Effectof ZnSo$_4$primingonstorability, seedqualityandbulbyieldinonionundermid- hill condition of north western Himalayas

Abstract

Seed storabilityand longevity is a major issue in onion seed and bulb. Priming can improve the storability in onion seeds. So a field and laboratoryexperiment was conducted to studythe effect of zinc sulphate priming on seed and bulb quality in onion. There were eleven treatment combinationsviz;T_1-0.50%$ZnSO_4$for6 hrs,T_2- 0.50%$ZnSO_4$for 12 hrs,T_3- 0.50 % $ZnSO_4$for 24 hrs,T_4-0.75%$ZnSO_4$for 6hrs,T_5-0.75%$ZnSO_4$for 12 hrs,T_6-0.75 %$ZnSO_4$for 24 hrs, T_7-1.0 % $ZnSO_4$for 6 hrs, T_8-1.0 % $ZnSO_4$for 12 hrs,T_9-1.0 % $ZnSO_4$for 24 hrs,T_{10}- Hydro- priming for 12 hrs, T_{11}– Control. Results indicated that treatment $T_6$was foundsignificantly best in improving seed quality parameters like germination (%), seedling length (cm), dry weight (g), speed of germination, seed vigour index (I&II) and field parameters like plant height 45days after transplanting (cm), plant height at maturity (cm), number of leaves per plant, equilateral and polar diameter of bulb (mm), bulb weight (g),number ofmarketablebulb per plot and bulb yield/plot (kg) while leaf length (cm), neck thickness (mm) were not significantly affected by the treatment T_6.

Keywords:Bulb,Onion,Priming,Seed,Treatment

Introduction

Onion (*Allium cepa* L.) belongs to the family Aliliaceae and is one of the most important monocotyledonous, cool season vegetable crops in India (Abhilash *et al*. 2023). Itis grown all around the world for its food as well as industrial application. Bioactive compounds such as polyphenols, fructans, fructo-oligosaccharides, fructans, and organo- sulfur compounds found in its extracts and essential oil make them a valuable source of vitamins and minerals (Sharifi-Rad *et al*. 2016). In 2022 onion area and production were 5 million hectares & 115.24 million tons (FAO, 2022).In India, onion is cultivated both in *kharif*and*Rabi*season(Tiwari*etal*.2022)andIndiaistopproducerofonioninworldwith 26.31 million tonnes production. Onion is commercially propagated both through bulbs and seed, but onion seed have short longevity and storability.Onion seed have thin coat do notgo throughadormancyperiod so they losetheir germinationcapacityquicklywithin one year (Padula *et al*. 2023).Having high-quality seeds is crucial to maintaining crop yields.

Regarding products like onion, there is a substantial market need for a considerably higher germ inability that guarantees high propagation and robust plant emergence.

Seed invigoration refers to the enhancement of seed vigour through any post-harvest treatment, leading to better field performance, increased storability, and improved germinability compared to the corresponding untreated seed. As one of the pre-sowing seed management techniques, seed priming involves partially soaking the seeds and then drying them back to produce an invigorating effect that expresses field emergence and ultimately yields (Thejeshwini*et al*.2019). Different seed priming techniques like hydro-priming, osmo-priming,andhalo-priming,solid-matrixpriming, and bio-primingcanimprovetheseed quality (Dhiman *et al.* 2022).

So this study was conducted to study the effect of $ZnSo_4$based priming on seed storability, seed quality and bulb yield in onion. The previous studies have shownthat zinc is a co-factorof various enzymes superoxide dismutase (SOD) involved in the detoxification of reactive oxygen species, such as O_2^-(superoxide radical) and H_2O_2(hydrogen peroxide) essential for the detoxification of reactive oxygen species (ROS) that are produced during ageing in plant cells (Prom-u-thai*et al.* 2012). Hence, zinc seed priming may be a reliable approachto raisethe zinc content inseeds to improve seed qualityparameters as comparedto soil application because of the small quantity of zinc required for seed priming and the simplicity of the process. So present study was conducted to find the suitable dose of zinc sulphate for priming and its effect on seed storabilityand bulb quality in onion.

