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Response of Oats Cultivars to Spraying with Nano and Mineral Zinc and Potassium on Yield and its Components

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Abstract. A field experiment was carried out at Al-Hamidhiya research station of the College of Agriculture - University of Anbar, located within 43.39 longitude, 33.44 latitude and 53 m heights above sea level during Winter seasons 2018-2019 and 2019-2020, with aim of studying the effect of levels of potassium fertilizer, nano and mineral zinc on the yield of three oat cultivars. The split-split-plot arrangement was used according to a randomized complete block design (RCBD) with three replications. The main plots included potassium concentrations (0, 6000, 3000 nm, and 6000 nm) mg K L⁻¹, while the subplot included zinc concentrations (0, 50 and 50 nm) mg Zn L⁻¹, while the cultivars were in the sub-sub plots (Hamel, Carrolup and Genzania). The results of the study indicate that the varieties differed significantly in all studied traits. Genzania cultivar outperformed in terms of grain yield (6.25 and 6.19 ton ha⁻¹) and biological yield (16.37 and 16.26 ton ha⁻¹) the two seasons, respectively. In addition, spraying zinc on the plant had a positive role in improving the yield and its components, as the treatment 50 mg Zn L⁻¹ gave grain yield of 6.24 and 6.06 tons' ha⁻¹ for both seasons respectively, adding potassium improved the components of the yield, which was reflected in the yield in which the treatment 6000 nm mg K L⁻¹ was superior with seed yield of 7.05 and 6.84 ton ha⁻¹ for the two seasons respectively. Also, the two-way interaction between the concentrations of potassium and zinc, potassium and cultivars, and zinc and cultivars had a significant effect on most of the studied traits. The three-way interaction between the study factors had a significant effect on the studied traits, which was evident in seed yield, as the combination (Genzania sprayed with 3000nm K + 50 mg Zn L⁻¹) gave the highest grain yield of 8.30 for the first season, while the plants of the variety Hamel sprayed with 6000nm K + 50 mg Zn L⁻¹ gave the highest grain yield of 7.440 ton ha⁻¹ for the second season.

1. Introduction

Oats (*Avena sativa* L.) is one of the most important global winter economic cereal crops [1]. Oats occupy the Fourth position after wheat, rice and maize, it occupies the first position in the world in medicinal uses [2]. Oats are used in the diet because their grains are free of gluten, as well as an important source of vitamins, amino acids and minerals that the human body needs, as well as its important role in reducing blood pressure and sugar and thus leads to the formation of a healthy body [3]. Its grain contains a high percentage of proteins, up to 13% [4]. Also, its grains and stems are provided as animal feed due to its high fodder amount [5]. The global area planted with oats in 2019 is about 9.42 million hectares [6]. Iraq still suffers from a decline in the productivity of the crop, despite its great importance in the world in terms of its food, fodder and industrial uses. The reason for the reluctance of some farmers to cultivate it is due to the lack of awareness and culture of the farmers. As well as the search for modern agricultural means and systems in order to increase production per unit area, which is the only way forward to face the ever-increasing hunger of the world's growing population during this period. That is why, in recent years, the world has turned to the use of agricultural technologies aimed at improving the growth of agricultural crops while increasing the efficiency of the use of plant nutrients [7]. In addition to its important role in increasing the process of photosynthesis and giving the highest yield of dry matter to the crop, and these fertilizers have a role in protecting plants from biotic and abiotic stresses that cause damage to economic crops [8]. The



excessive use of mineral fertilizers has led to the pollution of the agricultural environment, which has been accompanied by serious health problems harmful to human and animal health. For this reason, nanoscience may develop solutions to these problems and obstacles through the availability of nano-enriched nutrients that have higher and better performance when sprayed on the vegetative system of the plant [9]. one of the most important of these elements is zinc, which is one of the important micronutrients that plays a major role in the photosynthesis process, increasing the fertility rate in flowers and activating enzymes such as CAT and SOD [10]. Also, spraying potassium on the vegetative system of the plant may improve the transfer of water and nutrients from the leaves to the rest of the plant parts and stimulate its cells to grow and divide early while increasing the permeability of cell membranes contributing to the process of photosynthesis and resistance to diseases and insects [11]. Which in turn gives plants with strong stems more resistant to lodging and drought [12], thus increasing production in quantity and quality [13].

