RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
55 (6) 2256-2268, 2023
http://doi.org/10.54910/sabrao2023.55.6.36
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

RESPONSE OF MAIZE CULTIVARS TO FOLIAR APPLICATION OF ORGANIC AND NANO-COMPOUND NPK FERTILIZERS

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SUMMARY

The experiment proceeded in the Telafer site during the year 2022, with two seasons (spring and autumn) to study two maize (*Zea mays* L.) cultivars (Furat and Dijla) and eight levels of fertilizers (control treatment, 120 kg $N_{15}P_{15}K_{15}$ ha^{-1} of traditional compound fertilizer, 1.5 and 3 g $liter^{-1}$ of $N_{20}P_{20}K_{20}$ nano fertilizer, 1 and 2 ml $liter^{-1}$ of Optimum Plus organic fertilizer, 1.5g $liter^{-1}$ of $N_{20}P_{20}K_{20}$ nano fertilizer + 1 ml $liter^{-1}$ of organic fertilizer, and 3 g $liter^{-1}$ of $N_{20}P_{20}K_{20}$ nano fertilizer + 2ml $liter^{-1}$ of organic fertilizer) on yield traits of the maize grain. The research employed a randomized complete block design (RCBD) using the split-plot system, with the cultivars placed in the main plots, and the fertilizers in the secondary plots. Results indicated that the Furat cultivar excelled in all yield traits in the two seasons, except for the weight of the cob and the weight of 500 grains in the autumn season; cultivar Dijla was superior in the biological yield for the two seasons. As for the fertilizers, the treatment 2ml L^{-1} of the organic fertilizer achieved the highest rate in all studied traits for both seasons, except for the traits cob weight and biological yield, where the treatment was superior in 3 g L^{-1} of the $N_{20}P_{20}K_{20}$ nanofertilizer. The interaction showed significant differences in all studied traits of maize in both seasons.

Keywords: Maize (*Zea mays* L.), cultivars, organic fertilizer, NPK, nano fertilizer, foliar application, grain yield

Key findings: The possibility of replacing costly and field-strained ground fertilization with cheaper and more efficient foliar fertilization to grain yield and its components and its reflection on productivity and the maize (*Zea mays* L.) cultivars significantly impacted these traits.

Communicating Editor: Dr. Samrin Gul

Manuscript received: June 10, 2023; Accepted: October 20, 2023.

Citation: Zaki SM, Ahmed RF (2023). Response of maize cultivars to foliar application of organic and nano-compound NPK fertilizers. *SABRAO J. Breed. Genet.* 55(6): 2256-2268. http://doi.org/10.54910/sabrao2023.55.6.36.

INTRODUCTION

Maize (*Zea mays* L.) is one of the valuable cereal crops, ranking third globally in area and productivity after wheat and rice. The importance of maize is due to its multiple uses, as food for humans and animal fodder, as well as its use in many essential industries, such as the manufacture of oil, cornstarch, glues, ceramics, plastics, clothing dyes, printing ink, and cork work (Orhun, 2013). The productivity rate of maize is still minimal despite its great value, as the production rate in Iraq reached only 474,100 tons, while the global production rate already reached 1.15 billion tons (FAO, 2021). Given the low production rate in Iraq compared with the production rate abroad and the increasing demand for this crop, it is necessary to know different methods to improve productivity. Among these means is the use of cultivars suitable for the conditions of the agricultural region due to the variation of these cultivars and the prevailing fluctuating climatic conditions, which ultimately reflects in the increasing rate of productivity of maize. Khan *et al.* (2017) noted that the Jalal cultivar outperformed cultivars Azam and Local in grain yield and harvest index. Bawa (2021) indicated that the Obatampa cultivar excelled in the 100-grain weight and grain yield compared with cultivars IW-D-C3-CYN-F2, TZe-W-DT-STR-C4, DT-STR-W-C2, COMP1SYN, and GH120-DYF\D-POP.

