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Effect of nano-NPK fertilizer on some growth characteristics and yield of Maize (*Zea mays* L.).

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ABSTRACT
In the fall of 2022, a factorial experiment was carried out in the Bani Magan area, which is connected to the General Directorate of Agriculture of Sulaymaniyah and part of the Directorate of Agriculture of Chamchamal. The purpose of the experiment was to determine how different concentrations of nano-NPK (0, 2, and 4) $g.L^{-1}$ affected the responses of seven genotypes of maize crop to different growth traits and overall yield. The experiment's results were as follows: Plant height, total grain yield, and the amount of time between seeding and 50% of male flowering were all considerably greater at 4g L^{-1} NPK nano-compound fertilizer concentration. The two genotypes (DKC6664 and Yugoslavian) were greatly outperformed for the 42.52-day period from sowing to 50% male flowering, and the 46.52-day period from sowing to 50% female flowering for the genotype (DKC6664). The plant height of 204.66 and 202.77 cm was significantly exceeded by two genotypes (Babylon and Bahia). Additionally, the number of grains per ear (518.06 and 513.89) was significantly exceeded by both genotypes (Erbil 215481 and DKC6664). The genotype (Yugoslavian) was significantly exceeded for the weight of 100 grains, 34.55 (g), and the total grain yield was superior for both genotypes (DKC6664 and Erbil 215481) at 9.47 and 9.37 (ton ha^{-1}).
KEYWORDS: Maiz; NPK nano fertilizer; morphology; vegetative growth and yield traits.

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تأثير التسميد NPK النانوي في بعض صفات النمو والحاصل في الذرة الصفراء *Zea mays* L.

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الملخص
في خريف 2022 أجريت تجربة عاملية في منطقة باني مقان العائدة لمديرية زراعة جمجمال والتابعة للمديرية العامة لزراعة السليمانية، كان الهدف من التجربة هو تحديد مدى تأثير التراكيز المختلفة لسماد NPKالنانوي (0 و 2 و 4 غم لتر$^{-1}$) على استجابات سبعة تراكيب وراثية من محصول الذرةالصفراء لصفات النمو المختلفة والإنتاج الكلي وكانت نتائج التجربة على النحو التالي : ارتفاع النبات، وحاصل الحبوب الكلي وعدد الأيام من الزراعة حتى 50% تزهير الذكري كانت جميعها أكبر بكثير عند تركيز4غم لتر$^{-1}$ سماد مركبNPKالنانوي، تفوق الصنفان الوراثيان (DKC6664 واليوغوسلافي) بشكل كبير خلال الفترة 42.52 يوم من الزراعة إلى 50% تزهير ذكري، وفترة 46.52 يوم من الزراعة إلى 50% تزهير أنثوي للتركيب الوراثي (DKC6664) ارتفاع النبات 204.66 و 202.77 سم تم تجاوزها معنويا في التراكيب الوراثية (بابل وBahia) بالإضافة إلى ذلك تم تجاوز عدد الحبوب لكل عرنوص 518.06 و 513.89 حبة عرنوص$^{-1}$ بشكل ملحوظ من قبل كلا التركيبين لوراثيين(اربيل 215481 وDKC6664) تفوق االتركيب الوراثي (يوغوسلافي) معنوياً في وزن 100 حبة 34.55 غم، كما تفوق إنتاج الحبوب الكلي لكلا الصنفين (DKC6664 وأربيل 215481) بـ 9.47 و 9.37 طن هـ$^{-1}$.
الكلمات المفتاحية: الذرة الصفراء، التسميد **NPK** النانوي، الشكل الظاهري، صفات النمو، صفات الحاصل.

INTRODUCTION

Zea mays a member of the Poaceae family, is the third most significant plant in the world. (Jaaz, Ali and Al-Abdullah, 2019), (4.6)% fat, (2.2)% fiber, and (1.6)% minerals are included. Its relevance is illustrated by the numerous nutritional and commercial uses it finds in food and business, such as starch extraction from its grains, in addition to its vitamin content and 3,460 calories per kilogram. Furthermore, this crop's grains are blended with wheat at a rate of (15.5) % to create flour (Hamza, 2013). The adverse consequences of the reckless utilization of synthetic composts, remembering the issue of soil contamination for expansion to raising soil saltiness, made it important to consider involving current manures as an option in contrast to customary manures to give the supplements expected to establish development and increment efficiency. The very effective, environmentally friendly fertilizers known as nano fertilizers are among those that maintain the surroundings neat and the soil in outstanding condition (Miransari, 2011). Among the most cutting-edge and contemporary fertilizers now on the market, nano-fertilizers give crops all the vital mineral nutrients they need for healthy nourishment and treatment. Farmers want to solve environmental issues while maximizing crop health and yield by implementing nano-fertilizers, (Subbarao Ch, G andSirisha, 2013).