2. Materials and Methods

A field experiment was carried out at Al-Hamidhiya research station of the College of Agriculture - University of Anbar during the winter seasons 2018-2019 and 2019-2020 to study the effect of usual and nano zinc, and potassium concentrations on the components of oats yield. The split-split-plot arrangement was used according to a randomized complete block design (RCBD) with three replications. The main plots occupied four concentrations of regular and nano potassium (0, 6000, 3000nm, and 6000 nm mg K l⁻¹), while the sub plots occupied with three concentrations of regular and nano zinc (0, 50, 50 nm mg l⁻¹), while the sub-sub plots included three cultivars of oats (Hamel, Carrolup and Genzaina). The experimental land was plowed by two orthogonal plows by the Moldboard plow, then it was leveled, smoothed, and divided into experimental units with dimensions (2 x 3 = 6 m²), and each experimental unit contains 10 rows. Phosphate fertilizer was added in the form of triple super phosphate (P₂O₅ 46%) at a rate of 100 kg ha⁻¹ before planting, mixing it with the soil in one batch [14] While nitrogen fertilizer was added at a rate of 150 kg N ha⁻¹ in the form of three batches after germination, tillering stage of and booting stage, the seeds were planted at a rate of 100 kg ha⁻¹ on 24/11/2018 for the first season and 26/11/2019 for the second season. The field was Irrigation was carried out according to soil moisture and plant condition. and the control of the weeds was conducted whenever needed. The shoot was sprayed with potassium according to the above concentrations, at two stages according to the scale of Zadoks [15]. The five leaf unfolded stage ZGS 15, and the beginning of the tillering stage ZGS 20. Zinc was also sprayed on the plant at two stages, the first being at booting stage at the beginning of the elongation of the flag leaf sheath ZGS 41, and the second at the beginning of the flowering stage ZGS 61 and the concentrations were sprayed in the early morning using a knapsack sprayer with a capacity of 15 liters with the addition of a diffuser to increase complete wetness. The following characteristics were studied: number of panicle per square meter, number of grains per panicle, weight of 1000 grains, grain yield (ton ha⁻¹) and biological yield (ton ha⁻¹). The data was analyzed using the statistical program Genestat, and the arithmetic means were compared using the L.S.D test, at the probability level of 0.05. [16].

3. Results and Discussion

3.1. Number (panicle m⁻²)

The results in Table (1) show that the Genzania variety was significantly superior in the number of dahlias per square meter and gave the highest mean of 537.0 panicle m⁻² in the second season, while the cultivar Hamel gave the lowest average for the trait (467.4 panicle m⁻²), The variation in the number of panicle came as a result of the different varieties in their genetic composition and the ability of each cultivar to manufacture nutrients to produce effective tillers. This result is in line with those of [17]. and [18]. The results of Table (1) also indicate that there was a significant increase in the average number of panicles with the addition of the zinc-containing solution, as the nano-zinc treatment of 50 mg Zn liter⁻¹ recorded the highest mean of 568.8 panicle m⁻² for the first season, while the treatment of regular zinc (50 mg Zn Liter⁻¹), recorded the highest average of 533.9 panicle m⁻² for the second season. Whereas, the control treatment recorded the lowest mean of the trait, which was 525.6 and 456.6 panicle m⁻² for the two seasons, respectively. Zinc is one of the micro- nutrients that plays a major role in the activity of plant reproductive cells, as well as its great contribution to the process of transporting nutrients to the active sites in the plant, thus increasing the number of panicles per square meter unit [19]. As for the effect of the regular and nano potassium spray treatments, the results of Table (1) show the significant role of the potassium spray treatments in the characteristic of the number of panicles. Whereas, spraying

with a concentration of 6000 mg K L⁻¹ Nano potassium gave the highest rate of the trait (604.6 and 520.0 panicle m⁻²) for both seasons, respectively. Whereas, the control treatment (0 mg K L⁻¹) gave the lowest mean of 459.3 and 413.8 panicle m⁻² for the two seasons, respectively, this is due to the role of potassium in increasing the activity of meristematic tissues in plant cells, which leads to the expansion of their walls, as well as its effective contribution to the photosynthesis process, and thus increases the availability of manufactured materials that support the emergence and continued growth of fertile tillers [20]. This result is in line with the results of [21] and [22]. The interaction between potassium and zinc had a significant effect on this trait (Table 1.), as the combination (6000 mg K L⁻¹ nano + 50 mg Zn L⁻¹ nano) gave the highest mean of the trait (608.2 and 542.4 panicle m⁻²) for the two seasons, respectively. Whereas, the combination plants (0 mg K L⁻¹ + 0 mg Zn L⁻¹) gave the lowest mean of 395.9 and 390.6 panicle m⁻² for both seasons, respectively. There are significant interaction differences between cultivars and potassium spraying, as plants of the cultivar Carrolup sprayed with a 6000 mg K L⁻¹ nano recorded the highest rate of 609.8 panicle m⁻² in the first season. While the plants of Genzania cultivar treated with the same concentration recorded the highest mean of the trait (524.5 panicle m⁻²) in the second season.

