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Effect of Nanoparticles on Wheat Seed Germination and Seedling Growth

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***Abstract*—**Wheat is an important cereal crop for food security. Boosting the wheat production and productivity is the major challenge across the nation. Good quality of seed is required for maintaining optimum plant stand which ultimately increases grain yield. Ensuring a good germination is one of the key steps to ensure proper plant stand and moisture assurance during seed germination may help to speed up the germination. The tiny size of nanoparticles may help in entry of water into seed without disturbing their internal structure. Considering above, a laboratory experiment was conducted during 2012-13 at G.B. Pant University of Agriculture and Technology, Pantnagar, India. The completely randomized design was used for statistical analysis. The experiment was conducted in two phases. In the first phase, the appropriate concentration of nanoparticles for seed treatment was screened. In second phase seed soaking hours of nanoparticles for better seed germination were standardized. Wheat variety UP2526 was taken as test crop. Four nanoparticles (TiO_2, ZnO, nickel and chitosan) were taken for study. The crop germination studies were done in petri dishes and standard package and practices were used to raise the seedlings. The germination studies were done by following standard procedure. In first phase of the experiment, seeds were treated with 50 and 300 ppm of nanoparticles and control was also maintained for comparison. In the second phase of experiment, seeds were soaked for 4 hours, 6 hours and 8 hours with 50 ppm nanoparticles of TiO_2, ZnO, nickel and chitosan along with control treatment to identify the soaking time for better seed germination. Experiment revealed that the application of nanoparticles help to enhance seed germination. The study revealed that seed treatment with nanoparticles at 50 ppm concentration increases root length, shoot length, seedling length, shoot dry weight, seedling dry weight, seedling vigour index I and seedling vigour index II as compared to seed soaking at 300 ppm concentration. This experiment showed that seed soaking up to 4 hr was better as compared to 6 and 8 hrs. Seed soaking with nanoparticles specially TiO_2, ZnO, and chitosan proved to enhance germination and seedling growth indices of wheat crop.

Keywords—Nanoparticles, seed germination, seed soaking, wheat.

I. Introduction

WHEAT (*Triticum aestivum* L.) is one of the oldest and most important cereal crops. Wheat plays an important role in total cereal production and global food security [1]. India is the second largest producer of wheat in the world next to China. Wheat is the second most important crop in India after rice and contributes nearly 35% to the national food basket [2]. India will require 109 million tons of wheat to feed the population of 1.25 billion by 2020 A.D, which can be achieved by growth rate of 2.2% but the current growth rate is only 1.0% [3]. Wheat cultivation in India occupies 30.23 million hectare area with the production of 93.50 million tonnes and productivity of 30.93 q per ha [4]. It is very difficult to meet the food demand in future because land is shrinking and pressure on productivity enhancement is also increasing. Productivity of wheat can only be enhanced by application of scientific tools and techniques in agriculture. Modern science basically deals with three areas i.e. information technology, biotechnology and nanotechnology. These three sciences proved their worth in every sector of society, but agriculture is still lagging behind.

Nanotechnology is defined as the study of phenomena and the manipulation of materials at the atomic, molecular and macromolecular scales, where the properties differ from those at a larger scale [5]. Nanoparticles are the particles having size range between 1 and 100 nm [6], [7] and having different physicochemical properties as compared to the bulk materials [8]. Nanoparticles may help to improve nutrient use efficiency because of their small size, more surface area and their slow rate of release, which facilitate to the plants to take up most of the nutrients without any waste.

II. Materials and Methods

In order to evaluate the effect of nanoparticles on germination tests, two experiments were conducted following the techniques of Completely Randomized Design (CRD). For screening of nanoparticles, four nanoparticles (ZnO, nickel, TiO_2 & chitosan) at two concentration levels i.e. 50 ppm and 300 ppm were tested on wheat crop. To prepare solution, nanoparticles were directly suspended in deionized water and dispersed using mechanical stirrer and ultrasonicator (100W, 40 khz) for 30 min.

