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RESEARCH PAPER

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# Effect of silver, copper and iron nanoparticles on wheat germination

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## Abstract

The effect of the exposure of wheat (*Triticum aestivum*) seeds to silver, copper and iron nanoparticles on germination and seedling vigor index has been studied under laboratory conditions. Seeds were exposed to silver, copper and iron nanoparticles under various conditions. Germination percentage and root shoot length were calculated. The results showed a reduction in germination percentage on exposure to silver and copper nanoparticles while maximum germination percentage was on application of iron nanoparticles. Similarly while root and shoot growth was also enhanced under iron nanoparticles application while severereduction in root and shoot length was observed on exposure to copper nanoparticles. So copper has inhibitory while iron has stimulatory effect on wheat germination and growth.

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## Introduction

Nanotechnology is a rapidly developing industry, posing considerable impacts on economy, society and environment. Thus, it generates both positive and negative responses from governments, scientists and societal medium right through the world (Bai, 2005; Brumfiel, 2003; Roco, 2005; Service, 2000, 2003; Yang *et al.,* 2006). Nanoparticles, with at least one dimension of 100 nm or less, are increasingly being used for profitable purposes such as fillers, opacifiers, catalysts, semiconductors, cosmetics, microelectronics and drug carriers (Biswas and Wu, 2005). The production, use, and removal of nanoparticles will inexorably lead to their discharge into air, water and soil. The recent upsurge in nanotechnology has amplified the use of Ag in the form of nanoparticles (NPs) as additives in many industrial, medical, and consumer products (Benn and Wasterhoff 2008, Blaser *et al.* 2008) However, the growing use of Ag NPs in such diverse applications may foreshadow hazard for the ecosystem, considering reports on the release into the environment of Ag NPs from diverse products, including paints, clothes and washing machine liners (Kaegi *et al.* 2005, Impellitteri *et al.* 2009). Ag NPs harm root cell membranes, impair cell division and affect leaf transpiration, root elongation and plant biomass. Seed germination also is affected. The plants studied include cucumber, rye grass, onion, rice, zucchini, and the aquatic plant, *Lemna minor* (Yin *et al.* 2011, Barrena *et al.* 2009, Gubbins *et al.* 2011). Ag NPs associate with plant root surfaces (Mazumdar *et al.* 2011) and are transported into plant tissues (Stampoulis *et al.* 2009). Intact Ag NPs are found within rice root cells (Mazumdar *et al.* 2011). Roots and shoot tissues of different dicotyledonous plants form Ag NPs when challenged with Ag ions (Beattie *et al.* 2011). Studies of Ag speciation in rye grass (*Lolium multiflorum*) tissues suggest that Ag NPs applied to the roots are transformed to other forms such as $Ag_2O$ and $Ag_2S$ (Yin *et al.* 2011) Iron is one of the essential elements for plant growth and plays an important role in the photosynthetic reactions. Iron activates several enzymes and contributes in RNA synthesis and improves the performance of photosystems in plants (Sheykhbaglou *et al.* 2010). Some reports regarding influence of iron oxide upon the plant growth evidenced an optimistic influence in cereals, explained on the basis of significance of iron in the vegetal organism. The iron oxides can be a source of iron for the plant development. The biosynthesis of siderophores by plant was assumed to be enthused with the iron from iron oxides (Racuciu *et al.* 2007). Silver, copper and iron have been extensively applied on various crops effecting positively and negatively depending on crop and concentration of nanoparticles applied.  Due to mixed sort of effects of these nanoparticles on plants present study was planned to have a deep view about wheat response towards these nanoparticles as wheat is a crop of our major concern being staple food for majority of population. The main objective of this work was to quantify the possible effect of silver, copper and iron nanoparticles for possible phytotoxicity and stimulative effects on wheat seed germination and early growth stage.

## Materials and methods

### *Nanoparticles Preparation*

Silver, Copper and Iron nanoparticles have been prepared using organic method of synthesis developed by Dr. Abdul Razzaq (Unpublished information) and size was determined by Zeta analyzer from National institute of Biotechnology and Genetic Engineering (NIBGE) Faisalabad. Size was between range of 40-50nm.

### *Seeds Source*

Seeds of wheat (*Triticum aestivum* L.) variety NARC-2011 were used for determination of nanoparticles effect on wheat germination.

### *Germination Assay*

Seeds were immersed in a 10% sodium hypochlorite solution for 10 min to ensure surface sterility (USEPA, 1996), then, they were soaked in DI-water, nanoparticle suspensions for about 2 h after being rinsed three times with DI-water (Kikui *et al.*, 2005). One piece of filter paper was put into each Petri dish, and 5 ml of a test medium was added. Seeds were then transferred onto the filter paper, with 15 seeds per dish and 1 cm distance between each seed (Yang and Watts, 2005). Petri dishes were covered and sealed with tape, and placed in an incubator for 5 days. Then, seed germination percentage was calculated, and seedling root and shoot length was also measured.

