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Effect of Nano form ZnO priming Treatments on Growth and Yield of different Wheat Variety

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ABSTRACT: In order to determine the impact of nano form ZnO priming treatments on the yield and yield-contributing characteristics of six wheat varieties, the current experiment was conducted at the Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar. WH 1184, WH 1105, WH 1124, HD 2967, HD 2851, and PBW 343 wheat varieties' seeds were primed with 100 ppm ZnO nanoparticles before sowing in the field beside a control crop that had not been treated. All the types were assessed for yield and yield-contributing traits, including test weight, grain yield, biological yield, plant height, number of effective tillers, number of grains per spike, spike length, and number of spikelets per spike. The seeds of all wheat varieties when primed with 100 ppm ZnO nanoparticles at 4 hours duration gave significantly greater plant height, number of effective tillers, number grains per spike, number of spikelets per spike, test weight, grain and biological yield than untreated seeds. The maximum increase in plant height was recorded in WH1184 (5.04%) followed by PBW343 (4.92%). The maximum increase in number of grains per spike was recorded in HD2967 (14.48%) followed by WH1124 (6.16%). The maximum increase number of effective tillers per plant was recorded in PBW343 (14.46%) and HD 2967 (14.20%). The maximum increase in test weight was recorded in WH1124 (5.14%) and WH1105 (3.66%). The maximum increase in grain yield was recorded in HD2967 (14.3%) followed by WH1184 (12.3%) that of biological yield was recorded in WH1124 (15.26%) and WH1105 (11.10%).

Keywords: wheat, nano priming, ZnO, grain and biological yield.

INTRODUCTION

The rapid population growth and climate change-related problems are putting the world's food security in danger. By 2050, the world's population will be close to 9 billion, and food demand will rise by up to 70 per cent (UNPD, 2006). World requires an extra one billion tones of cereal production with the limited resources (Pask and Reynold 2013). Wheat (*Triticum aestivum* L.) has a central role in world food security; as it contributes about 30 per cent to the food basket which serves as a major staple food source for over 1/5th of human population worldwide (FAO, 2011). Therefore, there is a need to boost wheat yield, which can only be done by using scientific instruments and methods in agriculture. Information technology, biotechnology, and nanotechnology are the methods in modern science.

It is believed that the zinc content of cultivated soils worldwide is insufficient in 30 per cent of cases (Suzuki *et al.,* 2006). Zn deficiency is thought to affect around 10 Mha of the Indo-Gangetic plains in India (Singh *et al.,* 2005). Nanotechnology is an area of science that deals with the creation and use of nanoparticles that range in size from one to one hundred nanometers (nm) (Roco 2003). However, its application in agriculture is still limited (Tile *et al.,* 2016); even research work-related nanotechnology started around 50 years ago (Mukhopadhyay, 2014). These nanoparticles are currently used and are the subject of extensive research in various sectors, such as defence and security, medicine, textiles, biotechnology, electronics, cosmetics and paints, optical engineering, energy and communications (Biswas and Wu 2005). Zinc oxide nanoparticles (ZnO NPs) are the most often employed nanoparticles (NPs) because they have some advantages for agricultural output. Zinc oxide nanoparticles (ZnO NPs) have been shown to increase plant growth and yield parameters such as biomass, stem height, and spike length in wheat, as well as ameliorate zinc deficiency symptoms (Munir *et al.,* 2018; Rizwan *et al.,* 2019). By encouraging seed germination, seedling vigour and development, as well as improved stem and root development in peanuts, zinc oxide nanoparticles have tremendous potential to influence the output and growth of food crops (Prasad *et al.,* 2012).

On the other hand, many techniques are employed to deliver ZnO nanoparticles to wheat plants, including foliar spraying, soil mixing, and seed priming (Rizwan *et al.,* 2017). According to Moghaddasi *et al.* (2017), soil characteristics can limit the amount of nutrients that plants can absorb due to variations in the dissolution, aggregation, and surface qualities of NPs in the soil (Rizwan *et al.,* 2017). Simple and inexpensive, seed priming increases germination rates and reduces intrinsic physiological non-uniformity in germination by allowing primed seedlings to quickly absorb and renew their metabolism (Dimkpa *et al.,* 2012; Dimkpa, *et al.,* 2012b). Additionally, the priming of seeds can enhance the quality and quantity of crop growth (Rico *et al.,* 2014; Ali *et al.,* 2017). In order to remove soil constraints and assess the impact of ZnO NPs on the growth parameters of wheat, the seed priming approach was chosen.

