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Enhancement of Germination and Early Development of Sweet Corn Seeds Using Aerated Priming with KNO_3 and Reverse Osmosis Water

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Abstract. *The -sh2, bt2, su1, and se- genes in sweet corn cause faster seed deterioration and a lower germination rate. A potential solution to this issue is seed priming. Priming agents and the solution uptake method are key factors that affect the achievement of seed priming. This study aims to compare the influence of solution uptake methods in sweet corn seed priming as well as investigate the effect of KNO_3 on the germination and early development of sweet corn plants. The research was conducted in the Seed processing lab of the Department of Agricultural Production, Politeknik Negeri Jember. The seeds used in this study were sweet corn seeds var. Enno 1401. The study was designed with a completely randomized design (CRD). Seven treatments, namely non-primed, KNO_3 spraying, KNO_3 soaking, KNO_3 aeration, RO water spraying, RO water soaking, and RO water aeration, were observed. Data were analyzed using one-way ANOVA, followed by means analysis using Fisher's LSD (least significant difference) test at $P<0.05$. The result showed that aeration priming performed better than spraying and soaking in terms of germination percentage, MGT, and GRI of sweet corn seeds. However, aeration priming with KNO_3 gave lower results than RO water in terms of MGT and GRI. On the other hand, aeration priming with KNO_3 aeration gave the highest result in dry weight.*

Keywords: *Halopriming, Hydropriming, Invigoration, Seed hydration*

1. Introduction

Maize (*Zea mays* L.) is one of the most important food crops in the world used as a staple food, animal feed, oil, cereals, syrup, and other industrial products (Shah *et al*., 2016). It is grown widely across the globe with an average production of 1.16 billion tons per year which equals to around 231.8 billion USD (FAOSTAT, 2023). Maize is known as a rich source of carbohydrates, fiber, minerals, and vitamins such as vitamins B1, B2, B3, B5, B6, B9, C, E, and K (Sharma *et al*., 2022). It is remarkably adaptable and can grow in a variety of agroclimatic situations which leads to massive domestication and diverse variety development.

Among other maize varieties, sweet corn (*Zea mays* L. Var.*Saccharata*) is growing in popularity due to its sweeter taste and antioxidant activity. Sweet corn variety is basically maize that undergoes a mutation so that it collects twice as much sugar in the kernels as standard corn (Ngenoh *et al*., 2015). These mutated genes prevent the alteration of sugar into starch in the

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endosperm which causes the accumulation of sugar in the kernels (Heryanto *et al*., 2022). Four recessive genes—*sh2, bt2, su1,* and *se*—are the most frequent genes employed in breeding sweet corn (Santos *et al*., 2014). However, due to the lower starch content caused by these genes, sweet corn seeds have lower vigor which leads to faster deterioration and lower germination rate (Lee, 2001).

One way to overcome this problem is by seed priming. Seed priming is the controlled hydration of seeds prior to sowing, during which the seeds start to germinate but are redried before reaching the stage of radicle/epicotyl extension (Bradford, 1986). Seed priming has proven to improve plant survivability in hostile conditions by providing coordinated, quick, and on-demand germination and establishment as well as tolerance to a variety of challenges of many commodities (Pedrini *et al*., 2020), including maize. Some studies have reported the positive influence of seed priming on maize seedling performances using several priming agents, such as hydropriming PEG and GA_3 (Adhikari & Subedi, 2022), micronutrients (Nciizah *et al*., 2020), salicylicacid (AL-Obaedi, 2022), as well as potassium nitrate (KNO_3) (Anosheh *et al*., 2011). Since potassium nitrate aids in the formation of nitric oxide (NO), it is frequently used in seed priming (Hendricks & Taylorson, 1974), which breaks seed dormancy and promotes germination by interacting with reactive oxygen species (ROS), phytochrome signaling pathways, and ethylene production (Šírová *et al*., 2011).

Besides priming agents, the solution uptake method is also a determining key that affects the achievement of seed priming. Thongtip *et al*. (2022) mentioned that seeds may experience oxygen deprivation when soaked in a solution for a certain time. Santika *et al*. (2022) discovered that aerated priming in tomato seed resulted in better Mean Germination Time (MGT) and Germination Rate Index (GRI) compared to soaking and spraying. Aerated priming is a seed priming method where the seeds are immersed in a priming solution and concurrently streamed with air coming from an air pump. This method ensures that the seeds are safe from the lack of oxygen during priming. However, there has not been any reports regarding aerated priming application in maize, especially in sweet corn seeds. Thus, this research aimed to compare the influence of solution uptake methods in sweet corn seed priming as well as to investigate the effect of KNO_3 on the germination and early development of sweet corn plant.

2. Methods

This study was conducted at the Seed Processing Laboratory, Politeknik Negeri Jember, from August to November 2022. The seeds of sweet corn tested in this study were var. Enno 1401. This variety was released in 2022 with a high potential yield and high sugar content at 11-13 °Brix.

