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EFFECT OF NANO-FERTILIZER, SEEDING RATE AND NITROGEN FERTILIZATION ON BARLEY YIELD UNDER SINAI CONDITIONS

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ABSTRACT

*The present study was conducted at two field experiments in a private farm at Gilbana Zone in Sinai, East Qantarah District, Ismailia Governorate, Egypt***,** *during the two successive winter seasons 2015/2016 and 2016/2017. This investigation aimed to find out the effect of chemical nitrogen fertilizer levels (15, 30,45 and 60 kg N/fad.), barley seeding rate (40,60 and 80 kg/fad.) and nano-fertilizer application on yield and its components of barley***.** *The spilt-spilt plot design as a form of the randomized complete block design with three replications was followed.*

Application of nano-fertilizer appeared to produce high values in No. of both spike lets and grains per spike as well as the heavy grains/spike, 1000- grain weight and, increased grain yield/fad. Seeding rate of 80 kg/fad. appeared to produce the highest value in each of number of spikes/m^2 and grain yield/fad. Meanwhile, the seeding rate of 40 kg/fad. recorded the highest value in each of No. of both spike lets and grains per spike, weight of both grains/spike and 1000-grain . Nitrogen fertilization was very effective on all yield characteristics, so any increase in N levels was followed by a significant increase in each of No of spike lets/spike, grains/spike and spikes/m^2, also increased weight of both grains/spike and 1000-grain weight and grain yield per fa.

Conclusively, *these results finally recommend sowing barley with dense seeding rate of 80 kg/fad. and application of 60 kg N/ fad. In addition to application of nano-fertilizer to maximize grain yield /fad. under the experimental site and other likely environmental conditions.*

Key words: Barely, Nano fertilizer, Seeding rate, Nitrogen fertilization, yield and yield components .

INTRODUCTION

Barley has along history of use as human food and animal feed, of health benefits and malting and brewing in many countries around the world (Malcolmson *et al.* , 2005).

Nanotechnology improves the nutrient use efficiency and reduces costs of environmental protection, slow-release fertilizers are the excellent replacement to soluble fertilizers (Abobatta, 2018).

Nano-materials are defined as the materials with a single unit between one and a hundred nm in size in a minimum of one dimension (Liu and Lal, 2015).Nano-fertilizers and slow released fertilizers are appropriate alternatives to conventional fertilizers for gradual and controlled supply of nutrients in the soil (Mousavi-Fadzl and Fadeznia, 2008).

Abdel-Aziz, Heba *et al.* (2016)demonstrated that at all experimental stages the values of No. of spikelets/ spike, 100 kernel weight, No. of grains/spike, and grain weight / wheat plant were higher in nano-fertilizer treated plants than in normal fertilizer- treated ones. Kandil and Eman (2017) stated that the applied mineral fertilizer, alone, gave the lowest mean values of the studied traits. Spruogis *et al.* (2018)reported that, fertilization barley with N, P and K (50-60-70 kg/ha) and bioorganic nano-fertilizer 0.1-1.0 kg/ha sprayed twice increased grain and straw yields, 1000-grain weight. Ghorbanian *et al.* (2019) found that foliar application of SiO_2 nanoparticles achieved the higher value in each of 1000-grain weight, , grain weight/plant andgrain yield /ha compared to those of the control.

Mohammed Ali and Hashem (2012) stated that, the rate of barley seeding 150 kg/ha gave the highest means in each of tillers number/m^2, harvest index and grain yield(kg/ha) in both seasons. Tigabu and Asfadw (2016), revealed that using of 100kg /ha, gave the highest grain yield (2.78t/ha). Mekonnen (2018) reported that, 1000-grain weight and grain yield of barley were significantly decreased by raising seeding rate to up 100 kg seed/ ha. Amarjeet *et al.* (2020) stated that, insignificant variation was recorded in barley No. of grains/spike, 1000-grain weight and grain yield under the recommended seeding rate and 110% of recommended one. But, the closer spacing of 20 cm (row to row) produced higher grain yield (5.45 Mg/ha) than the recommended spacing of22.5 cm (5.30 Mg ha-1). Bekele *et al.* (2020) concluded that increment in malt barley seeding rate from 100-175 kg/ha decreased number of kernels/spike by 28.2%, 1000-grain weight by 23.51%. Also, harvest index value showed decrement with increasing seeding rate.

Nitrogen is the key element in achieving consistently high yields in cereals. Nitrogen is a constituent of many fundamental cell components such as nucleic acids, amino acids, enzymes, and photosynthetic pigments. Thus, grain yield of barley varieties is significantly influenced by rate of N fertilizer that means when assessing grain yield of cultivars in different rate of N fertilizer in different barely varieties Safina (2010) demonstrated that, No. of grains/spike and straw yield/fad. of some barley genotypes were linearly increased with increasing N level from 50 to 75 and up to 100 kg N/fad. O'Donovan *et al.* (2011), Jankovic *et al.* (2011), Shafi *et al.* (2011), Tigre *et al.,* (2014), Gezahegn and Kefadle (2016), and Seadh *et al.* (2017) found that, grain yield of barley, grain weight, and tillers /plant were increased by increasing N rate. Dubey *et al.* (2018), Morsy *et al.* (2018), Niguse and Kassaye (2018) and Terefe *et al*. (2018), demonstrated that, maximum values of number of spikelets/spike No. of grains/spike, 1000-grain weight of barley were recorded with 60 kg N/ha They added that grain application of yield successively increased with increase in nitrogen level from 0 to 60 kg N/ha.