Nanotechnology is one of the technologies used recently in many fields, including agriculture, with its significant contribution to developing the agricultural sector. As the small size of these nanoparticles contributes to the competency of the nanoparticles to penetrate the cell wall of the plant and thus increase the transmission of nanoparticles in plant cells, as well as increasing the ability of the plant to resist the pests and different stress conditions, ultimately reflects on enhancing the growth and yield of the plant (Grover *et al.*, 2012). Al-Zreejawi and Al-Juthery (2020) indicated that there was a significant increase when spraying treatments with nano compound fertilizer $N_{12}P_{12}K_{36}$ 2 g L^{-1} in grain yield, biological output, and the harvest index compared with two treatments 0 and 2 g l^{-1} of the nano compound fertilizer $N_{20}P_{20}K_{20}$. Al-Gym and Al-Asady (2020) noted that the treatment of 1.5 g L^{-1} of the nano compound fertilizer $N_{20}P_{20}k_{20}$ sprayed on the shoots + 7.5 kg ha^{-1} of the same fertilizer as a ground addition achieved the highest rate in the number of grains ear^{-1}, weight of 500 grains, grain yield, and biological outputs compared with spraying with distilled water.

Fertilization with nutrients in general and organic enrichment, in particular, is an imperative factor in growth and productivity of maize, as well as its vital role in increasing the plant's ability to withstand water stress conditions given its ability to secrete essential growth regulators that increase the capacity of roots to absorb large quantities of nutrients and balance water content, reducing adverse effects of water stress conditions and, hence, increase crop yield (Bhattacharyya and Jha, 2012; Bashan *et al.*, 2014). Payebo and Ogidi (2021) obtained significant differences between the levels 0 and 20 ton ha^{-1} of poultry manure and 20 ton ha^{-1} of cow manure, as 20 tons ha^{-1} of chickens manure recorded a high value in the 1000-grain weight, grain yield, and the number of grains ear^{-1} compared with the control treatment and 20 tons ha^{-1} of cow manure. Setyowati *et al.* (2022) noted an increase in ear weight and grain yield when adding high amounts of liquid organic fertilizer extracted from tomato plants (10 and 15 ml L^{-1}) compared with adding low quantities of it (0 and 5 ml L^{-1}).

MATERIALS AND METHODS

This study began in 2022 in two seasons (spring and autumn) in Telafer, which is 70 km west of the center of the city of Mosul at a longitude 42° 35′ 51″ East and latitude 36° 25′ 32″ North, to find out the response of yield traits of two maize (*Zea mays* L.) cultivars (Furat and Dijla) with eight levels of fertilizer treatments (control, which is spraying with water only, 120 kg ha^{-1} $N_{15}P_{15}K_{15}$ of traditional compound fertilizer, 1.5 and 3 g L^{-1} of $N_{20}P_{20}K_{20}$ nano fertilizer, 1 and 2 ml^{-1} of organic fertilizer Optimus Plus, 1.5 g L^{-1} of $N_{20}P_{20}K_{20}$ nano fertilizer + 1 ml^{-1} of organic fertilizer, and 3 g L^{-1} of $N_{20}P_{20}K_{20}$ + 2 ml^{-1} of organic fertilizer). The plant sowing in spring commenced on 31 March and in autumn on 18 July. The traditional compound fertilizer $N_{15}P_{15}K_{15}$ added to the soil occurred before sowing, and the nano compound fertilizer and organic fertilizer Optimus Plus proceeded to spray on the vegetative system of the plants in two batches. The first batch of spraying with the nano compound fertilizer was after 40 days of planting, and the second, 14 days after the first batch. The first batch for the organic fertilizer application was 47 days after planting, with the second 14 days after the first batch, depending on the instructional leaflets on the envelopes containing nano compound fertilizers and organic fertilizer issued by the manufacturer. Each experimental unit included four fences, 3 m long for each; the distance between each rail was 75 cm, and the distance between each hole was 25 cm. The study of yield traits ensued at different stages of plant life, including the ear weight (g), cob weight (g), the weight of the ear grains, the weight of 500 grains (g), the number of grains of the ear, grain yield (g 9 m^{-2}), biological yield (g 9 m^{-2}), and harvest index. Analyzing the soil's physical and chemical properties transpired before planting (Table 1). The meteorological station in the Nineveh Agriculture Directorate, Planning Department was also a basis for obtaining temperature and relative humidity data (Table 2).

Nano compound fertilizer $N_{20}P_{20}K_{20}$

It is a fertilizer that contains minute particles quickly dissolving in water and helps reduce the application rate of fertilizers added to plants (Figure 1).

Organic fertilizer (Optimus Plus)

It is an organic agricultural fertilizer manufactured with nanotechnology that contains a group of natural organic materials amounting to 30% amino acids, 5% total nitrogen, and 3% organic nitrogen (Figure 2).

Statistical analysis

The randomized complete block design (RCBD) comprised a split-plot arrangement, with the cultivars placed in main plots. Fertilizers' application continued in secondary plots, with three replications. The comparison between the averages of the treatments employed the Duncan's multiple range test.

