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AMELIORATION OF SALINITY TOLERANCE IN FOXTAIL MILLET BY APPLYING PLANT GROWTH REGULATORS

D. Biswas[1], M.A. Mannan[1*], M.A. Karim[1] and M.Y. Miah[2]

[1]Department of Agronomy, [2]Department of Soil Science
Bangabandhu Sheikh Mujibur Rahman Agricultural University
*Corresponding E-mail: mannanbsmrau@yahoo.com

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Abstract

A pot experiment was laid down at the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur from November 2018 to March 2019 to improving the salinity tolerance in Foxtail millet (BARI Kaon 1) using different plant growth regulators with different doses. Two salinity levels, i) control (0mM NaCl) and ii) 80 mMNaCl were maintained after 14 days of sowing to harvest. The plant growth regulators i) Humic acid (HA): a) @ 5 gL^{-1} water b) @ 10 gL^{-1}water ii) Gibberellic acid (GA_3): a) @10 g L^{-1}water b) @20 g L^{-1}water iii) Salicylic acid (SA): a) @ 50 g L^{-1}water b) @ 100 g L^{-1}water were sprayed at 7 days interval from salt imposition. The experiment was in a completely randomized design (CRD) with three replications. Results revealed that plant growth regulators improved the growth and yield performance of Foxtail millet under both control and saline conditions. Amelioration of salinity tolerance in Foxtail millet was well associated with lower proline content, higher chlorophyll content and SPAD value as well as dry matter production, which facilitated the Foxtail millet yield due to application of plant growth regulators. Among the plant growth regulators, humic acid (HA) @ 5 g L^{-1} water was the best treatment to improving the salinity tolerance in foxtail millet under saline condition.

Introduction

Salinity affects almost every aspect of the physiology and biochemistry of plants and significantly reduces yield. The major inhibitory effect of salinity on plant growth and yield has been attributed: 1) to osmotic effect,2) ionic toxicity and3) nutritional imbalance leading to a reduction in photosynthetic efficiency and other physiological disorders (Ali *et al.,* 2004). Generally, the trend and magnitude of adverse changes varied within species, varieties/genotypes according to the level of salinization. Salt stress leads to a decreased efficiency of photosynthesis and is known to influence the chlorophyll content of plant leaves (Meloni *et al.,* 2003). The decrease of chlorophyll synthesis may be due to a decrease of δ-aminolevulinic acid dehydratase (ALAD) activity under environmental stress (Vajpayee *et al.*, 2000), but there is no clear information on the behavior of this enzyme in leaves under salt stress conditions. Proline accumulation is one of the adaptations of plants to salinity. It has also been widely advocated that proline accumulation uses as a parameter of selection for salt stress tolerance (Ramanjulu and Sudhakar, 2001).

Foxtail millet has attracted international research attention due to its high stress tolerance, photosynthetic efficiency, nutritional values and health benefits (Liu *et al*., 2011, Vetriventhan *et al*., 2012). The existence of differences in salt tolerance not only amongst different species but also within certain species (Munns and Tester, 2008) offers an opportunity for identifying and developing salt-tolerant genotypes. Breeding for salinity tolerant in a crop is difficult due to the involvement of several genes controlling the character and lack of sufficient knowledge of the mechanisms controlling salt tolerance (Aktita and Cabusley, 2003). Therefore, the efforts have been made to improving salt tolerant in cultivated crops through exogenous application of different plant growth regulators. Humic acid (HA) is believed to have an important role in promotion of plant growth as a biostimulation. It can induce alteration in plant primary and secondary metabolism linked to abiotic stress tolerance, which leads to improved plant growth and increased resistance against abiotic stress (Saidimoradi *et al*., 2019). The mechanism of HA in promoting plant growth is not completely known, but several explanations proposed (Nardi *et al.*, 2002) attributed the beneficial effects of HA on plant growth to increasing minerals transport during cell membrane, oxygen uptake, respiration and photosynthesis, nutrients uptake and root and cell elongation. Gibberellic acid (GA3) treatment has alleviated the drastic effect of salinity in growth parameters (leaf area, dry weight of grains and photosynthetic pigments) and chemical constituents (carbohydrates, proteins, amino acids and proline content in two wheat cultivars (Sohag 3 and Giza 168) (Shaddad *et al*., 2013). Maggio *et al.* (2010) reported that GA_3 treatment in *Lens esculentum* reduced stomatal resistance and enhanced plant water use at low salinity.

Salicylic acid (SA) is naturally occurs in plants in very low amounts and participates in the regulation of many physiological processes in the plant such as nutrient uptake, chlorophyll and protein synthesis. Hossain *et al.* (2015) reported that NaCl induced reduction in the plant growth and yield of chickpea could be mitigated by exogenous application of plant growth regulators such as SA and GA_3 at a low concentration under low salinity stress. The aim of this study is to study the effects of different plant growth regulators to ameliorate salinity tolerance in foxtail millet variety BARI Kaon-1 (Titas). Therefore, the objectives of the research work is i) To study the effect of exogenous application of plant growth regulators on some physiological and biochemical parameters related to salinity tolerance in foxtail millet ii) To evaluate the growth and yield associated characters of foxtail millet in response to plant growth regulators under salinity; and iii) To determine the appropriate plant growth regulator and their doses this could effectively ameliorate the adverse effects of salt stress on foxtail millet.

