Doi: HTTPS://DOI.ORG/10.23910/2/2023.526b

Effect of Drought Stress on Growth of Soybean under Seedling Stage

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Article History

Article ID: IJEP0526b
Received on 01st July, 2023
Received in revised form on 30th July, 2023
Accepted in final form on 15th August, 2023

Abstract

The present study was conducted during September-October, 2022 at Greenhouse facility of Experimental Farm, Faculty of Agriculture Sciences, Mandsaur University, Mandsaur, Madhya Pradesh, India to identify drought tolerant genotypes. Total sixty genotypes were sown on dated 02/09/2022 by using polythene bags in completely randomized block design with four different water regimes and two replications in each set during month of *September*2022. Data were recorded for root-shoot parameters and relative leaf water content. Mean performance of root length showed that among 60 genotypes, thirty genotypes showed increased tap roots under severe water deficit conditions (0%). Under sever water stress condition (0%) highest root length was recorded of genotypes NRC138 (20.5 cm) followed by GW251 (18.15 cm) and RSC1107 (17.2 cm) respectively while lowest root length was noted in accession GW312 (3.4 cm) followed by NRC37 (5 cm) and NRC 142 (5.15 cm) respectively. Under0% water stress highest relative leaf water content was observed in genotype JS2034 (97.16%) followed by GW10 (93.47%) and GW159 (89.18%) whereas lowest was found in GW28 (20.96%) followed by GW100 (26.31%) and AGS25 (26.66%). On basis of mean data of root length, relative leaf water content, root shoot ratio by length and visual observation of plants, 11 genotypes were identified as drought tolerant and 19 genotypes were identified as medium tolerant. The identified drought tolerant genotypes may be used as water stress tolerant genotypes in future for improvement of crop in relation to drought tolerance.

Keywords: Soybean, drought, genotypes, greenhouse, water, stress, root, shoot

1. Introduction

Fluctuation in monsoon, climatic changes and varied eco-edaphic conditions are major issues that affect its productivity of rainfed crops including soybean (Hatfield and Prueger, 2015; Vijay et al., 2018; Kumari et al., 2020, Sharma et al., 2022). Drought is one of the major abiotic stress that can bitterly reduce crops yield production, productivity as well as growth including soybean (Rodziewicz et al., 2014; Sinclair et al., 2014; Mishra et al., 2017; Lamaoui et al., 2018; Arya et al., 2021 Choudhary et al., 2021; Nikzad et al., 2023; Lumactud et al., 2023). Because, in past in each year one or other regions or one or other stages of crop, it was suffered from drought (Manavalan et al., 2009). Drought can disturb with numerous physiological processes, including oxidative stress [Reddy et. al., 2004], membrane integrity (Zhang et al., 2019), and enzyme activity (Xu et al., 2015), all of which could reduce plant growth. Plants have evolved various mechanisms, including changing morphological structure, regulation of water transport, osmotic substance and hormone, nutrient synthesis and redistribution, superoxide anion scavenging mechanism, to adapt to adverse conditions [Anjum et al., 2011; Muller et al., 2011].

Oilseeds are the most important for boosts agricultural economy globally (Sharma et al., 2022). Soybean is an important oilseed crop and is widely cultivated worldwide [Sakthivelu et al., 2008]. It is known as Miracle Crop or Golden Bean of the 20th century due to its multiple uses, rich source of world's protein (42%) and oil (20%) (Ghosh et al., 2014; Syiem et al., 2022). India contributes 10% area in case of world's total cultivated soybean area but productivity is low (only 4%),, as compared to world average (Bhatia et al., 2014). Climate change is anticipated to increase the intensity and duration of drought in major soybean production regions, which could cause crop failures and food shortages [Dai, 2013; Jhao et al., 2017]. In case of soybean production, drought severely affects growth and development and may cause yield loss by approximately 40% in the worst year (Thao and Tran, 2014; Manavalan et al., 2009; Thu et al., 2014). Therefore, the effects of drought stress on soybean performance must be evaluated to reduce the threats of climate change by developing drought tolerant varieties. Since roots are the first portion of the plant to sense and respond to changes in soil moisture, screening root traits may help to identify those genotypes showing drought tolerance (Fenta et al., 2014; Reddy et al., 2017; Brand et al., 2016 and Singh et al., 2018).

The growth response of soybean roots to drought varies among cultivars and is dependent on soil bio-physiochemical properties and the timing of the drought stress on growth stage (Benjamin et al., 2006; Bengough et al., 2011; Vijay et al., 2018). Root characters influence the amount of water and nutrient uptake from soil and have important role in maintaining crop yield under drought conditions (Narayan et al., 2014; Abdemoghny et al., 2020). Drought affects the root architecture of soybean by increase or decrease pattern of branching density, root angle and depth, and biomass partitioning (Fenta et al., 2014). Drought tolerance of a crop is a polygenic trait correlated with various morpho-physiological traitss (Singh, 2004; Abdemoghny et al., 2020). Among various traits for drought resilience in plants, deep root system is known for drought tolerance. Under water limitation condition in upper soil, plant roots search water and nutrients deeply by enhancing root length (Zhang et al., 2011). In addition, smaller and thicker leaves with accumulation of water in leaves, accumulation of osmolytes like proline, total sugar, glycine-betaine etc. for better osmotic adjustment, higher cell membrane stability and high antioxidative status (SOD, CAT, APX, GPX) of plants determine the drought tolerance capacity of crop to overcome drought (Ullah et al., 2017; Dubey et al., 2021; Ghosh et al., 2021; Saha et al., 2022). Thus, the objective of this study was to evaluate the effects of several intensities of soil water deficit treatments on soybean root morphology, vegetative growth, and physiology of sixty accessions during early seedling vegetative stage.

2. Materials and Methods

2.1. Collection of germplasm

Sixty diverse soybean genotypes (consisting released varieties and germplasm) wereprocured from ICAR- IISR (Indian Institute of Soybean Research) Indore.

2.2. Experimental details

The present investigation was conducted at Experimental Farm, Faculty of Agriculture Sciences, MandsaurUniversity, Mandsaur (M.P.), India during September-October, 2022. Total sixty genotypes were sown on dated 02/09/2022 in Greenhouse by using polythene bags in completely randomized block design with four different water regimes and two replications in each set during *Kharif* season. Four different water regimes were applied for present investigation. Thus, whole experiment has a total of 480 bags.

2.3. Screening for drought tolerance

All the genotypes in the present study were cultivated inside the Greenhouse that will help to maintain consistent temperature range (28–30°C) and relative humidity (60–70%), together with a photoperiod of 12 hour light and 12 hour dark conditions. Initially, four seeds will be sown at 2 cm depth in plastic bag (100 cm height and 11 cm diameter). Regular irrigation was continued till two leaf stage of plants under both normal and water stress conditions. The bags will be filled with a sand based premixed standard soil (1% Sand: 1% Fam Yard Mannure and 1% Clay loamy Soil). Readymade 1/4 MS Media also was poured in every polythene bag with water during sowing time For healthy emergence of plants. Irrigation was thoroughly undertaken every single day to ensure the distribution of identical water amount for individual plant. After seed sowing at 15–20 days, the extra plants were rouged out except one to two healthy seedlings. After two leaf stage of plants, water was applied in ratio of 100% (control), 50% (stress S_1), 25% (stress S_2) and 0% (stress S_3) conditions till 30 days after sowing. For the dry treatments inside the Greenhouse, rainfall was excluded several days, so that the period began with a percentage of soil available water. This was done by covering the Greenhouse with a transparent white polythene sheet by unrolling during rainfall, so the plants grew only on water stored in the soil profile which was poured in bags.

