Effect of SO₂ Fumigation on Growth and Nodulation of Vigna mungo

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Vigna mungo was fumigated 2h/day with SO_2 at 0.25 ppm and 1 ppm. Lateral spread, plant height, number of leaves and total leaf area, RGR, LAR and root/shoot ratio due to SO_2 pollution were inhibited. The dry matter yield and productivity were significantly affected. Root nodulation was adversely affected by SO_2 treatment. SO_2 caused flowering and fruiting in advance of the control. In general, severity of phytotoxicity of SO_2 treatment increased with increase in concentration and duration of treatment.

Key Words - Growth Pollution SO₂ Vigna Yield

The toxicity of SO₂ to plants is attributed mainly to the formation of toxic ions such as H^+ , HSO_3^- , $SO_3^2^-$ and $SO_4^2^-$ which disturb both the mineral status of plants and its physiological process. The SO₂ in combination with moisture undergoes acidification and reduces soil PH which in tarn, reduces bacterial population responsible for reduced level of root nodulation. Phytotoxicity of SO₂ in inducing foliar injury, inhibiting growth and has been well documented photosynthesis (Jacobson & Hill 1971). Little work has been done on the effect of SO₅ on root nodulation (Singh & Rao 1982, Satyanarayana et al. 1985, Kumar & Singh 1986). The toxic productieffect of SO₂ pollution on growth, vity and nodule formation in Vigna mungoL. (urd bean) is reported.

MATERIALS & METHODS Certified seeds of early spring crop of urd bean Var. T 9 (age 60 days) were procured from Government seed agency. The seeds were grown in earthenware pots of 30 cm dia filled with garden soil and compost in 3:1 ratio. Three plants were grown in each pot. The experiment was conducted in ambient environment except for the fumigation period. The plants were fumigated in a fumigation chamber, with SO₂ gas according to the following schedule: A. Fumigation of plants with 0.25 ppm SO_2^- for 2h/day.

 T_{I} 10 day old plants were fumigated up to 60 days with alternate 10 days of fumigation and recuperation period,

 T_2 30 day old plants were fumigated up to 60 days without recuperation period.

B. Fumigation of plants with 1 ppm $SO_2\,$ for $\,2h/\,$ day.

 T_3 10 day old seedlings were fumigated up to 60 days with alternate 10 days fumigatian and recuperation period.

 T_4 30 day old plants were fumigated up to 60 days without recuperation period.

C. Control set was treated in identical condition except for $SO_2^{\frac{3}{2}}$ fumigation.

The fumigation was carried out in a 90 X 90 X 120 cm standard fumigation chamber with perforated base for air-inlet and an air-outlet at the top. From the base, SO₂ was supplied with the help of a flow regulated fan. The SO₂ was generated in standard SO₂ generator by mixing sodium metabisulphite and dilute sulphuric acid. The air from the chamber was sampled with standard air sampler, bubbled into O.1 M solution of sodium tetrachloromercurate and was measured for SO₂ concentration (West & Gaeke 1956). The temperature and relative humidity during the study period ranged from 18°C to 29°C and 50% to 60% respectively.

The sampling was done at 10 day interval to measure growth, dry matter yield and nodulation. Two replicates of 3 plants each were harvested, washed thoroughly, plant parts were separated and dried at 80°C. The productivity was computed on the basis of periodical harvesting and expressed as g plant⁻¹ day⁻¹. The relative growth rate (RGR), leaf area ratio (LAR) and root/ shoot ratio were calculated according to Blackman (1968) and Evans & Hughes (1961).

RESULTS The phytotoxic influence of SO_2 on growth parameters such as lateral spread, plant height, shoot and root length, number of branches and internodes, number of leaves and total leaf area of V. mungo has been identified. In general these growth parameters have been inhibited in SO_{a} fumigated plants (Table 1). The retardation in linear growth of plants and their lateral spread was greater in higher concentrations of SO_{a} . The effect on root growth was relatively higher than the shoot. The plants fumigated from the age of 30 days with continuous application showed greater retardation in growth parameteres than the plants fumigated with intermittent application. (Table 1).