Materials and Methods

The pot experiment was conducted under a semi-controlled environmental condition in the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from November 2018 to March 2019. It was located at 24.09^0 N latitude and 90.26^0 E longitudes at an elevation of 8.4 m from the mean sea level. The experimental soil was collected before the sowing of seeds. The physical and chemical properties of the soils were sand (40.51%), silt (28.71%), clay (30.78%), pH (6.18), organic carbon (1.45%), total nitrogen (0.712%), available P (7.24 mg $P100^{-1}$ g dry soil), exchangeable K (0.169 meq 100^{-1} g dry soil), Zn (7.07meq100^{-1}g dry soil) and the texture was sandy loam. The soil of the pot was fertilized uniformly with 0.40, 0.34 and 0.20 g urea, triple superphosphate and muriate of potash corresponding to 100-75-40 kg urea, triple superphosphate and muriate of potash per hectare, respectively (BARI, 2000).Foxtail millet variety: BARI Kaon -1 (Titas) was used in this experiment. BARI Kaon -1 was released by the Bangladesh Agricultural Research Institute (BARI).The experiment was laid out in Completely Randomized Design (CRD) with three replications. Ten healthy seeds were sown maintaining uniform spacing in each pot on 18 November 2018. Light irrigation was given by using the water cane to ensure uniform germination of seeds after sowing. The experiment consisted of the following two treatments: Factor A: salinity levels- 2: i. Control (0 mM NaCl) ii. 80 mM NaCl. Factor B: Plant growth regulators-3: i) Humic acid (HA): a) @ 5 g L^{-1} water b) @ 10 g L^{-1}water ii) Gibberellic acid (GA3): a) @ 10 g L^{-1}waterb) @ 20 g L^{-1}water iii) Salicylic acid (SA): a) @ 50 g L^{-1}water b) @ 100 g L^{-1}water. Seeds were sown in plastic pots of 24 cm (diameter) × 30 cm (height) in size filled with soil and kept inside plastichouse under natural light. After the seedling establishment, six uniform and healthy plants were allowed to grow in each pot. Weeding and pest control measures were taken properly as and when necessary. The salt solution was prepared by adding the required amount of NaCl in tap water making 80 mM salinity level. Saline treated pots were irrigated by saline solution from 14^{th} days after sowing (DAS) to maturity as and when necessary and control pots were irrigated by tap water. Different concentration of HA, GA3 and SA were applied once in a week from 20 DAS to flowering stage. Data on plant height, leaf fresh and dry weight were recorded at 20 and 40 days after salt imposition. SPAD values were measured at 07 days intervals of salt imposition. Leaf proline and chlorophyll content were measured at flowering stage. Leaf, stem, root and total dry matter weight and yield were recorded at harvest. SPAD (Soil Plant Analysis Development) value was determined from the top fully expanded leaf by a portable chlorophyll meter (Minolta SPAD-502).Chlorophyll content was estimated from the fully expanded uppermost leaf samples using the method described by Witham *et al.* (1986).Fully expanded uppermost leaf samples were collected and proline extractions were made using the method outlined by Bates *et al.* (1973).Leaf fresh and dry weight were recorded at 20 and 40 days after salt imposition. At the maturity stage crop was harvested. After harvest soil was washed out gently by tap water and plants were partitioned into root, stem and leaf. Yield and yield contributing characters like panicle weight, seed yield. Sodium and Potassium in the plant straw were determined after harvest following the method described by (Jackson, 1973). The recorded data were statistically analyzed by "CROPSTAT 7.2" software. The treatment means were compared by least significance difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Plant height differences of foxtail millet at vegetative stages indicated that plant height varied due to different plant growth regulators and their doses under saline conditions (Figure 1). At 20 days after salt imposition, salinity stress decreased plant height compared to control but different plant growth regulators increased plant height. The highest plant height was recorded 42.77 cm, when SA was applied @ 10 g L^{-1}water, followed by 41.22 cm, 39.60 cm and the lowest was 36.40 cm when HA was applied 5g L^{-1}water, GA3 10 g L^{-1}waterand SA 100g L^{-1}water, respectively after 20 days salt imposition. On the other hand at 40 days after salt imposition salinity also reduced plant height. Plant growth regulators increased plant height under the saline condition at 40 days after salt imposition. The highest plant height was recorded 85.85 cm, when GA3 was applied @ 10 g L^{-1}water,followed by 81.23 cm, 75.13 cm and the lowest was 62.57 cm when GA3 was applied 20 g L^{-1}water,SA 50g L^{-1}water, and SA 100 g L^{-1}water respectively (Figure 1). So it is clear that plant height is affected by salinity and application of growth regulators enhances the salinity tolerance in foxtail millet in respect of plant height. Salinity induced reduction in plant height is a common phenomenon and was also reported earlier for different crops, e.g., mungbean (Aziz, 2003); mungbean, cowpea and soybean (Egeh and Zamora, 1992). The reduction in plant height was probably resulted from a slow growth caused by osmotic stress imposed by a high concentration of salts in the rooting zone.