2.4. Examination of root and shoot growth at seedling stage under normal (control) and water stress conditions

After 30 days of sowing, the whole root systems from both droughts treated and well watered groups were gently removed by making vertical cut on polythene bags and washing roots by tape water for measurement of morphological observations. Roots were separated from the stems and washed with tape water. The roots were cleaned by tissue paper. Tap root was measured in cm by using one meter scale. Taproot and shoot length was measured immediately after its removal from soil. The aerial part of plant (shoot fresh weight) and root fresh weight developed under both well watered and drought conditions were measured to determine the sample fresh weight. For determination of root and shoot dry matters, the whole root and shoot systems were kept in drying oven at 65°C for 24 hours before being weighed using analytical balance.

2.5. Observations which were recorded are as follows:

2.5.1. Root length

After removing shoot portion from root, tap (main) root was measured in cm from base of tap root to collar root (root tip portion).

2.5.2. Shoot length

Shoot length was also measured in cm from root collar to the tip of main shoot.

2.5.3. Root fresh weight

Root fresh weight was measured in gram by using digital weighing balance.

2.5.4. Shoot fresh weight

Shoot fresh weight including leaves was measured in gram by measuring through digital analytical balance.

2.5.5. Root dry weight

Roots of plants sampled at 30 Days After Sowing was cut from the stem, dried moisture free in a hot air oven at 65°C for 24 hours before being weighed using analytical balance and expressed in g plant^{-1}.

2.5.6. Shoot dry weight

Shoots of plants sampled 30 Days After Sowing was cut from the root tip, dried moisture free in a hot air oven at 65°C for 24 hours. After it shoots dry weight data was measured by using analytical balance and expressed in g plant^{-1}.

2.5.7. Root: shoot ratio by weight

The root and shoot weight of selected plants was recorded as mentioned above. The shoot weight will be recorded separately after drying the shoot portion including leaves in hot air oven at 65°C for 24 hours before being weighed using analytical balance.

The Root: Shoot ratio by Weight was worked out as follows:

Root: Shoot Ratio=Root Dry Weight (in g)/Shoot Dry Weight (in g).

2.5.8. Root:Shoot ratio by length

The root and shoot length of selected plants was recorded as mentioned above.

The Root: Shoot ratio by Length by was calculated according to following formula as:

Root: Shoot Ratio by Length=Root Length (in cm)/Shoot Length (in cm).

2.1.9. Relative leaf water content

RWC has been suggested as an important criterion for screening genotypes for drought tolerance. The relative leaf water content was determined by the method suggested by Bars and Weatherly (1962).

3. Results and Discussion

It is well known that adequate water is essential for optimal growth and productivity of crops. However crops often get exposed to drought stress at different phonological phases affecting productivity. Crop Productivity under water stress might be reduced due to change in the morphological behavior, physiological/biochemical processes at the cellular and molecular levels of plants as it uses it as a survival mechanism under stress. Sever water stress conditions affects the overall, cell activities that finally reduce the plant growth. The cellular elongation process and the carbohydrates wall synthesis are sensitive to water deficit (Al-Quraan et al., 2021) and decrease in growth was the consequence of the turgiditylying down of these cells (Morgan, 1984). In, breeding for abiotic stress, screening and selection of desirable genotypes for drought tolerance is the first and foremost important step in any crop breeding program including pulses and oilseeds breeding (Jincya et al., 2019). Drought alone is a single factor which is bitterly affecting crop productivity. In India, few efforts were made to develop drought tolerant soybean varieties in India in past (Bhatia et al., 2014). So, identification of drought tolerant lines by proper screening and development of new varieties for overcome current drought situations and upcoming challenges of drought due to changing climatic conditions is essential. Keeping the above fact in view, sixty genotypes of soybean were evaluated for root length, root fresh weigh, root dry weight, root shoot ratio by weight, root shoot ratio by length and shoot length, shoot fresh weight, shoot dry weight and relative leaf water content parameters under mild (50% and 25%) and severe stress (0%) conditions along with control (100%). Mean performance of all root, shoot traits and relative leaf water content revealed significant variability among the genotypes and their interaction. Mean performance of root data showed that generally soil water deficit decreased root length. However, thirty genotypes showed increased tap roots under severe water deficit conditions (0%). The overall mean of tap roots under severe water deficit conditions (0%) and 50% water stress was recorded more (49.36 cm and 47.46) when they were compared to non-water stress (46.94 cm). Similar increasing pattern of root length was also reported by Amarapalli (2022) in green gram and Mohanlal et al. (2021) in black gram. As the plant was subjected to a water stress condition, the plant develops a good root length to uptake more amount of water from the soil.Theplants divert all the food sources from the photosynthesis process to root cell for their growth and development through develop a better root system. This confirms that the plant enhance root length to uptake enough water from the soil in water stress conditions for root length.

The genotypes which recorded high root length and high relative water content in percentage and healthy with dark green color leaves without showing any detrimental effect in stress conditions were considered as drought tolerant. Under water stress condition, roots of drought tolerant genotypes deep penetrate in soil and increase their root length for uptake water and nutrients. So, genotypes which showed high root length are considered as drought tolerant genotypes. In present study, the genotypes which appear increase root length equivalent to five cm or above, high relative leaf water content and visual dark green color of leaf and healthy plants under 0% water stress condition in comparison to non-water stress condition were considered as drought tolerant genotypes. Moreover, the genotypes which root length was increased but below five cm in compare to normal water condition (control) were considered as medium tolerant genotypes. The genotypes, recorded root length less than 5 cm (below 5 cm) under water stress, low RWC and less green plants are considered as medium susceptible whereas the genotypes which showed decreasing pattern of root length equivalent to 5 cm or more than five cm, low RWC and wilting type plants under water stress were considered as susceptible genotypes. On basis of these observations 11 genotypes were considered as drought tolerant, 19 genotypes as medium tolerant, 21 genotypes as medium susceptible and 9 genotypes as susceptible.