The analysis of variance revealed that no significant difference among N levels in harvest index, meanwhile, thousand grain weight increased almost linearly in all varieties with increasing rates of N (.Awulachew, 2019). Kassie and Tesfadye (2019)stated that, as N rates increased, malting barley grain yield and 1000-grain weight increased. Tanaka and Nakano (2019)reported that, grain yield of barley and 1000-grain weight markedly increased with increasing N application from 0 to 30 and up to 60 kg/ha.

Therefore, there is a need to study the effect of nano-fertilizer application, seeding rate and nitrogen fertilization on growth andgrain yield and its components of barely under Sinia conditions.

MATERIALS AND METHODS

The present study was conducted at two field experiments ina private farm at Gilbana Zone in Sinai, East Qantarah District, Ismailia Governorate, Egypt, under Agronomy branch supervision, Plant production Department, Faculty of Technology and Development, Zagazig University, Egypt, during the two successive winter seasons 2015/2016 and 2016/2017.This investigation aimed to find out the effect of nitrogen fertilizer levels (15, 30, 45 and60 kg N/fad.), seeding rate (40,60 and 80 kg /fad.) and nano- fertilizer application **(**The nano fertilizer contains total nitrogen (N) 19%, P_2O_5 19%,K_2O 19%,Fe0.48%, Mg0.80 %, Mn0.24%, Zn 0.35%, B 0.05%, Cu0.08%, Amino acids 1.10 %, Algarextracts 0.52%, Mo 100 ppm and Co 100ppm) on yield and its components of barley.

The spilt-spilt plot design as a form of the randomized complete block design with three replications was followed. Since ,nano- fertilizer treatments were allotted in the main plots, while the three seeding rates were arranged at random in the sub plots. Whereas, the four nitrogen fertilizer levels were devoted to sub- sub plots. Each sub-sub plot area was 6 m^2 [3 x 2 m].

The preceding crop was maize in both growing seasons, Giza 132 barley cultivar seeds were drilled in rows on November 25th in both seasons. Whole sprinkle treatment with nano- fertilizer was applied basally at two equal doses after 20 and 40 days from sowing date, respectively in all treatments. Nano-fertilizer was used at the rate of 5 kg/fad.with concentration of 2g./water liter at both applications.

The four nitrogen fertilizer levels (ammonium sulfate 20.6%) were splitted into three equal doses and applied after 20, 40 and 60 days from sowing. Sprinkler irrigation method was used. The normal agricultural practices of barley crop were carried out perfectly. The mechanical and chemical analysis of the soil are given in Table (1).

Table (1): Soil mechanical and chemical properties of the experimental sites at 30 cm soil depth (average of the two seasons).

Soil properties		
A	***Soil particles distribution*:**	**(%)**
	Coarse sand	**49.40**
	Fine sand	**37.60**
	Silt	**7.25**
	Clay	**5.75**
Soil texture: Sandy		
B	***Chemical properties:***	
	Soil (pH)7.82	
	Ec (ds/m)7.79	
	Organic matter (%)0.28	
	Total CaCO3 (%) 2.31	
C	***Soluble anions concentration (ppm)***	
	CL^-78.84	
	HCO_3^-0.48	
	SO_4^-0.53	
D	***Soluble cautions concentration:***	**(ppm)**
	Available N	**5.30**
	Available P_2O_5	**3.90**
	Available K_2O	**71.10**

Grain yield and its components:

At harvest which took place after 140 days from sowing, a sample of ten random spikes from each plot were taken and the following characters were determined:

1- **Spike length(cm.):** It was measured as distance from the base of main spike to the top of spike excluding owns for randomly ten spikes/ plot.

2- **Number of spikelets/ spike:** It was determined at harvesting as a mean of ten spikes.
3- **Number of grains/ spike:** It was counted as an average mean of ten main spikes/ plot.
4- **Grain weight (g.)/Spike:** It was counted as an average mean of ten main spikes/ plot.
5- **Number of spikes/ m^2:** Average grain yield/m^2 were estimated for each plot was calculated.
6- **1000-grain weight (g.):** It was determined by the mean weight of a random l000 grain sample of the plot.

The grain yield/ fad was calculated using the yield obtained from 1 meter length of 5 central rows (1m2).

7- **Grain yield (ard./fad.):** Average grain yield/m^2 (1met. length of 5 central rows) were estimated for each plot and the yield of grains /fad.(ardab =120 kg .) was calculated.

The proper statistical analysis of spilt-split design was used combined analysis was /formed for the characters recorded in both season.

