Response of growth, yield and quality of maize to the fertilizer combination of nitrogen and potassium and spraying with the potassium humate

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Abstract

The split-plot experiment was carried out in one of the agricultural fields- Al-Hussainiya district in the holy city of Kerbala for the fall season 2022, by planting the maize, Sumer cultivar was planted in a soil with clay loam texture. The experiment comprising two factors, and the first factor was the combinations of different levels of nitrogen (0, 150 and 300 kg N ha^{-1}) were identified with symbols, N_0, N_1, and N_2, respectively, Three levels of potassium (0, 80 and 160 kg K ha^{-1}) were symbolized as K_0, K_1, and K_2, respectively, the second factor was spraying with the organic nutrient potassium humate at two concentrations (1 and 2) g L^{-1}, the concentrations of potassium humate were occupied the main plots, while the fertilizer combinations of nitrogen and potassium filled the sub plots with three replications according to the randomized complete block design (RCBD).The results showed a significant effect of adding fertilizer combinations of nitrogen and potassium and spraying with the organic nutrient potassium humate (2 g L^{-1}) individually and overlapping in most growth, yield and quality traits, as the overlapping showed a significant superiority in increasing of leaf area (cm^2 $plant^{-1}$), stem diameter (mm), leaf chlorophyll index (SPAD unit), ear weight (g), plant yield (g $plant^{-1}$) and protein yield (g $plant^{-1}$), the interaction between the two study factors contributed to reducing the amount of mineral fertilizer to 50%, as there was no significant difference between the fertilizer combinations of nitrogen and potassium (150N + 80K) and (300N + 160K) Kg ha^{-1}, with a concentration of 2 gmL^{-1} of potassium humate.

Keywords: Maize (*Zea mays* L.), Fertilizer combination, nitrogen and potassium, potassium humate, spraying.

Introduction

Zea mays L. belongs to the Poaceae family, and it is one of the important grain crops that is widely cultivated all over the world [1]. It is considered one of the strategic crops, as it comes second after wheat in terms of the cultivated area, and it comes in the first place in the rate of grain produced for use in human and animal nutrition, as well as in various industrial fields [2]. Due to the high yield rate and fodder value of grains, stems and leaves, they are desirable and of great importance in many countries [3]. It is expected that the demand for the Maize crop will increase by 2050 [4]. The increase in the population all over the world, which is likely to reach (9.7) billion people by 2050 [5]. The decrease in food shortages, has introduced high-yielding varieties that are characterized by depleting fertilizer (NPK), which led to the need to provide fertilizers at high rates to increase food production, especially in developing countries and the low yield has led to the emergence of a global problem as a result of unbalanced fertilization and the wrong use of agricultural practices [6].Mineral fertilization has a major role in increasing the nutrient readiness (NPK) of the shoot, as it works to increase the total grain yield [7].Maize is considered one of the most responsive field crops to the addition of nitrogen, phosphate and potassium fertilizers, as it is affected by several genetic, environmental and climatic factors [8].Maize production is affected by poor soil fertility, which requires the addition of fertilizers to meet the crop's need for nutrients [9].Nitrogen and potassium are essential nutrients for field crops, which have many effects on plants, such as their effect on the process of carbon metabolism, activation of enzymes, production of protein and nucleic acids, and they are the most important molecules in the plant cell, and they work to resist diseases and insects [10]. As the amount needed by the plant varies according to the type and variety of the plant, as well as the stage of plant growth, and the quality of the grains formed [11]. The use of organic fertilizers is considered one of the alternative methods to increase vegetative growth and increase the yield of maize and other types of crops [12]. Organic nutrients are of great importance to plant growth because it contains elements useful to the plant that contribute to the formation of amino acids that enter into the formation of proteins and regulate osmotic pressure and increase plant resistance to stress conditions such as plants grown under salinity pressure as well as increase their water retention as well as stimulate crop growth and increase the absorption of nutrients and enhance plant resistance to stress conditions [13, 11].