The initial germination rate was at 79% (based on a preliminary study) which can still be improved further.

Two kinds of priming solutions were prepared: 0.75% KNO_3 and Reverse-Osmosis (RO) water. The priming methods studied were aeration, soaking, and spraying. A home-built aerator setup was used for the aeration method which was made by connecting plastic bottles, rubber tubes, and an electric air pump based on Santika *et al*. (2022). For the aeration procedure, 50 ml of the appropriate priming solution was placed in plastic bottles that were linked to an air pump, and the seeds were then allowed to aerate. To apply the soaking procedure, the seeds were placed in plastic bottles with 50 ml of the appropriate priming solutions inside of them, without any active aeration. The seeds were sprayed with the appropriate solutions and placed on germination paper using the spraying method. The seeds were primed for 24 hours in each treatment and exposed to 12 hours of light per day at 25 to 30 °C. Every treatment was carried out four times. After that, the seeds were allowed to air dry for three days in a public area. The dried seeds then are used in two studies: one on-field performance, and the other on germination. In the germination investigation, 100 seeds were used for each replication and germinated using the between-paper test method. The seedlings were then maintained at 25 to 30 °C for seven days (final count) under a 12-hour light cycle. For 42 days leading up to the field performance, the seeds were placed within polybags filled with a 2:1 mixture of topsoil and organic fertilizer.

The Final Germination Percentage (FGP), Mean Germination Time (MGT), and Germination Rate Index (GRI) were the observation parameters for the germination investigation. Only the final percentage of germination is reflected in FGP. A seed population's germination rate increases with its FGP value (Scott *et al*., 1984). Germination in this definition based on ISTA Rules is the emergence of 2 mm of radicles. According to ISTA Rules, germination is defined as the appearance of 2 mm of radicles. The mean time required for seeds to germinate is known as MGT. A population of seeds germinated more quickly the lower the MGT (Orchard, 1977). The percentage of germination on each day of the germination phase is shown in the GRI. Higher and quicker germination is indicated by higher GRI values (Esechie, 1994). For the germination investigation, the plant height (cm), stem diameter (cm), and dry mass (g) were the observation parameters.

The design of the experiment was completely randomized (CRD). One-way ANOVA was performed for analyzing all the data and means analysis using Fisher's LSD (least significant difference) test at $P<0.05$ followed after.

3. Results and Discussion

In this study, two types of solution (RO water and 0.75% KNO_3) were used as seed priming agents for sweet corn. Based on Table 1, the RO water solution is better than KNO_3 in terms of MGT and GRI. Several studies on various plant species confirm that hydro priming can increase the germination rate index, as well as shorter MGT (Moreno *et al*., 2018;Alias *et al*., 2018; Meena *et al*., 2001; Ramzan *et al*., 2010; Ghassemi-Golezani *et al*., 2010). However, the two solutions show a similar pattern where the aeration method produces better results than soaking and spraying in terms of MGT and GRI (Table 1). In tomato seed priming, aeration tends to increase germination percentage, MGT, and GRI both in KNO_3 and Water solution (Santika *et al*., 2022). Aerated solution seeds tended to absorb more water, suggesting that oxygen promotes water uptake (Yeoung *et al*., 1995). One disadvantage of using the spraying method in conjunction with hydro-priming is that it may occasionally lead to uneven hydration, which in turn produces un-uniform germination. Certain plant species with thin coats such as sweet corn could not benefit from it, where quick hydration can cause seed damage generated by nutrient leakage from the seed (Adnan *et al*., 2020). The solution's composition and osmotic potential, as well as the time, temperature, and level of aeration, all influence the seed priming response (Nascimento, 2003). During seed priming, oxygen is necessary (Heydecker *et al*., 1975; Bujalski *et al*., 1989). While some studies (Bradford *et al*., 1988; Nerson & Govers, 1986), recommend aeration during melon seed priming, others note negative consequences. Aerating the solution reduces the amount of time needed to prime lettuce seeds (Guedes & Cantliffe, 1981).

Table 1. Average of Germination Percentage, MGT, and GRI of primed sweet corn seeds