The collected data were statistically analyzed using the Analysis of Variance (ANOVA) to detect significance if any at treatment level. Differences among treatments were judged according to Duncan multiple rang test (Duncan, 1955). Means followed by different letters were statistically significant. In the interaction tables, small letters were used to compare means in columns, whereas capital ones were used to compare means in rows, using the COSTAT system for windows, version 6:311 (cohort software, Berkeley, CA, USA).

Regression analyses were conducted and regression equations describing the relationship between the dependent variables and N rate were fitted. Orthogonal contrasts were used to test for linear and quadratic responses to N rate.

RESULTS AND DISCUSSION

1. *Number of spikelets and grains/ spike*

Rerults in Table (2) show the effect of nano-fertilizer application, seeding rate and nitrogen fertilization on number of spikelets and grains/ barley spike in the two seasons .

1. a. *Nano-fertilizer effect:*

In the two growing seasons, application of nano-fertilizer produced much more spikelets and grains/ spike. The combined analysis supported this fact. The activity of water after adding nano-materials was increased and N, P and K

Table (2). Number of spikelets /spike and No. of grains/spike of barley as affected by nano-fertilizer, seeding rate, and nitrogen fertilization in both growing seasons and their combined.

Main effects and interactions	No. of spikelets/spike			No. of grains/spike		
	1st season	2nd season	Comb.	1st season	2nd season	Comb.
Nano-fertilizer application (A):						
Treated	27.56 a	28.49 a	28.02 a	20.79 a	21.86 a	21.33 a
Untreated	26.38 b	27.53 b	26.96 b	19.54 b	20.66 b	20.10 b
F-test	**	**	**	**	**	**
Seeding rate kg/fad. (S):						
40	27.98 a	28.39 a	28.18 a	21.21 a	22.03 a	21.62 a
60	26.55 b	27.76 b	27.16 b	19.86 b	21.03 b	20.44 b
80	26.39 b	27.87 b	27.13 b	19.42 b	20.72 c	20.07 c
F-test	**	**	**	**	*	**
Nitrogen fertilization kg/fad. (N):						
15	23.38 d	23.64 d	23.51 d	16.36 d	16.31 d	16.33 d
30	25.05 c	25.12 c	25.08 c	18.12 c	18.33 c	18.22 c
45	27.77 b	28.22 b	27.99 b	21.13 b	22.25 b	21.69 b
60	31.69 a	35.06 a	33.38 a	25.05 a	28.14 a	26.59 a
F-test	**	**	**	**	**	**
Interactions:						
AXS	NS	NS	NS	NS	*	NS
AXN	*	NS	*	**	**	**
SXN	*	NS	NS	**	**	**

Values having the different alphabetical letter(s) did significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

were absorbed by the plants along with the absorbed water, thus the production was also increased. These results are in a good line with those reported by Mardalipour *et al*.(2014), Abdel-Aziz *et al*. (2016), Janmohammadi *et al*.(2016b) and Kandil and Eman (2017).

1. b. *Seeding rate effect*:

The lowest seeding rate (40 kg/fad.) appeared to produce much more spikelets and grains/ spike as compared with the other two seeding rates. No significant difference between the two heavies seeding rates (60 to 80 kg/fad.)was observed in number of spikelets /spike in both seasons and their combined., Each increase in seeding rate from 40 , 60 and up to 80 kg/fad. was accompanied by a significant decrease in number of grains/spike. This was valid in the 2nd season and the combined analysis. As seeding rate increased, the number of grains/spike was decreased .Since, grain filling is depended on nutrient supply and environmental condition, increasing plant density resulted in increased competition for nutrients and sunlight at later stages, and finally most grains would fade at early stages, because of competition between growing grains to absorbing reserved matters and as a result low grains would be produced. This result obtained from this study was in line with Yasin and Omar (2013), Assefad *et al*. (2015) and Bekele *et al*. (2020).

1. c. *Nitrogen fertilization effect*:

Number of spikelets and grains/spike were significantly increased with each increment of N fertilizer rate up to 60 kg /fad. This was veridical in both growing seasons and their combined. Increase in the number of grains/spike might be due to better assimilation of carbohydrate in spike.

Assefad *et al*. (2015) reported that nitrogen increased the number of grains/ spike and this parameter is the best indicator of barley response to nitrogen. Number of grains/ spike had a linear and positive response to N fertilizer rate. These might be attributed to the ability of the plants that absorb high amount of N fertilizer, to translocate and assimilate N for the synthesis and development of spikelet during anthesis phase (Awulachew, 2019). Similarly , Shafi *et al*. (2011) reported that nitrogen applied at the rate of 60 kg/ ha resulted in maximum grains/ spike. In this direction similar conclusion were obtained bySafina (2010), Seadh *et al*. (2017), Dubey *et al*.(2018) and Terefe *et al*.(2018).

1. d. *Interaction effect:*

The combined results showed that the effect of the interaction between nano-fertilizer and N fertilization level (A x N) as shown in Table (2-a on No.

Table (2-a). Number of spikelets/spike of barley as affected by the interaction between nano-fertilizer application and nitrogen fertilization (combined data).