MaterialandMethods

Field and laboratoryexperiment was conductedonthe *Pandah*research farmand seed testing laboratory of Department of Seed Science and Technology, College of Horticulture, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during *Rabi* 2020-21. The Research Farm is located in the mid-hill region of HimachalPradeshatanelevationof 1250metresabovemeansealevelwithcoordinatesof 35.50 ^{o}N and 77.80^{o}E. Average maximumand minimumtemperatures, relative humidityand total precipitation were 25.02 °C, 7.04 °C, 52.85 % and 372.1 mm, respectively.For this experiment seeds of *Palam Lohit* variety were used. In the first week of November, 2020 priming was done in the laboratory. First of all seed were surface sterilized with $HgCl_{2-}$ (0.1%) for 5-10 minutes and after that seeds were rinsed in water. 10g seeds per treatmentwas used for this experiment.In sterilized petri dishes, blotter paper was layered twice, and then the seeds were added on top. After thoroughly mixing the primer, priming solutionswerepouredtopetridishesanddistributedonthewholeareaofblottingpapertoevenly

hydrate allthe seeds. Elevenpriming treatment combinationwere used viz;T_1- 0.50 %$ZnSO_4$for6hrs,T_2-0.50%$ZnSO_4$for12hrs,T_3-0.50 %$ZnSO_4$for24 hrs,T_4-0.75%$ZnSO_4$for6 hrs,T_5 -0.75%$ZnSO_4$for12hrs,T_6-0.75 %$ZnSO_4$for24hrs,T_7-1.0%$ZnSO_4$for6hrs,T_8-1.0%$ZnSO_4$ for 12 hrs, T_9-1.0 % $ZnSO_4$for 24 hrs, T_{10}- Hydro-priming for 12 hrs, T_{11}– Control. After priming seeds per shade dried at 25°C temperature and dried up-to 8% moisture content. Primed seeds were kept for storage in dark in air tight container under ambient conditions for testing the seed quality parameters. Seed quality parameters like germination(%), Seedling length (cm), seedling dry weight (mg), Seed vigour-I & II, electrical conductivity (dS m^{-1}), speed of germination were recorded after 1 week, 1 month, 3 months and6 months as per ISTArules (ISTA, 1985).For fieldexperiment primed onion seedswere sown as per treatmenton 3nd week of November in a plot size of 3.0 x 1.2 m with 10 cm height for nursery production. After 2 months nursery seedling were transplanted in the field with spacing of 15 x 10cm, in plot size of 1.5 x 10 m in randomized complete block design. All necessary cultural practices were followed for raising the crop and mature bulbs were harvested treatment wise one week after neck fall stage. Field parameters like plant height 45 days after transplanting (cm), leaf length (cm), number of leaves per plant,plant height at maturity (cm), polar diameter (cm), equilateral diameter of bulb (cm),neck thickness (mm),bulb weight (g), number of marketable bulb per plot, bulb yield per plot (kg/plot).All the data were analyzed according to procedure for Randomized Complete Block design and Completely Randomized Design as suggested by Gomez and Gomez 1984.

