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Influence of Salt and Water Stress on Growth and Yield of Soybean Genotypes

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ABSTRACT

Water uptake by the plant is difficult in saline and water stress condition due to decreasing osmotic potential of soil. Soybean yield is highly affected by the soil water scarcity. An experiment was conducted to evaluate the growth and yield of three selected soybean genotypes in salt and water stress conditions at a vinyl house. Three soybean genotypes, namely, Galarsum, BD 2331 and BARI Soybean 6, were tested in six different treatments. The six different treatments were: T1 (Control, no salt or water stress), T2 (Water shortage, WS), T3 (50 mM NaCl), T4 (50 mM NaCl + WS), T5 (75 mM NaCl) and T6 (75 mM NaCl + WS). Plant height, shoot dry weight and dry matter distribution in different parts were sharply decreased when the plants were exposed to the combined salt and water stress conditions. The combined effect of salt and water stress was more severe in yield reduction than the single effect. The seed yield of soybean was decreased with increase in salinity. Among the genotypes, dry matter reduction was the lowest in Galarsum. In addition, Galarsum also showed the highest filled pods and 100 seed weight. The maximum seed yield was found in Galarsum. Galarsum was found to be suitable to grow in saline and water stress condition. Therefore, this genotype can be recommended for saline and water shortage zones.

Keywords: Soybean, water stress, combined salinity and water stress, yield

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INTRODUCTION

Soybean has become an important crop in Bangladesh for its increasing demand as an ingredient of poultry and fish meal. Therefore, soybean is now one of the stable and economic crops in Bangladesh and it mostly concentrates in the coastal area of the southern part of the country, more specifically in greater Noakhali district. Its production area is increasing day by day and in the year 2013 it reached above 61000 ha (Chowdhury, 2014). In Bangladesh, thirty percent of the net cultivable areas are in the coast. Out of 2.85 million hectares of the coastal and off-shore areas, about 0.83 million hectares of the arable lands are affected by varying degrees of soil salinity (Karim et al., 1990). High levels of salt in the soil of the coastal region often cause serious limitations to crop production.

High levels of salt in soil can often cause serious limitations to crop production. Soybean is classified as a moderately salt-tolerant crop and the final yield of soybean is reduced when soil salinity exceeds 5 dS/m (Ashraf, 1994). It is common in the arid and semi-arid regions that when the crop growth season progresses, precipitation decreases, and temperature and evapotranspiration increase, resulting in rising salt concentration in the soil solution (Abdulrahman & Williams, 1981). Thus, salt and water stress prevails at the same time in the dry seasons, which very often adds extra harm on plant growth (Karim et al., 1993). Water shortage decreases matric potential that increases the resistance of water flow to the roots (Homaee et al., 2002), whereas soil salinity reduces the soil water potential but does not reduce water flow to the roots. Plant roots contain varying concentrations of ions that create a natural flow of water from the soil into the plant roots and maintain the root growth (Everard et al., 1994). Salinity has damaging effect on plant growth mostly due to the toxicity of specific ions or as a result of osmotic stress (Munns, 2002). However, the adverse effects of both salt and water stress are primarily due to the restriction of water uptake by the roots (Karim et al., 1993). Therefore, plants are unable to maintain metabolic activities or turgidity for normal growth because of the low osmotic potential in soil.

Raptan et al. (2001) reported that salinity decreased dry matter production in different plant parts of mungbean. Salinity also caused drastic reduction in grain yield of many crops including soybean (Ghassemi-Golezani et al., 2009), mungbean (Aziz et al., 2006) and peas (Duzdemir et al., 2009). Aziz et al. (2006) observed a relationship in salt tolerance between vegetative and maturity stages in mungbean.

Blum (1985) reported that salt tolerance at the seedling stage was highly predictive to that at the reproductive stage of crop plants. However, Ashraf and McNeilly (1988) and Kingsbury and Epstein (1986) did not find such relationship in salt tolerance between early and mature stages of growth in wheat. Soybean germplasms displayed a broad spectrum of salt tolerance capability and the degree of their salt tolerance varied with the developmental stages and environmental factors (Abel & MacKenzie, 1964; Maas & Hoffman, 1977; Blum, 1988; Chang et al., 1994). Moreover, soybean genotypes also varied in their growth responses to combined salt and water stress (Khan et al., 2014). At the terminal stage of the soybean crop, due to high evaporative demand of the air in the dry seasons, salt and water stress prevails at the same time, which very often adds extra harm on plant growth. Therefore, selection of soybean genotype for salt and water stress tolerance would be helpful for increasing total production of soybean that ultimately improve the income level of the soybean growers.