Root parameter is a major trait associated with soil water stress and large variations exist among genotypes of a crop species in terms of the association of root morphological traits and their functionality including root length (Clements et al., 1993; Aski et al., 2021). The genetic and molecular basis of root length in drought condition has been reported in legumes like QTLs for root surface area (Abdel-Haleem et al., 2011) and root length in soybean (Aski et al., 2021). Depth of rooting and density of root branches are essential features of root that directly uptake water and nutrient from the soil by plants when water and nutrients are limited (Wasson et al., 2012). In the early stages of plant growth, genotypes with vigorous root length take up water and minerals more effectively and have better seedling establishment (Xie et al., 2017; Aski et al., 2021). It increases photosynthetic ability, a higher output of biomass and a higher survival rate under water stress conditions. Under well water condition, genotypes namely GW99 with 18.2 cm, AGS25 with 15.7 cm, GW61 with value of 15.2 cm, GW188 with 15.1 cm, GW185 with 14.9 cm, GW143 (14.850), GW15 with 14.8 cm, GW51 with 14.05, GW382 with 14 cm, GW152 with 13.65 cm, PK472, GW 237 and TGX9336E with 13.25 cm, IC073710 (12.700), GW371 with (12.550) and GW13 with (12.50) cm recorded higher root length in comparison to other genotypes whereas genotypes GW34 with 7.20 cm followed by GW207 with 6.5 cm and GW10 with 5.5 cmexhibited low root length was notice in respectively. This indicates that these genotypes better performance under non-water stress condition.Under sever water stress condition (0%) genotypes NRC138 with 20.5 cm, GW251 with 18.15 cm, RSC1107 with 17.2 cm, GW159 with 17.1 cm, GW 152 with 17.05 cm, GW17 with 16.25 cm,GW21 (15.50),JS9560 with 14.75 cm, GW203 (14.60),JS2069 with 13.9 cm, AMS 2014-1 and GW223 with 13.75 showed highest root length while accessions GW253 with 6.1 cm followed by GW196 with 5.5 cm, GW45 with 5.4 cm GW214 with 5.2, NRC 142 with 5.15 cm, NRC37 with 5 cm, GW312 with 3.4 cm exhibited lowest root length respectively. The genotypes with longer roots have deeper root system would allow water extraction from lower soil profiles and thus, it is expected that the plant will perform better under moisture stress. Increase in root length is an adaptive mechanism for drought tolerant genotypes. Therefore, higher value may be used for the discrimination between drought tolerant and susceptible genotypes. Rauf and Sadaqat (2008) stated that increase in root length occurred due to higher osmotic adjustment ability of drought genotypes. Chun et al. (2005), (Petcu and Petcu, 2006) and Amarapalli (2022) also indicated that increase in root length occurred at expense of lateral roots (Table 1).

Water stress during seedling stage was most critical interms of shoot length (Baroowa and Gogoi, 2016). If water stress increase, shoot lengthdecrease. Perusal data of mean of shoot length under non water stress and water stress conditions depicted highest shoot length for the genotype GW155 (79.45 cm in normal water, 74.00 cm in 50%) and GW17 (73.25 cm) in 25% water stress condition and GW10 (90.50 cm) sever water stress condition 0%. The decline in the amount of water in drought condition is due to decline in cell growth and enlargement. According to Kramer, first effect of drought is decrease of growth of plants which is result of decrease in cell expansion. Cell expansion or cell elongation is mainly based on turgidity of the cell which is reduced under water stress conditions causing reduction in shoot length. Similar findings are also reported by Deshmukh et al., 2001 in sorghum, Babu and Rosaiah, 2017 in black gram. Mean value of shoot length reported that root length of genotypes AGS 218 more affected in 25% (17.90 cm) and 0% (14.10) water stress conditions, it means, in this genotype drought bitterly affects cell turgidity which decrease the rate of cell division and cell expansion and check cell growth and development of shoot length of genotype AGS 218. Under well water condition, genotypes namely GW155 with 79.45 cm, GW143 with 74.65 cm, GW15

Table 1: List of tolerant and medium tolerant genotypes

Sl. No.	Tolerant	Medium Tolerant	Medium susceptible	Suscep-tible
1.	GW-159	GW-164	GW-34	GW-371 (K-21C)
2.	GW-21	GW-152 (K-21C)	GW-371 (K-21C)	GW-237 (K-25)
3.	AMS-2014-1 (CHECK)	GW-134	GW-155	GW-99
4.	GW-10	AGS-218	GW-312	GW-143
5.	GW-17	GW-132	GW-15	GW-196
6.	GW-178	GW-28	GW-51(K-21)	NRC37 (CHECK)
7.	JS-2069	GW-87	GW-382	GW-188
8.	GW-251	GW-207	GW-108	GW-185
9.	RSC-1107 (CHECK)	GW-52	GW-100	AGS-25
10.	NRC-138	GW-286	IC-073710	
11.	JS-9560	GW-223	GW-13	
12.		GW-212	GW-89	
13.		NRC-127	GW-291	
14.		GW-203	GW-221	
15.		JS-2034	GW-214	
16.		GW-234	NRC-142	
17.		JS-20-116	GW-253	
18.		SQL-110	GW-225	
19.		PK-472 (CHECK)	TGX-9336E	
20.			GW-161	
21.			GW-45	

with 70.65 cm, GW-237 (k-25) with 69.05 cm GW188 with 67.15 cm GW-207 with 64.50 cm and showed higher shoot length in comparison to other genotypes whereas genotypes namely GW-234 with 12.20 cm and GW28 with 18.65 cm exhibited minimum shoot length respectively.Under sever water stress condition (0%) genotypes namely GW-10 with 90.50 cm, GW17 with (85.50), GW-223 with 76.25 cm, AMS-2014-1 with 71.35 and GW132,GW87, GW207 with 67.10 cm showed highest shoot length while accessions namely AGS-218 with 14.10 cm and PK-472 with 28.15 cm exhibited low shoot length.

Root and shoot biomasses are presented in Table 2, 3, 4 and 5 under non water stress and water stress conditions. Result of biomass of root and shoot indicated that water stress has a inhibitory impact on root and shoot biomass among all genotypes. The root length are positively correlated with yield and biomass (Zobel and Waisel, 2010; Aski et al., 2021).

Root fresh weight increased with the increase in severity of water stress. Estimated root fresh weight data showed that genotypes *viz.* GW13 with (0.39 g), GW15 with (0.38 g) and GW100 with (0.37 g) had high root fresh weight whereas low fresh weight was recorded in genotypes namely, NRC138 with (0.04 g), GW164 with (0.07 g) and GW212 with (0.08 g) under

Table 2: Mean performance of 60 soybean genotypes under control or non-water stress condition

