



Effect of ZnSO₄ Priming on Storability, Seed Quality and Bulb Yield in Onion under Mid-Hill Condition of North Western Himalayas

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Seed storability and longevity is a major issue in onion seed and bulb. Priming can improve the storability in onion seeds. So a field and laboratory experiment was conducted to study the effect of zinc sulphate priming on seed and bulb quality in onion. There were eleven treatment combinations viz; T₁ - 0.50 % ZnSO₄ for 6 hrs, T₂- 0.50 % ZnSO₄ for 12 hrs, T₃ - 0.50 % ZnSO₄ for 24 hrs, T₄ - 0.75 % ZnSO₄ for 6 hrs, T₅ -0.75 % ZnSO₄ for 12 hrs, T₆- 0.75 % ZnSO₄ for 24 hrs, T₇ - 1.0 % ZnSO₄ for 6 hrs, T₈-1.0 % ZnSO₄ for 12 hrs, T₉-1.0 % ZnSO₄ for 24 hrs, T₁₀ - Hydro- priming for 12 hrs, T₁₁ – Control. Results indicated that treatment T₆ was found significantly best in improving seed quality parameters like germination (%), seedling length (cm), dry weight (g), speed of

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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 of marketable bulb per plot and bulb yield/plot (kg) while leaf length (cm), neck thickness (mm) were not significantly affected by the treatment T₆.

Keywords: Enhancement; germination; vigour; zinc sulphate.

1. INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae and is one of the most important monocotyledonous, cool season vegetable crops in India [1]. It is 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 [2]. In 2022 onion area and production were 5 million hectares & 115.24 million tons [3]. In India, onion is cultivated both in *kharif* and *Rabi* season [4] and India is top producer of onion in world with 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 not go through a dormancy period so they lose their germination capacity quickly within one year [5]. 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 [6]. Different seed priming techniques like hydro-priming, osmo-priming, and halo-priming, solid-matrix priming, and bio-priming can improve the seed quality [7].

So, this study was conducted to study the effect of ZnSO₄ based priming on seed storability, seed quality and bulb yield in onion. The previous studies have shown that zinc is a co-factor of various enzymes superoxide dismutase (SOD) involved in the detoxification of reactive oxygen

species, such as O₂-(superoxide radical) and H₂O₂ (hydrogen peroxide) essential for the detoxification of reactive oxygen species (ROS) that are produced during ageing in plant cells [8]. Hence, zinc seed priming may be a reliable approach to raise the zinc content in seeds to improve seed quality parameters as compared to 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 storability and bulb quality in onion.

2. MATERIALS AND METHODS

Field and laboratory experiment was conducted on the *Pandah* research farm and 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 Himachal Pradesh at an elevation of 1250 metres above mean sea level with coordinates of 35.50 °N and 77.80 °E. Average maximum and minimum temperatures, relative humidity and 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 HgCl₂ - (0.1%) for 5-10 minutes and after that seeds were rinsed in water. 10g seeds per treatment was 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 solutions were poured to petri dishes and distributed on the whole area of blotting paper to evenly hydrate all the seeds. Eleven priming treatment combination were used viz; T₁ - 0.50 % ZnSO₄ for 6 hrs, T₂- 0.50 % ZnSO₄ for 12 hrs, T₃ - 0.50 % ZnSO₄ for 24 hrs, T₄ - 0.75 % ZnSO₄ for 6 hrs, T₅ -0.75 % ZnSO₄ for 12 hrs, T₆- 0.75 % ZnSO₄ for 24 hrs, T₇ - 1.0 % ZnSO₄ for 6 hrs, T₈-1.0 % ZnSO₄ for 12 hrs, T₉-1.0 % ZnSO₄ for 24 hrs, T₁₀ - Hydro-priming

for 12 hrs, T11 – 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 and 6 months as per ISTA rules [9].

For field experiment primed onion seeds were sown as per treatment on 3rd 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 [10].

