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SHORT-TERM WATERLOGGING EFFECT ON GROWTH AND YIELD OF MUNGBEAN

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ABSTRACT

Waterlogging stress is one of the most atrocious environmental factors restricting the productivity of mungbean in tropical and subtropical region. So a pot experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, during April to July 2019 to evaluate the growth and yield attributes of mungbean under waterlogging condition. The experiment comprised of four mungbean varieties, Green Diamond, Crystal, Satin and Celera and two treatments control and waterlogging which was laid out in two factor Randomized Complete Block Design with three replications. The results showed that both the varieties and waterlogging treatment had significant influence on growth and yield traits of mungbean plant. Celera showed the highest (37.04 cm) plant height in both control and waterlogging condition (31.06 cm). Among the four varieties Crystal created the highest SPAD value (50.07 units) than other varieties. After waterlogging, new leaves initiated by Green Diamond in 39 DAS followed by Celera. Number of leaves was higher (11) in Green Diamond in control and it became 4.66 in waterlogging. Celera produced higher pod per plant both in control and waterlogging. The highest yield per plant containing variety was Celera both in control (5.30 g) and (4.19 g) in waterlogging. Whereas the lowest under control in Green Diamond (3.80 g) and under waterlogging in Crystal (1.02 g). The relative yield indicated that Cerela is the most waterlogging tolerant (0.791), followed by Satin (0.563), Green Diamond (0.563) and Crystal (0.196).

Key words: water logging, growth, yield, Mungbean

INTRODUCTION

Bangladesh is a low lying country and almost all of Bangladesh lies on the largest delta in the world. Sudden flooding is a common disaster in our country due to its geographical position. Around 6.77 lakh hectares of croplands have been damaged by the recent flood that affected about 61 lakh people in 28 districts. Crops on 5.32 lakh hectares were destroyed and the rest damaged (BBS, 2019). In this phenomenon waterlogging tolerant crop varieties which are nitrogen producing are a blessing for our country. In tropical and subtropical region, heavy rainfall in the rainy season frequently induces short time flooding in the crop field. Soil flooding occurs over vast regions throughout the world adversely affecting approximately 10% of the global land area (FAO, 2002). Soil flooding has long been identified as a major abiotic stress and the constraints it imposes on roots have marked effects on plant growth and development (Parent *et al.*, 2008). Pounding of water due to rainfall, particularly in clay soil hampers root respiration. The problem is wide spread under flash flood due to climate change. A complete crop failure due to flooding is not uncommon. The effect of flooding on plant is obviously a reduced exchange of gasses between the plants and the environment (Maberly and Spense, 1989). Oxygen deficiency is the main constraint for plants have to deal with in a flooded situation (Crawford and Brandle, 1996). Flooding-induced stress may affects directly on the guard cell causing stomatal closure and reduces photosynthetic capacity of plants (Bradford and Hsiao, 1982). Despite this fact, very little information is available on the physiological responses of mungbean to soil waterlogging.

Mungbean [*Vigna radiata* (L.) Wilczek] is one of the important pulse crops of the world and is also known as greengram. Mungbean is a pulse crop under Fabaceae family, grown principally for its protein rich edible seeds. It is a short duration grain legume having wider adaptability and low input requirements. It is the third most popular pulse crop after chick pea and pigeon pea cultivated throughout India. Besides its utilization as food in many forms, haulms are used as fodder and green

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manure. It has the unique ability to fix the atmospheric nitrogen (58-109 kg ha^{-1}) in symbiotic association with *Rhizobium* bacteria, which not only enables it to meet its own nitrogen requirement but also benefits the succeeding crops (Ali, 1992). Due to its short term growth, nitrogen fixing capability, soil reinforcement and prevention of soil erosion, it is superior to other legumes. Though, pulses have been playing a vital role in the diet, the per capita availability of pulses has declined from 60.7 g day^{-1} in 1951 to 35.5 g day^{-1} in 2007 as against the FAO/WHO's recommendation of 80 g day^{-1}.Thus based on above statistics and the per capita availability, the production potential of pulses has to be increased substantially. It contains amino acids lysine, methionine and cysteine. It is rich in digestible protein (approximately 25–28 %) by virtue of N_2 fixation machinery and extensively grown in tropical and subtropical Asia because of its wider range of adaptability (Poehlman, 1991). This crop is fitted well in multi-cropping systems, because of its rapid growth and early maturity, results in the increase of small landholders' income and improvement of soil fertility (Nsoukpoe-Kossi *et al,*.1999). In Bangladesh, mungbean is traditionally cultivated in the winter months, but may be cultivated year round if there any stress tolerance variety presence. But, now-a-days it is successfully growing in summer season (Kharif-I and Kharif II seasons). It contributed 6.5% of the total pulse production of the country. It ranks third both in acreage and production among the pulses (BBS, 2019)). The yield of mungbean is quite lower than other grain legumes. For increasing pulse production it is urgently needed to extent cultivation of pulse crops rapidly to all possible areas of Bangladesh. But the cultivation of pulse crop in that area is not easy because of the lack of flood tolerant varieties of this crop. It is needed to develop stress tolerant high yielding varieties of mungbean by combining together the tolerant character that may have been distributed sporadically in different related genotypes. With this consideration the present study was conducted to assess the growth and yield attributes of mungbean genotypes under imposed waterlogging conditions and to identify the relative flood tolerant variety of mungbean if any.