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
1	GW-34	7.650	57.400	0.230	0.885	67.345	0.022	0.136	0.134	0.162
2	GW-371(K-21C)	12.550	56.700	0.179	0.560	74.755	0.019	0.065	0.219	0.293
3	GW-63(K-21)	8.750	54.100	0.183	1.357	93.150	0.016	0.300	0.162	0.054
4	GW-237(K-25)	13.250	69.050	0.345	0.970	81.145	0.042	0.265	0.193	0.157
5	GW-155	10.050	79.450	0.121	1.208	84.705	0.022	0.218	0.127	0.099
6	GW-159	8.200	55.000	0.135	0.762	46.880	0.014	0.117	0.149	0.120
7	GW-99	18.200	55.800	0.264	1.126	78.175	0.021	0.135	0.327	0.155
8	GW-164	7.550	30.650	0.067	0.808	81.265	0.019	0.165	0.247	0.111
9	GW-312	5.050	32.100	0.106	0.670	69.705	0.020	0.137	0.158	0.159
10	GW-143	14.850	74.650	0.236	1.066	76.660	0.023	0.143	0.199	0.158
11	GW-152(K-21-C)	13.650	29.555	0.240	0.524	42.635	0.024	0.066	0.462	0.363
12	GW-15	14.800	70.650	0.375	1.277	71.830	0.031	0.179	0.210	0.173
13	GW-51(K-21)	14.050	52.100	0.285	1.126	84.770	0.033	0.196	0.270	0.170
14	GW-21	7.700	39.755	0.104	0.366	29.055	0.018	0.049	0.194	0.358
15	GW-161	15.200	57.000	0.360	0.905	18.765	0.042	0.105	0.267	0.399
16	GW-234	12.450	12.200	0.075	0.481	20.705	0.032	0.122	1.023	0.260
17	GW-196	11.250	59.950	0.238	1.349	82.100	0.055	0.196	0.188	0.281
18	GW-382	14.000	43.750	0.240	0.309	84.190	0.020	0.077	0.320	0.260
19	GW-134	8.350	29.450	0.123	0.545	55.530	0.019	0.112	0.285	0.166
20	AMS-2014-1 (CHECK)	8.300	48.450	0.089	0.288	51.310	0.011	0.062	0.172	0.179
21	AGS-218	8.350	38.100	0.155	0.509	33.235	0.029	0.080	0.220	0.363
22	GW-108	11.350	47.050	0.325	1.013	92.815	0.021	0.190	0.241	0.111
23	GW-132	8.300	39.700	0.129	0.880	77.215	0.020	0.117	0.209	0.172
24	PK-472 (CHECK)	13.250	49.250	0.264	1.165	75.405	0.030	0.172	0.269	0.171
25	GW-100	11.350	57.000	0.370	0.712	37.060	0.030	0.107	0.199	0.282
26	GW-10	5.550	38.100	0.109	0.725	83.995	0.020	0.102	0.145	0.197
27	IC-073710	12.700	53.100	0.348	1.046	72.665	0.041	0.189	0.239	0.218
28	GW-17	9.000	51.000	0.277	1.126	53.885	0.029	0.196	0.177	0.146

Table 2: Continue...

Sl. No	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
29	GW-13	12.500	33.250	0.389	0.357	81.745	0.018	0.071	0.376	0.248
30	GW-28	8.350	18.650	0.341	0.191	54.980	0.037	0.054	0.450	0.687
31	NRC-37(CHECK)	10.500	53.100	0.185	1.213	87.240	0.022	0.189	0.198	0.114
32	GW-178	7.200	39.850	0.291	0.452	76.620	0.038	0.071	0.181	0.539
33	GW-87	11.200	41.300	0.333	0.805	75.315	0.036	0.123	0.272	0.293
34	GW-45	11.650	50.950	0.290	0.326	51.720	0.039	0.071	0.229	0.551
35	GW-89	10.050	50.000	0.153	0.509	77.030	0.018	0.110	0.201	0.165
36	JS-2069	7.700	25.950	0.145	0.316	40.505	0.012	0.065	0.297	0.177
37	GW-207	6.500	64.500	0.175	1.088	44.900	0.009	0.152	0.101	0.056
38	GW-188	15.100	67.150	0.300	1.412	75.770	0.024	0.258	0.225	0.093
39	GW-185	14.900	58.150	0.325	1.068	91.800	0.016	0.147	0.257	0.106
40	GW-52	8.650	48.000	0.130	0.929	62.130	0.023	0.141	0.185	0.160
41	GW-286	8.700	52.250	0.230	0.943	42.975	0.017	0.182	0.167	0.091
42	GW-223	11.900	34.000	0.205	0.483	49.000	0.020	0.074	0.350	0.263
43	GW-251	8.950	40.850	0.159	0.507	44.475	0.027	0.057	0.220	0.474
44	GW-291	10.750	47.300	0.205	0.754	90.525	0.028	0.059	0.227	0.478
45	GW-221	9.700	40.735	0.161	0.453	81.500	0.016	0.054	0.238	0.301
46	RSC-1107(CHECK)_	7.000	40.400	0.126	0.587	51.885	0.011	0.100	0.173	0.112
47	GW-212	8.450	21.100	0.084	0.041	30.680	0.009	0.025	0.400	0.348
48	NRC-138	9.450	29.555	0.042	0.524	20.675	0.018	0.066	0.320	0.266
49	GW-214	9.950	58.300	0.170	1.326	65.400	0.009	0.211	0.171	0.043
50	NRC-142	9.150	63.050	0.178	1.463	73.270	0.012	0.136	0.145	0.084
51	NRC-127	7.450	46.600	0.130	0.676	54.130	0.011	0.105	0.160	0.104
52	JS-9560	9.500	58.700	0.133	1.592	71.475	0.019	0.235	0.162	0.079
53	GW-203	12.000	36.200	0.136	0.884	39.065	0.017	0.123	0.332	0.135
54	JS-20-116	7.150	42.200	0.134	0.885	57.185	0.027	0.099	0.170	0.269
55	JS-2034	8.250	49.800	0.100	0.717	64.790	0.030	0.116	0.166	0.260
56	GW-253	8.900	53.050	0.155	0.689	81.360	0.028	0.070	0.168	0.396
57	GW-225	11.000	54.650	0.110	1.412	31.735	0.032	0.246	0.201	0.128
58	TGX-9336E	13.250	42.200	0.169	0.757	51.245	0.024	0.124	0.314	0.194
59	SQL-110	8.250	19.250	0.105	0.223	82.005	0.043	0.057	0.429	0.756
60	AGS-25	15.700	54.450	0.180	1.052	46.975	0.079	0.220	0.289	0.356
	Mean	10.424	46.943	0.199	0.807	62.851	0.025	0.130	0.246	0.234
	Min	5.050	12.200	0.042	0.041	18.765	0.009	0.025	0.101	0.043
	Max	18.200	79.450	0.389	1.592	93.150	0.079	0.300	1.023	0.756
	SE(d)	1.275	1.691	0.022	0.118	1.336	0.002	0.007	0.034	0.028
	CD (p=0.05)	2.557	3.392	0.044	0.236	2.680	0.004	0.014	0.067	0.057
	C.V. (%)	12.227	3.602	11.022	14.617	2.126	8.050	5.309	13.658	12.158

Table 3: Mean performance of 60 soybean genotypes under control or 50% water stress condition

