Research Article

Effects of seed priming with PbSO₄ and FeSO₄ on germination and growth of seedlings of *Beta vulgaris* L. under NaCl stress

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Abstract

The effects of priming on the seeds of *Beta vulgaris* L. with PbSO₄ and FeSO₄ under NaCl stress was observed at germination and seedling growth. For this purpose all seeds were primed with 100 and 200 ppm solution of PbSO₄ and FeSO₄ and then treated with various applications i.e. 60mM, 90mM and 120mM of NaCl solution. The results demonstrated that high level of salinity decreased the germination percentage and all other parameters of the growth of seedlings including shoot, root length, fresh & dry weight. It was recorded that seeds primed with PbSO₄ showed lowest germination speed with mean value of (481.42 & 499.77) and also the lowest germination percentage (56 % & 50%) at two concentrations level (100 & 200 ppm) respectively. FeSO₄ at 200ppm showed highest shoot length (8.18cm) and root length (4.2cm) than that of 100 & 200 ppm of PbSO₄ and 100ppm FeSO₄. Results concluded that priming can reduce the effects of salinity.

Keywords: *Beta vulgaris* L; FeSO₄; Growth; NaCl; PbSO₄; Salinity stress; Seed priming

Introduction

Sugar beet is botanically called "*Beta vulgaris* L." belonging to order Caryophyllales of family Chenopodiaceae. It is an important crop of temperate climates and contributes 30% of the World's annual sugar production. It is diploid plant with 2n=18 number of chromosomes and genome

size of estimated 714-758 mega-bases. Its genome contains 567 mega-bases of which 85 percent are assigned to chromosomes. In its assembly 85 percent repetitive sequence content was estimated. Since Roman times leafy beets have been grown but *Beta vulgaris* L. is most recently domesticated crop. In today's cultivars the sugar content

has been increased from 8-18 percent during the last 200 years of *Beta vulgaris* L. breeding [1].

It is mainly grown in Europe and Northern America. The current declared annual production of sugar in UK alone is 1.4 million [2]. Sugar beet comprises of 45% of World sugar production and this crop needs to be irrigated in semi-arid conditions. By the interaction of sodium or chloride ions the plant growth is badly affected as it causes imbalance in the uptake or distribution of nutrients into the plant [3].

Major effects of salinity are the inhibition of growth, development and water availability. Salt ions that cause nutritional imbalance reduces the photosynthetic efficiency and provokes physiological disorders in plant. Salinity also reduces the shoot growth and yield in plant. In the saline environment it is necessary to identify the tolerance and sensitivity of seed at early stage of seedlings for best crop production [4]. High concentrations of salt is involved in denaturing the cytosolic enzymes of plants [5].

Seed priming reduces the effects of salinity stress. In agriculture it is widely used tool to improve seed germination. Pre-sowing seed treatment improves the germination aspects including rate and percentage of germination and uniformity. In hydro-priming seeds are imbibed in low external water potentials to allow hydration [6]. During seeds germination the seed hydration involve three stages. First one is phase I or imbibition that is the water uptake stage that occurs in dormant or non- dormant seeds. Phase II is the lag phase in which little water uptake takes place and in which metabolic activities prepare the non-dormant seeds to germinate radicle. Phase III is that in which water uptake increases and it is associated with radicle growth. Seed priming enables the phase II to do rapid germination [7].

Lead is used in hair dyes, gasoline, rubber toys, leaded glass, paints, newsprint, pesticides and pottery. It is also present in batteries, chemicals, ceramics and fertilizers. Lead toxicity leads to reduction in root hair development in plants and also cause stunted growth due to reduced photosynthesis rate because lead deposition close stomata. Lead being heavy metal causes detrimental effects like water imbalance, inhibition of enzymatic system, changes in the permeability of membrane and interfere minerals absorption. Due to lead the germination and growth retardation has been reported by [8, 9].

Iron is an important micronutrient that plays a vital role in the production of corn. High saline soils being susceptible to iron deficiency reduces grain yield by 20 %. The effect of FeSO_4 was observed using several treatments on corn crops in order to alleviate iron deficiency for a better crop yields both on seed row and foliar row application [10].