The interaction between zinc spraying and the cultivars was significant on the number of panicle per square meter for the second season only, where the plants of Genzania variety sprayed with the regular Zn concentration of 50 mg Zn l⁻¹ gave the highest average of the number of panicle m⁻², while the plants of the cultivar Hamel sprayed with distilled water only gave the lowest average of 422.9 panicle m⁻². The results indicated the significance of the three-way interaction, the plants of the cultivar Carrolup sprayed with the combination (6000 mg K L⁻¹ Nano potassium + 50 mg Zn L⁻¹ regular zinc) recorded the highest mean of 623.6 panicle m⁻² for the first season. While two cultivars Carrolup and Genzania sprayed with the same treatment recorded the highest mean of 543.5 and 543.0 panicle m⁻² for the second season.

Table 1. The effect of zinc Usual and nano potassium on the characteristic of the number of panicles (panicle m⁻²) for the oats cultivars for the years 2018-2019 and 2019-2020

K mg L ⁻¹	Zn mg L ⁻¹	First season 2018-2019				Second season 2019-2020			
		Cultivars			K × Zn	Cultivars			K × Zn
		Hamel	Carrolup	Genzania	Zn	Hamel	Carrolup	Genzania	Zn
0	0	401.0	403.0	383.7	395.9	383.7	385.3	402.7	390.6
	50	486.7	428.0	486.3	467.0	412.7	413.6	409.3	411.8
	50nm	502.3	531.7	511.0	515.0	426.5	434.3	454.7	438.5
6000	0	530.0	551.7	545.2	542.3	443.3	458.0	460.0	453.7
	50	510.0	514.0	575.0	533.0	504.3	476.0	513.2	497.8
	50nm	551.7	556.0	566.0	557.9	504.7	516.0	516.0	512.2
3000nm	0	553.7	582.7	582.6	573.0	476.3	481.5	491.6	483.6
	50	582.0	579.3	578.3	579.8	486.2	491.0	496.5	491.2
	50nm	583.0	569.0	600.3	584.1	523.2	481.2	480.0	497.8
6000nm	0	582.0	594.7	597.3	591.3	488.4	507.0	508.1	501.2
	50	600.8	611.3	602.1	604.7	516.7	515.6	523.5	518.6
	50nm	622.0	623.6	608.2	617.9	543.0	543.5	540.8	542.4
L.S.D 5%		55.16		31972		48.74		28.21	
					MeanK				MeanK
K × Cultiva r	0	463.3	454.2	460.3	459.3	407.9	411.2	422.2	413.8
	6000	530.5	540.5	562.1	544.4	488.1	483.3	496.4	489.3
	3000nm	572.9	577.0	587.1	579.0	495.2	484.5	489.4	489.6
	6000nm	601.6	609.8	602.5	604.6	516.0	522.0	524.5	520.8
L.S.D 5%			30.97		18.987		29.98		21.75

					Mean Zn				Mean Zn
Zn	0	516.6	533.0	527.2	525.6	422.9	460.3	465.6	449.6
×	50	544.8	533.1	560.4	546.1	499.0	493.0	497.9	497.0
Cultivar	50nm	564.8	570.1	571.4	568.8	480.0	474.1	647.5	533.9
L.S.D 5%			NS		17.15		23.83		13.19
Mean		542.1	545.4	553.0	Mean	467.4	476.1	537.0	
Cultivar					Cultivar				
L.S.D 5%			NS				14.47		

