International Journal of Applied Research
Journal HP: www.intjar.com, ISSN: 2411-6610

Screening of grasspea genotype against salinity stress at early vegetative stage under laboratory condition

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ARTICLE INFO

Article history

Received 2 January 2018
Online release 17 January 2019

Keyword

Grasspea
Salinity
Vegetative stage

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ABSTRACT

Forty five grasspea genotypes were tested against salinity levels 0, 5, 10 and 15 dS/m in Hoagland solution under laboratory condition during 2017-2018, to study the salt tolerance of the genotypes at germination and seedling stages. Distilled water (0 dS/m) was used as a control. Germination percentage (GP), root length (RL), shoot length (SL) and dry matter/ plant (g) were significantly found to be affected by salinity. At 5 dS/m, the genotypes BD-5151, BD-4875, and BD-4842 had higher (more than 80%) germination percentage. The highest root length (above 12 cm) was observed in BD-5151 followed by genotype BD-5222 and BD-4842 (above 12 cm) at control (0 dS/m). At 5 dS/m the genotype BD-5151 showed the highest root length (above 5 cm) followed by the genotype BD-4842. At 10 dS/m the genotype BD-5151 expressed the highest root length following BD-5222 germplasm. At 5 dS/m the highest shoot length was found in genotypes BD-5151. At 10 dS/m the genotypes BD-5151 gave highest shoot length following BD-5222 and BD-4842. The BD-5151 gives the highest (0.126 g, 0.112 g 0.086 g and 0.040 g) dry matter/plant at control (0 dS/m), 5 dS/m, 10 dS/m and 15 dS/m respectively. The genotypes BD-5151, BD-5222 and BD-4842 showed better performance at 5 dS/m, and 10 dS/m and survived up to 15 days after germination.

Introduction

Out of 2.85 million hectares of the coastal and off shore areas about 1.00 million hectares are arable lands, which cover over 30% of the total cultivable lands of Bangladesh (Bhowmick et al., 2016). The cultivable areas in coastal districts are affected with varying degrees of soil salinity. Agricultural land use in these areas is very poor, which is roughly 50% of the country's average (Petersen and Shireen, 2001). Salinity causes unfavorable environment and hydrological situation that restrict normal crop production throughout the year. In general, soil salinity is believed to be mainly responsible for low land use as well as cropping intensity in the area (Rahman and Ahsan, 2001). Salinity in the country received very little attention in the past. Increased pressure of growing population in Bangladesh demands more food. Thus it has become increasingly important to explore the possibilities of increasing cultivable lands for crop production.

*Lathyrus*is a genus in the *Leguminosae* family and contains species such as *Lathyrus savitus* (grass pea) and *Lathyrus odorata* (sweet pea). Grasspea is used as a famine food, especially in India, the Middle East, and the parts of Asia, because the plants are extremely hardy and the seeds are high protein content. Grasspea is probably the most drought tolerant legume crop and it is also resistant to moderate salinity. Besides being an important source of human and animal food, the crop also plays an important role in the maintenance of soil fertility, particularly in southern regions. A major constraint on grasspea production in coastal area is soil salinity, predominately due to chloride and sulphate accumulation in the soil (Saxena, 1990). Although some soils are naturally saline, the secondary salanization largely about by the use of irrigation systems, that is the greatest threat to legume production in southeast regions, where water supplies are limited, irrigation is essential to increase yield. As with many other pulses, grasspea is a salt-sensitive crop and yields are seriously reduced particularly by chloride salinity (Manchanda and Sharma, 1990). The salinity effects on grasspea are wide ranging. Seed germination is delayed and reduced and vegetative plant growth is suppressed under saline conditions (Sharma et al., 1982).

