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Effect of seed invigoration with inorganic nanoparticles on seed yield in chilli (*Capsicum annum*)

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ABSTRACT

An experiment was conducted to study the effect of seed invigoration with inorganic nanoparticles on plant growth and seed yield of chilli. Seed invigoration with nano particles of ZnO and TiO_2 was found to be beneficial in improving yield and yield attributes. Seed treatment with nano ZnO @ 1300 mg kg^{-1} of seed and nano TiO_2 @ 900 mg kg^{-1} exhibited increased plant height, fruits per plant, fruit length, fruit yield, number of seeds per fruit and seed yield.

KEYWORDS: Seed invigoration, nanoparticle, seed quality

INTRODUCTION

The production of high-quality seeds is one of the most strategic resources for higher yield. Seed quality can be considered as a summation of all factors that contribute to seed performance. Seed treatments can be generally defined as, all operations that are executed on seeds after taking them from mother plant. These practices aim to improve yields by protecting from insects, diseases and ensuring uniform crop stand across a variety of environmental conditions and soil types. Since the treatments are applied to seeds, the land area which is exposed to active ingredients is reduced. The rate of chemicals applied per hectare is less thus the cost of cultivation can be decreased (Sharma, 2015). Seed invigoration with nanoparticles is a relatively novel technology successful in many crops. The size of nanoparticles being 100 nm (or less than 100nm) in one or more dimensions, have unique properties and they have the potential to improve plant metabolism. The positive effects of nanoparticles include enhanced germination per cent, length of root and shoot and vegetative biomass of seedlings in many crop plants (Agarwal & Rathore, 2014). Over the years, use of metal based nanoparticles like Gold, Titanium, Copper and Zinc are increasing exponentially because of their enhanced biological activities and physiochemical properties.

Many studies suggests that zinc oxide and titanium dioxide nanoparticles increase plant growth and development. Zinc oxide nanoparticles increases biomass accumulation, maintains membrane integrity and helps in the functioning of several enzymes (Burman. *et al*., 2013). Nano Zn application ameliorates rice growth as it releases nutrients slowly and gradually during critical growth stages (Raj & Subramanian, 2014). Seed dressing using ZnO increases number of pods/plant, shelling percentage and pod yield in peanut (Manjumdar *et al*., 2001). Similarly, nano TiO_2 also plays a key role in absorption of inorganic nutrients and breakdown of organic substances. It also helps to remove oxygen free radicles and thus increases photosynthetic rate (Khot *et al*., 2012). It stimulates Ribulose 1, 5-bisphosphate carboxylase (Rubisco) activity, thereby increases photosynthesis and thus increases plant growth and development (Yang *et al*., 2006). Hence, the study was formulated to assess the effect of seed treatment with nano grades of ZnO and TiO_2 on field performance and seed yield in chilli.

MATERIALS AND METHODS

The study was conducted in the Department of Seed Science and Technology, College of Horticulture, Kerala Agricultural University, Vellanikkara during May 2019. This area is located 22.25 m above mean sea level and its co-ordinates lies between 10.5452 °N and 76.2740 °E and the region is characterized by hot and humid climatic conditions.

Chilli seeds of variety Anugraha were dry dressed with nano grade ZnO and TiO_2. The seeds along with the treatments were taken in a screw capped glass bottles and was shaken

Table 1: Influence of nano grade ZnO and TiO_2 on yield attributes in chilli

Treatment	Plant height (cm)	Fruits/plant (Nos.)	Fruit length (cm)	Fruit weight (g)	Fruit yield (g)	Seeds/fruit (Nos.)	Seed yield/plant (g)
Control	60.33	85.33	6.43	2.30	195.5	50.33	17.18
n ZnO@500	62.00	90.00	6.90	2.86	255.00	54.66	24.62
n ZnO@900	66.00	88.00	6.80	2.80	246.33	58.66	23.22
n ZnO@1300	67.30	122.00	7.40	3.46	422.70	61.33	41.14
nTiO_2@500	65.80	93.00	7.23	2.56	238.70	52.33	24.32
n TiO_2@900	66.33	117.66	7.30	3.30	388.30	59.00	38.17
nTiO_2@1300	64.10	114.66	7.00	3.33	382.13	59.00	37.20

gently 5 times for 3 min at an interval of 3hrs. Untreated seeds served as control. The experiment was conducted in a Randomized block design. The treatments included, control; nano ZnO-500 mg kg^{-1}, nano ZnO-900 mg kg^{-1} , nano ZnO-1300 mg kg^{-1} , nano TiO_2-500 mg kg^{-1}, nano TiO_2-900 mg kg^{-1} nano TiO_2-1300 mg kg^{-1}. The twenty day old seedlings raised in the nursery were transplanted to main field. The experimental crop was raised as per Package of practices recommendations of Kerala Agricultural University.