Resultsand Discussion

Effect of various concentrations and duration of zinc sulphate priming on seed quality were determined in onion seed and storage studies were also carried out to check the storage potentialofonion seed. Among the varioustreatments, highest germination(%) wasrecorded in treatment T_6-0.75 % $ZnSO_4$for 24 hrs and lowest was recorded in T_{11}(control). With increase in storage period germination decreased from 82.39 % in first month to 74.50 % in 6 months of storage (Fig 1). This increase in germination (%) of onion seed on priming with zinc could be due to the role of zinc in promoting the releases of enzymes in breakdown of micro and macromolecules which enhances germination (Hamsaveni et al., 2003). Huded (2016) also reported increase in germination of chickpea seed in priming with $ZnSo_4$. In case of seedling length (SL) maximum was observed in T_6(12.67 cm) while minimum was observed in T_{11}. Seedling length significantly affected by storage period. At the start of storage, seedling length was 11.73 cmafter one week ofpriming it was reduced to 7.84 cmafter six months of storage (Fig 2). Zinc is a cofactorof more than 300 enzymes and also essential for formation oftryptophan,whichisaprecursorofauxin.Seedlinglengthincreasesduetohigher metabolic activity of IAA, which cause rapid cell division and cell elongation (Castillo-González *et al*. 2018).Imran *et al*. (2021) and Tuiwong*et al*. (2022) also reported that seed priming with zinc improves seedling length in spinach and rice. Seedling dry weight decreased significantly with increase in storage period (Fig 2). The dry weight of seedlings decreased significantly as storage time increased. The seedling dry weight was significantly highest (7.68 mg) at the start of storage periods and decreased to 5.99 mg after 6 months of storage. The primary pathway that might have accelerated seedling growth and development and allowed the seedling to reach autotrophic stages sufficiently in advance to produce relativelymore dryweight isthe glyoxylate cycle. Betterseedling lengthcombined with lipid consumption via this cycle could account for the maximum seedling dry weight (Ma *et al*. 2016). In chickpea seedling dry weight decreased in storage period (Huded, 2016). As Seed vigour index (I& II) are function of germination, seedling length and dry weight, so similar pattern were shown by seedling vigour index-I and II. Seed vigour index-I was measured at the start of storage, it was the highest (970.92) and significantly different from other storage periods. After 6 months ofstorage, it was reduced to 587.37. The highest seed vigour index-I (1,322.00) was observed in treatment T_6after one week of storage, when seeds were primed with 0.75 per cent $ZnSO_4$for 24 hours. After 6 months of storage, the seed vigour index-Iwas reduced to a minimum (366.37) in T_{11}(control) while Seed vigour index-II was significantly highest (790.47) in treatment T_6, where seeds were primed with 0.75 per cent $ZnSO_4$ for 24 hours. However, minimum seed vigour index-II (389.71) was recorded in T_{11}(control) (Fig 3). Seed vigour is known to diminish as storage period increases. The buildup of free radicals may be the cause of the decline in seed vigour. It has been shown that pre- treating seeds can significantly lessen the impact ofaging (Paparella *et al*. 2015). Zinc has an effect on membrane-bound NADPH oxidase, whichgenerates reactive oxygenspecies (ROS) during aging. It also contributesto the development ofantioxidative defense enzymes caused by oxidative stress, such as glutathione reductase and ascorbate peroxidase, which scavenge H_2O_2(Sweetman *et al*. 2024). 0.1% and 0.5% solution in rice improved the vigour in rice (Abbas *et al*. 