Research to improve salt tolerance in plants is mainly focused on biochemical and physiological aspects. The genes responsible for salt tolerance in some species have been identified but stress might occur as a complex mechanism of several interacting environmental factors that cause variations in plant phenotypes. Salt stress causes dehydration to plants, which is one of the abiotic stresses in plants (Ahmed et al., 2017). It is known that osmotic stress induces oxidative damage, reducing biosynthesis of compound osmo protectors; basically plants record their environment and respond with resistance or adaptation mechanisms. On the other hand, plant stress mechanisms are very different depending on the degree of stress tolerance, growth, and different development stages, evolution in time, materials and experimental plots, which increase their complexity. Azhar and Mcneilly, 1989 suggested that *in vitro* culture is an appropriate system for studies on salinity in plants because it easily recapitulates the results found in the field and in the greenhouses where environmental conditions are controlled. Salt tolerant genotype(s) need to identify to cope with the salinity problem in coastal areas of Bangladesh. Therefore, objective of this experiment was undertaken to evaluate genotypes of grasspea for their salt tolerance depending on phenotypic and enzymetic activity.

Materials and methods

The experiment was conducted from November 2017 to February2018 at Plant Physiology Laboratory, Plant Physiology Division, Bangladesh Agricultural Research Institute (BARI). Forty five (45) genotypes of Grasspea (BD-4792, BD-4801, BD-4829, BD-4830, BD-4833, BD-4834, BD-4842, BD-4843, BD-4844, BD-4845, BD-4846, BD-4851, BD-4856, BD-4860, BD-4875, BD-4877, BD-4894, BD-4897, BD-4899, BD-4909, BD-4916, BD-4945, BD-5099, BD-5106, BD-5115, BD-5143, BD-5150, BD-5151, BD-5152, BD-5164, BD-5168, BD-5172, BD-5191, BD-5192, BD-5193, BD-5194, BD-5195, BD-5196, BD-5197, BD-5198, BD-5199 and BD-5200) were collected from plant Genetics Resource Center (PGRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701, Bangladesh were used in the study. The experiment assessed the germination percentages (GP), root growth (cm), shoot growth (cm) and dry matter/ plant (g) of grasspea genotypes at different NaCl salinity levels. The NaCl concentrations were used 0 (control/ No salt), 5, 10, and 15 dS/m. The salt solution was prepared calculated amount of NaCl in distilled water. Subsequently, ten plants/pot were transferred to hydroponic culture in a Hoagland solution (The Hoagland solution: tap water ratio was 1:10 (w/w)) for an additional quantity (Ahmed et al., 2015). The pH of solution was maintained 6-7. Plastic pots were used in the experiment with a diameter of 10cm and arranged in a completely randomized design (CRD) with three replications. Each pot was supplied with 500ml of the respective treatment solution. Seeds were sown on the plastic pots having blotting paper. The germination count was taken after 72 hours of sowing of seeds. A seed was considered to have germinated when both the plumule and the radicle emerged > 0.5cm. After 15 days, the shoot and the root length of ten randomly selected seedlings from each replicate were measured following a draftsman ruler (Azhar and McNeilly, 1987).

Germination percentage (GP)

The average number of days required for plumule or radicle emergence was calculated as described by Ahmed et al., 2015).

Germination percentage (GP) = $\frac{a}{b} \times 100$

Where, a = Number of seeds germinated
b = Total numbers of seeds set

The plants were then collected from the pots and the following measurements were done

i. Root Length (cm).
ii. Shoot Length (cm)

Statistical Analysis

Data analysis was carried out by MSTAT-C where two ways analysis of variance (ANOVA) and correlation analysis were employed. Prior to data analysis, root and shoot length was log transformed. Consequently, the incomplete data obtained from these salinity levels had been excluded from the analysis of germination percentage (GP), germination rate (GR), root length (RL), shoot length (SL), and dry matter/plant.

Results and discussion

Germination Percentage

At different salinity levels, the germination percentage (GP) presented in Fig.1. A variation in the germination of grasspea genotypes under salinity was observed. Salinity stress decreased the rate of germination percentage at higher salinity level (15 dS/m). It was observed from Fig. 1 that at lower salinity level (5 dS/m), the genotypes BD-5151, BD-4875 and BD-4842 had higher (more than 80%) germination percentage. At 10 dS/m, BD-5151 had 80% germination. At 15 dS/m of salinity BD-5222 showed above 40% germination, Salinity level resulted in the reduction of germination percentage in almost all genotypes. Similar results were reported in triticale (Salim, 1989).

