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SELECTION OF MUNGBEAN GENOTYPES AGAINST WATERLOGGING STRESS

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Abstract

A pot experiment was conducted in the vinyl house of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, during kharif-I season (March to June 2022) to identify waterlog tolerant mungbean genotypes. Thirty mungbean genotypes (29 advanced lines and one variety, BARI Mung-6) were evaluated under waterlogging (96 hours) and normal conditions. Waterlogging caused a drastic reduction in dry matter and seed yield in mungbean, however, genotypes showed variable response to waterlogging. Under waterlog condition the higher relative yield was found in M11, M8, M30, M7, M16 and M14 while lower in M2 and M17. Dry matter production also varied among the genotypes due to waterlogging; however, dry matter production of the genotypes M8, M7, M22, M2, M19 and M11 were comparatively higher than other genotypes. Stress tolerance index (STI), yield index (YI) and relative yield (RY) of M16, M20, M7, M8, M11, M30 and M14 were higher than other genotypes. On the basis of dry matter production, STI, YI and RY, genotypes M7, M8, M11, M12, M16, and M20 could be selected as relatively tolerant genotypes against waterlogging stress.

Introduction

Mungbean *(Vigna radiata* (L.) Wilczak) is one of the important pulse crops in Bangladesh. It is a short-duration crop in various cropping systems, increases tenant farmers' income and improves soil fertility (Tomooka *et al.*, 1991). Its seeds contain about ~24% easily digestible protein, a significant amount of fiber, antioxidants and minerals. Seeds can be consumed as whole or split, as sprout or ground into flour for soup.

Various biotic and abiotic factors are responsible for low yield of mungbean. Abiotic stresses are a major environmental problem in agricultural crop production (Lesk *et al.*, 2016). Among the abiotic stresses, excess moisture or waterlogging stands prominent. Mungbean cannot withstand waterlogging, particularly during the early stages of growth (Singh and Singh 2011). Waterlogging of soil is a major limiting factor for crop growth in humid regions (Drew, 1991). Prolonged rainy period or heavy rainfall in the field with poor soil drainage significantly reduces the seed yield of grain legumes. The growth and seed yield of mungbean are adversely affected by waterlogging of the soil (Yadav and Saxena, 1998), but the yield response to waterlogging has not been studied as intensively as in some other leguminous crops, such as cowpea (Minchin and Summerfield, 1976) and soybean (Scott *et al.*, 1990). Mungbean is grown in kharif-I (the major growing season from last week of February to middle of March) and kharif-II (mid-August to last week of September) seasons in Bangladesh. Mungbean usually suffers from unexpected heavy rainfall at sowing or emergence time that cause total crop failure. Pre-sowing heavy rain causes delay in sowing resulting in poor seed yield. Delayed sown crops face excess rainfall at the time of reproductive phase which is the root cause of enormous losses of seed yield and quality. Reduction of growth and yield caused by waterlogging varies with the crop species and genotype (Wondimagegne *et al.*, 1992). Varietal difference of mungbean to waterlogging stress was reported by Bagga *et al.* (1984) and the effect on growth and physiological process, duration of flooding and stage at which the plant encountered the stress was studied by Islam (2003). Despite this fact, very little information is available on the responses of mungbean to soil waterlogging in Bangladesh. Waterlogging reduces plant growth by affecting one or several physiological processes. Several studies revealed that genotypes differed in their responses to water stress conditions. Genotypic differences of mungbean to waterlogging stress was reported by Bagga *et al.* (1984) and the effect on growth and physiological process, duration of flooding and stage at which the plant encountered the stress was studied by Islam (2003). However, the yield response of waterlogging in mungbean has not been studied as intensively done in some other legumes like soybean and cowpea (Khadeja *et al.*, 2022 and Omolayo *et al.*, 2022). Therefore, the present investigation was carried out to study the effect of waterlogging on mungbean genotypes and to find out the waterlogging tolerant genotypes.

Materials and Methods

A pot experiment was conducted at the vinyl house of Sher-e-Bangla Agricultural University campus during Kharif-I season of 2022. Thirty mungbean genotypes (29 advanced lines and BARI Mung-6) were used as test genotypes (Table 1) under normal and waterlogging conditions.