The following goals were the reason behind doing the study:

- To ascertain how the genotypes of the maize crop react when NPK Nano fertilizer is applied.
- Determine which NPK Nano fertilizer concentration is best for foliar application and how it affects the features, elements, as well as qualitative of the maize crop after harvest.
- Examining the relationship between maize genotypes with NPK Nano fertilizer levels.

MATERIALS AND METHODS

An experiment was conducted in the fall of 2022 the region of Bani Maqan, which is connected to the General Directorate of Sulaymaniyah Agriculture. Three replicates of the Rrandomized Complete Block Design (R.C.B.D.) split-plot arrangement experimental field were leveled and plowed prior to the completion of the agricultural tasks. After that, the land was split into three duplicates. the first element. Three distinct measurements of NPK nano compost (0, 2, and 4) g were splashed over the principal plots.L^{-1}. Plots were laid out utilizing seven assortments of maize (Sagunto, Erbil 215481, Jameson, Bahia, and auxiliary). The establishing days were 4/7/2022. The repeater for one trial unit included 21 lines, each estimating 3 meters long and 0.70 meters in separation from the other exploratory unit. Before the weakening step, 320 kg of compound manure (18% N and 46% P2O5) was added after development and the diminishing system to a solitary plant all around (Mahdi and Ahmad, 2020). thereafter, administering Urea (N46)% in a single batch during the branching stage (200 kg ha^{-1}) (Al-Jumaili and Al-Zubaidi, 2019).Harvesting occurred on 7,December , 2022. The statistical analysis was carried out using the SAS, 2012 program (Al-Zubaidi and Al-Jubawi, 2016). According to (Al-Zubaidi and Al-Jubouri 2022). The qualities under study were as follows: each experimental unit's two middle lines were randomly selected, and the following attributes were computed based on the means of ten plants.

1. Time interval until 50% (day) of the male blossoming, (Odongo and Bockholt, 1995).
2. Length of female blooming (day) to 50%, (Odongo and Bockholt, 1995).
3. Height of plant (cm), (Al-Jubouri and Al-Jubouri, 2020).
4. The number of grains (ear $^{-1}$) present in each ear: Ten haphazardly picked plants from each exploratory unit had their ear mean counts of grains determined, and a normal was made (Al-Hadidi, 2007).
5. By picking 100 grains indiscriminately among the grains of ten particular plants, the heaviness of 100 grains not set in stone. Thusly, the weight was acclimated to mirror a 15.5% dampness content. (Al-Sahook, 2006).
6. Grain yield (ton ha^{-1}): The unit of estimation was changed to ton ha^{-1} by increasing the grain yield per plant by the plant thickness. (Habib and Al-Hilf, 2019).

RESULT AND DISCUSSION

The time interval (day) between planting and 50% male flowering:

Table(1) Demonstrate notable variations between the different NPK Nano fertilizer spraying amounts for the aforementioned characteristics. The time from seeding to 50% male flowering was shortened for plants fed with 2 and 4 g L^{-1} with NPK Nano fertilizer (48.43 and 48.87 days, respectively). On the other hand, it took the control plants significantly longer 52.78 days to attain 50% male blooming. The table shows that there are notable differences between the genotypes: the Yugoslavian and DKC6664 genotypes were substantially earlier in terms of the number of days until 50% male flowering (42.04 and 42.52 days), while the Bahrain genotype was significantly later in reaching this milestone. The average duration of this stage was (58.88) days. Differences in genotypes are the reason for the variance in genotypes during male blooming. Moreover, the table indicates a noteworthy interplay between the genotypes and the NPK Nano fertilizer levels. The Yugoslavian genotype in conjunction with the 2g.l^{-1} NPK Nano fertilizer treatment caused a markedly early blooming, with plants reaching 50% male flowering in just 35.56 days. Conversely, it took 61.00 days to reach this stage because to the interaction between the Bahia genotype and the no-spray treatment.

Table 1. Effects of genotypes and their interactions with NPK Nano Fertilizer Spraying on the time interval from planting to 50% male blooming (day).