However, the yield response of the soybean genotypes to salt and water stress has not been reported. Therefore, this experiment was initiated with the objective to find out suitable soybean genotypes grown under salt and water stress conditions based on their growth and yield.

MATERIALS AND METHODS

Study Site

The experiment was conducted in a vinyl house of the Department of Agronomy at Banghabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, Bangladesh, during January to May, 2012. The location is situated at about 24^0 23´ north latitude, 90^0 08´ east longitude and at an altitude of 8.4m above sea level and adjacent to the capital city, Dhaka.

Cropping Season

The experiment was set up in winter (*Robi*) and carried out up to summer (*Kharif-1*) with crop duration.

The Test Crop

Three genotypes of soybean (*Glycine max* L.) viz. Galarsum, BD 2331 and BARI Soybean 6 were used to observe dry matter production and seed yield performance under salt and water stress condition. These genotypes were selected based on their performance at vegetative stage in a previous study (Khan et al., 2014).

Potting Preparation and Seed Sowing

The experiment was carried out in plastic pots having 30 cm in height and 24 cm inner diameter. Each pot contained 12 kg of air dried sandy loam soil. The soils of each pot were fertilised uniformly with 0.30, 0.90, 0.60 and 0.60 g pot^{-1} of urea, triple super phosphate, muriate of potash and gypsum, respectively, before sowing. Soybean seeds of the respective genotypes were washed several times in the tap water for surface cleaning, and then sown in the soil medium on January 20, 2012, in plastic pots. Five seeds were dibbled in soil at a depth of 1 cm.

Experimental Design and Treatments

The experiment was laid out in two factors Completely Randomized Design (CRD) with four replications. The factors were three genotypes (Galarsum, BD 2331 and BARI Soybean 6) of soybean, with six treatments of salinity and water stress. The environmental conditions were T1 (Control), T2 (Water shortage, irrigation with 70% depletion of available soil water when wilting sign developed), T3 (50 mM NaCl irrigation), T4 (50 mM NaCl irrigation + Water shortage), T5 (75 mM NaCl irrigation), and T6 (75 mM NaCl irrigation+ Water shortage). Treatments were imposed after three weeks of seedling emergence. In salt water irrigation and water shortage treatments, all pots were initially irrigated with salt water for a week, followed by water shortage and salt water irrigations thereafter. The control plants were irrigated with tap water only with maintained field capacity. Treatments were applied up to maturity.

Intercultural Operation

After the emergence and establishment, two uniform healthy seedlings per pot were allowed to grow for three weeks in equal environment. Admire 200SL @ 1 ml L^{-1} of water was sprayed at 10 and 25 days after emergence to control Jassids and white flies. Ripcord 10 EC @ 1 ml L^{-1} of water was sprayed at 45 and 60 days after emergence to control leaf roller and pod borer.

Harvesting and Data Recording

The crop was harvested at maturity from April 1-25, 2012. The plant samples were collected 56 days after emergence. Plant height was measured and different plant parts were separated before oven drying them at 70ºC for 4 days to measure the dry weight of shoot. After maturity, yield contributing characters like total pods per plant, filled pods per plant, 100-seed weight and seed yield per plant were recorded. Electrical conductivity of the pot soil was also recorded using EC meter at different times.

Statistical Analysis

The analysis of variance for growth parameters and crop yield were done following the ANOVA test and the mean values were compared by LSD (Least significant difference). Computation and preparation of graphs were done using Microsoft EXCEL 2003.

RESULTS AND DISCUSSION

Changes of Electrical Conductivity

The electrical conductivity was influenced by the different treatments (Table 1). It ranged from 1.05 to 14.4 dSm^{-1}. The highest electrical conductivity (14.4 dSm^{-1}) was found in 75 mM NaCl, followed by 50 mM NaCl (11.3 dSm^{-1}) at harvest. Among the days after emergence, 63 DAE showed the maximum electrical conductivity (9.30 dSm^{-1}) in 75 mM NaCl, followed by 56 DAE in the same salinity level. The minimum electrical conductivity (1.05 dSm^{-1}) was in 42 DAE at water stress. It was observed that electrical conductivity was increased with the increase in days after emergence. The electrical conductivity also increased with the increase in the salinity levels. Water stress + NaCl have decreased electrical conductivity compared to only NaCl due to maintaining 70% depletion of salt water irrigation.

