# Influence of Seed Priming Treatments on Yield Attributes, Seed Yield and Economic Returns of Barley (*Hordeum vulgare* L.)


## ABSTRACT

The effects of different seed priming treatments, namely tap water, $KNO_3$ 2.5%, Thiourea 1000 ppm, $CaCl_2$ 2%, $Nacl_2$ 2%, $ZnSo_4$ 1%, $KH_2PO_4$ 1% and Salicylic acid 100 ppm solutions, on yield attributes, seed yield and economic returns of Barley cv. K-1055 and K-409 in Factorial Randomized Block Design with three replications were investigated during Rabi 2022-23 and 2023-24 at Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. Analysis of variance revealed that the yield attributes and seed yield were significantly affected by various seed priming treatments. Priming with $KNO_3$ @ 2.5 % increased the seed yield by 21.70 % compared to the control., Priming with $KNO_3$ 2.5%, gave the highest economic returns with a cost to benefit ratio of 1:2.14.Therefore, these priming techniques could be used to improve the seed yield and profit.



*Keywords: Barley; priming; $KNO_3$; seed yield.*


## 1. INTRODUCTION

Barley (*Hordeumvulgare*L.) is a versatile cereal grain worldwide, ranking fourth in acreage and production after wheat, rice and maize [1].Barley belongs to the grass family Poaceae, tribe *Triticeae* and genus *Hordeum*, comprising nearly 350 species. Out of which *Hordeum*consists of about 32 species including the wild and cultivated one. Barley is a diploid with 2n=14 chromosomes.

The production of barley worldwide was estimated at around 142.22 million metric tons. Globally, the top barley-producing countries are Russia, Australia, Canada and United Kingdom. Russia shares 13% of the world's total barley production with an area 9 million hectares and production 19.03 million metric tons. Australia shares 8% of world's total barley production with the area 3.2 million hectares and production of 11.5 million metric tons. Canada shares 6% of world's total barley production with an area of 2.7 million hectares and production of 9.6 million metric tons [1]. Nowadays, barley accounts for 15 percent of world coarse grains in use. Approximately 70 % of barley grown worldwide is utilized for animal feed, 20 % for malting, and 5 % for direct human food consumption [2]. Nearly all temperate regions of the world cultivate barley as an important industrial crop, including North Africa, Europe, South and North America, Asia and Australia. The area under barley cultivation in India is approximately 0.62 million hectares with an annual production of 1.9 million metric tons [1]. Barley is mostly farmed in the northern plains of India, specifically in Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana and Punjab.

Barley grains have smothering and cooling properties that facilitate easy digestion. Barley is a healthy grain that has several advantages. It is an excellent source of minerals, vitamins, and dietary fiber. Barley, which is high in antioxidants, may help decrease cholesterol and promote heart health [3] It is also appropriate for managing diabetes it has a lower glycemic index than certain other grains and provides important amino acids [4].

Strategies for improving the growth and development of crop species have been investigated for many years.Seed priming is a pre-sowing procedure that creates a physiological condition that is more favorable for successful seed germination. Before the radical protrudes, seed priming regulates hydration, which initiates the regular metabolic process during the early stages of germination [5]. Numerous field crops, including wheat, sweet corn, mung beans, barley, lentils, cucumbers and others, have been shown to benefit from seed priming [6].

Priming with $KNO_3$ before planting, which stimulates various physiological and biochemical changes in seeds, leading to improved germination, early seedling growth, stress tolerance, and ultimately higher crop yield [7]. One study by E L Tayeb [8]investigated the effect of thiourea priming on barley seeds under high temperature stress. The results indicated that thiourea priming significantly improved the germination percentage, seedling growth and physiological attributes of barley under high temperature conditions. Kaur and Kaur [9] explored the effect of calcium chloride priming on improving germination and seedling growth in barley under saline conditions to mitigate the detrimental effects of salinity stress on barley seedlings. Priming with sodium chloride enhanced the water uptake by seeds and increased the activities of hydrolyzing enzymes, which are essential for the early stages of seed germination Farooq et al. [10].

Harris et al. [11]reported that priming of maize seeds with zinc sulfate improved seedling vigor, enhanced root growth, and increased tolerance to abiotic stresses such as drought and salinity and increased the activity of antioxidant enzymes, which play a crucial role in mitigating oxidative stress in plants. Abdulrahmaniet al. [12]reported that $KH_2PO_4$ priming enhanced the nutrient uptake and utilization efficiency in barley, leading to better growth and yield.PirastehAnoshehet al. [13],reported that SA priming promoted the activities of hydrolytic enzymes and improved the expression of stress-responsive genes in barley, leading to better yield seedling vigor and stress tolerance.

