EFFECT OF SULPHUR DIOXIDE ON GROWTH, CHLOROPHYLL AND SULPHUR CONTENTS OF TOMATO (SOLANUM LYCOPERSICUM L.)

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Abstract

The direct toxic effect of atmospheric pollutant such as sulphur dioxide on plants has been well documented. It is essentially a potent phytotoxic gas and its toxicity to plant is manifested in typical chronic or acute foliar symptom injury. The mode and extent of damage caused by this pollutant to tomato has not been precisely and systematically studied. Under such circumstances, the present investigation was undertaken under simulating condition to find out the possible extent of adaptability of tomato in SO_2 emission of our state. The effect of varying levels of sulphur dioxide (0.25, 0.5 and 1.0 ppm) fumigated for 1 hour, 2 hours and 3 hours under simulated conditions on tomato revealed that the important traits like leaf number, leaf area, fresh weight, dry weight and chlorophyll content in leaves were adversely affected, the latter treatment (SO_2 1.0 ppm with 3 hours exposure) being more uninnocuous in this regards. However, no significant variation was seen amongst the treatments in respect of tissue fresh and dry weight when compared with that of control (ambient SO_2). On the other hand, sulphur content in tissues increase progressively with increasing levels of SO_2 and time of fumigation and the variation observed within treatments was significant to each other. It is suggested that the lowest concentration of SO_2 (0.25 ppm) used in this study is more than sufficient to bring about a significant changes in most of the parameters studied.

Keywords: SO^2 fumigation, tomato, growth, chlorophyll, sulphur content

Introduction

The continued expansion of industrial activity and urbanization worldwide are the main factor contributing to gaseous air pollution. Among the gaseous pollutant, SO_2 is the primary pollutant because it is directly emitted from the pollution source as a product of combustion or processing of raw material that contain sulphur. The principal sources of SO_2 are burning of coal and oil with high sulphur content and smelting of sulphide ore. The direct toxic effect of atmospheric pollutants, sulphur dioxide in particular, on plants has been well documented (Rajput *et al.,* 1977 and Winner *et al.,* 1985) during the past two decades. It is essentially a potent phytotoxic gas and its toxicity to plant is manifested in typical chronic or acute foliar symptom injury. The relationship between foliar loss due to SO_2 exposure and yield reduction in various crops has also been studied by Barreti and Benedict (1970) and Winner *et al.* (1985). It has been known to cause injury in these crops by destroying chlorophyll, disrupting photosynthesis and reducing biomass production and productivity. Moreover, the extent of injury is species dependent and is likely to be influenced by the macro and micro-climate of that particular agro-ecosystem. The natural adaptability of a crop species to a particular ecosystem is determined taking into consideration the extent of injury and sustainability of that crop. The mode and extent of damage caused by this pollutant to tomato has not been precisely and systematically studied. The present investigation is a modest attempt under simulating condition which aims at finding out the possible extent of adaptability of tomato in SO_2 emission of our state.

Materials And Methods

The investigation was carried out during 2006-2007 in the Regional Research and Technology Transfer Station (RRTTS), Orissa University of Agriculture and Technology, Semiliguda, Koraput, Odisha, India. The 30 days old seedlings of tomato variety BT-2 were transplanted in 12″ x 8″ polythene bags filled with a mixture of soil (red lateritic having a pH 5.5), sand and manure (2:1:1). Sulphur dioxide for the study was prepared in the laboratory by heating copper turnings with conc. sulphuric acid. The gas is taken to the experimental plot where it is applied to the plants in the morning. The gas was brought in and applied to the chamber by keeping the volumetric flask upside down and opening the lid inside the chamber. Time to time stirring was done inside the chamber for uniform mixing of gas. The fumigation was given to the plants 60 days after transplanting. Sulphur dioxide gas was applied at three different concentrations i.e. at 0.25, 0.5 and 1.0 ppm for different duration i.e. for 1, 2 and 3h, by putting the plants in a specialized structure built in the dimension of 1m x 1m x 1m length, breadth and width covered with high density polythene strip.

