

SHORT COMMUNICATION

GROWTH AND YIELD RESPONSE OF GREEN GRAM CULTIVARS TO SIMULATED ACID RAIN STRESS

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Ten day-old plants of two green gram cultivars ADT-1 and Vamban were exposed to simulated sulphuric acid rain (SAR) of pH 5.5, 4.0, 2.5 and 7.0 (as control) for 5 consecutive days to determine their effects on growth and yield. The results indicated that acid showers of pH 5.5 and 4.0 favoured plant growth in both the cultivars. The photosynthetic pigments, soluble protein, reducing and total sugars and starch in both cultivars were higher at pH 5.5 and slowly decreased with increasing levels of acidity. The acid rains of pH 5.5 and 4.0 substantially increased the number of pods and seeds/plant in both cultivars. However, the acid rain of extreme acidity (pH 2.5) was found to be inhibitory. Among the two cultivars, Vamban was found to be more sensitive than ADT-1.

Key words: Green gram, growth, sulphuric acid, yield.

Acid rain has been termed a cumulative and secondary form of air pollutant. The adverse effects of acidic deposition on aquatic, wetland and forest ecosystems have been well documented (Evans 1988). Though it was considered a problem of heavily industrialized regions in Europe and America, signs of its occurrence in Asian regions were noticed recently (Rhodhe *et al.* 1992). India is considered as an acid rain hot spot and several metropolitan cities have been experiencing acidic precipitation (Mohan and Kumar 1998). The studies on the impact of acidity on crop plants have been confined to temperate regions only (Evans 1988). In the present investigation, growth and yield responses of two green gram cultivars to simulated sulphuric acid rain were studied.

Green gram [*Vigna radiata* (L.) Wilczek] cultivars ADT-1 and Vamban were sown in earthenware pots (25 x 25 cm) filled with a mixture of sand, red soil and farmyard manure (2 : 1 : 1 v/v). Plants were raised under green house conditions and irrigated with bore-well water to keep the soil moist. Ten day-old plants were sprayed with distilled water adjusted to pH 5.5, 4.0 and 2.5 using sulphuric acid to simulate acid rain. Double distilled water (pH 7.0) was sprayed to serve as control. Plants were

exposed to acidic showers of 5 min duration on each day for 5 consecutive days. Morphometric measurements were made at two stages viz. 25 and 35 days after sowing (DAS), respectively. Chlorophylls (Shoaf and Lium 1976), carotenoids (Ikan 1969), soluble protein (Lowry *et al.* 1951), soluble sugars (Dubois *et al.* 1956) and starch (Mc Cready *et al.* 1950) were estimated at above growth stages in first trifoliate leaves. The yield components were assessed continuously from the time of pod appearance until final harvest (65 DAS). Data were statistically analysed at 5% level of significance using Tukey's Multiple Range Test (TMRT) (Zar 1984).

Acid rain treatment of pH 5.5 and 4.0 significantly increased the plant height and biomass of both the cultivars (Table 1). Several workers have observed similar increase in growth parameter at acid rain treatment between pH 5.5 and 4.0. Ferenbaugh (1976) using sulphuric acid showers on *Phaseolus vulgaris* found a significant reduction in plant height at pH 3.0. Insignificant changes were evident in the present study in both the cultivars at 35 DAS in plants treated with a rain of pH 2.5. Wood and Bormann (1974) suggested that the reductions in growth observed at high acidity may be due to acid-auxin interaction.

At 25 DAS, the total chlorophyll pigments were reduced at pH 4.0 and 2.5 in cv. Vamban, whereas a comparable result with the control was observed in cv. ADT-1. The carotenoid contents increased significantly by 40% in both cultivars at pH 5.5 at both the stages (Table 1). In addition to the retardation in growth, the chlorophyll content, the sugar and starch contents were also decreased at pH 2.5 in cv. Vamban. On the other hand, the reducing sugars were increased by 22% and total sugars by 17% at pH 2.5 in cv. ADT-1. Such a differential sensitivity of cultivars to acid rain was also reported by several workers (Lee *et al.* 1981, Kumaravelu and Ramanujam 1998). The sulphate portion of sulphuric acid solution may be inhibiting events related to carbohydrate synthesis, or else, the preponderance of protons might have affected the membrane functions in cv. Vamban, as suggested by Wellburn (1988). The other cultivar ADT-1, which is a dwarf variety, was able to withstand the high rainfall acidity. The protein content of both cultivars follow a pattern similar to the carbohydrates (Table 1).

The yield attributes such as number of pods, seeds per plant and seed mass per plant were significantly increased due to acid rain of pH 5.5 and 4.0 in both cultivars. The inhibitory effect of pH 2.5 was stronger in cv. Vamban, though both cultivars responded adversely, But, the yield of ADT-1 at pH 2.5 was not affected significantly in terms of seed mass per pod or plant. The effects of acid rain on plant biomass and carbohydrate contents of both cultivars correlated well with the effects on yield. Cohen and Ruston (1925) while treating Timothy grass with sulphuric acid solutions covering a range of pH 2.2 to 3.7 concluded that all acidic treatments caused a decrease in yield. This is in perfect agreement with the observations made in cultivar Vamban (Table 2). The resilience of cv. ADT-1, may be due to nutritional advantages from the high acidic shower.

