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Effect of Zinc Nanoparticles Seed Treatment on Seed Quality Parameters in Bitter Gourd

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ABSTRACT: Zinc nanoparticles seed treatment was given to the bittergourd seeds (cv. Solan Hara) in the form of seed priming and seed coating. The experiment was conducted in open field conditions with Randomized Block Design having fourteen treatments replicated three times at the research farm of Department of Seed Science and Technology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (Himachal Pradesh) during 2022-2023. Out of the 14 treatments, 9 treatments comprised of seed priming with zinc nanoparticles @ 50 ppm, 100 ppm and 150 ppm for 12, 24 and 48 hours, 3 treatments comprised of seed coating with zinc nanoparticles @ 50 ppm, 100 ppm and 150 ppm, 1 treatment comprised of seed soaking in water for 36 hrs in addition to control. Based on present investigation, seed priming with ZnO NPs @ 150 ppm for 24 hrs was found to be superior over all other treatments in terms of days to 50% emergence (10.33 days), days to first picking (80.33 days), harvest duration (28 days), fruit length (17.11 cm), fruit diameter (4.48cm), number of seeds per fruit (24.18), number of seeds per plant (330.33), seed yield per plot (293.97 g) and 100 seed weight (17.20 g).

Keywords: Nanotechnology, seed priming, seed coating, ZnO, seed quality, germination, vigour.

INTRODUCTION

Bitter gourd (*Momordica charantia*) is a tropical and subtropical vine belonging to the family Cucurbitaceae. Bitter gourd is a monoecious annual climber and plays a significant part in the human diet as a source of carbohydrates, proteins, vitamins, minerals and other components required for sustaining good health (Ali *et al*., 2008). The bitterness of the fruit is due to presence of an alkaloid, Momordicin. In India bitter gourd is grown in an area of 1,70,000 hectare with an annual production of 13,34,000 MT (NHB, 2021).

The presence of thick, hard and impermeable seed coat in bitter gourd, which encloses the embryo, affects the seed germination by imposing mechanical constraints on embryonic growth (Pandita and Nagarajan 2004). The hardness and impermeability of the seed coat can hinder water absorption and gas exchange, which are essential for the initiation of the germination process. Hence field emergence is always a problem in bitter gourd. Seed priming and seed coating are the methods that can be used to address the issue of low and delayed seed germination in bitter gourd (Pandita and Nagarajan, 2004). Polymer used in seed coating acts as a temperature switch and protective coating by regulating the water uptake and subsequent germination of seed (John *et al.*, 2005). Seed priming is an effective technology to enhance rapid and uniform emergence, leading to better stand establishment and yield. Seeds are dried after priming to their original moisture content to enable standard handling, storing and planting (Varier *et al.*, 2010). Nanotechnology can be used for seed quality enhancement to improve seed germination, seed growth and yield by providing resistance to various stresses in plants (Nile *et al.*, 2022). The surface to mass ratio of nanoparticles is much larger than that of other particles and materials, which allows them to efficiently enhance catalysis, as well as to adsorb and deliver substances of interest. during the early phase of germination.

Zinc is an essential micronutrient for plants, playing a crucial role in various physiological and biochemical processes. Zinc plays a crucial role in the synthesis, transport and regulation of auxins responsible for various growth and developmental processes, including cell elongation, root formation, fruit and seed development.

MATERIALS AND METHODS

The experiment was carried out field experiment was conducted at Khaltoo experimental farm of the Department of Seed Science and Technology, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during Kharif season of 2022-23. The experiment was laid out using bitter gourd cultivar Solan Hara with Randomized Complete Block Design. There were fourteen treatments *viz.*, T_1 (Seed priming with ZnO NPs @ 50 ppm for 12 hrs, T_2

(Seed priming with ZnO NPs @ 50 ppm for 24 hrs), T_3 (Seed priming with ZnO NPs @ 50 ppm for 48 hrs), T_4 (Seed priming with ZnO NPs @ 100 ppm for 12 hrs), T_5 (Seed priming with ZnO NPs @ 100 ppm for 24 hrs), T_6 (Seed priming with ZnO NPs @ 100 ppm for 48 hrs), T_7 (Seed priming with ZnO NPs @ 150 ppm for 12 hrs), T_8 (Seed priming with ZnO NPs @ 150 ppm for 24 hrs), T_9 (Seed priming with ZnO NPs @ 150 ppm for 48 hrs), T_{10} (Seed coating with ZnO NPs @ 50 ppm), T_{11} (Seed coating with ZnO NPs @100 ppm), T_{12} (Seed coating with ZnO NPs @150 ppm), T_{13} (Seed soaking in water for 36 hrs), T_{14} (Untreated). Seeds of bitter gourd cv. 'Solan Hara' were surface sterilized with sodium hypochloride (2%) for 5 minutes.