Plant Height

The plant height of soybean genotypes was significantly influenced by the combined effects of genotypes and different treatments (salinity and water stress). Except for the control, BD 2331 showed the highest plant height (57.7 cm) which was identical to BARI soybean 6 and Galarsum in 50mM NaCl (Figure 1). The lowest plant height (33.5cm) was found in BARI Soybean 6 at 75 mM NaCl along with water stress. Among the treatment combinations, T_3 (50 mM NaCl) showed the highest plant height (average 56.3cm), followed by T_5 (75mMNaCl) and the lowest was in T_6 (75 mM NaCl + water stress) (Figure 1). It was observed that the plant height of soybean decreased with the increase in the salinity level. Similar results were also reported by Ozturk et al (2004) and Sari and Ceylan (2002). Osmotic potential and matric potential were decreased due to salt water and water shortage, respectively, in soil. The phenomena interrupted in water uptake, resulting in reduction of shoot growth.

Table 1
Changes in electrical conductivity in the growth media as influenced by the treatment and days after emergence (DAE)

Treatment	Electrical conductivity (dSm^{-1})				
	42 days after emergence	49 days after emergence	56 days after emergence	63 days after emergence	At harvest (70-95 DAS)*
Control	1.17	1.36	1.38	1.38	1.38
Water stress (WS)	1.05	1.17	1.21	1.21	1.21
50 mM NaCl	3.60	3.63	5.90	6.00	11.3
50 mM NaCl + WS	2.77	3.50	4.50	5.25	7.80
75 mM NaCl	5.50	5.83	8.75	9.30	14.4
75 mM NaCl + WS	4.51	4.90	4.90	7.20	9.55

* Maturity varied due to treatment effect

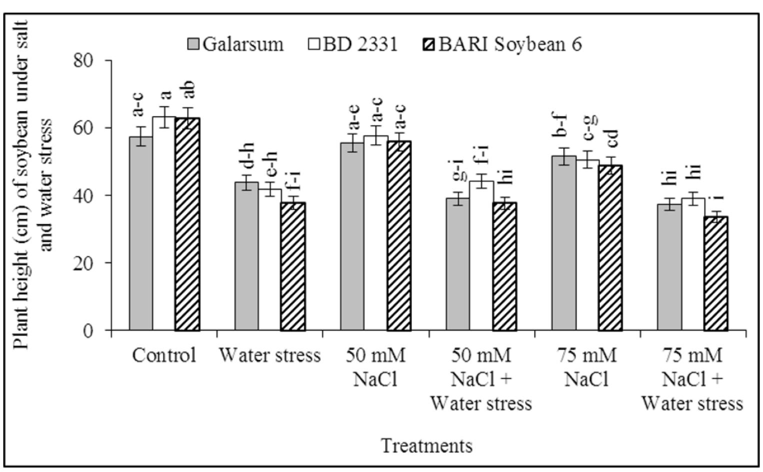

Figure 1. Plant height of soybean genotypes as influenced by the salinity and water stress at 56 days after emergence. Figure(s) in bars having common letter (s) do not differ significantly (*p*=0.05*)*

Among the genotypes, BD 2331 showed the maximum height (average 49.4 cm), followed by Galarsum (47.4 cm) and the minimum (46.1 cm) was in RARI soybean 6. Genotypic difference in reduction of plant height due to salinity was reported by Mannan et al. (2012) in soybean. Sultana et al. (2009) and Podder et al. (2012) also observed reduction of shoot growth of mungbean at different salinity levels, the result which is in agreement with the findings of our results.

