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Impact of Priming in Varying Potassium Nitrate Concentrations and Durations on Germination of Two Barley Varieties (*Hordeum vulgare* L.)

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أثر النقع في تركيزات مختلفة من نترات البوتاسيوم وفترات مختلفة على انبات صنفين من الشعير

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Abstract:
Seed priming is a useful treatment that is done before sowing to help seeds germinate and grow quickly in many crops. This study in the Botany Department's lab at Sebha University in Libya looked at 14 priming treatments in a completely random design (with three replicates) on two types of barley (Rehan and AboToreen). We measured the following traits: the percentage of seeds that germinated the germination index, the germination energy, the average time it took for seeds to germinate, the vigor of the seedlings, the length of the seedlings, and the fresh and dry weights of ten seedlings. Most traits showed big differences between treatments. The longest mean root length came from water priming for 6 hours, and the longest shoot length came from potassium nitrate (KNO_3) 5% for 12 hours. Fresh weight and vigor were optimized at certain duration–concentration combinations, demonstrating that both factors significantly influence barley germination and initial growth. Overall, the right priming solutions and exposure times can speed up emergence, boost vigor, and increase early biomass in barley. Simple water priming and 5% KNO_3 are two of the best choices for root and shoot growth, respectively.

Keywords: Crop development, Growth factors, Seed treatment, Seed viability, Soaking.

الملخص
نقع البذور هي معالجة مفيدة تجرى قبل الزراعة لمساعدة البذور على الانبات والنمو بسرعة في العديد من المحاصيل. هذه الدراسة في معمل قسم علم النبات في جامعة سبها تمت تحت 14 معاملة من النقع في تصميم عشوائي كامل مع تلات مكررات مع صنفين من الشعير (ريحان وابوطورين). قمنا بقياس الصفات التالية: نسبة انبات البذور ومؤشر الانبات وطاقة الانبات ومتوسط الوقت الذي استغرقته البذور للإنبات وقوة الباذرات وطول الرويشة والوزن الرطب والوزن الجاف لعشر. نباتات صغيرة. اظهرت معظم الصفات اختلافات كبيرة بين المعاملات. كان متوسط أطول طول جذري نتيجة للنقع في الماء لمدة 6 ساعات واطول متوسط لطول الرويشة جاء من النقع في نترات البوتاسيوم بتركيز 5% لمدة 12 ساعة، تم تحسن الوزن الرطب وقوة الانبات عند مدة زمنية معينة وتركيزات معينة. مما يوضح ان كلا من العاملين يؤثران بشكل كبير على انبات الشعير ونموه الابتدائي. بشكل عام يمكن ان تؤدي محاليل النقع الصحيحة واوقات التعرض المناسبة الى تسريع الانبات وزيادة قوة الانبات وزيادة الكتلة الحيوية المبكرة في الشعير، ويعتبر النقع في الماء العادي والنقع في نترات البوتاسيوم بتركيز 5%اتنين من أفضل الخيارات لنمو الجذر والرويشات على التوالي.

الكلمات المفتاحية: تطور المحاصيل، عوامل النمو، معالجة البذور، صلاحية البذور، النقع.

Introduction

Barley (*Hordeum vulgare* L.) is a highly important plant worldwide, valued both nutritionally and economically. Effective plant establishment results from seed germination, which depends on species and environmental characteristics. It has been established that potassium nitrate (KNO 3) can boost germination and seedling growth. The experiment aims to analyze the effect of different KNO3 ratios in priming on the germination and vigor of two barley cultivars (Rehan and Abo toreen) to maximize growth and yield capacity.

In reference to Alaswd (2023), KNO 3 priming (5% at 6 hours) increased the germination of barley seeds compared to salt stress without significantly altering the root length or fresh weight. On its part, Ben Youssef *et al*. (2021) and Kanjevac *et al*. (2021) also confirmed the positive role of KNO 3, particularly in combination with GA 3, in enhancing germination and seedling vigor of barley.