2014). Speed of germination was maximum (10.15) in treatment T_6, whereseeds were primed with 0.75 per cent $ZnSO_4$for 24 hours, which was at par with T_9, $T_3$and T_5. However, minimum speed of germination was found (7.75) in T_{11}(control). It decreases with increase in storage period (Fig 2).In the present studies, seeds were soaked in various solutions with high osmotic potential during priming. It raises the physiological andmetabolic states of every seed to a uniform state, allowing for maximal growth uniformity in theseedlingsandacceleratinggermination.Seedprimingisatechniqueforshorteningthe timebetweenseedsowingand seedlingemergence aswellassynchronizingtheemergenceof seedlings (Lutts et al. 2016). Priming improved germination speed in onion (Saranya *et al.* 2017). Seed priming with different zinc dosages for three different times, storage times, and their combination significantly affected the seeds electrical conductivity. The electrical conductivity of the seeds that were primed with 0.75 percent $ZnSO_4$for 24 hours (T_6) was significantly lower (0.154 dS m^{-1}), whereas T_{11}(control) had the highest electrical conductivity (0.265 dS m^{-1}). Treatment T_6had the lowest electrical conductivity (0.106 dS m^{1}) among various treatment combinations, which was statistically at par with $T_9$when calibrated atthestart ofthestorage.After 6 monthsofstorage, it wasreduced to 0.363dS m^{1}in T_{11}(control). The integrity of a seed's membrane has a major impact on its electrical conductivity. Water-soluble substances including sugars, amino acids, and electrolytes leak out of seeds as the cell membrane deteriorates with age and in less vigorous seeds. . Lipid peroxidation caused by the generation of reactive oxygen species (ROS) during seed ageingis the primary source of membrane damage. The reduction in electrical conductivity of zinc primed seed can be attributed to the fact that zinc in membranes appears to be linked to membrane lipids and proteins being protected from oxidation (Anjum *et al*. 2023). Zinc ions inhibit the production and peroxidative attack of oxygen free radicals generated in the membrane environment particularly during redox cycling of metals (e.g., Fe and Cu) on membrane binding site (Marreirro*et al*. 2017). The results revealed that treatments had both significant and non-significant effects on growth and yield parameters. After 45 days from transplanting, maximum plant height was observed in treatment T_6, and it was statistically at par withtreatmentsT_9, $T_3T_{5,}T_{8,}T_{2and}T_4$. Onother hand, treatment T_{10}, had theshortest plant height which was statistically equivalent to T_{11}(control) and T_1 (Table 1). Zinc governs the synthesis of indole acetic acid, which controls plant growth and it also activates a number of enzymatic activities that are required for chlorophyll synthesis and carbohydrate formation (Solanki, 2021). The fact that zinc is involved in chlorophyll synthesis might have favoured cell division, meristematic growth in apical tissue, cell expansion and synthesis of new cell walls, which ultimately might have led to an increase in plant height of primed seeds over untreatedseeds. These findings corroboratetothose ofTamindzic*et al*. (2021), who reported that Zn priming stimulated plant development and increased plant height in three maize hybrids. Interms of plant height at maturity, statisticalanalysis revealed that there were non-significant differences among the treatments. However, treatment T_6had the highest plant height (54.50 cm) and the lowest (43.40 cm) was observed in T_{11}(control). The number of leavesper plant wasconsiderablyinfluenced bythetreatments(Table1). The highest number of leaves per plant (8.37) recorded in treatment $T_6$was statistically at par with T_9(7.80) and T_3(7.57)whereas, the lowest (5.53)wasrecordedinT_{11}(control). Present findingsare in line withthoseofZalama and Fathala(2020) inonion. Highest leaf length(51.49 cm) was found in treatment T_6(Table 1). Treatment T_{11}(control), on the other hand had minimum leaflength(32.24cm)at 90daysaftertransplanting. Enhanced leaflengthismost likelyrelatedto zinc's function in early plant growth via increased net photosynthetic rate during the leaf development stage (Liu *et al.