Shoot Dry Weight

Shoot dry weight of soybean was significantly variable among the interaction effects of treatment and genotype. Except for the control, the shoot weight ranged from 2.37 to 6.63 g plant^{-1}. The highest shoot weight (6.63gplant^{-1}) was found in BD 2331 at 50 mM NaCl, which was significantly higher than the other treatment combinations. The lowest shoot weight (2.37g plant^{-1}) was recorded in BARI soybean6 at water stress condition (T_2) Table 2). Galarsun in 50 and 75 mM NaCl showed statistically similar shoot weight. It was observed that the shoot weight of soybean decreased with the increase in salinity levels. It was also found that NaCl, alone or in combination with water stress, produced more shoot biomass than the only water stress; this might be due to salt being added along with water. Here, plant received water which helped it to grow. Under water stress, the resistance of water flow into the root increased with the decrease in matric potential (Homaee et al., 2002). At given salt water content reduces the soil water potential but does not reduce water flow to the roots. Root cortical cells can osmotically adjust to some

Table 2
Shoot dry weight of soybean (g/plant) as influenced by the genotypes and treatment (salinity and water stress) (percentages to control in parenthesis) at 56 days after emergence

Treatment	Genotypes			
	Galarsum	BD 2331	BARI Soybean 6	Mean
Control	9.07 ± 0.29a (100)	8.67 ± 0.26ab (100)	8.49 ± 0.31b (100)	8.74
Water stress (WS)	3.26 ± 0.21gh (35.94)	2.68 ± 0.46ij (30.91)	2.37 ± 0.37j (27.92)	2.77
50 mM NaCl	5.86 ± 0.21d (64.61)	6.63 ± 0.18c (76.47)	5.30 ± 0.09e (62.43)	5.93
50 mM NaCl + WS	3.57 ± 0.10gh (39.36)	3.59 ± 0.18g (41.41)	3.25 ± 0.55gh (38.28)	3.49
75 mM NaCl	5.38 ± 0.08de (59.32)	5.20 ± 0.20e (59.98)	4.69 ± 0.68f (55.27)	5.09
75 mM NaCl + WS	3.41 ± 0.10gh (37.60)	3.10 ± 0.21hi (35.76)	3.18 ± 0.11gh (37.46)	3.23
Mean (Except control)	4.30	4.20	3.76	

Figure(s) in columns having common letter (s) do not differ significantly (*p*=0.05). CV % = 6.20

extent allowing water to move into the root. Therefore, the shoot dry weight of soybean was affected more in only water stress than the salt and water stress combined. This result corroborates with the findings of Meiri (1984), where the matric potential preferentially affected the shoot growth of bean more than the osmotic potential. Wang et al. (2011) also reported that shoot biomass was decreased significantly in tamarisk seedlings due to water scarcity under salt and water stress. The reduction in shoot dry weight due to salinity was observed by Jamil et al. (2007) in sugarbeet, Sultana et al. (2009) in mungbean, Chookhampaeng (2011) in pepper plant, and Mannan et al. (2013) in soybean. Among the genotypes, Galarsum showed the highest biomass (average 5.09 g plant^{-1}), followed by BD 2331 (4.98 g plant^{-1}) and the lowest was in BARI soybean 6.

Dry Matter Distribution

Dry matter distribution in different plant parts of soybean genotypes, as affected by water stress, salt stress and combination of salt and water stress at 56 days after emergence, is given in Figure 2. All plant parts were reduced by stresses in all genotypes and the reduction was more in the combined salt and water stress than the only salt stress in both the salinity levels (50 mM and 75 mM NaCl). It was observed that the dry matter reduction was increased with the increase in salinity in combination with water stress. At 75 mM NaCl salt and water stress, the highest dry matter of stem (1.38 g), petole (0.43 g) and leaves (1.55 g) was recorded in Galarsum and the lowest dry matter (1.27, 0.40 and 1.38 g for stem, petiole and leaves, respectively) was in BD 2331 genotype.

The dry matter reduction was more in the leaf, but it varied from one genotype to another. At 75 mM, NaCl along with water stress, the highest leaf weight (1.55 g) was found in Galarsum, followed by BARI Soybean 6 (1.42 g) and the lowest (1.38 g) was in BD 2331. Wang et al. (2011) also reported that the leaf biomass decreased significantly in tamarisk (*Tamarix chinensis* Lour) seedlings due to water scarcity under salt and water stress.

