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EFFECT OF NANO SILICA ON BREAD WHEAT UNDER WATER STRESS

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ABSTRACT

Two field experiments were conducted at Moshtohor region, Kalubia Governorate, Egypt, during 2020/21 and 2021/22 seasons, to study the effect of three water regimes (first treatment Normal irrigation at tillering stage, elongation stage, heading stage, milk stage and filling stage or irrigation intervals 30 days among irrigations. Second treatment Three irrigations at end tillering stage and starting elongation stage, at end heading stage and starting milk stage and filling stage or irrigation intervals 50 days among irrigations. Third treatment Two irrigations at end elongation stage and starting heading stage and filling stage or irrigation intervals 70 days between irrigations) and three silica nanoparticles (zero nano silica, 50 mg L^{-1} SiO2 and 100 mg L^{-1} SiO2) on growth characters of bread wheat. Results were showed that normal irrigation gave the highest values and highly significance for all growth traits under study.
Foliar application of silica nanoparticles were significantly increased in all studied traits.

Keywords: *Bread wheat, Water regimes, Nano-silica, Growth characters.*

1. INTRODUCTION

Wheat is deemed the major exporter of food in the world and Egypt. Increasing wheat output out of growing productivity and the cultivated space is a substantial national base to diminish the gap between the Egyptian output and consumption. Modern wheat varieties were developed to maximize grain yield under favorable environmental conditions (high input conditions especially water regime. In the light of the present national water policy concerning saving irrigation water expanding wheat area needs. Nanotechnology employs NPs having at least one dimension between 1 and 100 nm **(Auffan *et al*, 2009).** Although silicon (Si) is not traditionally considered as an essential element in plants, it has beneficial effect on plant growth, improves plant resistance to biotic stresses such as disease and various abiotic stressors such as cold, heat, drought, salinity and heavy metals and enhances photosynthesis (**Ma and Yamaji, 2006**).

There are many studies that have shown the effect of water regime or drought on wheat plants **(Fereres and Soriano, 2007, Dai, 2011, Hasanuzzaman *et al*, 2018, Sharma *et al*, 2017, O'Connell, 2017, Winter *et al*, 2017 and Ahmadian *et al*, 2021).**

Many investigators have reported high defers among nano silica applications treatments for growth of wheat **(Ma and Yamaji, 2006, Epstein, 2009, Schurt *et al*, 2014, Kashyap *et al*, 2016, Gao *et al*, 2018, Waraich *et al*, 2020 and Verma *et al*, 2021).**

There are many studies on the effect of nano silica under water regime or drought on wheat plant **(Ma, 2009, Van Bockhaven *et al*, 2013, Zhang *et al*, 2013, Alzahrani *et al*, 2018, Chen *et al*, 2018, Rastogi *et al*, 2019, Ahmad *et al*, 2020, Souri *et al*, 2020 and kandhol *et al*, 2022)**

Therefore, the present investigation was designed to study the performance and productivity of bread wheat under three irrigation intervals and three silica nanoparticles concentrations at Moshtohor region, Kalubia Governorate, Egypt.

2. MATERIALS AND METHODS

The present study was carried out during winter seasons 2020/2021 and 2021/2022 at Moshtohor region, Kalubia Governorate, Egypt, to study the effect of three water regimes (first treatment Normal irrigation at tillering stage, elongation stage, heading stage, milk stage and filling stage or irrigation intervals 30 days among irrigations. Second treatment Three irrigations at end tillering stage and starting elongation stage, at end heading stage and starting milk stage and filling stage or irrigation intervals 50 days among irrigations. Third treatment Two irrigations at end elongation stage and starting heading stage and filling stage or irrigation intervals 70 days between irrigations) and three silica nanoparticles spraying (zero nano silica, 50 mg L^{-1} SiO2 and 100 mg L^{-1} SiO2) on growth characters of bread wheat.

The ground was clay in texture, pH value, organic matter%, CaCO3% and EC (dSm^{-1}) were 7.92, 1.92%, 2.90% and 1.81 average of the first and second seasons.

=The treatments were designed in a split-plot design with three replications. Three water regimes were sorted at random in the master plots while, three silica nanoparticles spraying occupied the sub-plots. The sub-plot area was 10.5 m^2.

Wheat grains were planted in November 9th and 7th in the first and second seasons, respectively. In the two seasons, the preceding crop was corn. The normal cultural practices for growing wheat were followed as recommended for the region.