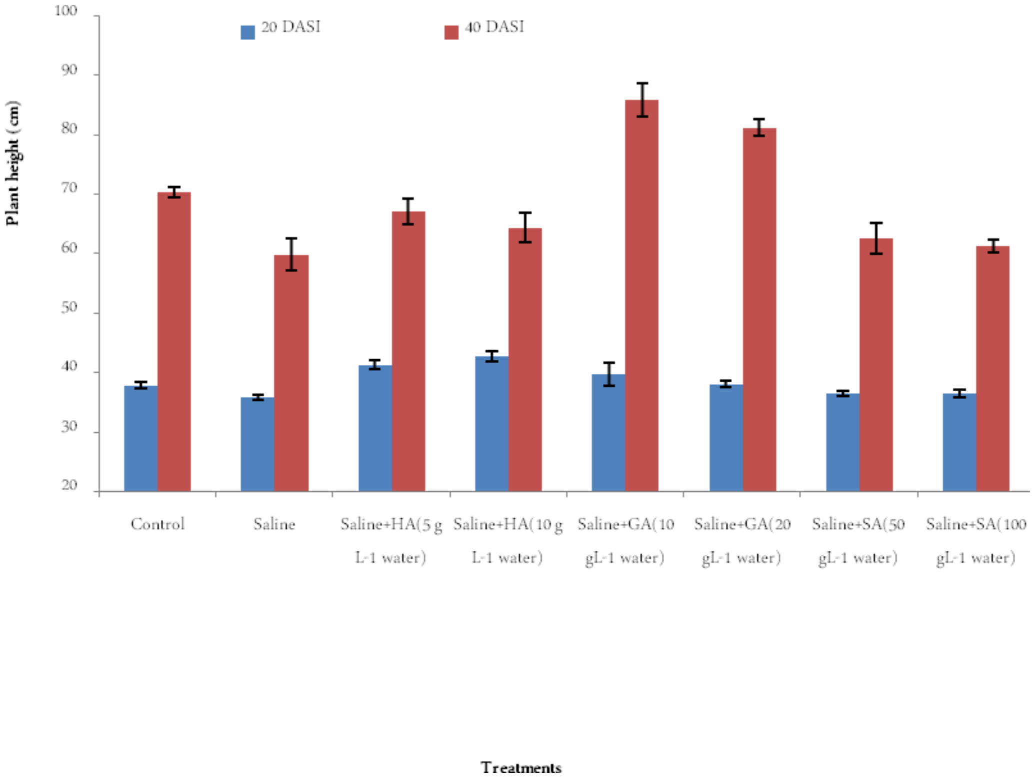

Fig. 1. Effect of growth regulators on plant height of foxtail millet at 20 and 40 days after salt imposition (DASI). Bars indicate (± SE).

Leaf fresh weight

Leaf fresh weight Foxtail millet was affected by plant growth regulators at 20 and 40 days after salt imposition (Figure 2). Leaf fresh weight was reduced due to salinity but the higher reduction was found at 40 days after salt imposition. Plant growth regulators increased leaf fresh weight under saline conditions. At 20 days after salt imposition the maximum leaf fresh weight was measured 2.11 g when HA was sprayed @ 5 g L^{-1} water and it was minimum (1.67 g) when SA was applied @ 100g L^{-1} water. The maximum leaf fresh weight was found 5.86 g when plant growth regulator HA was applied @ 5g L^{-1} water, followed 5.83 g and 5.64 g and the minimum fresh weight was observed 5.19 g, when HA @ 10g L^{-1} water, GA3 10 g L^{-1} water and SA 50 g L^{-1} water were applied, respectively (Figure 2). The spray of SA improved for instance shoot fresh weight per plant by 46.05%, GA_3 40.42% and Tria by 33.22% over the water-sprayed control in *Menthapiperita* reported by Daraksha and Mohammad (2018). The alleviation in growth of plants due to PGRs especially SA may be traced to the fact that PGRs increase membrane permeability, cell division and cell enlargement. The favorable response of plants to PGRs has also been reported by Yildirim *et al.* (2008), Babar *et al*. (2014) and Özkan and Baydar (2016).

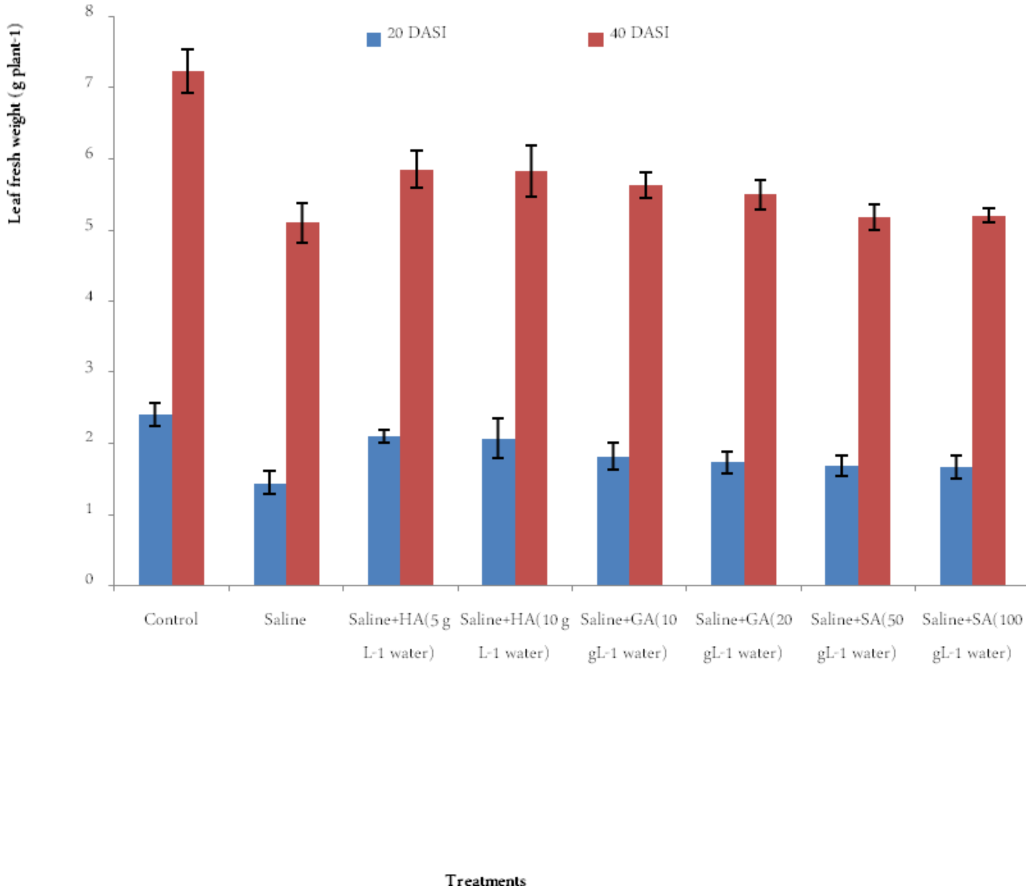

Fig. 2. Effect of growth regulators on leaf fresh weight of foxtail millet at 20 and 40 days after salt imposition (DASI). Bars indicate (± SE).

Stem fresh weight

It was found that stem fresh weight of Foxtail milled decreased under the saline condition at vegetative stage and higher reduction was found at 40 days after salt imposition (Figure 3). Plant growth regulators increased stem fresh weight under salinity stress. At 20 days after salt imposition the maximum stem fresh weight was found 2.87 g from HA @ 5 g L^{-1}watertreatment and the minimum stem fresh weight was found 2.61 g from GA3 g L^{-1}watertreatment. On the other hand, at 40 days after salt imposition, the maximum stem fresh weight was recorded 9.99 g from HA @ 5 g L^{-1}watertreated plant and the minimum was 8.31 g from SA @ 100 g L^{-1}watertreatment (Figure 3). Qureshi *et al.* (2013) reported that GA_3either applied singly or among calcium chloride, radically increased the vegetative growth parameters by increasing plant height, crown diameter, canopy spread, fresh and dry weight of plant and leaves, leaf area, fruit set percentage, number of, runners, trusses, flowers and fruits in strawberry.

