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Effect of magnetite (Fe_3O_4) nanoparticles on seed germinations and seedlings growth parameters in wheat crops

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Abstract
The present experiment was conducted to assess various germination parameters under different concentrations of magnetite (Fe_3O_4) nanoparticles. Seeds were treated with different nanoparticle concentration like T_1: Control (No Fe_3O_4 nanoparticle), T_2: Fe_3O_4 nanoparticle (100 µM), T_3: Fe_3O_4 nanoparticle (200 µM), T_4: Fe_3O_4 nanoparticle (400 µM), T_5: Fe_3O_4 nanoparticle (800 µM), T_6: Fe_3O_4 nanoparticle (1500 µM). Important parameters like germination percentage, germination index, Shoot length, root length, seedling vigour index, dry matter has been recorded at 3 days of germination in wheat variety namely HUW-234. Presented data depicted that the germination percentage, germination index, Shoot length, root length, dry matter and SVI significantly increasedat the nanoparticle (Fe_3O_4) treatment T_2, T_3, T_4 (100,200, 400 µM), but after increasing the nanoparticle (Fe_3O_4)concentrationT_5,T_6(800, 1500 µM) all parameters significantly reduced due to severe toxicities. Together, these results show that Fe_3O_4 NPs have a potential role in seed germination and seedlings establishment which play significant role plant growth, but at higher concentration its play toxic effects in wheat plants.

Keywords: Wheat, Nanoparticle, Seed germination, Seedling vigour index.

Introduction
Agriculture is the main source of food and is expected to feed ever increasing population Worldwide. Wheat (Triticum aestivum L.) is among the world's major cereals and is the staple food over 50% of the global population (FAO, 2018) [9]. Wheat as well as other crops face many biotic and abiotic stresses under ambient conditions such as drought, and heavy metal stress (Rizwan*et al*., 2016) [10]. Nanotechnology is a new technical revolution. Therefore, nanomaterials will become the new material for agricultural development, and represent new ideas and directions for global agricultural production (Chen and Yada, 2011) [1]. Nanoparticles (NPs) are ultrafine particles ranging in size from 1 to 100 nm and have been used in the fields of bioscience and biomedicine (Salata 2004) [2].The interaction of NPs with biological molecules (DNA and protein), cytotoxicity, uptake, pharmacokinetics, etc. have been examined in animal experiments (Hu and Zhou 2013) [3].There are indications of both positive and negative impacts of direct application of NPs in various plants (Thul*et al*., 2013) [4]. However, inhibition of germination and growth by silver and copper NPs has been reported in *Cucurbita pepo* (Musanite and White 2012) [5]. In another study,the toxic effect of nZVIin *Typha latifolia* at higher concentrations, but enhanced growth at lower concentrations. Nano-TiO_2 was observed to promote the growth of spinach through an increase in photosynthetic rate and nitrogen metabolism (Yang *et al*., 2006) [6]. Similarly, it was reported that increased growth and photosynthetic pigments in the presence of Ag NPs in *Brassica* plant. Both positive and impacts of NPs have been reported in alfalfa, cucumber and tomato plants by (Lopez-Moreno *et al*., 2010) [7]. There is considerable concern about the potentially harmful effects of these NPs due to their unique properties, such as high specific surface area, catalytic efficiency, surface energy, abundant reactive sites and strong adsorption, they may have significant effects on many organisms, especially plants which are essential base component of all ecosystem. As a result, NPs will inevitably interact with plant and these interactions such as uptake and accumulation in plant biomass will greatly affect their fate and transport in the environment, NPs could also adhere to plant roots and exert physical or chemical toxicity on plants (lee *et al*., 2010) [8]. Exogenous application of Fe_3O_4 NPs (2000 ppm) enhanced the

wheat growth and decreased the metal uptake by plants These reports showed that NPs response on metal uptake varies with the type of NPs, plants species as well as metal species (Konate*et al*., 2017) [11]. Seed priming technique has been introduced for growing crops which may improve the seed germination and vigour of seeds. It was shown that seed priming with gold NPs increased the seed germination of maize and rice (Mahakham*et al*., 2017) [12].