Table 1. Thirty mungbean genotypes used in the study

M1= V1000319- AG	M11=V1001854- BG	M21=V1004044- BG
M2= V1000542- BY	M12=V1002063- BG	M22=V1004069- BG
M3=V1000559- AG	M13=V1002195- AG	M23=V1004307- AG
M4=V1000723- AG	M14=V1002206- AG	M24=V1004789- BG
M5=V1000749- AG	M15=V1002432- AG	M25=V1004933- AG
M6=V1000764- AG	M16=V1002537- AG	M26=V1004937- AG
M7=V1001282- AG	M17=V1002926- AG	M27=V1004954- BG
M8=V1001406- BG	M18=V1003755- BG	M28=V1004968- AG
M9=V1001692- AG	M19=V1003925- BLM	M29=V1004973- BLM
M10-V1001698- BG	M20=V1004024- AG	M30=BARI Mung-6

The experiment was laid out in randomized complete block design (factorial) with 3 replications. Plastic pots (with small 4 holes in bottom of each pot; top diameter: 20 cm, bottom diameter: 15 cm and height 19 cm; capacity 10 kg soil) were filled up with well mixed soil and cowdung (4:1). Ten seeds were sown in each pot on 7^{th} March 2022. Fertilizers were applied @ 24-32-48-24-3-1.5 kg ha^{-1} NPKSZnB. All fertilizers were applied as basal at sowing. Irrigation was done as and when required for maintaining adequate soil moisture before imposing the treatment. After emergence plants were thinned to three plants in each pot. At 30 days after sowing, waterlogging was imposed by transferring each pot into a larger (top diameter: 35 cm, bottom diameter: 30 cm and height 40 cm; capacity 30 L) plastic bucket (Waleligm and Berhanu, 2015; and Selina *et al.,* 2002). Waterlogging treatments were given by filling the outer container with water up to 3-5 cm above the soil surface of the pot. After four consecutive days (96 hours) of waterlogging pots were removed from waterlogging and kept those at normal condition up to maturity to observe plant growth and seed yield.

Stress Tolerance Index (STI) was calculated according to Fernandez (1992): STI = $\frac{Y_s \times Y_p}{(Y_p)^2}$

Yield index (YI) was calculated as follows: $YI = (Ys)/(\bar{Y}s)$

Where, Ys and Yp are the yield of individual genotypes under stress and non-stress conditions, respectively; $\bar{Ys}$ and $\bar{Yp}$ are the average yield of all genotypes under stress and non-stress conditions, respectively.

The relative yield (RY) under waterlog condition was calculated as the yield of a specific genotype under waterlog divided by the highest yielding genotype in the population. At harvest yield and yield components data were collected from three pots and analyzed statistically using CropStat V. 7.2 software and mean separation was done by LSD test at 5% level of significance.

Results and Discussion

Effect of waterlogging

Yield and yield components of mungbean genotypes were significantly reduced by waterlogging (Table 2). Under normal condition plant height was 37.03 cm, which was reduced (32%) to 25.22 due to waterlogging. Kyu *et al.* (2021) and Amin *et al.* (2017) also reported reduced plant height (29-31%) in mungbean under waterlogging. Number of pod $plants^{-1}$ was reduced by about 55% due to waterlogging. Islam (1994) reported that waterlogging significantly reduced pods $plant^{-1}$ in mungbean and 36% more pods were produced in control plants than waterlogged plants. Pod length was also reduced due to waterlogging from 7.68 cm to 6.62 cm. Waterlogging caused reduction in number of seeds $pods^{-1}$; under normal condition it was 10 seeds $pods^{-1}$, which was reduced to 7.89 seeds pod^{-1}. Seed size was reduced due to waterlogging, 100-seed weight under normal condition was 4.58 g while under waterlogging it was 4.22 g. Seed yield $plant^{-1}$ was drastically reduced (57%) by waterlogging and it was 7.64 g $plant^{-1}$ under normal condition while that was only 3.34 g $plant^{-1}$ under waterlogging. Amin *et al.* (2017) reported 10 to 70% yield reduction in mungbean under waterlogging of various genotypes. Umaharan *et al.* (1997) reported that waterlogging during the vegetative period resulted in a significant decline in pod yield of cowpea and the reductions reflected in the number of pod $plant^{-1}$. Wang *et al.* (2013) reported that yield loss due to waterlogging may vary between 15% and 80% depended on the crop species and growth stage, soil type and duration of the stress.

