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SCREENING OF MUNGBEAN [*Vigna radiata* (L.) Wilczek] GENOTYPES ON THE BASIS OF MORPHO-PHYSIOLOGICAL PARAMETERS UNDER FLOODING STRESS

Dinesh Kumar Yadav and A. Hemantaranjan
Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221 005, UP, India, E-mail: pphdinesh@gmail.com, Corresponding author: Dinesh Kumar Yadav

Abstract: *A pot experiment was conducted with 15 mungbean [Vigna radiata (L.) Wilczek) genotypes viz., HUM-1, HUM-2, HUM-6, HUM-8, HUM-12, HUM-16, HUM-23, HUM-24, HUM-25, HUM-26, PDM-11, ML-1465, ML-1296, PUSA-0871 and PUSA-105 in the net house of the Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Seeds were sown in the plastic pots filled with 5 kg well mixed sandy loam soil. Eight seeds were sown in each pot for germination and after germination thinning was done and five plants were maintained for further growth and development. Flooding stress was imposed after 25 days of sowing and continued upto 7 days (one week). Morph-physiological parameters such as germination percentage, number of leaves plant-^{1}, leaf area plant^{-1} (cm^{2}), plant height (cm), fresh weight of shoot (g), dry weight of shoot (g), fresh weight of root and dry weight of root (g), were observed at interval of 5, 10, 15 and 20 days, after imposing flooding stress i.e., 25 days after sowing. Flooding stress affects all these parameters and slowly increased number of leaves, leaf area, plant height, fresh and dry weight of shoot, fresh and dry weight of root in the all 15 mungbean genotypes.*
Key words*: Flooding stress, Maize, Mungbean.*

Introduction: Mungbean (*Vigna radiata* L. Wilczek) is a member of the *Fabaceae* (pea) family. Mungbean commonly known as Greengram or golden gram. It is rich in digestible protein (approximately 25–28 %) by virtue of N_2 fixation machinery [1]. It is widely cultivated throughout the south Asia including India, Pakistan, Bangladesh, Sri Lanka, Thailand, Laos, Cambodia, Vietnam, Indonesia, Malaysia, South China and Formosa. Mungbean is a one of the most important short duration pulse crop in India. It ranks third among all pulses grown in India after chickpea and pigeonpea. India is the largest producer of pulses in the world with 24% share in the global production. The important pulse crops are chickpea (48%), pigeonpea (15%), mungbean (7%), urdbean (7%), lentil (5%) and field pea (5%). The major pulse-producing states are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka and Andhra Pradesh, which together account for about 80% of the total production [2].

Unfavorable environmental conditions such as drought, salinity, waterlogging etc. are major cause of poor stand establishment and low crop yield. Waterlogging or flooding stress is one the serious problem, which affects crop growth and yield. Mungbean cannot withstand waterlogging, particularly during the early stages of growth [3]. The main cause of damage under waterlogging is oxygen deficiency, which affects crop growth and development due to lack of respiration and other metabolic activities which leads reduction in the economic yield of the crop.

The present investigations were made to find out the flooding tolerant and susceptible mungbean genotypes on the basis of morpho-physiological observations such as germination percentage, number of leaves per plant, leaf area per plant, plant height, fresh and dry weight of shoot and root at early growth stage.

Materials and Methods

A pot-culture experiment was conducted with 15 different mungbean genotypes. Seeds were procured from the Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. Sowing was done in the month of June, 2012.

Eight healthy seeds of mungbean genotypes were sown in the plastic pots (size 15×15×15cm) having 5 kg pulverized soil and after germination of the seeds only five plants were maintained in each pot. Flooding stress was imposed at 25 days after sowing by replacing small pots into large sized plastic pots (size 30×30×30cm). Water level in the pots was maintained 5 cm above the soil surface of the pots. Following morpho-physiological parameters were recorded 4 times at interval of 5 days, after imposing flooding stress i.e., 25 days after sowing.

Germination Percentage: Germination percentage was recorded in all the 15 mungbean genotype by the following formulas:

Germination percentage= Total number of seed germinated/ Total number of seed sown × 100

Number of Leaves Plant^{-1}: Total number of leaves plant^{-1} was recorded 4 times by counting the leaves manually in all the mungbean genotypes at interval of 5 days upto 20 days, after imposing flooding stress.

Leaf Area Plant^{-1}: Leaf area plant^{-1} (cm^2) was observed in mungbean genotypes by Portable laser leaf area meter (CI-202) at interval of 5 days upto 20 dyas, after imposing flooding stress.

Plant Height: Plant height (cm) was taken 4 times manually through the scale and expressed in the centimeter at interval of 5 days, after imposing flooding stress.