Table 1 Effect os Sulphur Dioxide Fumigation on Growth of Vigna.

Growth	Treat-	Age of plant (days)						
parameter	ment	10	20	30	40	50	60	
Lateral	С	17.8	50.7	93.0	194.4	199.0	201.0	
spread	T ₁	17.8	42.4+	81.1	171.0	180.3	190.0	
(cm2)		17.8	$\frac{1}{37.5}$ +	61.6	120.0	140.6	147.1	
	Ť₄	-	_		98.7	100.0	1108.0	
Plant	С	21.0	27.8	30.4	32.4	34.0	34.4	
height	T _A	21.0	26.5***	28.8	30.6	31.7	33.2	
(cm)	T ₂		_		31.9	32.4	33.3	
		21.0	23.5***	23.9	28.1 31.0	28.9 31.5	29.2 32.0	
Root	C	5.5	11.0	11.7	13.0	14.0	14.3	
lentgh	Т	5.5	10.0*	10.7	11.4	13.6	13.5	
(cm)	Τ ₂				12.8	13.0	13.6	
	\mathbf{T}_{3}^{-}	5.5	7.8 *	8.1	9.1	9.9	10.0	
	14				12.0	12.5	12.9	
Shoot	С	15.5	16.7	18.7	19.3	19.9	20.1	
length	T ₁	15.5	16.5*	18.0	19.1	19.6	198	
(cm)	Τ₂			-	19.0	19.4	19.7	
•	T _s	15.5	15.7*	19.0	19.1	19.1	19.2	

Continued

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Growth	Treat-		Age of plant (days)						
parameter	ment	10	20	30	40	50	60		
Total leaf	С	40.0	70.0	100.2	201.0	414.0	700.0		
area	Tī	40.0	65.0*	90.0	188.0	390.0	672.2		
(cm ²)	$\begin{array}{c} T_{2} \\ T_{3} \\ T_{4} \end{array}$		* *	80.0 —	$ \begin{array}{r} 198.1 \\ 170.8 \\ 190.0 \end{array} $	385.3 360.2 376.5	663.7 650.0 640.5		
Number of	С	4	8	12	20	22	33		
leaves/	Tr	4	7	11	17	20	24		
plant	T 2 T 3 T 4	4 	6+	 10 	18 10 16	21 16 18	23 22 23		
Number	С	2	3	3	4	5	5		
of node/	T ₁	2	3	3	3	4	4		
plant	T 2 T 3 T 4	2	3	3	4 3 3	4 4 3	4 4 3		
Number of	С	1	2	2	3	4	5		
branches/	Τ _ī	1	1	2	2	3	4		
plant	$\begin{matrix} T_{2} \\ T_{3} \\ T_{4} \end{matrix}$	1	- 1 -	2	2 2 2	3 3 3	4 3 3		
Number of	С		_	_	-	6	8		
pod/plant	T 1 T 2 T 3 T 4				2 2 2	5 5 4 3	6 5 5 4		

Significance of difference from control

p < 0.005 p < 0.010 p < 0.025 + Not significant

Dry matter yield and productivity of fumigated plants were low compared with untreated plants (Table 2).

In general RGR increased up to 30 days followed by steady decline till the maturity of plant (Table 3). The SO₂ fumigated plants showed retardation in RGR and root/shoot ratio compared to control. The decrease corresponded to the concentration of SO₂ and duration of exposure time. However, the LAR values increased after an initial retardation.

Compared to control, the root nodule formation was considerably affected by SO_2 fumigation. Reduced number of nodule per plant was recorded in plants continuously by fumigated after 30 days compared with those of intermittent fumigation (Table 4).

