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Impact of Bio-Fertilizers and Nano Silica Rates on Bread Wheat Productivity under the New Valley conditions

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Abstract

To study the wheat productivity response to some bio-fertilizer types and nano silica rates under the New Valley conditions, a field experiment was implemented out in a private farm at the two successive growing seasons (2021/2022 and 2022/2023) in the New Valley governorate (El-Dakhla Oasis). The experiment was laid out using randomized complete blocks design in split plot arrangement were, the biofertilizers (Cerialen, Rhizobacteria and Azotobacter) plus control were assigned to the main plots, and Nano-Silica concentrations (0, 200, 400 and 600 ppm) were allocated in the sub-plots with four replications. All studied traits affected significantly by bio-fertilizer and nano silica rates in both seasons. Where, the Rhizobacteria biofertilizer gave tallest plants, longest spikes, the highest spikes number/m2, the heaviest weights of 1000-grain and grain yield/fad. Here too, increasing nano silica concentrations up to 600 ppm raise the number of spikes/m2, weight of 1000-grain and grain yield/fad, as well as plant height and spike length in both seasons. Furthermore, biofertilizers x nano-silica concentration interaction exhibited a significant impact on all studied traits in both seasons, except grain yield/fad in the first season. Rhizobacteria x 600 ppm interaction gave the highest mean values of plant height, spike length, number of spikes/m2, 1000 grain weight and grain yield/fad in both seasons.

Keywords: Bio-fertilizer, Nano silica, and Wheat (*Triticum aestivum*)

Introduction

Wheat (*Triticum aestivum.* L.) is a strategic crop and a major source of food both in Egypt and all over the world. It is known that the wheat crop is the first strategic crop in Egypt. It ranks first in terms of area as compared with other cereal crops. In Egypt, the wheat harvested area during 2021 season was about 3,320,376 fad. and the total production exceeded 9 million tons with an average of 2.712 ton/fad. While the consumption reached about 19 million tons in the same year which entails importing large quantities (more than 10 million tons) (**FAO, 2022**).

Biofertilization is considered one of the Eco-friendly practices which plays a good role in enhancement the soil fertility where their application improves both soil nutrients content, soil structure and decrease the chemical fertilizers requirements. Bio-fertilizers are other source of bio-organics plays a complementary role to satisfy the nutrients requirement of crops through biological nitrogen fixation, solubilization of insoluble native phosphorus sources, stimulation of plant growth and acceleration of decomposition process of plant residues. Azotobacter bacteria are important bio-inoculants for cereal crops, which fix the atmospheric nitrogen non-symbiotically. **El-Zeky (2005)** indicated that wheat grain inoculation with bio-fertilizer (*Cerialen*) gave a marked increase in plant height, spike length, weight of 1000 grain and grain yield/fad. **Al-Erwy *et al*., (2016), Mahato and Kafle (2018) & Kanitkar (2020)** detected that the bio-fertilizer (*Azotobacter* and *Rhizobium*) have a significant role in improving growth, wheat yield and its components so that Azotobacter can be used to get more grain yield. **Metwally (2019)** demonstrated that wheat grain inoculation with bio-fertilizer (*Cerialen*) recorded the highest mean values of plant height, spike length, spikes number/m^2, 1000-grain weight and grain yield. **Akhtar *et al*., (2021)** suggested that rhizobacteria plant growth promoter can improve wheat plants growth and wheat yield under drought stress.

The use of nano materials in fertilization strategies is a modern and an effective alternative to traditional fertilizers. Nano materials used as fertilizer obtain many advantages i.e., use in lower quantities and their high stability under different conditions which increases the easiness and ability to store them for longer periods. Nano silica fertilizer provides more chance for metabolic reactions in the plant which enhances the photosynthesis rate and consequently more dry matter production and yield productivity. **Ahmad *et al*., (2007)** showed that silicon application significantly increased plant height and spike weight of wheat. **Mushtaq *et al*. (2017)** indicated that Nano silicate improved growth of wheat. **Walsh *et al*. (2018)** denotes that positive response of wheat to silicon application and had affected grain crop under stress conditions. **Al-bourky *et al*., (2021)** stated that nano silicon significantly exceeded the plant height and number of spikes/m^2 of wheat. **Khoroshilov *et al*., (2021)** illustrated that Nano silicon application increased the number of productive stems, number of ears, number of grain/ear and 1000-grain weight of wheat.

