

Comparative study of aqueous extracts of *Celosia argentea* L. and Silver nanoparticles on seed germination and seedling growth of Pearl millet (*Pennisetum glaucum* (L.) R. Br.)

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Abstract

Celosia argentea is one of the most common weeds grown in Pearl millet (Bajra) fields. It is used to determine the allelopathic potential on the growth and developmental changes on crop plants. At the same time, Nanotechnology also emerging as an innovative technology in many fields of research such as agriculture, medicines, and industries. The present study was conducted to evaluate the allelopathic effects of *C. argentea* in the presence/absence of silver nanoparticles (Ag NPs) on seed germination, shoot and root length, germination index, and vigor index of P. millet. Experiment was conducted under control conditions in petri plates. Aqueous extracts of shoot of *C. argentea* with the concentration of 50% and Ag NPs of 50 ppm were applied on the P. millet seeds. Seed germination was observed on day 2 and day 5, length of hypocotyl and root number was measured on the 5th day. Results from the present study demonstrated that shoot extracts of *C. argentea* caused negative effects on the aforesaid parameters. However, exogenous application of Ag NPs caused positive effects and increased all the above parameters in the presence/absence of *C. argentea*. Therefore, it is concluded from the above study that, inhibitory effects of aqueous extracts may be due to the presence of allelochemicals in *C. argentea* and it is overcome by the application of Ag NPs. However, in-depth underlying mechanism of the inhibitory as well as stimulatory effects needs to be further explored.

Key words : Allelochemicals, Aqueous extracts, Nanotechnology, Seed germination

Allelopathy is a common biological occurrence by which higher plants of one species (the donor) have negative impacts on the germination, growth, or development of the

plants of a different species (the recipient)¹³. Elroy L. Rice described allelopathy as the result of the discharge of chemical substances into the environment in 1974¹⁶. The term “Nanotechnology” was coined by Eric Drexler, and involves dealing with materials whose structures exhibit appreciably special and increased chemical, physical, and biological possessions as a result of their particle size in the nanoscale. Nanotechnology has great effects on the commercial implementation of nano minerals in the fields of information technology, engineering, medicine, food, and pigments, with pharmaceutical, biological, and electrical applications. There have been different and often conflicting reports on the absorption, translocation, accumulation, biotransformation, and toxicity of nanoparticles in various plant species. The effects of silver nanoparticles (Ag NPs) are still under investigation^{14,15}. Recent studies have reported that a plant’s response to Ag NPs, enhancement or inhibition of growth, depends on the Ag NPs dosage. Exposure to specific concentrations of Ag NPs could enhance plant growth compared with non-exposed plants, whereas higher and lower concentrations could affect plant growth negatively^{7,9}. Of the reported Ag NPs concentrations used (25, 50, 100, 200 and 400 ppm); a 50- ppm treatment has been determined to be optimal for eliciting a growth response in *Brassica juncea* seedlings. The fresh weight, root and shoot length, and vigour index of seedlings are positively affected at this concentration. This dose was found to induce a 326% increase in root length and a 133% increase in the vigour index of the treated seedlings¹⁷. The present study was conducted to evaluate the allelopathic effects of *C. argentea* in the presence/absence of silver

nanoparticles (Ag NPs) on seed germination, shoot and root length, germination index, and vigour index of P. millet.

Growth condition and treatments :

Mature seeds of Pearl millet (Dhansakhti) were collected from Indian Institute of Millet Research, Hyderabad. Experiment was conducted in the lab of Botany Section, School of Sciences, Maulana Azad National Urdu University, Hyderabad. At the time of experiment fresh aqueous extract was prepared. 4gm of dried shoot powder soaked in 100ml of distilled water for 48 hr¹⁰. The extract was filtered through filter paper. Filtrate considered as stock solution stored in glass bottle until required. From this concentration 50% aqueous extract was prepared. Seeds were surface sterilized with 2% Sodium hypochlorite then washed with distilled water many times. 20 seeds were placed in petri-dishes with filter paper. Each petri dish treated with 4ml of *C. argentea* shoot extract (50 %) and Ag NPs (50ppm) alone as well as in combination (Fig. 2). Each treatment having three (03) replicates including control. All the treatments were kept at room temperature ($30^0 \pm 2^0$ C) in BOD incubator.

Sources of Nanoparticle :

Ag NPs were purchased from Nano Research Lab- Jamshedpur, 50 ppm of Ag NPs prepared for experiment.

Germination index :

Germination index was calculated with the formula given by Zheng and Tao¹⁸.

$$\text{Germination index} = \frac{\% \text{ Germination}}{\text{Days of Germination}}$$

Vigor index :

Vigor index was calculated with the formula given by Zhu and Hong²⁰

Vigor index = % Germination x Mean of seedling length (root + shoot)

Seed germination was observed after 2nd and 5th day, the radicle and plumule emergence up to 2mm was taken as criteria for germination. On the 5th day morphological characters like root and shoot length were measured.