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
1	GW-34	5.550	49.800	0.109	0.609	30.790	0.020	0.122	0.112	0.164
2	GW-371(K-21C)	10.500	51.750	0.107	0.790	86.635	0.017	0.079	0.203	0.217
3	GW-63(K-21)	10.700	49.500	0.220	0.976	34.560	0.020	0.217	0.217	0.090
4	GW-237(K-25)	10.850	65.750	0.347	0.842	77.110	0.044	0.231	0.165	0.191
5	GW-155	9.500	74.000	0.110	0.992	81.105	0.018	0.179	0.129	0.101
6	GW-159	9.200	56.250	0.190	0.705	55.850	0.019	0.109	0.164	0.174
7	GW-99	16.100	46.950	0.235	0.866	76.900	0.015	0.102	0.345	0.146
8	GW-164	8.300	33.150	0.074	0.730	81.695	0.010	0.147	0.250	0.067
9	GW-312	4.550	29.800	0.995	0.608	44.925	0.020	0.097	0.153	0.206
10	GW-143	12.600	72.450	0.208	0.923	80.365	0.020	0.124	0.174	0.162
11	GW-152(K-21-C)	14.150	33.100	0.253	0.535	45.905	0.035	0.065	0.428	0.534
12	GW-15	12.600	68.500	0.195	0.960	67.090	0.022	0.119	0.184	0.181
13	GW-51(K-21)	10.600	50.550	0.218	0.972	80.370	0.033	0.170	0.210	0.194
14	GW-21	8.450	42.750	0.112	0.677	37.860	0.017	0.133	0.198	0.124
15	GW-161	12.600	49.850	0.327	0.501	84.165	0.033	0.057	0.253	0.583
16	GW-234	9.600	15.050	0.057	0.279	32.735	0.024	0.071	0.641	0.343
17	GW-196	8.050	54.900	0.145	0.644	66.040	0.029	0.094	0.147	0.309
18	GW-382	9.250	33.850	0.194	0.213	81.105	0.014	0.053	0.273	0.270
19	GW-134	9.350	41.755	0.164	0.607	56.535	0.023	0.124	0.224	0.182
20	AMS-2014-1 (CHECK)	10.850	59.500	0.116	0.328	56.330	0.014	0.072	0.183	0.189
21	AGS-218	10.100	34.000	0.178	0.486	77.030	0.031	0.076	0.297	0.407
22	GW-108	8.500	45.450	0.118	1.055	84.040	0.015	0.194	0.187	0.074
23	GW-132	8.500	48.750	0.185	1.123	93.265	0.023	0.148	0.175	0.156
24	PK-472(CHECK)	10.800	44.200	0.258	0.829	20.555	0.011	0.123	0.245	0.085
25	GW-100	9.150	54.050	0.289	0.421	33.770	0.023	0.063	0.169	0.372
26	GW-10	7.100	59.050	0.148	0.817	82.595	0.012	0.115	0.121	0.103
27	IC-073710	8.300	41.500	0.176	0.497	81.135	0.031	0.129	0.200	0.235
28	GW-17	9.200	68.250	0.633	1.727	73.255	0.034	0.298	0.135	0.113
29	GW-13	9.850	38.050	0.185	0.612	92.420	0.009	0.122	0.259	0.070
30	GW-28	8.500	36.950	0.203	0.867	44.925	0.019	0.133	0.230	0.143
31	NRC-37(CHECK)	7.950	51.050	0.149	0.985	84.070	0.018	0.142	0.156	0.127
32	GW-178	7.750	46.500	0.274	0.938	78.005	0.044	0.147	0.167	0.296
33	GW-87	10.200	44.950	0.223	0.821	77.110	0.022	0.126	0.228	0.170
34	GW-45	10.950	48.050	0.275	0.188	44.200	0.039	0.041	0.228	0.942
35	GW-89	8.200	45.150	0.123	0.487	77.960	0.012	0.106	0.182	0.114
36	JS-2069	8.250	32.150	0.151	0.357	57.135	0.012	0.074	0.257	0.164
37	GW-207	6.900	65.150	0.194	1.091	49.205	0.011	0.149	0.106	0.071
38	GW-188	14.000	55.800	0.230	1.139	75.755	0.019	0.210	0.252	0.091

Table 3: Continue...

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
39	GW-185	13.650	52.150	0.299	0.698	82.665	0.013	0.095	0.262	0.137
40	GW-52	9.450	49.900	0.100	0.937	45.475	0.020	0.143	0.190	0.140
41	GW-286	7.200	44.400	0.195	0.921	66.540	0.013	0.163	0.163	0.077
42	GW-223	7.750	40.350	0.166	0.698	84.730	0.017	0.108	0.192	0.154
43	GW-251	9.700	45.400	0.165	0.611	47.140	0.028	0.069	0.214	0.402
44	GW-291	10.300	46.950	0.221	0.738	84.965	0.010	0.057	0.220	0.177
45	GW-221	7.350	31.350	0.090	0.422	56.680	0.013	0.051	0.235	0.260
46	RSC-1107(CHECK)_	9.650	41.700	0.142	0.803	61.740	0.013	0.135	0.232	0.093
47	GW-212	8.850	33.050	0.085	0.072	34.695	0.009	0.044	0.270	0.204
48	NRC-138	10.800	32.350	0.650	0.708	27.415	0.031	0.114	0.334	0.272
49	GW-214	8.100	55.850	0.135	1.184	49.205	0.006	0.189	0.145	0.032
50	NRC-142	6.150	60.700	0.115	1.386	66.590	0.008	0.130	0.101	0.058
51	NRC-127	9.100	50.600	0.142	0.792	82.115	0.012	0.124	0.180	0.097
52	JS-9560	9.800	53.950	0.150	1.588	75.615	0.023	0.234	0.182	0.099
53	GW-203	12.550	34.100	0.147	0.855	47.140	0.018	0.120	0.368	0.147
54	JS-20-116	9.400	55.750	0.215	0.894	59.100	0.032	0.100	0.169	0.318
55	JS-2034	7.550	51.900	0.145	1.005	67.040	0.035	0.163	0.146	0.212
56	GW-253	6.100	47.700	0.080	0.650	54.705	0.020	0.065	0.128	0.310
57	GW-225	8.250	52.300	0.088	0.859	57.735	0.030	0.150	0.158	0.201
58	TGX-9336E	14.350	57.400	0.044	0.941	56.485	0.012	0.155	0.251	0.074
59	SQL-110	8.500	22.600	0.090	0.324	71.265	0.042	0.082	0.376	0.513
60	AGS-25	13.100	49.350	0.070	0.833	35.645	0.022	0.151	0.266	0.144
	Mean	9.587	47.468	0.198	0.769	63.320	0.021	0.123	0.217	0.205
	Min	4.550	15.050	0.044	0.072	20.555	0.006	0.041	0.101	0.032
	Max	16.100	74.000	0.995	1.727	93.265	0.044	0.298	0.641	0.942
	SE(d)	0.858	2.028	0.028	0.113	2.892	0.003	0.002	0.023	0.035
	CD (p=0.05)	1.721	4.068	0.055	0.226	5.801	0.007	0.003	0.047	0.070
	C.V. (%)	8.951	4.272	13.960	14.667	4.567	15.913	1.406	10.748	17.128

Table 4: Mean performance of 60 soybean genotypes under control or 25% water stress condition

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
1	GW-34	7.400	53.050	0.117	0.618	71.435	0.022	0.125	0.140	0.172
2	GW-371(K-21C)	9.250	49.700	0.235	0.688	92.115	0.023	0.077	0.186	0.301
3	GW-63(K-21)	8.900	57.750	0.191	0.800	62.810	0.017	0.179	0.155	0.095
4	GW-237(K-25)	8.800	41.650	0.277	0.489	63.290	0.011	0.134	0.212	0.080
5	GW-155	8.950	68.000	0.111	0.765	61.090	0.023	0.109	0.132	0.212
6	GW-159	15.200	44.250	0.239	0.667	84.915	0.029	0.103	0.344	0.282

Table 4: Continue...