Using bio-fertilization with nano silica can safeguard soil fertility in the long term and obtain higher crops productivity supply alimentation of poised nutrients to crops. **Haggag *et al*., (2018)** proven that bio-fertilizer and nano silica improved wheat resistance to stress and increased yield productivity. **Parveen and Mushtaq (2019)** showed the intense role of nano and bio-fertilizer in improving soil fertility and crop yield. **Ahmadi *et al*., (2021)** recommended that utilization of bio-fertilizer and nano silicon for increasing grain yield. **Akhtar *et al*., (2021)** and **Akhtar *et al*., (2022)** concluded that use of nano silica with bio-fertilizer improved the growth, yield attributed and wheat yield.

The aime of this study was to determine the response of bread wheat (Giza171 cultivar) productivity to bio-fertilizer and nano silica under New Valley conditions.

Materials and Methods

The present investigation was carried out in a private farm at El-Dakhla Oasis, the New Valley governorate, EGYPT during two winter growing seasons (2021/2022 and 2022/2023) to study the response of bread wheat productivity to bio-fertilizer and nano silica under New Valley conditions. The experimental soil was clay and its structure as presented in Table 1.

Table (1): Some of the physical and chemical properties of soil samples from the experimental site in 2021/2022 and 2022/2023 seasons.

Season	Physical				Chemical				
	Sand (%)	Silt (%)	Clay (%)	Texture	N (Available (ppm)	P (Available (ppm)	K (Available (ppm)	Soil pH	EC ds/m
2021/ 2022	15.6	34.3	50.1	clay	30.56	21.15	286.47	7.81	10.53
2022/ 2023	15.5	34.5	50.0	clay	32.60	20.92	253.60	7.45	9.20

Experimental Design

The experiment was laid out in a randomized complete block design (RCBD) arrangement in a split-plot with four replications. Biofertilizer types (*Cerialen*, *Rhizobacteria* and *Azotobacter*) plus control were assigned in the whole units and the nano silica rates (0, 200, 400 and 600 ppm) were allocated in the sub-units. The area of the experimental unit was 10.5 m^2 (3 m width x3.5 m long). Nitrogen fertilizer was added with a rate of 75 kg/fad. as ammonium nitrate form (33.5%N). Phosphorus fertilizer at a recommend rate (200 kg/fad) in mono-calcium super phosphate (15.5% P_2O_5) was applied before sowing. Giza 171 wheat cultivar was sown on 15th November in both seasons. The experimental area was left without proceeding crops cultivation in both seasons. Other agricultural practices were performed as recommended for wheat production.

Characters of study and measurement

At harvest, five random guarded stems were chosen from each experimental unit to determine the plant height (cm) and spike length (cm).

One square meter was harvested at random from each experimental unit to count the number of spikes/m^2 the grains were separated from each sample (m^2) and was count of each one 1000-grain then was weighed at gram (g). Finally, each experimental unit was harvested individually to determine grain yield/plot after grains threshing from the straw and weighted in kilograms and converted into ardab/Fadden (one ardab weighted 150 kg).

Statistical analysis:

All obtained data were subjected to statistical analysis according to **Gomez and Gomez (1984)** using package of MSTATC and **Excel, 2003**. Mean comparisons were done using the least significant differences (LSD. at 5% level of probability).

Results and Discussion

Effect of biofertilizers

The results, as shown in **Table 2**, indicate that there are significant differences resulting from the effect of the treatments in all studied traits. Plant height, spike length, number of spikes/m^2, 1000-grain weight and grain yield/fad. greatly affected significantly by the tested types of bio-fertilizers in both seasons.