RESULTS AND DISCUSSION

Ear weight

In two seasons of 2022, the cultivar Furat achieved the highest significant mean for the ear weight trait (147.94 and 158.77 g, respectively), compared with the Dijla cultivar,

Table 1. Soil traits for Telafer site.

Clay ($g\ kg^{-1}$)	Silt ($g\ kg^{-1}$)	Sand ($g\ kg^{-1}$	Textural	Available N ($mg\ kg^{-1}$)	Available P ($mg\ kg^{-1}$)	Available K ($mg\ kg^{-1}$)	Organic Matter $g.kg^{-1}$	pH	EC (dc/ m)
51.05	32.5	16.45	mixture	0.03	6.56	13.00	4.76	7.5	0.20

Table 2. Temperature (°C) and Rainfall (mm) for the year 2022 in Telafer site.

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Temp. (°C) (Maximum)	21	28	39	40	41	43	37	39	30
Temp. (°C) (Minimum)	5	9	12	22	24	25	21	11	9
Rain (mm)	23	27	29	30	31	32	36	47	48

Mosul weather station/ Iraq.

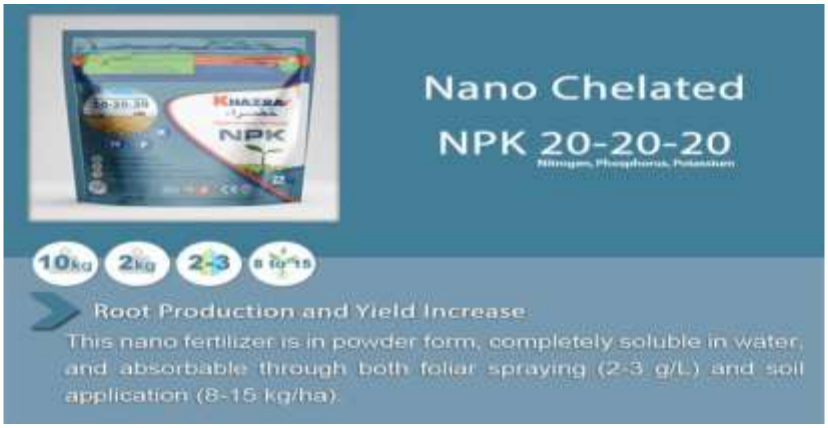

Figure 1. The neutral NPK nanofertilizer (20:20:20) used in the Experiment.

Figure 2. Optimus Plus organic fertilizer used in the experiment.

which attained the lowest quality mean at 143.76 and 154.14 g, respectively (Table 3). The superiority of cultivar Furat is due to its high ability to store the hugest possible amount of photosynthesis products, leading to an increase in ear weight. This result agreed with Elsahookie *et al.* (2021) and Muslimah *et al.* (2023).

Fertilizers significantly affected this trait in the two seasons. In spring, the nano compound fertilizer 3 g L^{-1} and the organic fertilizer 2 ml L^{-1} recorded the highest average (151.33 and 150.97 g, respectively), compared with the control recording the lowest average (137.07 g), while in autumn, the organic fertilizer 2 ml L^{-1} achieved the maximum average (163.57g) compared with the control, which acquired the least mean (148.93 g). It may be due to the organic and nano compound fertilizer raising the chlorophyll pigment, expanding the division of plant cells. As a result, the dry matter accumulation in the plant increases, including the ear weight. The result is in accord with the research outcomes of Brunner *et al.* (2020) and Setyowati *et al.* (2022).

The interaction showed a significant difference in this trait in the two seasons. In spring, acquiring the highest substantial mean emerged when the Furat cultivar had an overlap treatment with the nano compound fertilizer 3 g L^{-1}, the organic fertilizer 2 ml L^{-1}, and the nano compound fertilizer 3 g L^{-1} + organic fertilizer 2 ml L^{-1} resulting in near equal rates (154.13, 152.47, and 153.73 g, respectively) compared with the interaction of the cultivar Dijla with the traditional compound fertilizer of 120 kg ha^{-1} NPK, with the lowest average of the trait (134.50 g). In autumn, the interaction of Furat cultivar with the nano compound fertilizer 1.5 g L^{-1}, the organic fertilizer 2ml.L^{-1}, and the nano compound fertilizer 1.5 g L^{-1} + the organic fertilizer 1 ml L^{-1} recorded the highest average (164.40, 166.67, and 165.00 g, respectively) compared with the interaction of the cultivar Dijla with the control, which recorded the lowest rate for the feature (146.27 g).