Genotypes	Levels of NPK Nano fertilizer (g L^{-1})			Means
	0	2	4	
Sangunto	55.33 bc	57.33 ab	56.66 a-c	56.44 b

Erbil 215481	49.33 d-f	40.67 hi	40.00 e-g	45.33 d
Jameson	48.50 ef	53.00 cd	50.33 de	50.61 c
Bahia	61.00 a	57.66 ab	58.00 ab	58.88 a
Yugoslavian	49.33 d-f	35.56 j	42.66 gh	42.52 e
Babylon	60.33 a	57.66 ab	45.09 fg	54.36 b
DKC6664	45.66 fg	37.140 ij	43.33 gh	42.04 e
means	52.78 a	48.43 b	48.87 b	

Different letters within column indicating of significant differences ($p<0.05$)

2- Period from sowing until 50% flowering (day):

Table (2) shows that there are notable variations among the different NPK Nano-fertilizer spraying amounts in terms of the days from seeding to 50% female blooming. In just 55.80 days, plants fed with 2g L^{-1} of NPK Nano-fertilizer showed noticeably earlier blooming. In contrast, the plants without any spraying treatment showed a significant delay in reaching 50% female flowering, which took 57.48 days. Because for these differences in flowering time may be similar to those mentioned for the variations in days until 50% male flowering, which is likely influenced by the NPK Nano-fertilizer treatment. Furthermore, significant differences were observed among the genotypes regarding the number of days until 50% female flowering is reached. Genotype DKC6664 demonstrated significantly earlier flowering at a rate of 46.91 days. On the other hand, Genotypes Bahia and Babylon outperformed all other genotypes, taking 62.44 and 62.22 days, respectively, to reach 50% female flowering. The data also shows that there is a considerable interaction between the genotypes and the amounts of NPK nano-fertilizer sprayed. The combination between no spraying treatment and genotype Bahia resulted in a significant delay in reaching 50% female flowering (66.33 days). Additionally, the combination between comparison coefficient (possibly referring to a specific concentration of NPK Nano-fertilizer) and genotype Bahia showed a significant delay in reaching this stage, which took 66.33 days. The effect of nitrogen in the NPK Nano composite may be responsible for increasing cell size and division speed, leading to enhanced growth and vegetative activity, likely affecting the flowering time (66.33) days, which supports the tendency of the plant to focus on vegetative growth.

Table 2. Effects of genotypes and their interactions with NPK Nano Fertilizer Spraying on the time interval from planting to 50% Female blooming (day).

Genotypes	**Levels of NPK Nano fertilizer (g L^{-1})**			**Means**
	0	**2**	**4**	
Sangunto	49.76 g	54.55 f	61.66 c	55.32 d
Erbil 215481	58.00 d	58.33 d	53.61 f	56.64 c
Jameson	58.00 d	58.33 d	58.00 d	58.11 b
Bahia	66.33 a	55.33 ef	65.66 a	62.44 a
Yugoslavian	58.00 d	57.33 de	46.94 h	54.09 e
Babylon	57.00 de	63.66 b	66.00 a	62.22 a

DKC6664	55.33 ef	43.09 i	42.30 i	46.91 f
means	57.48 a	55.80 b	56.31 ab	

Different letters within column indicating of significant differences (p<0.05)

3-Plant height (cm):

It is clear from the data in Table (3) that the amount of NPK nanofertilizer sprayed has a big impact on the plant height characteristic. The height of those treated with 4g L^{-1} of NPK nano-fertilizer spraying was substantially higher, with a mean height of 187.19 cm, whereas the mean height of those treated with the control treatment was 175.04 cm. The inclusion of NPK Nano-fertilizer, which helps to supply necessary nutrients in appropriate quantities through its absorption by the stomata, translocation across cell membranes, and quick metabolism, is responsible for the 4 g L^{-1} spray treatment's excellence. This ultimately leads to the elongation of internodes and an increase in plant height by promoting cell division and creation, influencing plant growth and development, and controlling the activity of plant hormones such auxins and cytokines (Duete, Muraoka, Trivelin and Ambr-osano, 2008). Additionally, the data shows notable variations in plant height amongst the genotypes. At 204.66 cm, genotype Babylon had the highest average height; this difference was not statistically significant from genotype Bahia. Conversely, the genotypes DKC6664, Jameson, and Yugoslavian had the lowest mean heights, with respective measurements of 165.66, 165.00, and 164.44 cm. The duration of the vegetative development phase, or the time from planting to maturity, for each genotype of maize can vary depending on the genotype and is influenced by a combination of genetic and environmental variables. Plant height is influenced by these elements because they permit cell division and elongation. The data also shows that there is a strong interaction between the genotypes and the amounts of NPK nanofertilizer sprayed. The genotype Babylon and the treatment of 4g L^{-1} spraying produced the highest average plant height of 207.00 cm, which did not vary substantially from the genotype Bahia and the interaction of the same spraying level (206.66 cm). On the other hand, the genotype Jameson with the no-spray treatment combination had the lowest mean height of 156.33 cm.

