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Impact of Silver Nano particles on the Yield and Yield components of Oat (Avena sativa L.)varieties under two Agro-Ecosystems.

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ABSTRACT

The present study involved the applications of silver nano particles (AgNPs) to improve the yield of oat varieties under dry land conditions at two ecosystems, Kirkuk, Altun kopru and Erbil, Koya. A field experiment was implemented in the winter season of 2020 according to the randomized complete block design in a split-split plot arrangement. The experiment consisted three factors; the first factor consisting two locations Altun Kopru/Kirkuk and Koya/Erbil and the second factor consisting (0,10,20,30 and 40 ppm AgNPs) ; while the third factor consisting eight Oat varieties; (Pimula, Genzania, Hamel, Icarda short , Icarda tall, Kangaroo, Mitika and Possum). The results showed significant superiority of Nano silver spray in achieving the highest means for most studied indicators. Spraying of 30 ppm AgNPs achieved the highest means for plant height, tillers and panicles number ,grains yield, straw yield, biological yield except of panicle grains weight and harvest index. which the both achieved the highest means at 0 ppm. The Mitika variety recorded the lowest grain yield, straw yield, biological yield and the highest harvest index. The Hamel variety was superior in grain yield, straw yield, and biological yield. The Icarda short - variety recorded the highest grain yield and biological yield. while Possum and Pimula recorded the highest grain and Straw yield. In Koya location grains yield, biological yield and harvest index showed the significant superiority with Altun kupro location. All cultivars caused a significant increase in grain, straw and biological yield with the concentration increase of Nano silver spray from 0 to 30 ppm.

***Keywords*:** Nano silver, Semi arid area, Climate change, Agro-Ecosystems, Oat

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Introduction

Oat is an annual winter herbaceous, self pollinated grass and the most important cereal crop for human and animal consumption. The environmental damage caused by plenty use of agrochemical fertilizer is the problems of the present world and silver nanoparticles an alternative source of Eco-friendly fertilizer to achieve the desired biological effect. Application profile of nano particles rapidly expanded in agriculture where silver nano particles (AgNPs) are enhance nutrient use efficiency in plants [1]. Silver nanoparticles (AgNPs) are one of the most widely used nanoparticles involved in ecosystem [2].The positive role of nanotechnology in the plant ecosystem make the silver nanoparticles (AgNP) receiving special attention because of their ability to increase the growth and yield in many crops [3].Silver nanoparticles are a highly useful to wheat and flax plant growth was observed by[4]. While [5] mentioned the addition of 4 and 8 mg dm^{-3} AgNPs to barley seedling resulted in the highest seedlings with the longest roots. The researchers [6] indicated that treatment with AgNPs stabilized by specific compounds resulted in growth promotion and a reduced number of days to flowering, associated with enhanced wheat yield. Several studies have shown that oat cultivars differ in growth and yield characteristics. The researchers [7] and [8] reported significant differences among oat cultivars in plant height. In Finland, [9] found significant differences in the number of plant tillers among several oat genotypes. Similar results were obtained by [10-12] . Oat cultivars differed greatly from each other in the number of panicles/m^2 [7] and[10]. The differences in grain panicles/weight among four oat cultivars obtained by [13].The difference in the yield of oat grains according to the studied varieties is a result reached by the researchers [11,14 and 15]. In a study of eighteen Australian oat cultivars,[16]observed differences in oat straw production between cultivars. In India,[17]found significant differences among seven oat cultivars in biological yield A similar result was reached by [11].The results of [10]and[18] indicated that oat verities differed significantly in harvest index**.** In Turkey considerable variation in oat grain yield within the three sites conditions (Konya, Cumra and Obruk)reported by [19].In a field experiment conducted by [20]in Mexico , they found that oat yield varies between studied locations. In the Central Black Sea Region of Turkey at six different locations, [8] indicated significant differences in oat productivity among the studied locations (Amasya 3.16 (t. ha^{-1}), Çorum 2.21 (t. ha^{-1}), Tokat 2.94 (t. ha^{-1}), Sinop 2.75 (t. ha^{-1}), Samsun-Central 4.43(t.ha^{-1}) and Samsun-Bafra 3.94(t.ha^{-1}). In Iraq specially northern part of Iraq the studies about the effects of nano silver and ecosystem on oat is very rare, so the aim of this study is improving oat production by using modern nanotechnology(AgNPs) and selecting the

