaf Number, Leaf Area, Spike Length, Rows/Spikes, Spike Diameter, Number of grains/rows, Number of grain/spikes, gm/100grain, Biological Yield, Grain Yield, and Harvest Index) The results could be related to the effectiveness of the fertilizer and double dosing of the Urea fertilizer which helps with the vegetative and growth parameters of the plants [21]. The nitrogen in Urea fertilizer plays a great role in the growth and psychological status of the plants, and it also helps at improving the mineral composition of the plants, as well as development [22]. It may be urea is a limiting factor in this study ,also it is a source for Nitrogen which plays an importantnrole in chlorophyll formation then increase in yield. Other researchers have conducted experiments on the

Urea Fertilizer on maize growth and have found great results [23][24][25][21][26][27][28][29][30][31][32]. A great alternative to Urea Fertilizer, would be Chemical NPK, as it does have a decent effect on all parameters through all 4 tables: (Plant Height, Leaf Number, Leaf Area, Spike Length, Rows/Spikes, Spike Diameter, Number of grains/rows, Number of grain/spikes, gm/100grain, Biological Yield, Grain Yield, and Harvest Index). It could be related to the 20-20-20 composition of Nitrogen, Phosphor, and Potassium in NPK fertilizer that helps to provide the macro-nutrients that them plants need for growth and yield productivity [32]. Other researchers have also tested out NPK fertilizers and have found great results [33]. On the other hand, the other fertilizers, most notably Organic, Potassium Sulfate, and Triple Super Phosphate, had much less significance compared to Control. That may be due to many factors discovered, such as environmental or technological factors, practices, management, biological factors like diseases, insects, pests, and weeds and water quality.

Conclusion:

Findings suggested that nitrogen-based fertilizers, particularly urea, positively influenced reproductive and vegetative growth parameters like height, leaf and grain yields the most. Especially, urea had a greater positive effect on maize growth, its yield components, and harvest index in comparison with other treatments of organic fertilizer, potassium sulfate, and triple superphosphate. Even though chemical fertilizers such as NPK contributed to maize growth, this effect was usually lesser than with urea. The study highlights the role of proportionate combining of macro-nutrients like nitrogen, phosphate, and potassium to maize yield, as well as loss and sustainment of agricultural productivity. Moreover, organic and nano fertilized crops displayed some advantage, but the effects were minimal which indicates more research is needed to understand how they influence maize yields. Altogether, urea was identified as the greatest contributor for crop productivity, but treatment variation has the potential for closing the gap of inadequate soil

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تأثير انواع مختلفة من الاسمدة على النمو والحاصل ومكونات الحاصل لمحصول الذرة (*Zea mays* L) في التربة الجيرية.

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الخلاصة

تم إجراء التجربة لتقييم تأثير الأنواع المختلفة من الأسمدة على نمو الذرة ومحصولها ومكونات محصولها، وقد تمت التجربة في مزرعة قليسان للبحوث الزراعية في محافظة السليمانية بالعراق. وقد جرت الدراسة خلال موسم الزراعة الصيفي (2024). نُظمت المعاملات التجريبية ووضعت التجربة بتصميم القطاعات العشوائية الكاملة وبثلاث مكررات. وشملت المعالجات سبعة مستويات من الأسمدة المختلفة على سبيل المثال، 150 كجم نيتروجين هـ$^{-1}$، و150 كجم $\boldsymbol{P_2O_5}$ هـ$^{-1}$، 100 كجم بوتاسيوم هـ$^{-1}$، سماد عضوي من روث الماشية (10 طن هـ$^{-1}$)، سماد نانو ***(20 20 20) (NPK)*** (0.4 جم لتر$^{-1}$) وسماد كيميائي ***(20 20 20) (NPK)*** (150 كجم هـ$^{-1}$)، ونمطين وراثيين من الذرة (فجر ومتوسط). أظهرت النتائج أن التأثير كان كبيراً عند ***(P < 0.05)*** على معايير نمو نبات الذرة. أظهرت التجربة تأثير الأسمدة في معايير مثل: النمو الخضري، النمو التناسلي، الحبوب، ومعايير المحصول. بالمقارنة مع الضابطة، يعتبر اليوريا سمادًا فعالًا جدًا في النمو الخضري والتناسلي في ارتفاع النبات (183.01)، عدد الأوراق (17.91)، مساحة الأوراق (***446.32***)، وطول السنبلة (22.37)، وصف السنبلة (19.00)، وقطر السنبلة (5.02)، مقارنةً بسماد الضابطة (159.98)، (12.87)، (356.00)، (18.13)، (13.67)، (4.22) على التوالي. أخيرًا، في معاملات الحبوب والمحصول، كان تأثير اليوريا أكبر مقارنةً بالضبط في عدد صفوف الحبوب$^{-1}$ (48.17)، عدد سنابل الحبوب$^{-1}$ (915.67)، وزن 100 غرام من الحبوب (***29.43***)، والمحصول الحيوي (طن/هـ$^{-1}$) (30.65)، ومحصول الحبوب (طن/ هـ$^{-1}$) (14.20)، ومؤشر الحصاد % (46.74)، مقارنةً بمتغيرات التحكم (32.67)، (446.0)، (22.98)، (21.87)، (5.38)، (24.94) على التوالي.

الكلمات المفتاحية: الذرة، السماد العضوي، الأسمدة النانوية ***NPK***، الأسمدة الكيميائية.