Treatments	Germination (%)	MGT (day)	GRI
Combination			
Non-primed	79.50 ±1.04 c	2.62 ±0.08 c	38.52 ±1.48 a
KNO_3Spraying	80.25 ±1.18 c	2.73 ±0.09 c	38.94 ±1.35 a
KNO_3 Soaking	76.00 ±1.22 b	2.55 ±0.05 c	35.26 ±1.39 a
KNO_3 Aeration	74.75 ±1.11 b	2.24 ±0.06 b	37.04 ±1.42 a
RO Water Spraying	61.75 ±1.03 a	2.59 ±0.09 c	27.53 ±1.06 a
RO Water Soaking	79.75 ±1.31 c	2.36 ±0.07 bc	39.18 ±1.40 a
RO Water Aeration	84.00 ±1.08 d	1.86 ±0.08 a	59.75 ±1.58 b
LSD	3.37	0.22	4.09
Solution			
RO Water	75.17 ±1.73 a	2.27 ±0.08 a	45.48 ±3.13 b
0.75% KNO3	77.00 ±0.94 a	2.51 ±0.07 b	37.08 ±0.85 a
LSD	4.08	0.22	6.73
Solution Uptake Method			
Soaking	77.75 ±2.23 ab	2.45 ±0.07 b	48.39 ±1.17 a
Spraying	71.00 ±2.41 a	2.66 ±0.06 b	38.24 ±0.84 a
Aeration	79.38 ±2.27 b	2.05 ±0.08 a	48.39 ±4.40 b
LSD	6.78	0.22	1.97

Remarks:
Means within each cell followed by different letters are significantly different according to Fisher's Least Significant Difference test at $P \leq 0.05$.

Table 2. Average ofplant height, stem diameter, and dry mass of primed sweet corn seeds

Treatments	plant height at 28 DAP (cm)	stem diameter at 28 DAP (mm)	dry mass (g)
Combination			
Non-primed	43.73±4.77 a	18.83 ±0.92 b	176.1 ±5.0 ab
KNO_3 Spraying	42.71±4.59 a	17.33 ±0.83 ab	181.4 ±4.7 b
KNO_3 Soaking	49.87±3.05 a	19.61 ±0.74 b	195.4 ±4.4 bc
KNO_3 Aeration	44.94±4.20 a	19.03±0.78 b	204.0 ±4.5 c
RO Water Spraying	39.43±3.23 a	16.03 ±0.84 a	184.9 ±5.4 b
RO Water Soaking	47.09±1.89 a	20.08 ±0.76 b	169.3 ±6.4 ab
RO Water Aeration	39.43±4.42 a	19.04 ±0.68 b	165.4 ±5.5 a
LSD	11.35	2.34	15.2
Solution			
RO Water	43.50 ±1.99 a	18.38 ±0.65 a	173.2 ±4.0 a
KNO3	45.84 ±2.28 a	18.65 ±0.50 a	193.6 ±3.7 b
LSD	6.27	1.71	11.2
Solution Uptake Method			
Soaking	48.48 ±1.74 b	19.85 ±0.50 b	182.4 ±6.1 a
Spraying	44.46 ±2.83 a	16.68 ±0.60 a	183.2 ±3.4 a
Aeration	41.07 ±2.67 ab	19.03 ±0.48 b	184.7 ±6.0 a
LSD	7.24	1.55	15.61

Remarks:
Means within each cell followed by different letters are significantly different according to Fisher's Least Significant Difference test at $P \leq 0.05$.

There were no significant differences in corn plant height on all treatments (Table 2). In terms of stem diameter (28 DAP), both RO water and KNO_3 showed higher results than aeration when applied by aeration or soaking than the spraying method. The smallest stem diameter (28 DAP) was obtained by RO water spraying (16.03 ± 0.84 mm) which was not significantly different from KNO_3 spraying (17.33 ± 0.83 mm). The seed damage caused by uneven hydration and nutrient leakage caused by the spraying method during germination is thought to have an impact later on the disruption of sweet corn stem growth. In dry mass, KNO_3 aeration recorded the highest number (204,0 ± 4,5 g) while RO water aeration showed the lowest number (165,4 ± 5,5 g). Although RO water aeration shows the best numbers in germination percentage, MGT, and GRI (Table 1), it is inversely proportional to its dry mass. This might due to fact that KNO_3 contains potassium and nitrogen which act as nutrients in boosting the seedling metabolism resulting in better dry weight. In some cases, aeration during hydropriming can trigger the emergence of pathogenic fungi which can disturb the growth of plants (Nascimento, 2003). In other reports, the seeds primed with KNO_3 could demonstrate superior germination rate and seedling dry weight, as well as the most standard attributes for all parameters as compared to the control group (Ghobadi *et al*., 2012; Ahmadvand *et al*., 2012;Mohammadi & Amiri, 2010). For several kinds of crops, seed priming with nitrate salts can regulate essential growth characteristics even in unfavorable environmental circumstances (Thakur *et al*., 2019). As growth regulators to plants, nitrate salts boost the amount of photosynthetic assimilates that are translocated to areas that contribute to production (Srivastava *et al*., 2017).

4. Conclusion

It can be concluded that aeration priming performed better than spraying and soaking in terms of germination percentage, MGT, and GRI of sweet corn seeds. However, dissimilarly with other findings, aeration priming with KNO_3 gave lower results than RO water in terms of MGT, GRI. On the other hand, aeration priming with KNO_3 aeration gave the highest result in dry weight. Further researches regarding different type of solutes used in aeration priming, as well as the biochemical properties and the yield of primed sweet corn in the field need to be carried out.

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