## 2. MATERIALS AND METHODS

The experiment was carried out to determine the effect of various seed priming treatments on Barley yield attributes, seed yield and economic returns during the Rabi (winter) season in 2022-23 and 2023-24 at the Students Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P. The experiment comprised of two Barley cultivars *viz,* cv. K-409 ($V_1$) and K-1055($V_2$) with seed rate 100 kg $ha^{-1}$. Both varieties were primed with control ($T_0$), tap water($T_1$), $KNO_3$ 2.5% ($T_2$), Thiourea 1000 ppm($T_3$), $CaCl_2$ 2%($T_4$), $Nacl_2$ 2%($T_5$), $ZnSo_4$ 1%($T_6$), $KH_2PO_4$ 1% ($T_7$), Salicylic acid 100 ppm($T_8$) solutions. The crop was sown in the second fortnight of November, 2022-23 and 2023-24. Full doses of P and K, along with one-third of N, were applied as a basal dose at the time of sowing using inorganic sources of nutrients, such as DAP, MOP and Urea respectively. The remaining two-thirds of N were applied in two equal splits doses. The seed yield was calculated using the $m^{-2}$ area per plot and converted to q $ha^{-1}$. Individual data from the various yield attributes studied in the experiment were statistically analyzed. The standard error of the mean, a critical difference (C.D.) at 5% level of probability and coefficient of variance were calculated using standard procedures.For estimating the costs, the average expenditure on various inputs like human labour, machine power, seed, fertilizer, roughing, priming treatment cost and irrigation were worked out. These costs along with the interest on working capital (at the rate of 8 per cent per annum) formed the total variable cost. To work out the total cost of cultivation per hectare, the rental value of land, processing and packaging charges of seed were added to the total variable cost. For calculating the costs, the depreciation cost of owned farm inputs were also considered. The returns were calculated based on the actual prices received by the farmers. The return over variable cost, and net returns were calculated by deducting the respective costs from the gross returns.

The soil of the experimental plot was analyzed for its various physical and chemical characteristics in the Soil Testing Laboratory of the C. S. Azad University of Agriculture and Technology, Kanpur, in accordance with the accepted.

## 3. RESULTS AND DISCUSSION

The data presented in Table 1 to Table 5 revealed that both varieties of Barley when treated with various seed priming treatments showed significant effects on seed yield attributes and seed yield. Variety K-1055 exhibited significantly greater length of ears (8.46 cm), number of spikelets spike$^{-1}$(52.37), number of seeds spike$^{-1}$ (45.04) , raw seed yield(41.53 q ha$^{-1}$) and graded seed yield (37.61 q ha$^{-1}$) as compared to variety K-409 that may be due to differential response of variety.Similar results have been reported by Afzal et al. [14],Bakht et al. [15], and Siddique and Bose [16].

Pooled data of priming treatments also presented in Table1 to Table 5 revealed that the among the priming treatments, priming with $KNO_3$ @ 2.5 % ($T_2$) was significantly superior in terms of greater length of ears (9.12 cm), number of spikelets spike$^{-1}$ (55.80), number of seeds spike$^{-1}$(46.92), raw seed yield(44.33 q ha$^{-1}$) and graded seed yield(40.48 q ha$^{-1}$) followed by priming with thiourea @ 1000 ppm ($T_3$) while all the seed yield attributing characters and seed yield were minimum in control($T_0$).These results are in conformity withMohammadi G.R. [17], Srivastava et al. [18], Ahmadvandet al. [19]. The interaction effect of varieties and treatments was found to be significant for yield attributes and seed yield on pooled data basis presented in Table 1 to Table 5. Table revealed that the variety K-1055 and priming with $KNO_3$ ($V_2 \times T_2$) showed significant increased in length of ears (9.23 cm), number of spikelets spike$^{-1}$ (56.73), number of seeds spike$^{-1}$(48.03), raw seed yield (45.02 q ha$^{-1}$) and graded seed yield(41.16 q ha$^{-1}$) followed by variety K-1055 priming with thioura @ 1000 ppm ($V_2 \times T_3$) . The minimum

