Eurasian Journal of Soil Science 2022, 11(2), 151 - 156

Eurasian Journal of Soil Science

Journal homepage : http://ejss.fesss.org

# Seed priming with NaCl improves germination in maize under saline soil conditions

**Ganesh Mahara [a], Rajendra Bam [b], Min Kandel [b], Sampada Timilsina [c], Dhiraj Chaudhary [d], Janardan Lamichhane [c], Tirtha Raj Bajgai [e], Bhoj Raj Pant [f], Uttam Bhattarai [g], Jitendra Upadhyaya [h] ***

[a] Department of Agribusiness and Economics, Agriculture and Forestry University, Rampur, Chitwan, Nepal
[b] Department of Agri-Botany and Ecology, Institute of Agriculture and Animal Science, TU, Nepal
[c] Department of Biotechnology, Kathmandu University, Dhulikhel, Nepal
[d] Department of Environment Engineering, College of Science and Technology, Korea University Sejong Campus, South Korea
[e] Minhas Microbrewery, Distillery and Winery, 1314 44 Ave NE, Calgary, AB T2E 6L6 Canada
[f] Nepal Academy of Science and Technology, Lalitpur, Nepal
[g] Experimental Statistics Unit, College of Agricultural and Environmental Sciences, University of Georgia, Griffin Campus, Georgia, USA
[h] Institute of Agriculture and Animal Science, Tribhuvan University, Rampur Campus, Chitwan, Nepal

## Article Info

Received : 14.06.2021
Accepted : 18.11.2021
Available online : 23.11.2021

## Author(s)

G.Mahara
R.Bam
M.Kandel
S.Timilsina
D.Chaudhary
J.Lamichhane
T.R.Bajgai
B.R.Pant
U.Bhattarai
J.Upadhyaya *

* Corresponding author

## Abstract

Soil salinity is considered crucial for seed germination, seedling growth, and crop production in arid and semi-arid regions. Seed priming can be an effective solution to improve maize germination and growth, under salinity stress. An experiment was conducted to study the effect of seed priming with NaCl and salinity stress on germination and growth of maize variety Arun-2. Before sowing, eighty maize seeds were soaked in 5g/L aqueous NaCl solution for 12 hours at 27-degree Celsius. Primed and unprimed seeds were sown in 10-liter capacity plastic pots and watered with 200mL of 0, 2, 4, 6, and 8 g/L saline solutions at two days intervals. Germination percentage, shoot length, and number of leaves per plant were measured to access the germination and growth parameters. The results showed that priming seeds with NaCl solution significantly ($P<0.05$) improved the germination of maize seeds. Whereas, germination of Arun-2 was not significantly affected by salinity stress. Salinity has negative impacts on shoot length and number of leaves. The shoot length at 38 DAS was found to be the longest at salinity level 0 mg/L (8.61cm) and it was found to be shortest at highest salinity level i.e. 8 mg/L (3.12 cm). Increasing salt stress has severe effects on the growth of maize, both during the seedling and vegetative growth stages of the plant. Seed priming alleviated the inhibitory effect of salt stress on germination and seedling growth of maize. Thus, seed priming with 5 g/L NaCl solution could be useful to improve the germination and growth of maize under saline stress conditions.

**Keywords:** Maize, NaCl, salinity, seed germination, seed priming, seed growth.



## Introduction

Salinity is one of the crucial environmental factors that limit plant growth and productivity (Kaya et al., 2002). Saline soil contains a huge amount of soluble salts and sodium ions. These ions increase the osmotic potential in the soil which prevents easy absorption of water by the plants (Omuto et al., 2020). Salinity is a severe problem in arid and semi-arid regions of the world with less available water to the plants. Soil salinity

doi : https://doi.org/10.18393/ejss.1027558
: http://ejss.fesss.org/10.18393/ejss.1027558
Publisher : Federation of Eurasian Soil Science Societies
e-ISSN : 2147-4249

also causes various physiological disorders in plants. Elevated salinity level in soil affects water uptake, causes nutritional disparity, and inhibit photosynthetic efficiency in plants (Okon, 2019). Soil salinity drastically reduces the yield. These reductions may be due to various physiological disorders and biochemical changes resulted from saline soil.