3.2. Number of grain per panicle (grain panicle⁻¹)

The results of Table (2) indicates that there was a significant difference between cultivars in the number of grains in the panicle, as the two cultivars Genzania and Carrolup gave the highest mean of 37.98 and 38.96 grains panicle⁻¹ for the two cultivars and for the two seasons, respectively. While the cultivar Hamel gave the lowest average of 35.84 and 37.37 grains panicle⁻¹ for both seasons, respectively. The reason for the difference in varieties may be due to the difference in their genetic composition, this result agreed with the results of other researchers, [23] and [24]. The results of Table (2) shows that the number of grains in panicle gradually increased when plants were sprayed with zinc (regular and nano), as the concentration treatment of 50 mg L⁻¹ nano-Zn recorded the highest average of 37.98 and 39.01 grains panicle⁻¹ for both seasons, respectively. While the control treatment (0 mg Zn L⁻¹) gave the lowest mean of 35.56 and 36.97 grains panicle⁻¹ for both seasons, respectively. Zinc has an important role in increasing the fertility rate in flowers and reducing the abortion of florets, which leads to an increase in the number of grains in the panicle. This result is consistent with the results of [25] and [26]. Number of grains in panicle differed significantly for spraying potassium on the plant shoot, as it was found that plants sprayed with concentration 3000 and 6000 mg K L⁻¹ Nano potassium gave the highest mean of (43.11 and 43.88) grains panicle⁻¹ for the two treatments and for the two seasons, respectively, whereas, the control plants gave the lowest mean of 32.08 and 33.51 grains panicle⁻¹ for both seasons, respectively. The reason for this is that spraying potassium on the vegetative system of the plant increased the content of chlorophyll in the leaves, which in turn contributed to the process of photosynthesis, which led to an increase in the number of fertile spikelet's that make up the grains in the panicle. This result is consistent with [21]. and [22]. through their study on wheat. The results of Table (2) show that the averages of this trait were significantly affected by the interaction

Table 2. The effect of zinc Usual and Nano potassium on the characteristic of the number of grain perpanicle (grain panicle⁻¹) for the oats cultivars for the years 2018-2019 and 2019-2020

K mg L ⁻¹	Zn mg L ⁻¹	First season 2018-2019				Second season 2019-2020			
		Cultivars				Cultivars			
		Hamel	Carrolup	Genzania	K × Zn	Hamel	Carrolup	Genzania	K × Zn
	0	27.44	29.67	29.88	29.00	31.25	31.36	30.81	31.14
	50	32.12	32.29	33.08	32.50	33.35	32.91	34.73	33.66
	50nm	35.46	36.56	32.20	34.74	36.03	37.66	33.50	35.73
	0	31.87	30.87	35.63	32.79	34.70	35.12	32.46	34.09
6000	50	30.16	32.39	32.64	31.73	30.84	33.80	34.02	32.89
	50nm	32.30	36.07	37.83	35.40	35.56	36.15	37.32	36.34
	0	38.42	38.67	41.20	39.43	39.94	42.80	40.09	40.94
3000nm	50	40.01	44.03	43.75	42.60	41.54	44.60	42.71	42.95
	50nm	34.16	37.51	39.52	37.06	36.81	38.08	41.35	38.75
	0	41.35	39.48	42.21	41.01	41.00	41.35	42.75	41.70
6000nm	50	42.96	45.32	42.56	43.61	42.70	47.66	43.81	44.72
	50nm	43.79	45.04	45.29	44.71	44.72	46.03	44.93	45.23
L.S.D 5%			2.96		1959		NS		2919

						MeanK			MeanK	
K	0	31.67	32.84	31.72	32.08	33.55	33.98	33.01	33.51	
×	6000	31.44	33.11	35.36	33.31	33.70	35.02	34.60	34.44	
Cultivar	3000nm	37.53	40.07	41.49	39.70	39.43	41.83	41.38	40.88	
r	m									
	6000nm	42.70	43.28	43.35	43.11	42.81	45.01	43.83	43.88	
	m									
L.S.D 5%		1.96			1926	NS		1945		
					Mean			Mean		
Zn	0	34.77	34.67	37.23	35.56	36.72	37.66	36.52	36.97	
×	50	36.31	38.51	38.01	37.61	37.11	39.74	38.82	38.56	
Cultivar	50nm	36.43	38.79	38.71	37.98	38.28	39.48	39.28	39.01	
L.S.D 5%		1.26			0.72	N.S		13.19		
Mean		35.84	37.32	37.98	Mean	37.37	38.96	38.21		
Cultivar					Cultivar					
L.S.D 5%		0.75				1.08				

between the treatments of potassium and zinc spraying in both seasons, the plants sprayed with (6000 mg K L⁻¹ nano + 50 mg Zn L⁻¹ nano) gave the highest mean of 44.71 and 45.23 grains panicle⁻¹ for both seasons, respectively. While the control treatment gave the lowest mean of 29.00 and 31.14 grains panicle⁻¹ for the two seasons respectively. Also, the interaction of cultivars and potassium spray treatments significantly affected the number of grains in panicle and for the first season only. The plants of Genzania cultivar sprayed with 6000 mg K l⁻¹ Nano recorded the highest rate of (43.35 grains panicle⁻¹) while the treatment (Hamel + 6000 mg K liter⁻¹) recorded the lowest average of 31.44 grains panicle⁻¹. The interaction between the cultivars and the levels of regular and nano zinc spray had a significant effect on this trait in the first season only. The cultivar Carrolup sprayed with a concentration of 50 mg Zn L⁻¹ nano-zinc recorded the highest mean of 38.79 grains panicle⁻¹, while plants of the same variety sprayed with distilled water only recorded the lowest mean of 34.67 grains panicle⁻¹. The results of Table (2) indicate that the averages of this trait differed significantly due to the effect of the three-way interaction Among the factors of the study, as the combination (6000 mg L⁻¹ Nano potassium + 50 mg L⁻¹ regular zinc) recorded the highest average of 45.32 grains panicle⁻¹, while it gave Plants of the cultivar Hamel sprayed with the control treatment, the lowest rate of 27.44 grains panicle⁻¹.