ZnO NPs @ 50 ppm was prepared by dissolving 50 mg of ZnO NPs in 1000 ml of water, ZnO NPs @ 100 ppm was prepared by dissolving 100 mg of ZnO NPs in 1000 ml of water and ZnO NPs @ 150 ppm was prepared by dissolving 150 mg of ZnO NPs in 1000 ml of water.

Dispersion of nanoparticles was done by adding ZnO NPs to distilled water and stirring for 5 minutes which was followed by their dispersion in distilled water by water bath with ultrasonic treatment for 30 minutes. It was done because nanoparticles tend to agglomerate or form clusters due to van der Waals forces and electrostatic interactions between them. Dispersion breaks down these agglomerates, ensuring uniform distribution and maximizing their surface area for interaction.

For seed priming, sterilized seeds were thoroughly washed with water. Double layer of blotter paper was placed in sterilized petri plates and seeds were put over the double layered blotter papers in double layer of blotter paper. Priming solutions (50 ppm ZnO, 100 ppm ZnO and 150 ppm ZnO) were then added in petri-plates and spread equally on the whole surface of blotter paper to provide uniform moisture to all the seeds. Priming was carried out for three different durations (12 hrs, 24 hrs and 48 hrs) along with seed soaking in water for 36 hours. After completion of priming duration, seeds were removed from the solution, washed with tap water 3 times and then shade dried at room temperature to their original moisture content (8 %). Seed coating was done by mixing 5 ml solutions of different ZnO nanoparticles with 10 g seeds in a plastic container and then coating material (polykote polymer) was added and mixed thoroughly by shaking the container until there was a uniform coating on seeds and then seeds were dried in shade for 24 hours.

Days to 50 per cent emergence. Days to 50% emergence were calculated from the date of sowing to the date of 50 % emergence by counting seedling emergence in each plot daily.

Days to first picking. The number of days from sowing to first picking were counted.

Harvest duration (days). Days were counted from first picking to final harvest of fruits.

Fruit length (cm). Ten randomly selected fruits of second harvest were taken at red ripe stage and fruit length was measured with the help of scale and averaged to work out fruit length in centimetres.

Fruit diameter (cm). The same fruits which were used for the measurement of fruit length were used for calculating fruit diameter. The diameter of the fruit was measured at three different circumferences viz. centre, 1/4th of fruit from top and 1/4th of fruit from bottom with the help of vernier-caliper and average was worked out and expressed in centimeter.

Number of seeds per fruit. The number of seeds per fruit of 10 different fruits of a plant were counted and averaged.

Number of seeds per plant. The number of seeds from five randomly selected plants from each picking of each plot were counted and cumulative total after last picking was expressed as number of seeds per plant.

Seed yield per plot (g). Seed yield per plot was worked out by harvesting seeds from all plants in a plot and averaged to get seed yield/ plot (g).

100 seed weight (g). In each replication, 100 seeds were counted with the help of an electronic counter from the total seeds produced in each plot and were weighed on electronic balance to record the weight.

RESULTS AND DISCUSSION

Seed Quality Parameters. The data presented in Table 1 clearly implicit significant effect of different zinc nanoparticles seed treatment on various parameters

Days to 50% emergence. Minimum days to 50 % emergence (10.33 days) were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs). Whereas maximum days to 50 % emergence (14.00 days) were recorded in T_{14} (control). The possible explanation for minimum days to 50 % emergence in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) could be that zinc nanopriming promote early root growth by providing essential nutrients and growth-promoting substances directly to the seedling. This rapid root development can enhance nutrient and water uptake from the soil, further supporting the emergence and overall growth of crop.

Days to first picking. The data revealed that the minimum days to first picking (80.33 days) were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) with 81.67 days to first picking. However, maximum days to first picking (86.33 days) were observed in T_{14} (control). The possible reason for the minimum days to first picking in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) might be that Zn nanopriming positively affect plant growth by influencing nutrient uptake, hormone regulation, and stress responses which lead to accelerated vegetative growth, earlier onset of flowering and consequently, earlier fruit production. Nanopriming with zinc nanoparticles alter the metabolism of the seed, break down the starch that has been stored and stimulate the release of growth regulators, which ultimately improves nutrient uptake and promotes the growth and productivity of plant. The present results are in line with Lawre and Raskar (2014) who reported that the number of days required for flowering significantly decreased in all the treatments with ZnO NPs in onion.

Harvest duration (days). Maximum harvest duration (28.00 days) was recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) and T_7 (seed priming with ZnO NPs @ 150 ppm for 12 hrs) with 27.33 days and 27.00 days, respectively. Minimum harvest duration (21.00 days) was observed in T_{14} (control). Maximum harvest duration in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) could be due to that seed priming with zinc nanoparticles promote more uniform and faster germination. This lead to a more synchronized crop stand where plants are at similar stages of development, ultimately resulting in a more extended harvest duration.