varieties which suits drought and global warming conditions in Iraq

2- Materials and methods

The field experiment was conducted in winter season at two locations in a farmers, field in Kirkuk-Altun kopru at[35.8° N, 44.2°E , 285 masl] and Agriculture research station, Erbil- Koya at [36.1° N, 44.6°E, 560 masl] to determine the effect of different nano silver concentration(AgNPs)on the yield and its components of oat varieties. The seeds of oat varieties obtained from college of Agriculture /Tikrit University. Silver nano particles (AgNPs) were sprayed early in the morning by the method of foliar spray by two sprinkles, the first spray was at tillering stage and the second spray was at flowering stage. The experimental design was a randomized complete block in a split-split plot arrangement. Main plots consisted of two locations(the Altun kopru and the Koya Research Center),subplots consisted five nano silver concentration(0,10,20,30 and 40 ppm), and sub-subplots consisted eight varieties; Pimula, Genzania, Hamel, Icarda short , Kangaroo, Icarda tall, Mitika and Possum. The soil was smoothed and the land was divided according to the design used into plot. The seeds were sown by hand on the December,2019,at a rate of 500 seeds per square meter. Meteorological data was collected from the local weather station present at kirkuk and Koya are shown in table(1). Crop management operations were carried out, including fertilization(Tri Super Phosphate(P_2O_5 46%) used once before planting at a rate of 100 kg/ha and urea (N 46%) used twice first with the seeding and second at tillering stage at a rate of 50 kg/ha)and weed control, as needed. The plants were harvested on 20/6/2020 after reaching the full maturity stage. The seed were measured with sensitive electric balance after threshing and cleaning by winnowing

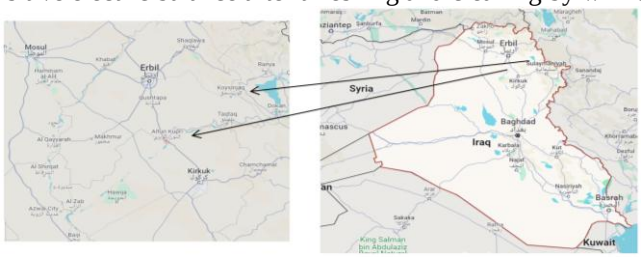

Figure 1.The areas of the study; Koya/ Erbil, and Alton kopru/ Kirkuk, Iraq.

Table 1. Some of the main meteorological data of both ACZs.

Months	Locations	Air temperature (˚C)			Precipitation (mm)	Pan Evap. (mm)	Relative Humidity (%)
		T_{max}	T_{min}	T_{mean}			
Nov	Altun kopru	21.83	9.26	15.55	5	3.61	36.625
	Koya	23.233	12.9	18.067	58.5	3.533	41.067
Dec	Altun kopru	17.53	8.14	12.84	42.5	1.82	63.635
	Koya	16.387	9.323	12.855	75.7	1.323	64.645
Jan	Altun kopru	14.26	5.28	9.42	75.5	1.44	73.13
	Koya	11.807	5.355	8.581	137.3	0.774	65.306
Feb	Altun kopru	15.94	5.45	10.69	29	2.07	66.595
	Koya	13.276	5.448	9.362	86.2	0.758	65.966
Mar	Altun kopru	22.44	10.17	16.26	128.5	3.19	64.665
	Koya	20.581	11.549	16.065	165.5	1.903	60.226
Apr	Altun kopru	27.44	13.03	20.23	22	4.64	55.32
	Koya	24.571	14.071	19.321	43.5	3.536	55.214
May	Altun kopru	33.62	15.58	24.60	9	6.59	41.98
	Koya	31.903	20.548	26.226	23	6.903	34.32258

Table 2. Physical and Chemical Analysis for the Study Soils.

Physical Soil Properties	pH	Ec (dSm^{-1})	O.M. (%)	N (ppm)	P (ppm)	K (ppm)	Sand (%)	Silt (%)	Clay (%)	Texture
Koya	7.6	0.30	1.20	1200	8.80	120	18.3	41.1	40.6	Silty clay
Altun kopru	6.8	0.12	0.62	350	1.26	106	66.0	16.0	18.0	Sandy loam

Soil analysis was done in the Kirkuk Agricultural Directorate in Soil Department Laboratory

Studied characteristics:- Plant height was measured from the soil surface to the base of panicle with the help of a meter tape.[10],Number of panicles were counted from one meter length of midline from each experimental unit.[10],Panicle grains weight measured from one meter length of one midline from each experimental unit [7]. Grain yield calculated from the yield of the harvested area (one meter length of midline) from each experimental unit and converted to ($t.ha^{-1}$) [10],Straw yield calculated considered as the biological yield without grain yield, biological yield was calculated from the weight of the entire dry plants harvested above and for an area of one meter length of midline and then converted to ($t.ha^{-1}$)[10], whereas the Harvest Index denotes the ratio of economic yield to biological yield and was calculated from the following equation: Harvest index = (grain yield/biological yield) × 100 [21]

Data were analyzed with analysis of variance (ANOVA) procedures using the SAS statistical software package. The mean separation among treatment means for Nano silver concentration, varieties and locations were obtained by using the Duncan's test Effects were considered in all statistical calculations for p-values <0.05.[22].