3.3. Weight of 1000 grain (gm)

The results of Table (3) indicate that the cultivars differed significantly in the trait of 1000 grain weight, as the Genzania cultivar recorded the highest mean of 33.70 gm in the first season, and did not differ significantly from the Carrolup cultivar. While for the second season, it was observed that the Carrolup cultivar gave the highest mean of 36.50 gm, and it did not differ significantly from Genzania cultivar. While the cultivar Hamel gave the lowest average of 32.27 and 35.27 gm for the two seasons, respectively. The reason for this difference between the cultivars may be due to the difference in their genetic composition. This result is in line with those of [18]. Zinc spraying on the vegetative system of the plant also led to a significant increase in this trait (Table 3), as the spraying treatment with a concentration of 50 mg Zn l⁻¹ regular zinc gave the highest average of 34.40 gm for the first season, While the spraying treatment of 50 mg Zn L⁻¹ nano-Zn gave the highest mean of 37.20 gm for the second season. Whereas, the control treatment gave the lowest average grain weight of 31.57 and 34.84 gm for both seasons, respectively. The increase in the weight of the grain is due to the role of micro-nutrients added during the flowering stage, in which the stage of grain filling coincides, and thus the reproductive growth increases and the vegetative growth decreases, which increases the opportunity for the efficiency of net photosynthesis to convert food products into a dry food substance in cereals and thus led to an increase in the grain weight [27]. This finding is in line with [26]. The weight of the grain was increased by adding potassium concentrations, as the spraying treatment of 6000 mg K L⁻¹ Nano potassium recorded the highest average grain weight of 37.54 and 41.73 gm for both seasons,

respectively, while the control treatment recorded the lowest average of 28.44 and 31.39 gm for the two seasons, respectively. Perhaps the reason for this is that the weight of the seeds increases with the increase in potassium concentrations in the grains through its role as a kinetic element that contributes to the transfer of photosynthetic products from the source (leaf) to the sink (grain) this result agreed with [28]. The results in Table (3) indicate that there was a significant difference in the grain weight as a result of the two-way interaction between potassium and zinc for both seasons. The combination (6000 mg K L⁻¹ nano + 50 mg Zn L⁻¹ regular zinc) recorded the highest average of 39.12 gm for the first season, while the combination (6000 mg Zn L⁻¹ nano + 50 mg Zn L⁻¹ nano) recorded the highest The average of 43.37 gm for the second season.

The results indicate a significant two-way interaction between the cultivars and the potassium spray treatments in the first season only, the Genzania cultivar sprayed with a concentration of 6000 mg K liter⁻¹ nano gave the highest rate of 37.96 gm, while the treatment (Carrolup with concentration 0 mg K liter⁻¹) recorded the lowest rate of 28.03 gm. The results also indicate a significant two-way interaction between the cultivars and the zinc spray treatments, the combination (Genzania with 50 mg Zn L⁻¹ regular zinc) gave the highest average grain weight of 35.21 gm, while the combination (Hamel with 0 mg Zn L⁻¹) gave the lowest mean of 30.88 gm. The results indicate a significant three-way interaction Among study factors for two seasons, The Genzania cultivar sprayed with the combination (6000 mg K L⁻¹ K-nano + 50 mg Zn L⁻¹ regular zinc) recorded the highest average grain weight of 39.80gm, while Carrolup plants sprayed with the same mixture recorded the highest average grain weight of 45.37 gm the second season.