Root Length

It was observed from the Figure. 2 that the highest root length (above 12 cm) was observed in BD-5151 followed by genotype BD-5222 and BD-4842 (above 12 cm) at control (0 dS/m). At 5 dS/m the genotype BD-5151 showed the highest shoot length (above 5 cm) followed by the genotype BD-4842. At 10 dS/m the genotype BD-5151 expressed the highest following germplasm BD-5222. The root and shoot lengths are the most important parameters for salt stress because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of the plant (Ahmed et al., 2014). For this reason, root and shoot length provides an important clue to the response of salt stress (Jamil and Rha, 2004, Ahmed et al., 2015). Salt stress inhibited the seedling growth (root and shoot length) but root length was more affected then shoots length (Ahmed et al., 2017).The Inhibition of plant growth by salinity may be due to the inhibitory effect of ions. The reduction in root and shoot development may be due to toxic effects of the NaCl used as well as unbalanced nutrient uptake by the seedlings. High salinity may inhibit root and shoot elongation due to slowing down the water uptake by the plant (Werner and Finkelstein, 1995). It could be concluded that the decrease of root absorption capacity was one of the main reasons of water imbalance due to salinity (Wang et al., 2006).Similar results were reported in grasspea (Ahmed et al., 2014) and field pea (Rahman et al., 2015).