In another experiment seed priming with two salts KNO_3 and NaCl at 1 and 2 % levels of solution was assessed in Chickpea (*Cicer arietinum* L.), the performance of KNO_3 was appreciated on the basis of significant improvement in germination, seedling growth and the enzyme peroxidase activity but reduced the lipid peroxidase activity with respect to NaCl [11]. The salt stress was examined on the melon (*Cucumis melo* L.) seeds both by hydropriming when seeds were soaked in distilled water at 25 °C for 22 hours and treating them with 0.5% KNO_3 solution by osmopriming. The results revealed that both hydro- and salt priming is advantageous to alleviate the adverse effects of salinity during initial growth but during severe salts effects hydropriming showed better results as compared to that of osmopriming [12].

Seed priming with NaCl and irrigation at seedling stage was investigated in tomato (*Lycopersicum esculentum* Mill.) plants aimed to enhance response of five-leaf stage under high salt stress. Experimental design

comprising of three groups i.e., non-primed, seeds primed with 0.05 M NaCl and seeds primed and irrigated with 0.05 M from sowing to salt applications at dose levels (0.1 M, 0.2 M, 0.4 M, and 0.6 M) for every 2-10 days while the control groups were treated with distilled water. The tissue samples of root and leaf were analysed for ascorbate peroxidase and catalase activity, electrolyte leakage and lipid peroxidation, pigment and proline contents. Lipid peroxidation and electrolyte leakage, chlorophyll content and chlorophyll to carotenoid ratios were less affected. Priming reduced germination time, increased root and hypocotyl length and enhanced fresh weights. There was also found improvement in the accumulation of proline and anthocyanin, being the osmoregulatory defense molecules and also the induction of antioxidant enzyme systems the plants showed adaptation towards severe salt stress [13].

In present studies, all growth parameters i.e. root, shoot length, fresh & dry weight of root and shoot of *Beta vulgaris* L. were recorded to obtain the effects of salinity on the growth of seedlings when seeds were primed with PbSO₄ and FeSO₄ at two different concentrations i.e. 100 & 200 ppm. Germination speed and germination percentage of seeds were also calculated in order to determine the effect of salinity being an important parameter.

Materials and methods

Experimental trials were carried out to investigate the effects of seed priming of *Beta vulgaris* L. with PbSO₄ and FeSO₄ under different doses of NaCl treatments using the method as defined by [14].

Experimental Design

Priming of seeds and application of salt stress

70% ethanol were used for the surface sterilization of seeds for 30 seconds followed by washing with distilled water. Seeds were then primed with two concentration levels

i.e., 100 and 200 ppm of PbSO₄ and FeSO₄ for 1 hour and then dried. Germination period was studied in 4 control groups with different experiments like seed without priming grown in fresh water, primed seed grown in distilled water, only sterilized seed without priming grown in distilled water, treatment of seeds without priming with different NaCl concentrations and experimental group in which seeds were primed with FeSO₄ and PbSO₄ and then grown in different concentrations of NaCl salinity (60mM, 90mM, 120mM). Repeating each experiment 3 times 63 petri plates were prepared. In each plate 7 seeds were placed which were lined with filter paper and moisten with 10-12 ml soln. All the plates were incubated at optimum temperature of 10-13⁰C for growth. After 36 hours seeds with the emergence of radicle were counted to be germinated.

Recording of data

Data for germinated seeds was recorded after every 24 hours and after 8 days of germination. Root and shoot length, fresh and dry biomass of seedlings were determined after 15 days of sowing. Root, shoot length were measured by using the simple ruler. Fresh weight was obtained using the electronics balance sartorius TE214S. Dry weight was determined for each case after 24 hours and percentage moisture content was calculated. The number of seeds germinated was counted daily till completion of germination and % of germination was calculated. Speed of germination was calculated by the formula as described by [15].

Statistical analysis

The data was statistically analyzed using t-test and Pearson Correlation was found.

Results and Discussion

Germination Speed of Seeds of *Beta vulgaris* L.