MATERIALS AND METHODS

A pot was conducted at the research field of the Department of Agroforestry and Environmental Science, at Sher-e-Bangla Agricutural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh with four mungbean varieties collected from Pulse Research Center, BARI, Gazipur and the experimental duration was April, 2019 to July, 2019. The experiment was laid out by two factors Randomized Complete Block Design (RCBD) with three replications such as factor A: mungbean varieties; V_1 - Green Diamond, V_2 – Crystal, V_3 – Satin and V_4 – Celera and factor B: Control (normal irrigation) and 72 hours artificial waterlogging condition. Each pot was filled with 8 kg previously prepared growth media (soil and cow dung mixture), compost (¼ of the soil volume) and 0.2g Urea 0.4g TSP and 0.12g MP. Eight seeds were sown in each pot at a depth of 1cm. Intercultural operations, weeding and other measures were taken when necessary. Pots were placed in the water chamber of brick built (4 × 1.5 × 1) $meter^3$) after 24 days of germination for 72 hours. The water level was 3 cm high from the soil level. Data obtained for morphological and yield parameters were statistically analyzed by using Statistix 10 software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments were accomplished by Dancan test. The significance of difference between pair of means was tested at 5% and 1% level of probability and means were compared using Least Significant Difference (LSD) test according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Waterlogging variably influenced the different mungbean varieties.

Plant height (cm)

Waterlogging significantly influenced plant height of the different mungbean varieties (Table 1) and it was highest in Celera (31.06 cm). On the other hand Green Diamond, Crystal, Satin varieties respectively showed the height 27.65 cm, 26.64 cm, 18.48 cm at 38 DAS after tolerating 72 hours waterlogging. After waterlogging, vegetative growth was being slow. Voesenek and Blom (1996) stated that the elongation of stems and petioles may enable plants to emerge from the water in aquatic and waterlogging tolerant terrestrial species. This variation in plant height might be recognized to the genetic characters. But if plants are reserved in the field for longer period the life span of plants are extended further 37 days giving new flowers and fruits. Waterlogging treatment 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, according to Solaiman *et al.* (2007); Pociecha *et al.* (2008); Celik and Turhan (2011).

Table 1. Effect of waterlogging on plant height (cm) of different mungbean varieties

Variety	Waterlogging	
	Control	72 hrs waterlogging
Green Diamond	32.663	27.657
Crystal	28.477	26.647
Satin	35.077	18.487
Celera	37.040	31.067
CV (%)	3.02	
LSD (5%)	0.333	

Number of leaves plant $^{-1}$ and leaf length

The influence of waterlogging on the number of leaves plant^{-1} and leaf length was significantly different in different mungbean varieties (Table 2). Highest numbers (11) of leaves were found at control in green diamond whereas lowest in Satin (8.00), which was statistically similar to that of Cerela (8.33) but significantly different from Crystal (9.00). In waterlogging, Crystal and Cerela showed the highest leaf number (5.00 for both) compared to that of Green Diamond and Satin (4.66 for both). The reason is that leaves are also very receptive to waterlogging stress; respiration changes in the leaf, leaf chlorophyll content, and photosynthetic assimilation have been detected during a waterlogging period (Parolin, 2000).