Fig. 1. Day 1 experimental set up

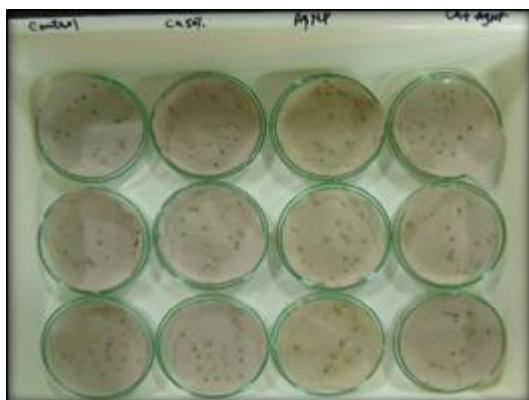


Fig. 2. Day 1 seeds placed in petri dishes

Germination index :

C. argentea shoot extract shown significantly decreased germination index of *P. millet* seeds, however increased with the presence of Ag NPs along with the combination of both extracts.

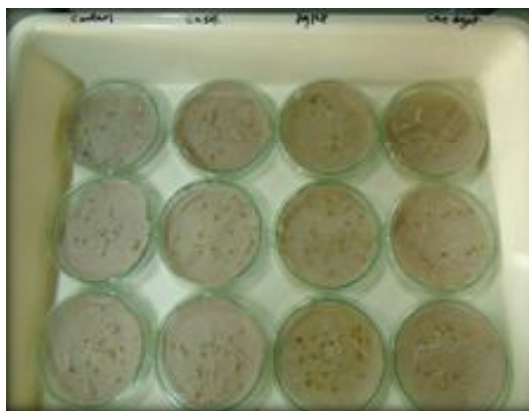


Fig. 3. Day 2 Showing seed germination

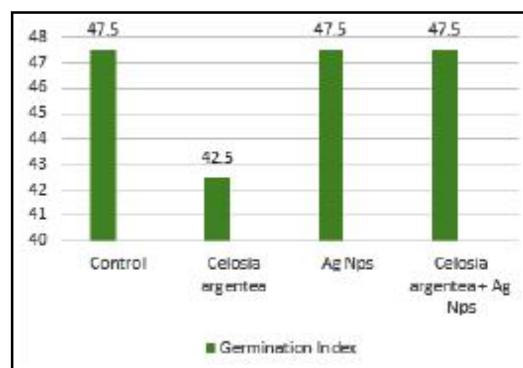


Fig. 4. Germination index of Pearl Millet seeds

Vigor index :

Seed vigor index significantly affected by the application of both Ag NPs and mixture of *Celosia argentea* and Ag NPs in dependent manner. Reduction in root and shoot length with the shoot extracts of *C. argentea*. Ag

NPs enhanced the seed germination and also root and shoot length increased.

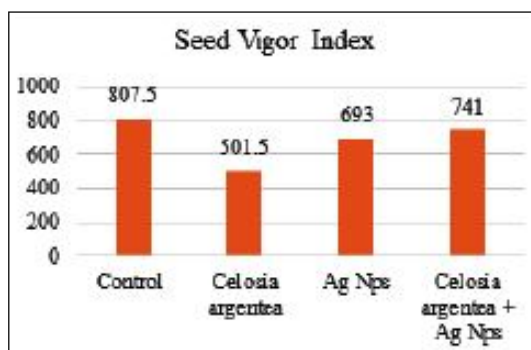


Fig. 5. Seed vigor index of Pearl millet seeds

Germination is important for determining the density of the final plant if planted seeds germinate completely and vigorously². The shoot extract of *C. argentea* inhibited seed germination of P. millet over the control (Fig. 4). Ag NPs have been used in agriculture to improve crop yield. This study showed that seeds of P. millet had shown positive response to silver NPs in terms of germination. Our results indicated that exposure to Ag NPs had significant effects on the seed germination of P. millet (Fig 5).

C. argentea is a predominant weed of leguminous crop fields and has been reported to reduce the yield of P. millet, maize and pulse legumes. The extracts of leaf, inflorescence and root of *C. argentea* caused adverse effects on the seedling growth of *Vigna mungo*¹. The decrease in root and shoot length was observed as per increase in concentration of root, inflorescence and leaf extracts. Aqueous shoot extract of *Amaranthus viridis* and *Parthenium hysterophorus* caused most inhibitory effect to shoot length of seedling of maize, rice and wheat. Aqueous shoot extracts

of *Amaranthus* inhibited germination of sunflower and soybean^{5,6}. The allelopathy workers like Monimoto *et al.*¹², Bogatek *et al.*³ indicated that various yield attributes in agricultural crops are highly influenced by leachates, extracts and residues of allelopathic plants. Allelopathy can be stimulatory or inhibitory depending on the identity of the compound. These allelochemicals (Metabolites) under suitable conditions may be released into the environment either by withering, leaching, exudation and volatilization. Harper, May and Ash analysis that allelopathy is an interference mechanism, in which live or dead plant materials release chemical substances, which inhibit or stimulate the associated plant growth^{4,11}. The silver nano solution coated seeds recorded better germination than the seeds treated with fungicide and concluded to use silver nano coating instead of using fungicides⁸. Silver NPs even at the highest dose employed (4,000 ppm) did not disturb the germination of the seedlings or the growth of *Ricinus communis*¹⁹.

Results of the current investigation clearly demonstrated that adverse effects of aqueous extract inhibit seed germination index and vigor index of P. millet. However, the Ag NPs application has mitigated the adverse effects by suppress of the activity of allelochemicals of *C. argentea*. However, the more in-depth work is needed to elucidate the detailed signalling and mechanism involved in plants at molecular level.

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