Potassium humate is considered to have a major role in increasing the process of carbon metabolism, reducing the activity of antioxidant enzymes (Peroxidase and Catalase), biosynthesis and ascorbic acid, In additio to the synthesis of proteins and carbohydrates in the produced grains, stimulating crop growth, increasing the absorption of nutrients, and enhancing plant resistance to stress conditions [14]. It was showed [15] that spraying with potassium humate on maize at a concentration of 3 g L^{-1} gave a significant increase in the traits of 1000 grain weight, grain yield and biological yield, which amounted to 24.4 g, 3.58 tons ha^{-1}, 8.49 tons ha^{-1} compared with the comparison treatment that gave the lowest average for these traits amounted to 15.3 g, 2.31 tons ha^{-1}, 5.8 2 tons ha^{-1}, respectively. Due to the importance of maize and the increasing demand for it and for a high quality and safer food, this study aims to reduce the amount of nitrogen and potassium fertilizers by overlapping with spraying with the organic nutrient potassium humate to find the best fertilizer combination with a positive effect on the growth, yield and quality of maize.

Materials and Methods

Executing the experiment

The experiment of split- plot panels was carried out in one of the agricultural fields in Ibn Al-Bitar Vocational High School / Al-Husseiniya District in the Holy Karbala, affiliated to the Directorate of Education in the Holy Province of Karbala for the autumn season 2022, by planting the Maize crop of Sumer cultivar was planted in a soil with clay loam texture.

Table (1): Chemical and physical properties of the study soil at a depth of 0 –30 cm before peanut planting.

Properties		Values
pH		7.2
EC (1:1)		2.18 ds m^{-1}
OM		1.41 g kg^{-1}
N available		30.44 mg kg^{-1}
K available		28.27 mg kg^{-1}
P available		10.8 mg kg^{-1}
Soil separators	Sand	250 G kg^{-1}
	Silt	360 G kg^{-1}
	Clay	390 G kg^{-1}
Texture		Clay loam

Field preparation and agricultural operations

The experiment included two factors: fertilizer combinations of nitrogen and potassium and spraying with organic nutrient potassium humate, spraying concentrations with organic potassium humate occupied the Main plots, while the fertilizer combinations of nitrogen and potassium filled the sub plots with three replications according to the randomized complete block design (RCBD). The soil of the field was prepared for cultivation by conducting plowing, smoothing and leveling operations, then it was divided into three replicates, each replicate contains 18 experimental units, thus the total number of experimental units was 54 experimental units with dimensions of 3×3 m^2, for each experimental unit representing an area of 9 m^2, a space of one metre was left m between the experimental units within one replicate. The experimental unit includes four lines, the rows and plants spacing were kept as 75 cm and 25 cm, respectively, with a plant density of 53333.33 plants ha^{-1}. The irrigation process took place immediately after the planting process, and the crop continued to be irrigated during the growing season according to the need. The weeding process was carried out manually whenever needed during the season to get rid of the weed plants. The weeding process was carried out manually whenever needed during the season to get rid of the weed plants. Maize, Sumer, was planted in the fall season on 25/6/2022, Fertilization was carried out with mono superphosphate fertilizer (19 P_2O_5%) as a source of phosphorus, and the addition was in one batch when planting for all treatments, the first factor included fertilizer combinations of nitrogen and potassium, urea fertilizer (46% N) and potassium sulfate (50% K_2O) as sources of nitrogen and potassium respectively, and three levels of nitrogen are (0, 150 and 300) kg N ha^{-1} and its symbol (N_0, N_1 and N_2) respectively, and three levels of potassium are (0, 80 and 160) kg K ha^{-1} and its symbol (K_0 , K_1 and K_2) respectively. The fertilizer combinations was added in two batches, the first was after a week to ten days had passed since germination, and the second was added at the beginning of the formation of silk threads. The second factor organic nutrient potassium humate was added spray on the plant, used two concentrations 1 and 2 g L^{-1}, and spraying was done in two stages: the first when the plants reach the stage 6-8, true leaves and the second stage when the appearance of male inflorescences, used manual sprayer dorsal capacity of 16 liters to conduct.The spraying process at early morning to avoid high temperatures until complete wetness of the plants, while the comparison treatment was sprayed with distilled water only and the use of diffuser (bright cleaning solution) were sprayed to reduce the surface tension of the water and ensure complete wetness of the leaves in order to increase the efficiency of the spray solution.