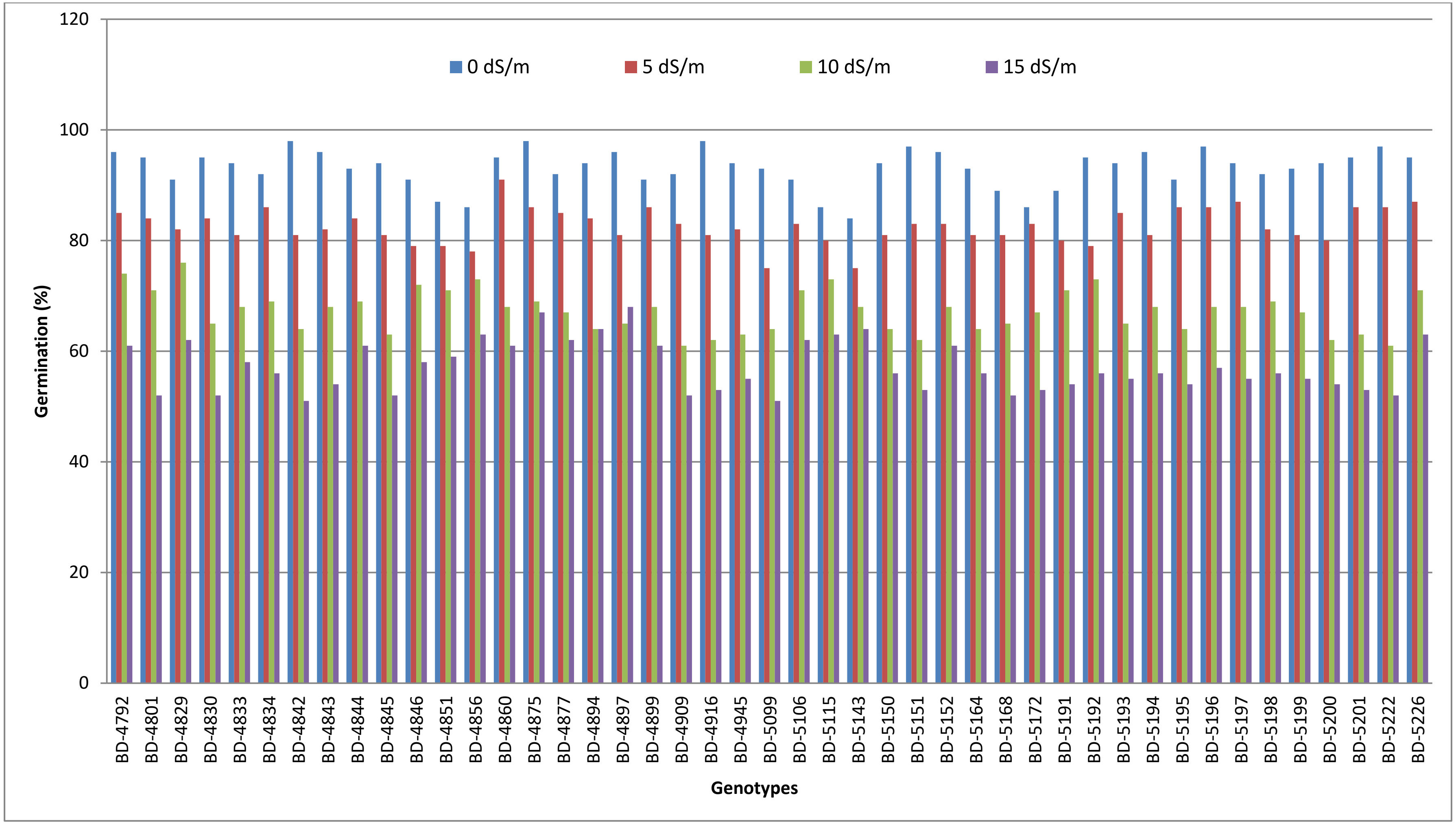

Fig. 1. Effect of different level of salinity on germination percentage (GP) of grasspea genotypes