Kalee and Ali, (2024), Demonstrated that the use of 10% KNO_3 resulted in a germination value of 81.6 and a vigor index of 626.2 in Al-Wafia, which is considered the most responsive variety, in wheat, 20% KNO_3 made seedlings stronger and longer in Aras and Buhooth 22, and it made the fresh and dry weights higher. However, higher concentrations slowed root growth while increasing enzymatic and antioxidant activities in a separate study, 50 mM KNO_3 improved the germination and growth of carrots (T-29) under heat stress. Germination increased by 36%, seedling growth by 28%, and root biomass by 16.75% (Mahmood *et al*., 2024), Correspondingly, the most significant improvement of Zea mays germination was found upon the incorporation of 15 mg/L KNO_3 along with 25 mg/L ellagic acid As indicated by (Tavabe, 2024).

Khudhair and Hamza (2023), reported that expanded growth in seed performance was also renowned when potassium nitrate and licorice extract were used. Germination reached 76% under cold and 75% under accelerated aging; KNO_3 improved germination traits and early growth, with maximum percentage and rate at 3% KNO_3; despite minor differences in height, root length, and biomass between primed and non-primed seedlings, establishment improved, supporting a 2.5% KNO_3 recommendation for horned melon (Mutetwa *et al*., 2023). VA priming with KNO_3 and GA 3 improved the germination rate, root growth, and seedling health of the seedlings compared to that of the untreated ones. The use of GA3, particularly, overcame dormancy. PKM CA 32 x CA 33, the longest roots, as well as CA 32 x CA 20, the tallest shoots, were recorded to be due to hybrid combinations. The most vigorous seeds were those that were treated with 1% KNO as stated by (Kabilan *et al*. 2022).

Bhat *et al*. (2022) discovered that reduced concentration of KNO_3 and $CaCl_2$ 2 enhanced germination and vigor indicators in the genotypes that were tested. The variety Mersa indicated the best final germination percentage (G %) and shoot length (SL), whereas the variety Tekeze-1 recorded the shortest mean germination time (MGT) and time to 50% (T50) (Mebratu, 2022). The best KNO_3 concentrations were 0.5 and 1.5, with Mersa performing the highest SL on 1.5 and Tekeze-1 responding the best on 0.5. GA 3 (50 ppm) outperformed all other treatments by producing the highest germination, root length, and shoot length. The researchers discovered that low KNO_3 concentrations (0.25 mm) enhanced water uptake and antioxidant enzyme systems, whilst higher concentrations (40 mm) inhibited growth (Kabilan *et al*., 2022).

Based on the findings of Hernández *et al*. (2021) even succeeded in observing the fact that the lower levels of KNO_3 encouraged a faster growth of seedlings due to alterations in the ratio of ABA to GAs. The application of 0.75% KNO_3 priming enhanced the photosynthesis and CO 2 uptake along with the health of rice seedlings, albeit the time of emergence increased. There was also a revitalization of seedling vitality due to priming when compared to non-primed seeds (Javed *et al*., 2020), On the same note, tomato seeds that were primed in 0.75 % KNO_3 emerged more rapidly and grew well. A mixture of 250 ppm of GA3 and 1 % of KNO_3 not only increased the germination and vigor of germinating Cordia gharaf seeds but also resulted in the highest germination percentage of 79.47 % along with the larger leaves (Dev and Sureshkumar, 2020).

Therefore, the main research purpose targets the discovery of optimal potassium nitrate concentrations combined with priming periods for seed germination. These conditions will enhance germination effectiveness and enable better production from farming ecosystems. The result will be improved agricultural product quality and secured food supplies.

Material and methods

The experimental activity conducted in the Plant Physiology Laboratory, Botany Department, Faculty of Science, Sabha University, took place during the 2024/2025 season. The experiment was designed to be completely randomized and contained 14 treatments and 3 replicates. The different priming concentrations of chemicals (5, 10, and 15 % potassium nitrate) and durations (6 and 12 hours) were used as treatments, as well as the control and distilled water priming. Rehan and Abo toreen varieties of barley seeds were soaked in this manner and positioned in Petri dishes covered with filter paper and their observations were recorded over 10 days. The collected data consisted of the percentage of germination, the mean duration of germination, the length of the root/shoot, fresh and dry mass, and indices of germination vigor.