The tallest plants (116.6 and 117.7 cm), the largest spike number/m^2 (540.3 and 557.0), the heaviest 1000-grain weight (55.60 and 57.05 g) and the biggest grain yields (15.13 and 16.50 ard,/fad.) in the two successive seasons respectively, as well as spike length (11.24 cm) in the 2nd season were obtained by Rhizobacteria treatment. Moreover, the longest spike (10.46 cm) in the 1st season was recorded by *Cerialen* treatment. These results may be due to nitrogen fixation by the bacterium contained in *Rhizobacteria* that enhances plant growth, hence it's reflected in spike character. Moreover, the increase in grain yield/fad. correlated with the number of spikes/m^2 and 1000 grain weight. **Namvar and Khandan (2013)** concluded that bio-fertilizer (*Azotobacter* sp.) inoculation increased plant height, number of spike/m^2, 1000 grains weight and grain yield of wheat. These results agree with those confirmed by **El-Zeky (2005), Al-Erwy *et al*. (2016), Mahato and Kafle (2018), Metwally (2019), Kanitkar (2020) and Akhtar *et al*. (2021).**

Effect of Nano-Silica rates:

Regarding nano silica concentrations, the results in the same table declared that the plant height, spike length, number of spikes/m^2, 1000 grain weight and grain yield/fad. in both seasons exerted highly significant influence by nano silica concentrations. In general, the above studied traits increased by increasing nano silica concentrations and the maximum mean values were realized by 600 ppm followed by 400 ppm in both seasons except number of spike m^2 in the first seasons 400 ppm followed by 600 ppm. It is clear from these data that application of nano silica to wheat enhanced the vegetative growth of the plant, increased weight and consequently reacted to wheat yield. **Ayman *et al*. (2020)** reported that nano silica has improved absorption of other nutrient such as nitrogen and phosphorus, as well as **Amer *et al*. (2022)** mentioned that nano silica remained superior by recording the highest yield attributes and this reflecting to maximum grain yield of wheat. These results are in accordance with those indicated by **Ahmad *et al*. (2007), Mardalipour *et al*. (2014), Mushtaq *et al*. (2017), Walsh *et al*. (2018) and Al-bourky *et al*. (2021).**

Table (2): Main effects of bio-fertilizer and nano silica rates on plant height(cm), spike length (cm), number of spikes/m^2, 1000-grain weight(g) and grain yield (ardb/fad) of wheat in 2021/2022 and 2022/2023 seasons.

Characters	Plant height (cm)		Spike length (cm)		Number of spikes/m^2		1000 grain weight (g)		Grain yield (ard./Fad)	
Main effects	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Bio-fertilizers										
Control	102.6	103.1	8.84	8.97	377.4	393.8	45.21	46.23	8.40	9.43
Cerialen	111.4	113.0	10.46	10.50	457.0	501.4	50.23	52.38	12.17	13.97
Rhizobacteria	116.6	117.7	10.45	11.24	540.3	557.0	55.60	57.05	15.13	16.50
Azotobacter	113.9	115.6	10.09	10.37	512.4	524.7	52.82	55.52	15.50	15.16
F- test	**	**	**	**	**	**	**	**	**	**
LSD 5 %	0.97	1.08	0.33	0.44	18.63	14.50	0.22	0.23	1.22	0.40
Nano silica										
Control	99.7	99.0	8.62	8.84	371.3	378.3	44.18	45.83	9.59	10.48
200 ppm	111.6	113.8	10.18	10.48	500.3	522.2	52.23	54.05	12.86	14.25

400 ppm	113.8	116.2	10.48	10.84	509.2	538.0	53.08	55.33	13.44	14.42
600 ppm	119.3	120.4	10.56	11.29	506.4	538.4	54.73	55.97	14.30	15.73
F – test	**	**	**	**	**	**	**	**	**	**
LSD 5 %	1.11	0.99	0.37	0.42	10.81	9.92	0.44	0.26	0.95	0.35