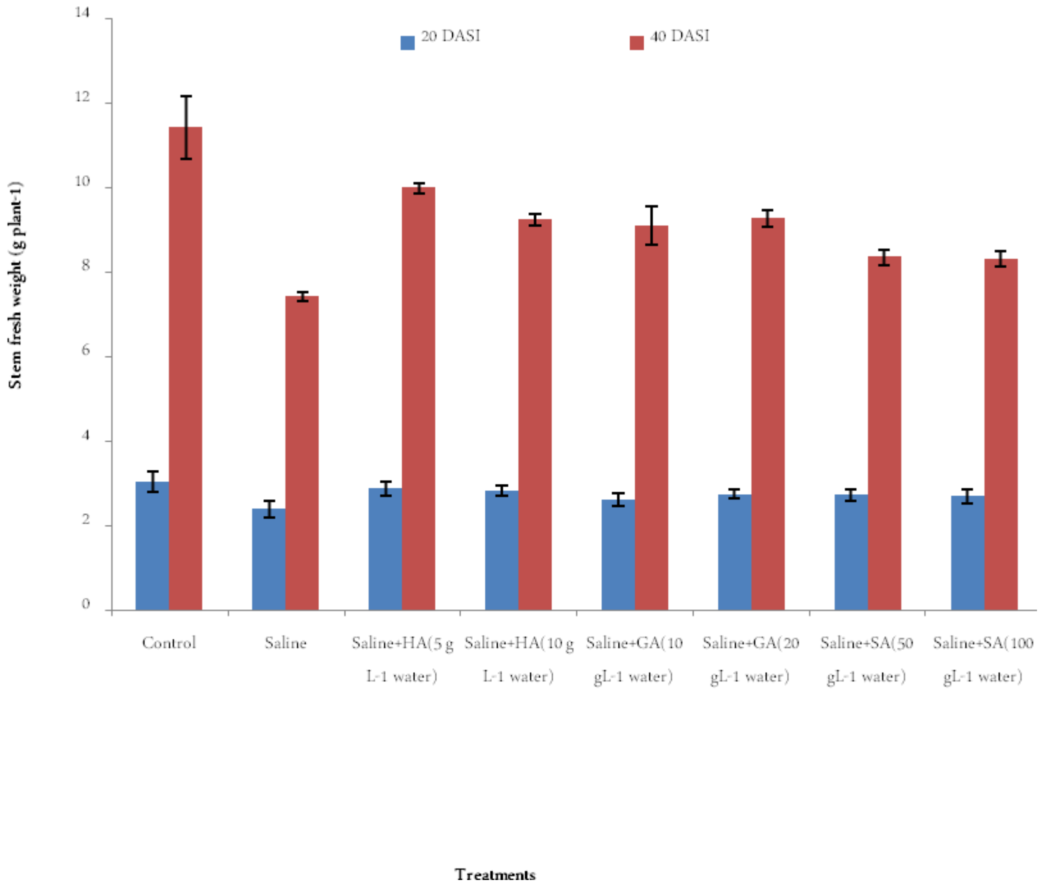

Fig. 3. Effect of growth regulators on stem fresh weight of foxtail millet at 20 and 40 days after salt imposition (DASI). Bars indicate (± SE).

Total fresh weight

The total fresh weight of Foxtail millet also affected by salinity as well as plant growth regulators. Total fresh weight was decreased due to salinity and a higher reduction was found at 40 days after salt imposition than 20 days after salt imposition. Plant growth regulator increased total fresh weight under salinity. At 20 days after salt imposition, the maximum total fresh weight was 4.98 gplant^{-1}, followed by 4.91 g plant^{-1}, 4.48 g plant^{-1} and the minimum was 4.39 g plant^{-1} when HA treated plant @ 5g L^{-1}water, HA @ 10g L^{-1}water, GA3 @ 20 g L^{-1}waterand SA @ 100 g L^{-1}waterrespectively (Figure 4). At 40 days after salt imposition maximum total dry weight (15.86 g) was recorded from HA @ 5 g L^{-1}watertreatment and it was a minimum 13.52 g when plant was treated with SA @ 100 g L^{-1} water (Figure 4). Salicylic acid, in comparison with gibberellic acid also showed some favorable effects on accumulation of fresh weight which supported by the work of Amborabe *et al*. (2002) and Karlidag *et al*. (2009) on fresh weight accumulation in strawberry plant shoots with further agreement with the finding of Khodary (2004) in increasing the total weight of plants in case of *Zea mays* as compared to control.