Maize is a moderately salt-sensitive crop (Carpıcı et al., 2009). Cultivation of maize under saline soil conditions affects plant germination, plant establishment and ultimately reduces the yield. The development of salt-tolerant maize requires a considerable amount of time and resources. Researchers found that Salt tolerance in maize can be induced by priming maize seeds with chloride salts (Ashraf and Rauf, 2001). Validation of this approach using locally cultivated genotypes could be beneficial to the low scale maize growers working on saline soil conditions.

Seed priming is a common method used in vegetable crops for better germination. It is getting popular and is being used as a successful method to improve seed germination and crop establishment in developing countries. This method is easy to use and cost-effective for resource-poor farmers and farming systems (Harris et al., 2002). Seed priming stimulates various biochemical changes (water imbibition, breaking of dormancy, activation of certain enzymes) in the seed that are essential to initiate the germination process (Ajouri et al., 2004). Several biochemical processes stimulating germination are activated by seed priming and the activation will remain even after re-desiccation of those seeds (Asgedom and Becker, 2001). Most of the seed priming works has been done on vegetable and other field crops, therefore this study was conducted to explore the effects of seed priming on growth parameters of maize plants under salinity stress condition.

Most of the rural populations in Nepal are based on agriculture. About 28 percent of the land is available for agricultural purposes (MoAD, 2019). Cereals are cultivated as major crops that contribute to the national economy and fulfills the dietary requirement of the people (MoAD, 2019). Among the cereal crops, maize is grown mostly across the country after the rice. However, most of the cultivated land in rural parts of Nepal are saline. Due to the sensitive nature of maize to saline soil, the germination and growth of maize under such conditions are greatly affected (Farooq et al., 2015). Advanced breeding programs to develop salt-tolerant varieties and/or use of modern biotechnological tools are well-established options to mitigate salinity stress in agriculture (Prasanna et al., 2021). Yet, the time required to develop salt-tolerant varieties is long. Unfortunately, local farmers are lagging to adopt the new technologies. Seed priming with chloride salts is fast and could be an effective technique to mitigate soil salinity problems in rural areas. The farmers can use their locally adapted germplasm and cope with the challenges of soil salinity. This experiment was conducted with the objective to see the effectiveness of seed priming with NaCl in maize germination and growth under saline soil conditions.

# Material and Methods

### Study Site and Experimental Design

The study was conducted at the experimental farm of Tribhuvan University, Gokuleshwor Campus, Baitadi Nepal in the summer season (April-June) of 2019. The study site is situated at 29° 40′ 0″ N, 80° 34′ 0″ E and 1600 meter above sea level. The average daily temperature during the research duration was 27 degree Celsius and the average relative humidity was 65 percent. Forty plastic containers (40 cm x 35 cm) were used for the experiment. Twenty pots were allotted to grow the primed seeds and the remaining twenty pots were allotted as unprimed (control) pots. The containers were kept at open environment and drilled at the bottom and the sides for water drainage and aeration, respectively. The bottom of each pot was lined with drainage sand to keep the soil well-drained and was filled with 1:3:1 of sand, local soil (the growth medium), and manure fertilizer, respectively. Ten seeds were sown in each pot at 2 cm depth in quadruplicates. The experiment was conducted with a completely randomized design with four replications. There were two factors in the experiment: salinity level and priming. Five salinity concentrations (0, 2, 4, 6, and 8 g NaCl/L) two methods of priming (primed and unprimed) were used. Each salinity level and priming combinations were randomized among the pots and were also replicated.

### Priming and salinity treatment

Maize variety 'Arun-2 was selected for the experiment due to short crop duration that is 80 to 90 days and suitable for mid-hills of Nepal. The variety was brought from local agrovet. The seeds were surface sterilized (disinfected) with sodium hypochlorite (NaOCl) solution for 3 minutes and then thoroughly washed for 5 minutes using distilled water. Subsequently, the seeds were primed by soaking with NaCl solution of 5 g/L for 12 hours at room temperature. The ratio of seed weight to NaCl solution was 1:5 (g/mL). After priming, seeds were removed and washed with tap water and then rinsed three times using distilled water. Finally, the seeds were placed between two filter papers to remove the moisture.