3-Results and Discussion

The effect of silver nano particles ,genotypes ,their interactions and locations on plant height, grain yield and its components were highly significant (P<0.05).

Plant height(cm)

The effect of foliar application of silver nanoparticles on the plant height is shown in Table 3. It was observed that spraying 30 ppm of AgNPs caused significant increase in plant height (79.5 cm)compare to concentrations(0 and10 ppm) while other concentration (20 and 40ppm) had non-significant effects on plant height. AgNPs significantly enhance the growth and NPK uptake by improving the root length ,leaf area, total chlorophyll and carotenoids in treated plants.[1and 23]. The results in Table 3 shows that, plant height was significantly different (p<0.05),the maximum plant height observed in both varieties Pimula (93.8 cm) and Hamel (93.3 cm) whereas lowest was in both varieties Mitika (51.2 cm) and Possum (51.9 cm). This result may be due to the genetic variation between the varieties and consistent with the findings of [7and 8]. Regarding the interactions between the concentrations of AgNPs and varieties was found to be significant. However, maximum plant height was recorded for Pimula(96.8 cm) and Genzania(96.7 cm) when concentrations of AgNPs was 10 and 20 ppm respectively, while Mitika and Possum varieties had minimum plant height (49,9 and 49,8 cm) when10 ppm AgNPs was applied.

Also the highest plant height was observed in Koya location (83.3 cm) and the lowest plant height was seen in Altun kopru location (71.1 cm). The results presented in table (1and 2) indicated to the superiority of the Koya location in soil chemical, physical properties, (availably of NPK, organic matter, and texture which helped to slow water drainage).Meteorological data, (precipitation and evaporation), all these environmental factors encouraged the oat height increasing. This result is consistent with that obtained by [8].

Table 3. Effect of Foliar Spraying with Nano silver, Oat varieties, and their Interactions on plant height(cm)at both locations Altun kopru and Koya.

Varieties	Nano silver concentrations(ppm)					Varieties Mean
	0	10	20	30	40	
Pimula	89.8 $^{a-d}$	96.8 ^{a}	94.5 $^{a-c}$	95.7 $^{a-b}$	92.3 $^{a-c}$	93.8 ^{a}
Genzania	86.3 $^{c-e}$	86.3 $^{c-e}$	96.7 ^{a}	94.4 $^{a-c}$	87.3 $^{c-e}$	90.2 ^{ab}
Hamel	89.6 $^{b-d}$	93.9 $^{a-c}$	95.5 ^{ab}	93.9 $^{a-c}$	93.8 $^{a-c}$	93.3 ^{a}
Icarda short	73.5 ^{h}	78.1^{f-h}	76.8 ^{gh}	79.3 $^{e-h}$	81.8 $^{d-h}$	77.8 ^{d}
Kangaroo	83.5 $^{d-f}$	78.3 $^{e-h}$	80.4 $^{e-h}$	85.5 $^{d-e}$	79.5 $^{e-h}$	81.4 ^{c}
Icarda Tall	81.0 $^{e-h}$	72.8 ^{i}	74.0 ^{h}	82.6 $^{d-g}$	79.8 $^{e-h}$	78.0 ^{d}
Mitika	50.9 ^{i}	49.9 ^{i}	50.4 ^{i}	52.0 ^{i}	52.8 ^{i}	51.2 ^{e}
Possum	54.4 ^{i}	49.8 ^{i}	50.78 ^{i}	52.6 ^{i}	51.9 ^{i}	51.9 ^{e}
AgNPS Mean	76.1^{b}	75.7 ^{b}	77.3 ^{ab}	79.5 ^{a}	77.4 ^{ab}	
Location Mean						
Altun kopru				Koya		
71.1 ^{b}				83.4 ^{a}		

*Means followed by the same letter for individual factors and their interactions are not significantly different at p ≤ 0.05 according to Duncan`s multiple range test and vice versa.