Table (2): The composition of the potassium humate

pH	**9 - 11**
Humic and Fulvic acid	85 %
Potassium (K_2O	10 – 12%
Water Solubility	99.8%
Moisture	15%
Appearance	Black Shiny Flakes
Classification	Organic Fertilizer

Data Collection

Plant samples were taken from each experimental unit and dried in an electric oven at a temperature of 65 °C for 48 hours, to measure the required traits. [16]. The plant traits studied were calculated from an average of five randomly taken plants and from each experimental unit. The leaf area was calculated at the 100% flowering stage for five plants and its average was extracted according to the following equation: Leaf area = leaf length under the main pin x maximum width of the same leaf x 0.75. The stem diameter was measured at the 100% flowering stage by a Vernier meter up to one mm from the second node on the stem. The average weight of five ears (g) harvested randomly for each experimental unit was taken, 1000 grains were counted manually from the grains of each treatment at random, and weighed with a sensitive electronic scale, and the average was taken. Grain Yield (g $plant^{-1}$), the yield of one plant (g $plant^{-1}$) was calculated for five plants, then the average was extracted. The protein yield (g $plant^{-1}$) was calculated through the following equation:

Protein yield = (protein ratio in grain * yield per plant) \100 [17].

The chlorophyll in leaves at the male flowering stage was measured using a digital handheld SPAD-502 Meter in the field directly and for the average of five randomly taken plants and from the two midlines of each experimental unit [18].

Statistical analysis

The data were collected from the field experiment and the results were statistically analyzed according to the analysis of variance (ANOVA) as per the split-plot design [19]. The least significant difference ($LSD_{0.05}$) test was used to compare and separate the mean differences. The statistics software GenStat12 was employed.

Results and Discussion

According to analysis of variance, Fertilizer combinations, potassium humate organic nutrient Concentrations, and interactions of Fertilizer combinations × potassium humate organic nutrient Concentrations, revealed significant ($p \leq 0.05$) differences for the majority of the traits (Table 3).

Table (3): Analysis of variance with two factors (potassium humate and the fertilizer combination of nitrogen and potassium), and their interaction for various traits in maize.

Source of variation	d.f	Leaf area (cm^2 $plant^{-1}$)	Stem diameter (mm)	Index of chlorophyll in leaves (SPAD).	Ear weight (g)	Weight of 1000 grain (g)	Plant yield (g $plant^{-1}$)	Protein yield in grains (g $plant^{-1}$).
Replications	2	192139.1	26.45071	159.8683	3711.35	974.273	7707.42	198.4992
Potassium humate	1	231542.5*	5.43402*	67.9169*	9989.20*	19.850*	4620.38**	136.8213*
Error A	2	3619.5	0.01154	0.8552	66.89	0.967	0.29	2.5140
Fertilizer Combination	8	251044.6**	11.22295**	41.3217**	8303.98**	4.946^{NS}	6147.46**	168.8753**
Potassium humate ×fertilizer combination	8	16025.8**	0.21917**	0.8742*	518.02**	1.444^{NS}	237.86**	6.8783*
Error B	32	908.2	0.01418	0.2469	15.68	2.450	19.45	0.5857

Leaf area (cm^2 $plant^{-1}$)

The results are shown in table 4, the fertilizing combination N_2K_2 was superior in giving it the highest average leaf area of 4409 cm^2 $plant^{-1}$, followed by (N_2K_1, N_1K_2, and N_1K_1), which gave (4408.50, 4395.00, and 4393.33) cm^2 $plant^{-1}$, respectively, while it was less the average leaf area when the control treatment N_0K_0 was 3916.00 cm^2 $plant^{-1}$, the addition of the fertilizer combination of nitrogen and potassium had a significant effect on increasing the growth traits. The reason for increasing the leafy area of the plant may be attributed to the role of nitrogen, which contributed to increasing vegetative growth as well as its role in increasing the meristematic activity of the cells. It also works to increase the carbon metabolism process and prolong its duration and increase the speed of division cells and increased chlorophyll increases the number of leaves and their surface area [20].In addition, potassium works to delay the aging of the leaves as well as improve the turgor and water potential of the leaves and increase the process of carbon metabolism, as it leads to an increase in cell division and as a result the leaf area increases [21].This agrees with [22] who found that increasing the levels of potassium fertilizer works to increase the leaf area of the plant.