Nano- fertilizer application	Nitrogen fertilization (kg N/fad.) 15	30	45	60
Treated	**D 23.49 a**	**C 25.74 a**	**B 28.49 a**	**A 34.37 a**
Untreated	**D 23.52 a**	**C 24.43 b**	**B 27.50 b**	**A 32.38 b**

Table(2-b). Number of grains /spike of barley as affected by the interaction between nano-fertilizer application and nitrogen fertilization (combined data).

Nano- fertilizer Application	Nitrogen fertilization (kg N/fad.) 15	30	45	60
Treated	**D 16.37 a**	**C 18.90 a**	**B 22.56 a**	**A 27.47 a**
Untreated	**C 16.30 a**	**C 17.55 b**	**B 20.81 b**	**A 25.72 b**

of spikelets/spike was inoperative under the lowest N dose. Whereas, under the three higher dosesthis trait was supreme by application of nano-fertilizer. On the other hand, the increase rate in No. of spikelets/spike due to each increment of N fertilization was much more higher when nano-fertilizer was applied (3.62) than without nano-fertilizer (2.95).

Concerning the significant interaction effect between nano-fertilizer application and N fertilization on No. of grains /spike Table (2-b). the results showed similar trends of No. of spikelets. Also, the increase rate in no. of grains/spike due to each addition of level was much more higher under nano-fertilizer application (3.70) than without nano-fertilizer application (3.14).

In addition, the significant interaction effect between seeding rate and N fertilization respecting No. of grains /spike Table (2-c) indicated that the highest grain number (28.78) achieved by sowing with the lowest seeding rate and application of the highest N dose. Meanwhile, the lowest grains number/spike was recorded by the sowing with the highest seeding rate as well as application of the lowest N dose. Under the two lower N rats, number of grains/spike did not significantly vary due to varying seeding rate. However, under the two higher rates of N this number was higher when the lowest seeding rate was used.

2. ***Grain weight/spike (g) and No. of spike/m^2:***

2. a. ***Nano-fertilizer effect:***

Both grain weight/spike (g) and No. of spikes/m^2 were significantly superior with application nano-fertilizer compared to without application. This was fact in both growing seasons and their combined. The results of grain weight/spike are in accordance with those reported by Mardalipour *et al.*(2014), Janmohammadi *et al*.(2016b) and Ghorbanian *et al*. (2019). Also, for No. of spikes/m^2 the obtained results are in agreement with those reported by Moaveni *et al*.(2011), Kandil and Eman (2017) and Morsy *et al.(*2018).

Table(2-c). Number of grains /spike of barley as affected by the interaction between seeding rate and nitrogen fertilization (combined data).

Seeding rate (kg/fad.)	**Nitrogen fertilization (kg N/fad.)** 15	30	45	60
40	D 16.63 a	C 18.70 a	B 22.39 a	A 28.78 a
60	C 16.57 a	C 18.14 a	B 21.49 b	A 25.58 b
80	D 15.82 a	C 17.84 a	B 21.18 b	A 25.43 b

2. b. ***Seeding rate effect*:**

In both seasons, planting barley by the lowest seeding rate (40 kg/fad.) produced the heaviest grains/spike compared to that of the other two seeding rates. Sowing with the lowest seeding rate, resulted maximizing light interception, penetration, distribution in crop canopy and average light utilization efficiency of the leaves in the canopy, and thus effect yield of a plant. These results are confirmed with the results obtained by Noworolnik (2010), Donovan *et al*.(2011) and Yasin and Omar (2013). Difference between the two higher seeding rates in grain weight/spike did not reach the level of significance. This was the true in both growing seasons and their combined.

Concerning, No. of spikes/m2 , results revealed that it took the opposite trend so, the heaviest seeding rate give higher spikes number/ m2 compared to the lowest and moderate seeding rates. Maximum spike numbers in barley were achieved at the highest seeding rate used in every site-year. Such increment in No. of spikes/m^2 due to increasing sowing density could be attributed to increasing number of plants/ m^2. These findings are in harmony with those reported by Noworolnik (2010), Yasin and Omar (2013) and Abdel-Hady, Safada (2018). The difference in No. of spikes/m^2 between the two seeding rates (40 and 60 kg/fad.) was nonentity.

Table (3). Grain weight (g) /spike and No. of spikes/m^2 of barley as affected by nano-fertilizer, seeding rate, and nitrogen fertilization in two growing seasons and their combined.

Main effects and interactions	Grain weight (g)/spike 1st season	2nd season	Comb.	No. of spikes /cm^2 1st season	2nd season	Comb.
Nano- fertilizer application (A):						
Treated	0.731 a	0.778 a	0.754 a	344.4 a	343.8 a	344.1 a
Untreated	0.681 b	0.728 b	0.704 b	340 1 b	340.8 b	340.5 b
F-test	**	**	**	**	*	**
Seeding rate kg/fad. (S)						
40	0.743 a	0.788 a	0.765 a	341.5 b	340.8 b	341.1 b
60	0.693 b	0.741 b	0.717 b	341.0 b	341.4 b	341.2 b
80	0.682 b	0.731 b	0.706 b	344.2 a	344.7 a	344.5 a
F-test	**	**	**	**	*	**
Nitrogen fertilization kg/fad. (N):						
15	0.497 d	0.505 d	0.501 d	334.5 d	335.7 d	335 1 d
30	0.587 c	0.587 c	0.587 c	339.6 c	340.3 c	340.0 c
45	0.795 b	0.825 b	0.810 b	345.8 b	345.8 b	345.7 b
60	0.946 a	1.095 a	1.020 a	349.2 a	347.5 a	348.3 a
F-test	**	**	**	**	*	**
Interactions:						
AXS	NS	*	*	NS	NS	NS
AXN	**	*	**	NS	NS	NS
SXN	NS	NS	*	NS	NS	NS