Fruit length (cm). The highest fruit length (17.11 cm) was observed in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) with fruit length of 16.66 cm. While minimum fruit length (12.70 cm) was recorded in T_{14} (control).

Fruit diameter (cm). The data depicted in table 1 indicated non significant effect of different zinc nanoparticles seed treatment on fruit diameter. However maximum fruit diameter (4.48 cm) was observed in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs). While T_{14} (control) recorded minimum fruit diameter (3.68 cm).

Number of seeds per fruit. The maximum number of seeds per fruit (24.18) were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @150 ppm for 48 hrs) having 23.83 seeds per fruit. The minimum number of seeds per fruit (20.68) were observed in the T_{14} (control).

Number of seeds per plant. The maximum number of seeds per plant (330.33) were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @150 ppm for 48 hrs) with 317.64 number of seeds per plant. The minimum number of seeds per plant (199.80) were recorded in the T_{14} (control). Maximum number of seeds per plant were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) because zinc plays a role in flower bud initiation and development. Nanopriming with zinc might stimulate the formation of flower buds, resulting in a higher number of flowers and ultimately more fruits and seeds.The present findings are in line with those of Ram *et al*. (2023) who reported that highest number of spiklets per spike and maximum number of grains per spike was recorded in the wheat seeds primed with ZnO NPs as compared to the control.

Seed yield per plot (g). The data on seed yield per plot as influenced by different zinc nanoparticles seed treatment is depicted in table. The maximum seed yield per plot (293.97 g) were recorded in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) with seed yield per plot (290.62 g). On the other hand, minimum seed yield per plot (228.66 g) was recorded in T_{14} (control).

100 seed weight (g). The data enumerated in table 8 indicate that zinc nanoparticles seed treatment have significant effect on 100 seed weight. Maximum 100 seed weight (17.20 g) was observed in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) with 100 seed weight of 17.10 g whereas, minimum 100 seed weight (15.76 g) was observed in T_{14} (control).

Table 1: Effect of zinc nanoparticles seed treatment on quality seed production of bitter gourd cv. Solan Hara.

Treatment details	Days to 50 per cent emergence	Days to first picking	Harvest duration (days)	Fruit length (cm)	Fruit diameter (cm)	Number of seeds per fruit	Number of seeds per plant	Seed yield per plot (g)	100 seed weight (g)
T_1	12.66	84.33	23.67	13.96	4.00	23.68	268.26	266.05	16.02
T_2	12.00	83.33	24.33	14.90	4.14	23.29	271.50	270.69	16.25
T_3	12.33	83.67	24.00	14.70	4.01	22.76	265.43	269.08	16.17
T_4	11.66	83.00	25.33	14.91	4.15	22.36	275.43	271.18	16.27
T_5	11.66	82.66	26.00	15.16	4.19	22.15	280.40	272.25	16.31
T_6	11.33	82.33	26.67	15.26	4.22	21.81	283.50	275.08	16.44
T_7	11.00	82.00	27.00	15.70	4.31	22.43	291.60	277.90	16.55
T_8	10.33	80.33	28.00	17.11	4.48	24.18	330.33	293.97	17.20
T_9	10.67	81.67	27.33	16.66	4.42	23.83	317.64	290.62	17.10
T_{10}	13.00	84.00	22.66	14.36	3.98	22.95	252.23	264.59	16.06
T_{11}	12.66	83.33	23.00	14.50	4.00	23.94	263.90	266.89	16.11
T_{12}	13.33	84.33	22.33	14.13	3.91	22.74	257.40	264.20	16.01
T_{13}	13.66	86.33	21.67	13.03	3.70	22.98	237.36	248.73	16.01
T_{14}	14.00	86.33	21.00	12.70	3.68	20.68	199.80	228.66	15.76
Mean	12.16	83.40	24.5	14.79	4.08	22.84	271.05	268.56	16.30
$CD_{0.05}$	1.20	1.27	1.37	1.20	NS	0.97	10.92	4.64	0.27

100 seed weight (g). The data enumerated in table 8 indicate that zinc nanoparticles seed treatment have significant effect on 100 seed weight. Maximum 100 seed weight (17.20 g) was observed in T_8 (seed priming with ZnO NPs @ 150 ppm for 24 hrs) which was statistically at par with T_9 (seed priming with ZnO NPs @ 150 ppm for 48 hrs) with 100 seed weight of 17.10 g whereas, minimum 100 seed weight (15.76 g) was observed in T_{14} (control).

Fig. 1. Field view at flowering stage.

CONCLUSIONS

From the present study, it is concluded that seed priming with ZnO NPs @ 150 ppm for 24 hrs produced better results with regard to seed quality parameters *i.e*., days to 50% emergence, days to first picking, harvest duration, fruit length, fruit diameter, number of seeds per fruit, number of seeds per plant, seed yield per plot and 100 seed weight. Hence it can be recommended for commercial seed production of bitter gourd.

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