Panicles number (panicle/m^{-1})

Attention: Number of plant tillers = Number of plant panicles

According to table 4 the effect of nano silver, oat varieties , their interactions and locations had a significant effect on panicles number. The panicles number increased significantly in plants treated with AgNPs, regardless of the concentration,

which increased from the control (65.8 up to 76.3 and 75.7 panicle/m^{-1})at 30 and 40 ppm treatment respectively. AgNPs significantly enhance the growth and NPK uptake by improving the root length ,leaf area, Total chlorophyll and carotenoids in treated plants so enhance the yield [1,3 and 23],and varieties caused a significant effect and the oat Possum and Icarda short varieties were superior in panicles number (88.2 and 87.3 panicle/m^{-1})respectively, while oat Genzania variety gave the lowest number (57.7 panicle/m^{-1}). This result may be due to the genetic variation between the varieties. These results were confirmed by[7,11and12]. Application of AgNPs on all varieties caused a significant increase in panicles number with the concentration increase of AgNPs except Icarda tall in which the AgNPs concentration increase caused a significant reduce in panicles number .Also the highest and lowest panicles number observed in Altun kopru and Koya location (79.3 and 66.2 panicle/m^{-1})respectively. May be relative high temperatures and low precipitation in Altun kopru ,Table 1 an important environmental variable make plant end its life cycle by early flowering and panicles forming as a mechanism of drought escape and the opposite was true for the Koya location.

Table 4. Effect of Foliar Spraying with Nano silver, Oat varieties and their interactions on panicles number (panicle/m^{-1})at both locations Altun kopru and Koya

	Nano silver concentrations(ppm)					
Varieties	0	10	20	30	40	Varieties Mean
Pimula	48.0 ^{mn}	66.8 $^{h-l}$	68.3 $^{g-l}$	66.5 $^{h-l}$	64.8 $^{i-l}$	62.9 ^{d}
Genzania	41.3 ^{n}	56.3 ^{lm}	62.8 $^{i-l}$	65.0 $^{i-l}$	63.3 $^{i-l}$	57.7 ^{e}
Hamel	55.5 ^{lm}	57.4 $^{k-m}$	64.8 $^{i-l}$	65.5 $^{i-l}$	60.3 $^{j-m}$	60.7 ^{de}
Icarda short	90.1 $^{a-c}$	75.3 $^{d-i}$	91.5 $^{a-c}$	87.5 $^{a-d}$	92.3 ^{ab}	87.3 ^{a}
Kangaroo	59.6 $^{j-m}$	79.0 $^{b-h}$	64.5 $^{i-l}$	71.8 $^{e-j}$	79.8 $^{b-h}$	70.9 ^{c}
Icarda tall	83.2 $^{a-f}$	70.0 $^{f-k}$	83.0 $^{b-f}$	78.8 $^{c-h}$	78.5 $^{c-h}$	78.7 ^{b}
Mitika	66.5 $^{h-l}$	72.3 $^{e-j}$	81.3 $^{b-g}$	79.3 $^{b-h}$	79.3 $^{b-h}$	75.7 ^{bc}
Possum	82.5 $^{c-f}$	90.5 $^{a-c}$	84.5 $^{a-e}$	96.0 ^{a}	87.5 $^{a-d}$	88.2 ^{a}
AgNPS Mean	65.8 ^{c}	70.9 ^{b}	75.1 ^{a}	76.3 ^{a}	75.7 ^{a}	
	Location Mean					
	Altun kopru				Koya	
	79.3 ^{a}				66.3 ^{b}	

*Means followed by the same letter for individual factors and their interactions are not significantly different at $p \leq 0.05$ according to Duncan`s multiple range test and vice versa.

Panicle grain weight (g/panicle)

The results in table 5 shows that the addition of nano silver had a significant effect in reducing panicle grain weight compared to the untreated AgNPs plants, except for the concentration of 30 ppm AgNPs, which was (1.1 g/panicle and 1.2 g/panicle)of plants untreated with AgNPs, The data pertaining to panicle grain weight are given in table 5 , AgNPs reduced the number of flowering days[6] and this prolongs the grain filling period and then obtains a higher yield revealed that the panicle grain weight was significantly influenced by different varieties .Among the varieties, Hamel variety recorded significantly higher panicle grain weight (1.5 g/panicle) as compared to all other varieties, whereas, the lowest panicle grain weight (0.8 g/panicle) was recorded in Mitika. This result agrees with [13]. Application of AgNPS on all varieties caused a significant decrease in panicle grain weight with the concentration increase of AgNPS except Hamel in which the AgNPS concentration increase to 10 ppm caused a significant increase in panicle grain weight(1.7 g/panicle) and Genzania at concentration 30 ppm achieved a significant increase in panicle grain weight (1.6 g/panicle).Also the highest and lowest panicle grain weight observed in Location Koya and Altun kupro (1.4 and 0.8 g/panicle)respectively. The superiority of Koya location is due to its provision of growth requirements (NPK, organic matter and precipitation) during the grain filling stage (Tables 1 and 2) .

Table 5. Effect of Foliar Spraying with Nano silver ,Oat varieties and their combinations on panicle grain weight (g /panicle) at both locations Altun kopru and Koya.