Germination speed was greatly affected by salinity. In control groups slowest germination speed was recorded in seeds

grown in 120mM NaCl concentration without priming (525.41). In distilled water (non-primed), highest germination speed was recorded as (435.34) than to the non-primed

seeds in fresh water as (448.29), followed by 60mM NaCl as (482.21) and then 90mM NaCl (493.73) as shown in (Fig 1).

Figure 1. Effects on germination speed of *Beta vulgaris* L. seeds grown under different control groups

When seeds were primed with 100 and 200ppm of PbSO_4 , 200ppm showed slower germination speed (499.77) than that of 100ppm as (481.42). In case of seeds primed with FeSO_4 , at 100ppm germination speed was slow as (385.42) in comparison to that at 200ppm with (376.07). It was observed that FeSO_4 at 200 ppm showed highest speed of germination. In case of priming with PbSO_4 , at 100ppm had (0.0328) $P(T \leq t)$ value showing significant effect than that at 200ppm (0.0656) exhibiting non-significant. When seeds were primed with FeSO_4 at 100 and 200ppm, they had (0.0046) and (0.0092) $P(T \leq t)$ values respectively showing significant effects on speed germination (Fig.

2). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter.

Germination percentage of Seeds of *Beta vulgaris* L.

Salinity greatly affected the germination percentage. Non-primed seeds in distilled water had highest germination % as (86.6%) than the seeds that grown in fresh water (non-primed) (80%), followed by less germination percentages as at 60mM NaCl (73.3%), 90mM NaCl (66.7%) and 120mM NaCl (53.3%). 120mM NaCl treated seeds had lowest germination percentage as shown in (Fig. 3).

Figure 2. Effects of seeds priming with 100ppm and 200ppm of PbSO₄ and FeSO₄ on the speed germination of *Beta vulgaris* L. seeds grown under different concentrations of NaCl

Figure 3. Effects on germination percentage of *Beta vulgaris* L. seeds grown under different control groups

When seeds were primed with 100 and 200ppm of PbSO₄, 200ppm showed lower germination % (50%) than that of 100ppm with % germination (56.67%). In case of seeds primed with FeSO₄, at 100ppm germination % was lower as (70%) but at 200ppm higher germination % as (76.67%) was observed. Primed seeds with 100ppm and 200ppm PbSO₄ showed (5.79E-08) and

(1.16E-07) P(T<=t) value. In case of priming with FeSO₄ at 100ppm P(T<=t) value was (5.79E-08) and at 200ppm as (1.16E-07). Here both nutrients exhibited non-significant effects on germination percentage (Fig. 4). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO₄ and FeSO₄ in this growth parameter.

Figure 4. Effects of seeds priming with 100ppm and 200ppm of PbSO₄ and FeSO₄ on germination % of *Beta vulgaris* L. seeds grown under different concentrations of NaCl

Biomass moisture content or % of oven dry weight of shoot

Lowest O.D weight % of shoot was recorded in 120mM NaCl sown seedlings with value (63%). Highest O.D wt. % of shoot was

recorded in distilled water seedlings as (82%) than in fresh water sown seedlings (80%) followed by 60mM NaCl (79%), 90mM NaCl (74%) and 120mM NaCl (63%) as shown in (Fig. 5).

Figure 5. Effects on %age O.D wt. of shoot of *Beta vulgaris* L seedlings grown under different control groups

When seeds were primed with 100 and 200ppm of PbSO₄, the results revealed that 200ppm exhibited lower O.D wt. % of shoot

(21.5%) than that at 100ppm concentration as (27.75%). In case of seeds primed with FeSO₄, at 100 and 200ppm the O.D wt. % of

shoot was recorded as (44.25%) and (77%) respectively. It was observed that 200ppm of FeSO_4 showed the highest value of O.D wt. % of shoot. In case of priming with PbSO_4 at 100ppm, $P(T \leq t)$ value was (0.012) and at 200ppm concentration it was (0.025), both had significant effects on this growth trait. Priming of seeds with FeSO_4 at 100 and

200ppm also showed significant effects on O.D wt. %age of shoot with (0.008) and (0.016) $P(T \leq t)$ values respectively (Fig. 6). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter.