Table 3. Effects on plant height (cm) of genotypes, NPK Nano Fertilizer Spraying, and their interplay.

Genotypes	**Levels of NPK Nano fertilizer (g L^{-1})**			**Means**
	0	**2**	**4**	
Sangunto	175. 00 fg	176. 00 fg	188. 66 e	179. 88 b
Erbil 215481	164. 00 J	169. 67 hi	195. 66 d	176.44 c
Jameson	156. 33 K	161 .66 j	177. 00 f	165.00 d
Bahia	200. 00 c	201. 66 bc	206. 66 a	202.77 a
Yugoslavian	163. 33 J	167. 66 I	162. 33 j	164.44 d
Babylon	204. 33 ab	202. 66 bc	207. 00 a	204.66 a

DKC6664	162 .33 J	161. 66 j	173. 00 gh	165.66 d
means	175. 04 C	177. 28 b	187.19 a	

Different letters within column indicating of significant differences ($p<0.05$)

4- The Number of Grains Per ear (grain.ear^{-1})

Table (4) shows that there was a considerable impact on grain number when NPK Nano fertilizer was sprayed at several amounts. ear^{-1}, where the spraying treatment gave it the greatest rate for this feature, reaching (512.72) grains, greatly above 4 g.L^{-1}. ear^{-1} Nevertheless, the non-spraying treatment had the lowest trait rate, coming in at 379.96 grain.ear^{-1}. This could be on the grounds that the parts of the nano-compost particles have an impact in controlling chemical movement, improving fundamental and enzymatic exercises, and providing supplements that are immediately retained, offering another alternative. In request to collect the dry matter required for the cycles of fertilization and treatment, the plant should likewise deliver more instant metabolites, increment the effectiveness of carbon digestion, and proposition the most obvious opportunity for floret fetus removal decrease by lessening rivalry between the plants for the food item (Attia and Jadoua, 1999). This expands the likelihood that florets will fertilize, bringing about the development of grains and an ascent in their amount inside the ear. Moreover, Table (4's) results exhibit that there are remarkable varieties in the genotypes with respect to the number of grains. Ear^{-1}, since the two genotypes (DKC6664 and Erbil 215481) performed best with the best grain rates (518.06 and 513.89) ear^{-1}, correspondingly, with the number of grains showing the most reduced rate. For the Jameson genotype, ear^{-1} arrived at 338.03 grains. ear^{-1}). This shows the colossal hereditary assortment across genotypes for this quality, as every genotype has the hereditary ability to deliver a specific number of grains per ear. For this trademark, there was a critical cooperation between the genotypes and the NPK Nano fertilizer splashing sums. Specifically, subsequent to showering at 4 gm L^{-1}, the genotypes of Sangunto, Erbil 215481, and DKC6664 had the best mean grain ear^{-1} (602.53, 570.00, and 598.00), though the genotypes of Jameson showed the least mean (291.77) grains.ear^{-1}.

Table 4. Effects of genotypes, NPK Nano Fertilizer Spraying, and their interplay on the quantity of grains per ear (seed.ear^{-1}).

Genotypes	Levels of NPK Nano fertilizer (g L^{-1})			Means
	0	2	4	
Sangunto	383.78 f-h	470.37 cd	602.53 a	485.56 b
Erbil 215481	457.33 c-e	526.83 b	570.00 a	518.06 a
Jameson	291.77 j	307.17 j	415.17 e-g	338.03 e
Bahia	393.13 f-h	437.00 c-f	482.73 b-d	437.62 c
Yugoslavian	321.13 ij	354.50 hi	435.33 d-f	370.32 d
Babylon	353.27 hi	469.00 cd	485.28 bc	435.85 c
DKC6664	459.33 c-e	484.33 bc	598.00 a	513.89 a

means	379.96 c	435.60 b	512.72 a

Different letters within column indicating of significant differences (p<0.05)

5- Quantity of 100 grains (gm)

Applying different dosages of NPK Nano fertilizer significantly affected the feature, as Table (5) demonstrates. the application of 4 g of spray. With a mean of 30.28 g, L^{-1} outperformed the other treatments and differed little from the non-spraying condition. The lowest mean of the characteristic obtained (29.42 g) was 2 g during spraying.L^{-1}. The same data shows that the genotypes varied significantly from one another. Both the Babylon and the Yugoslav genotypes exhibited the lowest rates, whereas the Yugoslav genotype generated the largest average weight of 100 grains (34.55) g. The genotypes of this trademark and the measures of NPK nano manure treatment fundamentally collaborated, as proven by their normal load of 100 grains, or 26.22 g. The Yugoslavian genotype, in blend with the two showering medicines (2 and 4 g.L^{-1}), yielded the most elevated normal, 35 and 34.66 g, separately. Both the genotype (Bahia) and genotype 2 g.L^{-1} showed the least normal (24.33) g.