Ear grains' weight

The Furat cultivar was markedly superior in ear grains' weight in the two seasons (115.02 and 126.96 g, respectively) compared with the Dijla cultivar, which achieved 111.06 and 123.08 g, respectively (Table 4). It refers to the growth of the cultivar Furat in the weight of the ear (Table 3) by a greater percentage than in the weight of the cob (Elsahookie *et al.,* 2021).

Fertilizer affected this trait for both seasons, with the highest significant mean for the trait observed appeared with the organic fertilizer treatment 2 ml L^{-1} (119.59 and 131.77g, respectively) in the two seasons, while the low average showed with the control in the two seasons amounting to 104.49 and 119.47 g, respectively. The superiority of this treatment may be attributable to the increase in the ear's weight (Table 3) compared with the weight of the cob. The result agreed with Leomo *et al. (*2021). The interaction showed significant differences in this trait in the two seasons, wherein spring recorded the high rate recorded when the Furat cultivar overlapped

Table 3. Response of ear weight (g) to cultivars and fertilizers and the interaction between them***.***

Spring Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	138.22 g	135.92 h	137.07 f
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	143.08 f	134.50 h	138.79 e
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	148.05 b-d	145.75 de	146.90 c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	154.13 a	148.53 bc	151.33 a
Org. Fertilizer 1 ml L^{-1}	143.69 ef	141.63 f	142.66 d
Org. Fertilizer 2 ml L^{-1}	152.47 a	149.47 b	150.97 a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	150.11 b	148.02 b-d	149.06 b
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	153.73 a	146.26 cd	149.99 ab
Cultivars' averages	147.94 a	143.76 b	
Autumn Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	151.60 ef	146.27 g	148.93 e
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	152.00 ef	153.20 de	152.60 d
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	164.40 a	149.33 fg	156.87 bc
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	156.07 cd	159.27 bc	157.67 bc
Org. Fertilizer 1 ml L^{-1}	157.57 bc	153.40 de	155.48 c
Org. Fertilizer 2 ml L^{-1}	166.67 a	160.47 b	163.57 a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	165.00 a	152.63 ef	158.82 b
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	156.87 c	158.53 bc	157.70 bc
Cultivars' averages	158.77 a	154.14 b	

Similar letters within factors or interaction do not significantly differ from each other in the probability levels of 1% and 5%**.**

Table 4. Response of ear grains' weight (g) to cultivars and fertilizers and the interaction between them***.***

Fertilizer	Cultivars		Fertilizer averages
Spring Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	101.47i	107.50h	104.49e
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	110.47fg	101.06i	105.76e
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	112.53d-f	109.56gh	111.04e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	122.30ab	114.70c-e	118.50ab
Org. Fertilizer 1 ml L^{-1}	114.99cd	113.13de	114.06c
Org. Fertilizer 2 ml L^{-1}	123.19a	115.98c	119.56a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	114.90cd	112.15ef	113.53c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	120.34b	114.40c-e	117.37b
Cultivars' averages	115.02a	111.06b	
Autumn Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	120.33ef	118.60f	119.47e
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	122.06de	121.07d-f	121.57d
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	132.60a	115.20g	123.90c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	125.62bc	122.47de	124.04c
Org. Fertilizer 1 ml L^{-1}	123.40cd	125.87bc	124.63c
Org. Fertilizer 2 ml L^{-1}	131.73a	131.80a	131.77a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	132.27a	123.10c-e	127.68b
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	127.67b	126.53b	127.10b
Cultivars' averages	126.96a	123.08b	

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with the organic fertilizer 2 ml L^{-1} reaching 123.19 g, and the lowest rate when the cultivar Dijla overlapped with the traditional compound fertilizer of 120 kg ha^{-1} (101.06 g). For autumn, the highest obtained rate emanated when the Furat cultivar was interacting with the nano compound fertilizer 1.5 g L^{-1}, the organic fertilizer 2 ml L^{-1}, and the nano compound fertilizer 1.5 g L^{-1} + the organic fertilizer 1 ml L^{-1}, and the cultivar Dijla's interaction with the organic fertilizer 2 ml L^{-1} (132.60, 131.73, 132.27, and 131.80 g, respectively). The lowest rate resulted in the cultivar's application with the control, reaching 118.60 g.