The fumigated plants flowered early and pods matured by 5 to 10 days (Table 1).

plant (days) 10	part		I'M AINT	cigne (8/P	(man)			LIVUUU	uvity (g/pia	nt/day)	
10		С	Tf	T_2	$T_3^{(i)}$	T 4	C	T ₁	T_{2}	T_3	T
	Root Shoot	0.05 0.35	0.05 0.35	1	0.05 0.35	1 1	0.040	0.040	ł	0.040	I
20	R oot Shoot	$0.06 \\ 0.41$	$0.06 \\ 0.40$	1	$0.06 \\ 0.40$	1 1	0.023	0.023	ļ	0.023	ļ
30	Root Shoot	0.16	0.15 1.31	Ĺ	0.15		0.051	0.049	1	0.048	Prove
40	Root Shoot	0.24 3.33	0.24 3.30	0.24 3.31	$0.24 \\ 3.25$	0.24 3.29	0.089	0.088	0*089	0.087	600.0
50	Root Shoot	0.33 4.75	0.32 4.72	0.31	0.31 4.68	0.30 4.05	0.010	0.010	0.010	600.0	0.008
60	Root Shoot	0.35 4.96	0.33	0.32 4.81	0.32 4.76	0.19 4.21	0.088	0.086	0.085	0.084	0.067
cheri-						Age of pla	int (days)				
ent -		Ċ	RGR (E	g/g/day)				LAR (cn	13/g)		
	70	30	40		50	60	20	30	40	50	. 60
	0.016	0.118	0.084	0.	.035	0.004	124	94	61	69	105
·	0.013	0.115	0.088	0.	.035	0.002	120	89	57	65	66
51	I	I	I	0	,034	0.002	I	1	١	66	66
	0.013	0.114	0.087	1 0	.035	0.001	107	74	58	64	81

Effect of Sulabur Dioxide Toxicity on Standing Dry Biomass and Productivity of Vigna

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Esperies	Experiment		Age of plant (days)				
Experim	10	20	30	40	50	60	
С		7	15	18	22	23	
T		6^{+}	14*	16	18*	20*	
Т				17 +	18*	19*	
Т		4*	13++	14 +	16*	18*	
Т				16	17*	17*	

 Table 4 Effect of SO 2 Toxicity on Nodulation

 (Number) of V. mungo

Significance of difference from control

* P < 0.005, ** P < 0.010 + Not significant

DISCUSSION In general SO₂ fumigation inhibited growth parameters of urd bean. The height of plants and its lateral spread, shoot and root length, number of leaves and total leaf area, dry biomass and productivity were significantly reduced. Retardation in such growth parameters due to SO₂ pollution has been observed (Pandey & Rao 1979, Rao *et al.* 1981, Satyanarayana *et al.* 1985, Kumar & Singh 1986). SO₂ inhibits photosynthetic activity either by degrading chlorophyll (Rao & LeBlanc 1966) or by affecting enzyme activity (Ziegler 1972 Mansfield & Jones 1984) which might lead to reduction in growth.

The reduction in yield may be attributed to the reduction of leaf area and reduced photosynthesis. Koziol & Jordan (1978) proposed that in response to SO₂ toxicity, carbohydrate is diverted from sites of growth and storage to the site where repair is needed. Such a diversion of material would adversly affect productivity.

The daily rate of gain in dry weight (RGR) and the area of assimilating surface producing I gram of dry weight of plant (LAR) were reduced, compared to the control (Hogsett *et al.* 1984). Since RGR and LAR are the products of photosynthesis

which are retarded after the treatment of SO_{2*} . Root/shoot ratio of SO_{2} fumigated plant is reduced, confirming the earlier observations (Ashenden & Mansfield 1977, Bell *et al.* 1979, Satyanarayana *et al.* 1985 Kumar & Singh 1986). Reduction in rest growth in comparison to shoot may't be due to the low translocation of food as a result of reduced photosynthesis and an inhibition in phloem loading system in SO_{2} treated plants (Teh & Swanson 1982).

 S_{O_2} inhibited root nodulation (Singh & Rao 1982, Satyanarayana *et al.* 1985 Kumar & Singh 1936). The acid precipitation of soil due to SO_2 might reduce bacterial population which in turn, affects the formation of root nodule (Tamm 1976).

It may be hypothesized that during recuperation period, the metabolism of plants returns to normal. This could be the reason for reduced phytotoxic effect in alternate treatment compared with the daily fumigated plant.

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