Each salinity level 0, 2, 4, 6, 8g/L) was applied on four pots that contained the primed seeds, and another four pots that contained unprimed seeds. Each pot was irrigated with 200 mL of saline solution at two days intervals. After the 10th day of seedling, plants were thinned to maintain three plants per pot. The number of seeds germinated were counted five days after seeding and converted into percentage germination. Shoot length and number of leaves per plant were measured starting from ten days after seeding and measured at one-week intervals. Shoot length was measured for five consecutive weeks and the number of leaves was measured for three weeks.

The data were analyzed using two-way ANOVA in MSTAT 5.4 software. Mean comparisons were made using least-square means (LSD) tests and significance were detected when the p-values were less than 0.05.

## Results

The effects of seed priming and salinity concentration on seed germination, shoot growth, and the number of leaves were discussed below.

### Effect of priming with NaCl on seed germination

Significant improvement in germination percentage was observed in primed seed (95.50) compared to normal seed (78.50) (Figure 1). There were no significant differences in percent germination among the salinity levels (Figure 2). The mean value showed that the maximum germination percent (90%) was observed in salinity level 2g/L and 8g/L, whereas the minimum germination percentage (82.5) was reported when the salinity level was 6g/L.

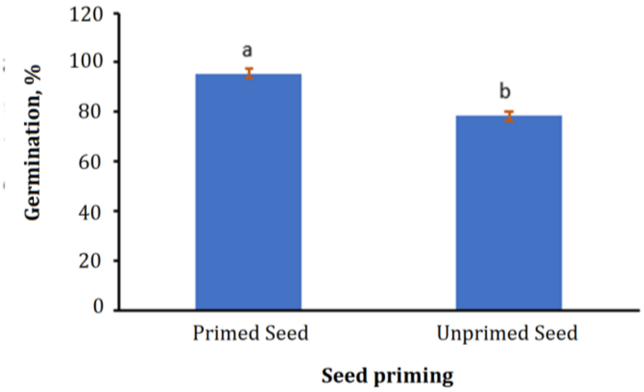


Figure 1. Effect of seed priming on germination percentage of maize seed. Different letters at the top of the bars represent significant differences at $p<0.05$.

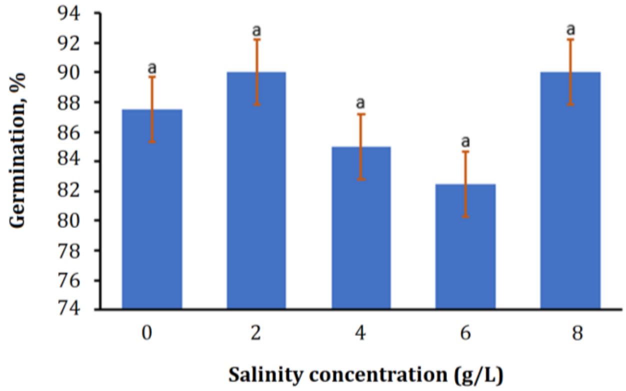


Figure 2. Effect of salinity on germination percentage of maize seed. The same letters at the top of the bars represent no significant differences.

### Effect of seed treatment and salinity level on shoot length

Shoot lengths were measured every week from the 10th day of seeding. Analysis of variance showed significant days after seeding (DAS) and salinity level interaction. Therefore, mean comparisons among the salinity levels were conducted separately for each day after seeding (DAS). No significant mean differences in shoot length were observed among the salinity levels at 10 days after seeding (Figure 3). However, salinity level 6g/L showed the maximum shoot length (2.18 cm). There were significant differences in mean shoot length among different salinity levels at 17, 24, 31, and 38 days after seeding. The mean shoot length showed a decreasing trend as the salinity level increases. Furthermore, there were significant differences in shoot length when the salinity level was 0 compared to any other salinity level (Figure 4). Shoot length at salinity level 2g/L was different from salinity level 8g/L at 17, 25, 31, and 38 DAS. Shoot length at salinity level of 2g/L did not differ from shoot length at salinity level 4g/L. Similarly, shoot length at salinity level 4g/L did not differ from the shoot length at 6g/L at 17, 24, and 38 DAS. However, they differed at 31 DAS. Overall analysis indicated that shoot length is higher when there is no salinity in the soil. No differences between the mild salinity levels (2g/L and 4g/L) were observed, but higher salinity (8g/L) drastically reduced the shoot length in maize. There were no significant differences in shoot length between the primed and unprimed seeds (Figure 5). However, the means of unprimed seeds were lower at all the days after seeding.