On the basis of findings of first experiments, 50 ppm concentration was used for testing for soaking period of wheat. To prepare solution, nanoparticles were directly suspended in deionized water and dispersed using mechanical stirrer and ultrasonicator (100W, 40 khz) for 30 min. Then 25 seeds were soaked separately in solution (1 gm seed in 1 ml solution of nanoparticles) of these nanoparticles for 4, 6 and 8 hours respectively. After soaking, seeds were placed in petri dishes which contain two moist towel papers. These seeds were arranged in petri dishes in such a manner that radical end of each seed oriented downwards. The petri dishes were placed in an incubator maintained at 20±1 ºC. Water was

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regularly poured to maintain optimum moisture level of germination media i.e. towel paper. The seeds were examined every day.

At the end of final germination count mean germination time was calculated by the formula suggested by [9]:

$$MGT = \frac{\sum(nXdi)}{Number\ of\ seed\ sown}$$

where, n= number of seeds newly germinated on ith day; di= number of the day

Seedling vigour index-I and seedling vigour index-II were computed as per the formula suggested by [8]:

$$SVI - I = \text{Germination \% X Seedling length (cm/seedling)}$$
$$SVI - II = \text{Germination \% X seedling dry weight (mg/seedling)}$$

III. Results and Discussion

A. Effect of Nanoparticles on Germination Tests of Wheat at Different Concentrations

Germination percentage, germination rate, mean germination time (MGT) and root dry weight did not differ significantly due to different concentrations of nanoparticles, while root length, shoot length, seedling length, shoot dry weight, seedling dry weight, SVI I and SVI II of the seedlings were significantly affected by different concentrations of the nanoparticles (Table I). Seed soaking with TiO_2 @ 50 ppm increased root length shoot length, seedling length and SVI over control treatment by 35.16, 62.11, 41.84 and 43.73%, respectively. Significantly higher root length, shoot length, seedling length, and SVI-I was recorded for with TiO_2 @ 50 ppm, which was at par with nickel @ 50 ppm, chitosan @ 50 ppm and ZnO @ 50 ppm for root length, seedling length and SVI I. Higher shoot length was observed with TiO_2 @ 50 ppm which was at par with ZnO @300 ppm, chitosan @ 50 ppm, chitosan @ 300 ppm, ZnO @ 50 ppm and TiO_2 @ 300 ppm seed treatments, respectively.

Seed soaking with ZnO @ 50 ppm increased shoot dry weight, seedling dry weight and SVI-II over control treatment by 10.36, 18.42 and 20.02%, respectively. The highest shoot dry weight, seedling dry weight and SVI-II was recorded for ZnO @ 50 ppm which was at par with TiO_2 @ 50 ppm, nickel @ 50 ppm, chitosan @ 50 ppm and 300 ppm.

B. Effect of Different Nanoparticles on Germination Tests of Wheat at Different Periods of Seed Soaking

Overall mean germination indices were recorded to decrease with increase in the period of seed soaking (Table II). Among the germination indices, the germination percentage was not affected by different nanoparticle soaking, while germination rate for 4 and 6 hour soaking and MGT for 6 hour soaking were significantly affected due different nanoparticles. The highest germination rate was found with chitosan nanoparticles for 4 and 6 hours soaking which was significantly higher than control while remained at par with other treatments and was 26.45 and 21.39% higher than control, respectively. At 6 soaking lowest MGT was recorded with nickel nanoparticles which was statistically at par with other nanoparticles soaking and 17.52% lower than control treatment.