Table (4): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Leaf area (cm^2 $plant^{-1}$)

Fertilizer combination	potassium humate concentration ($mg\ L^{-1}$)		Means
	1	2	
N_0K_0	3911.33	3920.67	3916.00
N_0K_1	3963.00	3988.00	3975.50
N_0K_2	3992.00	4030.00	4011.00
N_1K_0	4001.00	4265.67	4133.33
N_1K_1	4320.67	4466.00	4393.33
N_1K_2	4325.67	4464.33	4395.00
N_2K_0	4013.33	4324.67	4169.00
N_2K_1	4348.00	4469.00	4408.50
N_2K_2	4346.33	4471.67	4409.00
Means	4135.70	4266.67	
$LSD_{0.05}$ Fertilizer combination = 35.44, $LSD_{0.05}$ Potassium humate concentration = 70.45, $LSD_{0.05}$ Fc × Ph Interactions = 60.72			

The results are shown in table 4, the spraying of the organic nutrient potassium humate at a concentration of 2 g L^{-1} ,was significantly superior by giving it the highest average for this trait amounted to 4266.67 cm^2 $plant^{-1}$, compared to the concentration of 1g L^{-1} which recorded the lowest average for this trait amounted to 4135.70 cm^2 $plant^{-1}$, with an increase of 3.16%, the results show the plant's response to spraying with the organic nutrient potassium humate, and it may be due to its positive effect in increasing the plant growth rate, as it contributes to increasing the efficiency of the carbon metabolism process in the plant, which is reflected positively on the vegetative growth, especially the increase in leafy area, in addition to the nutrients that this nutrient contains major (N, P and K) and amino acids, which reflected positively on increasing the growth of the vegetative system by increasing the activation of cell division and their elongation and then widening, especially the leaves, and this in turn leads to an increase in the leaf area, as a result of the activity of humic acid, which is similar to gibberellins [23]. As for the interaction between the fertilizing combinations and the application of the organic nutrient potassium humate in the leaf area, the results of

Table 4, indicated that the treatment (N_2K_2 × concentration 2 g L^{-1}) achieved the highest interference value for this traits amounting to 4471.67 cm^2 $plant^{-1}$, which was significantly superior to all overlap treatments. Other treatments, except for (N_1K_1, N_1K_2, and N_2K_1 × concentration 2 g L^{-1}), which amounted to (4466.00, 4464.33, and 4469.00) cm^2 $plant^{-1}$ sequentially without significant difference, while the treatment recorded (N_0K_0 × concentration 1 g L^{-1}) the lowest value of overlap was 3911.33 cm^2 $Plant^{-1}$.

Stem diameter (mm)

It is noted from table 5, that the diameter of the stem has increased significantly with the increase in the levels of mineral fertilization with fertilizer combinations of nitrogen and potassium, as the fertilizer combination N_2K_1 gave the highest mean diameter of the stem amounted to 22.90 mm, which did not differ significantly from the fertilizer combinations (N_1K_1, N_1K_2, and N_2K_2), which amounted to (22.84, 22.86 and 22.88) mm respectively, while it was significantly superior to the rest of the treatments with an increase rate of 20.00% compared to the control treatment N_0K_0, which amounted to 19.12 mm .the reason for the increase in the diameter of the stem may be due to the availability of nitrogen during the growth stages, which leads to the accumulation of carbohydrates and salts, which causes an increase in the expansion of the diameter of the stem [24] and that potassium has a major role in increasing the diameter of the stem because it contributes to the activation of the carbon metabolism process and an increase in the size of cells and their division [11].

The results of table 5, indicated that there was a significant difference in the average diameter of the stem when spraying with the organic nutrient potassium humate, as the concentration exceeded 2 g L^{-1} and gave the highest average for this traits of 22.02 mm, with an increase of 3.00% compared to the concentration 1g L^{-1} which gave the lowest average It reached 21.39 mm. The increase in the diameter of the stem is due to the positive effect of the organic nutrient, which increased the activity and effectiveness of plant enzymes and increased their production, which leads to an increase in the diameter of the stem [25]. As for the interaction between the fertilizer combinations and the application of the organic nutrient potassium humate in the diameter of the stem, the results of table 5, indicated that the treatment (N_2K_1 × concentration 2 g L^{-1}) achieved the highest interference value for this traits amounted to 23.22 mm, which was significantly superior to all other interaction treatments. Except for the treatments (N_1K_1, N_1K_2 and N_2K_2 × concentration 2 g L^{-1}), which amounted to (23.10, 23.12, and 23.15) mm, respectively, without significant difference, while the treatment (N_0K_0 × concentration 1g L^{-1}) recorded the lowest value of interference. It amounted to 18.94 mm.