Figure 6. Effects of seeds priming with two concentrations of PbSO_4 and FeSO_4 on %age O.D wt. of shoot of *Beta vulgaris* L. seedlings grown under different NaCl concentrations

Biomass moisture content or % of oven dry weight of root

Highest O.D wt. % of root was recorded in distilled water with value (88.5%) followed by non-primed fresh water seedlings (86.2%)

and then in 60mM NaCl (72%), 90mM NaCl (48%) and 120mM NaCl (44%). Non-primed seeds grown in 120mM NaCl had lowest O.D wt. % of root as shown in (Fig. 7).

Figure 7. Effects of %age O.D wt. of roots of *Beta vulgaris* L. seedlings grown under different control groups

When seeds primed with 100 and 200ppm of PbSO_4 concentrations were analyzed for this parameter, 200ppm exhibited lower % of O.D wt. of roots as (25.5%) in comparison to that of 100ppm with little high value (27.75%). In case of seeds primed with FeSO_4 , at 100ppm (30.5%) O.D wt. of roots was found lower than that of 200ppm with higher value as (65.25%). The results revealed that FeSO_4 at 200ppm showed highest % of O.D wt. of roots. Primed seeds

with PbSO_4 at 100ppm concentration (0.019) and at 200ppm (0.037) $P(T \leq t)$ values were recorded and had significant effects on this parameter. Seeds primed with FeSO_4 at 100ppm had (0.005) and 200ppm had (0.011) $P(T \leq t)$ values which also showed significant effect on % of O.D wt. of roots. Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter (Fig. 8).

Figure 8. Effects of seeds priming with different concentrations of PbSO_4 and FeSO_4 on %age O.D wt. of root of *Beta vulgaris* L. grown under different NaCl concentrations

Fresh weight of roots (g) of *Beta vulgaris* L. *Beta vulgaris* L. seeds without priming when grown in distilled water, freshwater, 60mM NaCl, 90mM NaCl and 120mM NaCl concentrations, the results exhibited the lowest fresh weight of roots recorded in 120mM NaCl as (0.029 g) and the highest in distilled water as (0.099 g). Seedlings that were grown in fresh water had (0.087g) fresh

biomass of roots but differ from different concentrations of NaCl i.e. at 60mM NaCl (0.080g), at 90mM NaCl (0.046) and at 120mM (0.029) and thus was higher from NaCl treated seedlings but less than that of distilled water as in (Fig. 9). with order of decrease: Distilled water > fresh water > 60mM > 90mM > 120mM

Figure 9. Effects on fresh weight of roots of *Beta vulgaris* L. seedlings grown under different control groups

When seeds were primed with 100 and 200ppm of PbSO_4 , 200ppm showed lower fresh weight of root as (0.0038 g) than that of 100ppm with fresh wt. value for *Beta* root as (0.0042 g). In case of seeds primed with FeSO_4 , for 100 and 200ppm concentrations then the fresh weight of roots of seedlings were recorded as (0.004 g) and (0.028 g) respectively. Thus FeSO_4 at 100 ppm showed the lowest (0.004 g) fresh weight of root among all the treatments. Seeds primed with

PbSO_4 at 100ppm had $P(T \leq t)$ value as recorded was (0.0005) and for that of 200ppm it was (0.0010). Primed seeds with FeSO_4 at 100 and 200ppm concentrations had (0.0007) and (0.0014) $P(T \leq t)$ values respectively. Both demonstrated the significant effects on the fresh weight of roots of seedlings (Fig. 10). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter.

Figure 10. Effects of seeds priming with two concentrations of PbSO_4 and FeSO_4 on fresh weight of roots of *Beta vulgaris* L. seedlings grown under different concentrations of NaCl
Dry weight of roots (g) of *Beta vulgaris* L.