Table 2. Effect of waterlogging on yield and yield component on genotypes

Treatment	Plant height (cm)	No of pods $plant^{-1}$	Pod length (cm)	Seeds pod^{-1}	100-seed weight (g)	Grain Yield (g $plant^{-1}$)
Normal	37.93	22.19	7.68	10.20	4.58	7.69
Waterlogging	26.12	9.61	6.62	8.09	4.22	3.34
$LSD_{(0.05)}$	1.50	0.53	0.37	0.33	0.20	0.23
CV (%)	6.10	11.70	8.40	7.82	6.80	5.40

Effect of genotypes

Yield and yield components of the mungbean genotypes showed significant variability (Table 3). Highest plant height was observed in M24 (41.55 cm), which was identical with M2, M8, M12, M18, M26, M28 and M30 but significantly higher than other genotypes. Moderate type of plant height was observed in M2 (36.4 cm) which was statistically similar with M3, M5, M13, M17, M19, M20 and M21. Rest of the genotypes were short stature and shortest plant was found in M23 (27.75 cm). Number of pods $plant^{-1}$ of the genotypes varied significantly. The highest pods $plant^{-1}$ (27.35) was observed in M20, which was significantly higher than all other genotypes. The lowest number of pods plant (7.6) was found in M15, which was identical with M12, M11 and M30. Significant variation was found in pod length of the genotypes. The highest pod length (11.30 cm) was recorded in M12, which was significantly higher than other genotypes. The lowest pod length (6.14 cm) was observed in M19, which was identical with rest of the Genotypes. The highest number of seeds pod^{-1} was found in M12 (11.30), which was identical with M26, M28, M22, M25, M5 and M2. The lowest number of seeds pod^{-1}was found in M15 (6.35), which was identical with M8. The bold seeded genotypes were M30, M15, M13 and M11 and their 100-seed weight were 6.89, 6.65g, 6.52g and 6.38g, respectively.

Table 3. Effect of genotypes on yield and yield components of mungbean

Treatment	Plant height (cm)	No of pods plant^{-1}	pod length (cm)	Seeds pod^{-1}	100-seed weight (g)	Seed Yield (g plant^{-1})
M1	30.40	14.90	7.11	9.15	3.95	5.11
M2	36.40	15.95	7.31	10.15	3.09	4.94
M3	32.30	20.10	6.28	8.50	3.56	5.29
M4	25.50	16.45	6.91	8.10	3.84	4.59
M5	34.60	17.10	7.08	10.20	3.90	5.31
M6	26.25	17.60	6.96	9.15	3.95	5.12
M7	31.40	22.95	6.52	9.75	3.38	6.07
M8	39.10	21.35	6.78	7.05	3.25	5.42
M9	26.15	14.45	6.89	9.25	3.37	4.13
M10	30.50	19.85	6.20	9.45	3.40	5.24
M11	29.55	8.75	8.21	9.15	6.38	4.17
M12	39.50	8.35	11.30	11.30	5.99	6.10
M13	34.25	10.10	8.10	7.85	6.52	5.26
M14	27.65	10.95	7.46	8.30	5.62	4.33
M15	29.25	7.60	6.30	6.35	6.65	3.81
M16	24.70	22.00	6.99	8.25	4.92	8.11
M17	32.15	16.20	6.51	8.80	3.82	7.13
M18	37.50	20.25	6.66	9.20	3.92	6.94
M19	32.35	16.25	6.14	8.50	3.46	3.88
M20	31.88	27.35	7.50	9.55	4.66	10.48
M21	34.85	18.70	6.68	9.30	4.56	5.71
M22	31.40	22.20	7.14	10.40	4.73	9.15
M23	27.75	13.45	6.68	9.90	4.09	4.63
M24	41.55	18.60	6.65	8.40	4.28	5.92
M25	30.80	15.35	7.25	10.20	3.84	5.56
M26	37.15	13.60	7.08	10.60	3.98	4.83
M27	31.05	9.95	7.48	9.40	4.81	3.94
M28	37.75	13.45	7.34	10.40	4.00	5.38
M29	28.80	14.40	7.04	9.20	3.25	4.03
M30	38.25	15.50	9.07	8.60	3.89	4.99
LSD (0.05)	5.83	2.04	1.42	1.27	0.79	0.88
CV (%)	6.10	11.70	8.40	7.82	6.80	5.40