MATERIALS AND METHODS

The field study was carried out in the rabi season of 2020–21 at the research farm of the Department of Seed Science and Technology at Chaudhary Charan Singh Haryana Agricultural University, Hisar. The location is located between 29°10' N latitude and 73°43' E longitude and is about 215.2 m above mean sea level. It is part of the Trans-Gangetic Plain. Split plot design was used to set up the experiment. For the experiment, six wheat varieties- WH 1184, WH 1105, WH 1124, HD 2967, HD 2851, and PBW 343 were employed. Each variety's seeds were sown in the field alongside untreated control seeds after being primed for 4 hours with 100 ppm ZnO nanoparticles. Each treatment was replicated thrice. When different wheat varieties reached physiological maturity, the number of productive tillers was counted. A few days prior to crop harvest, yield parameters such spikelet length, spikelet number, and grain number were recorded. Following harvest, the grain and biological yields were noted. All of the parameter data were statistically analysed using analysis of variance for split plot design. OPSTAT software was used to evaluate the means at a $P > 0.05$.

RESULTS

Plant height (cm) and number of effective tillers. The data related to effect of different ZnO nanoparticles priming on plant height and days to maturity of six different wheat varieties is presented in the table 1. The seeds of all wheat varieties when primed with 100 ppm ZnO nanoparticles gave significantly greater plant height than untreated seeds. Maximum plant height was recorded in seeds primed with 100 ppm ZnO nanoprticles in WH1184 (106.67 cm) followed by HD2967 (99.79cm). The maximum increase in plant height was recorded in WH1184 (5.04%) followed by PBW343 (4.92%).

Similarly, highest number of effective tillers per plant was recorded in similar treatment in WH1184 (10.00) followed by HD 2967 (9.97). The maximum increase number of effective tillers per plant was recorded in PBW343 (14.46%) followed by HD 2967 (14.20%).

Table 1: Effect of nanoform ZnO priming on, plant height and No. of effective tillers/plant of different wheat cultivars.

Plant height (cm)					No. of effective tillers/plant		
Trt., Var.	ZnO (100 ppm)		Untreated	Per cent change	ZnO (100 ppm)	Untreated	Percent change
WH1184	106.67		101.55	5.04	10.00	8.87	12.74
HD2967	99.79		96.58	3.32	9.97	8.73	14.20
WH1105	99.13		98.85	0.28	9.10	8.80	3.41
WH1124	95.02		90.83	4.61	8.00	7.53	6.24
HD2851	85.98		83.75	2.66	8.43	8.30	1.57
PBW343	92.25		87.92	4.92	8.47	7.40	14.46
Mean	96.47		93.25		8.99	8.27	
Factors	V		T	(V × T)	V	T	(V × T)
C.D.(P=0.05)	2.46		1.42	NS	0.64	0.37	NS

Number of grains and spikelets per spike. Data in the table 2 represents the average value of number of grains per spike and number of spikelets per spike in six different wheat varieties. The seeds of all wheat varieties which was primed with 100 ppm ZnO nanoparticles reported significantly higher No. of grains per spike and No. of spikelets per spike as compared to untreated seeds. Maximum No. of grains per spike was recorded in seeds primed with 100 ppm ZnO nanoprticles in HD2967 (55.33) followed by WH1105 (51.33). The maximum increase in number of grains per spike was recorded in HD2967 (14.48%) followed by WH1124 (6.16%).

Maximum No. of spikelets per spike was recorded in seeds primed with 100 ppm ZnO nanoprticles in HD 2967 (22.33) followed by WH1184 (22). The maximum increase in No. of spikelets per spike was recorded in WH1184 (15.36%) followed by HD 2967 (13.39%).

Table 2: Effect of nanoform ZnO priming on, No. of grains per spike and No. of spikelets of different wheat cultivars.