Materials and methods

In the present study, 6 different concentrations of Magnetite (Fe_3O_4) nanoparticle a was made each treatment contained 5 healthy and uniform sized seed in each petriplates. In experiment, three petriplates per combination will be arranged and experiments repeated three times after an interval of 3 days data had taken in a BOD chamber. Thereafter, germination percentage, germination index, Shoot length, root length, dry matter and Seedling vigour Index was observed and analyzed.

a. **Germination percentage (%):** Number of germinated seeds were recorded after 48 hours after initiation of germination. Germination percentage was calculated (Association of official seed analysis, 1983) as follows: Germination percentage = (No of seed germinated/total number of seed sown) x 100.
b. **Germination Index (GI):** Germination index of wheat seed were calculated by the formula given by Rana*et al*.(2006)[17], GI= (4×N1) + (3×N2) + · · · +, Where N1, N2...N4 is the number of germinated seeds on the first, second andsubsequent days until 3rd day and the multipliers (*e.g*. 4, 3...*etc*.) are weights given to the days of the germination.
c. **Seedling vigor index (SVI):** Seedling vigor index measured in 7 day old seedling calculated by the formula given by Goodi, and sharifzadeh, (2006) [18]. SVI= germination% × Dry wt. of 7 days old seedling.
d. **d) Root and shoot length:** The maximum root and shoot length was measured with the help of scale at 3rd days of germinations.
e. **Total dry matter:** Seedlings were excised and placed into an oven (NSW-142) at 105ºC for 5 mins and then 65ºC till for constant weight. Dry weight is taken atelectrical balance (ADGR-200) at 3 days.

Results and discussion

Germination percentage is the most important traits reveals germination capacity of plant. The value of GI indicates both the germination percentage and germination speed. Likewise, shoot length represents the vertical growth of the plants, root length is the important seedling parameters indicates the better establishment of seedlings and dry matter measure the production photosynthates in relation to productivity. Whereas SVI is the important parameter indicates the seedling establishment and growth. Seeds were treated with different nanoparticle concentration like T_1: Control (No Fe_3O_4 nanoparticle), T_2: Fe_3O_4 nanoparticle (100 µM), T_3: Fe_3O_4 nanoparticle (200 µM), T_4: Fe_3O_4 nanoparticle (400 µM), T_5: Fe_3O_4 nanoparticle (800 µM), T_6: Fe_3O_4 nanoparticle (1500 µM). GP, GI, Shoot length, root length, SVI has been represented in table 1 and fig. 1, 2, 3, 4. The mean data of all the parameters was recorded at 3 days of germination in wheat variety namely HUW-234. Presented data depicted that the germination percentage, GI, Shoot length, root length, dry matter and SVI significantly increased at the nanoparticle treatment T_2, T_3, T_4 (100,200, 400 µM). But after increasing the nanoparticle concentration T5, T6 **(**800, 1500 µM) all parameters significantly reduced due to toxicity, hence I choose best two concentration of nanoparticle on the basis of observation had taken T_3: Fe_3O_4 nanoparticle (200 µM), T_4: Fe_3O_4 nanoparticle (400 µM),