### *Statistical analysis*

Each treatment was conducted with three replicates, and the results were presented as mean standard deviation. The statistical analysis of experimental data utilized the Student's t-test. Each of the experimental values was compared to its corresponding control.

## Results and discussion

Three different types of nanoparticles with three different types of treatment were studied and results were recorded in Table 1. Which indicated that all three types of nanoparticles affected the rate of germination, germination percentage, shoot length, root length and seedling vigor positively or negatively.

**Table 1.** Over all view of nanoparticles impact on germination percentage and seedling vigor index.

| Treatment | % germination | Shoot length | Root length | Vigor index |
|---|---|---|---|---|
| Control | 100 | 3.85± 0.4 | 7.18 ± 1.8 | 1103 |
| AgDNP | 80 | 2.9 ± 0.34 | 2.3 ± 0.5 | 416 |
| AgNPD | 93 | 3.25 ± 0.35 | 4.8 ± 0.9 | 753 |
| AgNP2 | 87 | 2.9 ± 0.19 | 3.1 ± 0.9 | 522 |
| CuDNP | 87 | 2.2 ± 0.51 | 2 ± 0.2 | 365 |
| CuNPD | 100 | 2.95 ± 0.42 | 3.3 ± 0.5 | 630 |
| CuNP2 | 80 | 1.9 ± 0.34 | 0.35 ± 0.2 | 180 |
| FeNPD | 87 | 3.95 ± 0.38 | 6.5 ± 1.2 | 913.5 |
| FeDNP | 100 | 2.85 ± 0.47 | 2.6 ± 0.9 | 550 |
| FeNP2 | 100 | 3.25 ± 0.47 | 4 ± 1.5 | 730 |

### *Effect of nanoparticle suspensions on seed germination percentage*

Effects of nanoparticles on seed germination are shown in Fig. 1. Seed germination strictly depends on way of treatment. When seeds were soaked in silver nanoparticles and then placed in distilled water for germination there was significant increase in germination percentage as compared to seeds when soaked in water or nanoparticles and placed in nanoparticles suspension for germination. In case of copper there was significant increase in germination percentage on soaking in nanoparticles suspension for two hours and severe reduction was observed on soaking and incubation in copper nanoparticles. Iron showed different behavior as compared to other two nanoparticles which showed increase in germination percentage on soaking in nanoparticles and incubation in distilled water. In case of iron nanoparticles there was increase in germination percentage on soaking and incubation in nanoparticles suspension were not affected by the nanoparticles Ajouri *et al.* (2004) reported that seed priming with Zn was very effective in improving seed germination and seedling development in barley.

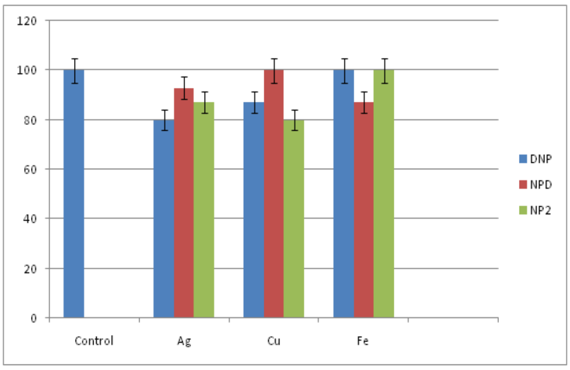

**Fig. 1.** Effect of seed soaking in distilled water nanoparticles suspension on seed germination.

### *Effect of seed soaking on root growth*

To examine which process (seed soaking or incubation after the soaking) primarily retarded the root growth, three treatments were used: (DNP) seeds were incubated in Petri dishes with 5 ml nanoparticle suspensions after being soaked in DI-water for 2 h. (NPD) seeds were soaked in nanoparticle suspensions for 2 h, and were then transferred into Petri dishes with 5 ml DI-water for incubation after bein rinsed three times with DI-water; and (NP2) both seed soaking and incubation were performed in nanoparticle suspensions. Silver nanoparticles resulted in reduction in root growth when seeds were soaked in distilled water and incubated in nanoparticles while root growth enhanced on soaking in nanoparticles and incubated in distilled water. When *Phaselous radiatus*, *Sorghum bicolor* and *Lolium multiflorum*were subjected to silver nanoparticles resulted in reduced root growth, root length and biomass were observed (Yin *et al.*, 2011; Lee *et al.*, 2012). Copper nanoparticles resulted in severe reduction in root growth when seeds were soaked and incubated in copper nanoparticles as in in accordance with the reports on radish, rape, corn, lettuce and cucumber by Lin and Xing, 2007. Iron nanoparticles exhibited severe reduction in root growth when seeds were soaked in nanoparticles and incubated in distilled water while root growth enhanced on soaking in distilled water and incubation in nanoparticles suspension.