Table 2. Effect of waterlogging on leaf number per plant and leaf length (cm) of different mungbean varieties

Variety × Treatments	No. of leaf at 38 days after waterlogging	Leaf length (cm)
Green Diamond ×Control	11.00 a	9.15 b
Satin × Control	8.00 c	9.87 a
Crystal × Control	9.00 b	7.70 c
Celera × Control	8.33 bc	6.33 d
Green Diamond × Waterlogging	4.66 d	7.56 c
Crystal × Waterlogging	5.00 d	3.90 f
Satin × Waterlogging	4.66 d	7.26 c
Celera × Waterlogging	5.00 d	4.66 e
CV%	7.60	4.80

The highest leaf length (9.87 cm) was measured at control situation in Satin and lowest in Crystal variety (3.9 cm). Green Diamond, Satin, Celera gave 7.56, 7.26 and 4.66 cm leaf length respectively in waterlogging condition. Similar result was also observed by Islam (2005). This might be due to the senescence and abscission of lower leaves at maturity. Solaiman *et al*. 2007; Pociecha *et al*. 2008;

Celik and Turhan (2011) reported that waterlogging treatment caused reduction in plant growth in terms of leaf area and growth rate.

Leaf chlorophyll content

Waterlogging reduced chlorophyll content which was statistically significant (Fig.1). Green Diamond (V_1), Crystal (V_2), Satin (V_3) and Celera (V_4) contained 49.30, 50.07, 46.01 and 41.25 SPAD unit respectively, in control. On the other hand, after facing waterlogging stress chlorophyll content of each variety was reduced extremely. It was measured after waterlogging in mungbean varieties respectively 35.733, 46.03, 29.53, and 35.016 SPAD unit. Highest reduction percentage of chlorophyll content observed in Satin (V_3), and less reduction detected in Crystal (V_2) followed by Celera (V_4).

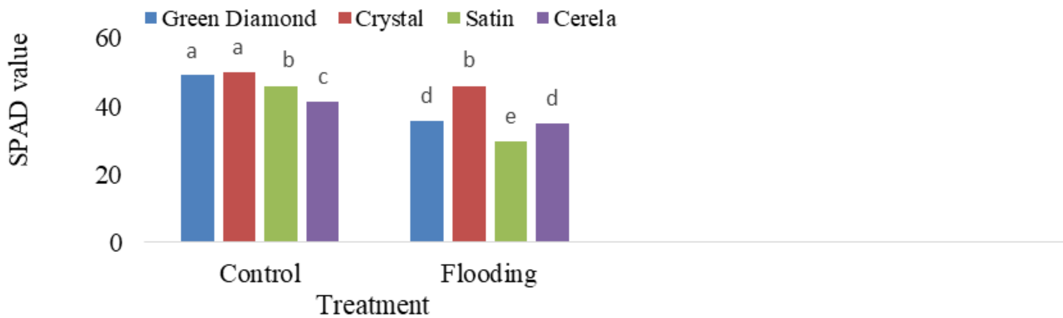

Fig.1. Effects of waterlogging on leaf chlorophyll content of different mungbean varieties after 39 DAS [LSD $_{0.05}$ =0.693]

Days required to turning into normal condition of plant after waterlogging

After 72 hours waterlogging, plants became wilted. Each variety took different time duration to turn into normal condition from wilting which was significantly different. Celera and Green Diamond being normal in 31~32 DAS. On the other hand Crystal took 36 DAS and Satin took 34 DAS (Fig. 2). Some leaves were abscised for more water uptake. Plants had to operate their energies into renewed pigment production, and re-greened chlorotic leaves at the onset of recovery (Smethurst *et al.,* 2005). Relatively waterlogging-tolerant genotypes had an altered root distribution (i.e. near the soil surface) pattern while grown in waterlogged conditions as demonstrated by shallow root system-root length was short (~100 mm) in waterlogged plants. It is promising that during the recovery period the shallow root resumed growth and reached the same length as in the drained control, allowing access to soil moisture at depth as the soil profile dries later in the season (Malik *et al.,* 2001).

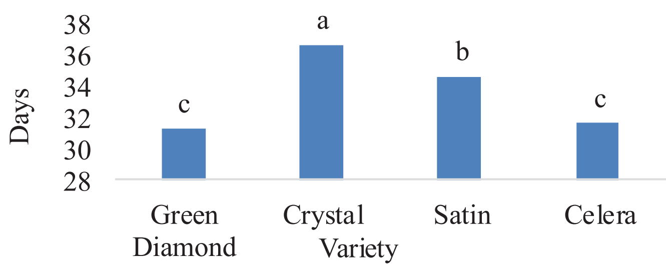

Fig. 2. Required days to turn into normal condition for mungbean varieties [LSD 0.05 =1.89] Waterlogging effects on new leaf initiation

New leaf initiated after waterlogging condition and plants being vigorous day after day. The first day of initiated leaf was difference among varieties which was statistically significant (Fig. 3). Firstly in Green diamond leaf initiated at 39.66 days after emergence that was after 12 days of waterlogging then in Celera, it took 40.33 days. Others two variety Crystal and Satin took 16 days and 19 days after waterlogging. Leaf initiation increase photosynthesis rate and its must be effective for yield.