Seeds grown in 60mM, 90mM and 120mM NaCl concentrations had low dry biomass of roots as (0.046g), (0.031g) and (0.020g) respectively in comparison to that of freshwater (0.047g) and distilled water as (0.053g). Highest dry biomass of roots was

recorded in case of distilled water grown seedlings than that of the fresh water and three different concentrations of NaCl as shown in (Fig. 11) with decreasing order of O.D wt. as follows: distilled water > fresh water > 60mM > 90mM > 120mM Na Cl.

Figure 11. Effects on dry root weight of *Beta vulgaris* L. seedlings grown under different control groups

When seeds were primed with 100 and 200ppm of PbSO_4 , 200ppm showed lowest dry weight of root as (0.0031g) than that of the 100ppm as (0.0033 g). Seeds primed with FeSO_4 at 100ppm had lower value as (0.0035 g) and 200ppm higher value as (0.017 g) of the dry weight of root. It was observed that PbSO_4 showed lower dry weight of roots of seedlings among all the nutrients primed seeds. Priming of seeds with PbSO_4 at 100ppm showed (0.008) and at 200ppm (0.016) $P(T \leq t)$ values thus having significant effect on this parameter. On the other hand $P(T \leq t)$ values for primed seeds with FeSO_4 at 100 and 200 ppm concentrations recorded were (0.0006) and (0.0013) respectively. That also exhibited significant effects on dry weight of root of seedlings (Fig. 12). Data also explained the strong weak positive correlation between the

two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter.

Fresh weight of shoot (g) of *Beta vulgaris* L.

The fresh weight of shoot of *Beta vulgaris* L. was highest in seedlings that were grown in distilled water with value (0.0246g) than that grown in freshwater seedlings as (0.196g) followed by fresh wt. values at 60mM NaCl as (0.193g), 90mM NaCl as (0.146g) and 120mM NaCl as (0.093g) in decreasing manner. There is less difference between the fresh biomass of seedlings emerged from non-primed seeds but grown in fresh water as (0.196g) and at 60mM NaCl treated seedlings as (0.193g) as shown in (Fig. 13). The decreasing trend in various trials is as: distilled water > fresh water > 60mM > 90mM > 120mM NaCl.

Figure 12. Effects of seeds priming with two concentrations of PbSO₄ and FeSO₄ on dry weight of roots of *Beta vulgaris* L. seedlings grown under different concentrations of NaCl

Figure 13. Effects on fresh weight of shoot of *Beta vulgaris* L. seedlings grown under different control groups

Seeds primed with 100 and 200ppm of PbSO₄ when grown, 200ppm showed less fresh weight of shoot as (0.026 g) than that of 100ppm having fresh wt. as (0.047). In case of seeds primed with FeSO₄, at both concentrations 100 and 200ppm fresh weight of shoot were recorded (0.054 g) and (0.171 g) respectively. For seeds primed with PbSO₄ at 100ppm, P(T<=t) value was (0.0076) and at 200ppm it was (0.015). Primed seeds with FeSO₄ at 100ppm had (0.0003) P(T<=t) and for 200ppm it was (0.0005). Both FeSO₄ and PbSO₄ showed significant effects on fresh

weight of shoot (Fig. 14). Data also explained the positive correlation between the two concentrations i.e 100 & 200ppm of PbSO₄ and FeSO₄ in this growth parameter.

Dry weight of shoot (g) of *Beta vulgaris* L. For control groups seedlings grown under 60mM, 90mM and 120mM NaCl concentrations had less dry weight of shoot than that of the seedlings of non-primed seeds grown in fresh water. Distilled water grown seedlings had highest dry weight of shoot (0.135g) when compared with that of the above control groups i.e fresh water grown

seedlings with (0.109 g), then of 60mM NaCl (0.108 g), followed by 90 mM NaCl (0.084 g) and lastly 120mM NaCl grown seedlings with (0.057 g) dry wt. of shoot as shown in

(Fig. 15). Order of decreasing dry wt. of shoot in different control groups is as: distilled water > fresh water > 60mM > 90mM > 120mM Na Cl.