Among the seedling growth indices root length, shoot length, seedling length, root dry matter, shoot dry matter, and seedling dry matter were affected significantly by different nanoparticles (Table III). For 4 hours seed soaking, all the growth indices namely; root length, shoot length, seedling length, root dry matter, shoot dry matter, and seedling dry matter, recorded highest for chitosan nanoparticles which were 22, 17.29, 20.46, 17.64, 18.32 and 17.88% higher than control, respectively, while remained at par with other nanoparticles. Seed soaking for 6 hours produced highest root length, shoot length, seedling length and shoot dry matter with ZnO, which was statistically at par with chitosan and nickel treatments. Nano ZnO increased root length, shoot length, seedling length and shoot dry matter by 16.70, 20.63, 17.96 and 14.42%, respectively over control treatment. However root dry matter and seedling dry matter were found non-significant. For 8 hour seed soaking, root length, seedling length and root dry matter were significantly highest for chitosan nanoparticles which were 14.70, 17.44 and 15.18% higher than control treatments. The highest shoot length was recorded for chitosan which was at par with nickel and TiO_2 treatments. Similarly, higher seedling dry matter was observed for chitosan, which was statistically at par with TiO_2 treatment. Chitosan recorded 17.44 and 15.00% higher shoot length and seedling dry matter, respectively. Nano TiO_2 observed highest shoot dry matter which was at par with chitosan. The shoot dry matter with nano TiO_2 treatment was 16.23% higher over control treatment.

Mean seed vigor indices also decreased with increase in seed soaking period (Table II). Seedling vigour index I (SVI I) at 4, 6, and 8 hours and SVI II at 4 and 8 hours soaking were found significant due to treatments. For 4 hour soaking, the highest SVI I and SVI II were found with chitosan nanoparticles which were significantly at par with other nanoparticles and 25.48 and 22.79% higher over control treatment. For 6 hour soaking, the highest SVI I was found highest with ZnO nanoparticles being 19.60% over control treatment and was statistically higher than TiO_2 nanoparticles and control while remained at par with other treatments. However, SVI II for 6 hours soaking was non-significant. For 8 hours soaking, significantly higher SVI-I was observed with chitosan nanoparticles which was 19.22% higher over control. On the other hand, highest SVI II was also recorded with chitosan nanoparticles statistically at par with TiO_2 and 15% higher than control treatment. TiO_2 treatment @ 10 ppm reduced MGT of wheat by 34% as compared to control [9]. Seed treated with 1000 ppm ZnO recorded significantly higher germination and seedling vigor index than control. ZnO also increased leaf chlorophyll content irrespective of concentrations compared to bulk $ZnSO_4$ and control and the highest chlorophyll content was 1.97 mg/g [10]. Experimental findings showed that higher germination percentage, seedling vigour, seedling length and seedling dry weight can be achieved by application of nanoparticles [11]-[13]. TiO_2

nanoparticles accelerated spinach growth by improving light absorbance and activity of Rubisco activase [13]. Similarly [16] also reported that Nano-TiO_2 [anatase] improved plant growth by enhancing nitrogen metabolism which promotes the absorption of nitrate in spinach and by accelerating conversion of inorganic nitrogen into organic nitrogen, which increases the fresh weights and dry weights. Nano-anatase TiO_2 increased the Hill reaction and activity of chloroplasts, which accelerated FeCy reduction and oxygen evolution [15]. Also TiO_2 nanoparticles have capability to influence relative water content in leaves [16]. Seed priming with nanoparticles might help to penetrate water through seed coat resulted more water is absorbed in seeds hastened the seed germination, better establishment [17], increase emergence rate [18].

TABLE I
EFFECT OF DIFFERENT CONCENTRATIONS OF NANOPARTICLES ON GERMINATION PARAMETERS OF WHEAT

Treatments (NP)	NP Concentration (ppm)	Germination %	Germination Rate	Mean germination time	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Root dry wt. (mg)	Shoot dry wt. (mg)	Seedling dry wt. (mg)	SVI I	SVI II
TiO_2	50	98.6	19.3	1.41	9.1	3.6	12.7	7.0	4.3	11.3	1262	1122
	300	96.0	18.8	1.37	7.7	3.2	11.0	6.5	4.0	10.5	1056	1011
ZnO	50	98.6	18.6	1.47	8.4	3.3	11.7	7.0	4.5	11.5	1159	1141
	300	97.3	17.8	1.49	7.7	3.4	11.2	6.7	3.8	10.6	1090	1031
Nickel	50	98.6	19.0	1.44	8.6	3.0	11.7	7.0	4.1	11.1	1157	1098
	300	97.3	18.1	1.47	7.5	2.7	10.2	6.6	3.7	10.4	1000	1015
Chitosen	50	96.0	18.8	1.37	8.4	3.4	11.8	6.9	4.1	11.1	1141	1068
	300	97.3	17.8	1.49	7.8	3.3	11.2	6.9	4.0	10.9	1096	1067
Control	0	97.3	17.1	1.55	6.7	2.2	9.0	6.3	3.4	9.7	878	950
S.Em		1.4	6.4	0.04	0.3	0.2	0.3	0.1	0.1	0.2	54	32
C.D (5 %)		NS	NS	NS	1.0	0.5	1.0	NS	0.4	0.7	160	95
C.V (%)		2.4	4.4	5.0	7.5	10.1	5.4	4.3	7.0	4.1	8	5