The lowest 100-seed weight (3.09g) was observed in M2, which was identical with M8, M29, M9, M7, M10, M19, M3, M17, M4 and M25. Seed yield of the genotypes varied significantly among the genotypes studied. Varietal/genotypic difference of mungbean to waterlogging effect was reported by Bagga *et al.* (1984).

Interaction effect

Genotype and waterlogging interaction showed significant variation on seed yield and yield components (Table 4).

Table 4. Interaction effect of genotypes and waterlogging on yield and yield components of mungbean

Treatments		Plant height (cm)	No of pods plant^{-1}	Pod length (cm)	Seeds/pod	100-seed weight (g)	Seed Yield (g plant^{-1})
M1	N	36.2	20.9	7.21	9.4	4.02	7.15
	W	24.6	8.9	7.00	8.9	3.87	3.07
M2	N	43.6	25.3	7.82	11.3	3.25	7.81
	W	29.2	6.6	6.80	9.0	2.92	2.06
M3	N	39.7	27.3	6.71	9.9	3.57	7.07
	W	24.9	12.9	5.84	7.1	3.54	3.52
M4	N	32.4	22.3	7.21	8.5	3.86	5.97
	W	18.6	10.6	6.60	7.7	3.82	3.21
M5	N	40.6	23.3	7.33	10.3	3.96	6.91
	W	28.6	10.9	6.83	10.1	3.83	3.72
M6	N	33.1	24.6	7.58	10.0	4.19	7.26
	W	19.4	10.6	6.33	8.3	3.71	2.99
M7	N	37.4	28.3	6.76	11.3	3.50	7.22
	W	25.4	17.6	6.28	8.2	3.25	4.92
M8	N	43.6	25.6	7.28	8.9	3.44	5.75
	W	34.6	17.1	6.27	5.2	3.06	5.08
M9	N	32.6	19.3	7.48	9.5	3.53	5.54
	W	19.7	9.6	6.30	9.0	3.21	2.72
M10	N	38.4	27.1	6.49	10.4	3.67	6.97
	W	22.6	12.6	5.90	8.5	3.12	3.52
M11	N	31.7	8.9	8.31	10.4	6.39	4.19
	W	27.4	8.6	8.11	7.9	6.37	4.14
M12	N	40.9	11.1	12.87	13.8	6.44	7.88
	W	38.1	5.6	9.72	8.8	5.54	4.32
M13	N	40.6	12.6	9.03	9.5	6.64	7.20
	W	27.9	7.6	7.17	6.2	6.40	3.33
M14	N	30.7	13.3	8.39	9.8	5.83	5.49
	W	24.6	8.6	6.53	6.8	5.40	3.18
M15	N	32.6	9.6	7.14	7.5	6.77	5.13
	W	25.9	5.6	5.45	5.2	6.53	2.49
M16	N	30.2	29.1	7.35	8.8	5.33	10.26
	W	19.2	14.9	6.63	7.7	4.50	5.95
M17	N	40.2	25.1	7.02	9.5	3.83	11.93
	W	24.1	7.3	5.99	8.1	3.80	2.32
M18	N	50.6	30.6	7.17	10.5	4.14	10.62
	W	24.4	9.9	6.15	7.9	3.70	3.26
M19	N	34.1	21.9	6.61	10.1	3.61	5.41
	W	30.6	10.6	5.66	6.9	3.30	2.34
M20	N	36.65	42.1	7.79	10.0	4.71	16.16
	W	27.1	12.6	7.21	9.1	4.61	4.80
M21	N	38.5	28.3	7.06	10.1	5.04	8.11
	W	31.2	9.1	6.29	8.5	4.07	3.30
M22	N	36.2	34.1	8.02	11.7	5.02	14.34
	W	26.6	10.3	6.26	9.1	4.43	3.96
M23	N	29.4	20.3	7.06	10.7	4.30	6.88
	W	26.1	6.6	6.30	9.1	3.88	2.38
M24	N	47.4	27.6	7.33	9.9	4.45	8.61
	W	35.7	9.6	5.97	6.9	4.10	3.22
M25	N	40.2	24.6	7.76	11.5	3.99	8.82
	W	21.4	6.1	6.73	8.9	3.68	2.31
M26	N	45.4	17.9	7.45	11.6	3.83	6.38
	W	28.9	9.3	6.71	9.6	4.13	3.29
M27	N	42.2	15.6	8.36	10.7	5.28	6.01
	W	19.9	4.3	6.60	8.1	4.33	1.86
M28	N	47.1	18.6	7.64	11.1	4.18	7.96
	W	28.4	8.3	7.03	9.7	3.81	2.80
M29	N	33.9	18.9	7.50	10.1	3.61	5.98
	W	23.7	9.9	6.57	8.3	2.89	2.09
M30	N	41.6	17.6	8.69	9.3	6.98	5.73
	W	24.9	6.1	7.44	7.9	6.80	4.25
LSD (0.05)		8.25	2.89	2.00	1.80	1.11	1.24
CV (%)		6.10	11.70	8.40	7.82	6.80	5.40

