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Is seed priming with gamma rays able to promote yield of corn in saline condition?

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Abstract
Salt stress is a major problem in the corn cultivation, which reduces corn yield quantity and quality worldwide especially in the arid and semi-arid regions. Nuclear technologies can be used as useful method for mitigating salt stress effect on plants. In the current evaluation, the influence of gamma irradiation (GI) at 25 Gy on corn seeds (SC703) was studied in salt stress amelioration of corn in the field. It was observed that GI increased total chlorophyll content of corn leaves under saline condition. In addition, plants from gamma-irradiated seeds had a greater plant weight, and their economical traits (cob weight and grain number) were higher compared to control plants. Thus, it can be concluded that low dose GI may be able to ameliorate the effect of salt stress on corn plant.
Keywords: Cob weight, Grain number, Photosynthetic pigments

Introduction
Corn, as one of the most important crops, has the highest industrial use.[1]. Corn has the second highest cultivation area (42 billion hectares) after rice (*Oryza sativa* L.) in the world. However, corn faces various biotic and abiotic stresses during the growing season, which reduce its economic yield. Among the various stresses, salt stress is one of the most important factors that corn faces.Soil and water salinity is one of the most important problems of modern agriculture. Generally, an EC greater than 4 $dS.m^{-1}$ is considered as salinity stress in crops. Soil salinity occurs due to improper irrigation operations, deforestation and destruction of natural vegetation during the construction of new lands for agriculture under irrigated cultivation systems [2]. Nuclear technologies, along with other common methods, can be used as a useful solution to quickly solve many agricultural problems. Production of new cultivars with higher yields, optimal resistance to biotic and abiotic environmental stresses, control of pests and diseases, prevention of crop rotation during storage, etc. are the most important uses of nuclear science and technology in agriculture [3]. It has been reported that low doses of gamma rays do not cause genetic changes and only affect plant growth and development by changing the hormonal balance and changing the activity of enzymes [4]. This study was conducted to investigate the possibility of using gamma irradiation (GI) to reduce the effect of salinity on corn.

Experimental
Preparation of the materials
Seeds of corn, single cross 703, were exposed to GI at 25 Gy dose (based on the results of the seed germination test) and were then planted in the field along with control (no GI). In this regard, corn seeds (control and gamma treated) were planted in the field in a saline soil (EC = 5.4 dS/m) in May 20, 2019 in five replications. Irrigation (EC=3.9 dS/m) was performed using a drip irrigation system every seven day during the growing season. Plant samples were harvested at the third leaf stage (V3), silk stage (R1), and grain dough stage (R4) from the youngest fully expanded leaf and total chlorophyll was measured using method described by Porra [5]. To do this the light absorption of leaf samples was measured at 647 and 663 wave lendth using a spectrophotometer (Unico®, 280S UV/VIS). At the grain dough stage (R4) plants were harvested in each plot and cob number, dry weight of biomass, and grain number per cob was measured. A completely randomized block design with five replications was used to do the experiment. Planting spacing was 0.12 cm * 0.75 cm, and the area of each plot was 99 m^2 (8.25 m * 12 m). Anova was performed using Proc GLM, using SAS v.9.4. Least significant different (LSD) also was used for mean comparison.

Results and discussion
Total chlorophyll content was significantly higher in GI treatment at all measurement stages (Figure 1.a). Total chlorophyll content showed a downward trend in growing season, so that it decreased from 46-50 mg g^{-1} fw at V3 to 16-19 mg g^{-1} fw at R4. Similar to our result, Aly et al [6] observed that GI (100 and 200 Gy) increased

photosynthetic pigments (chlorophyll a and b) in bread wheat (*Triticum aestivum* L.) under salt stress condition. In *Lepidium Sativum* L. also GI induced chlorophyll content increment so that chlorophyll a, b, and total chlorophyll increased by 10.4, 30.3, and 14.9 percent respectively due to GI of 5 Gy [7].

The results showed that gamma treated corn seeds produced a larger size plants in the salinity stress condition in the field. GI significantly increased plant weight ($p<0.01$), cob weight ($p<0.01$), and grain number per cob ($p<0.01$). The results showed that cob dry weight was increased due to GI ($p<0.01$) by 2.9 times (Figure 1.b). Plant dry weight also showed an increment by 1.7 times, rather than control (Figure 1.c). Grain number per cob was dramatically greater ($p<0.001$) in the GI treatment so that grain number per cob was 2.3 times higher in GI treatment (Figure 1.d).

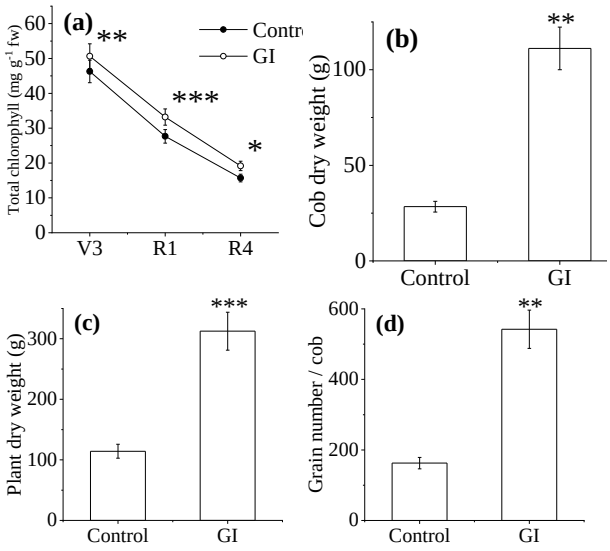

Figure 1- Effect of gamma irradiation; GI (25 Gy) on total chlorophyll (a), cob dry weight (b), plant dry weight (c), grain number per cob (d) of corn under saline condition. V3; third leaf stage, R1; silk stage , R4; dough stage, under saline condition.*; significant at $p < 0.05$, **; significant at $p < 0.01$, ***; significant at $p < 0.001$ (LSD)

It has been reported that GI induced defense against salinity stress [8]. It has been reported that lower dose of GI may stimulate cell division and enzymatic activity which can improve water and mineral uptake by the plant. This can contribute to the increase of chlorophyll content, photosynthesis activity, and dry matter production [7]. Our results indicated that all of traits related to economical yield were higher in the GI treatment. As shown above, GI ameliorate salt stress by increasing photosynthetic pigment. Therefore, gamma application caused plant to allocate more assimilate to economic organs.

Conclusions

In the current study GI of seed effectively increased total chlorophyll of corn plant, under salt stress condition. Consequently, gamma irradiated seeds produced a greater plant size with grater grain number per cob. Thus, it can be concluded that GI may be able to ameliorate the effect of salt stress on corn. Future studies on the effect of gamma irradiation on underlying mechanisms of corn response to salinity stress will be helpful for a better understanding of this subject.

Acknowledgments

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