TABLE II
GERMINATION INDICES AND SEEDLING VIGOUR INDICES OF WHEAT AS INFLUENCED BY SEED SOAKING WITH NANOPARTICLES AT DIFFERENT TIME INTERVAL

Treatments (NP)	Germination %			Germination rate			MGT			SVI I			SVI II		
	Soaking hours														
	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8
TiO_2	98.6	97.3	96.0	18.1	17.8	17.6	1.2	1.1	1.1	1709	1521	1482	1177	1083	1075
ZnO	98.6	97.3	96.0	17.8	17.8	17.5	1.2	1.1	1.1	1694	1700	1413	1171	1161	1023
Chitosan	100.0	98.6	97.3	18.5	18.3	17.6	1.2	1.1	1.1	1766	1648	1684	1233	1137	1141
Nickel	98.6	97.3	97.3	18.0	17.4	17.8	1.2	1.1	1.1	1704	1667	1527	1170	1154	1024
Control	96.0	96.0	97.3	14.6	15.1	16.1	1.4	1.3	1.3	1407	1421	1434	1004	1049	992
S.Em±	1.4	1.2	2.0	0.6	0.3	0.4	0.3	0.1	0.1	47.9	47.3	28	38	38	30
C.D (5%)	NS	NS	NS	1.9	0.9	NS	NS	0.1	NS	151	149	88	122	NS	94
C.V (%)	2.5	2.1	3.7	6.1	3.1	4.8	4.2	7.0	7.6	5.01	5.1	3	5	5	4
Mean	98.4	97.3	96.8	17.3	17.3	17.3	1.3	1.2	1.1	1656	1591	1508	1151	1117	1051

TABLE III
SEEDLING GROWTH INDICES OF WHEAT AS INFLUENCED BY SEED SOAKING WITH NANOPARTICLES AT DIFFERENT TIME INTERVAL

Treatments (NP)	Root length (cm)			Shoot length (cm)			Seedling length (cm)			Root dry matter (mg)			Shoot dry matter (mg)			Seedling dry matter (mg)		
	Soaking hours																	
	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8
TiO_2	11.7	10.8	10.2	5.5	4.8	5.1	17.3	15.6	15.4	6.1	5.8	5.4	5.8	5.3	5.7	11.9	11.1	11.2
ZnO	11.6	11.7	10.4	5.5	5.7	4.3	17.1	17.4	14.7	6.0	6.0	5.5	5.8	5.8	5.1	11.8	11.9	10.6
Chitosan	12.0	11.0	11.5	5.6	5.6	5.7	17.6	16.7	17.3	6.2	5.8	6.0	6.0	5.7	5.6	12.3	11.5	11.7
Nickel	11.7	11.5	10.0	5.5	5.5	5.6	17.2	17.1	15.6	6.1	6.1	5.3	5.7	5.7	5.2	11.8	11.8	10.5
Control	9.8	10.0	10.0	4.8	4.7	4.6	14.6	14.8	14.7	5.3	5.8	5.2	5.1	5.1	4.9	10.4	10.9	10.2
S.Em±	0.2	0.2	0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.3
C.D (5%)	0.8	0.8	0.6	0.2	0.4	0.6	1.0	1.2	1.1	0.5	NS	0.5	0.4	0.4	0.5	0.9	NS	0.9
C.V (%)	4.03	4.24	3.22	2.8	4.7	6.7	3.5	4.1\	4.0	5.4	5.9	5.0	4.2	4.1	5.3	4.5	4.7	5.0
Mean	11.4	11.0	10.4	5.4	5.3	5.1	16.8	16.3	15.5	5.9	5.9	5.5	5.7	5.5	5.0	11.6	11.4	10.8