Treatments:
Control (no priming)
Priming in distilled water for 6 hours
Priming in KNO_3 at a concentration of 6% for 6 hours
Priming in KNO_3 at a concentration of 10% for 6 hours
Priming in KNO_3 at a concentration of 15% for 6 hours
Priming in distilled water for 12 hours
Priming in KNO_3 at a concentration of 12% for 6 hours
Priming in KNO_3 at a concentration of 10% for 12 hours
Priming in KNO_3 at a concentration of 15% for 12 hours

Experimental Factors
Treatments: Nine concentrations or treatments for the seeds, in addition to the control (no treatment).
Varieties: Two barley varieties (Rehan and Abo toreen).

Preparation of Potassium Nitrate Solutions
0% concentration was distilled water only.
5% concentration was 400 mL of distilled water + 20 g potassium nitrate.
10% concentration was 400 mL of distilled water + 40 g potassium nitrate.
15% concentration was 400 mL of distilled water + 60 g potassium nitrate.
The potassium nitrate solutions were prepared using a magnetic stirrer to ensure complete dissolution in distilled water. Sixteen labeled bottles were prepared, each containing equal volumes of the different concentrations. Thirty seeds were placed in each bottle, and the soaking periods were set for 6 and 12 hours.
Fifty-four Petri dishes were prepared with filter paper. The seeds were planted in the dishes according to their soaking duration, including the dry seeds. Distilled Water was added to maintain the necessary moisture for growth. The dishes were kept at room temperature.
The growth process was monitored daily for 10 days from the time of planting, and the targeted measurements were taken at specified intervals.
Target Measurements:
Germination percentage (G %) was characterized as the generation of normal seedlings, according to ISTA, 2006), and was calculated for 5 and 10 days by using the following formula:
Germination percentage (measured after 10 days of planting) = (Number of germinated seedlings / Total number of seedlings) * 100
Mean germination time (MGT) has been calculated, supported by the subsequent equation of Alvarado *et al*., 1987. The calculation was performed utilizing the subsequent formula:
Mean germination time (measured after 5 days of planting) = (Number of germinated seedlings / Total number of seedlings) * 100
Root Length Measurement: Three seedlings were carefully uprooted randomly from each replicate. The uprooted seedlings were washed with tap water. Root length was measured with a ruler; root length (cm) was recorded ten days after planting.
Shoot Length Measurement: Three germinated seedlings randomly selected from each replicate (the same seedlings used for root length measurement) were measured from the point of separation from the stem with a ruler. Shoot length (cm) was recorded ten days after planting.
Fresh Weight: Also, three germinated seedlings were randomly selected from each replicate and weighed using a sensitive electronic scale to obtain the average.
Dry Weight: Three germinated seedlings were randomly selected from each replicate (the same ones measured for fresh weight), placed in paper bags, and put in an oven at 70 degrees Celsius for 24 hours. They were weighed using a sensitive electronic scale (four decimal places) to obtain the average. It was determined utilizing the subsequent formula.
Germination Power (for the first reading): Calculated using the following calculation:
Germination Power = Germination Rate (Germination Speed) * (Root Length + Shoot Length) * 100
Germination Power (for the second reading): Calculated using the following equation:
Germination Power = Germination Rate (for the second reading) * (Root Length + Shoot Length) * 100

Results
Data in Table 2 presents that there is a significant effect of the priming concentrations on each variety as well as between the two varieties (Rehan and Abo toreen).

Germination Percentage (G %):
The highest average value of (G%) was observed in the (distilled Water priming 6 Hours) treatment for both varieties, with values of 9.9 for Rehan and 9.96 for Abo toreen the lowest G% was recorded in the " KNO_3

Concentration 15%+ priming 6 Hours" treatment, showing values of 6.03 for Rehan and 6.6 for Abo toreen, there is a substantial impact of the treatments on the germination percentage. The best treatment for maximizing G% in both varieties was the distilled water priming for 6 hours. However, this result is considered unexpected.

Mean Germination Time (MG strong):
The greatest strength of MG was obtained at 5 % KNO_3 after 12 hours (Rehan: 173807.77, Abo toreen: 173191.11), whereas the least was recorded in the case of 15 % KNO_3 after 12 hours. This validates the massive impact of priming remedies on MG vigor.

Mean Germination Speed (MG SPEED):
The highest and lowest MG velocities occurred during an event where the water assessment was conducted within 6 hours (Rehan: 99, Abo toreen: 99.66) and in an assessment of the respective 6 hours at 15% KNO_3 (Rehan: 60.33, Abo toreen: 66).