	No. of grains per spike			No. of spikelets per spike		
Trt., Var.	**ZnO (100 ppm)**	**Untreated**	**Per cent increase**	**ZnO (100 ppm)**	**Untreated**	**Per cent increase**
WH1184	50.33	49.00	2.71	22.00	19.07	15.36
HD2967	55.33	48.33	14.48	22.33	19.60	13.93
WH1105	51.33	50.00	2.66	19.53	18.40	6.14
WH1124	46.00	43.33	6.16	18.73	17.67	6.00
HD2851	44.67	43.00	3.88	21.13	19.27	9.65
PBW343	50.00	49.00	2.04	18.20	17.73	2.65
Mean	49.44	47.28		20.32	18.62	
Factors	V	T	(V × T)	V	T	(V×T)
C.D. (P= 0.05)	2.34	1.35	3.31	1.25	0.72	NS

Test Weight (g) and spike length (cm). The data pertaining to the effect of seed treatment with ZnO nanoparticles and soaking duration on test weight and spike length of different six wheat varieties is presented in Table 3. The seeds of all six varities treated with 100 ppm ZnO nanoparticles gave significantly greater test weight and spike length than untreated seeds. The test weight was recorded maximum in seeds primed with 100 ppm ZnO NPs at 4 h soaking duration in PBW 343 (42.64g) followed by WH1105 (42.50g). The maximum increase in test weight was recorded in WH1124 (5.14%) followed by WH1105 (3.66%).

Maximum spike length was recorded in seeds primed with 100 ppm ZnO nanoprticles in WH1105 (10.48cm) followed by WH1184 (10.32cm). The maximum increase in spike length was recorded in PBW 343 (7.19%) followed by HD 2851 (5.22%).

Table 3: Effect of nanoform ZnO priming on, test weight and spike length of different wheat cultivars.

	Test Weight (g)			Spike length (cm)		
Trt., Var.	**ZnO (100 ppm)**	**Untreated**	**Per cent change**	**ZnO (100 ppm)**	**Untreated**	**Per cent change**
WH1184	40.07	39.87	0.50	10.32	10.13	1.88
HD2967	41.20	39.85	3.39	9.68	9.57	1.15
WH1105	42.50	41.00	3.66	10.48	9.98	5.01
WH1124	39.50	37.57	5.14	8.57	8.44	1.54
HD2851	40.85	39.73	2.82	9.68	9.20	5.22
PBW343	42.64	41.62	2.45	8.95	8.35	7.19
Mean	41.13	39.94		9.59	9.30	
Factors	V	T	(V X T)	V	T	(V XT)
C.D.(P=0.05)	1.26	0.73	NS	0.45	0.26	NS

Grain and Biological yield (kg/plot). The data related to effect of different ZnO nanoparticles priming on grain and biological yield of six different wheat varieties is presented in the Table 4. The seeds of all wheat varieties when primed with 100 ppm ZnO nanoparticles gave significantly greater grain and biological yield than untreated seeds. Maximum grain yield was recorded in seeds primed with 100 ppm ZnO nanoprticles in HD2967 (7.00 Kg/plot) followed by WH1184 (6.93 Kg/plot). The maximum increase in grain yield was recorded in HD2967 (14.3%) followed by WH1184 (12.3%).

Maximum biological yield was recorded in seeds primed with 100 ppm ZnO nanoprticles in WH1184 (22.67 Kg/plot) followed by WH1105 (19.92 Kg/plot). The maximum increase in biological yield was recorded in WH1124 (15.26%) followed by WH1105 (11.10%).

Table 4: Effect of nanoform ZnO priming on grain and biological yield of different wheat varieties.

	Grain Yield (kg)/plot			Biological Yield (kg)/plot		
Trt., Var.	**ZnO (100 ppm)**	**Untreated**	**Percent increase**	**ZnO (100 ppm)**	**Untreated**	**Percent increase**
WH1184	6.93	6.17	12.3	22.67	20.52	10.48
HD2967	7.00	6.12	14.3	17.67	16.10	9.75
WH1105	6.56	6.06	8.25	19.92	17.93	11.10
WH1124	6.12	5.52	10.8	17.67	15.33	15.26
HD2851	6.59	6.14	7.32	19.59	18.33	6.87
PBW343	5.66	5.12	10.5	18.07	17.00	6.29
Mean	6.48	5.86		19.26	17.53	
Factors	V	T	(V × T)	V	T	(V × T)
C.D.(P=0.05)	0.39	0.22	NS	1.64	0.95	NS

DISCUSSION

When primed with 100 ppm ZnO nanoparticles, the seeds of all wheat varieties produced noticeably taller plants and longer spikes than untreated seeds. Different varieties react to ZnO NPs in different ways. The extraordinary role that zinc plays in the synthesis of auxin, which enhances the vegetative growth of the plant including plant height, may account for the rise in plant height caused by the administration of ZnO NPs (Rastogi *et al.,* 2013). The likely cause of the spike length increase was the function of zinc in growth hormones (auxin). The increase in spikelet number may have been favoured by the longer spikes and improved carbohydrate nutrition made possible by zinc replenishment. According to Ljubičić *et al.* (2020), ZnO nanoparticles can greatly improve wheat plant height and spike length. However, the plant's reaction to ZnO nanoparticles also significantly depends on the application's dose and the genotype of the wheat.