### Effect of seed priming with Nacl on leaf number

There were significant differences in the number of leaves among the salinity levels at 10, 17, and 24 days after sowing (Figure 6). On days 17 and 24, the mean number of leaves at salinity level 0 was different from the mean number of leaves at any other salinity level. At 10 days after sowing the number of leaves per plant at 2g/L was different from 0g/L, but not different from salinity level 4, 6, and 8g/L. This indicated, during the initial days of plant growth, salt stress did not have a significant effect on number of leaves. At 17 DAS increasing the salt stress reduced the number of leaves in plants. Data also showed that there were differences in the number of leaves per plant when salt stress was moderate (2g/L and 4g/L) compared to high salt stress (6g/L and 8g/L). Salinity stress drastically reduced the number of leaves at 24 DAS. The reduction in leaf number was more when the salinity stress was increased (Figure 7). There were no significant differences in leaf number between primed and unprimed seeds (Figure 8). However, the mean value indicated that the leaf numbers were more in primed seeds compared to unprimed seeds.

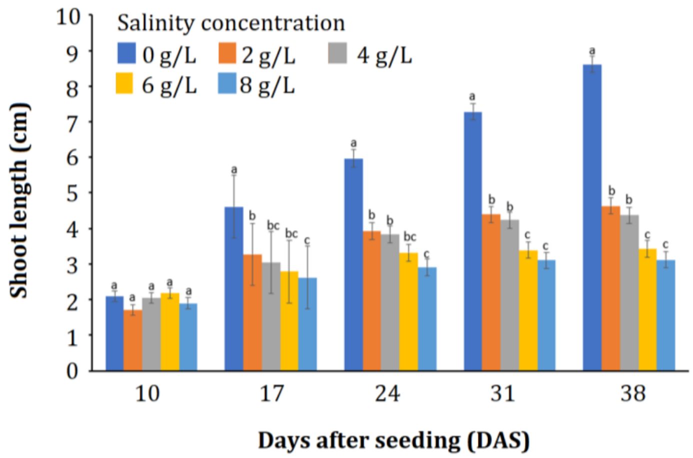


Figure 3. Effect of salinity on shoot length of maize seedling. The same letters at the top of the bars represent no significant differences. Different letters indicate significant differences at P<0.05.

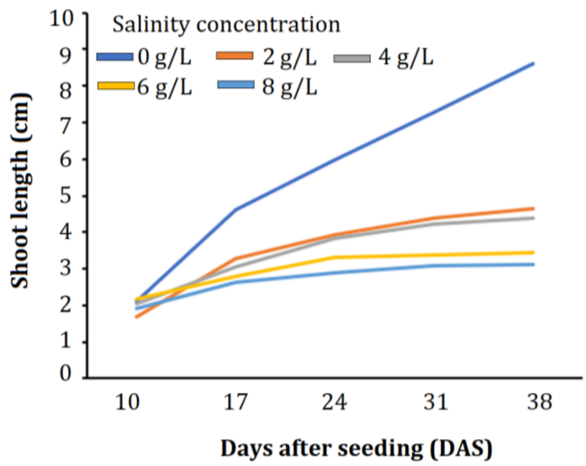


Figure 4. Effect of salinity on shoot length of maize seedling. 0g/L indicates no salt treatment. The shoot length is negatively affected by salinity stress compared to non-stressed.

