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Effect of sulphur dioxide on growth and nodulation of pigeonpea

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Abstract. Effect of sulphur dioxide on the growth of pigeonpea (*Cajanus cajan* (L.) Millsp.) was studied. Five day old pigeonpea seedlings were exposed to 10 and 20 ppm SO_2 in glass chambers for 3 hr/day continuously for two weeks. Analyses were made in 25-day old seedlings with respect to foliar injury, morphological characteristics, dry matter accumulation and nodule number. Sulphur dioxide affected leaves showed chlorosis, tip burn and marginal necrosis. Root growth and nodulation were very much reduced in fumigated seedlings. Sulphur dioxide exposure decreased dry matter accumulation in all the parts of the seedling.

Keywords. Sulphur dioxide; *Cajanus cajan*; morphological characteristics; dry matter accumulation; nodulation.

1. Introduction

The impact of air pollutants on agricultural crops has not been assessed so far. Sulphur dioxide is one of the most common industrial air pollutants. It has been established that sulphur dioxide causes deleterious effects on plants (Thomas and Hendricks 1956; Ricks and Williams 1975; Pandey and Rao 1978). Sulphur dioxide enter the plant mostly through stomata and at toxic concentrations induces alterations in various biochemical and physiological processes leading to reduced growth (Thomas 1961; Thomas and Hendricks 1956; Rao and LeBlanc 1965; Coker 1967; Daines 1968; Syratt and Wanstall 1969; Bell and Clough 1973; Ashenden 1978). Since most of the studies are based on their local general vegetation, as there is little work on its influence on crop plants and the degree of response and deleterious effects varies from plant to plant, the present investigation is concerned with the effect of high SO_2 concentrations of short term exposures on the growth and development of pigeonpea; an important pulse crop of India. These simulation studies may help in understanding the mode and mechanism of the deleterious effects of SO_2 on this crop plant.

2. Materials and methods

Pigeonpea (*Cajanus cajan* (L.) Millsp.) cv. PDM1 seeds were planted in pots (18 cm diameter) containing soil and farmyard manure in 3:1 ratio. For proper nodulation the seeds were washed and soaked in distilled water for 3 hr to remove water soluble Rhizobial growth inhibiting substances, if any from seed coats and then the seeds were inoculated with 7-day-old cultures of *Rhizobium* isolated from the same cultivar and grown in yeast mannitol agar broth. Since the *Rhizobia* that infect pigeonpea is a slow growing type (cowpea type) they require 6–14 days to form 1–2 mm colonies (Dye 1980). Therefore 7-day-old cultures were used. After 5 days thinning was done, keeping 10 plants per pot. Three pots were fumigated in each concentration of 10 and 20 ppm

SO_2 for 3 hr/day in 0·45 m^3 glass chambers for a period of 2 weeks. During that period control seedlings were kept in glass chambers without SO_2. The seedlings were always fumigated from 8·00 a.m. to 11·00 a.m. after which the plants were allowed to grow under normal conditions. Desired SO_2 concentrations in glass chambers (0·45 m^3) were obtained by reacting Na_2SO_3 with dilute H_2SO_4 by the relationship that 2·6 mg of Na_2SO_3 with dilute H_2SO_4 releases 1 ppm SO_2 in 1 m^3 air (Rao and Le Blanc 1965). The released SO_2 get mixed with air in the chamber and produces the desired SO_2 concentration. Analyses were made on 25-day-old seedlings.

Fresh weights of the control and fumigated seedlings were determined immediately on harvest. The materials were kept in hot air oven at 80°C until constant dry weights were obtained.

Shoot/root ratios were determined by the procedure of Evans and Hughes (1961) as presented in the following formulae:

$$\text{Shoot/root ratio (dry weight)} = \frac{\text{Mean shoot dry weight in mg}}{\text{Mean root dry weight in mg}}$$

The level of injury such as chlorosis and necrosis was expressed in qualitative terms.

3. Results and discussion

The symptoms, chlorosis, tip burn and marginal necrosis were observed in both concentrations, however, the damaging effect was more with 20 ppm than with 10 ppm SO_2.

The shoot length and root length recorded higher values for the control than the fumigated seedlings. Among the fumigated plants those received 20 ppm SO_2 showed lower values than those treated with 10 ppm SO_2. The root length was more affected than shoot length. The root length of seedlings exposed to 10 and 20 ppm SO_2 were reduced by 52·47% and 61·15% respectively on compared to the controls (table 1).

Nodule number was also reduced in pigeonpea seedlings due to SO_2 exposure. Control seedlings showed on an average 23·4 nodules per seedling, whereas 9·2 and 3·6 nodules per seedling were observed in 10 and 20 ppm SO_2 exposed seedlings respectively. The number of leaves per seedling were also reduced in the fumigated seedlings (table 1).