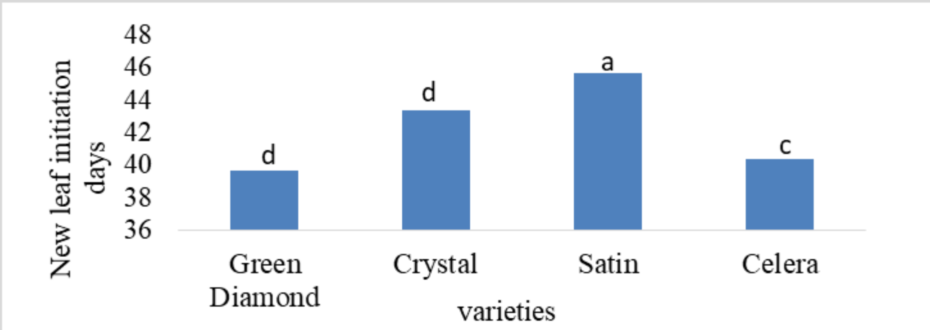

Fig. 3. Required days to initiation of new leaf after waterlogging condition [LSD 0.05 =0.490]

Effects of waterlogging on 50% flowering of mungbean varieties

Effect of waterlogging on days to 50% flowering of four mungbean genotypes was significantly different from each other and they took 10-12 more days than control environment. Crystal and Satin took 34.33 and 34.3 days to 50% flowering, respectively (Table 3). Indeterminate plants flower until some environmental condition triggers them to stop. Too cold, too hot, too dry or too wet can trigger indeterminate plants to stop flowering. Similarly Kumar *et al.* (2013) reported that both tolerant and sensitive Mungbean genotypes showed the inhibition of flowering and pod setting under waterlogging.

Table 3. Effect of waterlogging on days to 50% flowering and pod number of different mungbean varieties

Variety × Treatments	Days of 50% flowering	Pod number
Green Diamond ×Control	31.00 e	12.33 c
Satin × Control	34.33 d	10.33 d
Crystal × Control	34.33 d	14.00 b
Celera × Control	29.00 f	20.00 a
Green Diamond × Waterlogging	43.00 b	9.33 de
Crystal × Waterlogging	47.33 a	7.66 f
Satin × Waterlogging	47.66 a	8.66 ec
Celera × Waterlogging	41.00 c	12.33 c
CV%	2.63	7.33

Effects of waterlogging on pod number and pod length of mungbean

The number of pods per plant was found significantly different for waterlogging. The highest (20) number of pods per plant was obtained from control (Table 3) in variety Celera and the lowest (7.66) from Satin after waterlogging. Similar result was also observed in legumes by Solaiman *et al.*, (2007), Pociecha *et al.* (2008) under waterlogging condition. Islam (2005) reported that significantly reduced pods plant^{-1} in mungbean and 36% more pods were produced in control plants than waterlogged plants. Varieties showed significant difference in pod length (Fig. 4). The longest pod length (9.87cm) was recorded in V_1 (Green Diamond) and the shortest (3.9 cm) in V_2 (Crystal) in waterlogging. These results have the agreement with the results of Sarkar *et al.* (2004) who described that pod length differed from varieties to varieties. The possible reason of this difference could be the genetic make-up of the varieties.

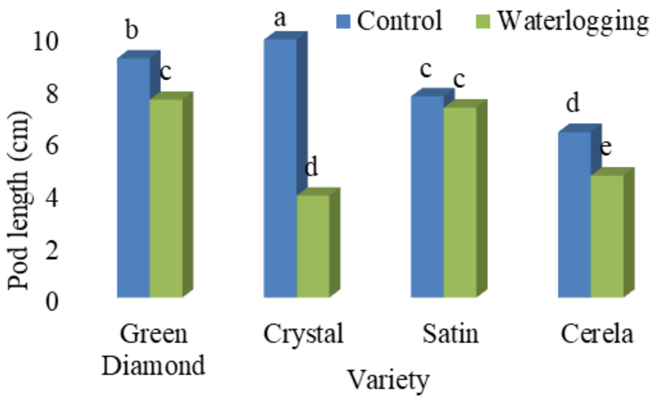

Fig. 4. Effect of waterlogging on pod length (cm) of different mungbean varieties [LSD $_{0.05}$= 0.173]