Varieties	Nano silver concentrations (Ppm)					
	0	10	20	30	40	Varieties Mean
Pimula	1.5 $^{a-c}$	1.4 ^{bc}	1.1 $^{e-h}$	1.3 $^{c-f}$	1.1^{e-i}	1.3 ^{b}
Genzania	1.5 $^{a-c}$	1.3 $^{c-e}$	1.4 $^{b-d}$	1.6 ^{ab}	1.1^{e-h}	1.4 ^{b}
Hamel	1.5 $^{a-c}$	1.7 ^{a}	1.4 $^{b-d}$	1.4 $^{a-c}$	1.4 $^{b-d}$	1.5 ^{a}
Icarda short	1.1 $^{e-I}$	0.7 $^{j-l}$	1.0 $^{g-k}$	1.1 $^{e-i}$	1.0 $^{e-j}$	1.0 ^{c}

Kangaroo	1.1 d-g	0.8 h-l	1.0 g-k	1.0 g-k	0.8 h-l	0.9 c-d
Icarda tall	0.9 g-l	0.8 h-l	0.8 h-l	1.0 f-j	0.7 j-l	0.8 de
Mitika	1.0 e-j	0.6 l	0.8 h-l	0.8 h-l	0.7 kl	0.8 e
Possum	1.1 d-g	0.8 h-l	0.8 i-l	1.0 e-j	0.9 g-k	0.9 c-d
AgNPS Mean	1.2 a	1.0 b	1.1 b	1.1 a	1.0 b	

Locations Mean

Altun Kopru	Koya
0.8 b	1.4 a

*Means followed by the same letter for individual factors and their interactions are not significantly different at $p \leq 0.05$ according to Duncan`s multiple range test and vice versa.

Grain yield(t.*ha*$^{-1}$)

Table 6 shows the effect of foliar spraying with nano silver, oat varieties and their interaction on oat grain yield. Spraying plants with 30 ppm AgNPS caused a significant increase in grain yield (4.1 t.ha^{-1})respectively compared to 10 ppm of nano silver was (3.2 t.ha^{-1}),this superiority because of The Panicles number increased significantly in plants treated with AgNPS (Table 4). Similar results have been reported by[3]and[6].

The data are given in Table 6 , revealed that the grain yield was significantly influenced by different varieties .Among the varieties, Hamel, Icarda short and Possum recorded significantly higher grain yield(3.9 ,4.3 and 4.2 t.ha^{-1}) respectively as compared to all other varieties, whereas, the lowest grain yield (2.9 t.ha^{-1}) was recorded in Mitika, And the differences Among the varieties Pimula ,Genzania, Kangaroo, Icarda Tall and Mitika were no significant, These results may be due to superiority of Hamel in panicle grain weight (Table 5) and superiority of the both (Icarda short and Possum) in panicles number (Table 4), These results are consistent with what was found by[11],[14],[15]and [21] their results indicated that oat verities differed significantly in grain yield.Application of AgNPS on all varieties caused a significant increase in grain yield with the concentration increase of AgNPS to 30 ppm except Icarda short and Possum in which the AgNPS concentration increase caused reduce in grain yield. Also the highest grain yield was observed in Koya Location (4.0 t.ha^{-1}) and the lowest grain yield was seen in Altun kopru Location (3.1 t.ha^{-1}), These results may be due to superiority of Koya Location in panicle grain weight which is approximately reached double of Altun kupro Location(Table 5). These results are in accordance with those have been reported by[8]and [15].

Table 6. Effect of Foliar Spraying with Nano silver, Oat varieties and their combinations on grain yield(t.ha^{-1}) at both locations Altun kopru and Koya

	Nano silver concentrations(ppm)					
Varieties	0	10	20	30	40	Varieties Mean
Pimula	2.0 m	4.1 a-h	3.5 c-l	4.0 a-i	3.1 f-m	3.3 b
Genzania	2.3 lm	2.8 i-m	4.0 a-i	4.2 a-f	3.0 g-m	3.3 b
Hamel	2.9 h-m	4.0 a-i	4.4 a-e	4.6 a-d	3.7 b-k	3.9 a
Icarda short	4.8 a-c	2.8 i-m	4.4 a-e	4.7 a-d	4.7 a-d	4.3 a
Kangaroo	2.9 h-m	3.3 e-l	3.2 e-m	3.5 d-l	3.3 e-l	3.2 b
Icarda tall	3.7 b-j	2.8 i-m	3.4 e-l	4.0 a-i	3. g-m	3.4 b
Mitika	2.9 h-m	2.5 k-m	3.4 e-l	3.3 e-l	2.6 j-m	3.0 b
Possum	5.0 a	3.7 b-k	3.4 e-l	4.8 ab	4.3 a-f	4.2 a
AgNPS Mean	3.3 c	3.2 c	3.7 b	4.1 a	3.4 b c	

Locations Mean

Altun kopru	Koya
3.1 b	4.0 a

*Means followed by the same letter for individual factors and their interactions are not significantly different at $p \leq 0.05$ according to Duncan`s multiple range test and vice versa.