Root length:
It is indicated in Figure 1 that the highest value (8.35 cm) of the root length was obtained with a 6-hour water priming, whereas the lowest value (2.40 cm) obtained was at 15 % KNO_3 for 6 hours. In the case of Abo toreen, the root length submerged in water for over 12 hours was the longest (6.30 cm), followed by the shortest among the others (2.21 cm) in the 5% KNO_3-treated water-priming treatment.

Shoot length:
Figure (2) shows that Rehan, the 5 % KNO_3 after 6 hours, measured the maximum shoot length, and the shoot length was 13.96 cm, whereas the least value of shoot length was 4.38 cm. The maximum and minimum shoot lengths in Abo toreen were 15.71 and 5.61 cm, respectively, at less than 15 % KNO_3 in 6 hours.

Fresh weight:
As illustrated in Figure 3, Rehan exhibited the maximum fresh weight (0.310 g) when using 5 % KNO_3 in 6 hours, whereas the minimum one (0.139 g) was obtained with 15 % KNO_3 in 12 hours. In Abo toreen, 6-hour water priming and the minimum (0.162 g) recorded the maximum fresh weight (0.167 g) by priming 6 hours with 15% KNO_3.

Dry weight:
Rehan gave the maximum dry weight of 0.087 g using 10 % KNO_3 after 6 hours of treatment; nonetheless, the minimum dry weight (0.036 g) was recorded by applying water priming for 12 hours. In Abo toreen, 5% KNO_3 was able to produce a maximum dry weight of (0.052g) after 6 hours, and the minimum was (0.035 g) after priming in water, which had 12 h (Fig. 4).

Table 2: Mean Values of Germination Percentage, Germination Strength, and Germination Speed.

KNO3 concentrations	G%		MG strong (energy)		MG SPEED	
	REHAN	ABOTOREEN	REHAN	ABOTOREEN	REHAN	ABOTOREEN
Distilled Water priming 6 H	9.9 a	9.96 a	173654.44 a	125303.33 ab	99 a	99.66 a
KNO3 5%+ priming 6 H	9.1 ab	9.6 a	173807.77 a	105280.00 ab	91 ab	96 a
KNO3 10%+ priming 6 Hs	8.4 b	7.16 b	110995.55 bc	65747.77 b	84 b	71.66 b
KNO3 15%+ priming 6 H	6.03 c	6.6 b	59947.77 de	45664.44 b	60.33 c	66 b
Distilled Water priming 12 H	9.63 a	9.8 a	153725.55 ab	115288.88 ab	96.33 a	98 a
KNO3 5 %+ priming 12 H	9.33 ab	9.2 a	90077.33 ab	173191.11 a	93.33 ab	92 a
KNO3 10%+ Soak 12 H	8.5 b	7.3 b	92932.22 cd	63025.55 b	85 b	73 b
KNO3 15%+ priming 12 H	5.96 c	6.66 b	43306.66 e	51031.33 b	59.66 c	66.66 b
LSd	1.0463	1.8205	45159.926	83865.795	10.463	18.205

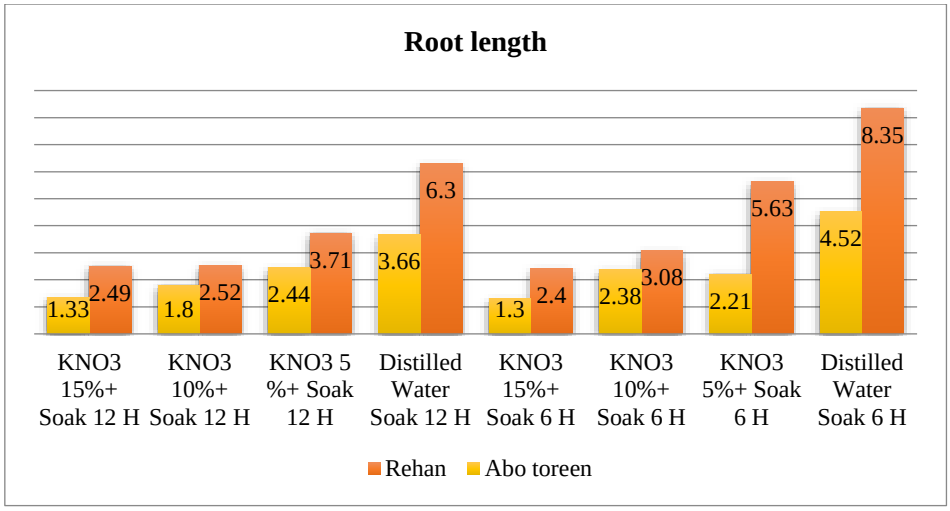

Figure 1: Average root length value for the Abu Toreen variety and the Rehan variety.