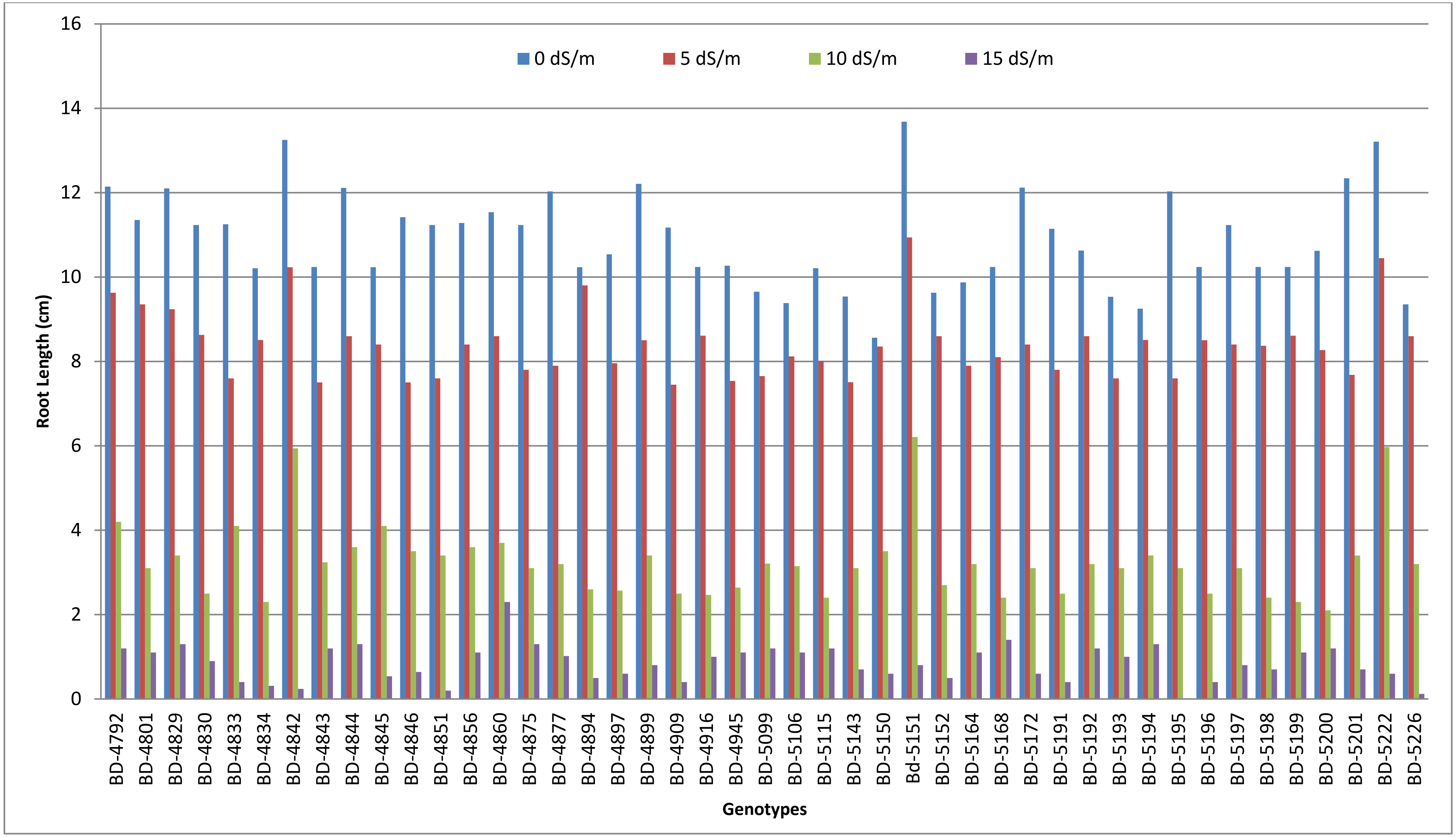

Fig. 2. Effect of salinity on Root Length (cm) of grasspea genotypes