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
7	GW-99	13.750	44.200	0.244	0.873	70.550	0.029	0.102	0.313	0.283
8	GW-164	8.500	38.750	0.079	0.660	80.695	0.028	0.138	0.220	0.201
9	GW-312	3.750	30.010	0.885	0.651	42.165	0.015	0.085	0.125	0.178
10	GW-143	7.350	65.800	0.141	0.964	67.395	0.016	0.128	0.112	0.125
11	GW-152(K-21-C)	14.550	37.650	0.294	0.573	54.950	0.040	0.073	0.388	0.545
12	GW-15	9.350	64.800	0.115	0.853	26.435	0.027	0.088	0.144	0.303
13	GW-51(K-21)	9.100	39.600	0.225	0.648	70.320	0.024	0.114	0.231	0.207
14	GW-21	13.750	46.300	0.170	0.425	76.965	0.023	0.096	0.297	0.235
15	GW-161	7.250	37.000	0.187	0.412	85.905	0.015	0.045	0.196	0.324
16	GW-234	8.200	31.050	0.066	1.267	32.380	0.022	0.319	0.265	0.069
17	GW-196	6.150	36.900	0.136	0.143	80.330	0.025	0.047	0.168	0.536
18	GW-382	8.800	37.900	0.205	0.170	77.100	0.015	0.043	0.232	0.348
19	GW-134	10.100	42.300	0.183	0.690	65.405	0.023	0.140	0.239	0.161
20	AMS-2014-1(CHECK)	11.450	70.000	0.121	0.649	61.290	0.015	0.141	0.164	0.108
21	AGS-218	8.350	17.900	0.141	0.403	47.090	0.027	0.069	0.467	0.387
22	GW-108	6.800	44.700	0.089	0.982	74.765	0.015	0.182	0.152	0.079
23	GW-132	9.100	63.500	0.131	1.698	89.705	0.018	0.223	0.143	0.079
24	PK-472(CHECK)	10.850	37.150	0.355	0.364	30.905	0.029	0.053	0.293	0.540
25	GW-100	8.200	52.050	0.255	0.220	29.485	0.019	0.032	0.158	0.591
26	GW-10	9.100	73.250	0.225	0.847	90.310	0.024	0.120	0.124	0.196
27	IC-073710	7.650	39.500	0.138	0.263	77.840	0.023	0.068	0.194	0.334
28	GW-17	10.100	73.250	0.212	0.847	76.990	0.032	0.146	0.138	0.216
29	GW-13	8.900	49.150	0.175	1.271	84.770	0.008	0.253	0.181	0.030
30	GW-28	10.850	44.650	0.228	1.153	33.285	0.020	0.179	0.243	0.112
31	NRC-37(CHECK)	6.600	47.900	0.124	0.538	79.995	0.016	0.082	0.138	0.195
32	GW-178	8.900	53.000	0.210	1.449	79.205	0.047	0.226	0.168	0.206
33	GW-87	6.300	33.000	0.498	0.375	56.810	0.084	0.052	0.192	1.635
34	GW-45	8.200	40.750	0.188	0.244	42.225	0.027	0.053	0.201	0.505
35	GW-89	7.000	42.950	0.092	0.310	62.235	0.008	0.068	0.163	0.112
36	JS-2069	9.050	43.150	0.165	0.433	46.630	0.025	0.090	0.210	0.281
37	GW-207	8.900	66.650	0.218	0.917	54.980	0.013	0.132	0.134	0.098
38	GW-188	10.150	44.700	0.214	1.030	75.755	0.018	0.191	0.227	0.092
39	GW-185	9.650	49.200	0.211	0.624	83.180	0.008	0.085	0.196	0.095
40	GW-52	11.150	48.000	0.170	0.921	65.405	0.027	0.141	0.233	0.188
41	GW-286	6.300	40.150	0.160	0.853	72.700	0.010	0.155	0.157	0.065
42	GW-223	9.150	50.900	0.188	0.837	80.810	0.017	0.128	0.179	0.133
43	GW-251	12.250	52.700	0.205	0.723	67.170	0.032	0.080	0.233	0.391
44	GW-291	10.200	44.650	0.245	0.609	77.795	0.010	0.047	0.228	0.205
45	GW-221	7.250	37.100	0.085	0.453	53.885	0.013	0.054	0.196	0.231

Table 4: Continue...

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
46	RSC-1107(CHECK)_	11.500	42.350	0.143	0.770	68.835	0.014	0.129	0.272	0.105
47	GW-212	10.650	41.500	0.011	0.104	51.050	0.012	0.064	0.257	0.180
48	NRC-138	16.450	34.950	0.135	0.723	31.000	0.053	0.121	0.471	0.436
49	GW-214	7.100	53.700	0.128	1.062	40.890	0.006	0.170	0.133	0.036
50	NRC-142	5.500	58.000	0.095	1.301	49.205	0.006	0.122	0.095	0.045
51	NRC-127	10.900	55.800	0.148	0.938	85.430	0.012	0.144	0.196	0.080
52	JS-9560	13.750	46.650	0.184	1.576	80.480	0.027	0.233	0.295	0.114
53	GW-203	14.200	35.450	0.149	0.990	57.325	0.017	0.138	0.401	0.123
54	JS-20-116	12.500	38.900	0.366	0.813	72.670	0.055	0.082	0.321	0.670
55	JS-2034	10.700	54.900	0.164	1.447	84.050	0.037	0.234	0.195	0.157
56	GW-253	6.550	42.300	0.090	0.624	67.140	0.021	0.062	0.155	0.342
57	GW-225	7.700	55.650	0.060	1.739	46.880	0.027	0.302	0.139	0.090
58	TGX-9336E	12.300	50.900	0.290	0.785	45.780	0.083	0.130	0.243	0.641
59	SQL-110	10.550	25.100	0.177	0.369	82.815	0.041	0.092	0.420	0.440
60	AGS-25	10.900	42.200	0.160	0.796	31.420	0.048	0.145	0.259	0.333
	Mean	9.546	46.749	0.191	0.757	64.274	0.025	0.123	0.218	0.259
	Min	3.750	17.900	0.011	0.104	26.435	0.006	0.032	0.095	0.030
	Max	16.450	73.250	0.885	1.739	92.115	0.084	0.319	0.471	1.635
	SE(d)	0.829	1.901	0.024	0.120	1.365	0.003	0.002	0.021	0.030
	CD (p=0.05)	1.663	3.814	0.048	0.240	2.738	0.005	0.005	0.043	0.060
	C.V. (%)	8.686	4.067	12.644	15.815	2.124	10.871	1.829	9.787	11.614

