

WATERLOGGING TOLERANCE OF SOYBEAN

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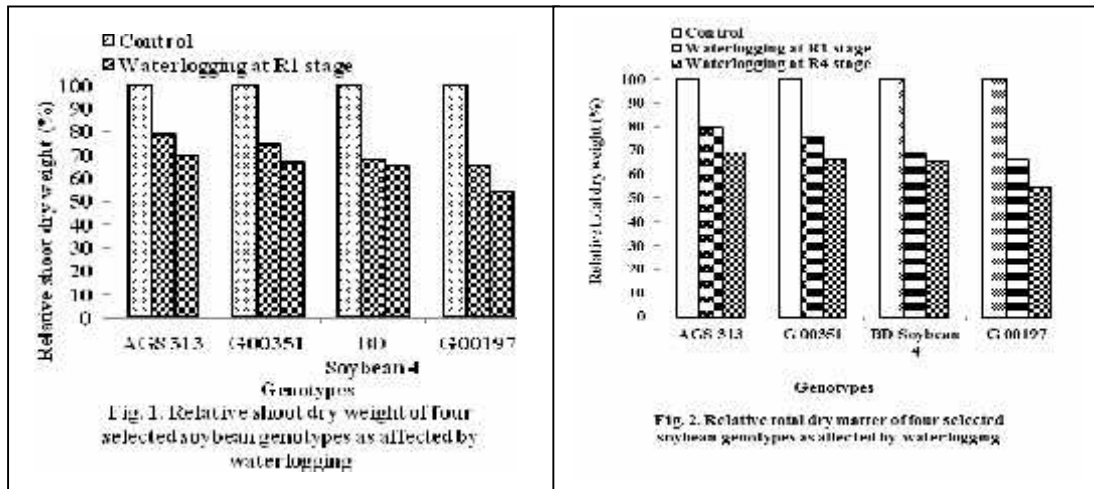
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Soybean (*Glycine max* L.) is one of the most important oil crops and rich in protein which have various uses for human food. Water logging induced several physiological disturbances in growth, dry matter, photosynthesis and pod formation that resulted in lower yield (Solaiman *et al.*, 2007; Pociecha *et al.*, 2008; Celik and Turhan, 2011; Hasanuzzaman *et al.* 2016). Waterlogging reduced seed yield primarily by reducing the number of pods per plant and pod setting (Ahmad *et al.*, 2003; Ahmed *et al.*, 2002). Linkemer *et al.* (1998) identified some vegetative stages sensitive to waterlogging as well as some reproductive stages. Soybean germplasms display a spectrum of waterlogging tolerance capability. The degree of flooding tolerance of soybean germplasms varies with the developmental stages. The present study was, therefore undertaken to evaluate the effect of excess water on dry matter accumulation and yield of soybean.

A field experiment was carried out at the Agronomy field, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during December, 2013 to April 2014. The treatments were four soybean genotypes viz. i) AGS 313 ii) G 00351 iii) BD Soybean 4 (Bangladesh Soybean 4) iv) G 00197 and three waterlogging i) Control (no waterlogging) ii) waterlogging at R1 (Blooming) stage iii) waterlogging at R4 (full pod) stages for one week. These four genotypes were screened out from 50 soybean genotypes at early stage waterlogging on the basis of relative shoot dry matter accumulation. The experiment was laid out in split-plot design with three replications where waterlogging treatments were assigned in main plot and four soybean genotypes to sub-plots. Waterlogging plot area was surrounded by polythene anchored into the ground and extending 30 cm above the ground to hold water. Seed of each soybean genotypes was sown in December 2013 maintaining 30 cm line to line and 5 cm plant to plant distance. After sowing of seeds, light irrigation was given to ensure uniform germination of seeds. Control plots were irrigated at 30 and 50 DAS (days after sowing) all over the growing period. Waterlogging treated plots were irrigated at Blooming and Full pod stages. Water level of the each flooding treatments was maintained at 2.5 to 5.0 cm above ground every alternate day during the 7-day period. The plots were kept weed free. The experimental area was fertilized with 50, 160, 110, 100, 8 kg ha⁻¹ Urea, TSP, MoP, Gypsum and Boron, respectively. The entire amount of TSP, MoP, Gypsum, Boron and half of urea were applied as basal dose. Rest urea was applied before flowering. Necessary plant protection measures were taken to maintain optimum growth of the plants. At maturity five plants were randomly selected and plants were segmented into leaf, stem and roots and oven dried for 72 hours at 70° C. The observations on t dry matter per plant (including root), and yield attributes were recorded. Seed yield was adjusted to 12% moisture content. The data recorded on different parameters were statistically analyzed and the differences between the treatments means were compared by LSD test (Gomez and Gomez, 1984).