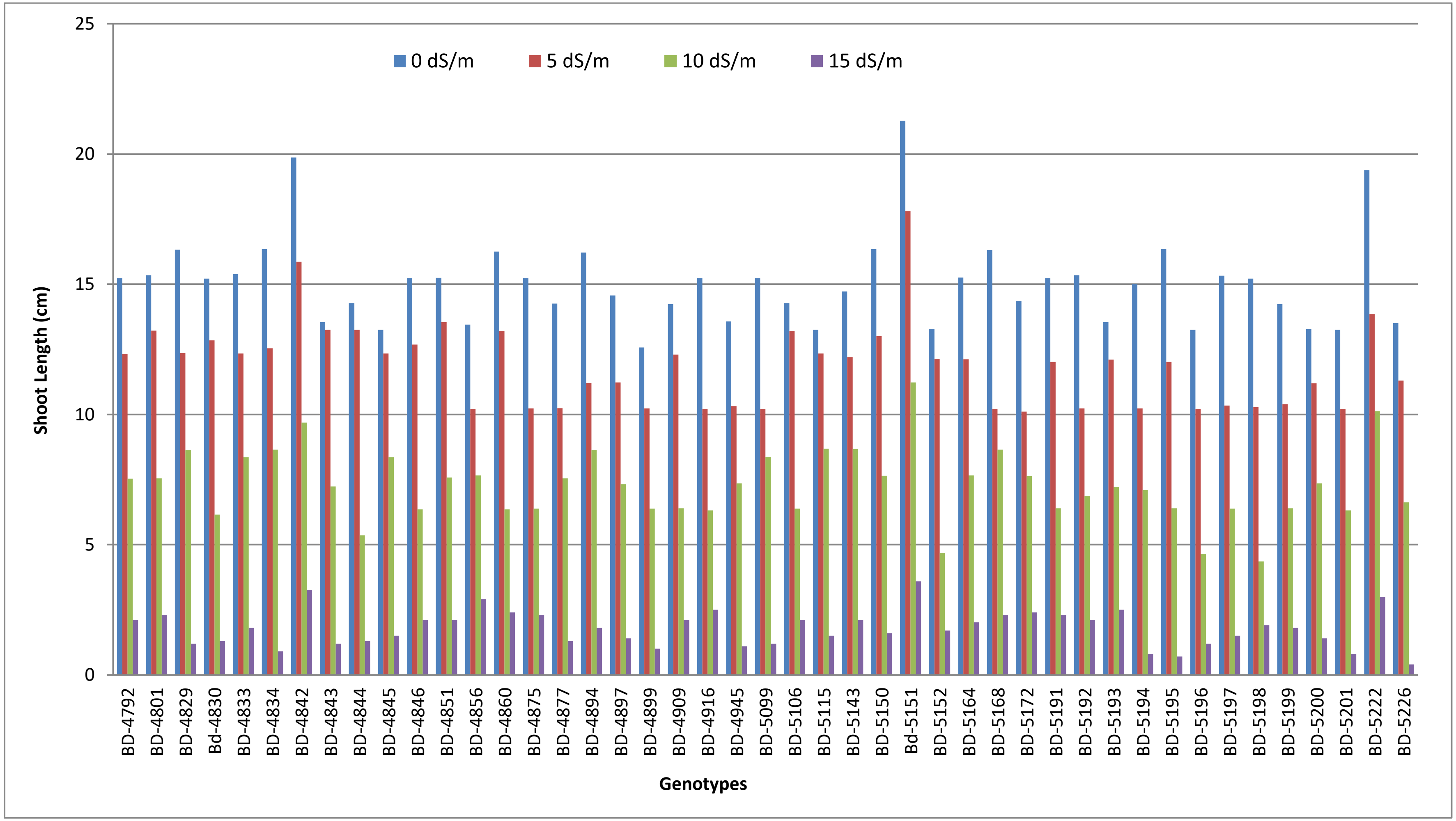

Fig. 3. Effect of different level of salinity on Shoot Length (cm) of grasspea genotypes