Figure 14. Effects of seeds priming with two concentrations of PbSO₄ and FeSO₄ on fresh weight of shoot of *Beta vulgaris* L. seedlings grown under different concentrations of NaCl

Figure 15. Effects on dry weight of shoots of *Beta vulgaris* L. grown under different control groups

When seeds primed with 100 and 200ppm of PbSO₄ were grown, 200ppm showed lower dry weight of shoot as (0.021 g) than that of 100ppm with (0.037 g). In case of seeds primed with FeSO₄, at 100 and 200ppm concentrations, the dry weight of shoot

recorded were (0.037 g) and (0.097 g) respectively.

For the seeds primed with PbSO₄ the P(T<=t) value at 100ppm was (0.011) and at 200ppm it was (0.023). It exhibited significant effects on this growth parameter. Similarly seeds primed with FeSO₄ at 100 and 200ppm had

(0.00018) and (0.00036) $P(T \leq t)$ values which also showed significant effects on the dry weight of shoots of seedlings of *Beta vulgaris* L. (Fig. 16). Data also explained the

weak positive correlation between the two concentrations i.e 100 & 200ppm of $PbSO_4$ and $FeSO_4$ in this growth parameter.

Figure 16. Effects of seeds priming with two concentrations of $PbSO_4$ and $FeSO_4$ on dry weight of shoots of *Beta vulgaris* L. seedlings grown under different Concentrations of NaCl

Seedlings root length (cm) of *Beta vulgaris* L.

At 120mM NaCl concentration the seedlings of beet had low root length with value (1.9cm) whereas in distilled water grown seedlings root length was (4.4cm) and was greatest than that of from all the control groups like non-primed fresh water grown seedlings as (4.2cm), for 60mM NaCl concentration as (3.8cm), then for 90mM NaCl concentration as (2.9cm) and at 120mM NaCl concentration it was as (1.9cm). There was a little difference between the values for this parameter in case of distilled water and fresh water as shown in (Fig. 17). Order of decreasing seedling root length is as: distilled water > fresh water > 60 mM > 90mM > 120mM Na Cl.

When seeds were primed with 100 and 200ppm of $PbSO_4$, 200ppm showed lower

root length (2.1cm) than that of 100ppm with root length (2.5 cm). In case of seeds primed with $FeSO_4$, at 100 and 200ppm concentrations (3.1cm) and (4.2cm) root length values were recorded respectively. The results revealed that 200ppm of $FeSO_4$ showed the highest root length value. Primed seeds with $PbSO_4$ at 100ppm and 200ppm had $P(T \leq t)$ values as (0.001) and (0.002) respectively. 100ppm showed significant increase in root length while 200 showed significant reduction. $FeSO_4$ at 100ppm exhibited $P(T \leq t)$ value as (0.001) and at 200ppm concentrations this value was (0.003). It also demonstrated the significant effects on root length of seedlings of *Beta vulgaris* L. (Fig. 18). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of $PbSO_4$ and $FeSO_4$ in this growth parameter

Figure 17. Effects on root length of seedlings of *Beta vulgaris* L. grown under different control groups

Figure 18. Effects of seeds priming with two concentrations of $PbSO_4$ and $FeSO_4$ on root length parameter of *Beta vulgaris* L. seedlings grown under different concentrations of NaCl

Seedlings shoot length (cm) of *Beta vulgaris* L.

In distilled water when seeds of *Beta vulgaris* L. were grown the seedlings had greatest shoot length (6.2cm) followed by that of seedlings emerged from the seeds when grown in fresh water as (5.3cm) and then further decrease in values of this parameter when seeds were sown in different

concentrations of NaCl i.e. at 60mM value as (5.0cm), at 90mM as (4.1cm) and at 120mM as (2.1cm) showing the decreasing trend as shown in (Fig. 19). Order of decreasing as: distilled water > fresh water > 60mM > 90mM > 120mM NaCl concentration. When seeds were primed with 100 and 200ppm of $PbSO_4$, the results revealed that 200ppm showed lowest shoot length (2.62