Values having the different alphabetical letter(s) did significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

2. c. *Nitrogen fertilization effect:*

Grain weight /spike as well as number of spikes /m^2were significantly increased by each increment of N fertilizer level from 15 up to 60 kg N/fad. This was the true in both seasons and their combined. In case of N levels, maximum tillers/ $m^2$was produced with the application of 60 kg N/ ha when compared with other treatments. The probable reason might be that optimum nitrogen availability plays an essential role in plant growth whereas low or very high dose of nitrogen caused reduction in above ground vegetative growth of plant (Shafi *et al*., 2011). Similar results were reported by Seadh *et al*. (2017).

2. d. *Interaction effect:*

The interaction effect of nano-fertilizer and seeding rate on grain weight/spike was significant and is shown in Table (3-a).

Application of nano-fertilizer gave heavier grains/spike under the three tested of seeding rates. On other hand, the heaviest grains/spike was achieved due to the interaction effect between the lowest seeding rate (40 kg/fad.) and application of nano-fertilizer. Whereas, the lightest grains /spike (0.691g) was recorded under the above mentioned seeding rate without application of nano-fertilizer.

Table (3-a). Grain weight /spikeas (g .) affected by the interaction between nano-fertilizer application and seeding rate (combined data).

Nano- fertilizer Application	Seeding seed (kg/fad.) 40	60	80
Treated	**C 0.772 a**	**A 0.806 a**	**B 0.736 a**
Untreated	**B 0.691 b**	**A 0.725 b**	**B 0.697 b**

Grain weight/spike was significantly influenced by the interaction effect between nano-fertilizer and N fertilization Table (3-b). The results showed that grain weight/spike responded to nano-fertilizer when N fertilizer rate reached to 30 and up 60 kg/fad. However, under the lowest N rate (15 kg/fad.) this weight did not affected.

On the other hand, the rate of increase in grain weight/spike due to each increment of N fertilization level was much more higher when application of nano-fertilizer was added than without application of nano-fertilizer one.

Also, grain weight/spike was significantly affected by the interaction between seeding rate and N fertilization Table (3-c). Under the lowest N fertilization level, any increase in seeding rate from 40 to 60 and to 80 kg/fad. was accompanied by a significant decrease in grain weight/spike. Meanwhile,

Table (3-b). Grain weight /spikeas (g.) affected by the interaction between nano- fertilizer application and nitrogen fertilization (combined data).

Nano- fertilizer Application	Nitrogen fertilization (kg N/fad.) 15	30	45	60
Treated	D 0.506 a	C 0.614 a	B 0.850 a	A 1.048 a
Untreated	D 0.495 a	C 0.561 b	B 0.771 b	A 0.992 b

Table (3-c). Grain weight/spike (g.) as affected by the interaction between seeding rate and nitrogen fertilization (combined data).

Seeding rate (kg/fad.)	Nitrogen fertilization (kg N/fad.) 15	30	45	60
40	D 0.515 a	C 0.624 a	B 0.850 a	A 1.072 a
60	D 0.508 b	C 0.568 b	B 0.797 b	A 0.995 b
80	D 0.479 c	C 0.570 b	B 0.783 b	A 0.994 b

under the three other N fertilization rates, this weight was significantly decreased by increasing seeding rate only from 40 to 60 kg/fad.

3. *Thousand-grain weight (g) and grain yield (ardab/fad.):*

3. a. Nano-fertilizer effect:

Nano-fertilizer application (Table 4), results indicated significant differences in the first seasons and the combined analysis whereas, application of nano-fertilizer gave heavier 1000-grain than that of without application. In this direction similar conclusions were obtained by Abdel-Aziz, *et al*.(2016). Janmohammadi *et al*.(2016b),Kandil and Eman (2017), Morsy *et al*.(2018) and Ghorbanian *et al*.(2019).While in the second season, difference between with and without application did not reach the level of significance.

The superiority of nano-fertilizer application in almost the studied all grain yield attributes (Tables 2, 3 and 4) could account for superiority in grain yield/fad. The combined analysis showed that nano-fertilizer application was increased grain yield/fad. with about 7.72%. These results are in agreement with those reported by Abdel-Aziz *et al*. (2016). They found that all grain yield variables of wheat plants treated with nano-composite NPK fertilizer were increased about 63.82 % for grain yield. The possible reasons are: (i) nano NPK

Table (4). Thousand grain weight (g.) and grain yield (ardab/fad.) of barley as affected by nano-fertilizer, seeding rate, and nitrogen fertilization in both growing seasons and their combined.