Pods per Plant

The number of pods per plant was significantly affected by the salinity and water stress (Table 3). The lowest number of pods of 12.22 per plant (21.7% to control) was recorded in Galarsum at 75 mM NaCl with water stress, followed by BD2331 (12.67) at the same salt concentration. All the three genotypes also produced identical number of pods in 50 and 75mM NaCl in combination with water stress. It was also observed that soybean genotypes showed significantly lower number of pods plant^{-1} in salt, along with water stress than salt stress only. It is difficult for the plant to uptake water in either saline or water stress condition due to the decreasing osmotic potential of soil. Water stress was caused by the salinity or water shortage as a result of decreased pod number in peas (Duzdemir et al., 2009). Westgate and Peterson (1993) reported that soybean yield is more sensitive to drought stress during its early reproductive stage (i.e., flowering to early pod expansion) than the other developmental stages. Drought stress during this period increases the rate of pod dropping (Westgate & Peterson, 1993), leads to a lesser number of pods per plant (Desclaux et al., 2000) and ultimately decreases seed yield (Kokubun et al., 2001).

Filled Pods per Plant

The number of filled pods of soybean was significantly variable among the interaction effects of genotypes and treatment (Table

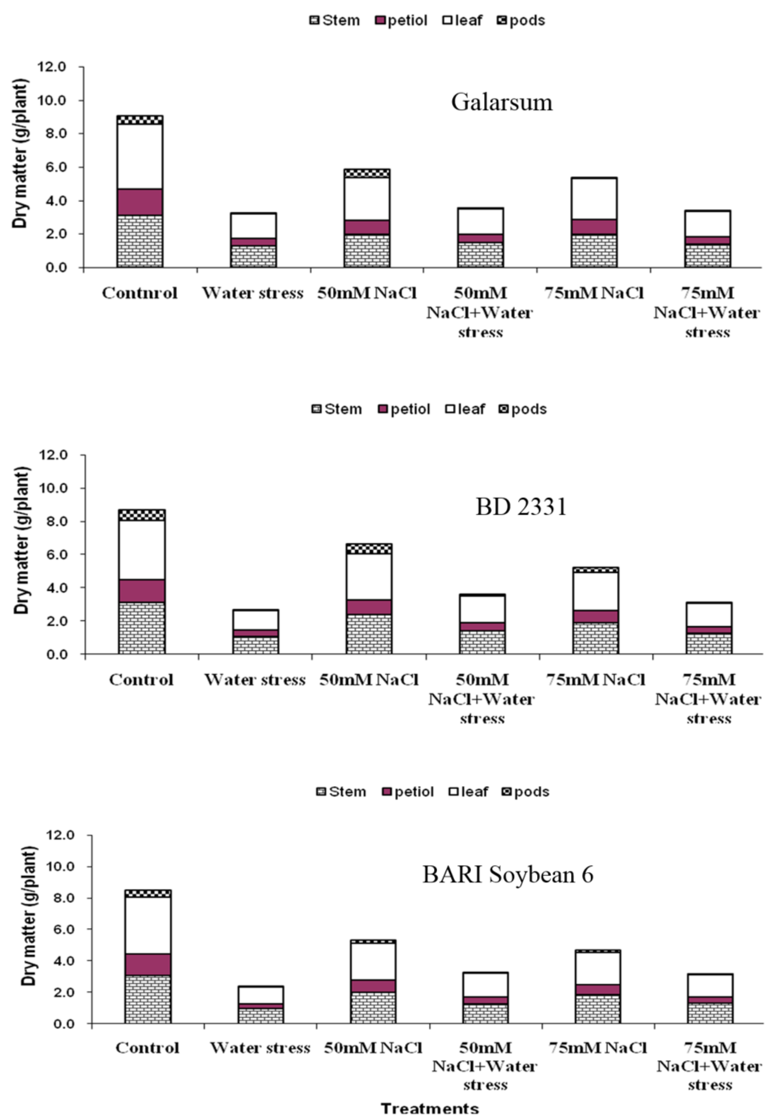

Figure 2. Dry matter accumulation in different plant parts of soybean as influenced by the genotypes and treatment (salinity and water stress at 56 days after emergence