Table 5: Mean performance of 60 soybean genotypes under 0% water stress condition

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
1	GW-34	8.15	43.15	0.111	0.580	72.13	0.021	0.117	0.189	0.176
2	GW-371(K-21C)	7.50	46.20	0.210	0.493	70.50	0.020	0.057	0.162	0.359
3	GW-63(K-21)	10.30	40.60	0.214	0.693	29.57	0.021	0.156	0.254	0.132
4	GW-237(K-25)	6.95	57.60	0.206	0.687	20.06	0.013	0.187	0.122	0.067
5	GW-155	8.70	65.80	0.109	0.656	48.59	0.021	0.092	0.133	0.228
6	GW-159	17.10	45.50	0.223	0.639	90.35	0.026	0.098	0.376	0.265
7	GW-99	8.95	46.20	0.188	0.725	56.04	0.011	0.083	0.193	0.128
8	GW-164	8.85	39.65	0.085	0.648	81.48	0.018	0.132	0.223	0.137
9	GW-312	3.40	28.25	0.789	0.601	41.23	0.011	0.068	0.120	0.162
10	GW-143	7.05	45.60	0.131	0.469	64.13	0.013	0.062	0.155	0.211
11	GW-152(K-21-C)	17.05	48.10	0.311	0.809	69.14	0.041	0.104	0.355	0.390
12	GW-15	10.85	45.45	0.125	0.712	51.58	0.036	0.072	0.239	0.501
13	GW-51(K-21)	9.25	28.90	0.241	0.545	75.76	0.023	0.096	0.321	0.243

Table 5: Continue...

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
14	GW-21	15.50	49.10	0.315	1.116	80.27	0.024	0.221	0.316	0.109
15	GW-161	6.85	34.65	0.149	0.350	72.84	0.012	0.039	0.198	0.311
16	GW-234	6.65	48.45	0.044	0.525	54.19	0.022	0.132	0.137	0.164
17	GW-196	5.55	31.00	0.137	0.125	83.74	0.026	0.155	0.179	0.185
18	GW-382	9.70	30.00	0.215	0.187	40.66	0.017	0.046	0.324	0.375
19	GW-134	12.95	45.00	0.210	1.015	76.56	0.026	0.204	0.288	0.125
20	AMS-2014-1(CHECK)	13.75	71.35	0.123	1.066	66.52	0.018	0.230	0.193	0.078
21	AGS-218	12.85	14.10	0.175	0.353	68.93	0.030	0.053	0.911	0.575
22	GW-108	9.40	43.30	0.099	0.946	66.41	0.018	0.176	0.218	0.103
23	GW-132	9.90	67.10	0.135	1.776	85.74	0.018	0.233	0.148	0.077
24	PK-472(CHECK)	9.60	28.15	0.224	0.603	70.56	0.049	0.089	0.342	0.550
25	GW-100	7.10	48.95	0.235	0.181	26.74	0.018	0.031	0.146	0.574
26	GW-10	10.30	90.50	0.214	0.939	94.00	0.021	0.134	0.115	0.153
27	IC-073710	7.70	32.35	0.131	0.295	56.33	0.022	0.073	0.239	0.306
28	GW-17	16.25	85.50	0.234	1.329	87.38	0.038	0.229	0.190	0.166
29	GW-13	9.60	57.45	0.188	1.560	49.26	0.013	0.310	0.167	0.042
30	GW-28	12.55	54.25	0.329	1.531	21.24	0.033	0.238	0.232	0.137
31	NRC-37(CHECK)	5.00	46.35	0.105	0.480	74.67	0.014	0.074	0.108	0.190
32	GW-178	13.30	60.00	0.265	2.275	83.89	0.047	0.355	0.222	0.133
33	GW-87	12.55	67.10	0.347	1.335	72.17	0.040	0.208	0.188	0.191
34	GW-45	5.45	35.70	0.065	0.192	61.20	0.009	0.044	0.154	0.198
35	GW-89	5.70	39.70	0.060	0.185	53.13	0.004	0.165	0.144	0.023
36	JS-2069	13.90	57.85	0.189	0.522	68.97	0.015	0.111	0.240	0.135
37	GW-207	11.00	67.10	0.242	1.335	54.04	0.016	0.208	0.164	0.077
38	GW-188	8.30	40.15	0.135	0.759	46.88	0.011	0.141	0.207	0.075
39	GW-185	8.65	47.05	0.188	0.512	47.74	0.007	0.068	0.184	0.096
40	GW-52	10.95	35.70	0.160	0.606	59.88	0.026	0.094	0.307	0.278
41	GW-286	10.10	63.80	0.295	1.300	87.24	0.135	0.236	0.158	0.574
42	GW-223	13.75	76.25	0.123	0.872	89.15	0.018	0.133	0.181	0.134
43	GW-251	18.15	66.60	0.395	0.917	77.14	0.059	0.102	0.273	0.582
44	GW-291	8.80	43.30	0.185	0.653	70.54	0.005	0.050	0.204	0.090
45	GW-221	8.25	40.75	0.100	0.456	67.15	0.041	0.055	0.203	0.750
46	RSC-1107(CHECK)_	17.20	43.50	0.174	0.881	71.94	0.017	0.147	0.396	0.112
47	GW-212	12.00	55.60	0.013	0.185	61.25	0.015	0.115	0.217	0.126
48	NRC-138	20.50	52.85	0.175	0.816	46.34	0.057	0.127	0.388	0.445
49	GW-214	5.20	50.80	0.095	0.903	36.94	0.005	0.145	0.103	0.031
50	NRC-142	5.15	55.70	0.092	1.236	44.75	0.007	0.116	0.093	0.061
51	NRC-127	11.65	58.85	0.164	1.239	84.68	0.016	0.186	0.198	0.084
52	JS-9560	14.75	46.65	0.193	1.477	89.21	0.028	0.219	0.317	0.126

Table 5: Continue...

Sl. No.	Genotypes	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	RWC %	Root dry weight (g)	Shoot dry weight (g)	Root shoot ratio by length	Root shoot ratio by weight
53	GW-203	14.60	38.05	0.170	1.250	65.54	0.019	0.173	0.384	0.110
54	JS-20-116	11.70	48.00	0.335	0.889	69.85	0.058	0.089	0.245	0.648
55	JS-2034	12.50	62.85	0.191	2.348	95.84	0.039	0.378	0.199	0.103
56	GW-253	6.15	60.80	0.095	0.752	58.62	0.032	0.074	0.101	0.428
57	GW-225	9.45	57.50	0.095	2.089	31.83	0.031	0.363	0.165	0.085
58	TGX-9336E	10.45	56.25	0.225	0.872	37.15	0.077	0.144	0.186	0.534
59	SQL-110	9.75	37.25	0.163	1.023	84.15	0.040	0.247	0.262	0.160
60	AGS-25	9.60	37.10	0.045	0.706	26.91	0.014	0.128	0.259	0.105
	Mean	10.41	49.36	0.186	0.854	63.18	0.026	0.144	0.227	0.229
	Min	3.40	14.10	0.013	0.125	20.06	0.004	0.031	0.093	0.023
	Max	20.50	90.50	0.789	2.348	95.84	0.135	0.378	0.911	0.750
	SE(d)	0.84	2.43	0.021	0.110	1.37	0.002	0.009	0.019	0.033
	CD (p=0.05)	1.68	4.88	0.042	0.220	2.74	0.005	0.017	0.039	0.066
	C.V. (%)	8.06	4.93	11.350	12.871	2.16	8.641	6.036	8.532	14.413

non water stress condition respectively. Under 0% stress condition, high root fresh weight was recorded for genotype GW312 with (0.79 g) followed by GW251 with (0.40 g) and GW87 with (0.35 g)whereaslowest root fresh weight was recorded by GW212 with (0.01 g), AGS25 with (0.05 g), GW89 with (0.06 g) and GW45 with (0.07 g) respectively.