The treatments were replicated thrice and fitted into a factorial randomized block design. All the operations were performed on the same day. Observations on growth, flowering and fruiting were recorded seven days after the treatment. In general, SO_2 damage was assessed on the basis of its area affected. The damage exceeding more than 50% of its total area was considered as completely affected and less than 50% was considered as to be normal. The chlorophyll content was calculated by using the formula by Mach-lachan and Zalik (1963) and the procedure for sulfur estimation was adopted from Patterson (1978).

Results And Discussion

Number of leaf and leaf area

Data pertaining to various traits revealed that damage to leaf injury, which includes both leaf number and its area, increased progressively in tomato studied with increasing levels of SO_2 and time of fumigation (Table 1). Moreover, the damage was highly significant at the highest level of SO_2 (1.0 ppm) when compared to that of control. In the present study, percent injury recorded for leaf number and leaf area was in order of 61 to 95.83 and 52 to 82, respectively. The injury manifested might be attributed to higher sulphur content in plant and as such the plant could not be capable of metabolizing and utilizing the SO_2 absorbed outwardly (Stratigakos and Ormrod 1985). Such injury has been ascribed to the faster accumulation of SO_2 than its oxidation and assimilation in the plant tissues, exceeding threshold accumulation in the intercellular spaces of the leaf and causing cell injury (Thomas 1961). Alternately, it has also been contemplated that SO_2 in combination with aldehydes and sugars forms secondary products which decompose slowly to release H_2SO_3 or H_2SO_4 into the plant cell, that becoming more uninnocuous to the system (Haselhoff and Lindau, 1903).

Number of flower and fruits.

The data presented in Table 1 revealed that the flowers present on the plant during the treatment recorded injury which lies between 43% and 75%. The tomato fruits also were less affected by the treatment as compared to flowers. A few fruits dropped off in higher doses (22- 33%). The results indicated that low concentration of SO_2 (0.25 ppm) has little effect compared to its highest level (1 ppm). Supporting evidences to these findings also came from Reinert and Gray (1981) and Olszyk and Tibbitis (1982).

Fresh and dry matter content

Decrease in fresh weight and dry weight of the tissues was gradual with increasing concentrations of SO_2 (Table 1). The values obtained in respect of the above parameters seem to be inconsistent when compared with that of control. The treatment effect was not significant although there was a marked difference in the data pertaining to this parameter. Further, reduction in the fresh and dry matter was more manifested in shoot than in root of plants. Alternatively, accumulation of sulphur in the tissue beyond its threshold level might be the cause of varying injury (Thomas, 1961) observed in the current investigation. However, least damage was reached to root due to SO_2 fumigation compared to foliages that accounts for the fresh weight of control plants. The present findings are in agreement with the results of Mandal *et al*. (1980) and Thompson *et al*. (1982).

Chlorophyll content

The chlorophyll content of leaves declined significantly with increasing levels of SO_2. Reduction in chlorophyll content determine to be 39 to 65%, lowest value being recorded at 1.0 ppm SO_2 treatment fumigated for 3h (Table 1). Greater damage to the chloroplast machinery due to the SO_2 treatment is the main cause of decrease in chlorophyll content in the leaves. The chlorophyll content decreased with increasing SO_2 concentration and the effect is being more accentuated when the simulation period is increased. The decrease in chlorophyll content has been ascribed to the disruption of the chloroplast membrane due to phytotoxic nature of SO_2,(Winner *et al.* 1985) resulting in leaching of pigments (Rath *et al.* 1994). Such interference of SO_2 is believed to promote secondary processes which breakdown chlorophyll and kills the cells.