Table 3. The effect of zinc Usual and nano potassium on the characteristic of 1000 grain weight (gm) for the oats cultivars for the years 2018-2019 and 2019-2020

K mg L ⁻¹ Cultivars	Zn mg L ⁻¹	First season 2018-2019				Second season 2019-2020			
		Cultivars			K × Zn	Cultivars			K × Zn
		Hamel	Carrolup	Genzania		Hamel	Carrolup	Genzania	
0	0	23.81	25.32	25.57	24.90	28.69	29.49	28.25	28.81
	50	28.42	29.80	32.17	30.13	31.04	30.86	33.25	31.71
	50nm	32.39	28.99	29.50	30.29	33.33	35.78	31.85	33.66
6000	0	28.07	32.82	27.53	29.47	32.81	34.00	30.94	32.58
	50	29.70	29.10	29.71	29.43	29.06	31.84	32.08	30.99
	50nm	29.63	33.16	34.46	32.42	33.50	34.29	36.34	34.71
3000nm	0	35.73	35.70	37.04	36.16	38.12	40.87	36.76	38.58
	50	37.00	40.29	39.41	38.90	39.70	36.26	42.09	39.35
	50nm	29.12	34.34	35.39	32.95	34.88	36.73	39.61	37.07
6000nm	0	35.91	35.57	35.87	35.78	39.03	38.61	40.49	39.38
	50	38.58	38.99	39.80	39.12	40.21	45.37	41.79	42.46
	50nm	36.87	389.07	38.22	37.96	42.84	43.90	43.35	43.37
L.S.D 5%		2.21			1.51	3.52			2.03
					Mean K				MeanK
K × Cultivar	0	28.21	28.03	29.08	28.44	31.02	32.04	31.12	31.39
	6000	29.13	31.69	30.49	30.44	31.79	33.38	33.12	32.76
	3000nm	33.95	36.78	37.28	36.00	37.57	37.95	39.49	38.33
	6000nm	37.12	37.54	37.96	37.54	40.69	42.63	41.88	41.73
L.S.D 5%		1.40			1915	NS			0983

					Mean Zn				Mean Zn
Zn	0	30.88	32.35	31.50	31.58	34.66	35.74	34.11	34.84
×	50	33.43	34.54	35.21	34.40	35.00	36.08	37.30	36.13
Cultivar	50nm	32.00	33.64	34.39	33.34	36.14	37.68	37.79	37.20
L.S.D 5%			1907		0971		NS		1918
Mean Cultivar		32.10	33.51	33.70	Mean	35.27	36.50	36.40	
L.S.D 5%			0.59		Cultivar		1.04		

3.4. Grain yield (tons ha⁻¹)

The results of Table (4) show that Genzanmia was significantly superior with the highest average grain yield of 6.25 and 6.19 tons' ha⁻¹ for both seasons, respectively. While the cultivar Hamel gave the lowest average grain yield of 5.89 and 5.57 tons' ha⁻¹ for both seasons respectively. The reason for the superiority of Genzanmia cultivar is due to its superiority in the number of Table (1), number of Table (2), and weight of the grain Table (3) which led to an increase in grain yield. This result is in line with the results of other researchers [29]:[30]:[31]. Table (4) also shows that there is a significant difference between the cultivars in this trait when spraying plants with concentrations of regular and nano zinc, as the plants sprayed with the treatment 50 mg Zn L⁻¹ regular zinc gave the highest average of 6.24 and 6.06 tons' ha⁻¹ for the two seasons respectively. While the control treatment gave the lowest mean of 5.83 and 5.66 tons' ha⁻¹ for both seasons, respectively. The reason is that the increase in the grain yield is due to its superiority in the yield components (the number of panicles, the number of grains in the panicle and the weight of 1000 grains) (Tables, 1, 2 and 3), all of which affected the increase in the yield. This result agreed with the results of [32]. the addition of Nano and Ordinary Potassium fertilizer had a significant effect on the grain yield, if the spraying treatment of 6000 mg KL⁻¹ Nano potassium recorded the highest rate of grain yield amounted to 7.05 and 6.84 tons' ha⁻¹ for both seasons respectively. The reason for the superiority of the grain yield is due to the superiority of the treatment 6000 mg K L⁻¹ in the yield components (Tables 1, 2, and 3). This result is consistent with the results of [22]

