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# SYNTHETIC AMENDMENT TO MITIGATE SALINITY STRESS IN WINTER PULSES

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## ABSTRACT

A pot experiment was conducted to investigate the effect of synthetic amendments on mitigation of negative effects of salinity stress on growth, physiology and yield of some winter pulses. The treatment consisted of four pulses, viz. BARI Masur-4, BARI Khesari-2, BARI Felon-1 and BU Chola-1; and four salinity amendment treatments, viz. control (no salinity or amendment), saline (100 mM NaCl), saline + $GA_3$, saline + SA. The experiment was designed followed CRD with three replications. Saline treated pots were irrigated with 100 mM NaCl saline solution from 14$^{th}$ days after sowing (DAS) to maturity, and control plants were irrigated with tap water. Synthetic amendments $GA_3$ and SA were applied at 200 and 400 ppm, respectively. The $GA_3$ and SA were sprayed at 7 days interval from the day of salinity imposed up to harvest. Physiological parameters were measured at flowering stage, while growth and yield parameters were recorded at harvest. Results revealed that salinity decreased plant height, dry weight of different plant parts, chlorophyll content and yield but increased leaf proline content of winter pulses. Application of $GA_3$ and SA were found to mitigate the negative effects of salinity stress. Among the synthetic amendments the $GA_3$ @ 200 ppm performed better than SA. Among the pulses studied BARI Felon-1 was more responsive to GA3 under saline condition.

**Keywords:** $GA_3$, SA, salinity tolerance, pulses

## Introduction

Salinity is a major problem that restricts yield of almost 40 million hectares of irrigated land, which is approximately one-third of the irrigated land on earth. It was estimated that about 50% of the arable land will be affected by salt stress by the year 2050 (Munns and Tester 2008). Saline soils possess high levels of sodium and chloride contents and thus, exert adverse abiotic stress on plants. Salinity induces osmotic and ionic imbalance inside plant's cell, vis a vis affecting plant growth, physiological processes and metabolism (Abdel-Hamid 2014). High salt concentrations are toxic to seed germination, seedling growth, vegetative growth, flowering and fruit set, and ultimately diminish economic yield and quality of produce (Arora *et al.* 2008). Different strategies have been proposed to improve crop growth under saline conditions. A fundamental approach is to develop salt tolerant plants (Ashraf *et al.* 2002) through genetic means and screening processes. The success of this approach depends, among others, on the availability of genetic source of tolerance and reliable screening techniques, identification and successful transfer of genetic components of tolerance to desired genetic backgrounds, and development of elite breeding lines and cultivars with salt tolerance and other desirable agricultural characters. Such extensive processes linger the development of successful salt tolerant cultivars in most crop species.

The effects of salinity can also be minimized with improved irrigation and drainage techniques but the cost of engineering and management is very high. An alternative and technically simpler approach is to induce salt tolerance in plant through application of different synthetic amendments in soil as well as foliar application of certain chemicals and plant growth regulating compounds. The gibberelic acid ($GA_3$) usually regulates growth and development of the plants, and was helpful in enhancing wheat and rice growth under saline conditions. Shaddad *et al. (2013)* reported that $GA_3$ treatment alleviated the drastic effect of salinity on leaf area, dry weight of grains, photosynthetic pigments, carbohydrates, proteins, amino acids and proline content in two wheat cultivars (Sohag 3 and Giza 168). The salicylic acid (SA) is considered as a hormone-like substance, which plays an important role in photosynthetic rate and stomatal conductance. However, in sufficient information exist on the effect of synthetic amendment on salinity tolerance of winter pulses. Therefore, this study was aimed to assess the effectiveness of $GA_3$ and SA to mitigate salinity stress in winter pulses.

## Materials and Methods

The pot experiment was carried out in the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur from December 2017 to March 2018 to investigate the effect of synthetic amendments to mitigate the negative effects of salinity on growth, physiology and yield of different pulses. The experimental soil was collected from Codda, Gazipur. The properties of soil is presented in Table 1.