Straw yield (t.ha^{-1})

The effects of nano silver, oat varieties with their interactions on the plants straw yield are shown in table 7. Exposure of plants to 0 and 30 ppm resulted in a significant increase in straw yield from (3.4 t.ha^{-1})to (4.7 t.ha^{-1}). A significant increase in plant height and plant tillers by spraying the nano silver causes a significant increase in straw yield table (3,4).The straw yield was significantly differed between varieties , and Pimula variety was superior in straw yield (4.9 t.ha^{-1}), while Mitika variety recorded lowest straw yield (2.6 t.ha^{-1}). Superiority of Pimula in straw yield may be due to its superiority in plant height (Table 3).This result agreed with[16]. All varieties caused a significant increase in straw yield with the concentration increase of AgNPS to 30 ppm except oat Hamel variety in which the AgNPS concentration 20 ppm was

superior in straw yield (5.8 t.ha^{-1}) . Also the non significant difference straw yield observed in Altun kopru and Koya Location

Table 7. Effect of Foliar Spraying with Nano silver, Oat varieties and theircombinations on straw yield (t.ha^{-1}) at both locations Altun kopru and Koya.

	Nano silver concentration(Ppm)					Varieties
Varieties	0	10	20	30	40	Mean
Pimula	3.1 $^{h-m}$	5.8 ^{ab}	5.5 ^{ab}	5.6 ^{ab}	4.6 $^{b-f}$	4.9 ^{a}
Genzania	3.0 $^{j-m}$	3.7 $^{e-k}$	4.8 $^{a-e}$	5.3 $^{a-c}$	3.8 $^{d-k}$	4.1 ^{cd}
Hamel	3.2 $^{h-m}$	4.8 $^{a-e}$	5.8 ^{a}	5.5 ^{ab}	4.2 $^{c-j}$	4.7 ^{ab}
Icarda short	4.3 $^{c-h}$	2.7 $^{k-m}$	4.3 $^{c-h}$	4.7 $^{a-e}$	4.3 $^{c-h}$	4.1 ^{cd}
Kangaroo	3.8 $^{d-k}$	4.3 $^{c-i}$	4.7 $^{b-g}$	5.0 $^{a-d}$	4.7 $^{a-e}$	4.4 ^{bc}
Icarda Tall	3.4 $^{h-l}$	2.7 $^{k-m}$	3.4 $^{f-l}$	3.8 $^{d-k}$	3.0 $^{i-m}$	3.3 ^{e}
Mitika	2.3 ^{lm}	2.1 ^{m}	3.0 $^{j-m}$	3.1 $^{h-m}$	2.3 ^{lm}	2.6 ^{f}
Possum	4.2 $^{c-j}$	3.3 $^{g-m}$	3.1 $^{i-m}$	4.3 $^{c-h}$	3.8 $^{d-k}$	3.8 ^{d}
AgNPS Mean	3.4 ^{c}	3.7 ^{bc}	4.3 ^{a}	4.7 ^{a}	3.8 ^{b}	

Locations Mean

Altun kopru	Koya
4.0 ^{a}	3.9 ^{a}

*Means followed by the same letter for individual factors and their interactions are not significantly different at p ≤ 0.05 according to Duncan`s multiple range test and vice versa.

Biological yield(t.ha^{-1})

The results presented in Table 8 show the effect of nano silver and oat varieties with their interaction AgNPs on the biological yield in oat plant. It is observed that AgNPS significantly increased the biological yield in oat plant compared to control treatment, except for the concentrations 10 and 40 ppm which not differ significantly with the control treatment. The increase in the biological yield of oats when spraying 30 ppm nano silver is due to the increase in grain yield and straw yield (Tables 6 and 7).Table 8 result also showed that, biological yield were significantly different (p<0.05) between varieties, the maximum biological yield observed in both varieties Hamel (8.6 t.ha^{-1})and Icarda short (8.3 t.ha^{-1}) whereas, lowest is in variety Mitika (5.5 t.ha^{-1}). This result is due to their superiority in grain yield and straw yield,(Tables 6 and 7). Similar results have been reported by[17].All varieties caused a significant increase in biological yield with the concentration increase of AgNPS to 30 ppm except Pimula in which the AgNPS concentration 10 ppm was superior in biological yield (9.9 t.ha^{-1}) and Hamel in which the AgNPS concentration 20 ppm was superior in biological yield (10.3 t.ha^{-1}). Also the significant superiority in biological yield was observed in Koya Location(8.0 t.ha^{-1}). The high productivity of both grain and straw yield in Koya Location made it excel in biological yield (Tables 6 and 7).

