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Khushi Sharma
Department of Genetics and Plant
Breeding, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Dr. Bineeta M Bara
Department of Genetics and Plant
Breeding, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Dr. Ann Maxton
Department of Genetics and Plant
Breeding, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Corresponding Author:
Khushi Sharma
Department of Genetics and Plant
Breeding, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Effect of inorganic salts on seed germination and seedling growth parameters of proso millet (*Panicum miliaceum* L.) variety K2

Khushi Sharma, Bineeta M Bara and Ann Maxton

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Abstract

Proso millet (*Panicum miliaceum* L.) is an important climate-resilient cereal crop known for its nutritional value and adaptability to marginal environments. However, salinity stress remains a major constraint affecting seed germination and seedling establishment. The present study was conducted to evaluate the effect of different inorganic salts on seed germination and seedling growth parameters of proso millet variety K2 under laboratory conditions. The experiment was carried out in a Completely Randomized Design (CRD) with four replications and consisted of 11 treatments including control. The treatments involved different concentrations of sodium chloride (NaCl), calcium chloride (CaCl₂), potassium chloride (KCl), zinc oxide (ZnO), and potassium dihydrogen phosphate (KH₂PO₄). Observations were recorded on germination energy, germination percentage, seedling vigor, root length, shoot length, and other seedling growth traits. The results indicated significant variation among treatments for all the characters studied. Among the treatments, KCl at 2% concentration recorded the highest germination energy (91%), while KH₂PO₄ at 2% concentration produced the maximum germination percentage (95%). In contrast, CaCl₂ at 2% concentration exhibited the lowest performance for most traits. The findings suggest that seed treatment with KCl and KH₂PO₄ can improve seed germination and seedling establishment in proso millet under stress conditions. These treatments may be effectively utilized for enhancing crop performance and productivity in saline-prone areas.

Keywords: Proso millet, inorganic salts, seed germination, salinity stress, seedling vigor, KCl, KH₂PO₄

Introduction

Proso millet (*Panicum miliaceum* L.), commonly known as common millet or broomcorn millet, is one of the oldest cultivated cereal crops in the world. It belongs to the family Poaceae and is widely cultivated in arid and semi-arid regions because of its short duration, low water requirement, and high adaptability to poor soil conditions. In India, proso millet is commonly referred to as “Cheena” and is valued for its nutritional richness, including proteins, dietary fiber, vitamins, and essential minerals.

Millet has gained increasing attention in recent years due to their role in nutritional security and climate-resilient agriculture. Proso millet possesses a low glycemic index and gluten-free properties, making it suitable for diabetic and health-conscious consumers. The crop is also recognized for its ability to tolerate drought and marginal environmental conditions.

Despite its adaptability, salinity stress is one of the major abiotic factors limiting crop establishment and productivity. Soil salinity affects seed germination by reducing water uptake and causing ionic imbalance and toxicity within plant tissues. Germination and early seedling stages are considered highly sensitive phases in the crop growth cycle. Poor germination under saline conditions leads to weak seedling establishment and ultimately reduces yield.

Different inorganic salts influence germination and seedling growth in different ways. While excessive salt concentrations may inhibit growth, some salts at suitable concentrations can improve physiological and metabolic activities associated with germination. Seed priming and salt treatments have been reported to enhance enzyme activity, nutrient mobilization, and osmotic adjustment, thereby improving germination and seedling vigor.

Considering the importance of proso millet as a climate-smart crop and the increasing problem

of soil salinity, the present investigation was undertaken to evaluate the effect of different inorganic salts on seed germination and seedling growth parameters of proso millet variety K2.

Materials and Methods

The experiment was conducted in the Post Graduate Laboratory of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, during the Zaid season of 2026.