The nanosilicon dioxide was procured from Nanoamor (United States). The shape of SiO2 nanoparticles was spherical. Their average size and purity were 20 nm and 99.5%, respectively. Characterization of SiO2 nanoparticles by Field Emission Scanning Electron Microscope image (FESEM) and X-ray diffraction pattern of SiO2 nanoparticles. Dry powder SiO2 nanoparticles were purchased from US Research Nanomaterials. SiO2 nanoparticles were prepared at two concentrations (50, 100 mg L^{-1}) by dissolving in Hoagland's solution and dispersed with a high-power probe-type. Hoagland's solution without SiO2 nanoparticles was used as a control. Spray was done three times (45, 60 and 75 days after planting).

We measured fresh weight of shoot and root at 95 days after planting. Plants were covered in aluminum foil and dried at 70°C for 48 h, and then dry weight was measured.

Analysis of difference was done for the data of every season individually and combined analysis was proceeded for the data over the first and second seasons as stated by **Snedecor and Cochran (1980).**Treatment means were compared using least significant difference test at 0.05 level of significance. Using the MSTAT-C Statistical Software package (**Michigan State University, 1983**).

3. Results and Discussion

Analysis of variance for whole treatments in each season moreover the combined analysis is exhibited in **Table 1**. Test of homogeneity detected that the error difference for the first and second seasons were homogenous, therefore combined analysis was treated. Year's mean squares were extremely significant for all the studied characteristics were significant except root dry weight was insignificant. Water regime mean squares were extremely significant for all treatments in first and second seasons as well as the combined data. Nano silica treatments mean squares were hilly significant for all traits in first and second seasons plus the combined data. The interaction between years and water regime mean squares was not significant for all studied characters except root dry weight was significant. The interaction between years and nano silica treatments mean squares was insignificant for all of the studied characters. The interaction between water regime and nano silica treatments mean squares was significant for all studied characters except shoot dry weight in the first season and root dry weight in the second season were significant. The interaction between years, water regime and nano silica treatments mean squares were not significant for all of the studied traits.

-Effect of water regime.

The outcomes indicated in **Table 2** show clearly that, there were highly significant variance between water regime treatments in the combined analysis. Drought stress at 70 days treatment significantly decreased means of shoot fresh weight, root fresh weight, shoot dry weight and root dry weight compared to the normal irrigation

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Table (1) Mean square values and significance for some growth characters of wheat in 2020/2021, 2021/2022 seasons and their combined analysis**.**

SOV	df	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
			2020/21 season		
Rep	**2**	26.259	0.778	5.815	0.037
Drought	**2**	1967.3**	404.3**	907.1**	328.4**
Err.(a)	**4**	24.926	2.778	2.148	1.259
Silica	**2**	46.8**	34.7**	42.4**	49.1**
DxS	**4**	8.981**	2.444*	1.148	2.037**
Err.(b)	**12**	1.370	0.500	0.426	0.352
			2021/22 season		
Rep	**2**	6.481	0.481	1.037	1.037
Drought	**2**	1418.0**	429.5**	858.9**	279.3**
Err.(a)	**4**	3.704	0.704	0.259	1.148
Silica	**2**	56.481**	38.037**	36.148**	51.370**
DxS	**4**	3.037**	1.759*	2.370**	0.315
Err.(b)	**12**	0.407	0.407	0.352	0.222
			Combined analysis		
Years	**1**	124.519	40.907	22.685	6.000
R(Y)	**4**	16.370	0.630	3.426	0.537
Drought	**2**	3362.0**	831.685**	1765.72**	602.463**
D(Y)	**2**	23.352	2.241	0.352	5.389
Err.(a)	**8**	14.315	1.741	1.204	1.204
Silica	**2**	102.389**	72.296**	78.500**	100.463**
S(Y)	**2**	0.907	0.519	0.130	0.056
DxS	**4**	9.944**	4.102**	3.222**	1.741**
DxSxY	**4**	2.074	0.102	0.296	0.611
Err.(b)	**24**	0.889	0.454	0.389	0.287

*** and ** significant at 5% and 1% level of probability, respectively**

It could be decreases fresh and dry weights of shoot and root under drought stress by suggests less relative water absorption or water maintenance in wheat plants, when faced with drought. Moreover, reducing water use efficiency and RWC in plants under drought stress decreased turgor pressure and plant size. Thus, it may be a reason for decline in weight of wheat plants under drought stress. The results were obtained by **Fereres and Soriano (2007), Dai (2011), Hasanuzzaman *et al* (2018), Sharma *et al* (2017) O'Connell (2017), Winter *et al* (2017) and Ahmadian *et al* (2021).**

- Nano silica effect.