* 2016). In terms of neck thickness, there were non-significant differencesamong thetreatments. However,treatment hadthe minimumneck thickness(8.38 mm). On the other hand, T_{11}(control) recorded the maximum neck thickness (11.83 mm). The largest equatorial diameter (61.71 mm) was observed in treatment T_6, where and it was statistically at par with T_9 (58.70 mm), where seeds were primed with 1.0 per cent $ZnSO_4$for 24 hours. However, minimum (46.78) was observed in T_{11}(control).Polar diameter of bulb had also reported similar pattern. This might be due to improved photosynthate usage and enhanced photosynthate allocation to economically valuable regions of the crop such as the bulb. Aldolases are the enzymes responsible for transport of photosynthates from the cytoplasm into the chloroplast. In the absence of zinc, the activity of these enzymes has been reported to decrease leading to carbohydrates accumulation in plant leaves. As a result, increased photosynthates accumulation in the bulbs for plants with more leaves might have resulted in higher individual average bulb weight, bulb diameter (polar and equatorial) and high percentage of marketable bulbs.The results on bulb polar diameter revealed that it was strongly changed by various priming treatments, as shown in Table 1. Treatment T_6had the largest polar diameter (55.30 mm), which was statistically comparable to T_9 (54.70 mm), T_8(53.85mm),T_{10}(52.65mm),T_5(52.04mm),T_3(51.54mm),T_7(51.11mm),T_4(50.44mm) andT_2(50.52mm).TreatmentT_{11}(control),ontheotherhandhadthelowestpolardiameter (43.93 mm). The average weight of bulbs was found to differ significantly betweentreatments (Table 1). In terms of bulb weight, treatment $T_6$was determined to be superior over allthe treatments. It generated bulbs weighing upto 90.56 gon an average. Ontheother hand, T_{11} (control) had the lowest bulb weight (48.92 g).The largest number of marketable bulbs per plot (97.67) was obtained in treatment T_6, which was statistically at par with T_5(93.33), T_4 (91.33), T_9 (90.00), T_3 (90.00) and T_8 (90.00). However, minimum number of marketable bulbs (76.33) was obtained in T_{11}(control). In the current study, seed priming raised a level of bulb production. Throughout the onion's life cycle, the zinc treatment produced a robust and healthy root system, which may have improved the efficiency of nutrienttransferfrom theleavestothebulbs(ZalamaandFathala,2020).When seedswere primed with 0.75 per cent $ZnSO_4$for 24 hours (T_6), the highest bulb yield per plot (9.00 kg) was achieved, which was statistically at par with T_9(7.95) and T_3(7.79). Treatment T_{11}(control), on the other hand had the lowest bulb production per plot (4.4 kg). The increased yield could be the result of improved crop development and growth. Plant productivity is enhanced by zinc's physiological role in seed germination and seedling development. Furthermore, zinc has been linked to a number of metabolic processes, including the production of chlorophyll, hormone biosynthesis, and the majority of enzymatic reactionsthat regulate numerous biosynthetic pathways. All of these processes could have improved oniondevelopment intermsofbulb yieldandqualitytraits(Zalama and Fathala, 2020). From laboratory and field experiment it can be concluded that to improve seed quality, storability and bulb quality they can treated with 0.75 % $ZnSO_4$for 24 hrs.