Fresh Weight of Shoot and Roots: The fresh and dry weights of shoot and roots were recorded and expressed in g plant^{-1}. Plants were removed from the pots by removing soil in such a way that the root remained intact. Plants were washed properly under running tap water so that it may not have soil or any other impurities adhered to its surface and then collected in the poly bags and these samples were transferred immediately into the lab for measurement of fresh weight of both shoot and roots though electronic balance (Sartorius, BT-224 S).

Dry Weight of Shoot and Roots: After measurement of fresh weight of shoot and roots plant samples were kept in the envelopes and putted into the Hot Air Oven at 100 °C for one hour. Then after temperature was decreased and maintained 71 °C till the constant weight of the samples were not obtained.

Results

Germination Percentage: Data pertaining to germination percentage among 15 mungbean genotypes (Table 1) were found maximum germination percentage (100 %) in genotypes viz., HUM-1, HUM-16 and PUSA-105 and followed by (87.5%) in genotypes viz., HUM-2, HUM-6, HUM-8, HUM-23, HUM-26, PDM-11, ML-1465, PUSA-0871 where as minimum germination percentage (62.5 %) was found in genotype HUM-25 and followed by (75.0 %) in genotypes viz., HUM-12, HUM-24, ML-1296. Germination percentage of the seed is directly associated to the seed quality, seed viability and seed vigour. For better growth and development of the crop, proper seedling establishment is necessary which indicates the good yield of the crop. About 30 to 50 % of the crop yield depends upon the high-quality seed. Therefore, before sowing the selection of seed is a key factor for proper germination, crop growth and development and finally achieving better economic yield.

Table 1: Germination percentage of 15 different mungbean (*Vigna radiata* L.) genotypes

GENOTYPE	Total number of seed sown	Total number of seed germinated	Germination percentage
HUM-1	8.00	8.00	**100**
HUM-2	8.00	7.00	**87.5**
HUM-6	8.00	7.00	**87.5**
HUM-8	8.00	7.00	**87.5**
HUM-12	8.00	6.00	**75.0**
HUM-16	8.00	8.00	**100**
HUM-23	8.00	7.00	**87.5**
HUM-24	8.00	6.00	**75.0**
HUM-25	8.00	5.00	**62.5**
HUM-26	8.00	7.00	**87.5**
PDM-11	8.00	7.00	**87.5**
ML-1465	8.00	7.00	**87.5**
ML-1296	8.00	6.00	**75.0**
PUSA-0871	8.00	7.00	**87.5**
PUSA-105	8.00	8.00	**100**

Number of Leaves Plant^{-1}: Number of leaves plan^{-1}t was observed 4 times in mungbean genotypes after exposure of flooding stress at interval of 5 days data are presented in the Table 2. It was found that the maximum number of leaves was found in the genotype HUM-24, PUSA-0871, HUM-24, PUSA-105 and HUM-23 at 5, 10, 15 and 20 days after flooding, respectively. However, the minimum number of leaves was recorded in the genotypes ML-1465 at all the intervals i.e., 5, 10, 15 and 20 days under flooding stress. In the, number of leaves genotypic differences were found significantly at interval of 5, 10, 15 and 20 days under flooding stress. The number of leaves was increased more in the top 5 genotypes HUM-2 (20 %), HUM-1 (13.63 %), HUM-25 (7.15 %), HUM-23 (6.25) and PUSA-0871 (5.88 %) while these were minimum in the genotype HUM-6 (2.48 %), HUM-8 (2.32), HUM-12 (2.2 %), HUM-16 (2.32 %), HUM-24 (2.04 %) and PUSA-105 (2.17 %) at 10 days interval over 5 days of interval. However, at 15 and 20 days of intervals the maximum increment in number of leaf was observed in the genotype HUM-23 (12.71 %) and HUM-2 (13.24 %) while it was minimum in the genotype HUM-2 (2.15 %) and HUM-23 (1.82 %), respectively.