**Table 1. Physico-chemical properties of initial soil**

| Soil properties | Unit | Values |
|---|---|---|
| Soil texture | | Sandy loam |
| pH (1.0:2.5, soil: water) | | 6.93 |
| Soil organic carbon | % | 0.61 |
| Total N | % | 0.070 |
| Available P | mg 100 $g^{-1}$ | 0.08 |
| Exchangeable K | $cmol_c$ $kg^{-1}$ dry soil | 0.790 |
| Available S | µg $g^{-1}$ | 10.00 |
| CEC | $cmol_c$ $kg^{-1}$ dry soil | 13.05 |
| EC | $dSm^{-1}$. | 0.4 |

The treatment consisted of four pulses, viz. lautil (BARI Masur-4), grass pea (BARI Khesari-2), cowpea (BARI Felon-1) and chickpea BU Chola-1; and four salinity amendment treatments, such as control (no salinity or amendment), saline (no amendment), saline + $GA_3$ (amendment), saline + SA (amendment). The experiment was designed in CRD with three replications. Saline treated pots were irrigated with 100 mM NaCl saline solution from $14^{th}$ days after sowing (DAS) to maturity and control plants were irrigated with tap water. Synthetic amendments $GA_3$ and SA were applied as 200 and 400 ppm, respectively. The $GA_3$ and SA were sprayed at 7 days interval from salinity imposed up to harvest. Leaf chlorophyll and proline content were measured at flowering stage. Data on growth and yield parameters like plant height, leaf dry weight, stem dry weight, number of pod $plant^{-1}$, 100-seed weight and grain yield $plant^{-1}$ were recorded at harvest. The recorded data were statistically analyzed by “CROPSTAT 7.2” software to examine the significant variation of the results due to different treatments. The treatment means were compared by least significance difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

## Results and Discussion

Soil salinity caused a significant effect in plant height of winter pulses. Relative plant height of the pulses ranged from 52.37% to 66.80% at 100 mM salinity. Plant height reduction due to salinity was lower in the variety BARI Khesari-2 (33.2%), while that was higher in BU Chola-1 (46.63 %) (Figure 1). Synthetic amendments increased the plant height of pulses under salt stress. The highest relative plant height (72.06%) was recorded in BARI Khesari-2 when soil was treated with SA and the lowest height (48.01%) was observed when soil was treated with $GA_3$. Salinity induced reduction in plant height is a common phenomenon and was also found in 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. Biswas *et al.* (2019) found plant height of foxtail millet was affected by salinity and application of growth regulators, humic acid and gibberelic acid enhanced the salinity tolerance in foxtail millet in respect of plant height.

Leaf dry weight of different pulses reduced significantly at salinity stress conditions. Leaf dry weight was increased after synthetic amendment application. Synthetic amendment significantly increased leaf dry weight under saline conditions. Highest relative leaf dry weight (62.80%) was observed in BARI Felon-1 when $GA_3$ was sprayed and it was lowest (39.94%) in BARI Felon-1, when SA was sprayed (Figure 2). Under salt stress condition, cell expansion of leaf is reduced due to low turgor and thus leaf area was decreased, which ultimately decreased leaf dry weight. Lower doses of SA and $GA_3$ show remarkable effect on dry matter production under saline condition. Similar results also reported by Yildirim *et al.* (2008) who reported that exogenous application of SA ameliorated the negative effect of salt stress on dry weight of plants. Hossain *et al*. (2015) found the positive effects of SA and $GA_3$ in increasing dry matter production in chickpea under saline condition.