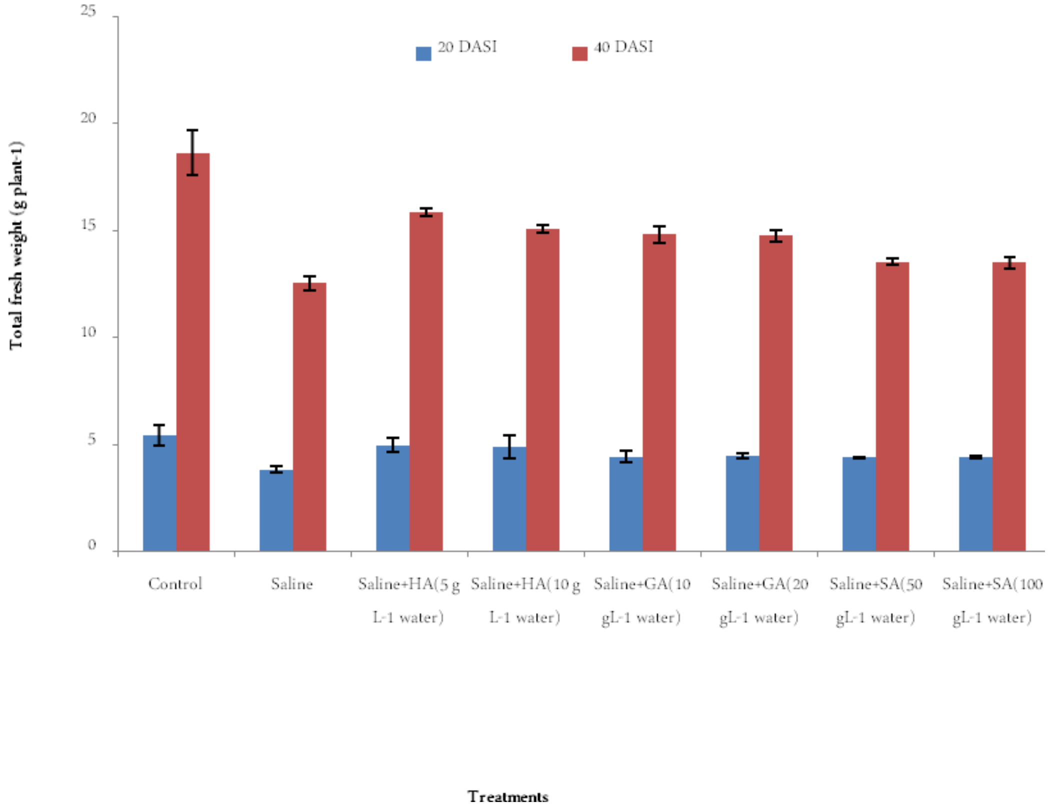

Fig. 4. Effect of growth regulators on total fresh weight per plant (g) of foxtail millet at 20 and 40 days after salt imposition (DASI). Bars indicate (± SE).

SPAD value

SPAD value of leaf of Foxtail millet was recorded from 7 days after salt imposition to 42 days after salt imposition at 7 days intervals. It was found that SPAD value was increased up to 28 days under saline condition then SPAD value decreased. Among the plant growth regulators HA @ 5 g L^{-1}waterhad the positive effects of increasing SPAD value under salinity (Figure 5). Other plant growth regulators had no positive effects on SPAD value of Foxtail millet leaves. It indicates that longer the exposure to salinity stress higher the decreases the SPAD value.Purcarea and Cachita-Cosma(2011) reported that SA pre-treatment as a foliar spray ameliorated the total chlorophyll (SPAD) pigment content of wheat seedling leaves under salt stress.

Chlorophyll content

The chlorophyll content of Foxtail millet leaf was reduced significantly at salinity stress conditions. The highest total chlorophyll (1.70 mg g^{-1}) was found in the control condition and it was lowest (0.58 mg g^{-1}) under saline condition (Figure 6).

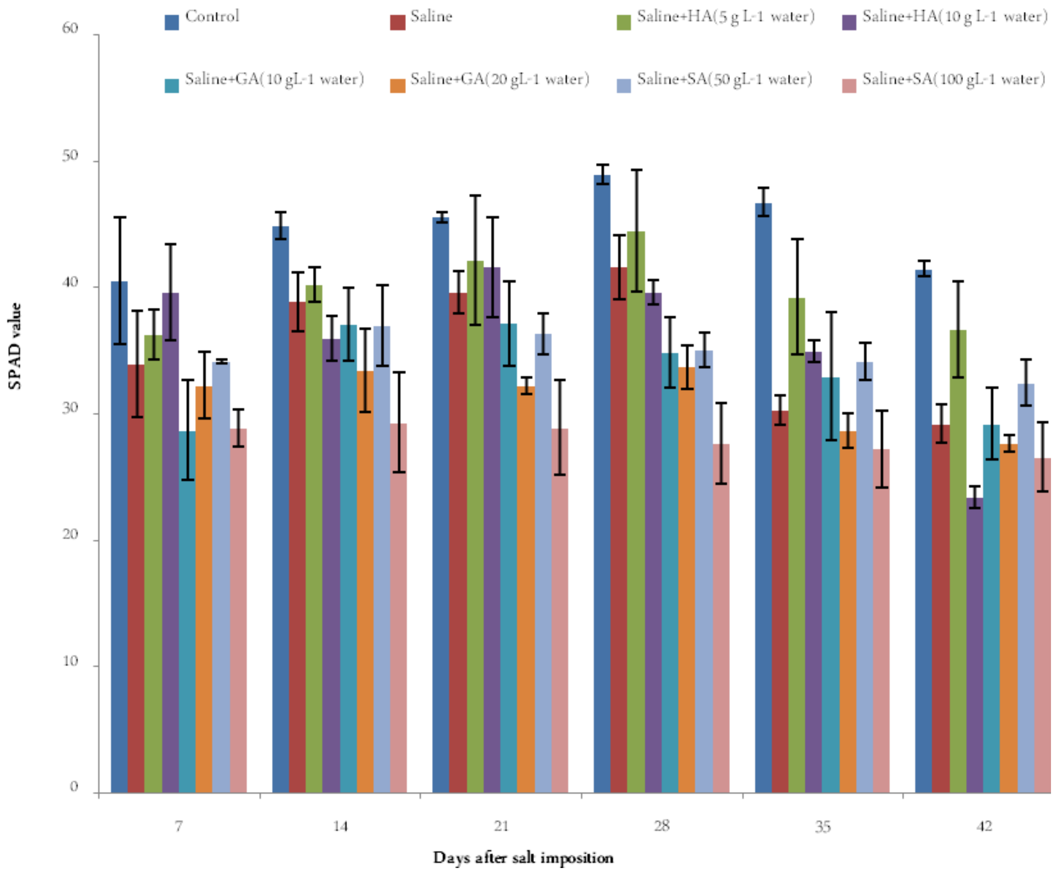

Fig. 5. Effect of growth regulators on SPAD value of foxtail millet at different days after salt imposition (DASI). Bar indicate (±SE).