3. RESULTS AND 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 potential of onion seed. Among the various treatments, highest germination (%) was recorded in treatment T6-0.75 % ZnSO₄ for 24 hrs and lowest was recorded in T11 (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 [11]. Huded [12] also reported increase in germination of chickpea seed in priming with ZnSo₄. In case of seedling length (SL) maximum was observed in T6 (12.67 cm) while minimum was observed in T11. Seedling length significantly affected by storage period. At

the start of storage, seedling length was 11.73 cm after one week of priming it was reduced to 7.84 cm after six months of storage (Fig. 2). Zinc is a cofactor of more than 300 enzymes and also essential for formation of tryptophan, which is a precursor of auxin. Seedling length increases due to higher metabolic activity of IAA, which cause rapid cell division and cell elongation [13]. Imran et al. [14] and Tuiwong et al. [15] 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 relatively more dry weight is the glyoxylate cycle. Better seedling length combined with lipid consumption via this cycle could account for the maximum seedling dry weight [16]. In chickpea seedling dry weight decreased in storage period [12]. 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 of storage, it was reduced to 587.37. The highest seed vigour index-I (1,322.00) was observed in treatment T6 after one week of storage, when seeds were primed with 0.75 per cent ZnSO₄ for 24 hours. After 6 months of storage, the seed vigour index-I was reduced to a minimum (366.37) in T11 (control) while Seed vigour index-II was significantly highest (790.47) in treatment T6, where seeds were primed with 0.75 per cent ZnSO₄ for 24 hours. However, minimum seed vigour index-II (389.71) was recorded in T11 (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 of aging [17]. Zinc has an effect on membrane-bound NADPH oxidase, which generates reactive oxygen species (ROS) during aging. It also contributes to the development of antioxidative defense enzymes caused by oxidative stress, such as glutathione reductase and ascorbate peroxidase, which scavenge H₂O₂ [18]. 0.1% and 0.5% solution in rice

improved the vigour in rice [19]. Speed of germination was maximum (10.15) in treatment T6, where seeds were primed with 0.75 per cent ZnSO₄ for 24 hours, which was at par with T9, T3 and T5. However, minimum speed of germination was found (7.75) in T11 (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 and metabolic states of every seed to a uniform state, allowing for maximal growth uniformity in the seedlings and accelerating germination. Seed priming is a technique for shortening the time between seed sowing and seedling emergence as well as synchronizing the emergence of seedlings [20]. Priming improved germination speed in onion [21]. 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 ZnSO₄ for 24 hours (T6) was significantly lower (0.154 dS m⁻¹), whereas T11 (control) had the highest electrical conductivity (0.265 dS m⁻¹). Treatment T6 had the lowest electrical conductivity (0.106 dS m⁻¹) among various treatment combinations, which was statistically at par with T9 when calibrated at the start of the storage. After 6 months of storage, it was reduced to 0.363 dS m⁻¹ in T11 (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 ageing is 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 [22]. 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 [23]. 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 T6, and it was statistically at par with treatments T9, T3 T5, T8, T2 and T4. On other hand,

treatment T10, had the shortest plant height which was statistically equivalent to T11 (control) and T1 (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 [24]. 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 untreated seeds. These findings corroborate to those of Tamindzic et al. [25], who reported that Zn priming stimulated plant development and increased plant height in three maize hybrids. In terms of plant height at maturity, statistical analysis revealed that there were non-significant differences among the treatments. However, treatment T6 had the highest plant height (54.50 cm) and the lowest (43.40 cm) was observed in T11 (control). The number of leaves per plant was considerably influenced by the treatments (Table 1). The highest number of leaves per plant (8.37) recorded in treatment T6 was statistically at par with T9 (7.80) and T3 (7.57) whereas, the lowest (5.53) was recorded in T11 (control). Present findings are in line with those of Zalama and Fathala [26] in onion. Highest leaf length (51.49 cm) was found in treatment T6 (Table 1). Treatment T11 (control), on the other hand had minimum leaf length (32.24 cm) at 90 days after transplanting. Enhanced leaf length is most likely related to 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 differences among the treatments. However, treatment had the minimum neck thickness (8.38 mm). On the other hand, T11 (control) recorded the maximum neck thickness (11.83 mm). The largest equatorial diameter (61.71 mm) was observed in treatment T6, where and it was statistically at par with T9 (58.70 mm), where seeds were primed with 1.0 per cent ZnSO₄ for 24 hours. However, minimum (46.78) was observed in T11 (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 T6 had the largest polar diameter (55.30 mm), which was statistically comparable to T9 (54.70 mm), T8 (53.85 mm), T10 (52.65 mm), T5 (52.04 mm), T3 (51.54 mm), T7 (51.11 mm), T4 (50.44 mm) and T2 (50.52 mm). Treatment T11 (control), on the other hand had the lowest polar diameter (43.93 mm). The average weight of bulbs was found to differ significantly between treatments (Table 1). In terms of bulb weight, treatment T6 was determined to be superior over all the treatments. It generated bulbs weighing up to 90.56 g on an average. On the other hand, T11 (control) had the lowest bulb weight (48.92 g). The largest number of marketable bulbs per plot (97.67) was obtained in treatment T6, which was statistically at par with T5 (93.33), T4 (91.33), T9 (90.00), T3 (90.00) and T8 (90.00). However, minimum number of marketable bulbs (76.33) was obtained in T11 (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 nutrient transfer from the leaves