Cob weight

The cob weight has nonsignificant effects from the variation of the two cultivars in the two seasons (Table 5). Fertilizers significantly affected these traits in the two seasons. In the spring season, cob weight significantly increased when applied with the nano compound fertilizer 1.5 g L^{-1} and the nano compound fertilizer 1.5 g L^{-1} + the organic fertilizer 1 ml L^{-1} (35.86 and 35.54 g, respectively), and the trait decreased significantly to 28.94 g when the organic fertilizer was 1 ml L^{-1}. In autumn season, highest rate of the trait was evident when the nano-compound fertilizer was 3 g L^{-1}, which was equal to 33.62 g. The lowest rate came from the control at 29.47 g. It may be due to the superior ear grains' weight (Table 4) at the expense of the weight of the cob. The result agreed with the past findings of Laekemariam and Gidago (2012).

Table 5. Response of cob weight (g) to cultivars and fertilizers and the interaction between them.

Fertilizer	Cultivars		Fertilizer averages
Spring Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	36.74a	28.42f	32.58b
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	32.52e	33.44c-e	32.98b
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	35.52a-c	36.20a-b	35.86a
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	31.83e	33.83b-e	32.83b
Org. Fertilizer 1 ml L^{-1}	29.37f	28.50f	28.94c
Org. Fertilizer 2 ml L^{-1}	29.28f	33.48c-e	31.38b
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	35.21a-d	35.87a-c	35.54a
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	33.39c-e	32.86de	33.13b
Cultivars' averages	32.98 a	32.83 a	
Autumn Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	31.27b-e	27.67e	29.47c
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	29.93de	32.13b-d	31.03a-c
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	31.80bd	34.13a-c	32.97ab
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	30.45c-e	36.80a	33.62a
Org. Fertilizer 1 ml L^{-1}	34.17a-c	27.53e	30.85a-c
Org. Fertilizer 2 ml L^{-1}	34.93ab	28.67de	31.80a-c
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	32.73b-d	29.57de	31.15a-c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	29.20de	32.80b-d	30.60c
Cultivars' averages	31.81 a	31.06 a	

Similar letters within factors or interaction do not significantly differ from each other in the probability levels of 1% and 5%.

The interaction led to the appearance of a significant difference in this trait in the two seasons, wherein spring season had highest mean when the Furat cultivar overlapped with the control (28.42 g), and in autumn season, the highest mean for the trait appeared when the Dijla cultivar overlapped with the nano compound fertilizer 3 g L^{-1}, reaching 36.80 g. The lowest rate was when the cultivar Dijla interacted with the organic fertilizer 1 ml L^{-1} (27.53 g).

500-grain weight

In the 500-grain weight, cultivar Furat showed a significant superiority in the spring season (136.79 g) compared with the cultivar Dijla, which recorded the lowest rate (130.92 g) (Table 6). The reason for the increase in this trait in the Furat cultivar may be due to a raise in ear grains weight (Table 4). It is consistent with Bawa (2021). No significant variance were evident in this trait in the autumn season. The results were in line with the findings of Alnori and Al-Obady (2013) in studying maize genotypes.

In the fertilizer factor, the organic fertilizer 2 ml L^{-1} was significantly superior in this trait in the two seasons (149.50 and 164.17 g, respectively) compared with the control, which achieved the lowest rate (110.00 and 120.67 g, respectively). It may be attributable to role of the organic fertilizer in prolonging the effective period of grain filling by increasing the leaf area and delaying the aging of the leaves, which leads to an increase in chlorophyll content of the leaves and, thus, an increase in the dry matter accumulation in the grains, in addition increasing the ear grains' weight (Table 4). A reflection on the

Table 6. Response of 500 grain weight (g) to cultivars and fertilizers and the interaction between them.

Fertilizer	Cultivars		Fertilizer averages
Spring Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	115.67h	104.33j	110.00f
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	131.00f	110.00i	120.50e
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	123.67g	146.67bc	135.17c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	142.33c-e	g121.00	131.67d
Org. Fertilizer 1 ml L^{-1}	143.33c-e	144.00cd	143.67b
Org. Fertilizer 2 ml L^{-1}	158.67a	140.33de	149.50a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	130.67f	139.00e	134.83c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	149.00b	142.00c-e	145.50b
Cultivars' averages	136.79a	130.92b	
Autumn Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	128.00g	113.33h	120.67g
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	136.67f	137.00f	136.83f
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	144.33e	147.00de	145.67e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	148.00c-e	151.00cd	149.50d
Org. Fertilizer 1 ml L^{-1}	148.00c-e	146.67e	147.33de
Org. Fertilizer 2 ml L^{-1}	169.33a	159.00b	164.17a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1} + Org. fertilizer 1 ml L^{-1}	156.33b	151.33c	153.83c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	158.67b	159.33b	159.00b
Cultivars' averages	148.67 a	145.58 a	

Similar letters within factors or interaction do not significantly differ from each other in the probability levels of 1% and 5%.

grains' weight trait has reports from past findings (Mahmood *et al.,* 2017; Kandil *et al.*, 2020).