N= normal, W= waterlogged

Irrespective of genotypes, plant height was reduced due to waterlogging, under normal condition, the maximum plant was observed in M18, which was identical with M24, M28, M26, M8, M2 and M27 and the shortest plant in M1. Under waterlogging maximum plant height was found in M2, which was statistically similar with other Genotypes under waterlogging except M4, M6, M9, M16 and M27. Under waterlogging the minimum plant height was found in M4, which was identical with M6, M9, M16 and M27. Pods plant^{-1} was significantly reduced by waterlogging, Genotypes M7, M8 and M16 produced comparatively higher number of pods plant^{-1} both in normal and waterlogging conditions. Nawata *et al.* (1991) reported that in yard long bean, the yield reduction in plants subjected to long-term waterlogging was due to reduction in pod number per plant. The percentage of reduction over control treatment in pod formation due to continuous 6 days waterlogging ranged from 24.39% to 69.66% depending on the genotypes. Pod length also reduced by waterlogging and highest pod length was recorded in M12 both in normal and waterlogging conditions. Seeds pod^{-1} was significantly reduced by waterlogging and among the genotypes higher number of seeds pod^{-1} was found in M5, followed by M28, M22 and M20 under waterlogging. Umaharan *et al.* (1997) reported that waterlogging during the vegetative period resulted in a significant decline in pod yield of cowpea and the reductions reflected in the number of pod plant^{-1}. Seeds pod^{-1} of M8 and M15 was drastically reduced by waterlogging followed by M14 and M19. Seed size also reduced by waterlogging and it varied among the genotypes. Highest 100-seed weight was found in M30 both in normal and waterlogging conditions. Seed size was drastically reduced in M2 and M29 under waterlogging. Seed yield/plant was significantly reduced by waterlogging. Under normal condition the better yielding genotypes were M20, M22, M18, M17 and M16. Under waterlogging condition better yielding genotypes were M16, M7, M8, M20 and M22. Wang *et al.* (2013) reported that yield loss due to waterlogging may vary between 15% and 80% depended on the crop species and growth stage, soil type and duration of the stress.

Dry matter production

Figure 1 shows dry matter production at harvest of the genotypes under normal and waterlogging conditions. Dry matter was greatly reduced by waterlogging. Under normal conditions the highest dry matter was observed in M10 followed by M8, M20, M18, M22, M24 and the lowest in M14. Under waterlogging condition highest dry matter was found in M8 followed by M7, M22, M2, M19, M11 and the lowest in M14. Kyu *et al.* (2021) also reported 60-65% dry matter reduction due to waterlogging in mungbean.