Sulphur content

The sulphur content in tomato plant tissues increased with increase in levels of SO_2 fumigation (Table 1). Increase in sulphur content of tissues with increasing levels of SO_2 is probably due to in ability of plants to metabolize and assimilate the excess SO_2 at cellular level thus results in its accumulation to manifold. In case of tomato Sulphur content in the plant tissues merely increased by more than five fold at 1 ppm for three hour as compared to that of control plant. This is quite natural and is also evident from the earlier report of Mishra, 1980 and Rath *et al.* (1994). Apparently, SO_2 can cause some growth reduction in the absence of visible manifestation when a threshold concentration is exceeded. Under these conditions, it appears that H_2SO_3 or SO_4^{-2} can accumulate in the cells of the plants and inhibit photosynthesis without necessarily killing the cells. At sub-threshold concentrations, the sulphite is oxidized to the non-toxic sulphate as rapidly as it is absorbed, so that inhibition of photosynthesis does not occur. Similarly, at concentrations below those causing any visible symptoms, cause a reduction of photosynthesis, early senescence, an unthrifty appearance, reduce growth and yield and increase susceptibility to disease and insects.

Conclusion

Sulphur dioxide treatments in tomato were found to be harmful even at lower dose and duration of exposure which increased gradually with increasing concentrations and durations. However, lower concentration i.e. at 0.25 ppm of SO_2, the injuries to various morpho physiological parameters were subtle. It is suggested that the lowest concentration of SO_2 (0.25 ppm) used in this study is more than sufficient to bring about a significant changes in most of the parameters studied. However basing on the present results it is hoped that this preliminary study would throw a light to the researchers and environmentalist from the view of increasing day to day global pollution and its effect on crop canopy as a whole.

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Table1. Effect of varying level of so_2 simulation on growth parameters, chlorophyll and sulphur contents in plant tissue of tomato

Treatments Parameters	Concentration of SO_2 (ppm)									Control T_0H_0	F. Test	LSD at 5%
	0.25			0.50			1.00					
	1 Hour	2 Hour	3 Hour	1 Hour	2 Hour	3 Hour	1 Hour	2 Hour	3 Hour			
No. of leaves												
Initial	59	51	63	49	43	53	58	56	48	**46**	*	8.28
Damaged	36	35	46	37	35	47	52	46	46	-		
% Injury	61.00	68.62	73.01	75.50	81.39	88.67	89.80	92.00	95.83	-		
Leaf area (cm^2)												
Initial	440.00	380.00	469.00	365.00	320.00	395.00	432.00	417.00	358.00	**343.00**	*	1.87
Damage	229.00	217.00	296.00	237.00	208.00	276.00	311.00	317.00	293.00			
% Injury	52.00	57.00	63.00	65.00	65.00	70.00	72.00	76.00	82.00			
No. of flowers												
Initial	7	6	4	5	7	8	6	5	8	**6**	*	2.44
Damage	3	3.	2	3	4	6	4	3	6			
% Injury	43.00	50.00	50.00	60.00	57.00	75.00	67.00	60.00	75.00			
No. of fruits												
Initial	4	2	5	6	5	5	9	10	6	**5**	NS	
Damage	-	-	-	-	-	1	2	3	2	-		
% Injury	-	-	-	-	-	20.00	22.00	30.00	33.00	-		
Fresh weight(g)												
Shoot	48.00	42.00	52.00	48.00	35.00	40.00	43.00	46.00	39.00	**38.00**	NS	
Root	23.00	21.00	27.00	25.00	19.00	22.00	24.00	26.00	23.00	**16.00**		
S/R Ratio	2.10	1.99	1.91	1.90	1.86	1.83	1.81	1.77	1.71	**2.36**		
Dry weight(g)												
Shoot	6.50	5.60	6.90	5.40	6.40	5.80	6.20	4.70	5.30	**5.10**	NS	
Root	1.60	1.50	2.10	1.90	2.30	2.20	2.50	2.00	2.70	**1.60**		
S/R Ratio	4.06	3.67	3.30	2.84	2.77	2.65	2.46	2.37	1.96	**3.16**		
Chlorophyll content (mg/g)												
Fresh Leaf	5.49	5.24	5.07	4.82	4.65	4.48	4.23	3.80	3.30	**8.45**	*	0.03
% of Control	65.00	62.00	60.00	57.00	55.00	53.00	50.00	45.00	39.00	**100.00**		
Sulphur content (ppm)												
	0.07	0.09	0.11	0.13	0.16	0.18	0.19	0.20	0.22	**0.04**	*	0.15

*- F.Test Significant