Main effects and interactions	1000 - grain weight (g.) 1st season	2nd season	Comb.	Grain yield (ardab/fad.) 1st season	2nd season	Comb.
Nano- fertilizer application (A):						
Treated	34.74 a	34.81	34.77 a	8.861 a	9.357 a	9.109 a
Untreated	34.13 b	34.64	34.39 b	8.164 b	8.749 b	8.456 b
F-test	**	NS	**	**	**	**
Seeding rate kg/fad. (S):						
40	34.91 a	35.04 a	34.98 a	8.192 c	8.741 c	8.466 c
60	34.55 b	34.62 b	34.58 b	8.306 b	8.887 b	8.596 b
80	33.84 c	34.52 b	34.18 c	9.039 a	9.532 a	9.285 a
F-test	**	**	**	**	**	**
Nitrogen fertilization kg/fad. (N):						
15	30.38 c	30.91 d	30.64 c	5.818 d	5.942 d	5.880 d
30	32.65 b	31.74 c	32.20 b	6.980 c	6.947 c	6.963 c
45	37.61 a	37.33 b	37.47 a	9.687 b	10.020 b	9.853 b
60	37.10 a	38.92 a	38.01 a	11.560 a	13.290 a	12.425 a
F-test	**	**	**	**	**	**
Interactions:						
AXS	NS	**	**	*	**	NS
AXN	NS	*	**	**	*	NS
SXN	NS	*	**	*	**	*

Values having the different alphabetical letter(s) did significantly differ at the 0.05 level of significance, according to Duncan's multiple range test.

fertilizer promotes the plant to absorb water of soil and nutrients, then the photosynthesis is improved (Wu, 2013); (ii) nano NPK is considered the biological pump for plants to absorb nutrients and water, As reported by Ditta and Arshad (2016), Janmohammadi *et al*.(2016a), Abdulhady *et al*.(2018) and Spruogis*et al*.(2018).

3. b. ***Seeding rate effect:***

Seeding rate results indicated highly significant differences in both 1000-grain weight and grain yield (ardab / fad.) throughout the both growing seasons and the combined.

In the first season and the combined, 1000-grain weight was significantly decreased by any increase of seeding rate from 40 to 60 andup to 80 kg/fad. While in the second season this weight was only significantly decreased by raising seeding rate from 40 to 60 kg/fad.

Bekele *et al*. (2020) reported that when seeding rate increased from 100-175 kg/ha resulted in decreased 1000-grain weight by 23.51%.This could be due to high density caused to increasing number of spikes, and as result of competition would increase and little photosynthesis would available to grain filling and finally 1000-grain weight would reduce due to increasing number of spike. Therefore insufficient photosynthesis during grain filling stage in thick density may be the possible reason to decrease 1000-grain weight**.** This result is in line with those reported by O'Donovan *et al.* (2011),Iqbal and Ali (2010), Yasin and Omar (2013) and Mekonnen (2018).

Concerning the influence of seeding rate on grain yield/ fad. the results revealed highly significant differences during both growing seasons and their combined analysis where, the highest seeding rate of 80 kg /fad. appeared to produce the highest grain yield/fad.. In addition to, each increase in seeding rate from 40 to 80 kg/fad. was accompanied by a significant increase in grain yield/fad. This was valid in the two seasons and the combined analysis.

The superiority of seeding rate (80 kg /fad.) over the low and moderate rates of 40 to 60 kg/ fad. amounted to about 1.11% and 9.67%, in respective order. The increase in in yield with increasing seeding rate is due to more spikes being produced as a result of more plants being established. This explains why maintaining adequate plant populations is important for maximizing grain yields, given the low number of spikes produced, on average/ plants, as well as because tillering can never fully compensate for in adequate plant stands. Higher seeding rates are recommended because they also allow for greater crop competition against weeds.

When a reference is made to the data related to the yield attributes and components, it would revealed that the individual plant showed enhanced number of spikelets/spike and number of grains/spike Table (2), grain weight/spike and 1000-grain weight Table (4). The superiority seeding rate in all these mentioned characters was not adequate to compensate for the reduction grain yield/fad. The obtained results agree with findings of Mohammed and Hashem (2012) and Tigabu and Asfadw (2016).

3. c. *Nitrogen fertilization effect:*

Regarding the effect of nitrogen fertilizer levels on 1000-grain weight, results showed the highly significant effect of nitrogen on that trait(.1000-grain weight) was positively and significantly responded to N level up to 45 kg /fad. in the first season and the combined analysis. While ,in the second season this response was continued up to the highest N dose (60 kg/fad.) . These results are in accordance with those obtained by Shafi *et al*. (2011), Jankovic *et al*. (2011), Seadh *et al*.(2017), Dubey *et al*.(2018) and Kassie and Tesfadye (2019). Meanwhile, Mengistu and Abera (2014) and Terefe *et al*. (2018) reported that 1000 seed of malt barley weights had a linear and negative response to N fertilizer rates and exhibited non-significant difference among control and the rest of applied N treatments.