The experimental material consisted of seeds of proso millet variety K2. The study included 11 treatments comprising different inorganic salts and concentrations along with a control. The treatments were as follows:

Treatment	Description
T ₀	Control
T ₁	NaCl 1%
T ₂	NaCl 2%
T ₃	CaCl ₂ 1%
T ₄	CaCl ₂ 2%
T ₅	KCl 1%
T ₆	KCl 2%
T ₇	ZnO 1%
T ₈	ZnO 2%
T ₉	KH ₂ PO ₄ 1%
T ₁₀	KH ₂ PO ₄ 2%

The experiment was laid out in a Completely Randomized Design (CRD) with four replications. Seeds were soaked in respective salt solutions for the recommended duration before germination. After treatment, the seeds were placed under laboratory conditions for germination studies.

Observations were recorded on various seed germination and seedling growth parameters including germination energy, germination percentage, root length, shoot length, seedling length, fresh weight, dry weight, and vigor indices. Standard procedures prescribed under seed testing guidelines were followed for data collection.

The recorded data were subjected to analysis of variance (ANOVA) to determine the significance of differences among treatments.

Results and Discussion

The results of the present investigation revealed significant differences among treatments for germination and seedling growth parameters, indicating that inorganic salts exerted considerable influence on early growth of proso millet.

Germination energy

Germination energy ranged from 78% to 91% with a grand mean of 84.27%. The highest germination energy was recorded in treatment T₆ (KCl 2%) with 91%, followed by T₈ (ZnO 2%) with 90%. The lowest germination energy was observed in T₄ (CaCl₂ 2%) with 78%.

The superior performance of KCl-treated seeds may be attributed to improved osmotic regulation and activation of metabolic processes involved in seed germination. Potassium plays a crucial role in enzyme activation, protein synthesis, and maintenance of cellular water balance. Similar findings have been reported in millet and cereal crops where potassium-based seed treatments enhanced germination and seedling vigor.

Germination percentage

The germination percentage varied from 78% to 95%, with an

average of 87.09%. The maximum germination percentage was recorded in T₁₀ (KH₂PO₄ 2%) with 95%, followed by T₆ (KCl 2%) with 94%. The minimum germination percentage was observed in T₄ (CaCl₂ 2%).

The improved germination observed in KH₂PO₄-treated seeds may be due to the beneficial role of phosphorus in energy transfer and early seedling development. Potassium dihydrogen phosphate likely enhanced nutrient availability and accelerated physiological activities associated with germination.

Seedling growth parameters

The treatments also significantly influenced root length, shoot length, and seedling vigor. Treatments involving KCl and KH₂PO₄ generally produced vigorous seedlings with better root and shoot development compared to the control and calcium chloride treatments.

Enhanced root growth under KCl treatment may be associated with improved water uptake and nutrient translocation. Zinc oxide treatments also showed positive effects on seedling growth, possibly due to the role of zinc in enzyme systems and chlorophyll synthesis.

In contrast, higher concentrations of CaCl₂ adversely affected most parameters. Excess calcium ions may have caused osmotic stress and reduced water absorption during germination, leading to poor seedling establishment.

Seedling vigor

Seedling vigor is an important indicator of seed quality and field establishment potential. Higher vigor indices observed in KCl and KH₂PO₄ treatments indicated that these salts improved both germination and seedling growth simultaneously. Vigorous seedlings are more capable of tolerating adverse environmental conditions and establishing healthy crop stands.

The significant variability among treatments suggests that seed priming with appropriate inorganic salts can be an effective strategy for improving seed performance in proso millet. These findings are particularly important for saline and drought-prone regions where successful crop establishment is often a challenge.

Conclusion

The present study demonstrated that inorganic salt treatments significantly affected seed germination and seedling growth parameters of proso millet variety K2. Among all treatments, KCl at 2% concentration proved most effective in enhancing germination energy, while KH₂PO₄ at 2% concentration resulted in the highest germination percentage. Treatments involving KCl and KH₂PO₄ also improved seedling vigor and growth performance compared to the control.

On the other hand, CaCl₂ at higher concentration negatively affected germination and seedling development. The study indicates that suitable inorganic salt treatments can be effectively used as seed enhancement techniques for improving germination and early seedling establishment in proso millet under saline conditions.

The findings of this investigation may contribute to the development of sustainable crop management practices and support millet cultivation in stress-prone environments.

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