Table 8.Effect of Foliar Spraying with Nano silver, Oat varieties and their combinations on biological yield*(t.ha^{-1})* at both locations Altun kopru and Koya **.**

	Nano silver concentrations(Ppm)					
Varieties	0	10	20	30	40	Variety Mean
Pimula	5.1 ^{mn}	9.9 $^{a-c}$	9.1 $^{a-g}$	9.6 $^{a-c}$	7.7 $^{c-k}$	8.2 ^{ab}
Genzania	5.3 $^{k-n}$	6.4 $^{h-n}$	8.8 $^{a-h}$	9.5 $^{a-d}$	6.8 $^{h-n}$	7.4 ^{bc}
Hamel	6.1 $^{i-n}$	8.8 $^{a-h}$	10.3 ^{a}	10.2 ^{ab}	7.8 $^{a-j}$	8.6 ^{a}
Icarda short	9.1 $^{a-g}$	5.4 $^{j-n}$	8.8 $^{a-h}$	9.4 $^{a-e}$	9.0 $^{a-g}$	8.3 ^{a}
Kangaroo	6.7 $^{g-n}$	7.6 $^{c-l}$	7.8 $^{b-j}$	8.4 $^{a-i}$	7.9 $^{a-i}$	7.7 ^{ab}
Icarda tall	7.1 $^{d-m}$	5.5 $^{j-n}$	6.8 $^{f-n}$	7.8 $^{a-j}$	6.0 $^{i-n}$	6.6 ^{c}
Mitika	5.2 $^{l-n}$	4.6 ^{n}	6.4 $^{h-n}$	6.4 $^{h-n}$	4.9 ^{mn}	5.5 ^{d}
Possum	9.2 $^{a-f}$	7.0 $^{e-n}$	6.4 $^{h-n}$	9.1 $^{a-g}$	8.1 $^{a-i}$	8.0 ^{ab}
AgNPS Mean	6.7 ^{c}	6.9 ^{c}	8.0 ^{b}	8.8 ^{a}	7.3 ^{c}	

Location Mean

Altun kopru	Koya
7.1 ^{b}	8.0 ^{a}

*Means followed by the same letter for individual factors and their interactions are not significantly different at p ≤ 0.05 according to Duncan`s multiple range test and vice versa.

Harvest index(%)

The effect of nano silver and oat varieties and their interactions on harvest index in oat plant is shown in Table 9. Nano silver application decreased harvest index significantly for concentrations 20,30 and 40 ppm AgNPS control treatment gave significantly highest harvest index (48.2 %) .It is observed that AgNPS significantly increased the grain and straw yield in oat plant compared to control treatment, but the amount of increase in straw yield was more than grain yield which made the harvest index decrease with concentrations of nano silver, (Tables 6 and 7).

The data revealed that the harvest index was significantly influenced by varieties. Among the varieties, Mitika recorded significantly higher harvest index of 52.9 % as compared to all other varieties, whereas, the lowest harvest index was recorded in Pimula (41.0 %) and Kangaroo(41.9 %). It is observed that the grain yield of the Mitika variety was higher than the straw yield compared to the other varieties, which made it superior in the harvest index (Tables 6 and 7). These findings corroborated the results reported by[2]. Regarding the interactions between the concentrations of AgNPS and varieties was found to be significant. Application of AgNPS on cultivars Hamel ,Icarda short, Kangaroo, Icarda tall and Mitika caused a significant decrease in harvest index with the increase concentration of AgNPS .Maximum harvest index (55.2 %) was recorded for Mitika when concentrations of Ag NPs was 0 ppm, while Pimula had minimum harvest index (39.2 %) with 20 ppm was applied. Also the highest and lowest harvest index observed in Location Koya and Altun kupro (50.2 and 44.7 %) respectively. The high grain yield and lower straw yield made the Koya location superior to the Altun kupro location in the harvest index, Table (6 and 7) .

Table(9)Effect of Foliar Spraying with Nano silver, Oat varieties and theircombinations on harvest index(%) at both locations Altun kopru and Koya.