to the bulbs [26]. When seeds were primed with 0.75 per cent ZnSO₄ for 24 hours (T6), the highest bulb yield per plot (9.00 kg) was achieved, which was statistically at par with T9 (7.95) and T3 (7.79). Treatment T11 (control), on the other hand had the lowest bulb production per plot (4.4 kg) [27]. 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 reactions that regulate numerous biosynthetic pathways. All of these processes could have improved onion development in terms of bulb yield and quality traits [26].

3.1 Economics

Out of all the treatments that were examined for this study, treatment T₆ (0.75 % ZnSO₄ for 24 hrs) had the highest benefit: cost ratio (3.19: 1), while treatment T₁₁ (control) had the lowest benefit: cost ratio (1.16:1). Data analysis also revealed that, compared to non-treated seeds, treatment T₆ (0.75 % ZnSO₄ for 24 hours) had the highest gross income per hectare of Rs 7, 20,000. The modest amounts of ZnSO₄ utilized per hectare and its low cost are likely the cause of the most significant net returns and B: C ratios [28-30].

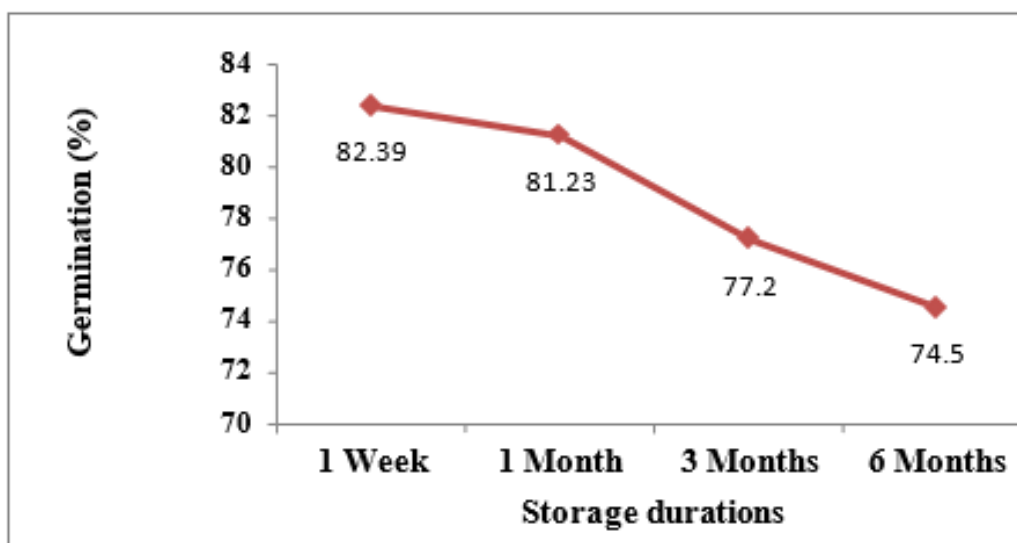


Fig. 1. Effect of ZnSO₄ priming on germination (%) in onion seeds

Table 1. All used treatments and different parameters

Treatment	PH 45DAT	NL/P	PHM	LL (cm)	NT (mm)	EDB (mm)	PDB (mm)	BW (g)	NMB/P	BY/P (kg)