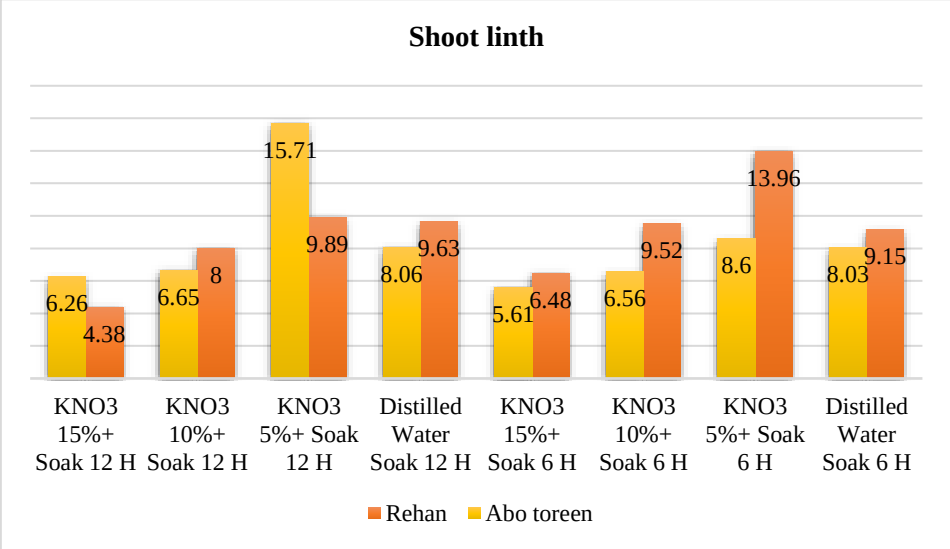

Figure 2: Average shoot length value for the Abu Toreen variety and the Rehan variety.

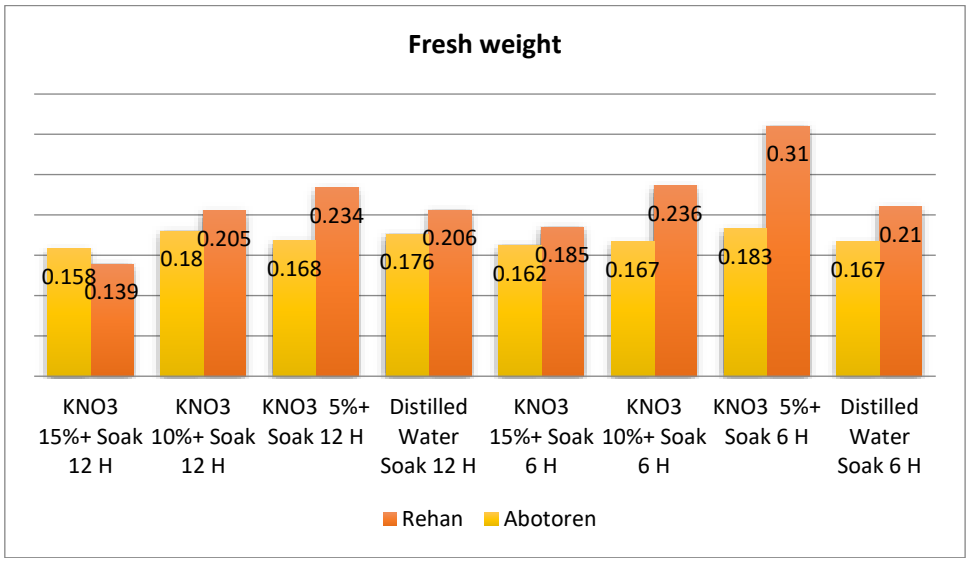

Figure 3: Average fresh weight value for the Abu Toreen variety and the Rehan variety.