This trait was significantly superior in the interaction between the cultivar Furat with organic fertilizer 2 ml L^{-1} in the two seasons, which amounted to 158.67 and 169.33 g, respectively, compared with the interaction of cultivar Dijla with the control, giving the lowest rate (104.33 and 113.33 g, respectively).

Number of grains per ear

Cultivar Furat showed superiority for the grains per ear in two seasons, which was equal to 358.51 and 375.41 grains ear^{-1}, respectively, compared with the cultivar Dijla, which showed the lowest rate (342.79 and 355. 88 grains ear^{-1}, respectively) in the two seasons (Table 7). It is due to the Furat cultivar's ability to produce the most number of grains compared with the Dijla cultivar. The results matched the findings of Chozin *et al.* (2017) and Kebede (2019) in maize cultivars.

As for the fertilizers, the organic fertilizer 2 ml L^{-1} was significantly superior in this trait in the two seasons, as it reached 377.84 and 390.60 grains ear^{-1}, respectively, compared with the control, which achieved the lowest rate for the trait (286.95 and 330.37 grains ear^{-1}, respectively). It may refer to the organic fertilizer improving plant growth and increasing the fertilization rate to produce the maximum number of grains (Kandil *et al.,* 2020; Payebo and Ogidi, 2021).

The interaction of the two cultivars with fertilizers in the spring season revealed the Furat cultivar with organic fertilizer 2 ml L^{-1} recorded the highest significant average, which reached 385.72 grains ear^{-1} compared with the

Table 7. Response of the number of grains per ear to cultivars and fertilizers and the interaction between them.

Spring Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	290.60i	283.30j	286.95g
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	324.83g	316.58h	320.70f
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	372.07cd	370.31cd	371.19b
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	373.80c	343.10f	358.45d
Org. Fertilizer 1 ml L^{-1}	369.67c-e	364.67e	365.17c
Org. Fertilizer 2 ml L^{-1}	385.72a	369.95c-e	377.84a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}+ Org. fertilizer 1 ml L^{-1}	372.29cd	326.55g	349.42e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	379.11b	367.87d-e	373.49b
Cultivars' averages	358.51a	342.79b	
Autumn Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	369.53ef	291.20k	330.37g
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	349.13ij	362.27g	355.70e
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	371.87e	365.93fg	368.90d
Nano $N_{20}P_{20}K_{20}$ 3 gL^{-1}	387.40cd	344.87j	366.13d
Org. Fertilizer 1 ml L^{-1}	351.00hi	350.40h-j	350.70g
Org. Fertilizer 2 ml L^{-1}	396.33b	384.87d	390.60a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}+ Org. fertilizer 1 ml L^{-1}	403.60a	355.27h	379.43c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	374.40e	392.27bc	383.33b
Cultivars' averages	375.41a	355.88b	

Similar letters within factors or interaction do not significantly differ from each other in the probability levels of 1% and 5%.

overlapping of the cultivar Dijla with the control, achieving the lowest mean for the trait (283.30 grains ear^{-1}). Meanwhile, in autumn, the interaction of the Furat cultivar with the nano compound fertilizer 1.5 g L^{-1} + the organic fertilizer 1 ml L^{-1} recorded the highest significant average (403.60 grains ear^{-1}) compared with the overlapping of the cultivar Dijla and the control, which gave the lowest average (291.20 grain ear^{-1}).

Grain yield

It is clear from Table 8 that the Furat cultivar proved significantly superior in grain yield by giving the highest mean for the trait, which reached 6786.68 and 7581.48 g $9m^{-2}$, respectively, in the two seasons compared with the cultivar Dijla, with the lowest rate (6521.14 and 7353.78 g $9m^{-2}$, respectively), in the two seasons. The increase in grain yield of the Furat cultivar is due to the boost in yield components, the weight of 500 grains, and the number of grains per ear (Tables 6 and 7). These results were consistent with the findings of Khan *et al.* (2017) and Bawa (2021) in maize genotypes.

