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Ameliorating Seed Germination and Seedling growth of Nano-Primed Wheat and Flax Seeds Using Seven Biogenic Metal-Based Nanoparticles

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Abstract: We had biosynthesized seven nanoparticles in our previous researches, including calcinated and non-calcinated zinc oxide, zinc, magnesium oxide, silver, copper and iron nanoparticles. The effect of these biogenic nanoparticles and their counterpart metallic salts including zinc acetate, magnesium sulphate, silver nitrate, copper sulphate and iron (III) chloride was studied on two popularly grown plants, wheat and flax, in laboratory condition to obtain preliminary information for future field experiments. Germination percentage, shoot length, root length, seedlings length, root-shoot ratio, seedling vigor index (SVI), shoot length stress tolerance index (SLSI) and root length stress tolerance index (RLSI) were calculated at 2nd and 7th days of the experiment. According to the results, the response of the plants to metal containing nanoparticles and metal salts mainly depend on type of the metal, plant species, concentration of the NP suspension or salt solution, condition of the exposure and the stage of growth.

Introduction: In recent years, a large number of reports have analyzed the influence of various nanostructures on different crops especially on their early developmental stage, seed germination and seedling development. Seed germination, i.e., the emergence of the radicle and primary root's elongation, is considered as the most sensitive stage of a plant life cycle. Priming with nanoparticle (nano-priming) could lead to positive, negative, or no impacts on germination process, depending on NPs type, size, concentration, duration of the exposure, or the growing conditions. Exact outcomes of the seed priming also consider as a technique to control the hydrate content of the seeds, stimulating metabolic activities for germination [1-2].

Materials and methods: Concentrations of 50, 100, 150 ppm of previously synthesized NPs [3] (C-ZnO, NC-ZnO, Zn, MgO, $AgNO_3$, Cu and Fe) and also their counterpart metal salts ($Zn(CH_2COO)_2$, MgSO4, $AgNO_3$, $CuSO_4$ and $FeCl_3$) dispersed in distilled water. Seeds of wheat (Triticum aestivum L.) variety Firuza 40 and flax (Linum usitatissi-mum L.) variety Semi Lini were used, 30 randomly selected seeds with three replications in each treatment. Germination percentages, shoot and length, seedlings length, root-shoot ratio, seedling vigor index (SVI), shoot length stress tolerance index (SLSI) and root length stress tolerance index (RLSI) were calculated at 2nd and 7th days. Means and standard deviations were derived from measurements on three replicates for each treatment and controls.

Results and Discussion: Plant growth parameters varied considerably among plants and also different priming solutions with various concentrations (Fig.1). Both effects of "stimulation" and "phytotoxicity" and "no significant effect" of NPs and salts was observed. NPs or metal ions are absorbed on surface of seeds and gradually release to show their effect during a period of 7 days. The reason of difference between responses is as result of gradually release of ions from NPs by sub-toxic levels rather than the exposure to a large number of ions in priming with metal salts which may cause stress in the germination process.

Conclusion: According to results, response of tested plants to a certain NP was different between flax and wheat concentrations of NPs. Another result is that flax was more sensitive to priming with metal salts and NPs in comparison with wheat. Furthermore, the influence of these treatments was investigated in earlier stages of growth, in 2nd day of the experiment, in comparison with 7th day of the experiment. Among the studied NPs, Zn and Ag NPs exhibited the best biological effects on growth and development of wheat and flax respectively. Finally, NP treatments were more effective than metal salt treatments in root and shoot development.

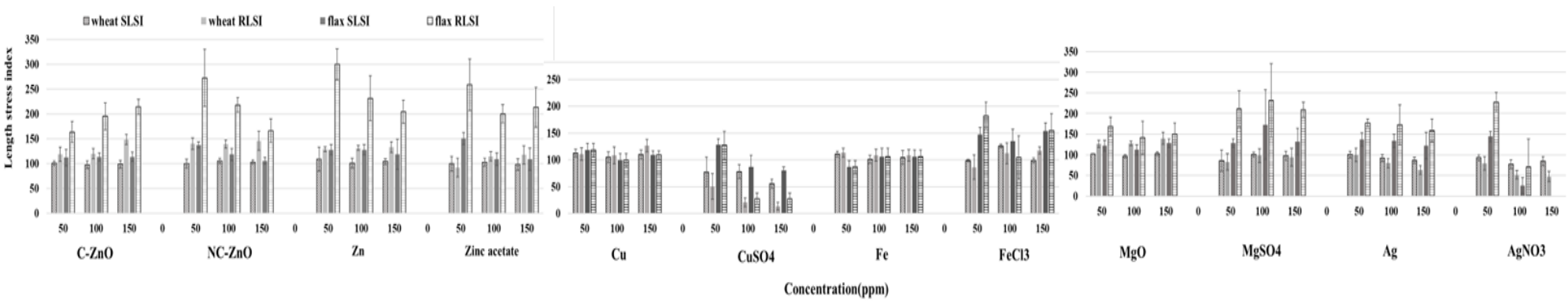

Figure 1. Dose response effect of NPs and their correspondent salts on shoot and root stress tolerance indexes (SLSI and RLSI, respectively) of wheat and flax seeds at 7th day of experiment.

References

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