Effect of waterlogging on number of seeds per pod, hundred fresh seed weight (g) and dry weight (g) of different mungbean varieties

Waterlogging reduced the number of seeds per pod significantly over the control. Among the varieties, Celera recorded highest number of seeds (11) per pod. Without Celera in all other varieties seeds per pod reduced in the waterlogging (Table 4). Similar differences in genotypes were also observed in green gram (Laosuwan *et al*., 1994 and Yadav and Saxena, 1998). The highest 100-seed weight was found in Crystal (8.00 g) at control. Green Diamond and Celera showed less reduction of 100-seed weight from control to waterlogging, this was respectively in control 3.97g, 3.71g and after waterlogging stress 2.59 g, 3.57 g. Genotypic variation in 1000-seed weight was observed by Tomar *et al.* (1996) in mungbean that also supported the present experimental results. The maximum 100 seed dry weight (7.25g) was observed in Crystal at control and minimum (2.03 g) in same variety by Green Diamond (2.25 g).

Table 4. Effect of waterlogging on seed per pod, 100 fresh seed weight, dry seed weight and yield of different mungbean varieties

Variety × Treatments	No. of Seed per pod	100 fresh seed wt. (g)	Oven dry wt. of 100 seed (g)	Yield/ plant (g)
Green Diamond ×Control	10.00 ab	3.97 b	3.59 b	3.80 d
Satin × Control	11.00 a	8.00 a	7.25 a	4.60 bc
Crystal × Control	10.00 b	7.85 a	7.12 a	5.20 ab
Celera × Control	11.00 ab	3.71 b	3.36 b	5.30 a
Green Diamond × Waterlogging	8.66 c	2.59 cd	2.25 c	1.23 f (0.324)
Crystal × Waterlogging	10.00 b	2.27 d	2.03 c	1.02 f (0.196)
Satin × Waterlogging	8.66 c	2.99 c	2.53 c	2.59 e (0.563)
Celera × Waterlogging	11.00 a	3.57 b	3.2 b	4.19 cd (0.791)
CV%	4.15	7.17	4.80	10.49

Figures in the parenthesis indicate relative seed yield

Effect of waterlogging on yield per plant (g) of mungbean

The effect of waterlogging on yield per plant of different mungbean varieties was also varied significantly (Table 4). The highest yield was found in Celera (3.08 g), then satin (5.2 g), Crystal (4.6 g) and Green Diamond (3.80 g). In Control according to yield performance per plant the varietal series is Celera > Satin> Crystal> Green Diamond. On the other hand, in waterlogging, Celera also contained the highest yield (4.19 g) per plant and it was not much reduced like other verities. The varietal series by yield per plant in waterlogging treatment is Celera > Satin > Crystal > Green Diamond. Similar results were also reported in greengram (Laosuwan *et al*., 1994, and Ahmed *et al.* 2002); in blackgram (Pallavi *et al*., 2004) and in soybean (Sorte *et al*., 1996. Reduction in seed yield under waterlogged condition was due to oxygen deficiency and anaerobic conditions and less root activity. It was fundamentally due to diminish of water absorbing ability of the plants as specified by the reduction in leaf turgidity as well as translocation of dry matter from the vegetative growth to the reproductive structures (seeds) possibly due to damage caused to the root system. Such inhibition may also be due to adverse effects of waterlogging on water and mineral uptake. Reduction in seed yield was mainly due to impairment of water absorbing ability of the plants or inhibition of synthesis and transportation of photosynthetic assimilate (Kumar *et al*., 2013).

CONCLUSION

Waterlogging stress is one of the most atrocious environmental factors restricting the productivity of mungbean. Considering the findings it may be concluded that plant height, leaf number, seed moisture percentage and chlorophyll content reduced significantly due to waterlogging. Highest plant height was found in Celera (37.06 cm) and shortest was in Satin (18.48 cm) at waterlogging condition. Yield reduced significantly in waterlogging condition. Maximum number of pods (12.33) per plant obtained from Celera and the minimum was in crystal (7.66) at waterlogging. The highest 100-seed weight in Celera (3.57 g) and the lowest in Crystal (2.27 g) at waterlogging. The Celera was more waterlogging stress tolerant than Green Diamond, Crystal and Satin. Therefore, Celera can be added in the existing cropping pattern at short term waterlogging condition in tropical and subtropical regions.

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