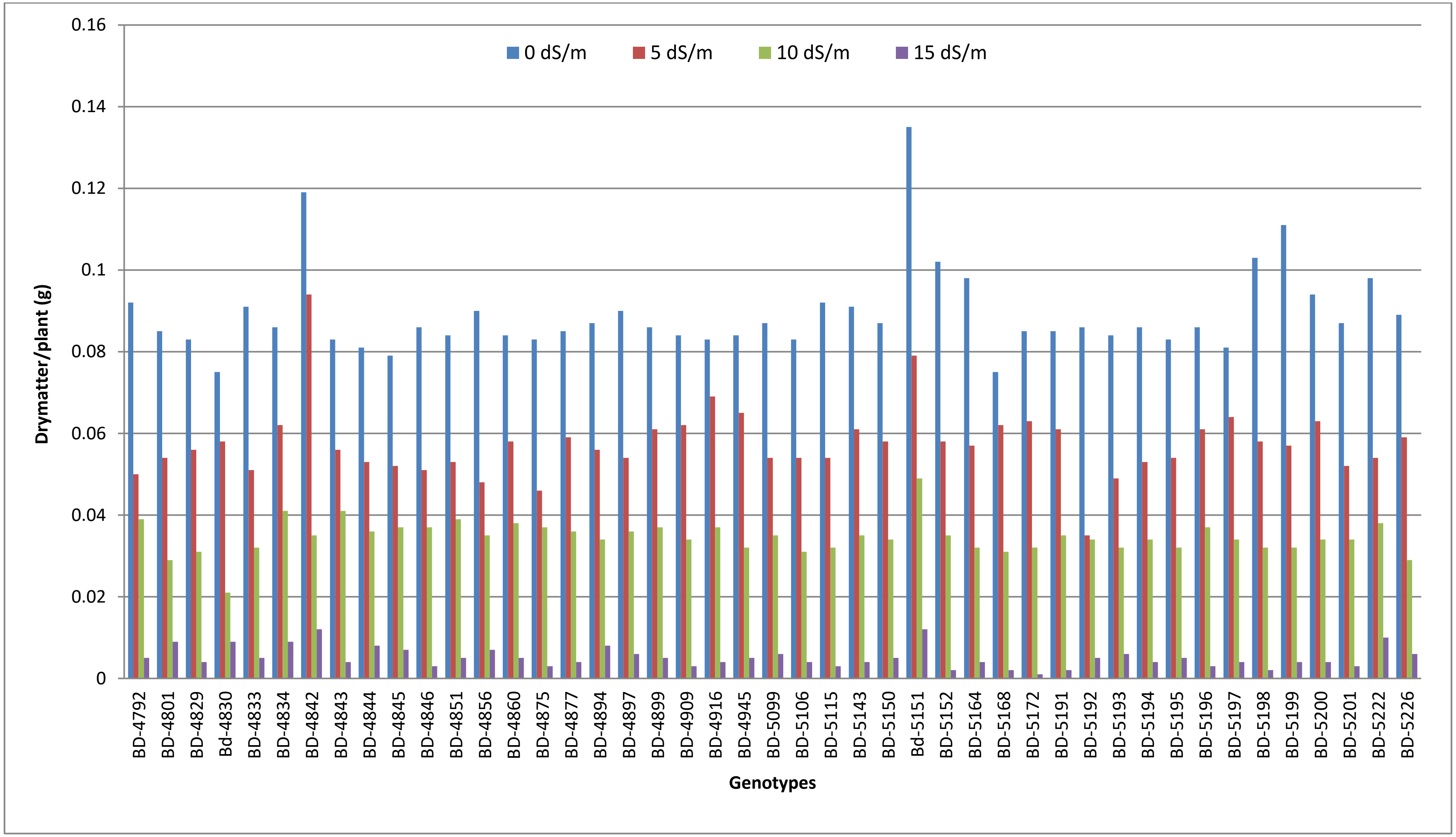

Fig. 4. Effect of different level of salinity on dry matter/plant (g) of grasspea genotypes

Shoot length

From Figure 3, the highest shoot length was found in genotypes BD-5151, gave at 5 dS/m (above 15 cm). At 10 dS/m salinity level, the genotypes BD-5151 gave highest shoot length (above 10 cm) following BD-5222 and BD-4842. BD-5179 gave the lowest shoot length at all levels of salinity. The shoot lengths is the most important parameters for salt stress because shoot supply nutrients to the rest of the plant. Due to increase salinity, the shoot length would be decreased drastically (Ahmed et al., 2017). From this experiment, it found similar that increasing salinity level, the shoot length is decreased. Root and shoot length provides an important clue to the response of plants to salt stress (Ahmed et al., 2014). Salt stress inhibited the seedling growth (root and shoot length) but root length was more affected then shoots length .Inhibition of plant growth by salinity may be due to the inhibitory effect of ions. The reduction in root and shoot development may be due to toxic effects of the NaCl used as well as unbalanced nutrient uptake by the seedlings (Werner and Finkelstein, 1995).

Dry matter/plant

The BD-5151 gives the highest (0.126 g, 0.112 g, 0.086 g and 0.040 g) dry matter/plant at control (0 dS/m), 5 dS/m, 10 dS/m and 15 dS/m, respectively. It also found considering the dry matter/ plant (g) that increasing salinity level reduces the dry matter production (Ahmed et al., 2015). In increased salinity, cell division is stunted due to saline ion effect and at over doses of salinity, cell wall damaged and as a result the dry matter production will be stopped. In this experiment it is similarly found the BD-5151, BD-5222 and other all genotype reduces the dry matter production in increased soil salinity. It is evident that the existence of genetic variation in salt tolerance is a prerequisite for development of salt tolerant cultivars through selection/ or breeding. It might be pointed out from figure 4 that stress resistance can vary among plant species and seed lots of plant species (Ahmed et al., 2015, Ahmed et al., 2014). It was identified that seed lots of woody plants that may produce more dry matter and have a good survival rate under saline conditions. Both of these measures of tolerance may be useful when selecting seed lots and families' within-seed lots to grow at a given level of soil salinity. These results are in agreement with other studies (Rahman et al., 2014).

Conclusion

Considering all the parameters, results revealed that the genotypes BD-5151, BD-5222 and BD-4842 were more tolerant to salinity than other genotypes.

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