Total chlorophyll content increased when different plant growth regulators were applied under saline conditions. Among the different plant growth regulators, HA @ 5 g L^{-1}waterproduced the highest total chlorophyll (1.20 mgg^{-1}) and it was lowest (0.75 mgg^{-1}) for SA @ 100 g L^{-1}water. When plants are grown under saline conditions, photosynthetic activity decreases leading to reduced plant growth, leaf area, chlorophyll content and chlorophyll fluorescence reported by Muhammad *et al.* (2007). Photosynthesis is one of the most severely affected processes during salinity stress (Sudhir and Murthy, 2004) owing to decrease in stomatal conductance, internal CO_2 partial pressure (Sultan *et al.,* 1999) and stomatal closure that affects the gaseous exchange (Bethkey and Drew 1992). This positive effect of SA could be attributed to increased CO_2 assimilation and photosynthetic rate and increased mineral uptake by the stressed plant under SA treatment (Khan *et al*., 2000; Fariduddin *et al*., 2003; Szepsi *et al*., 2005). Zeid (2011) also reported an alleviation of adverse effect of salinity on chlorophyll content in barley with GA_3 treatment. Ali *et al.* (2012) recorded restoration of altered pigments by application of GA_3 under saline condition in *Hibiscus sabdariffa*. Exogenously applied SA significantly enhanced net photosynthetic rate which could be due to improving the functional state of the photosynthetic machinery in plants either by the mobilization of internal tissue nitrate or by chlorophyll biosynthesis (Shi *et al*., 2006).

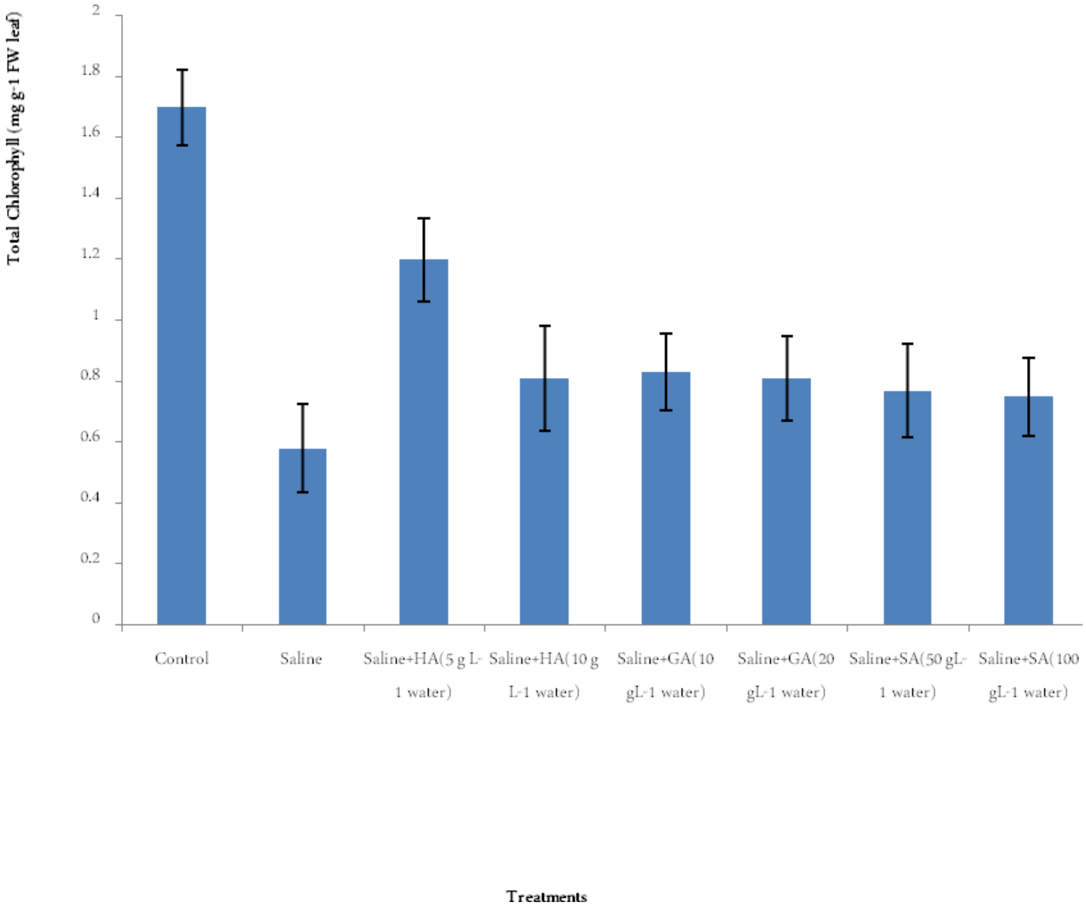

Fig. 6. Effect of growth regulators on total chlorophyll content of foxtail millet at flowering stage Bar indicate (±SE).

Proline content

Proline is a kind of stress protein. Proline accumulation under stress condition occurred because Calvin cycle of photosynthesis affected by salinity stress; as a result, N content could not be properly metabolized content of foxtail millet varied significantly with different doses of plant growth regulators under salinity conditions (Figure 7). The lowest proline content (0.08 µ moleg^{-1}) was found under the control condition but under salinity, proline content increased and it was 1.54µ moleg^{-1}. When plant growth regulators were applied under saline conditions proline content were decreased compared to solely saline treatment. The lowest proline content (1.20µ moleg-^{1}) was recorded from HA @ 5 g L^{-1}watertreatment compared to other plant growth regulators treatment. Lower accumulation of proline under saline condition after application of synthetic amendments (plant growth regulators) indicates that synthetic amendments reduce the salinity effects on winter pulses. Kasim and Dowidar (2006) observed lower proline content inGA3 primed radish seedlings under NaCl treatment. They suggested that, this decrease in the amino acid in GA3 primed seedlings may be due to their incorporation in some new proteins or their utilization in the synthesis of certain existing proteins.