Table 2: Effect of flooding stress on number of leaf plant^{-1} in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	12.67	14.67	15.33	15.00
HUM-2	12.00	15.00	15.33	17.67
HUM-6	13.00	13.33	13.67	14.00
HUM-8	14.33	14.67	15.00	15.33
HUM-12	14.33	14.67	15.67	16.00
HUM-16	14.33	14.67	16.00	16.33
HUM-23	15.00	16.00	18.33	18.67
HUM-24	16.33	16.67	17.00	17.67
HUM-25	13.00	14.00	14.33	15.00
HUM-26	15.00	15.33	16.33	16.67
PDM-11	15.33	16.00	16.67	17.33
ML-1465	11.00	11.67	12.00	13.00
ML-1296	13.67	14.33	14.67	16.67
PUSA-0871	16.00	17.00	16.33	17.00
PUSA-105	15.33	15.67	17.00	17.33
ANOVA				
SEm±	0.85	0.78	0.75	1.29
CD at 5 %	2.47	2.26	2.18	NS

Leaf Area Plant^{-1} (cm^2): Total leaf area plant^{-1} was observed at interval of 5 days after imposing flooding stress i.e., 25 days after sowing data are presented in the Table 3. Genotype HUM-16 registered higher leaf area per plant 244, 250.33, 257 and 266 cm^2 while, it was minimum in the genotype ML-1465 at interval of 5, 10, 15 and 20 days after flooding stress. Genotype HUM-1, HUM-6, HUM-8, HUM-23, HUM-24, HUM, 25, PDM-11, ML-1296 and PUSA-105 has minor differences in the leaf area but lesser to the HUM-16 at all four intervals (i.e., 5, 10, 15 & 20 days) of flooding stress. Data's were found significant at P ≤ 0.05. Genotypic differences were found significantly at all the intervals under flooding stress.

Table 3: Effect of flooding stress on leaf area plant^{-1} (cm^2) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	183.33	190.00	193.67	200.00
HUM-2	144.67	157.67	161.67	175.67
HUM-6	153.33	181.67	184.67	188.00
HUM-8	185.00	196.67	200.33	236.00
HUM-12	138.33	151.33	159.67	162.00
HUM-16	244.00	250.33	257.00	266.00
HUM-23	172.67	215.67	225.67	234.33
HUM-24	190.67	211.00	216.00	220.33
HUM-25	165.00	204.00	206.67	211.67
HUM-26	213.00	218.67	223.33	236.67
PDM-11	194.67	206.33	212.33	218.33
ML-1465	77.33	122.00	130.67	136.00
ML-1296	113.67	165.33	185.67	248.67
PUSA-0871	143.33	144.00	164.00	176.00
PUSA-105	186.67	230.00	239.33	241.67
ANOVA				
SEm±	12.41	12.89	12.58	10.78
CD at 5 %	36.01	37.41	36.50	31.28

Plant Height (cm): Plant height was observed in all 15 mungbean genotypes at interval of 5 days upto 20 days, after imposing flooding stress i.e., 25 days after sowing. All values were significant and data's were presented in the Table 4. Maximum plant height was recorded in the genotype HUM-16 which is 29, 29.33, 30.33 and 31 cm while it was observed minimum in the genotype ML-1296 at 5 days and in the genotype ML-1465 at 10, 15 & 20 days of flooding interval, respectively. Under flooding stress plant height was increased in all the genotypes in the order of HUM-16 = HUM-23 > HUM-25 > HUM-6 > HUM-26 > HUM-24 > HUM-8 > HUM-1 > HUM-2 = PUSA-0871 > ML-1296 > HUM-12 = PDM-11 > PUSA-105 at 20 days of interval.

Table 4: Effect of flooding stress on plant height (cm) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	24.67	25.10	27.33	27.67
HUM-2	20.67	24.00	25.03	25.67
HUM-6	21.00	25.67	29.33	29.67
HUM-8	24.67	25.90	26.33	28.33
HUM-12	21.67	22.00	24.33	24.67
HUM-16	29.00	29.33	30.33	31.00
HUM-23	22.00	24.33	28.67	31.00
HUM-24	27.00	27.53	28.00	28.67
HUM-25	22.67	25.67	27.67	30.33
HUM-26	25.67	27.00	27.33	29.00
PDM-11	21.67	23.67	24.00	24.67
ML-1465	16.00	17.00	18.00	18.33
ML-1296	14.67	19.00	20.00	25.00
PUSA-0871	22.67	23.67	24.67	25.67
PUSA-105	19.67	20.67	21.00	22.00
ANOVA				
SEm±	0.899	1.20	1.08	0.95
CD at 5 %	2.61	3.48	3.15	2.75

Fresh Weight of Shoot (g): Fresh weight of shoot was observed plant^{-1} under flooding stress and data are given in the table 5. Among all the mungbean genotypes, HUM-16 has maximum fresh weight i.e., 9.37, 11.37 and 12.26 g at 5, 10 and 20 days of intervals, respectively and minimum i.e., 4.9, 5.2 & 5.43 g, fresh weight was found in the genotype HUM-12 at 10, 15 and 20 days of intervals, respectively. Genotypic differences were found in all the genotypes at all days of flooding intervals. Genotype HUM-8 and HUM-26 having the minimum differences in the fresh weight at 5, 10, 15 and 20 days of flooding stress but the values were lesser than the genotype HUM-16.