** indicated to highly significant at 0.01 probability level.
LSD= Least Significant Difference

With respect to the interaction between bio-fertilizer with nano silica concentration, the data in Table 3 declared that all studied traits exerted a highly significant influenced by this interaction in both seasons, except grain yield did not significant by this interaction in the 1st season. The longest spikes (11.40 and 12.43 cm) followed by (11.25 and 11.98 cm) were detected by Rhizobacteria x 600 ppm followed by *Cerialen* x 400 ppm nano silica concentration interaction treatments in the 1st and 2nd seasons, respectively. As well as the greatest No. of spikes/m² (587.5 and 611.0) followed by (575.0 and 589.0), the heaviest 1000 grain (59.31 and 60.07 g) followed by (57.33 and 60.02 g) were observed by Rhizobacteria x 600 ppm followed by Rhizobacteria x 400 ppm nano silica concentration interaction treatments without significant differences between them in the 1st and 2nd seasons, respectively. Moreover, the tallest plants (125.0 and 126.3 cm) followed by 120.8 and 122.5 cm), the heaviest grain yield/fad. (17.63 and 20.01 ard.) followed by (15.99 and 17.10 ard.) were recorded from Rhizobacteria x 600 ppm interactions followed by Rhizobacteria x 400 ppm nano silica concentration interaction treatments with significant differences between them in the 1st and 2nd seasons, respectively. Hence, the heaviest grain yield accompanied with the greatest number of spikes/m² and heaviest 1000 grain. Here, the relation between the bio-fertilizer and nano silica concentration was detected in both seasons. **Mardalipour *et al.*, (2014)** pointed out that bio-fertilizer and nano silica rate increased spike length, spikes number/m² and seed weight. These results confirmed with those found by **Haggag *et al*. (2018), Parveen & Mushtaq (2019), Ahmadi *et al*. (2021), Akhtar *et al*. (2021) and Akhtar *et al*. (2022).**

Table (3): The interaction effect of biofertilizer and nano-silica rates on plant height(cm), spike length (cm), number of spikes/m², 1000-grain(g) and grain yield (ard./fad) of wheat in 2021/2022 and 2022/2023 seasons.

Interaction	Characters	Plant height (cm)		Spike length (cm)		Number of spikes/m²		1000 grain weight (g)		Grain yield (ard./Fad)	
		2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Control	**Control**	93.2	89.5	8.15	8.22	322.0	304.0	41.55	41.62	6.55	7.27
	200 ppm	103.8	106.0	3.63	8.77	424.3	427.0	45.15	47.55	7.92	10.03
	400 ppm	104.6	106.8	8.13	9.02	496.8	441.0	46.64	47.51	8.74	10.12
	600 ppm	108.8	110.3	9.45	9.87	457.8	403.0	47.05	48.24	10.75	10.31
Cerialen	**Control**	100.8	101.8	8.45	8.65	336.0	364.0	42.15	44.56	8.85	11.02
	200 ppm	111.8	113.3	10.59	10.43	465.3	525.0	50.74	52.73	12.90	14.14
	400 ppm	112.0	118.3	11.25	11.28	502.0	553.0	52.73	55.70	13.58	14.02
	600 ppm	121.0	121.8	11.20	11.68	524.3	567.0	54.95	56.55	13.34	15.99
Rhizobacteria	**Control**	103.8	102.8	8.83	8.80	433.5	444.0	48.66	50.00	11.30	11.86

	200 ppm	117.0	119.5	10.65	11.78	565.3	584.0	57.10	58.61	15.58	17.02
	400 ppm	120.8	122.5	10.93	11.78	575.4	589.0	57.33	60.02	15.92	17.10
	600 ppm	125.0	126.3	11.40	12.43	587.6	611.0	59.31	60.07	17.63	20.01
Azotobacter	**Control**	101.3	102.0	9.05	9.70	393.5	401.0	44.00	47.14	11.66	11.78
	200 ppm	114.0	116.8	10.48	10.93	546.0	5528	55.94	67.83	15.02	15.81
	400 ppm	118.0	120.3	10.63	11.10	554.0	569.0	55.65	58.10	15.44	16.44
	600 ppm	122.3	123.3	10.20	11.18	556.0	576.0	557.0	54.01	15.47	16.61
F_{test}		**	**	**	**	**	**	**	**	N.S.	**
$LSD_{5\%}$		2.22	1.99	0.75	0.85	21.63	19.84	0.88	0.53	-	0.70

** indicated to highly significant at 0.01 probability level. N.S. = Insignificant differences.
LSD= Least Significant Difference.

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