The present investigation confirmed the differential sensitivity of crop cultivars to different pH ranges. Cultivar Vamban was more sensitive to acidity than cv. ADT-1. At pH 5.5 and 4.0, both the cultivars were

Table 1. Effects of sulphuric acid shower on growth, fresh and dry weight, photosynthetic pigments, proteins, sugars and starch of the first trifoliolate leaves of two green gram cultivars. Values within a row followed by different letters are significantly different at 5% level of significance (V1 = ADT-1, V2 = Vamban)

Parameter	Cultivar	25 DAS				35 DAS			
		pH 7.0	5.5	4	2.5	pH 7.0	5.5	4	2.5
Plant height (cm)	V1	12.03 a	13.28 a	12.98a	13.12 a	16.23 a	20.48 b	18.95 a	16.70 a
	V2	16.51 a	18.97 bc	20.05 b	17.10 ac	21.40 a	22.40 a	22.75 a	22.12 a
Plant fresh weight (g plant ⁻¹)	V1	0.75	0.99 b	0.89 b	0.89 b	1.57 a	2.23 b	1.83 b	1.47 a
	V2	1.18 a	1.45 b	1.38 b	1.07 a	1.86 a	2.54 b	2.17 b	1.72 a
Plant dry weight (g plant ⁻¹)	V1	0.16 a	0.20 b	0.19 b	0.15 a	0.31 a	0.42 b	0.35 a	0.25 c
	V2	0.25 ac	0.30 b	0.26 a	0.21 c	0.36 a	0.48 b	0.40 a	0.30 c
Total Chlorophyll (mg g ⁻¹ Fw)	V1	2.20 a	2.74 b	2.45 a	2.21 a	1.92 a	2.19 a	1.93 ab	1.64 b
	V2	2.56 a	2.91 a	2.29 ab	1.96 b	1.96 a	2.30 b	1.91 a	1.70 a
Carotenoids (mg g ⁻¹ Fw)	V1	0.78 a	1.09 b	0.93 bc	0.84 ac	0.60 a	0.69 b	0.67 ab	0.56 a
	V2	0.85 a	0.98 b	0.96 ab	0.86 ab	0.57 a	0.67 b	0.65 ab	0.54 a
Reducing sugars (mg g ⁻¹ Fw)	V1	17.87 a	19.48 ab	19.37 ab	21.78 b	18.12 a	22.33 b	21.34 bc	19.29 ac
	V2	15.51 a	17.65 a	15.39 ab	13.14 b	20.31 a	21.41 a	19.34 a	17.59 a
Total sugars (mg g ⁻¹ Fw)	V1	26.72 a	30.58 ab	28.06 ab	31.17 b	32.19 a	36.84 a	34.18 a	33.74 a
	V2	33.92 a	42.06 b	38.74 ab	24.92 c	27.63 a	28.60 a	27.99 a	26.83 a
Starch (mg g ⁻¹ Fw)	V1	70.48 a	77.68 a	75.02 a	67.71 a	99.89 a	105.45 a	112.71 a	109.23 a
	V2	87.56 a	93.25 a	87.15 a	78.92 a	131.53 a	121.15 a	120.61 a	107.85 a
Protein (mg g ⁻¹ Fw)	V1	2.37 a	3.20 b	2.87 b	2.34 a	2.29 a	2.81 b	2.71 bc	2.50 ac
	V2	3.91 a	4.32 a	3.69 a	3.48 a	3.34 a	3.51 a	3.07 ab	2.81 b

Table 2. Effects of sulphuric acid shower on the yield components of two green gram cultivars ADT-1 and Vamban. Values within a row followed by different letter are significantly different at 5% level of significance

Parameters	ADT-1				Vamban			
	pH 7.0	5.5	4	2.5	pH 7.0	5.5	4	2.5
No. of pods plant ⁻¹	12.4 a	16.7 b	17.2 b	13.2 a	20.6 a	24.2 b	23.7 ab	20.3 a
No. of seeds pod ⁻¹	7.5 a	8.1 a	7.9 a	7.8 a	8.8 a	9.9 a	9.3 a	8.5 a
No. of seeds plant ⁻¹	93.0 a	135.3 b	135.9 b	102.9 a	181.3 a	239.6 b	220.4 b	172.6 a
Seed mass pod ⁻¹ (g)	0.143 a	0.162 ab	0.182 b	0.172 b	0.308 ac	0.366 b	0.335 ab	0.272 c
Seed mass plant ⁻¹ (g)	1.77 a	2.71 b	3.13 c	2.27 b	6.35 a	8.86 b	7.94 b	5.52 a
Mass seed ⁻¹ (g)	0.019 a	0.020 a	0.023 b	0.022 b	0.035 a	0.037 a	0.036 a	0.032 a
Length of the pod (cm)	4.54 a	4.55 a	5.08 a	4.67 a	5.87 a	6.39 a	5.92 a	5.62 a
Fresh wt. of the pod (g)	1.44 a	1.57 ab	1.51 ab	1.71 b	3.19a	3.27 b	3.49 ab	3.01 a

benefited similarly. It further indicates that the recent trend of increasing acidity in the rain showers of India, may not pose an immediate threat to plants' performance as the adverse effect was discernible below pH 4.0 only. However, this clue needs to be examined widely before generalizations can be made.

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