REFERENCES

[1] Food and Agricultural Organization of the United Nations, 2010. FAOSTAT 2010.
[2] Ministry of Agriculture and Farmers Welfare, 2017. Annual report 2016-17.
[3] J. J. Ramsden, "What is nanotechnology",*Nanotechnol. Perceptions*, 2005, 1: 3-17.
[4] P. Ball, "Natural strategies for the molecular engineer. Nanotechnology", *Biol. Trace Element Res.*, 2002, 146:101-106.
[5] M. C. Roco, "Broader societal issue on nanotechnology", *J. of Nanopart. Res.*, 2003, 5: 181-189.

[6] A. Nel, T. Xia, L. Madler, and N. Li, "Toxic potential of materials at the nanolevel", *Science*, 2006, 311: 622-627.
[7] F. T. Bonner, "Germination responses of loblolly pine to temperature differences on a two way thermogradient plate" *J. Seed Technol*., 1983, 8(1): 6-14.
[8] A. A. Abdul-Baki, and J. B. Anderson, "Vigour determination in soyabean seed by multiple criteria", *Crop sci,* 1973.13: 630-632.
[9] F. Hassan, R. Parviz, N. Shahtahmassebi, and A. Fotova, "Impact of bulk and nano sized TiO_2 on wheat seed germination and seedling growth of spinach" *Trace Element Res., 2012,* **146:**101-106.
[10] T. N. V. K. V. Prasad, P. Sudhakar, Y. Sreenivasulu, P. Latha, V. Munaswamy, K. Raja Reddy, T.S. Sreeprasad, P. R. Sajanlal and T. Pradeep, "Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut", *J. Pl. Nutri.,* 2012, 35:6, 905-927.
[11] L. Zheng, F. S. Hong, S. P. Lu, and C. Liu, "Effect of nano TiO_2 on strength of naturally aged seeds and growth of spinach"*, Biol. Trace Elem. Res*., 2005, 104(1), 82-93.
[12] P. Mahajan, S.K. Dhoke, and A.S. Khanna, "Effect of nano-ZnO particle suspension on growth of mung (*Vigna radiata*) seedlings using plant agar method", *J. Nanotechnol.*, 2005, Article ID 696535, pp 1-7.
[13] H. Mahmoodzadeh, M. Nabavi, and H. Kashefi, "Effect of Nanoscale Titanium Dioxide Particles on the Germination and Growth of Canola (*Brassica napus*)." *J. Orn. Hort. Pl*., 2013, 3 (1): 25-32.
[14] F. Yang, F. Hong, and W. You, "Influences of nano-anatase TiO_2 on the nitrogen metabolism of growing spinach," *Biol. Tr. Elem. Res.*, 2006, 110(2): 179-190.
[15] F. Hong, J. Zhou, C. Liu, F. Yang, W. You, F. Gao, C. Wu, and P. Yang, "Effect of Nano-TiO_2 on photochemical reaction of chloroplasts of spinach. *Biol. Tr. Elem. Res*., 2005, 105(1-3): 269-279.
[16] M. Payam, T. Alireza, A. Hosseein, and M. Kosra, "Effect of nano particles TiO_2 spraying on different parameters of wheat (*Triticum aestivum* L.)", *Adv. Env. Biol.,* 2011, 5(8): 2217-2219.
[17] A. Rashid, P.A. Hollington, D. Harris, and P. Khan, "On-farm seed priming for barley on normal, saline and saline-sodic soils in North West frontier province of Pakistan using on-farm seed priming," *Europ. J. Agron,* 2006, 24: 276-281.
[18] W. Heydecker, and P. Coolbear, "Seed treatments for improved performance survey and attempted prognosis," *Seed Sci. Technol.,* 1977, 5: 353-375.