**Table 1. Effect of priming treatments for 6 hours on length of ears (cm) in Barley varietiesK-409 and K-1055**

| Treatments | 2022-23 | | | 2023-24 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean |
| $T_0$ | 7.36 | 7.42 | 7.39 | 7.41 | 7.87 | 7.64 | 7.38 | 7.65 | 7.51 |
| $T_1$ | 7.61 | 7.71 | 7.66 | 7.77 | 8.11 | 7.94 | 7.69 | 7.91 | 7.80 |
| $T_2$ | 8.96 | 9.10 | 9.03 | 9.05 | 9.36 | 9.21 | 9.01 | 9.23 | 9.12 |
| $T_3$ | 8.74 | 8.87 | 8.81 | 8.97 | 9.04 | 9.01 | 8.86 | 8.96 | 8.91 |
| $T_4$ | 7.95 | 8.04 | 8.00 | 8.04 | 8.45 | 8.25 | 8.00 | 8.25 | 8.12 |
| $T_5$ | 7.68 | 7.89 | 7.78 | 7.87 | 8.24 | 8.05 | 7.78 | 8.06 | 7.92 |
| $T_6$ | 8.69 | 8.72 | 8.71 | 8.81 | 8.89 | 8.85 | 8.75 | 8.81 | 8.78 |
| $T_7$ | 8.38 | 8.41 | 8.40 | 8.42 | 8.76 | 8.59 | 8.40 | 8.59 | 8.49 |
| $T_8$ | 8.53 | 8.57 | 8.55 | 8.74 | 8.91 | 8.83 | 8.63 | 8.74 | 8.69 |
| **Mean** | **8.21** | **8.30** | **8.26** | **8.34** | **8.63** | **8.48** | **8.28** | **8.46** | **8.37** |
| **Factors** | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | |
| **V** | **0.002** | **0.04** | | **0.01** | **0.02** | | **0.01** | **0.03** | |
| **T** | **0.004** | **0.01** | | **0.02** | **0.04** | | **0.01** | **0.02** | |
| **V×T** | **0.006** | **0.013** | | **0.03** | **0.055** | | **0.02** | **0.034** | |
| **CV(%)** | **6.91** | | | **6.32** | | | **6.62** | | |

**Table 2. Effect of priming treatments for 6 hours on number of spikelets spike$^{-1}$ in Barley varietiesK-409 and K-1055**

| Treatments | 2022-23 | | | 2023-24 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean |
| $T_0$ | 45.53 | 47.20 | 46.37 | 46.27 | 48.33 | 47.30 | 45.90 | 47.77 | 46.83 |
| $T_1$ | 47.53 | 49.20 | 48.37 | 48.13 | 50.27 | 49.20 | 47.83 | 49.73 | 48.78 |
| $T_2$ | 54.20 | 55.80 | 55.00 | 55.53 | 57.67 | 56.60 | 54.87 | 56.73 | 55.80 |
| $T_3$ | 53.27 | 55.07 | 54.17 | 54.20 | 56.73 | 55.47 | 53.73 | 55.90 | 54.82 |
| $T_4$ | 49.60 | 50.40 | 50.00 | 50.53 | 52.27 | 51.40 | 50.07 | 51.33 | 50.70 |
| $T_5$ | 48.47 | 49.47 | 48.97 | 48.60 | 50.47 | 49.53 | 48.53 | 49.97 | 49.25 |
| $T_6$ | 52.27 | 53.13 | 52.70 | 53.33 | 55.33 | 54.33 | 52.80 | 54.23 | 53.52 |
| $T_7$ | 50.93 | 51.27 | 51.10 | 51.47 | 53.47 | 52.47 | 51.20 | 52.37 | 51.78 |
| $T_8$ | 51.40 | 52.40 | 51.90 | 52.73 | 54.13 | 53.43 | 52.07 | 53.27 | 52.67 |
| **Mean** | **50.36** | **51.55** | **50.95** | **51.20** | **53.19** | **52.19** | **50.78** | **52.37** | **51.57** |
| **Factors** | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | |
| **V** | **0.057** | **0.11** | | **0.05** | **0.11** | | **0.06** | **0.11** | |
| **T** | **0.12** | **0.24** | | **0.11** | **0.23** | | **0.12** | **0.24** | |
| **V×T** | **0.17** | **0.34** | | **0.16** | **0.32** | | **0.17** | **0.33** | |
| **CV(%)** | **5.51** | | | **5.94** | | | **5.73** | | |