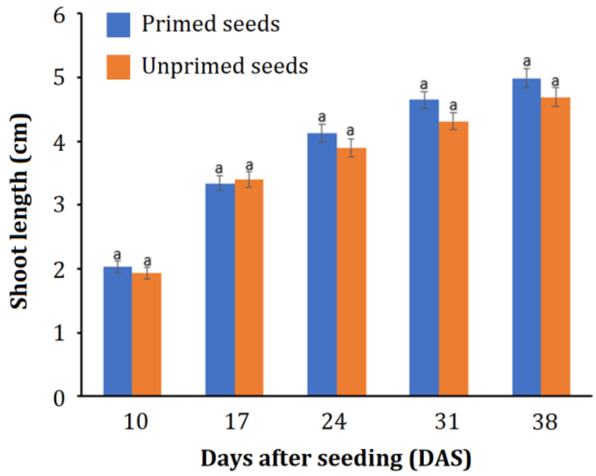


Figure 5. Effect of seed priming on shoot length of maize seedling. The same letters at the top of the bars represent no significant differences.

## Discussion

Seed priming is one of the effective methods to mitigate salinity stress in plants (Imran et al., 2018). Various priming techniques have been suggested by many researchers. Polyethylene glycol (PEG), water, chloride salt of sodium, potassium, and calcium are some of the priming agents used in seed priming (Ashraf and Rauf, 2001). No standard priming agent was found to be clearly better than the other. Seed priming stimulates various metabolic and physiological processes in plants during germination and early growth (Abraha and Yohannes, 2013). The present study investigated the effect of seed priming and salinity stress on the germination and growth of maize. Sodium chloride solution was used as a salt to prime maize seeds before sowing. Salinity did not have a significant effect on the germination of maize seeds. There were significant differences in germination percentage between primed and unprimed seeds. Higher germination percentage was observed in primed seeds compared to the unprimed ones. One of the reasons for better germination of primed seeds in stress conditions was due to the improvement in water imbibition (Chen et al., 2021). Seed priming with sodium salt was also found to be increase the water use efficiency in maize (El-

Sanatawy et al., 2021). Besides imbibition, pre-sowing treatment of maize seeds with sodium salt may have initiated the early metabolic process, activated various enzymes, and enhanced physiological activities inside the seed (Marthandan et al., 2020). There were no statistically significant differences in shoot length and number of leaves between primed and unprimed seeds. However, it has been reported that better seedling growth and vigor in primed seeds compared to the unprimed ones. Chen et al. (2021) found that seed priming helped to reduce salt stress damage and also improved seed germination and vigor. They further found, seed priming promoted a strong establishment of seedling and has better root and shoot traits. No significant differences between primed and unprimed seeds for shoot length and number of leaves were observed. This may be due to higher variation in our experimental data. It may also be due to lower seed weight: NaCl ratio or due to a varietal response of Arun-2. However, in all the cases the mean values of shoot length and number of leaves were higher in primed seeds compared to the unprimed ones.

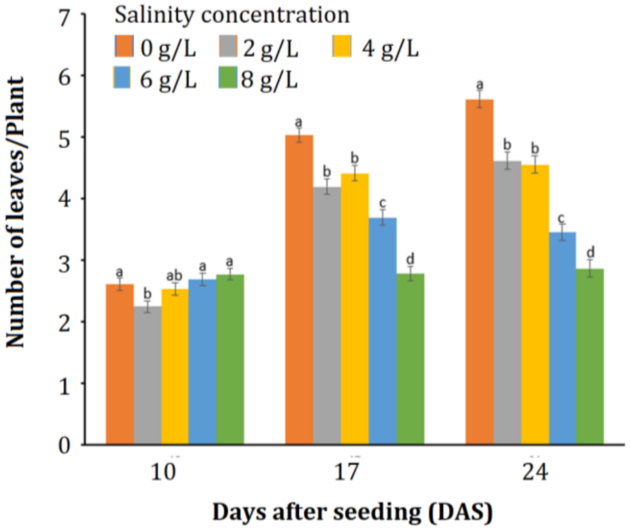


Figure 6. Effect of salinity on number of leaves/Plant of maize seedling. The same letters at the top of the bars represent no significant differences. Different letters indicate significant differences at P<0.05.