It was also noteworthy that significant differences appeared between the fertilizers in this trait in the two seasons, as the grain yield remarkably increased when treated with the organic fertilizer 2 ml L^{-1}, reaching 8036.32 and 8981.28 g $9m^{-2}$, respectively, in the two seasons compared with the control, with the grain yield at the lowest rate (5384.48 and 6135.84 g $9m^{-2}$, respectively), in the two seasons. The increase in grain yield when treated with high organic fertilizer was due to the superiority of the high concentration of organic fertilizers in both traits, the weight of

Table 8. Response of grain yield (g $9m^{-2}$) to cultivars and fertilizers and the interaction between them***.***

Fertilizer	Cultivars		Fertilizer averages
Spring Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	5155.20k	5613.80j	5384.48f
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	5785.00ij	5255.20k	5535.28f
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	6427.70h	5937.90i	6182.80e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	7213.10cd	6771.80e-g	6992.48c
Org. Fertilizer 1 ml L^{-1}	6689.30fg	6570.70gh	6630.00d
Org. Fertilizer 2 ml L^{-1}	8278.60a	7794.10b	8036.32a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	7004.30de	6837.00ef	6920.64c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	7740.30b	7358.20c	7549.28b
Cultivars' averages	6786.68a	6521.14b	
Autumn Season			
	Furat	Dijla	
Control treatment (Con. Treat.)	6180.32i	6091.36i	6135.84h
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	6448.00h	6392.32h	6420.16g
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	7637.76d	6635.52g	7136.64f
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	7356.32e	7171.68f	7264.00e
Org. Fertilizer 1 ml L^{-1}	7344.80e	7491.52de	7418.16d
Org. Fertilizer 2 ml L^{-1}	8979.04a	8983.52a	8981.28a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	8126.40c	7561.28d	7843.84c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	8579.20b	8503.04b	8541.12b
Cultivars' averages	7581.48a	7353.78b	

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500 grains, and the number of ear grains (Tables 6 and 7). These results agreed with Mahmood *et al.* (2017) and Setyowati *et al.* (2022) in maize crops.

This trait also had significant effects from the two cultivars when overlapped with fertilizers in the two seasons. In spring, the interaction of the Furat cultivar with the organic fertilizer 2 ml L^{-1} recorded the maximum mean (8278.60 g $9m^{-2}$) compared with the interaction of the Furat cultivar with the control, which recorded the lowest rate for the trait (5155.20 g $9m^{-2}$). In autumn, the interaction of the cultivar Furat with organic fertilizer 2 ml L^{-1} and the overlap of the cultivar Dijla with the organic fertilizer 2 ml L^{-1} gave the maximum mean (8979.04 and 8983.52 g $9m^{-2}$, respectively), compared with the interaction of the cultivar Dijla with the control recording the lowest rate (6091.36 g $9m^{-2}$).

Biological yield

Cultivar Dijla was significantly superior in biological yield in the two seasons by giving the highest rate for the trait (22,016.00 and 21,061.46 g $9m^{-2}$, respectively) compared with the cultivar Furat, which gave the lowest rate (20,964.56 and 20,009.20 g $9m^{-2}$, respectively) (Table 9). The reason is that the rise in biological yield in cultivar Dijla may be due to an increase in grain yield (Table 8), including an upsurge in straw yield (Ali *et al.,* 2018).

It was apparent that there was a significant increase in the biological yield in the two seasons when treated with the nano compound fertilizer 3 ml L^{-1}, as it reached 23,270.00 and 21,721.60 g $9m^{-2}$, respectively, compared with the treatment of organic fertilizer 1 ml L^{-1}, with the biological yield as

Table 9. Response of biological yield (g $9m^{-2}$) to cultivars and fertilizers and the interaction between them**.**

Spring Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	19881.1h	21455.8e	20668.5e
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	19612.6h	21864.0d-e	20738.3e
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	22960.3bc	20440.0fg	21700.2c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	22774.7c	23765.3a	23270.0a
Org. Fertilizer 1 ml L^{-1}	20368.0g	20896.0f	20632.0e
Org. Fertilizer 2 ml L^{-1}	20879.0fg	23312.0ab	22095.5b
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	20830.2fg	22189.9d	21510.1cd
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	20410.4fg	22205.0d	21307.7d
Cultivars' averages	20964.56 b	22016.00 a	
Autumn Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	19571.2gh	21657.6bc	20614.4c
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	21337.6cd	19811.2fg	20574.4c
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	18812.8j	21432.5cd	20122.6d
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	21878.4b	21564.8bc	21721.6a
Org. Fertilizer 1 ml L^{-1}	18976.0ij	20256.0e	19616.0e
Org. Fertilizer 2 ml L^{-1}	19260.8hi	22531.2a	20896.0b
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	20006.4ef	20092.8ef	20049.6d
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	20230.4e	21145.6d	20688.0cd
Cultivars' averages	20009.20b	21061.46a	

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the lowest average (20,632.00 and 19,616.00 g $9m^{-2}$, respectively) in the two seasons. This increase is due to the role of the positive organic fertilizer in boosting the grain yield (Table 8) and the rise in the straw yield (Laekemariam and Gidago, 2012; Mahmood *et al.,* 2017).