Varieties	AgNPS concentrations(Ppm)					Varieties
	0	10	20	30	40	Mean
Pimula	40.6 $^{n-o}$	42.5 $^{k-n}$	39.2 ^{o}	41.4 $^{l-o}$	41.2 $^{m-o}$	41.0 ^{f}
Genzania	42.6 $^{k-n}$	44.6 $^{j-k}$	45.8 $^{h-j}$	44.8 $^{i-k}$	43.9 $^{j-m}$	44.4 ^{e}
Hamel	47.9 $^{f-h}$	47.3 $^{g-i}$	43.8 $^{j-m}$	46.1 $^{h-j}$	47.7 $^{f-h}$	46.6 ^{d}
Icarda short	52.2 $^{b-d}$	51.1 $^{b-e}$	50.2 $^{c-f}$	49.3 $^{d-g}$	51.2 $^{b-e}$	50.8 ^{c}
Kangaroo	44.1 $^{j-l}$	43.0 $^{k-n}$	40.5 $^{n-o}$	41.4 $^{l-o}$	40.8 ^{no}	41.9 ^{f}
Icarda tall	52.1 $^{b-d}$	51.5 $^{b-e}$	49.5 $^{d-g}$	49.8 $^{c-g}$	49.1 $^{e-f}$	50.4 ^{c}
Mitika	55.2 ^{a}	53.3 ^{ab}	52.1 $^{b-d}$	51.5 $^{b-e}$	52.4 ^{bc}	52.9 ^{a}
Possum	51.3 $^{b-e}$	51.7 $^{b-e}$	52.0 $^{b-d}$	52.1 $^{b-d}$	52.1 $^{b-d}$	51.8 ^{b}
AgNPS Mean	48.2 ^{a}	48.1^{ab}	46.6 ^{c}	47.1^{c}	47.3^{bc}	
			Location Mean			
	Altun kopru				Koya	
	44.7 ^{b}				50.2 ^{a}	

*Means followed by the same letter for individual factors and their interactions are not significantlydiff at $p \leq 0.05$according to Duncan`s multiple range test and vice versa

Conclusion

From this study it can be concluded that oat spray by silver nano particles caused significant increase in grain ,straw and biological yield and the high yield was at concentration 30 ppm . Icarda short and Hamel varieties recorded significantly higher grain and biological yield while Pimula variety recorded higher straw yield. Koya location achieved highest grain and biological yield while straw yield was in Altun kupro location, rainfall and temperatures caused serious problems for both the natural ecosystem and agricultural production growing population.

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تأثير جسيمات الفضة النانوية في الحاصل ومكوناته لأصناف من الشوفان (Avena sativa L) في نظامين بيئيين زراعيين.

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الخلاصة

تضمنت هذه الدراسة تطبيقات جسيمات النانو الفضية (*AgNPs*) لتحسين حاصل أصناف الشوفان تحت ظروف الأراضي الجافة في نظامين بيئيين كركوك/ألتون كوبري وأربيل/كوية. تم تنفيذ تجربة حقلية خلال الموسم الزراعي الشتوي لعام 2020 وفقًا لتصميم القطع العشوائية الكاملة وبترتيب الالواح المنشقة- المنشقة. تضمنت التجربة ثلاثة عوامل؛ العامل الأول موقعين بيئيين مختلفين هما ألتون كوبري/كركوك وكوية/أربيل والعامل الثاني أربع مستويات من الفضة النانوي (0 و10و20و30و40 جزءًا في المليون)؛ بينما العامل الثالث تضمنت ثمانية أصناف من الشوفان (*Pimula, Genzania, Hamel, Icarda short , Icarda tall, Kangaroo, Mitika and Possum*) . أظهرت النتائج تفوقًا معنويًا لرش الفضة النانوية في تحقيق أعلى المتوسطات لمعظم الصفات المدروسة،حقق الرش(30 جزءًا في المليون) أعلى المتوسطات لارتفاع النبات وعدد الأشطاء والسنابل وحاصل الحبوب وحاصل القش والحاصل البيولوجي باستثناء وزن حبوب

السنابل ودليل الحصاد حيث تحقق لكلاهما أعلى المتوسطات عند(0 جزء في المليون). سجل الصنف *Hamel* تفوقًا معنويا في حاصل الحبوب وحاصل القش والحاصل البيولوجي، وسجل الصنف *Icarda short* أعلى حاصل حبوب و حاصل بيولوجي. بينما سجل *Possum* و *Pimula* أعلى حاصل حبوب والقش. سجل الصنف *Mitika* أعلى دليل حصاد. أظهر موقع كوية تفوقًا معنويًا على موقع التون كوبري في حاصل الحبوب والحاصل البيولوجي ودليل الحصاد. زاد جميع الأصناف معنويا في حاصل الحبوب والقش والحاصل البيولوجي عند زيادة مستوى رش الفضة النانوية من 0 إلى 30 جزءًا في المليون.

الكلمات المفتاحية: الفضة النانوية، المناطق شبه جافة، الشوفان.