Table (5): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Stem diameter (mm)

Fertilizer combination	potassium humate concentration (mg L^{-1})		Means
	1	2	

N_0K_0	18.94	19.30	19.12
N_0K_1	20.01	20.30	20.15
N_0K_2	20.94	21.53	21.24
N_1K_0	21.01	21.67	21.34
N_1K_1	22.58	23.10	22.84
N_1K_2	22.61	23.12	22.86
N_2K_0	21.21	22.81	22.01
N_2K_1	22.58	23.22	22.90
N_2K_2	22.61	23.15	22.88
Means	21.39	22.02	
$LSD_{0.05}$ Fertilizer combination =0.14, $LSD_{0.05}$ Potassium humate concentration =0.12, $LSD_{0.05}$ Fc × Ph Interactions = 0.19			

Index of chlorophyll in leaves (SPAD unit)

The results shown in table 6, indicate that there is a significant difference in the index of chlorophyll in the leaves of the maize plant when fertilizing with fertilizer combinations of nitrogen and potassium, as the fertilizer combination N_2K_1 gave the highest average of 46.78 SPAD units, with an increase of 15.00% compared to the comparison treatment N_0K_0 that gave the lowest average for this traits, it was 40.84 SPAD units, followed by, without significant difference, the combinations (N_1K_1, N_2K_2, and N_1K_2) that gave (46.74, 46.60, and 46.43) SPAD units, respectively. The addition of fertilizer combination of nitrogen and potassium to the soil increased the available form of them in the soil solution and thus increased the efficiency of their absorption by plant roots, which resulted in an increase in the concentration of nitrogen and potassium in the plant and then increased the content of leaves of chlorophyll, as nitrogen is involved in building and forming chlorophyll, in addition to its role in the formation and construction of amino and fatty acids that are involved in the formation of chloroplasts and the activation of enzymes related to the formation of chlorophyll [26]. As for potassium, it works to increase the percentage of nitrogen in the leaf, which is included in the synthesis of chlorophyll, and therefore it is necessary for the formation of chlorophyll and delaying the aging of leaves through its role in delaying the catabolism of protein and activating the enzyme RUBP, which has a major role in the process of carbon metabolism. Potassium also activates the microelements that work on the survival of an amount of iron to form chlorophyll and activate the enzymes Phosphoenolpyruvate carboxylase and Hexokinase [27].

Table (6): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Index of chlorophyll in leaves (SPAD unit)

Fertilizer combination	potassium humate concentration (mg L^{-1})		Means
	1	2	
N_0K_0	39.81	41.88	40.84

N_0K_1	39.95	41.95	40.95
N_0K_2	40.70	41.79	41.24
N_1K_0	44.11	45.42	44.77
N_1K_1	45.06	48.43	46.74
N_1K_2	45.04	47.81	46.43
N_2K_0	43.96	45.87	44.91
N_2K_1	45.43	48.14	46.78
N_2K_2	45.13	48.08	46.60
Means	43.24	45.48	
$LSD_{0.05}$ Fertilizer combination =0.58, $LSD_{0.05}$ Potassium humate concentration =1.06, $LSD_{0.05}$ Fc × Ph Interactions = 0.96			

The results are shown in table 6, there is a significant difference in the index of chlorophyll in the leaves of the maize plant when spraying the organic nutrient potassium humate, as the concentration exceeded 2 g L^{-1}, giving it the highest mean of 45.48 SPAD units, with an increase of 5.18%, compared to concentration 1g L^{-1}, which gave the lowest average of 43.24 SPAD units. Spraying with organic nutrients affects respiration, carbon metabolism, and increases antioxidants, thus preserving the chlorophyll content of leaves from catabolism [28]. The results of Table 6, show that the interaction between the fertilizer combinations of nitrogen and potassium and spraying with the organic nutrient potassium humate significantly affected the chlorophyll index in the leaves and the highest average was 48.43 SPAD units when the overlap treatment (N_1K_1 × concentration 2 g L^{-1}) which was significantly superior to all treatments Other interferences except for the treatments (N_1K_2, N_2K_1, and N_2K_2 × concentration 2 g L^{-1}), which amounted to (47.81, 48.14, and 48.08) mm, respectively, without significant difference, while the treatment recorded (N_0K_0 × concentration 1 g L^{-1}), The lowest overlap value was 39.81 SPAD units.