Table 5: Effect of flooding stress on fresh weight of shoot plant^{-1} (g) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	6.1	7.13	7.30	7.48
HUM-2	5.02	5.57	5.60	6.13
HUM-6	5.87	6.80	7.50	7.07
HUM-8	8.47	8.57	9.00	10.86
HUM-12	4.07	4.90	5.20	5.43
HUM-16	9.37	9.63	10.30	12.26
HUM-23	7.25	9.17	11.37	11.80
HUM-24	7.30	7.57	8.03	9.83
HUM-25	5.78	7.53	7.17	8.70
HUM-26	8.33	8.63	9.07	9.60
PDM-11	7.08	7.30	8.10	9.37
ML-1465	3.90	5.00	5.27	6.00
ML-1296	4.37	6.17	6.68	8.33
PUSA-0871	5.23	5.60	7.17	7.23
PUSA-105	6.57	8.03	9.23	10.46
ANOVA				
SEm±	0.50	0.45	0.618	0.50
CD at 5 %	1.44	1.39	1.80	1.46

Dry Weight of Shoot (g): Dry weight of the shoot was measured plant^{-1} basis and expressed in gram, data are presented in the Table 6. It was found that the genotype PUSA-105 accumulated higher (1.57 g) dry mass and minimum dry mass was observed in the genotype ML-1565, at 5 days of flooding intervals. However, at 10 and 20 days of flooding intervals genotype HUM-16 has maximum i.e., 1.65 & 2.30 g dry weight per plant while it was minimum in the genotype HUM-12 i.e., 0.72 & 1.00 g, respectively. Among all the mungbean genotypes HUM-16 has greater increment in the dry mass i.e., 21.74 % at 20 days over 15 days of flooding intervals. Genotypic differences were observed significant in all the 15 mungbean genotypes at 5, 10, 15 and 20 days of flooding intervals.

Table 6: Effect of flooding stress on dry weight of shoot plant^{-1} (g) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	0.90	1.03	1.10	1.20
HUM-2	0.78	0.87	0.94	1.02
HUM-6	1.41	1.61	1.74	1.83
HUM-8	0.93	1.36	1.50	1.63
HUM-12	0.62	0.72	0.83	1.00
HUM-16	1.11	1.65	1.80	2.30
HUM-23	1.40	1.58	1.82	1.94
HUM-24	0.90	1.33	1.43	1.52
HUM-25	1.36	1.47	1.61	1.75
HUM-26	1.16	1.33	1.57	1.66
PDM-11	0.45	1.17	1.40	1.60
ML-1465	0.53	0.77	0.87	0.97
ML-1296	1.05	1.60	1.72	1.88
PUSA-0871	0.87	0.93	0.96	1.10
PUSA-105	1.57	1.61	1.70	1.85
ANOVA				
SEm±	0.119	0.128	0.085	0.111
CD at 5 %	0.345	0.371	0.246	0.323

Fresh Weight of Root (g): The fresh weight of root was recorded plant^{-1} and found that the genotype HUM-26 and HUM-16 has higher fresh weights and minimum in the genotype ML-1465 at 5 days of flooding intervals, data are presented in the Table 7. However, at 10, 15 and 20 days of flooding intervals the maximum fresh weight of root was recorded in the genotype PUSA-105 while the minimum fresh weight was in the genotype PUSA-0871 at 10 days. At 15 and 20 days of flooding interval genotype HUM-25 registered lesser amount of fresh weight. Genotypic differences were found significant in all the mungbean genotypes at except 15 days of flooding intervals.

Table 7: Effect of flooding stress on fresh weight of root plant^{-1} (g) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	0.42	0.67	0.81	0.96
HUM-2	0.30	0.71	0.82	0.90
HUM-6	0.33	0.47	0.79	0.91
HUM-8	0.40	0.58	0.64	0.85
HUM-12	0.29	0.58	0.61	0.67
HUM-16	0.55	0.65	0.74	1.00
HUM-23	0.56	0.69	0.68	0.83
HUM-24	0.58	0.65	0.70	0.90
HUM-25	0.30	0.43	0.48	0.57
HUM-26	0.60	0.63	0.75	0.90
PDM-11	0.47	0.53	0.60	0.65
ML-1465	0.50	0.64	0.80	0.91
ML-1296	0.32	0.39	0.72	0.74
PUSA-0871	0.25	0.30	0.78	1.10
PUSA-105	0.50	0.75	0.82	1.33
ANOVA				
SEm±	0.039	0.069	0.071	0.097
CD at 5 %	0.113	0.199	NS	0.283

Dry Weight of Root (g): Dry weight of roots plant^{-1} was examined in the mungbean genotypes under flooding stress at different days after imposing flooding stress and data given in the Table 8. Dry weight in all the genotypes was increased in very slow rates under flooding stress. The maximum (0.107 g) dry weight was recorded in the genotype HUM-23 at 5 days of flooding intervals while at 10, 15 and 20 days of flooding interval genotype HUM-16 accumulated maximum root dry weight i.e., 0.133, 0.140 and 0.220 g, respectively.