Rersults in Table 4 show that, grainyield/ fad. was obviously controlled by nitrogen application. Each increase in nitrogen fertilization doses was followed by a significant increase in this yield. These results were confirmed in both seasons and their combined analysis. The combined results indicated that application of 60 kg N/fad resulted in increases of 111.2, 78.3 and 26.0% compared to applying of 15, 30, and 45 kg N/fad, in respective order. The highest value of yield attributing characters were obtained under highest nitrogen level because plants were subjected to utilize the greatest amount of available nitrogen which resulted into increased translocation of photosynthesis from source to sink and thus led to rich growth and various yield attributing characters (Dubey*et al*., 2018).

In this investigation, N-fertilization was very effective on all yield characteristics studied viz. number of spikelets and grains/ spike as well as number of spikes/m^2 and weight of both grains/spike and 1000 grain which showed remarkable differences due to various N level (Tables 2, 3 and 4). All the yield attributes studied herein responded to more N application up to 60 kg N/fad. These findings are in harmony with those reported by Ryan *et al*.(2009), Safina (2010), Gezahegn and Kefadle (2016), Morsy*et al*.(2018), Terefe*et al.* (2018) and Awulachew (2019).

This might be due to the good influence of that major element on the growth traits and the attributing characteristics of barley grain yield. Also, it might be due to cumulative effect of growth and yield attributing characters owing to fertilization. Greater availability of metabolites and nutrients to developing reproductive structures seems to have resulted in increase in all the yield-attributing characters which ultimately improved the yield of the crop Singh *et al.*(2010). The increase in grain yield in response with increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photo-assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains (Gooding and Davies, 1997).

3. d. ***Interaction effect:***

Respecting the significant interaction effects among the studied fadctors regarding the combined results, the interaction effect between nano-fertilizer application and seeding rate (Table 4-a) indicated that the heaviest 1000 grain was achieved with nano-fertilizer under the lowest seeding rate (35.21g) whereas, the lightest 1000-grain was obtained without nano-fertilizer under the highest seeding rate (34.0 g). Only a significant difference in 1000-grain weight between with and without nano-fertilizer was showed under the lowest seeding rate.

On the other hand, 1000-grain weight was significantly decreased by raising seeding rate above 40 kg/fad. under with nano-fertilizer however, under without nano-fertilizer that weight was gradually decreased by raising rate from 40 to 60 and up to 80 kg/fad.

Table (4-a). Thousand grain weight (g.) of barley as affected by the interaction between nano-fertilizer application and seeding rate (combined data).

Nano- fertilizer Application	Seeding seed (kg/fad.) 40	60	80
Treated	A 35.21 a	B 34.75 a	B 34.36 a
Untreated	A 34.74 b	AB 34.42 a	B 34.00 a

Furthermore, the significant interaction effect between nano-fertilizer application and N fertilization Table (4-b), the results showed that 1000 grain weight was significantly increased only by nano-fertilizer under the N levels 45 and 60 kg/fad. Adding nano-fertilizer and the highest N rate produced the heaviest 1000 grain while, without nano-fertilizer with the lowest N level was recorded the lightest one.

Table (4-b). 1000- grain weight (g.) of barley as affected by the interaction between nano-fertilizer application and nitrogen fertilization (combined data).

Nano- fertilizer Application	Nitrogen fertilization (kg N/fad.) 15	30	45	60
Treated	**C 30.89 a**	**B 32.14 a**	**A 37.79 a**	**A 38.27 a**
Untreated	**C 30.40 a**	**B 32.25 a**	**A 37.15 b**	**A 37.75 b**

Finally, the significant interaction effect between seeding rate and N fertilization Table (4-c), indicated that the heaviest 1000 grain (38.92 g) was obtained by using the moderate seeding rate with the highest N level. Meanwhile, using the heaviest seeding rate with the lowest N level recorded the lightest 1000- grains (30.22 g).

Under application of 30 and 45 kg N/fad., 1000-grain weight was significantly decreased by raising seeding rate much more 40 kg seed/fad., however under the highest N level this weight took the opposite trend by raising seeding rate only up to 60 kg/fad.

It is evident that, the rate of increase in 1000- grain weight due to each increment of N level was much more higher when 60 kg seed/fad was used (2.74 g) than in the two other seeding rates 2.59 and 2.26 g for 40 and 80 kg seed/fad., respectively.

Table (4-c). 1000- grain weight (g.) of barley as affected by the interaction between seeding rate and nitrogen fertilization (combined data).

Seeding rate (kg/fad.)	Nitrogen fertilization (kg N/fad.) 15	30	45	60
40	**C 31.03 a**	**B 33.33 a**	**A 38.25 a**	**A 37.31 b**
60	**C 30.69 a**	**C 31.30 b**	**B 37.43 b**	**A 38.92 a**
80	**D 30.22 a**	**C 31.30 b**	**B 36.74 b**	**A 37.80 b**

Grain yield/fad was significantly affected by the interaction between seeding rate and N fertilization. This was true for grain yield/fad. in both seasons and their combined. Results in Table (4-d) show the effect of this interaction on grain yield /fad., according to the combined analysis.

