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EFFECTS OF SOIL FLOODING ON ROOTS, PHOTOSYNTHESIS AND WATER RELATIONS IN MUNGBEAN (*VIGNA RADIATA* (L.) WILCZEK)

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Abstract

Two mungbean (*Vigna radiata* (L.) Wilczek) genotypes (GK48 - flood tolerant and BARImug5- flood susceptible) were flooded at vegetative and flowering stages for 5 and 10 days, respectively. Flooding damaged the lateral roots of GK48 wholly, but it recovered quickly by forming numerous adventitious roots. Flooding significantly reduced photosynthetic rate (P_n) and leaf water potential (Ψ_l) in both the genotypes but GK48 tended to regain P_n and Ψ_l during post-flooding phase. It appeared that GK48 withstands flooding to a great extent.

Soil flooding greatly impairs plant performance, although many of the plant species have the ability to develop a combination of mechanisms enabling them to grow under flooding conditions (Kozlowski 1984). There are many reports on the flood tolerance in various crops like wheat, maize, tomato, but such study on mungbean is limited. Flooding is reported to reduce growth and chlorophyll content, and death of roots in mungbean (Islam *et al.* 2007). In this paper, the flooding induced changes in the root growth, photosynthesis and water relations of tolerant and susceptible genotypes of mungbean plants in relation to adaptive mechanism were studied.

The experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh during August-October, 2001. Two mungbean genotypes *viz.* GK48 (flood-tolerant) and BARImug5 (flood susceptible) were flooded for 5 and 10 days for both vegetative and flowering stages. Flooding depth was maintained 2.5 cm above the soil surface. Treatments were arranged in a RCB design with six single plant replicates. At each time of flooding and recovery, both flooded and non-flooded plants were sampled to measure the growth and photosynthetic rate (P_n) using a portable photosynthesis measuring system. Water potential (Ψ_l) was measured following the procedure described by Saneoka *et al.* (1995).

The adventitious roots were found to develop within 48 hours of flooding (Table 1). Development of adventitious roots in GK48 was five times higher than that of BARImung5 during 5-day-flooding. Lateral roots of BARImung5 were almost totally damaged when flooding prolonged. In contrast, plants of GK48 compensated their lateral roots by producing numerous adventitious roots during 5-day-flooding. Interestingly, the production of the adventitious roots in flooded plants of GK48 at flowering stage superseded the control plants during post-flooding phase. However, BARImung5 remained far from compensating. The malfunctioning of root systems under anoxia and enhanced production of adventitious roots was found to occur in many plant species like maize (Wenkert *et al.* 1981), *Rumex* spp. (Visser *et al.* 1996), etc.

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Table 1. Lateral and adventitious root mass of two mungbean genotypes as affected by the duration of flooding.

Stages of flooding	Flooding regimes (days)	Dry weight of lateral and adventitious root (mg/plant)			
		At the end of flooding		After two weeks of drying	
		Control	Flooded***	Control	Flooded
		Genotype GK48			
Vegetative	5	0.049*	0.021 (43)	0.300	0.273 (91)
	10	0.159	0.143 (90)	0.389	0.345 (89)
Flowering	5	0.300**	0.243 (81)	0.497	0.629** (127)
	10	0.389*	0.126 (40)	0.566*	0.353 (62)
		Genotype BARImung5			
Vegetative	5	0.068*	0.006 (9)	0.348*	0.214 (61)
	10	0.177*	0.114 (64)	0.568*	0.292 (51)
Flowering	5	0.348*	0.189 (54)	0.696*	0.494 (71)
	10	0.568*	0.063 (11)	0.518*	0.200 (39)

*(p < 0.01) and **(p = 0.05), significantly higher in comparison to flooded and control plants (t-test). ***Weight of adventitious root mass at vegetative stage, lateral and adventitious root mass at flowering stage; Figures in parenthesis are per cent of flooded values relative to control.

P_n drastically reduced at vegetative stage and reduction was greater for 5 days compared to 10 days of flooding (Table 2). P_n of many field crops with flooding have been reported to decline progressively at different growth stages (Pociecha *et al.* 2008, Cho *et al.* 2006). However, flooded plants tended to recover from the flooding injury by accelerating P_n during the post-flooding phase. In general, P_n recovery in GK48 was greater than BARImung5. The highest recovery was observed for 5 days flooding at flowering stage, but the genotypes failed to recover P_n to a great extent when flooding was extended to 10 days. Similar results were also observed by Ahmed *et al.* (2002) where P_n of mungbean recovered quickly from short-term flooding and found far from recovering when flooding prolonged (Musgrave and Vanhoy 1989).

Table 2. Photosynthesis rate of two mungbean genotypes as affected by duration of flooding.

Stages of flooding	Flooding regimes (days)	Photosynthesis rate (μ mol/m²/s)			
		At the end of flooding		After two weeks of drying	
		Control	Flooded	Control	Flooded
		Genotype GK48			
Vegetative	5	28.95*	2.02(7)	34.92	37.97 (109)
	10	31.61	6.31(20)	34.76	37.40 (108)
Flowering	5	34.92**	11.37 (33)	30.96	38.94**(126)
	10	34.79*	5.47(16)	24.13*	16.26 (67)
		Genotype BARImung5			
Vegetative	5	30.67*	1.49 (5)	34.63*	33.10 (96)
	10	35.07*	5.06 (14)	37.14*	31.36 (84)
Flowering	5	34.63*	3.48 (10)	29.43*	33.54 (114)
	10	37.14*	1.14 (3)	26.76*	10.68 (40)

*(p < 0.01) and **(p = 0.05), significantly higher than the flooded and control plants (t-test).

Five days flooding at vegetative stage caused a sharp drop in Ψ_l in GK48 but BARImung5 appeared to be unaffected (Table 3). In contrast, Ψ_l in GK48 remained unaltered when flooded for 10 days. Response of Ψ_l to soil flooding at flowering stage was rather reverse compared to vegetative stage. Although dropping of Ψ_l of flooded plants continued during subsequent recovery period, the differences in Ψ_l between flooded and non-flooded plants narrowed down due to increase of Ψ_l in control plants. Flooding for 10 days had shown a lesser degree of difference in Ψ_l particularly in GK48. The results are not in agreement with the report by Ahmed *et al.* (2002) who found that flooding had no significant effect on Ψ_l in mungbean, although Ψ_l appeared to be increased during flooding.

Table 3. Leaf water potential of two mungbean genotypes as affected by the duration and stages of flooding.

Stages of flooding	Flooding regimes (days)	Leaf water potential (MPa)			
		At the end of flooding		After two weeks of drying	
		Control	Flooded	Control	Flooded
		Genotype GK48			
Vegetative	5	−0.22*	−0.34 (155)	−0.17	−0.24 (141)
	10	−0.20	−0.23 (115)	−0.27	−0.38 (141)
Flowering	5	−0.17**	−0.47 (276)	−0.44	−0.59** (134)
	10	−0.27*	−0.40 (148)	−0.47*	−0.32 (68)
		Genotype BARImung5			
Vegetative	5	−0.20*	−0.23 (115)	−0.24*	−0.48 (200)
	10	−0.19*	−0.27 (142)	−0.30*	−0.56 (187)
Flowering	5	−0.24*	−0.51 (213)	−0.51*	−0.75 (147)
	10	−0.30*	−0.63 (210)	−0.59*	−0.54 (92)

*(p < 0.01) and **(p = 0.05), significantly higher in comparison of flooded and control plants (t-test).

The adaptive strategies of flood-tolerant GK48 to endure flooding are the quick formation of such roots as well as better maintenance of P_n and water relations.

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