The interaction between cultivars with fertilizers showed significant differences in this trait in the two seasons. In spring, the cultivar Dijla with nano compound fertilizer 3 g L^{-1} recorded the highest average (23,765.30 g $9m^{-2}$) compared with the interaction of the cultivar Furat with the control and the overlap of the cultivar Furat with the traditional compound fertilizer 120 kg ha^{-1}, providing the lowest rates (19,881.10 and 19,612.60 g.$9m^{-2}$, respectively). For autumn, the interaction of cultivar Dijla and organic fertilizer 2 ml L^{-1} was significantly superior, reaching 22,531.20 g $9m^{-2}$, compared with the interaction of the cultivar Furat with the nano compound fertilizer 1.5 g L^{-1}, which gave the lowest value (18,812.80 g $9m^{-2}$).

Harvest index

The Furat cultivar was meaningfully superior in the harvest index in the two seasons (32.42% and 38.05%) compared with (29.59% and 34.92%) in the cultivar Dijla, respectively (Table 10). The increase in the harvest index in the Furat cultivar is due to a rise in grain yield (Table 8) at the expense of the straw yield (Kebede, 2019).

This trait incurred significant influences from the variation of fertilizers in the two seasons, as the harvest index increased significantly when the organic fertilizer 2 ml L^{-1} reached 37.04% and 43.25% compared with

Table 10. Response of harvest index (%) to cultivars and fertilizers and the interaction between them***.***

Spring Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	25.93i	26.16i	26.05f
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	92.50gh	24.18j	26.84f
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	27.99h	29.08h	28.53e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	31.68ef	28.50h	30.09d
Org. Fertilizer 1 ml L^{-1}	32.04d-f	31.45f	31.74c
Org. Fertilizer 2 ml L^{-1}	40.56a	33.43cd	37.04a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	33.63c	30.82fg	32.22c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	37.93b	33.14c-e	35.53b
Cultivars' averages	32.42a	29.59b	
Autumn Season			
Fertilizer	Cultivars		Fertilizer averages
	Furat	Dijla	
Control treatment (Con. Treat.)	31.58gh	28.13j	29.85h
$N_{15}P_{15}K_{15}$ Traditional 120 kg ha^{-1}	30.22i	32.27g	31.24g
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}	40.60c	30.96hi	35.78e
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1}	33.62f	33.26f	33.44f
Org. Fertilizer 1 ml L^{-1}	38.71d	36.99e	37.85d
Org. Fertilizer 2 ml L^{-1}	46.62a	39.88c	43.25a
Nano $N_{20}P_{20}K_{20}$ 1.5 g L^{-1}**+** Org. fertilizer 1 ml L^{-1}	40.62c	37.64e	39.13c
Nano $N_{20}P_{20}K_{20}$ 3 g L^{-1} + Org. fertilizer 2 ml L^{-1}	42.41b	40.22c	41.31b
Cultivars' averages	38.05a	34.92b	

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26.05% and 29.85% in the control, respectively. It may be because of the grain yield increase at a high concentration of organic fertilizer (Table 8), including straw yield (Mahmood *et al.,* 2017).

The interaction significantly differed in this trait in the two seasons. In the spring, the harvest index rose substantially to the highest rate when the Furat cultivar overlapped with the organic fertilizer 2 ml L^{-1} and reached 40.56% compared with the interaction of the Dijla cultivar with the control, where the harvest index decreased to the lowest rate (25.93%). In autumn, the maximum harvest was distinct when the cultivar Furat overlapped with the organic fertilizer 2 ml L^{-1} (46.62%), with the lowest evidence of harvest observed when the cultivar Dijla interacted with the control (28.13%).

CONCLUSIONS

Increasing the effectiveness of the organic fertilizer (Optimus Plus) boosted the spray levels for most of the studied properties. In general, the superiority of the cultivar Furat over the cultivar Dijla was undeniable in both the spring and autumn seasons and for most of the studied traits.

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