Table 8: Effect of flooding stress on dry weight of root plant^{-1} (g) in mungbean (*Vigna radiata* L.) genotypes after 25 days of sowing

GENOTYPE	Days after flooding stress			
	5	10	15	20
HUM-1	0.093	0.097	0.107	0.195
HUM-2	0.047	0.070	0.083	0.100
HUM-6	0.105	0.127	0.143	0.163
HUM-8	0.063	0.080	0.088	0.147
HUM-12	0.043	0.050	0.073	0.103
HUM-16	0.097	0.133	0.140	0.225
HUM-23	0.107	0.117	0.127	0.167
HUM-24	0.063	0.077	0.120	0.133

HUM-25	0.047	0.083	0.087	0.120
HUM-26	0.085	0.103	0.117	0.137
PDM-11	0.100	0.113	0.123	0.133
ML-1465	0.050	0.060	0.113	0.123
ML-1296	0.053	0.063	0.100	0.120
PUSA-0871	0.037	0.080	0.088	0.130
PUSA-105	0.100	0.123	0.133	0.147
		ANOVA		
SEm±	0.008	0.011	0.013	0.028
CD at 5 %	0.023	0.032	0.037	NS

Discussion

During the study of flooding stress induced several physiological disturbances, including number of leaf, leaf area, plant height, fresh and dry weights of shoot and root. Flooding stress caused reduction in plant growth in terms of leaf area and growth rate in all the genotypes and the level of reduction was more pronounced in sensitive genotypes. Similar to our observations inhibition of growth has been reported in sensitive genotypes in field bean [4], tomato [5] and common bean [6]. The loss in biomass and limited leaf-area expansion appeared to be related to slow metabolic activities of roots experiencing hypoxia [7,8]. It was determined that flooding treatment decreased the leaf area (21% and18%) in common bean genotypes [6]. Under waterlogged condition, the minimum leaflet number per plant was mainly due to enhanced senescence of lower leaves [9]. Expressed that six days of waterlogged pigeonpea genotypes suffered a severe loss in leaf area and leaf senescence is induced. The waterlogging stress caused a significant decreased plant height compared with the non-waterlogged control and it was significantly reduced (23 to 30%) due to waterlogging treatment according to [10, 11].

Flooding stress normally reduced the growth of plant components resulting in lesser total dry weight. Flooding stress reduced relative total dry weight as a result of reduced dry weight of plant components. Tolerant genotypes had more dry matter because they were lesser affected by flooding stress. The tolerant genotypes maintained greater root and shoot dry matter under flooding stress than the sensitive genotypes. In our experiment some genotypes have such type of adaptation. Therefore, tolerant genotypes with vigorous shoot and root growth were better able to tolerate transient flooding stress [12]. The reduction in root dry matter is probably due to reduction in dry matter of both tap root and adventitious root as a result of a reduction in root length and branching. Earlier studies also showed the decline of both plant growth and accumulation and redistribution of dry matter by waterlogging after anthesis in wheat [13, 14, 15].

Conclusions: During this course of study it was observed that, among all the 15 mungbean genotypes germination percentage, leaf area plant^{-1}, plant height (cm), fresh weight of shoot (g), dry weight of shoot and root (g) was found maximum in HUM-16 at 5, 10, 15 and 20 days of flooding intervals while these parameters were minimum in the genotype HUM-12 except number of leaf, leaf area, plant height and fresh weight of root. Genotype ML-1465 has minimum number of leaves, leaf area and plant height at all the intervals of flooding stress. On the basis of above observations we can conclude that the genotype HUM-16 has greater ability to tolerate flooding stress. If we conclude on the basis of total average dry weights (shoot + root) genotype HUM-16 has maximum value followed by HUM-6, HUM-23, PUSA-105, HUM-25, ML-1296, HUM-26, HUM-8, HUM-24, PDM-11, HUM-1, HUM-2, PUSA-0871, ML-1465 and HUM-12.

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