It is obvious that with application of N fertilizer much more the lowest dose (45 kg./fad.) grain yield/fad. positively and significantly responded only to the highest seeding rate. Whereas, under the lowest N dose this yield was positively and significantly increased by any increment in seeding rate up to 80 kg/fad. The highest grain yield /fad. was achieved by using the highest seeding rate (80 kg/fad.) with application of the highest N dose (60 kg N/fad.). Whereas, the lowest grain yield was recorded by the lowest seeding rate under the lowest N level.

Table (4-d). Grain yield (ardab/fad.) of barley as affected by the interaction between seeding rate and nitrogen fertilization (combined data).

Seeding rate (kg/fad.)	**Nitrogen fertilization (kg N/fad.)**			
	15	**30**	**45**	**60**
40	**D** **5.590 c**	**C** **6.701 b**	**B** **9.515 b**	**A** **12.060 b**
60	**D** **5.957 b**	**C** **6.752 b**	**B** **9.600 b**	**A** **12.070 b**
80	**D** **6.095 a**	**C** **7.438 a**	**B** **10.450 a**	**A** **13.150 a**

Conclusion

This investigation was carried out on barley with the hope of increasing grain yield through a complementary effect could be traced between application of nano-fertilizer, seeding rate and nitrogen fertilization specially under Sinai conditions and changes in climate fadctors. Application of nano-fertilizer appeared to produce the highest value in No. of both spikelets and grains/ spike as well as weight of grains/spike, 1000- grain weight and grain yield/fad. The seeding rate of 80 kg/fad. appeared to produce the highest values in each of number of spikes/m^2 and grain yield/fad. Meanwhile, the seeding rate of 40 kg/fad. recorded the highest values in No. of both spikelets and grains/ spike, weight of both grains/spike and 1000-grain. Nitrogen fertilization was very effective on all yield characteristics, so any increase in N levels was followed by a significant increase in each of No. spikelets/spike, grains/spike and spikes/m^2, also weight of both grains/spike and 1000-grain weight.

These results finally recommend sowing barley with dense seeding rate of 80 kg/fad. and application of 60 kg N/ fad. In addition to application of nano-fertilizer to maximize grain yield /fad. under the experimental site and other likely environmental conditions.

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تأثير سماد النانو ومعدل التقاوي والتسميد النيتروجيني على محصول الشعير تحت ظروف سيناء

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أجريت تجربتان حقليتان بأحدي المزارع الخاصة بمنطقة جلبانة بسيناء مركز القنطرة شرق محافظة الاسماعيلية – مصر خلال موسمي الشتاء 2015/ 2016 و 2016/ 2017 وتهدف هذه الدراسة الى تقييم تأثير التسميد بالنانو (19% ن ، 19% فو2 أ 5، 19% بو2 أ ، 0.48% حديد، 0.80 % مغنسيوم ، 0.24 % منجنيز، 0.35 % زنك, 0,05 % بروم ، 8 0,0 % نحاس، 1.1% أحماض أمينية, 0.52 % مستخلص الجار ، 100 جزء في المليون موليبدنم و100 جزء في المليون كوبلت ، وثلاث معدلات تقاوى (40 ، 60 و80 كجم/ فدان)، واربع مستويات تسميد نيتروجيني (15، 30، 45 و60 كجم ن/ فدان) والوقوف على تأثير مختلف هذه المعاملات على محصول الحبوب ومكوناته لصنف الشعير جيزة 132.

كان التصميم التجريبي هو القطع المنشقة مرتين في قطاعات كاملة العشوائية بثلاث مكررات، وقد وضع التسميد بالنانو في القطع الرئيسية، ومعدلات التقاوي في القطع المنشقة الاولى تحت اربعة مستويات من التسميد النيتروجيني في القطع المنشقة الثانية.

كان لسماد النانو تأثيرات معنوية على محصول الحبوب ومكوناته خلال موسمي الزراعة حيث اظهرت النتائج أعلى القيم في كل من عدد السنيبلات/ سنبلة ، عدد الحبوب / السنبلة ، وزن الالف حبة ومحصول الحبوب/ فدان .

أثر معدل التقاوي معنويًا على معظم صفات المحصول ومكوناته وسجل معدل التقاوي 80 كجم/ فدان أعلى قيمة في كلا من عدد السنابل/ م2 ومحصول الحبوب/ فدان, بينما حقق معدل التقاوي 40 كجم/ فدان أعلى قيمة في عدد السنبلات/ السنبلة وعدد الحبوب بالسنبلة.

أثر التسميد النيتروجيني معنويا على محصول الحبوب ومكوناته خلال موسمي الزراعة حيث ازدادت قيمتهم معنويا بزيادة مستويات التسميد في كلا من عدد السنيبلات/ السنبلة، عدد الحبوب/ السنبلة، عدد السنابل/ م2، وزن الالف حبة ومحصول الحبوب/ فدان .

التوصية: توصى الدراسة بزراعة محصول الشعير صنف جيزة 132 بمعدل 80 كجم/ فدان والتسميد النيتروجيني بمعدل 60 كجم/ فدان مع المعاملة بسماد النانو وذلك تحت ظروف منطقة سيناء.