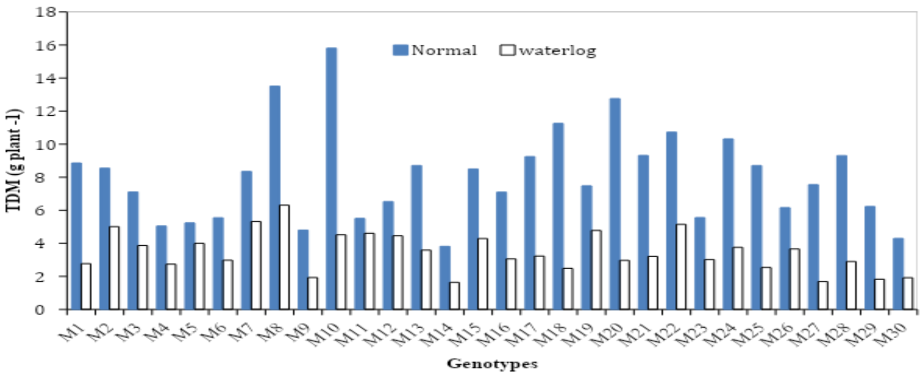

Fig. 1. Total dry matter production at harvest in mungbean genotypes under normal and waterlogging conditions.

Stress tolerance index, Yield index and relative yield

Highest STI was found in M20 (1.52) followed by M22, M16, M7, and M12 and the lowest was found in M27 (Table 5).

The highest YI was found in M16 followed by M8, M7, M20, and M12 while the lowest YI was found in M27. Among the genotypes highest relative yield was found in M16 followed by M8, M7, M20, and M12.

Table 5. Stress tolerance index (STI), yield index (YI) and relative yield (RY) of mungbean genotypes under normal and waterlogging condition

Genotypes	Seed Yield (g plant^{-1})		Index		RY
	Normal (Yp)	Waterlogged (Ys)	STI	YI	
M1	7.15	3.07	0.43	1.10	0.57
M2	7.81	2.06	0.32	0.74	0.38
M3	7.07	3.52	0.49	1.26	0.65
M4	5.97	3.21	0.38	1.15	0.59
M5	6.91	3.72	0.50	1.33	0.69
M6	7.26	2.99	0.43	1.07	0.55
M7	7.22	4.92	0.70	1.76	0.91
M8	5.75	5.08	0.57	1.82	0.94
M9	5.54	2.72	0.29	0.97	0.50
M10	6.97	3.52	0.48	1.26	0.65
M11	4.19	4.14	0.34	1.48	0.77
M12	7.88	4.32	0.67	1.55	0.80
M13	7.20	3.33	0.47	1.19	0.62
M14	5.49	3.18	0.34	1.14	0.59
M15	5.13	2.49	0.25	0.89	0.46
M16	10.26	5.25	1.06	1.88	0.97
M17	11.93	2.32	0.54	0.83	0.43
M18	10.62	3.26	0.68	1.17	0.60
M19	5.41	2.34	0.25	0.84	0.43
M20	16.16	4.80	1.52	1.72	0.89
M21	8.11	3.30	0.53	1.18	0.61
M22	14.34	3.96	1.11	1.42	0.73
M23	6.88	2.38	0.32	0.85	0.44
M24	8.61	3.22	0.54	1.15	0.60
M25	8.82	2.31	0.40	0.82	0.43
M26	6.38	3.29	0.41	1.18	0.61
M27	6.01	1.86	0.22	0.67	0.34
M28	7.96	2.80	0.44	1.00	0.52
M29	5.98	2.09	0.24	0.75	0.39
M30	5.73	4.25	0.48	1.52	0.79

Ys= yield of individual genotype under stress, Yp = yield of individual genotype under non-stress condition, RY= relative yield.

Conclusion

On the basis of dry matter production, stress tolerance index, yield index and relative yield, mungbean genotypes M7, M8, M11, M12, M16, and M20 could be selected as comparatively tolerant against waterlogging.

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