Depending on the level of SO_2 exposure a reduction in the fresh and dry weight of the

Table 1. Effect of sulphur dioxide on shoot length, root length, nodule number and leaf number of pigeonpea seedling (mean of 30 seedlings with SE)

SO_2 con.	Shoot (cm)	Root (cm)	Nodule number	Number of leaves
0 ppm	26·43 ±0·69	27·88 ±1·83	23·40 ±0·73	6·10 ±0·17
10 ppm	17·44 ±0·34	13·25 ±0·62	9·20 ±0·69	5·60 ±0·16
20 ppm	16·65 ±0·32	10·83 ±0·62	3·60 ±0·49	4·50 ±0·16

Table 2. Effect of sulphur dioxide on fresh weight, dry weight and shoot/root ratio of pigeonpea seedling (mean of 3 replicates with SE)

	Sulphur dioxide concentration		
	0 ppm	10 ppm	20 ppm
Fresh weight (mg)			
Whole seedling	2470·43 ±17·89	1255·22 ±13·66	962·83 ±1·12
Stem	544·99 ±6·73	293·32 ±1·26	240·41 ±1·10
Leaf	1016·10 ±4·33	689·99 ±3·78	528·75 ±1·25
Root	909·44 ±6·75	271·90 ±8·66	193·66 ±0·79
Dry weight (mg)			
Whole seedling	353·93 ±4·87	171·36 ±1·57	154·11 ±0·18
Stem	104·61 ±1·97	48·71 ±0·29	45·83 ±0·54
Leaf	184·44 ±1·69	100·71 ±0·73	88·66 ±0·29
Root	64·88 ±1·29	21·94 ±0·58	19·62 ±0·57
Shoot/root ratio	1·60 ±0·00	2·22 ±0·07	2·33 ±0·06

whole seedling as well as its different parts (stem, leaf and root) was observed. Of all the plant parts roots were much affected. The roots showed 66·18 % and 66·67 % decrease in dry weight in 10 and 20 ppm SO_2 exposed seedlings respectively over the controls. The stem growth showed 53·43 % reduction in 10 ppm and 56·18 % reduction in 20 ppm SO_2 exposed seedlings. The dry weights of the leaves of SO_2 fumigated seedlings showed 45·39 % and 51·93 % decrease in 10 and 20 ppm respectively. Since the root system of the fumigated seedlings were very much affected, the shoot/root ratio was increased in fumigated seedlings than the control seedlings (table 2).

The growth reduction may be due to the reduced photosynthetic area probably resulting in reduced photosynthesis (Rao and Le Blanc 1965; Cocker 1967). The reduced root growth and nodulation may be due to the reduced photosynthate being available for translocation to the roots (Ashenden 1978; Mejstrik 1980; Marshall and Furnier 1981; Jones and Mansfield 1982; Singh and Rao 1982).

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References

Ashenden T W 1978 Growth reduction in Cocksfoot (*Dactylis glomerata* L.) as a result of SO_2 pollution; *Environ. Pollut.* **15** 161–166

Bell J N B and W S Clough 1973 Depression of yield in rye grass exposed to sulphur dioxide; *Nature (London)* **241** 47–49

Coker P D 1967 Effects of SO_2 pollution on the Bark epiphytes; *Trans. Br. Bryol. Soc.* **5** 341–347

Daines R H 1968 Sulphur dioxide and plant response; *J. Occup. Med.* **10** 516–34

Dye M 1980 Functions and maintenance of a Rhizobium collection in *Recent Advances in Biological Nitrogen Fixation* (ed) N S Subba Rao (Oxford and IBH Publishing Company New Delhi) pp 435–471

Evans G C and A P Hughes 1961 Plant and the aerial environment. 1. The effect of artificial shading on *Impatiens parviflora*; *New Phytol.* **60** 150–180

Jones T and T A Mansfield 1982 The effects of SO_2 on growth and development of seedlings of *Phleum pratense* under different light and temperature environments; *Environ. Pollut. Series (A)* **27** 57–71

Marshall P E and G R Furnier 1981 Growth responses of *Alianthus altissima* seedlings to SO_2; *Environ. Pollut. Series (A)* **25** 149–153

Mejstrik V 1980 The influence of low SO_2 concentrations on growth reduction of *Nicotiana tabacum L.* cv. samsun and *Cucumis sativus* L. cv. Unikat; *Environ. Pollut. Series (A)* **21** 73–76

Pandey S N and D N Rao 1978 Effects of coal, smoke, sulphur dioxide pollution on the accumulation of certain minerals and chlorophyll content of wheat plants; *Trop. Ecol.* **19** 155–162

Rao D N and F Le Blanc 1965 Effects of sulphur dioxide on lichen algae with special reference to chlorophyll; *Bryologist* **69** 69–75

Ricks G R and R J H Williams 1975 Effects of Atmospheric pollution on Deciduous Wood Land Part 3: Effects on photosynthetic pigments of leaves of *Quercus petraea* (Mattuschka) Leibl. *Environ. Pollut.* **8** 97–106

Singh M and D N Rao 1982 The influence of ozone and sulphur dioxide on *Cicer arietinum* L.; *J. Indian Bot. Soc.* **61** 51–58

Syratt W J and P J Wanstall 1969 The effects of sulphur dioxide on epiphytic Bryophytes; *Proc. Eur. Congr. Air Pollut.* **1** 79–85

Thomas M D 1961 Effects of air pollution on plants; in *Air Pollution* (Monograph WHO) **46** 233–278

Thomas M D and R H Hendricks 1956 Effects of Air pollution on plants; in *Air Pollution Hand Book* (New York: McGraw Hill Book Company)