cm) than that of the 100ppm having (3.00 cm) shoot length. In case of seeds primed with FeSO_4 , at 100ppm this length was (4.02 cm) and at 200ppm as (8.18 cm). The results clearly revealed the highest value of shoot length of seedlings as recorded at 200ppm of FeSO_4 . Primed seeds with PbSO_4 at 100 and 200ppm had (0.002) and (0.004) $P(T \leq t)$

values whereas this value for FeSO_4 at 100ppm was (0.00014) and for 200ppm as (0.00028). Both showed significant ($P < 0.05$) effects on shoot length (Fig. 20). Data also explained the strong positive correlation between the two concentrations i.e 100 & 200ppm of PbSO_4 and FeSO_4 in this growth parameter.

Figure 19. Effects on shoot length of seedlings of *Beta vulgaris* L. grown under different control groups

Figure 20. Effects of seeds priming with two concentrations of PbSO_4 and FeSO_4 on shoot length of *Beta vulgaris* L. seedlings grown under different concentrations of NaCl

Present study revealed that highest level of salinity decreased the growth of seedlings. Non-primed seeds grown in 120mM NaCl showed less shoot length as (2.1cm) and root length as (1.9cm). Salinity retarded the shoot and root elongation due to low water uptake in *Arabidopsis thaliana* [16]. Root growth of safflower was more affected by salinity than the shoot growth [17]. Salinity rapidly retarded root growth and water, nutrient uptake from the soil that is essential for plant as suggested by [18]. All these results are in conformity to our findings regarding root and shoot length and growth of seedlings of *Beta vulgaris* affected by different concentrations by salt but priming of seeds reduced the effects of NaCl.

Toxic effects of certain ions, higher amount of salts inhibited water absorption by germinating seeds and thus decreased the germination [19]. During imbibition rate of germination and final seeds germination was reduced with the decrease of water movement in seeds as suggested by [20]. With the increase of salt concentration in medium the germination percentage was decreased [21]. From our present studies it was observed that the seeds in control groups (non-primed seeds) which were grown in fresh water and distilled water required less time to germinate as compared to those sown in 60mM, 90mM and 120mM of NaCl concentrations (non-primed). Similar results in control groups for germination percentage were found highest and in high salinity conditions the germination percentage was low as investigated and described by [22]. Similar results were reported in a study of *Beta vulgaris* L. where five varieties of the tested plant showed pronounced effects of inhibition on seed germination, percentage of germination, rate of germination, relative germination percentage and seedling growth when treated with all NaCl application levels but higher salt concentration exhibited maximum inhibition. The application of

isotonic mannitol solution indicated that inhibition of *Beta vulgaris* seed germination towards salt NaCl effect was principally a specific ionic effect and the role of osmotic effect is little [23]. In another study the seeds of *Salicornia rubra* Nels were germinated at 5 temperature regimes and 6 salinity levels in order to define optimal conditions for germination and retrieval from salinity. The plant showed maximum germination when exposed to temperature regime of 25°C night and 35°C day whereas lower temperature regime 5-15°C considerably inhibited the germination of seeds and further increase in salinity suppressed the germination [24]. All these previous reported results supported our findings regarding germination of seeds and growth of seedlings at different physiological parameters.

Effects of priming were observed on germination of seeds and yield of corn (*Zea mays* var. S.C704) using the experimental design of (control, ZnSO₄, KH₂PO₄, H₂O and KNO₃) salts and time duration (control, 6, 12, 18 and 24 hrs) for priming. Increased germination rate and percentage, seed numbers in row, number of seed row, length and diameter of ear, biological and seed yield, yield component and 1000-seed weight and harvest index [25].

In the present study seeds of sugar beet were primed with FeSO₄ and PbSO₄ at two concentration levels i.e. 100ppm & 200ppm to explore the effects of priming under NaCl stress at three different concentration levels. Priming enhanced the germination of sugar beet seedlings and it also increased all growth parameters such as root, shoot length and fresh and dry weight of root and shoot of beet seedlings.