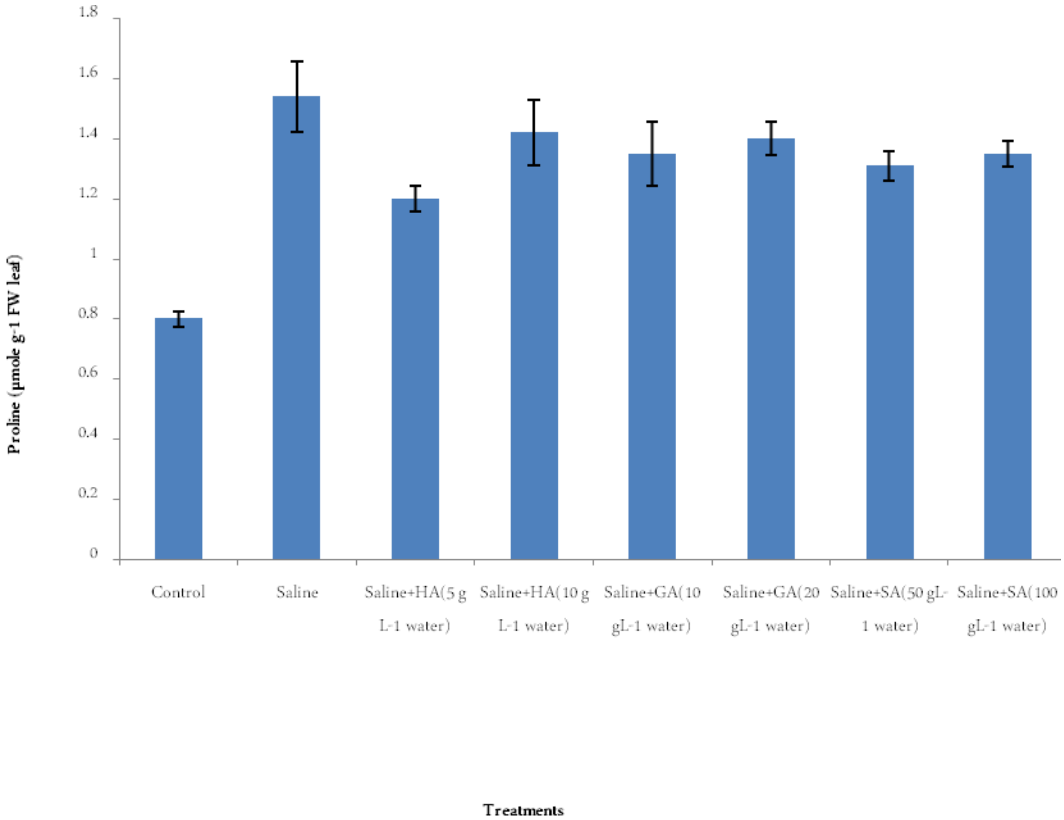

Fig. 7. Effect of growth regulators on proline content of foxtail millet at flowering stage
Bar indicate (±SE).

Dry matter production

Leaf, stem, root and total dry weight of Foxtail millet plant reduced under saline condition. Different plant growth regulators increased the dry matter of different plant parts (Table 1). The highest leaf dry matter (2.54 g) was recorded from HA @ 5 g L^{-1}watertreatment, followed by 2.21 g, 1.84 g and the lowest dry leaf weight (1.30 g) found from HA @ 10g L^{-1}water, GA3 @ 5 g L^{-1}waterand SA 50 g L^{-1}watertreatment, respectively. The highest stem dry matter (6.65 g) was recorded from HA @ 5 g L^{-1}watertreatment, followed by 3.80 g, 3.66 g and the lowest dry leaf weight (3.45 g) found from GA @ 10 g L^{-1}water,HA @ 10 g L^{-1}waterand SA 50 g L^{-1}watertreatment, respectively. The highest root dry matter (0.71 g) was recorded from HA @ 5g L^{-1}watertreatment, followed by 0.65 g, 0.57 g and the lowest root dry weight (0.47 g) found from HA @ 10g L^{-1}water, GA3 @ 10 g L^{-1}waterand SA 100 L^{-1}watertreatment, respectively. The highest total dry matter (9.90 g) was recorded from HA @ 5 g L^{-1}watertreatment, followed by 6.52 g, 6.21 g and the lowest dry leaf weight (5.27 g) found from HA @ 10g L^{-1}water, GA3 @ 10 L^{-1}waterand SA 50 g L^{-1}watertreatment, respectively. Reduction in dry matter production under saline condition was also reported by Patil *et al.* (1996) and Raptan *et al*. (2001) in mungbean. Increasing salinity level resulted in significant reductions of shoot biomass, root length and volume.

Table 1. Effect of growth regulators on dry matter production of Foxtail millet under saline condition at harvest

Treatments	Leaf dry weight (g plant^{-1})	Stem dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Total dry weight (g plant^{-1})
Control	2.22	4.20	1.15	7.57
Saline (8 dSm^{-1})	1.13 (50.90)	3.27 (77.85)	0.40 (34.78)	4.8 (63.41)
Saline + HA (5 g L^{-1}water)	2.54 (114.41)	6.65 (158.33)	0.71 (61.73)	9.90 (130.78)
Saline + HA (10 g L^{-1}water)	2.21 (99.94)	3.66 (87.14)	0.65 (56.52)	6.52 (86.125)
Saline + GA3 (10g L^{-1}water)	1.84 (82.83)	3.80 (90.47)	0.57 (49.56)	6.21 (82.03)
Saline + GA3 (20g L^{-1}water)	1.62 (58.56)	3.54 (84.29)	0.56 (48.70)	5.27 (69.62)
Saline + SA (50 g L^{-1}water)	1.30 (62.61)	3.45 (82.14)	0.52 (45.22)	5.27 (69.62)
Saline + SA (100g L^{-1}water)	1.39 (62.61)	3.47 (82.62)	0.47 (40.87)	5.33 (70.41)
$LSD_{(0.05)}$	0.22	0.85	0.72	0.72
CV (%)	7.3	1.4	6.6	9.0

HA- Humic acid, GA3-Gibberelic acid, SA- Salicylic acid; Values in parenthesis indicates % of control