Ear weight (g)

It is noted from table 7, that the ear weight increased significantly with the increase in the levels of mineral fertilization with fertilizer combinations of nitrogen and potassium, as the fertilizer combination N_2K_2 gave the highest average ear weight of 226.46 g, which did not differ significantly from the fertilizer combinations (N_1K_1, N_1K_2, and N_2K_1), which amounted to (222.70, 222.28 and 223.31) g, respectively, while it significantly outperformed the rest of the treatments with an increase of 60.00% compared to the comparison treatment N0K0 which amounted to 141.11 g. Nitrogen and potassium contribute to an increase in ear weight through their effect on the process of carbon metabolism, cell division, an increase in the resulting nutrients and a decrease in competition for them, which leads to a decrease in abortion in flowers and an increase in ear weight [11]. The results were consistent with what was obtained by [29], as they found a significant increase in the ear weight characteristic when nitrogen and potassium were added to the maize crop. It is observed from the results of table 7, that there was a significant difference in the average weight of the ear when spraying with the organic nutrient potassium humate, as the concentration exceeded 2 g L^{-1} and gave the highest average for this traits amounted to 200.76 g, with an increase of 15.00% compared to the concentration 1 g L^{-1}, which gave the lowest average of 173.56 g. Spraying with an organic nutrient contributes to increasing the vital activities of the plant and the absorption of nutrients, which increases the efficiency of the carbon metabolism process, which leads to the accumulation of nutrients in grains and an increase in their size and weight, and thus an increase in ear weight [30]. The results of table 7, showed that the interaction between the two study factors had a significant effect on the increase in ear weight. The treatment (N_1K_1 × concentration 2 g L^{-1}) achieved the highest value of interaction amounting to 250.26 g, which was significantly superior to all other treatments except for (N_1K_2 , N_2K_1 and N_2K_2 × concentration 2 g L^{-1}), which amounted to (246.92, 243.57, and 244.71) g, sequentially without significant difference, while the treatment (N_0K_0 ×concentration 1 g L^{-1}), recorded the lowest value of interference, amounting to 136.62 g .

Table (7): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Ear weight (g)

Fertilizer combination	**potassium humate concentration (mg L^{-1})**		**Means**
	1	**2**	
N_0K_0	136.62	145.60	141.11
N_0K_1	143.19	152.78	147.99
N_0K_2	147.11	159.03	153.07
N_1K_0	152.94	161.48	157.21
N_1K_1	195.13	250.26	222.70
N_1K_2	197.65	246.92	222.28
N_2K_0	178.14	202.52	190.33
N_2K_1	203.06	243.57	223.31
N_2K_2	208.21	244.71	226.46
Means	173.56	200.76	
$LSD_{0.05}$ Fertilizer combination =4.65, $LSD_{0.05}$ Potassium humate concentration =9.57, $LSD_{0.05}$ Fc × Ph Interactions = 8.121			

Weight of 1000 grain (g)

It is clear from table 8, that there is no significant difference in the average weight of 1000 grains when fertilizing with fertilizer combinations of nitrogen and potassium. As for spraying with the organic nutrient potassium humate, the concentration of 2 g L^{-1}, was significantly higher, giving it the highest average of 141.99 g, with an increase of 1.00%, compared to the concentration of 1 g L^{-1}, which gave the lowest average of 140.77 g. The reason for the increase is attributed to the significant effect of the organic nutrient potassium humate and what it contains of potassium, humic and fulvic acid, and that spraying it on the leaves led to raising the plant's efficiency in increasing the activity of the carbon metabolism process and in the transfer of sugars from the leaves to other parts of the plant in addition to its role in increasing the absorption of nitrogen, which it is involved in the formation of proteins and thus increases the nutrients stored in grains and increases their size and weight [28]. As for the overlap, the results indicated that there was no significant difference between the treatments of the fertilizer combinations of nitrogen and potassium and the application of the organic nutrient potassium humate.