Soil salinity caused a significant effect in stem dry weight of winter pulses. Relative stem dry weight of the pulses ranged from 32.19 to 47.34% at 100 mM NaCl salinity. Stem dry weight reduction due to salinity was lower in BARI Masur-4 (52.66%), while that was higher in BU Chola-1 (67.81%) (Figure 3). Synthetic amendments

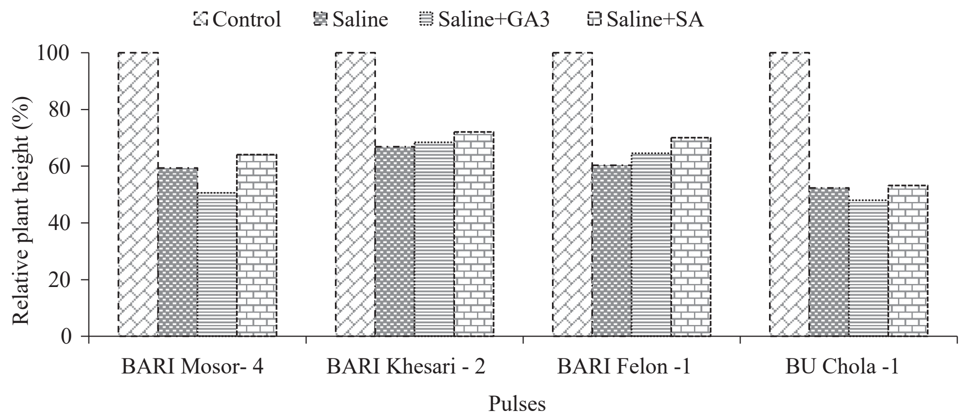


**Figure 1.** Effect of synthetic amaendment on plant height of winter pulses under saline condition.

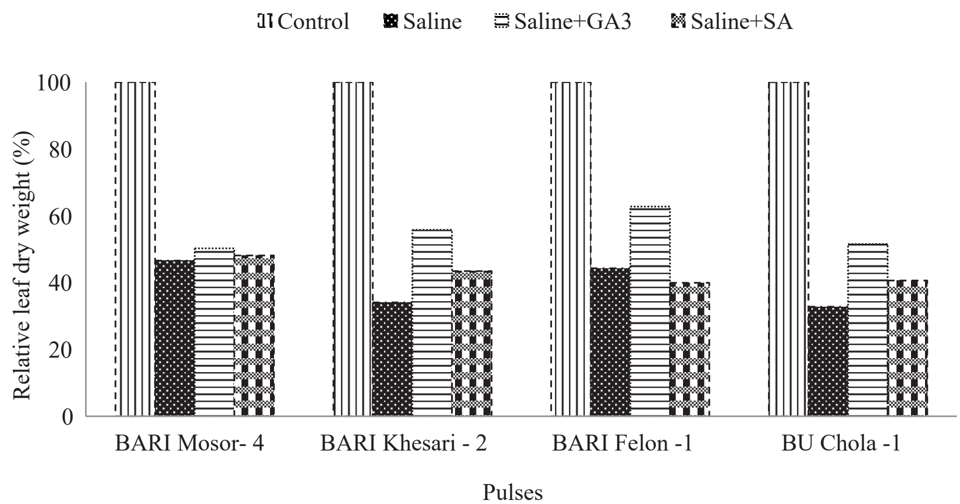


**Figure 2.** Effect of synthetic amaendment on leaf dry weight of winter pulses under saline condition.

significantly increased the stem dry weight of pulses under salt stress. Highest relative stem dry weight (69.43%) was recorded in BARI Felon-1 when soil was treated with $GA_3$ and the lowest stem dry weight (37.85%) was observed when plant was treated with SA. The dry weight of both leaf and stem was significantly inhibited by salinity stress. Similar results were reported in wheat plants by Datta *et al.* (1998). To alleviate deleterious effects of salinity, different types of phytohormones have been used. Of these, gibberellins have been the main focus of some plant scientists (Hisamatsu *et al. 2000*); treatment with gibberellic acid has been reported to be helpful in enhancing wheat growth under saline conditions (Parasher and Varma 1988). Exogenous application of salicylic acid enhanced the photosynthetic rate and also maintained the stability of membranes, thereby improved the growth of salinity stressed barley plants (El-Tayeb 2005).