The interaction treatments between potassium and zinc concentrations significantly affected grain yield, as the results showed that the combination (3000 mg k liter⁻¹ nano potassium + 50 mg Zn liter⁻¹ regular zinc) gave the highest grain yield of 8.05 tons' ha⁻¹ for the first season, whereas, in the second season, the combination of 3000 mg K L⁻¹ Nano potassium + 50 mg Zn L⁻¹ regular) gave the highest mean of 7.29 tons' ha⁻¹. The interaction between the cultivars and the potassium spray treatments significantly affected grain yield. The combination (Hamel with 6000 mg K L⁻¹ Nano potassium) gave the highest rate of 7.21 tons' ha⁻¹, while it the combination (Carrolup with 6000nm mg KL⁻¹) had the lowest average of 4.75 and 4.92 tons' ha⁻¹ for the two seasons respectively. The results showed that there was a significant difference in the grain yield trait due to the effect of the two-way interaction between the cultivars and the zinc spray treatments for the second season only (Table 4), as the combination (Gezania + 50 mg Zn L⁻¹) recorded the highest mean of 6.27 tons' ha⁻¹, While the combination (Hamel + 0 mg Zn l⁻¹) recorded the lowest average of 5.37 tons' ha⁻¹.The results showed a significant three-way interaction in grain yield, the plants of the cultivar Gezania sprayed with the combination (3000 mg k L⁻¹ Nano potassium + 50 mg Z L⁻¹ regular zinc) gave the highest grain yield of 8.30 tons' ha- 1 for the first season, and plants of the cultivar Hamel sprayed with the combination (3000 mg k L⁻¹ Nano K + 50 mg Z L⁻¹ regular zinc) had the highest grain yield of 7.44 tons' ha⁻¹ in the second season.

Table 4. The effect of zinc Usual and nano potassium on the characteristic of grain yield (tons' ha⁻¹) for the oats cultivars for the years 2018-2019 and 2019-2020.

K mg L ⁻¹ Cultivar	Zn mg L ⁻¹	First season 2018- 2019		Second season 2019-2020	
		Cultivars	K	Cultivars	K

s		Hamel	Carrolup	Genzania	× Zn	Hamel	Carrolup	Genzania	× Zn
0	0	3.97	4.18	4.42	4.19	3.61	3.99	5.33	4.31
	50	4.96	4.39	4.95	4.77	5.19	5.36	5.81	5.46
	50nm	5.33	5.89	4.60	5.73	5.96	5.97	6.42	6.19
6000	0	5.00	5.90	5.77	5.56	5.97	6.70	6.72	6.46
	50	4.00	5.34	6.08	5.14	3.83	4.16	4.82	4.27
	50nm	5.60	6.27	6.75	6.21	4.94	5.03	5.77	5.25
3000nm	0	7.06	7.40	6.39	6.95	5.79	6.77	6.76	6.44
	50	7.88	7.97	8.30	8.05	7.26	7.13	7.32	7.23
	50nm	5.21	5.65	6.48	5.79	3.80	4.05	5.08	4.31
6000nm	0	7.00	5.75	7.07	6.67	6.11	6.43	6.28	6.27
	50	7.15	7.54	6.31	7.00	7.44	7.62	6.77	7.29
	50nm	7.48	7.62	7.957	7.56	6.95	6.78	7.16	6.96
L.S.D 5%		0.52		0.931		0.65		0.944	
K × Cultivar	0	4.75	4.82	4.75	5.78	4.92	5.11	5.85	5.29
	6000	4.87	5.84	6.20	5.64	4.92	5.30	5.77	5.33
	3000nm	6.72	7.01	7.06	6.93	5.62	5.98	6.39	6.00
	6000nm	7.21	6.97	6.98	7.05	6.83	6.94	6.74	6.84
	L.S.D 5%		0.33		0.25		0.38		0.28
Zn × Cultivar	0	5.76	5.81	5.91	5.83	5.41	5.46	6.11	5.66
	50	6.00	6.31	6.41	6.24	5.93	6.06	6.18	6.06
	50nm	5.91	6.36	6.43	6.23	5.37	5.97	6.27	5.87
	L.S.D 5%		NS		0.13		0.933		0.23
	Mean Cultivar	5.89	6.16	6.25	Mean Cultivar	5.57	5.83	6.19	
L.S.D 5%		0.15				0.17			

3.5. Biological yield (ton ha⁻¹)

The results of indicate that Genzania cultivar was significantly superior in the highest average biological yield of 16.37 and 16.26 tons' ha⁻¹, which did not differ significantly from Carrolup cultivar in both seasons (Table 5). while the cultivar Hamel gave the lowest average of 16.01 and 15.80 tons' ha⁻¹ for the two seasons respectively. Perhaps the reason for the superiority of Genzania variety is due to its superiority in grain yield Table (4) This result is in line with the results of [33]:[34]. There is a significant effect of spraying with zinc (Table 5), the concentration of 50 mg Zn L⁻¹ regular zinc gave the highest average of biological yield of 16.39 and 16.25 tons' ha⁻¹ for both seasons, respectively, and did not differ significantly from nano-zinc in the first season, and was superior to the rest of the other concentrations, and the reason for the increase in biological yield may be due to its superiority in grain yield (Tables, 4). This result agrees with the results of [20] The results of Table (5) showed that spraying oats plants with regular and nano potassium led to a significant increase in biological yield for both seasons, the two treatments 3000 and 6000 mg K L⁻¹ Nano potassium gave the highest mean of 17.16 and 16.98 ton ha⁻¹, while the control treatment (distilled water only) recorded the lowest mean of 14.66