4). The least number of filled pods of 7.91 per plant (16.59% to control) was found in BARI Soybean 6 at 75 mM NaCl salt combined with water stress. In 50 mM NaCl, BARI sotbean 6 also showed the highest filled pods (17.11), which was followed by Galarsum (15.89 pods plant^{-1}) in the same salt concentration. Among the genotypes, Galarsum showed the highest filled pods (average: 13.0 pods plant^{-1}), followed by BD 2331(average: 13.0 pods plant^{-1}) and the minimum was in BARI Soybean 6 (average 11.32 pods plant^{-1}). The numbers of filled pods decreased to 41.04, 26.42 and 18.23% of the control under 75 mM NaCl salinity in Galarsum, BD 2331 and BARI Soybean 6, respectively. Under water stress, the number of filled pods decreased to 41.07, 29.87 and 30.06% of the control in Galarsum, BD 2331 and BARI Soybean 6, respectively. The reduction in the filled pods might be due to the reduction of pollen fertility caused by water stress and/or salt stress. Duzdemir et al. (2009) reported that the number of seeds in peas decreased by water shortage was caused by salinity or water stress. Salinity induced reduction in the number of seed in soybean was also reported by Ghassemi-Golezani et al. (2009).

100-Seed Weight

The 100-seed weight ranged from 4.44 to 9.86 g (Table 5). The lowest 100-seed weight of 4.44 g (48.37% to control) was recorded in BARI Soybean 6 at 75 mM NaCl salt stress, which was statistically similar with BD 2331 (4.98 g) at the same treatment, and this was also identical with all genotypes at 75 mM NaCl along with water stress. However, Galarsum showed the highest 100-seed weight than the other genotypes at 50 and 75 mM NaCl salt stress

Table 3
Number of pods in soybean (number plant^{-1}) as influenced by the genotypes and treatment (salinity and water stress) (percentages to control in parenthesis)

Treatment	Genotypes			
	Galarsum	BD 2331	BARI Soybean 6	Mean
Control	42.33 ± 6.11b (100)	61.00 ± 9.17a (100)	56.33 ± 6.66a (100)	53.2
Water stress (WS)	16.67 ± 3.06e (39.38)	17.67 ± 4.16de (28.97)	17.00 ± 3.61e (30.18)	17.1
50 mM NaCl	23.78 ± 1.39cd (56.18)	23.89 ± 4.55cd (39.16)	27.33 ± 3.18c (48.52)	25.0
50 mM NaCl + WS	12.89 ± 0.51e (30.45)	14.56 ± 1.58e (23.87)	13.44 ± 2.27e (23.86)	13.6
75 mM NaCl	24.00 ± 1.20cd (56.70)	23.44 ± 1.07cd (38.43)	24.33 ± 2.08c (43.19)	23.9
75 mM NaCl + WS	13.11 ± 0.51e (30.97)	12.67 ± 3.53e (20.77)	12.22 ± 0.84e (21.69)	12.7
Mean (except control)	18.1	18.4	18.9	

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alone or in combination with water stress. It was also observed that salinity badly affected the 100-seed weight of soybean, while the reduction of 100-seed weight was not significant in water stress in comparison to the control. Yield components like pod number and individual seed weight are genetically determined and subjected

Table 4
Filled pods of soybean (number plant^{-1}) as influenced by the genotypes and treatment (salinity and water stress) (percentages to control in parenthesis)

Treatment	Genotypes			
	Galarsum	BD 2331	BARI Soybean 6	Mean
Control	37.33 ± 3.21b (100)	51.33 ± 3.51a (100)	47.67 ± 4.51a (100)	45.4
Water stress (WS)	15.33 ± 3.06c (41.07)	15.33 ± 3.06c (29.87)	14.33 ± 3.06cd (30.06)	15.0
50 mM NaCl	15.89 ± 1.84c (42.57)	15.67 ± 3.33c (30.53)	17.11 ± 1.92c (35.89)	16.2
50 mM NaCl + WS	10.33 ± 0.33de (27.67)	8.50 ± 1.50e (16.56)	8.56 ± 2.59e (17.96)	9.13
75 mM NaCl	15.32 ± 1.22c (41.04)	13.56 ± 1.71cd (26.42)	8.69 ± 1.02e (18.23)	12.5
75 mM NaCl + WS	8.11 ± 1.26e (21.73)	8.44 ± 2.59e (16.44)	7.91 ± 1.33e (16.59)	8.15
Mean (except control)	13.0	12.3	11.3	

Figure(s) in columns having common letter (s) do not differ significantly (p=0.05).CV (%) = 14.2

Table 5
100-seed weight (g) of soybean as influenced by the genotypes and treatment (salinity and water stress) (percentages to control in parenthesis)