Shoot dry weight of all soybean genotypes were significantly affected by waterlogging (Fig. 1). Reduction was higher when plant was subjected to waterlogging at R4 stage than R1 stage. The highest relative shoot dry matter (69.35%) was accumulated by genotype AGS 313, while G00351 and BD soybean-4 produced only 66.97 and 65.29 %, respectively and the lowest (54.21%) in genotype G00197 (54.21%) at R4 stage of flooding. A similar trend in shoot growth was found when flooding treatment was imposed at R1 stage. The reduction in shoot dry matter is probably due to reduction in shoot length and branching. Tolerant genotypes with vigorous shoot and root growth were better able to tolerate transient waterlogging (Hartley *et al.*, 1993).



Reduction in total dry matter (DM) production and the variation in DM production among genotypes due to waterlogging are in Fig. 2. Both R1 and R4 stages of waterlogging affected significantly the total dry matter production in all the soybean genotypes. Total dry matter reduction due to waterlogging was lower at R4 stage than that at R1 stage. Waterlogging induced differences in total dry matter production among the genotypes were caused by the differences in the reduction of root, leaf and stem dry matter than control. The minimum reduction in total dry matter was noticed in genotype AGS 313 (31.05%), whereas the maximum (45.43%) in G00197 (Fig. 2). The dry matter reduction in G00351 and BD soybean 4 were (34%) and (35%), respectively. The total dry matter in genotype AGS 313 was less affected even at R1 stage waterlogging, which could be attributed to more efficient production of leaf, stem, and root dry matter. Waterlogging generally reduced the growth of plant components resulting in low total dry weight (TDW). Tolerant genotypes had more dry matter because they were lesser affected by waterlogging. The tolerant genotypes maintained greater root, shoot and leaf dry matter under waterlogging than the sensitive cultivars.

Waterlogging reduced significantly number of pods per plant compared to that in control in all the four soybean genotypes. The reduction was smaller at R1 stage waterlogging compared to that at R4 stage. In control treatment, Bangladesh soybean 4 produced the highest number of pods per plant (85.86) while waterlogging treatment was imposed at R1 and at R4 stage was 66 and 53, respectively (Table 1). The highest relative pods number per plant produced by genotype AGS 313 which was 90.86 % at R1 stage and 84.78% at R4 stage of waterlogging. The highest relative pods per plant in genotype AGS 313 might have attributed to a lower reduction in shoot dry matter as well as total dry matter. Waterlogging

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also reduced the average number of seeds per pod significantly in all the soybean genotypes studied (Table 1). The number of seeds per pod was affected a little by R1 stage flooding in all the genotypes. Under R4 stage flooding, the highest relative seeds number per pod was produced by the genotype AGS 313 (72.04%), followed by G 00351 (66.47%), BD soybean 4 (64.82%) and the lowest by G 00197 (59.25 %). The highest seeds number per pod in genotype AGS 313 was probably due to the lowest reduction in pollen fertility due to waterlogging as reported by Omae *et al.* (2005). Waterlogging induced reduction in seeds per pod was higher at later stage waterlogging as reported by Umaharan *et al.* (1997) and Zhou and Lin (1995).