Table (8): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Weight of 1000 grain (g)

Fertilizer combination	potassium humate concentration (mg L^{-1})		Means
	1	2	
N_0K_0	138.31	140.91	139.61
N_0K_1	140.13	143.06	141.60
N_0K_2	141.63	142.74	142.18
N_1K_0	142.80	142.53	142.66
N_1K_1	140.08	141.22	140.65
N_1K_2	140.97	141.66	141.32
N_2K_0	141.51	142.32	141.92
N_2K_1	141.25	141.96	141.60
N_2K_2	140.28	141.49	140.89
Means	140.77	141.99	
$LSD_{0.05}$ Fertilizer combination = NS, $LSD_{0.05}$ Potassium humate concentration =1.15, $LSD_{0.05}$ Fc × Ph Interactions = NS			

Plant yield (g plant^{-1}).

The results shown in table 9, that there is a significant difference in the average yield plant (g plant^{-1}), when fertilizing with fertilizer combinations of nitrogen and potassium, as the fertilizer combination N_2K_1 gave the highest average of 184.53 g plant^{-1}, with an increase of 78.00% compared to the comparison treatment N_0K_0 that gave the lowest average for this characteristic, it amounted to 103.84 g plant^{-1}, followed by the combinations (N_1K_1, N_1K_2, and N_2K_2) without significant difference which gave (179.88, 181.84, and 184.41) g plant^{-1}, respectively. The reason for the increase in grain yield is due to the role of nitrogen and potassium, as nitrogen contributes to an increase in the process of carbon metabolism, which leads to an increase in the formation of chlorophyll, proteins, enzymes, and most growth regulators that have a major role in increasing grain yield [31]. As for potassium, it contributes to an increase in grain yield as a result of increasing the number of grains in the row [32]. The reason for this may be attributed to the formation and transport of carbohydrates and the construction of proteins and amino acids, which leads to an increase in the efficiency of carbon metabolism and as a result, the grain yield increases [33]. The results show that there is a significant difference in the average plant yield (g plant^{-1}), when spraying the organic nutrient potassium humate, as the concentration exceeded 2g L$^{-1,}$ giving it the highest average of 159.83 g plant^{-1}, with an increase of 13.00%, compared to the concentration 1g L^{-1}, which gave the lowest mean of 141.33 g L^{-1}. The organic nutrient potassium humate is characterized by its high content of potassium, humic and fulvic acid, as humic acid inhibits the activity of the enzyme (IAA oxidase), which leads to an increase in the activity of auxin (IAA), which plays a role in stimulating plant and root growth. It is useful that spraying with the organic nutrient leads to its enrichment With the necessary nutrients and increasing the plant's resistance to drought and high temperature to a large extent, it also leads to an increase in the growth of the root group and its improvement and the leafy area of the plant, which is reflected in the performance of the crop, especially the carbon representation and the increase of the represented materials and their transmission to the flowers as they work to increase the percentage of fertility in them and thus increase the number of grains in the row and the spider [34] and [28]. This leads to an increase in the formation of processed food and then its transfer to the grain, which leads to an increase in the grain yield [30].

Table (9): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Plant yield (g plant^{-1})

Fertilizer combination	**potassium humate concentration (mg L^{-1})**		**Means**
	1	**2**	
N_0K_0	100.50	107.19	103.84
N_0K_1	116.88	125.25	121.06
N_0K_2	124.69	130.63	127.66
N_1K_0	126.06	135.13	130.59
N_1K_1	159.88	199.88	179.88
N_1K_2	167.31	196.38	181.84
N_2K_0	135.31	147.56	141.44
N_2K_1	170.19	198.88	184.53
N_2K_2	171.19	197.63	184.41
Means	141.33	159.83	
$LSD_{0.05}$ Fertilizer combination =5.18, $LSD_{0.05}$ Potassium humate concentration =0.62, $LSD_{0.05}$ Fc × Ph Interactions = 6.92			

This is consistent with the findings of [35] and [36] a dding nitrogen and potassium increased the growth, productivity, and quality of the various crop plants. The results of Table (9) showed that the interaction between the two factors of the study had a significant effect on increasing the average yield per plant (g plant^{-1}), as the treatment (N_1K_1 ×concentration 2 g L$^{-1)}$ achieved the highest value of interaction amounting to 199.88 g plant^{-1}, which Significantly superior to all other treatments except for (N_1K_2, N_2K_1 and N_2K_2 × concentration 2 g L^{-1}), which amounted to (196.38, 198.88 and 197.63) g plant^{-1}, respectively, without significant difference, while the treatment recorded (N_0K_0 × concentration 1 g L^{-1}), the lowest interference value was 100.50 g plant^{-1}.