and 15.36 tons' ha⁻¹ for the two seasons respectively. The reason for the superiority of the above two treatments may be attributed to their superiority in grain yield (Table 4). This finding is in line with [28]:[22]. It was observed that there was a significant difference in the characteristic of the biological yield, the highest mean of biological yield of 18.10 and 17.46 tons' ha⁻¹ for both combinations and for the two seasons respectively, while the control treatment gave the lowest mean of 14.04 and 14.19 tons' ha⁻¹ for both combinations and two seasons respectively. 17.13 and 17.12 tons' ha⁻¹ for both seasons respectively. Whereas, plants of the cultivar Hamel sprayed with distilled water only recorded the lowest mean of 14.10 and 15.09 tons' ha⁻¹ for the two seasons respectively. The results showed a significant three-way interaction in biological yield for two seasons. Genzania plants sprayed with the combination (6000 mg K L⁻¹ Nano K + 50 mg Zn L⁻¹ regular zinc) gave the highest average biological yield in the first season of 18.18 tons' ha⁻¹, while Carrolup plants sprayed with the same combination gave the highest average biological yield in the second season (17.80 tons' ha⁻¹). Whereas, plants of the cultivar Hamel sprayed with the control treatment (0 mg K L⁻¹ + 0 mg Zn L⁻¹) gave the lowest mean of 13.17 and 13.75 tons' ha⁻¹ for both combinations.

Table 5. The effect of zinc Usual and nano potassium on the characteristic of Biological yield (tons'ha⁻¹) for the oats cultivars for the years 2018-2019 and 2019-2020

K mg L ⁻¹	Zn mg L ⁻¹	First season 2018-2019			Second season 2019-2020				
		Cultivars			Cultivars				
		Hamel	Carrolup	Genzania	K × Zn	Hamel	Carrolup	Genzania	K × Zn

	0	13.17	14.32	14.63	14.04	13.75	14.08	14.74	14.19
0	50	14.13	14.54	15.07	14.59	15.38	15.58	16.01	15.66
	50nm	15.00	16.03	14.99	15.34	16.14	16.40	16.16	16.23
	0	15.86	16.36	16.25	16.15	16.62	16.18	16.87	16.56
6000	50	15.10	15.70	16.43	15.74	13.99	14.37	14.98	14.45
	50nm	16.33	16.41	16.96	16.57	15.12	15.20	15.98	15.44
	0	16.12	15.87	17.19	16.36	16.35	17.03	16.94	16.79
3000nm	50	17.25	17.66	16.41	17.11	17.47	17.34	17.49	17.43
	50nm	17.60	17.68	17.67	17.65	13.97	14.59	15.28	14.61
	0	17.24	17.52	16.54	17.10	16.29	16.58	16.46	16.44
6000nm	50	18.01	18.13	18.18	18.10	17.64	17.80	16.95	17.46
	50nm	15.33	15.73	16.22	15.76	16.82	16.97	17.30	17.03
L.S.D 5%			0.56		031		062		0.39
					Mean				Mean
					K				K
K	0	14.10	14.97	14.90	14.66	15.09	15.35	15.64	15.36
×	6000	15.76	16.15	16.55	16.16	15.24	15.25	15.94	15.48
Cultivar	3000nm	17.00	17.07	17.09	17.16	15.93	16.32	16.57	16.28
	6000nm	16.86	17.13	16.98	16.99	16.91	17.12	16.90	16.98
L.S.D 5%			0.34		0.23		0.34		0.21
					Mean				Mean
					Zn				Zn
Zn	0	15.85	16.08	16.15	16.01	15.75	15.97	16.26	15.99
×	50	16.12	16.51	16.52	16.39	16.12	16.27	16.36	16.25
Cultivar	50nm	16.07	16.46	16.46	16.38	15.51	15.79	16.18	15.83
L.S.D 5%			NS		0.15		NS		1918
Mean		16.01	16.33	16.37	Mean	15.80	16.01	16.26	
Cultivar					Cultiva				
					r				
L.S.D 5%			0.17				0.17		

4. Conclusion

It was concluded from this study, that oats cultivars vary in their response to the environmental conditions of the study area, as well as in the extent of their response to mineral nutrition with zinc and potassium, whether nano or mineral. The nano-fertilizer also showed a significant effect on the characteristics of the study through an effect on yield components and grain yield.

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