Table 5. Effects of genotypes and their interactions with NPK Nano Fertilizer Spraying on the weight of 100 grains (grams).

Genotypes	**Levels of NPK Nano fertilizer (g L^{-1})**			**Means**
	0	**2**	**4**	
Sangunto	28. 00 ij	27. 00 jk	26. 66 jk	22 e
Erbil 215481	29. 33 g-i	30. 00 gh	31. 00 e-g	11 d
Jameson	32. 33 c-f	30. 66 fg	32. 66 b-e	88 c
Bahia	28. 33 h-j	24. 33 l	26. 00 kl	22 e
Yugoslavian	34. 00 a-c	35. 00 a	34. 66 a	55 a
Babylon	26. 66 jk	25. 33 kl	26. 66 jk	22 e
DKC6664	32. 00 d-f	33. 66 a-d	34. 33 ab	33 b
means	30. 09 a	29 .42 b	28 a	

Different letters within column indicating of significant differences (p<0.05)

6- Grain Yield Total (ton ha^{-1})

The results shown in Table (6) demonstrate that the application of NPK Nano fertilizer at varying rates had a noteworthy impact on the overall grain yield. Specifically, the 4g L^{-1} spraying treatment yielded the highest mean for this trait, reaching (10.11) tons ha^{-1}, whereas the no-spray treatment yielded the lowest mean, reaching (7.31) tons ha^{-1}. The NPK Nano fertilizer's ability to directly stimulate cell division and expansion processes is what accounts for the 4g.l^{-1} spray treatment's excellence. Plant growth rates were accelerated by this by raising Higher chlorophyll content, more green area, and specific plant chemicals that promote cell division and expansion processes all contributed to higher plant growth rates. As a result, the yield components rose as well as the photosynthetic process's ability to produce dry matter and transmit it from sources to receptors more quickly. The genotypes for the attributes associated with total grain production in Table (6) also show substantial variance, with the genotype DKC6664 greatly outperforming the genotype Erbil 215481 at the maximum rate of 9.47 tons ha^{-1} and not statistically differing from it. while Jameson's genotype had the lowest mean of 7.30 tons ha^{-1}. Grain production often varies among genotypes because of genetic variation as well as variations in physiological and environmental performance. The genotypes of traits associated with the total grain yield, ton ha^{-1}, are shown in the same table, and there is a significant interaction between the quantities of NPK nano fertilizer sprayed. The genotype (Erbil 215481) is located the treatment of $4g^{-1}$ spraying produced the greatest mean (11.46) tons ha^{-1}, whereas the genotypes (Babylon) and the no-spraying treatment produced the lowest mean (6.37) tons ha^{-1}.

Table 6. Effects of genotypes, NPK Nano Fertilizer Spraying, and their interplay on overall grain yield (ton ha^{-1}).

Genotypes	**Levels of NPK Nano fertilizer ($g\ L^{-1}$)**			**Means**
	0	**2**	**4**	
Sangunto	7. 71 f-h	8. 79 de	10. 45 b	98 b
Erbil 215481	7. 95 fg	8. 69 de	11. 46 a	37 a
Jameson	6. 54 i	6. 50 i	8. 87 c-e	30 d
Bahia	7. 23 h	7. 70 f-h	8. 91 c-e	95 c
Yugoslavian	7. 36 gh	8. 58 e	10. 83 b	92 b
Babylon	6. 37 i	8. 60 e	9. 24 cd	07 c
DKC6664	02 f	41 c	10. 99ab	47 a
means	7. 31 c	8. 33 b	11 a	

Different letters within column indicating of significant differences ($p<0.05$)

CONCLUSION

Because NPK Nano fertilizer directly affects cell division and expansion processes, increasing the amount of green area on plants and their chlorophyll content, as well as certain plant compounds that activate these processes, caused a rise in the rates of plant growth. This is why the level of NPK Nano fertilizer $4g.l^{-1}$ yielded the most grain. which enhanced plant growth rates, increased the rate at which dry matter is produced by photosynthesis, and accelerated the transfer of that material from sources to receptors. The yield components increased as a result of these factors., which in turn increased the plant's grain yield. In the grain yield, for all genotypes, where the genotype variation's role manifested in the yield's characteristics, and grain per ear as it is represented in the plant's physiological functioning.

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