According to Naderi and Abedi (2012), Zn plays a crucial function in preserving and upholding the structural stability of cell membranes, which may account for the rise in vegetative development in plants. The creation of chlorophyll, sustaining membrane functions, the synthesis of cytochromes and nucleotides, seed development, and stalk maturation all depend on zinc, a critical element for plants. In the presence of a Zn shortage, crop maturation takes longer while tillering, leaf blade area, and chlorophyll content decline. Tillering can be completely stopped if the shortage is severe (Dobermann and Fairhurst 2000). The importance of Zn in the creation of chromatin structure and consequently in cell division may have contributed to the increase in the number of tillers, which are significant culminators of yield.

The probable reason for the spike length increase may have been zinc's function in growth hormones (auxin). The increase in spikelet number may have been favoured by the longer spikes and improved carbohydrate nutrition made possible by zinc replenishment. The efficacy of zinc on these components is also depicted in research of several other workers (Abbas *et al.,* 2011; Shehu *et al.,* 2011). Another crucial element in the spectrum of yield components is the quantity of grains per spike. The availability of zinc, which has been considered to be necessary for seed development, is definitely a factor (Ronen 2016). With ZnO NP treatments, there are more spikelets per spike, which equates to more grains.

Zinc is essential for several biological processes, including photosynthesis, respiration, chlorophyll synthesis, biomass generation, and dry matter output. The present results draws support from the findings of Tondey *et al.* (2021) reported that in comparison to bulk $ZnSO_4$ and control treatments, maize seeds treated with ZnO NPs (20 mg /L) produced more vegetative and yield metrics (number of plants, plant height, stover yield and plant biomass), hemicellulose content, and shoot zinc content. In this concern, Prasad *et al.* (2012) stated that some crops may produce more and grow more quickly when exposed to zinc oxide. Additionally, they stated that a 1000 ppm concentration of zinc oxide nanoscale treatment (25 nm mean particle size) improved seed germination and plant growth in peanuts. Zn can also be employed for protein synthesis, membrane function, cell elongation, and stress tolerance, according to Cakmak (2000). With respect to the effect of Zn on yield and yield components, these results are consistent with those stated by Asadazade *et al.* (2015) on sunflower plant. Wheat plant yield parameters may have increased due to growth parameters and photosynthetic pigment concentrations, which led to a rise in the synthesis of all substances and bio constituents and their transfer from leaves and other plant organs to seed formation.

For the growth and development of plants, zinc is a crucial trace element. It is one of the most crucial components for the organic growth of other crops, such as wheat. This is because over 300 enzymes involved in various physiological processes require zinc as an important cofactor (Auld, 2001). Nano ZnO was found by Adhikari *et al.* (2015) to be able to boost and maintain maize growth. The application of nano ZnO improved plant height, root volume, root length, and dry matter weight. Rizwan *et al.* (2019) reported that Zinc oxide nanoparticles may ameliorate zinc deficiency, raise root volume, improve plant growth and yield parameters, such as biomass, stem height, and spike length in wheat, and boost seed germination. The number of panicles per plant, panicle length, number of grains per panicle, and 100-grain weight all significantly increased after the application of nano-fertilizers of CuO and ZnO, according to Sandanayake *et al.* (2022). Furthermore, both conventional and inbred rice cultivars showed increases in yield. Similar findings were reported by Waqas *et al.* (2022) in rice, Prajapati *et al.* (2018) in wheat, Farnia *et al.* (2015) in maize, Salama *et al.* (2019) in *Phaseolus vulgaris* and Munir *et al.* (2018) in wheat.

CONCLUSIONS

We attempted to assess the impact of ZnO NPs on wheat growth and yield in the current study. With the seed priming of 100 ppm of ZnO NPs in comparison to the control in several wheat varieties, plant growth, photosynthesis, and biomass grains all rose linearly. Therefore, administering Zn in the form of nanoparticles may aid in boosting agricultural productivity. The mechanistic understanding of the application of NPs in this field, however, may be further improved by field investigations with various nanostructure sizes, shapes, circumstances, and plants.

Conflict of Interest. None.

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