In case of our experiment for priming with FeSO₄ micronutrient it was observed that seeds had high germination speed than that of the control groups (Fresh water & distilled water). Similar results were observed in the experiment on Dill seeds (*Anethum*

graveolens L). Priming with 1% and 1.5% Fe + 1% B in combined form or solely speeded up the germination of Dill seeds as compared to that of unprimed control as reported by [26].

When seeds were primed with PbSO₄ then we investigated that due to toxic effects of Pb the % of germination, root and shoot length and dry biomass was reduced at 100ppm concentration than that of the control groups (fresh water & distilled water). These results were in conformity to that of the results obtained in experiment on *Leucaena leucocephala* (Lam.) de Wit seeds. When seeds were primed with lead at concentration 25ppm to 100ppm it was observed that lead had toxic effect on seedlings growth, the germination speed decreased at 75ppm, root growth reduced at 50 ppm, seedling dry weight decreased at 25ppm as described by [27].

Pepper cultivars Beldi, Baklouti and Anaheim seeds were primed with 10 mM KCl, 10 mM CaCl₂ and 50 mM NaCl for 36, 36 and 24 hrs. time interval respectively and then treated with salinity concentrations of 0 (control), 2, 4, 6, 8, 10 and 12 gm/l of KCl. Seedlings emerged from the germination of primed seeds improved water content, soluble sugar, polyphenols, soluble proteins, carotenoid content and total biomass at salt concentrations of 6gm/l. Hence priming of seeds of Pepper (*Capsicum annuum* L.) could be used to improve germination and growth in saline environment due to the reason that salinity affects carotenoid content, number of leaves per plant, leaf area, root length and plant biomass at salt concentration of 6 gm/l. [28].

In another research where hot Pepper cv. Hot Queen seeds were primed with different priming agents like (distilled water, NaCl, KNO₃, ascorbic acid, salicylic acid, acetyl salicylic acid, PEG-8000 to check seed vigour effects. Fresh weight of seedlings was significantly affected. Seeds primed with

KNO₃ produced maximum fresh weight whereas salicylic acid, acetyl salicylic acid and PEG-8000 produced fresh weight statistically at par. Seedlings emerged from the seeds primed with distilled water and NaCl produced the same fresh weight statistically. Seeds primed with KNO₃ showed supreme vigour, then acetyl salicylic acid and followed by PEG-8000 whereas seedlings emerged from unprimed seeds showed slightest vigour. Vigour index of seeds primed with distilled water, NaCl and ascorbic acid were all statistically at par with each other [29]. It was concluded from the discussion that priming enhanced the tolerance of seedlings resistance towards salinity. These results from various studies support our findings regarding physiological parameters of germination and growth of seedlings emerged from primed seeds sown under various level of salinity stress.

In this research study our results recommended that priming with FeSO₄ demonstrated best results between other nutrients priming. These findings are similar with the findings obtained in barley (*Hordeum vulgare* L.) where seeds priming with Fe improved germination and seedling growth as described by [30]. Similar effects of Fe on growth and seed germination have also been described by [31].

In present study when seeds were treated with PbSO₄ it shortens root and shoots length. A comparison made between 100 and 200ppm of PbSO₄ and control indicated that growth was retarded at 200. Similar results in shoot height of wheat were also reported with increasing Pb application by [32].

Conclusion and recommendation

The results of the present work concluded that salinity affects all the growth aspects like speed of germination and % of germination, shoot, root length, fresh & dry biomass of shoot and root of *Beta vulgaris* L. Seeds primed with FeSO₄ decreased the impact of salinity and enhanced the development of

seeding and seedlings growth, but seeds primed with PbSO₄ did not show promising results in germination or growth of seedlings. It is further suggested that seeds should be primed with micronutrients before sowing in order to produce tolerance in plants against salt stress. This technique of priming can prove useful to accelerate the rate of germination, growth and eventually yield of commercially key crops with an image not having any hazardous effects to environment and agricultural land.

Authors' contributions

Conceived, designed the experiments and supervised the research work: AM Khan, Performed the experiments and wrote the article: K Moatter, Helped in experiments and data analysis: S Iqbal, I Dilshad, TA Qadri & F Abdullah, Proof read the article: SA Gilani.

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