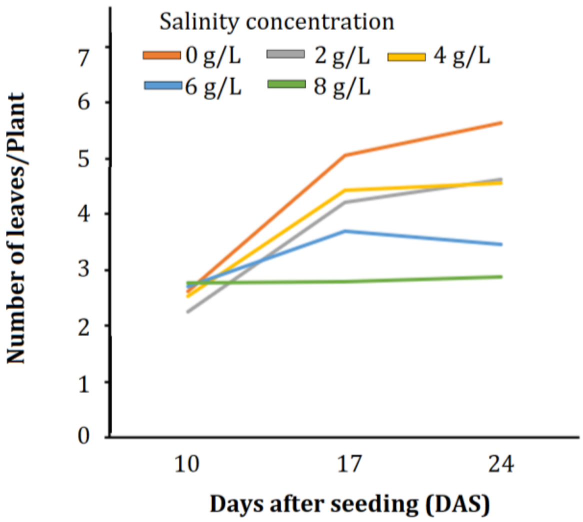


Figure 7. Effect of salinity on number of leaves/Plant of maize seedling. 0g/L indicates no salt treatment. The number of leaves/Plant is negatively affected by salinity stress compared to non-stressed.

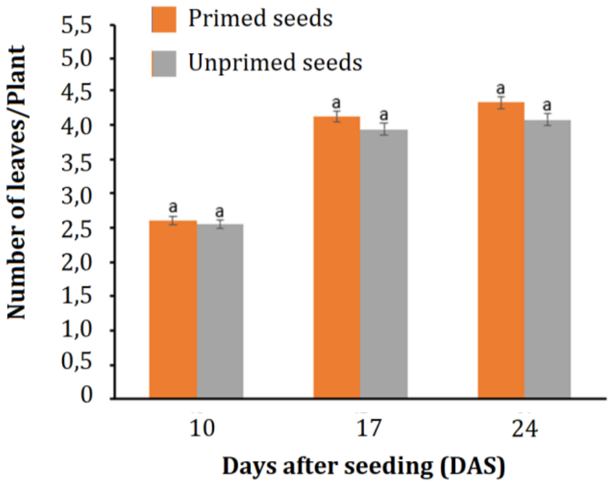


Figure 8. Effect of seed priming on number of leaves/Plant of maize seedling. The same letters at the top of the bars represent no significant differences.

Salinity stress significantly reduced the shoot length and leaf number in maize. Even the mild salinity stress significantly reduced the shoot length compared to the non-stressed condition. The shoot length decreased drastically as the salinity level increased. Similarly, the number of leaves also decreased with the increase in salinity stress. Reduction in seedling growth with increased salinity level was also found by Tsegay and Andargie (2018). This reduction was due to the decrease in water uptake capacity of the seedlings. Alterations in various physiological activities such as change in enzyme activity, reduced sink activity, reduction in stomatal conductance, and reduction in photosynthetic activity were responsible for reduced shoot growth in saline soil conditions (Chutipaijit et al., 2011). Higher salinity concentration had severe effects on plant growth. Apart from distortion in plant growth, in some cases, plants do not even reach the reproductive stage (Bakht et al., 2011). The reduction in number of leaves with increased salinity stress may also have negative effects on the photosynthetic activity of the plants. This ultimately affects the proper growth and development of plants.

## Conclusion

Salinity inhibits germination and seedling growth in maize. Seed priming is an effective method to increase salinity tolerance in maize fields. The better performance of primed seeds in this experiment illustrates the necessity of priming seeds before sowing in the saline soils. Seed priming induces germination and helps in the overall growth and development of the plant. Salt sensitive nature of maize variety Arun-2 makes it unsuitable to grow in saline soil without seed priming. Although our research found the usefulness of seed priming in the early growth stages of maize, additional research on late growth and reproductive stages would be beneficial. Advanced research on priming induced alteration of physiological and biochemical attributes in maize will be the goal of our future research.

## References


Abraha, B., Yohannes, G., 2013. The role of seed priming in improving seedling growth of maize (Zea mays L.) under salt stress at field conditions. *Agricultural Sciences* 4(12): 666-672.

Ajouri, A., Asgedom, H., Becker, M., 2004. Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. *Journal of Soil Science and Plant Nutrition* 167(5): 630-636.

Asgedom, H., Becker, M., 2001. Effects of seed priming with nutrient solutions on germination, seedling growth and weed competitiveness of cereals in Eritrea. In: Proceeding of the Deutcher Tropentag, University of Bonn and ATSAF. Margraf Publishers Press, Weickersheim, 282p.