**Table 3. Effect of priming treatments for 6 hours on number of seeds spike$^{-1}$ in Barley varietiesK-409 and K-1055**

| Treatments | 2022-23 | | | 2023-24 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean |
| $T_0$ | 41.07 | 41.93 | 41.50 | 42.20 | 43.07 | 42.63 | 41.63 | 42.50 | 42.07 |
| $T_1$ | 41.67 | 43.07 | 42.37 | 42.73 | 43.80 | 43.27 | 42.20 | 43.43 | 42.82 |
| $T_2$ | 45.40 | 47.53 | 46.47 | 46.20 | 48.53 | 47.37 | 45.80 | 48.03 | 46.92 |
| $T_3$ | 44.33 | 46.53 | 45.43 | 45.67 | 47.67 | 46.67 | 45.00 | 47.10 | 46.05 |
| $T_4$ | 42.53 | 42.87 | 42.70 | 43.67 | 45.53 | 44.60 | 43.10 | 44.20 | 43.65 |
| $T_5$ | 42.07 | 42.60 | 42.33 | 43.07 | 44.47 | 43.77 | 42.57 | 43.53 | 43.05 |
| $T_6$ | 43.87 | 45.93 | 44.90 | 45.13 | 46.73 | 45.93 | 44.50 | 46.33 | 45.42 |
| $T_7$ | 42.67 | 44.13 | 43.40 | 43.73 | 45.13 | 44.43 | 43.20 | 44.63 | 43.92 |
| $T_8$ | 43.27 | 44.87 | 44.07 | 44.20 | 46.27 | 45.23 | 43.73 | 45.57 | 44.65 |
| **Mean** | **42.99** | **44.39** | **43.69** | **44.07** | **45.69** | **44.88** | **43.53** | **45.04** | **44.28** |
| **Factors** | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | |
| **V** | **0.06** | **0.11** | | **0.06** | **0.12** | | **0.06** | **0.12** | |
| **T** | **0.12** | **0.26** | | **0.13** | **0.27** | | **0.13** | **0.27** | |
| **V×T** | **0.17** | **0.37** | | **0.18** | **0.38** | | **0.18** | **0.38** | |
| **CV(%)** | **3.77** | | | **3.51** | | | **3.64** | | |

**Table 4. Effect of priming treatments for 6 hours on raw seed yield q ha$^{-1}$ in Barley varietiesK-409 and K-1055**

| Treatments | 2022-23 | | | 2023-24 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean |
| $T_0$ | 36.18 | 37.47 | 36.82 | 37.18 | 38.22 | 37.70 | 36.68 | 37.85 | 37.26 |
| $T_1$ | 37.09 | 38.28 | 37.69 | 38.23 | 40.11 | 39.17 | 37.66 | 39.19 | 38.43 |
| $T_2$ | 43.26 | 44.31 | 43.78 | 44.43 | 45.72 | 45.07 | 43.84 | 45.02 | 44.43 |
| $T_3$ | 42.47 | 43.46 | 42.97 | 43.47 | 45.16 | 44.32 | 42.97 | 44.31 | 43.64 |
| $T_4$ | 38.42 | 39.04 | 38.73 | 39.25 | 41.25 | 40.25 | 38.83 | 40.14 | 39.49 |
| $T_5$ | 37.92 | 38.89 | 38.40 | 38.77 | 40.53 | 39.65 | 38.34 | 39.71 | 39.03 |
| $T_6$ | 41.26 | 42.12 | 41.69 | 42.87 | 44.57 | 43.72 | 42.07 | 43.35 | 42.71 |
| $T_7$ | 39.67 | 40.62 | 40.14 | 41.54 | 42.87 | 42.21 | 40.61 | 41.74 | 41.17 |
| $T_8$ | 40.12 | 41.25 | 40.68 | 42.16 | 43.68 | 42.92 | 41.14 | 42.47 | 41.80 |
| **Mean** | **39.60** | **40.60** | **40.10** | **40.88** | **42.46** | **41.67** | **40.24** | **41.53** | **40.88** |
| **Factors** | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | |
| **V** | **0.04** | **0.09** | | **0.06** | **0.12** | | **0.05** | **0.11** | |
| **T** | **0.12** | **0.26** | | **0.14** | **0.32** | | **0.13** | **0.29** | |
| **V×T** | **0.18** | **0.42** | | **0.21** | **0.51** | | **0.19** | **0.46** | |
| **CV(%)** | **5.98** | | | **6.16** | | | **6.07** | | |