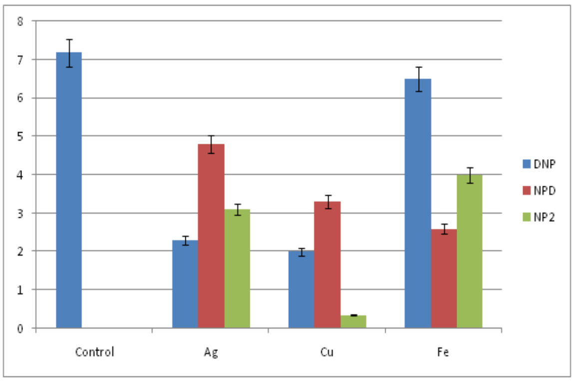

**Fig. 2.** Silver, copper and Iron nanoparticles effect on root growth of wheat.

*Effect of seed soaking on shoot growth*

Shoot growth was also observed with the same treatments as applied for root growth to examine the impact on nanoparticles effect on wheat growth. Silver nanoparticles exhibited no significant difference in response to different treatment of soaking and incubation. Shoot growth increased on soaking in nanoparticles suspension and incubated in distilled water. Shoot growth significantly increased on soaking in nanoparticles suspension and incubation in distilled water in case of copper nanoparticles. Iron naoparticles resulted in significant increase in shoot growth on soaking in nanoparticles and incubated in distilled water. Even significant increase occurred with iron treatment as compared to control.

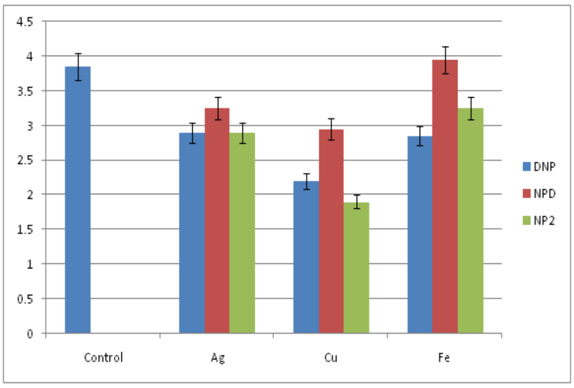

**Fig. 3.** Silver, copper and Iron nanoparticles effect on shoot growth of wheat.

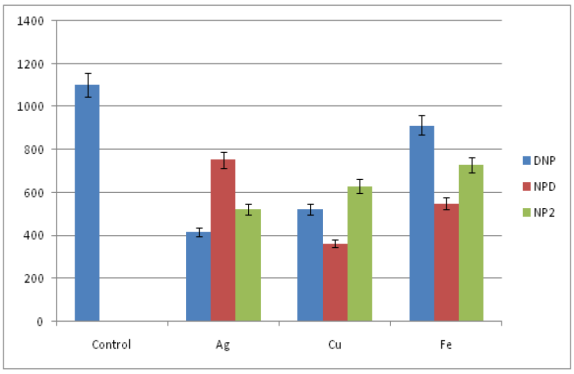

**Fig. 4.** Effect of nanoparticles on seedling vigor index of wheat.

*Effect of seed soaking on seedling vigor*

Wheat seeds responded variably toward various treatments. Seedling vigor increases on silver treatment as soaking in nanoparticles and incubated in distilled water. Severe reduction in seedling vigor occurred when seeds were soaked in copper nanoparticles and incubated in distilled water. Iron nanoparticles exhibited increase in soaking in distilled water and incubated in nanoparticles such promotory effect of nanoscale $SiO_2$ and $TiO_2$ on germination was reported in soya bean (Lu *et al.,* 2002), while severe reduction in seedling vigor on soaking in nanoparticles and incubated in distilled water. Such inhibitory effects of nanoparticles were also reported by Lin and Xing (2007) on radish, rape, and rye grass.

## Conclusions

Applications of nanoparticles can promote earlier plant germination and improve plant production. The laboratory study was conducted to determine inhibitory or stimulatory effect of nanosized Ag, Fe and Cu on wheat. Another goal was to compare and determine the suitable nanoparticles for stimulating growth of wheat. According to present study iron nanoparticles has stimulatory while copper has inhibitory effect on wheat.

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