Seed weight decreased significantly at R1 stage flooding, which further decreased at R4 stage (Table 2). At R1 stage flooding, 100-seed weight ranged from 7.91 to 17.93g, whereas at R4 stage waterlogging from 5.81 g to 17.89 g. Relative grain weight was the highest in AGS 313 (87.06%), followed by G 00351 (82.25%) and BD soybean 4 (72.10%), and lowest in G 00197 (71.55%) at R4 stage waterlogging. A remarkable reduction in the size of seeds was observed at R4 stage water logging in all the genotypes.

Table 1. Number of pods plant⁻¹ and number of seeds pod⁻¹ of four selected soybean genotypes as affected by waterlogging

Genotypes	Number of pods plant ⁻¹			Number of seeds pod ⁻¹		
	Control	Flooding at R1 stage	Flooding at R4 stage	Control	Flooding at R1 stage	Flooding at R4 stage
AGS 313	28.46	25.86 (90.86)	24.13 (84.78)	1.86	1.52 (81.72)	1.34 (72.04)
G 00351	20.53	17.06 (83.09)	12.93 (62.98)	1.73	1.32 (76.30)	1.15 (66.47)
BD Soybean 4	85.86	65.66 (76.47)	53.35 (62.21)	1.99	1.46 (73.33)	1.29 (64.82)
G 00197	53.26	34.86 (65.45)	25.25 (47.40)	1.89	1.22 (64.45)	1.12 (59.25)
LSD _(0.05)		8.55			0.32	
CV (%)		13.20			11.42	

Values in parenthesis indicates per cent of control

Seed yield was reduced by waterlogging in all the soybean genotypes studied and the decreasing rate was higher in R4 stage than R1 stage. Seed yield of different genotypes ranged from 1.69 to 2.70 t ha⁻¹ under normal conditions and that from 1.10 to 2.09 and 0.80 to 2.84 t ha⁻¹ respectively under R1 and R4 stage flooding conditions. (Table 2). The highest relative seed yield was found in genotype AGS 313 at both the waterlogging stages and the lowest was genotype G 00197. The highest relative pod number per plant and individual seed weight in genotype AGS 313 mostly contributed to the highest relative seed yield of this genotype.

Waterlogging reduced seed yield primarily by reducing the number of pod per plant and pod setting. The yield of soybean subjected to wet conditions at the vegetative growth stage may be reduced by 17–43% (Oosterhuis *et al.*, 1990; Scott *et al.*, 1990). Genotypic sensitivity to waterlogging could be related to the level of endogenous plant hormones, which increase dropping of flowers and/or the loss of pod setting, as also observed in other crops (Lakitan *et al.*, 1992; Umaharan *et al.*, 1997)

Table 2. 100-seed weight and grain yield (t ha^{-1}) of four selected soybean genotypes as affected by waterlogging

Genotypes	100 -seed weight (g)			Seed yield (t ha^{-1})		
	Control	Flooding at R1 stage	Flooding at R4 stage	Control	Flooding at R1 stage	Flooding at R4 stage
AGS 313	18.25	17.93 (98.24)	15.89 (87.06)	2.70	2.09 (77.40)	1.84 (68.14)
G 00351	12.35	12.08 (97.81)	10.19 (82.25)	2.54	1.73 (68.11)	1.50 (59.05)
BD Soybean 4	7.60	7.30 (96.05)	5.48 (72.10)	2.28	1.50 (65.78)	1.12 (49.12)
G 00197	8.12	7.91 (97.41)	5.81 (71.55)	1.69	1.10 (65.08)	0.80 (47.33)
LSD _(0.05)		0.92			0.36	
CV (%)		14.77			12.17	

Values in parenthesis indicates per cent of control

Based on the study it may be concluded that waterlogged affects adversely the dry matter accumulation and yield of soybean plants and the reduction was higher at Full pod stage flooding than in Blooming stage flooding. The genotype AGS 313 showed higher waterlogging tolerance while genotype G00197 was susceptible in terms of dry matter accumulation and yield performance.

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