**Table 5. Effect of priming treatments for 6 hours on graded seed yield q ha$^{-1}$ in Barley varietiesK-409 and K-1055**

| Treatments | 2022-23 | | | 2023-24 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean | $V_1$ | $V_2$ | Mean |
| $T_0$ | 32.14 | 33.58 | 32.86 | 33.04 | 34.26 | 33.65 | 32.59 | 33.92 | 33.26 |
| $T_1$ | 33.05 | 34.40 | 33.72 | 34.07 | 36.05 | 35.06 | 33.56 | 35.22 | 34.39 |
| $T_2$ | 39.26 | 40.51 | 39.88 | 40.33 | 41.81 | 41.07 | 39.79 | 41.16 | 40.48 |
| $T_3$ | 38.45 | 39.73 | 39.09 | 39.36 | 41.16 | 40.26 | 38.91 | 40.44 | 39.67 |
| $T_4$ | 34.48 | 35.22 | 34.85 | 35.24 | 37.22 | 36.23 | 34.86 | 36.22 | 35.54 |
| $T_5$ | 33.89 | 35.04 | 34.47 | 34.66 | 36.52 | 35.59 | 34.27 | 35.78 | 35.03 |
| $T_6$ | 37.50 | 38.27 | 37.89 | 38.97 | 40.51 | 39.74 | 38.23 | 39.39 | 38.81 |
| $T_7$ | 35.65 | 36.81 | 36.23 | 37.34 | 38.86 | 38.10 | 36.50 | 37.83 | 37.17 |
| $T_8$ | 36.07 | 37.45 | 36.76 | 37.92 | 39.66 | 38.79 | 37.00 | 38.55 | 37.77 |
| **Mean** | **35.61** | **36.78** | **36.19** | **36.77** | **38.45** | **37.61** | **36.19** | **37.61** | **36.90** |
| **Factors** | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | | **SE(d)** | **CD 5%** | |
| **V** | **0.03** | **0.08** | | **0.05** | **0.10** | | **0.04** | **0.09** | |
| **T** | **0.11** | **0.25** | | **0.13** | **0.31** | | **0.12** | **0.28** | |
| **V×T** | **0.17** | **0.41** | | **0.18** | **0.43** | | **0.17** | **0.42** | |
| **CV(%)** | **6.32** | | | **6.47** | | | **6.40** | | |

**Table 6. Economic analysis of Barley crop under different priming treatments**

| Treatments | Cost of cultivation (Rs. ha$^{-1}$) | Gross income (Rs. ha$^{-1}$) | Net income (Rs. ha$^{-1}$) | B:C ratio |
|---|---|---|---|---|
| $T_0$ | 66674.40 | 184178 | 117503.60 | 1.76 |
| $T_1$ | 67100.28 | 190241 | 123140.72 | 1.83 |
| $T_2$ | 70766.28 | 222339 | 151572.70 | 2.14 |
| $T_3$ | 69691.44 | 218088 | 148396.60 | 2.12 |
| $T_4$ | 67538.12 | 196157 | 128618.90 | 1.90 |
| $T_5$ | 68275.48 | 193559 | 125283.5 | 1.83 |
| $T_6$ | 69950.92 | 213393 | 143442.10 | 2.05 |
| $T_7$ | 70100.68 | 204901 | 134800.3 | 1.92 |
| $T_8$ | 68353.17 | 208134 | 139780.80 | 2.04 |

length of ears (cm), number of spikelets spike$^{-1}$, number of seeds spike$^{-1}$, raw seed yield and graded seed yield was observed in variety K-409 in control ($V_1 \times T_0$). These results are in conformity withPatra et al. [20], Farooq et al. [10], Dhiman et al. [21] Data regarding economic returns presented in Table 6 revealed that among the priming treatments, priming with $KNO_3$ @ 2.5% given maximum economic returns followed by priming with Thiourea @ 1000 ppm while minimum economic returns was found in control ($T_0$). Similar results have been reported by Tiwari et al. [22], Siddique and Bose [16].

## 4. CONCLUSION

This research culminated in the conclusion that the seed priming with $KNO_3$ at a concentration of 2.5 % for a duration of 6 hours significantly enhances yield attributing characteristics and seed yield of Barley. Among the given treatments the lowest cost was observed in priming with tap water for 6 hours however priming with KNO3 @ 2.5 % for 6 hours give best economic returns with 1:2.14 Costs to benefit ratio. Among the assessed varieties, variety K-1055 demonstrated superior performance, indicating its potential for practical utility at the farmer level.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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