Shoot fresh weight decreased under water stress condition. Under normal water condition highest shoot fresh weight was noticed for genotype JS9560 with (1.59 g), followed by NRC142 with (1.46 g) and (GW188 and GW225 with 1.41 g and low shoot fresh was produced by genotypeGW212 with (0.04 g), GW28 with (0.19 g), and SQL110 with (0.22 g). Under severe water stress condition, highest soot fresh weight was revealed by genotype JS2034 with (2.348) followed by GW178 with (2.275), GW225 with (2.089) while lowest was denoted by GW100 with (0.18 g). Overall mean performance of shoot fresh weight (g plant^{-1}) decreased under the mild water stress conditions (50% and 25%) but increases under sever water stress condition (0%). The overall mean of shoot fresh weight recorded significantly higher in 0% water stress condition (0.85 g plant^{-1}) which was at par with means of non-water stress (0.81 g plant^{-1}), 50% water stress condition (0.79 g plant^{-1}) and 25% water stress condition (0.76 g plant^{-1}) respectively. In different water regimes (100 ml, 50 ml, 25 ml and 0 ml), highest shoot fresh weight was recorded for the genotype JS9560 (1.59 g plant^{-1}) for normal water (100%), GW17 (1.73 g plant^{-1}) for 50%, GW225 (1.74 g plant^{-1}) for 25% and JS2034 (2.35 g plant^{-1}) respectively.

Relative leaf water content is very important parameter for characterization of genotypes in relation to drought tolerance. Research studies in drought conditions in different crops reported that drought tolerant genotypes showed high relative leaf water content under drought condition. Under well water condition, GW 63(K-21) with 93.15%, GW108 with 92.81%, GW185 with 91.80%, GW-291 with 90.52%, NRC37 with 87.24% and GW51 with 84.70% showed higher relative water content in comparison to other genotypes whereas genotypes namely GW161 with 18.76%,NRC138 with (20.67%), GW234 with 20.70% and GW21 With 29.05% exhibited minimum relative water content respectively. Among the 60 genotype, under sever water stress condition (0%) genotypes *viz.* JS2034 with 95.84%, GW-10 with 94.00%, GW159 with 90.35%, JS9560 with 89.21%, GW223 with 89.15% and GW17 With 87.38% expressed highest relative water content while accessions namely GW237 with 20.06%, GW28 with 21.24% and GW100 With 26.74%, exhibited lowrelative water content respectively. This variation in relative water content may be attributed to different ability of genotypes to absorb water from soil or the ability to control transpiration loss of water through stomata. It may also be due to variation among the tested genotypes to accumulate and adjust osmolytes to maintain tissue turgerand hence physiological activities (Ameselmani et al., 2011; Baroowa and Gogoi, 2016). However, in our research study, overall mean performance of relative leaf water content showed increasing pattern in mild water stress conditions (63.32% in 50% water stress condition and 64.27% in 25% water stress condition) but decreased in severe water stress condition (63.18% in 0% water stress condition).

Root dry weight increased with the increase in severity of water stress. Mean performance of root dry weight (Table 1) depicted that genotype AGS25 (0.08 g) had highest root dry weight under non-water stress condition whereas genotypes GW178 (0.04 g), GW87 (0.08 g) and GW286 (0.14 g) had highest root dry weight in 50, 25 and 0 water stress conditions respectively.

Shoot dry weight is also very important morphological trait which is studied in drought. Under normal water condition, GW63 (0.30 g) revealed significantly highest soot dry weight while GW17 (0.30 g) under 50% water stress, GW234 (0.32 g) under 25% and JS2034 (0.38 g) expressed highest shoot dry weight. The variation in shoot growth was due to behavior of genotypes under different reduced water stress conditions. Similar results are earlier reported by Kaur et al., 2017, Jincya et al., 2021 and Amarapali, 2022).

Root shoot ratio is a good indicator for drought screening, when a genotype express high root to shoot ratio, it indicates that a genotype have a good drought escape mechanism. The root to shoot ratio by length increased with the increase in severity of water stress. The root shoot ratio by length is also used to predict the distribution of biomass among roots and shoots (Xu et al., 2015). In soybean seedlings, the water deficit situation raises the root shoot ratio by length by altering enzymatic activity and carbohydrate balancing. For the parameter root shoot ratio by length, the genotype GW234 recorded highest mean value of 1.02 in control. The genotype AGS218 recorded value of 0.91 under severe water stress whereas under 50% and 25% water stress conditions, GW234 and NRC138 recorded highest value of 0.64 and 0.47 respectively. These genotypes may be selected on basis of root shoot ratio by length in drought screening and breeding program. Because these genotypes showing good drought escape mechanism by developing a much better root system than shoot system in water stress condition. This much better root system and density maximize water uptake from the soil and gives guarantee the survival and growth under water stress condition. Hence, higher increment of root biomass in genotypes may be correlated to their tolerance capacity to water deficit condition (Baroowa and Gogoi, 2016).

The root to shoot ratio by weight decreased with the increase in severity of water stress. For the parameter, root shoot ratio by weight, the genotype SQL110 recorded highest mean value of 0.756 g in control. The genotype GW221recordedhighest mean value of 0.750 g under severe water stress whereas under 50% water stress condition highest value was produced by GW45 (0.942 g) and under 25% water stress condition, highest mean value was noticed for GW87 (1.635 g). Lowest mean value for this trait under normal water was observed for GW214 (0.04 g) whereas under 50%, 25 % and 0%, lowest mean value was noticed for GW214 (0.03 g), GW13 (0.03 g) and GW89 (0.02 g) respectively.

4. Conclusion

11 genotypes were identified as drought tolerant, 19 genotypes as medium tolerant, 21 as medium susceptible and nine as susceptible. The identified 11 drought tolerant and 19 medium tolerant genotypes may be used directly or as a parent for development of new varieties for upcoming challenges of drought due to climate changes.

5. Acknowledgement

Authors are extremely grateful of Madhya Pradesh Council of Science and Technology (MPCOST) for providing financial assistance (Grant No. 2793). Soybean germplasm obtained from ICAR-Indian Institute of Soybean Research (ICAR-IISR), Indore is gratefully acknowledged.

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