Yield and yield contributing characters

Salinity decreased panicle length, panicle dry weight and yieldplant^{-1}of Foxtail millet however, the application of plant growth regulators increased in this parameter (Table 2). The highest panicle length was 12.37 cm under the saline condition when plant growth regulator HA @ 5 g L^{-1} water was applied. The lowest panicle length (8.98 cm) was recorded when SA was applied @ 100 g L^{-1} water at saline condition. The highest panicle dry weight (3.70 g) was recorded from HA @ 5 g L^{-1} water treatment, followed by 3.57 g, 3.29 g and the lowest dry leaf weight (3.05 g) found from HA @ 10g L^{-1} water, GA3 @ 10 g L^{-1} water and SA 50 g L^{-1} water treatment, respectively. The highest grain yield (7.69 g) was recorded from HA @ 5 g L^{-1}water treatment, followed by 6.66 g, 5.41 g and the lowest grain yield (3.91 g) obtained from HA @ 10g L^{-1} water, GA3 @ 10 g L^{-1} water and SA 50 g L^{-1} water treatment, respectively. The exogenous application of PGRs like auxins, gibberellins, cytokinins produces some benefit in alleviating the adverse effects of salt stress and also improves germination, growth, development and seed yields and yield quality (Egamberdieva, 2009; Majid *et al.,* 2011, Khan *et al*., 2004, Afzal *et al*., 2006).

Na and K in straw

Plant growth regulators significantly influenced the straw Na (%) and K (%) in Foxtail millet (Figure 8). It was found that salinity increased Na (%) and decreased K (%) in straw compared to the control condition. Different plant growth regulators decreased Na (%) and increased K (%) under saline conditions. The highest reduction of Na (%) was found in HA @ 5 g L^{-1} water treatment and the lowest reduction was in treatment SA @ 100g L^{-1} water. On the other hand the highest increase of K (%) in straw was found in treatment HA @ 5 g L^{-1} water and it was lowest in treatment SA @ 50 g L^{-1} water under saline condition. Exogenous application of nutrients, IAA, or their combination considerably reduced Na+ concentration and significantly improved K+, Ca2+, and P levels in the salt stressed maize plants reported by Cengiz Kaya *et al.* (2013).

Table 2. Effect of growth regulators on panicle length, panicle dry weight and yield of Foxtail millet under saline condition

Treatments	Panicle length (cm)	Panicle dry weight (g plant^{-1})	Grain yield (g plant^{-1})
Control	15.79	3.88	10.18
Saline (8 dSm^{-1})	8.23 (52.12)	2.61 (67.26)	3.40 (33.40)
Saline + HA (5 g L^{-1}water)	12.37 (78.34)	3.70 (95.36)	7.69 (75.54)
Saline + HA (10g L^{-1}water)	10.10 (63.96)	3.57 (92.01)	6.66 (65.42)
Saline + GA3 (10g L^{-1}water)	9.71 (61.49)	3.29 (84.79)	5.41 (53.14)
Saline + GA3 (20g L^{-1}water)	9.37 (58.56)	3.19 (82.21)	5.08 (49.90)
Saline + SA (50g L^{-1}water)	9.14 (57.88)	3.05 (78.61)	3.91 (38.41)
Saline + SA (100g L^{-1}water)	8.98 (56.87)	3.17 (81.70)	4.01 (39.39)
$LSD_{(0.05)}$	0.72	1.03	0.50
CV (%)	3.8	4.1	4.9

HA- Humic acid, GA3-Gibberelic acid, SA- Salicylic acid; Values in parenthesis indicates % of control

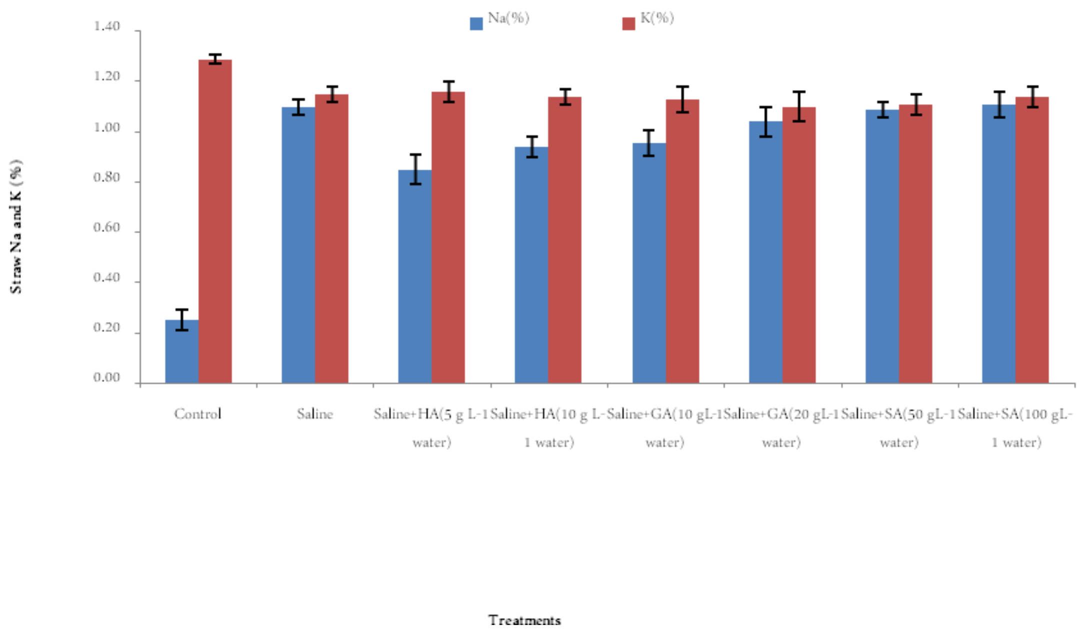

Fig. 8. Effect of growth regulators on straw Na and K content of Foxtail millet at harvest. Bar indicate (±SE).

Conclusion

Application of plant growth regulators increased plant height, leaf fresh weight, stem fresh weight as well as total dry weight, SPAD value, chlorophyll content but decreased proline content in Foxtail millet under saline condition. Plant growth regulators increased panicle length, panicle dry weight and finally yield of Foxtail millet at the saline condition. Among the plant growth regulators applied humic acid @ 5 g L^{-1} water showed the best performance in improving the salinity tolerance in Foxtail millet.

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