Total chlorophyll of winter pulses also was reduced significantly at salinity stress condition. Chlorophyll content was increased after amendment application. Synthetic amendment significantly increased total chlorophyll of different pulses under saline conditions (Figure 4). Highest relative total chlorophyll (62.13%) was observed in BARI Felon-1 leaf when sprayed $GA_3$ @ 200 ppm and the lowest relative total chlorophyll (29.52%) was observed when SA sprayed @ 400 ppm in BARI Khesari-2. 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). This positive effect of synthetic amendment could be attributed to an increased $CO_2$ assimilation, chlorophyll content, photosynthetic rate and increased mineral uptake by the stressed plant under SA treatment (Szepsi *et al.* 2005). Zeid (2011) also reported an alleviation of adverse

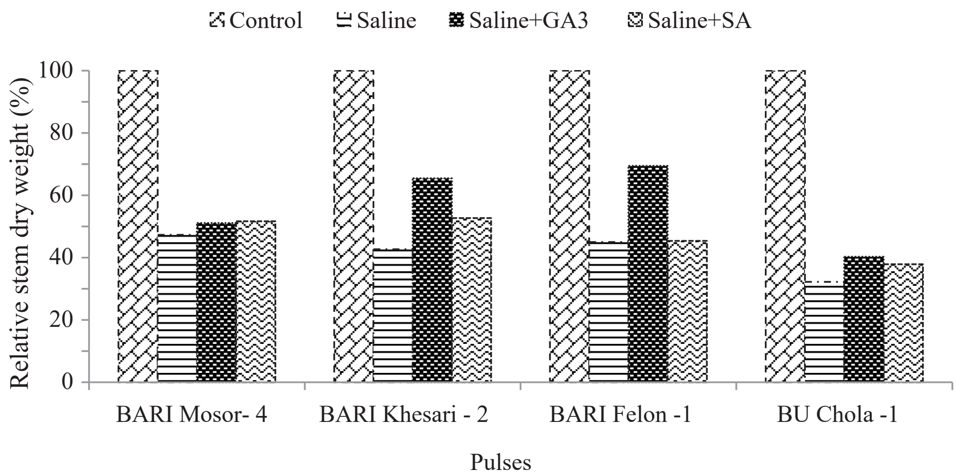


**Figure 3.** Effect of synthetic amaendment on stem dry weight of winter pulses under saline condition.

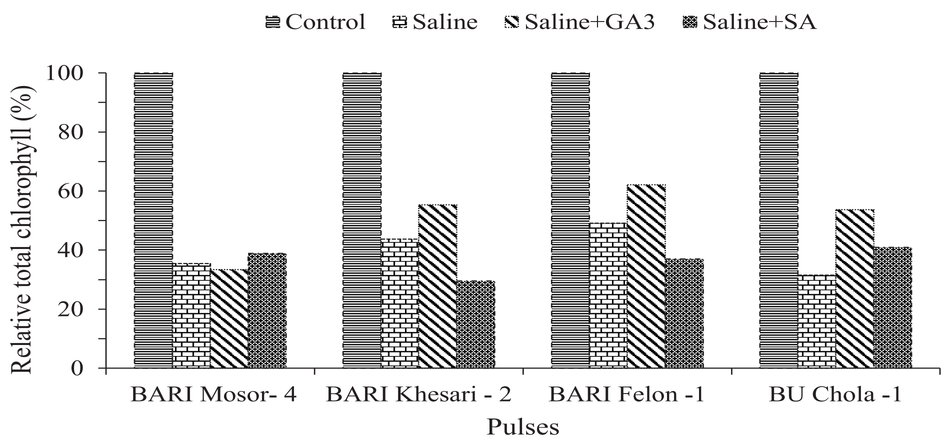


**Figure 4.** Effect of synthetic amendments on total chlorophyll of winter pulses under saline condition.

effect of salinity on chlorophyll content in barley with $GA_3$ treatment. 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). Biswas *et al.* (2019) also found increased chlorophyll content in foxtail millet through exogenous application of humic acid and gibberelic acids under saline condition.