Protein yield in grains (g plant^{-1}).

It is noted from Table 10, that the protein yield in grains increased significantly with the increase in the levels of mineral fertilization with fertilizer combinations of nitrogen and potassium., as the fertilizer combination N_2K_2 gave the highest average protein yield amounting to 21.58 g plant^{-1}, which did not differ significantly from the fertilizer combinations (N_1K_1, N1K2 And N2K1), which amounted to (20.81,21.09 and 21.46) g plant^{-1}, respectively, while it significantly outperformed the rest of the treatments with an increase of 144.00% compared to the comparison treatment, N0K0, which amounted to 8.86 g plant^{-1}. The provision of nitrogen is important in the formation of amino acids through the formation of the amine group, which is the basic material in the formation of protein [11].The increase in the protein content of grains may be due to an increase in the nitrogen content in the leaves. Cereals for protein production, and the increase in protein content may be due to the fact that nitrogen plays a large role in protein synthesis [37]. Potassium also plays a major role in increasing the percentage of protein in grains because of its positive effect in preserving the activity and effectiveness of leaves and increasing the carbohydrate manufacturing process to ammonia NH_3 , as ammonia is linked with ketone acid to produce amino acids and thus the formation of proteins, and it also enters the process of separating the ribosome from the newly formed protein, which leads to the opportunity to produce a new protein [38] and [39]. The results of table 10, indicated that there was a significant difference in the average protein yield in grains when spraying with the organic nutrient potassium humate, as the concentration exceeded 2 g L^{-1} and gave the highest average for this characteristic amounted to 17.51 g plant^{-1}, with an increase of 22.00% compared to the concentration 1 g L^{-1}, which was given the lowest average was 14.33 g plant^{-1}. As well, spraying with the organic nutrient potassium humate increases the concentration of nucleic acids in the plant cell, which are essential for many biochemical processes inside the cell, as the activation of chemical processes leads to an increase in the synthesis of enzymes and an increase in protein and carbohydrate content in grains [14] and [37]. The results of table 10, show that the interaction between fertilizer combinations of nitrogen and potassium and spraying with the organic nutrient potassium humate had a significant effect on the protein yield in grains, and the highest average was 24.25 g plant^{-1}, when the overlap treatment (N_1K_1 × concentration 2 g L^{-1}), which was significantly superior to all overlap treatments. Other treatments except for (N_1K_2, N_2K_1, and N_2K_2 × concentration 2 g L^{-1}), which amounted to (23.68, 23.78, and 23.75) g plant^{-1}, sequentially without significant difference, while the treatment (N_0K_0 × concentration 1 g L^{-1}) recorded the lowest value for overlap amounted to 8.40 g plant^{-1}.

Table (10): Effect of spraying with potassium humate and the fertilizer combination of nitrogen and potassium on Protein yield in grains (g plant^{-1})

Fertilizer combination	potassium humate concentration (mg L^{-1})		Means
	1	2	
N_0K_0	8.40	9.33	8.86
N_0K_1	9.86	11.15	10.51

N_0K_2	10.87	11.94	11.40
N_1K_0	11.67	13.43	12.55
N_1K_1	17.37	24.25	20.81
N_1K_2	18.50	23.68	21.09
N_2K_0	13.69	16.28	14.99
N_2K_1	19.14	23.78	21.46
N_2K_2	19.42	23.75	21.58
Means	14.33	17.51	
$LSD_{0.05}$ Fertilizer combination =0.900, $LSD_{0.05}$ Potassium humate concentration = 1.857, $LSD_{0.05}$ Fc × Ph Interactions = 1.572			

The present results enable us to conclude that spraying organic nutrient potassium humate and fertilizer combinations of nitrogen and potassium, increase vegetative growth, which enhances photosynthesis and thus improves the composition of crop components that lead to an enhancement in the grain yield and quality of maize. The interaction between the spraying organic nutrient potassium humate (2 g L^{-1}), and fertilizer combinations of nitrogen and potassium (N_1K_1) was found best responsive in improving the growth, grain yield, and quality of maize, the interaction between the two study factors contributed to reducing the amount of mineral fertilizer to 50%

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