Ashraf, M., Rauf, H., 2001. Inducing salt tolerance in maize (Zea mays L.) through seed priming with chloride salts: Growth and ion transport at early growth stages. *Acta Physiologiae Plantarum* 23: 407-417.

Bakht, J., Shafi, M., Jamal, Y., Sher, H., 2011. Response of maize (Zea mays L.) to seed priming with NaCl and salinity stress. *Spanish Journal of Agricultural Research* 9(1): 252-261.

Carpıcı, E.B., Celik, N., Bayram, G., 2009. Effects of salt stress on germination of some maize (Zea mays L.) cultivars. *African Journal of Biotechnology* 8(19): 4918- 4922.

Chen, X., Zhang, R., Xing, Y., Jiang, B., Li, B., Xu, X., Zhou, Y., 2021. The efficacy of different seed priming agents for promoting sorghum germination under salt stress. *PLOS ONE* 16(1): e0245505.

Chutipaijit, S., Cha-um, S., Sompornpailin, K., 2011. High contents of proline and anthocyanin increase protective response to salinity in Oryza sativa L. spp. Indica. *Australian Journal of Crop Science* 5(10): 1191-1198.

El-Sanatawy, A.M., Ash-Shormillesy, S.M.A.I., Qabil, N., Awad, M.F., Mansour, E., 2021. Seed halo-priming improves seedling vigor, grain yield, and water use efficiency of maize under varying irrigation regimes. *Water* 13: 2115.

Farooq, M., Hussain, M., Wakel, A., Siddique, K.H.M., 2015. Salt stress in maize: effects, resistance mechanisms, and management. A review. *Agronomy for Sustainable Development* 35: 461–481.

Harris, D., Tripathi, R.S., Joshi, A., 2002. On-farm seed priming to improve crop establishment and yield in direct-seeded rice. In Direct seeding: Research strategies and opportunities. IRRI, Philippines. pp: 231-240.

Imran, M., Boelt, B., Mühling, K.H., 2018. Zinc seed priming improves salt resistance in maize. *Journal of Agronomy and Crop Science* 204(4): 390-399.

Kaya, C., Kirnak, H., Higgs, D., Saltali, K., 2002. Supplementary calcium enhances plant growth and fruit yield in strawberry cultivars grown at high (NaCl) salinity. *Scientia Horticulturae* 93: 65-74.

Marthandan, V., Geetha, R., Kumutha, K., Renganathan, V.G., Karthiyekan, A., Ramalingam, J., 2020. Seed priming: A feasible strategy to enhance drought tolerance in crop plants. *International Journal of Molecular Sciences* 21: 8258.

MoAD, 2019. Ministry of Agriculture and Development (MoAD). Statistical information on Nepalese Agriculture 2018/19. Agribusiness Promotion and Statistics Division, Ministry of Agriculture Development, Kathmandu, Nepal.

Okon, O.G., 2019. Effect of salinity on physiological processes in plants. In: Microorganisms in Saline Environments: Strategies and Functions. Giri, B., Varma, A., (Eds). Springer, Cham. pp 237-262.

Omuto, C.T., Vargas, R.R., EI Mobarak, A.M., Mohamed, N., Viatkin, K., Yigini, Y., 2020. Mapping of salt-affected soils: Technical manual. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy. 112p.

Prasanna, B.M., Cairns, J.E., Zaidi, P.H., Beyene, Y., Makumbi, D., Gowda, M., Magorokosho, C., Zaman-Allah, M., Olsen, M., Das, A., Worku, M., Gethi, J., Vivek, B.S., Nair, S.K., Rashhid, Z., Vinyan, M.T., Issa, A.B., Vicente, F.S., Dhliwayo, T., Zhang, X., 2021. Beat the stress: breeding for climate resilience in maize for the tropical rainfed environments. *Theoretical and Applied Genetics* 134: 1729–1752.

Tsegay, B.A., Andargie, M., 2018. Seed priming with gibberellic acid (GA3) alleviates salinity induced inhibition of germination and seedling growth of Zea mays L., Pisum sativum Var. abyssinicum A. Braun and Lathyrus sativus L. *Journal of Crop Science and Biotechnology* 21(3): 261-267.