Results in **Table 2** showed that, shoot fresh weight, root fresh weight, shoot dry weight and root dry weight were highly significant affected by silica nanoparticles in the combined analysis. It is obvious that the significant greatest values of shoot fresh weight (113.61 g), root fresh weight (30.83 g), shoot dry weight (95.61 g) and root dry weight (29.55 g) were outputted by 100 mg L^{-1} sprayed treatment compared with other silica nanoparticles treatments. Otherwise, the control treatment (zero silica nanoparticles) outputting the minimum values of shoot fresh weight (108.88 g), root fresh weight (26.83 g), shoot dry weight (91.44 g) and root dry weight (24.83 g). Increasing in shoot and root weights at 50 and 100 mg L^{-1} concentrations proved that silicon oxide nanoparticles facilitated water uptake and its transportation into plant. This beneficial effects of silicon oxide might be associated to its hydrophilicity. These results agree with those obtained by **Ma and Yamaji (2006), Epstein (2009), Schurt *et al* (2014), Kashyap *et al* (2016), Gao *et al* (2018), Waraich *et al* (2020) and Verma *et al* (2021)**.

-Interaction effect.

Significant influence of interaction between water regime and nano silica was get for shoot fresh weight, root fresh weight, shoot dry weight and root dry weight in combined data (**Table 3**). Irrigation at 30 days and sprayed with 100 mg L^{-1} concentration treatment afford the highest values of height of shoot fresh weight (130.50 g), root fresh weight (39.16 g), shoot dry weight (107.00 g) and root dry weight (33.33 g). On the other hand, irrigation at 70 days and sprayed with zero silica treatment gave the lowest values of shoot fresh weight (98.83 g), root fresh weight (22.33 g), shoot dry weight (82.83 g) and root dry weight (20.66 g). The results obtained by **Ma (2009), Van Bockhaven *et al* (2013), Zhang *et al* (2013), Alzahrani *et al* (2018), Chen *et al* (2018), Rastogi *et al* (2019), Ahmad *et al* (2020), Souri *et al* (2020) and kandhol *et al* (2022).**

Table (2) Some growth characters of wheat as affected by water regime and nano silica spraying (over the combined analysis)

Treatments	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
Water regime				
30 days	**126.83**	**36.55**	**104.22**	**33.72**
50 days	**106.77**	**26.61**	**92.00**	**24.88**
70 days	**100.72**	**23.55**	**84.61**	**22.83**
LSD at 5%	**2.90**	**1.01**	**0.84**	**0.84**
Nano silica				
Zero	**108.88**	**26.83**	**91.44**	**24.83**
50 mg L^{-1}	**111.83**	**29.05**	**93.77**	**27.05**
100 mg L^{-1}	**113.61**	**30.83**	**95.61**	**29.55**
LSD at 5%	**0.64**	**0.46**	**0.42**	**0.36**

Table (3) Effect of the interaction between water regime and nano silica spraying on some growth characters of wheat (over the combined analysis)

Water regime	Nano silica	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
	Zero	122.83	33.50	101.16	31.00
30 days	**50 mg L^{-1}**	127.16	37.00	104.50	33.33
	100 mg L^{-1}	130.50	39.16	107.00	33.33
	Zero	105.00	24.66	90.33	22.83
50 days	**50 mg L^{-1}**	107.00	26.66	92.00	25.00
	100 mg L^{-1}	108.33	28.50	93.66	26.83
	Zero	98.83	22.33	82.83	20.66
70 days	**50 mg L^{-1}**	101.33	23.50	84.83	22.83
	100 mg L^{-1}	102.00	24.83	86.16	25.00
LSD at 5%		**1.12**	**0.80**	**0.74**	**0.63**

4. CONCLUSION

We concluded that, the best irrigation was recorded at 30 days from sowing. Also, the treatment of SiO_2 lead to significant increase in the growth parameters and metabolic activities at 100g/L SiO_2 in root and shoot system, compared with reference control.

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