T1	16.46	6.03	45.40	33.58	9.67	50.74	47.28	57.12	84.33	5.66
T2	21.25	7.33	47.03	39.53	9.55	52.92	50.52	65.93	89.00	6.50
T3	23.81	7.57	51.33	42.31	8.85	56.13	51.54	78.52	90.00	7.79
T4	21.18	6.57	46.87	34.17	9.97	51.88	50.55	57.90	91.33	5.82
T5	22.63	7.37	49.93	40.23	9.54	55.69	52.04	70.19	93.33	6.95
T6	26.28	8.37	54.50	51.49	8.38	61.71	55.30	90.56	97.67	9.00
T7	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 – plant height 45 days after transplanting, NL/P – number of leaves/plant, LL –leaf length, NT- neck thickness, EDB – equilateral bulb diameter, PDB- polar bulb diameter, BW – bulb weight, NMB/P – number of marketable bulbs per plot, BY/P- bulb yield per plot

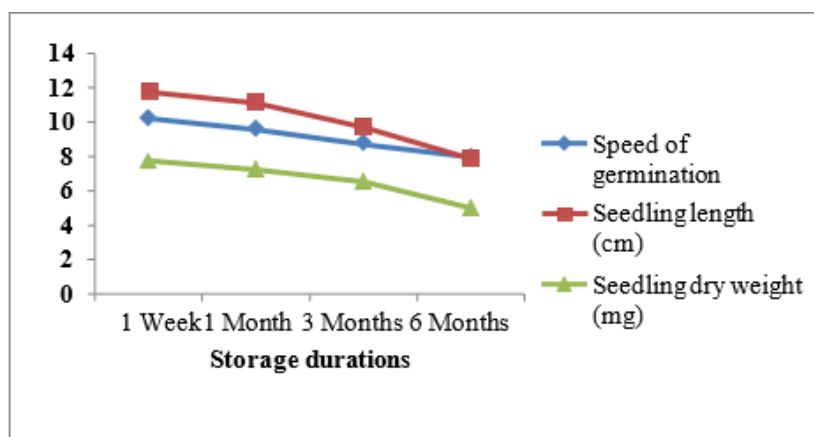


Fig. 2. Effect of ZnSO4 priming on seed quality parameters in onion seeds

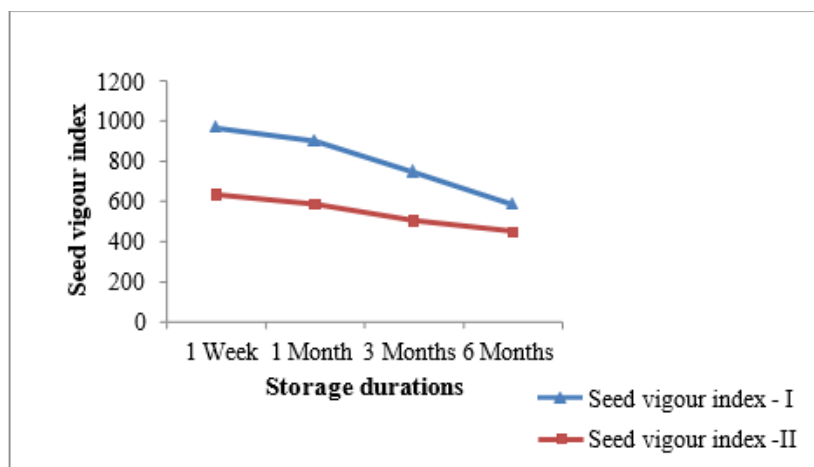


Fig. 3. Effect of ZnSO4 priming on Seed Vigour Index (I&II) in onion seed

4. CONCLUSION

Seed priming with 0.75 % ZnSO₄ for 24 hrs can be used for improving seed quality, bulb quality and extend the storage life of onion seeds under mid hills conditions of north western Himalayas. This treatment resulted economically sustainable due to its maximum B: C ratio, low cost and high yield produced per hectare.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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