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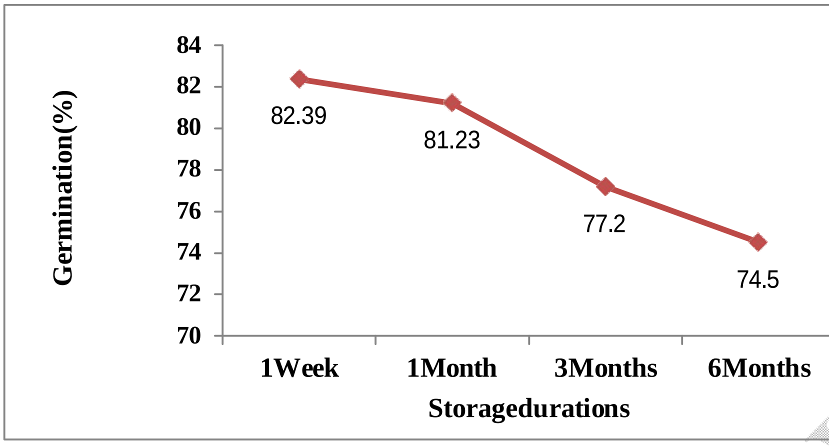

Fig1 .Effect of $ZnSO_4$priming ongermination(%)inonionseeds

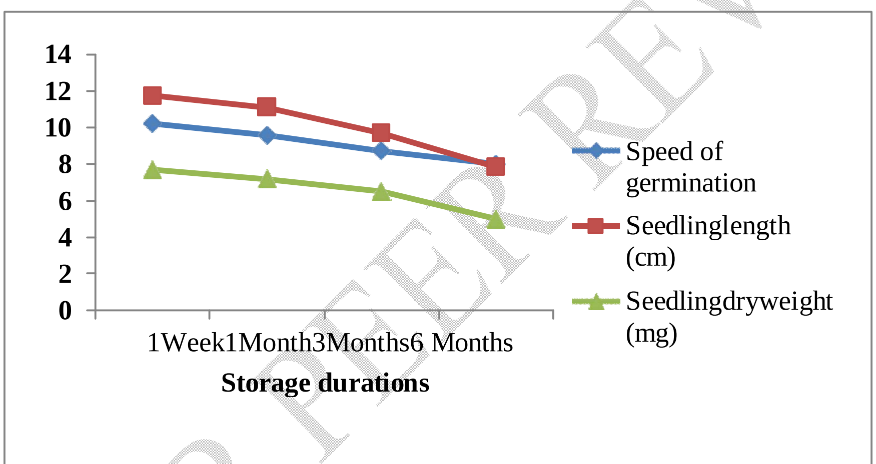

Fig2.Effectof$ZnSO_4$primingonseedqualityparametersinonionseeds

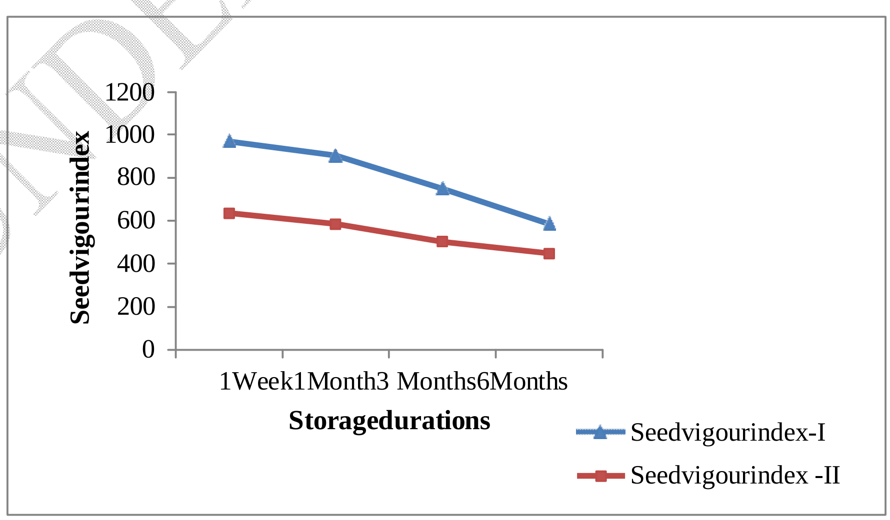

Fig3.Effectof$ZnSO_4$priming onSeedVigour Index(I&II) inonionseed

Table 1. All used treatments and different parameters

Treatment	PH45DAT	NL/P	PHM	LL (cm)	NT(mm)	EDB (mm)	PDB (mm)	BW(g)	NMB/P	BY/P (kg)
T_1	16.46	6.03	45.40	33.58	9.67	50.74	47.28	57.12	84.33	5.66
T_2	21.25	7.33	47.03	39.53	9.55	52.92	50.52	65.93	89.00	6.50
T_3	23.81	7.57	51.33	42.31	8.85	56.13	51.54	78.52	90.00	7.79
T_4	21.18	6.57	46.87	34.17	9.97	51.88	50.55	57.90	91.33	5.82
T_5	22.63	7.37	49.93	40.23	9.54	55.69	52.04	70.19	93.33	6.95
T_6	26.28	8.37	54.50	51.49	8.38	61.71	55.30	90.56	97.67	9.00
T_7	16.51	6.83	44.90	36.59	10.52	51.31	51.11	61.68	87.67	6.23
T8	22.29	7.33	46.23	41.86	9.56	52.33	53.85	68.80	90.00	6.89
T9	25.93	7.80	52.07	44.49	9.24	58.70	54.70	82.50	90.00	7.95
T10	16.15	6.73	50.70	39.33	10.83	53.95	52.65	54.23	84.33	5.34
T11	14.8	5.53	43.40	32.24	11.83	46.78	43.93	48.92	76.33	4.40
Mean	20.66	7.04	48.40	39.62	9.81	53.83	51.22	66.94	88.55	6.59
C.D.	5.13	0.93	NS	2.88	NS	5.34	5.83	5.89	7.87	1.62

PH–plantheight45daysaftertransplanting,NL/P–numberofleaves/plant,LL–leaflength,NT-neckthickness,EDB–equilateralbulb diameter, PDB-polar bulb diameter, BW – bulb weight, NMB/P – number of marketable bulbs per plot, BY/P- bulb yield per plot