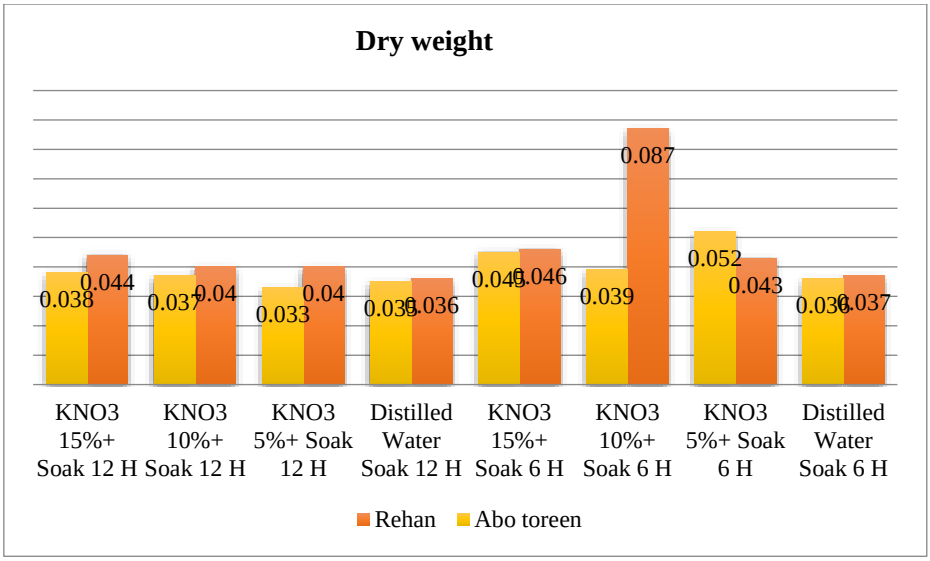

Figure 4: Average dry weight value for the Abu Toreen variety and the Rehan variety.

Discussion

The use of potassium nitrate (KNO_3) on seed germination and seedling characteristics showed statistically positive results in several variables.

Germination Rate:

Statistics showed that the best germination rate was produced when seeds were primed in distilled water, which was not in line with the results of Tavabe *et al*. (2024), and Ruttanaruangboworn *et al*. (2017). This can be because of priming times or KNO_3 concentration.

Power of germination:

The maximum value occurred in the 5% KNO_3 and 12 hours of priming, as the seedling vigor was higher (Javed *et al*., 2020; Tavabe *et al*., 2024).

Speed of Germination:

6 hours of pre-treatment of priming seeds in distilled water yielded a faster rate of germination ،which is in contrast to the results of (Ruttanaruangboworn *et al*., 2017) and (Moaaz *et al*., 2020).

Fresh Weight:

These treatments had a higher fresh weight compared to the other treatments, which used seed priming in 5 % potassium nitrate solution (Tavabe *et al*., 2024; Kalee *et al*., 2024; Khafagy *et al*., 2017).

Dry Weight:

The beneficial use of nutrients was demonstrated by the highest value of dry weight attained as a result of treatment with the Rehan variety, seeds primed with 10% KNO_3 for 6 hours, and this weight demonstrates nutrient utilization efficiency (Tavabe *et al*., 2024; Kalee *et al*., 2024; Khafagy *et al*., 2017).

Root Length:

When watered with distilled water for 6 hours, it exhibited maximum root length, facilitating enhanced water absorption (Tavabe *et al*., 2024; Mebratu, 2022).

Shoot Length:

Among all the treatments, the most optimal shoot length was obtained in the seeds primed with 5% KNO_3 for 6 hours treatment in the Rehan cultivar, and the 5% KNO_3 for 12 treatment in the Abo toreen was the most optimal in average root length, indicating that there were differences in the cultivar responses (Tavabe *et al*., 2024; Mebratu, 2022).

Conclusion

This study showed that seed priming therapies are of utmost importance in improving barley germination and seedling qualities. Although distilled water (6 hours) was found to be the most appropriate medium to produce rapid and uniform germination, 5 % KNO_3 (12 hours) gave the most vigorous seedlings. Negatively, 15% KNO_3 treatments occurred. The study advises using moderate levels and longer durations of KNO_3 soil priming to achieve maximum establishment of seedlings in barley.

Compliance with ethical standards

Disclosure of conflict of interest

The author(s) declare that they have no conflict of interest.

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