Proline content of winter pulses was increased significantly at salinity stress condition. Highest relative proline content was measured in leaf of BARI Masur-4 (151.53%) and the lowest was in BARI Khesari-2 (130.37%) under saline condition (Figure 5). Proline content was decreased in leaf of pulses after synthetic amendment application under saline condition indicated that synthetic amendment has salinity stress mitigation effect. Highest relative proline content was recorded in BARI Masur-4 (135.38%) when plant sprayed by $GA_3$ and it was lowest in BARI Felon-1 (104.65%) when sprayed by SA. Alia and Gahiza (2007) have found that $GA_3$ treatments reduced the proline accumulation in salinity stressed *Zea mays* and *Anabaena* plants, respectively. Lower accumulation of proline under saline condition after application of synthetic amendment indicates that synthetic amendments reduce the salinity effects on winter pulses.

Winter pulses exposed to salinity caused a significant reduction in number of pod plant-1, the reduction was higher in BARI Khesari-2 (75.02%) and it was lowest in BU Chola-1 (56.89%) (Table 2). Synthetic amendments with $GA_3$ and SA increased the number of pod plant$^{-1}$ at 100 mM NaCl salinity. Highest relative number of pod plant$^{-1}$ was observed in BARI Felon-1 (60.00%) when $GA_3$ was applied @ 200 ppm and it was 30.75% when sprayed was done using SA in BARI Khesari-2 under saline condition. Salt stress caused a significant decrease

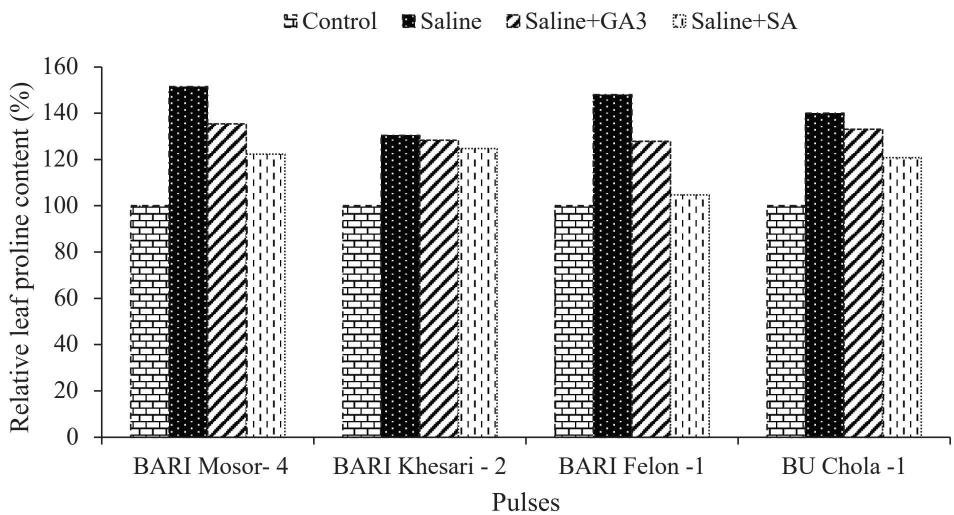


**Figure 5.** Effect of synthetic amendments on leaf proline content of winter pulses under saline condition.

in 100-seed weight of winter pulses (Table 3). Synthetic amendments with both $GA_3$ and SA significantly increased the 100-seed weight of pulses under salt stress condition. Application of $GA_3$ @ 200 ppm performed the best among the synthetic amendments. Highest relative 100-seed weight (67.00%) was observed in BARI Felon-1 when sprayed $GA_3$ (Table 3). Salinity induced reduction of 1000-grain weight was reported by Rashid (2005) in lentil.