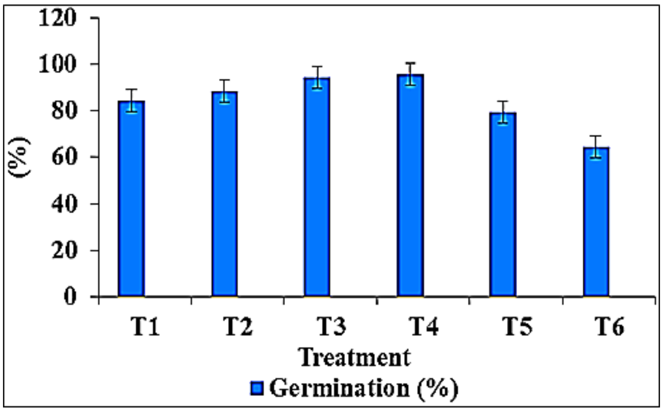

Fig a: Effect of magnetite (Fe_3O_4) nanoparticle on Germination percentage

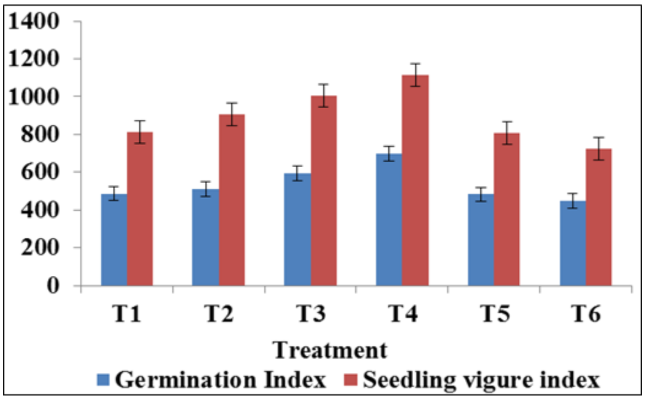

Fig b: Effect of magnetite (Fe_3O_4) Germination Index and SVI

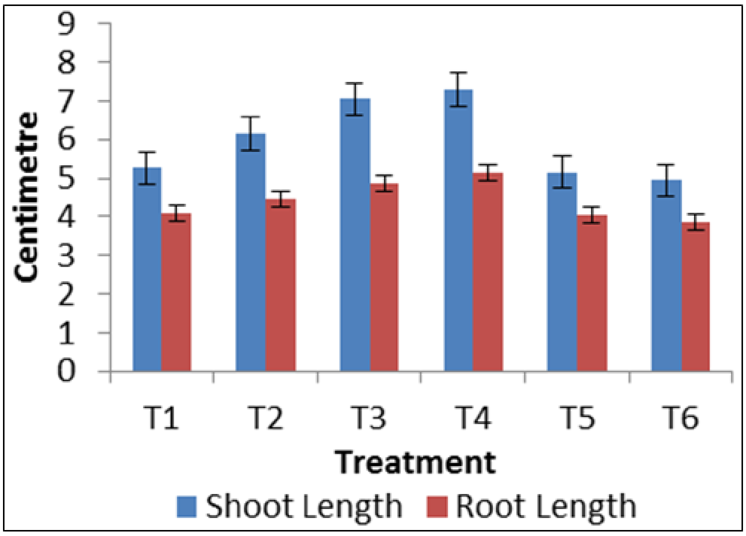

Fig c: Effect of Magnetite (Fe_3O_4) nanoparticle on Shoot and Root length

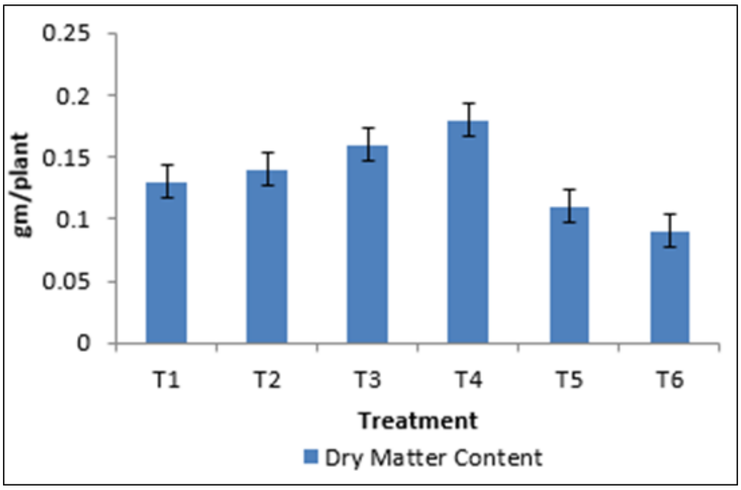

Fig d: Effect of Magnetite (Fe_3O_4) nanoparticle on Total dry matter

In our experiment (Figure a) percent germination was recorded highest in T_4 (Fe_3O_4 NPs,400 µM) (95.8%) and lowest in T_6 (Fe_3O_4 NPs,1500 µM) (64.3%).Similar treatment results were obtained for germination index, Seedling vigour index, Shoot length, Root length, dry matter content of wheat seedlings(Figure b, c, d). Magnetite (Fe_3O_4),Treatment at lower doses (200,400 µM) showing better performance, might be due to nanoparticles easily penetrate into the seeds through seed coat, and initiates number of biochemical and molecular process. Later higher concentrations of nanoparticles produced ROS in sub cellular organelles, significantly reduced biochemical activities in plants. Results showed that Ag Np exposure significantly inhibit seed germination and root cell division, plant biomass, leaf area, shoot growth, and root abscission in Spirodela polyrrhiza (Jiang *et al*.,2012)[14]. Another study found that in wheat crops, Ag NPs applications reduced the shoots and roots length consequently reduced the yields (Dimpka*et al*., 2013)[15]. Similarly, in rice crops showed that reductions of root elongation, shoot-root dry weight, fresh weights under toxicities of silver nanoparticles (Nair *et al*., 2014) [16]. The effect of ZnO nanoparticles (NPs) was tested on wheat (Triticum aestivum) grown in hydroponics media. It was observed that ZnO NPs, at 50 mg/L have positive effect on seed germination, number of roots, plant biomass and overall growth of roots, shoots and leaves. These findings could be further applied to the agricultural fields to enhance the crop production (Awasthi *et al*., 2017) [13].

Conclusions

In the presented study, we have evaluated the effect of iron oxide (Fe_3O_4) nanoparticles on wheat germination and seedling growth. The NP concentration of 400 µM have highest positive effect in terms of enhanced seed germination, overall roots, shoots and leaves length, and on the whole fresh biomass. It was observed that increasing concentrations of nanoparticles showed positive effects until 400 µM, higher than this concentrations followed negative results. These findings could further be used for agricultural applications, to enhance the seed germination and improve the overall yield in wheat crops. Moreover, further research is required under both lab and field conditions, to use Fe_3O_4 NPs for practical applications of agriculture for better crop productions.

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