Plant height was measured at 120 days after transplanting from ground level to the tip of the main stem from five representative plants, randomly selected from each plot. Total number of fruits harvested per plant was recorded. The fruit length was measured from distal end to proximal length using meter scale in randomly selected ten fruits. Fruits collected from five plants were weighed using weighing balance and yield was expressed in grams. The fruits per plant, number of seeds per fruit and seed yield per plant were also recorded.

RESULTS AND DISCUSSION

The influence of seed invigoration with nano grade Zinc Oxide and Titanium dioxide on yield attributes in chilli (*Capsicum annum*) is presented in Table 1. The nano particle seed invigoration treatments performed significantly higher over the control. Among the treatments, nano ZnO @ 1300 mg kg^{-1} of seed recorded the highest plant height (67.3 cm), fruits per plant (122), fruit length (7.40 cm), fruit weight (3.46g), fruit yield (422.70 g), number of seeds per fruit (62) and seed yield (41.14 g). In maize by using nano ZnO at 400 ppm obtained highly significant results for yield, plant height, cob length and number of grains per cob when compared to control (Subbaiah, 2014).

Similarly, Raliya *et al*., (2015) reported that nano ZnO recorded an increase in plant height by 24.5 % and Poornima and Koti, (2019) noticed a significant increase in ear head length of sorghum at 500 ppm (19.33 cm) which was followed by 1000 ppm (19 cm). In pepper, García-López *et al*., (2018) recorded that ZnO nanoparticles @ 1000 mg L^{-1} produced more fruits per plant (64) over control. Nanoparticle treatments with ZnO @1000 ppm recorded highest fruit weight in carrot (Elizabath *et al*., 2017). Khanm *et al*., (2017) and Sadak and Bakry, (2020) noticed a significant increase in fruit yield and seed yield respectively, when treated with different doses of nano ZnO.

When Chickpea seeds were treated with nano ZnO, an increment in IAA levels was observed in roots which in turn increased plant growth (Avinash *et al*., 2010). Agronomic efficiency of Zn treatments are influenced by particle size. When particle size is reduced, number of particles per unit weight is increased and thus surface area is also increased (Mortvedt, 1992). Nano particles helps in slow release of nutrients to plants and makes them available to nanoscale plant pores and therefore result in efficient nutrient use, increased plant growth and yield (Suppan, 2013).

In case of TiO_2 seed treatments, nano TiO_2 @ 900 mg kg^1 recorded highest plant height (66.33 cm), fruits per plant (118), fruit length (7.30 cm), fruit yield (388.30 g), number of seeds per fruit (59) and seed yield (38.17 g). Nano TiO_2 @ 1300 mg kg^1 recorded highest fruit weight (3.33g) and number of seeds per fruit (59).

An increase in yield and yield promoting traits was observed by Debnath *et al*., (2020) in rice when treated with nano TiO_2 at 500, 1000 and 2000 mg kg^{-1}. According to Jaberzadeh *et al*., (2013), nanoTiO_2 at 50 ppm recorded an increase in panicle length by 3.2% and at 0.02 % recorded highest fruit weight. Similarly, Rezaei *et al*., (2015) reported that treatments with nano TiO_2 at 0.05% recorded highest seed yield of 2416.16 kg ha^{-1} in soyabean and Owolade and Ogunleti, (2008) noticed that application of titanium on cowpea at 125 ml ha^{-1} increased number of seeds per pod. Enhancement in plant growth and yield might be due to the action of titanium in several cellular mechanisms.

Nanoparticles interact with the living cells at molecular level. They act on plant metabolism by regulating genes, interferes with oxidative process or by providing micronutrients. According to Poornima and Koti, (2019), the reason for increased performance may be due to the increased uptake and translocation efficiency of nano particles. Zinc is essential for pollen function, chlorophyll production, germination and fertilization. Increased germination per cent in seeds treated with nano-TiO_2 could be the generation of hydroxide and superoxide anions that increased intake of oxygen and water needed for quick germination and as a result it enhances plant growth and thus yield.

CONCLUSION

Nanotechnology is an emerging discipline with novel applications in agriculture. The most commonly used and widely applied types of nano particles are Zinc and Titanium. The nanoparticle treatments at higher concentration performed better than at lower concentrations. Nanoparticles of ZnO @ 1300 mg kg^{-1} of seed and nano TiO_2 @ 900 mg kg^{-1}recorded superior results throughout the experiment. The results indicated that dry dressing with zinc oxide and titanium dioxide nanoparticles in chilli is effective in improving field performance and yield in chilli.

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