Salt stress caused a significant decrease in yield of winter pulses (Table 4). Synthetic amendments with both $GA_3$ and SA significantly increased the yield of pulses under salinity. Highest relative yield (48.00%) was observed when $GA_3$ was applied @ 200 ppm in BARI Felon-1 and it was 19.79% in BU Chola-1 when SA was applied @ 400 ppm under saline condition. Arfan *et al.* (2007) reported that foliar application of salicylic acid increased grain yield and growth of spring wheat. 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 (Majid *et al.*, 2011). $GA_3$-priming-induced increase in wheat grain yield was attributed to the $GA_3$-priming-induced modulation of ions uptake and partitioning (within shoots and roots) and hormones homeostasis under saline conditions (Iqbal and Ashraf, 2010).

## Conclusion

From the findings of this study it could be concluded that salinity decreased plant height, dry weight of different plant parts, chlorophyll content and yield but increased leaf proline content of winter pulses. Applications of $GA_3$ and SA were found to mitigate the negative effects of salinity stress. Among the synthetic amendments used $GA_3$ @ 200 ppm performed better than SA. Among the

**Table 2. Effect of synthetic amendments on number of pods plant$^{-1}$ of winter pulses under saline condition**

| Pulses | Number of pod plant$^{-1}$ | | | |
|---|---|---|---|---|
| | Control | Saline | Saline + $GA_3$ | Saline + SA |
| BARI Masor-4 | 189.33 | 73.00 (38.55) | 68.19d (36.00) | 74.66 (39.43) |
| BARI Khesari-2 | 17.33 | 4.35 (24.98) | 7.66 (44.20) | 5.38 (30.75) |
| BARI Felon-1 | 12.00 | 4.43 (36.08) | 7.20 (60.00) | 6.00 (50.00) |
| BU Chola-1 | 38.66 | 16.67 (43.11) | 19.68 (50.90) | 18.33 (47.10) |
| LSD (0.05) | | | 29.85 | |
| CV (%) | | | 8.23 | |

Values presented in parentheses indicate percent values to the control.

**Table 3. Effect of synthetic amendments on number of 100-seed weight of winter pulses under saline condition**

| Pulses | 100-seed weight (g) | | |
|---|---|---|---|
| | Saline | Saline + $GA_3$ | Saline + SA |
| BARI Masor-4 | 0.71 (44.09) | 0.99 (61.49) | 0.77 (47.82) |
| BARI Khesari-2 | 2.09 (42.22) | 3.23 (65.25) | 2.75 (55.55) |
| BARI Felon-1 | 4.61 (50.21) | 6.15 (67.00) | 5.61 (61.11) |
| BU Chola-1 | 5.95 (40.72) | 9.64 (65.98) | 7.10 (48.59) |
| LSD (0.05) | | 1.71 | |
| CV (%) | | 7.24 | |

Values presented in parentheses indicate percent values to the control.

**Table 4. Effect of synthetic amendments on grain yield of winter pulses under saline condition**

| Pulses | Grain yield (g $plant^{-1}$) | | | |
|---|---|---|---|---|
| | Control | Saline | Saline + $GA_3$ | Saline + SA |
| BARI Masor-4 | 3.90 | 0.43 (10.89) | 1.61 (41.28) | 0.97 (24.61) |
| BARI Khesari-2 | 2.95 | 0.48 (16.40) | 1.32 (26.10) | 0.78 (26.20) |
| BARI Felon-1 | 13.98 | 2.98 (21.33) | 6.71 (48.00) | 5.46 (39.08) |
| BU Chola-1 | 6.87 | 0.85 (12.22) | 2.55 (37.11) | 1.37 (19.79) |
| LSD (0.05) | | 1.64 | | |
| CV (%) | | 9.07 | | |

Values presented in parentheses indicate percent values to the control.

winter pulses studied BARI Felon-1 was more responsive to $GA_3$ under saline condition.

## Acknowledgement

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