Treatment	Genotypes			
	Galarsum	BD 2331	BARI Soybean 6	Mean
Control	9.86 ± 0.37a (100)	9.06 ± 0.27ab (100)	9.18 ± 0.27ab (100)	9.37
Water stress (WS)	8.67 ± 0.46b (87.93)	8.99 ± 0.51b (99.23)	9.13 ± 0.41ab (99.46)	8.93
50 mM NaCl	6.11 ± 0.60cd (61.97)	5.79 ± 0.06cdef (63.91)	6.07 ± 0.30cd (66.12)	5.99
50 mM NaCl + WS	6.53 ± 0.49c (66.23)	6.01 ± 0.29cd (66.34)	5.84 ± 0.66cde (63.62)	6.13
75 mM NaCl	5.40 ± 1.39defg (54.77)	4.98 ± 0.37fgh (54.97)	4.44 ± 0.39h (48.37)	4.94
75 mM NaCl + WS	5.02 ± 0.52efgh (50.91)	4.80 ± 0.26gh (52.98)	4.99 ± 0.30efgh (54.36)	4.94
Mean (except control)	6.35	6.11	6.09	

Figure(s) in columns having common letter (s) do not differ significantly (p=0.05). CV (%) = 7.67

to environmental conditions that prevail during reproductive development. Salinity and water stress delayed flowering and enhanced pod maturity that shortened the pod development period. Short period of maturity ultimately affected grain growth making the grain shriveled under saline conditions (Ghassemi-Golezani et al., 2009; Mannan et al., 2013).

Seed Yield

Seed yield of soybean genotypes was significantly influenced by salinity and water stress. The seed yield varied from 0.55 to 8.36 g plant^{-1} (Table 6). The lowest seed yield of 0.55 g plant^{-1} (7.11% to control) was found in BARI Soybean 6 at 75 mM NaCl salt combined with water stress which was followed by BD 2331 (0.59 g plant^{-1}) in the same salt concentration. Among the salt and water stress treatments, Galarsum showed the highest seed yield (1.92 g plant^{-1}) in only water stress, followed by BARI soybean 6 in 50 mM NaCl. All genotypes of soybean produced statistically similar seed yield in only water stress and in 50 mM NaCl. It was observed that the combined effect of salt and water stress was more severe in yield reduction than the single effect of salt or water stress. Moreover, the seed yield of soybean was decreased with the increase in salinity level. Among the genotypes, Galarsum showed the highest seed yield (average 1.34 g plant^{-1}), followed by BD2331 (average 1.20 g plant^{-1}) and the lowest was in BARI Soybean 6 (Table 6). The water uptake by the plant is difficult under saline and water stress conditions due to decreasing osmotic potential of soil. Soybean yield is highly affected by soil water scarcity (Doss et al., 1974). Water shortage during the early reproductive stage increases the rate of pod dropping (Westgate & Peterson, 1993), leads to a less number of pods per plant (Desclaux et al., 2000) and ultimately decreases seed yield (Kokubun et al., 2001). Meanwhile, salinity leads to many metabolic changes that are identical to those caused by water stress, and there are still salt specific effects. Accumulation of the toxic level of Na^+ in leaves results in necrosis and premature leaf senescence (Munns, 2002). During seed development, sucrose is delivered via the phloem from source leaves to the developing seeds to support the growth (Patrick, 1988). Leaf senescence or defoliation leads to short supply of current photosynthates (Grodzinski et al., 1998; Komor, 2000) that ultimately reduces seed yield under salinity and water stress. Duzdemir et al. (2009) reported that seed yield of pea is very sensitive to water stress or salinity. The reduction in seed yield of mungbean and soybean due to salinity has also been reported by several authors (Raptan et al., 2001; Aziz et al., 2006; Sultana et al., 2009; Ghassemi-Golezani et al., 2009; Mannan et al., 2013).

CONCLUSION

Plant height, shoot dry weight and dry matter distribution in different parts were sharply decreased when the plants were exposed to the combined salt and water stress conditions. The combined effect of salt and water stress was more severe in yield reduction than the single effect alone. The seed yield of soybean was decreased with the increase in salinity. Among the genotypes, dry matter reduction was the lowest in Galarsum. Galarsum also showed the highest filled pods, seed yield and 100 seed weight. This means that Galarsum was found to be suitable to grow in saline (50 mM NaCl) and water stress (70% depletion of available soil moisture) conditions. Therefore, this genotype can be recommended for saline and water shortage zones.

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