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RESPONSE OF BIOCHEMICAL ACTIVITY OF SUNFLOWER TOSULPHUR DIOXIDE POLLUTION

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ABSTRACT

Earth's environment is favourable for the evolution and survival of various forms of life. But the ever-growing population coupled with a strong desire of man to raise the standards of living has subsequently led to environmental degradation through various forms and one such form is air pollution which is responsible for climate change and the consistent changes in climate lead to natural disasters. The injury caused by air pollutants is often evident on plants before it can affect humans or animals, thus the effect of air pollution leading to climate change is widely studied through plants. Present study deals with the long term effects of sulphur dioxide, one of the most common, widespread, phytotoxic, man-made primary pollutant on the ornamental cultivar of sunflower i.e., *Helianthus annuus* L.cv. Single Miniature (family Asteraceae) on fumigation with four cumulative doses 2612, 3265, 3918 and 4571µg m^{-3} of SO_2 at different plant age along with a control set. By observing change in biochemical parameters (photosynthetic pigments chlorophyll **a**, **b,** carotenoids and leaf extract pH), it has been possible to correlate the concentration of pollutant and the injury it causes to the plant.

Keywords: Chlorophyll, *Helianthus*, pollutant, SO_2, sunflower

INTRODUCTION

We live on the Earth which is a unique planet as its environment is favourable for the evolution and survival of various forms of life. But the uncontrolled growing population coupled with a strong desire to raise the standards of living has subsequently led to environmental degradation through various forms and one such form is air pollution which is responsible for climate change and the consistent changes in climate lead to natural disasters. Among the various air pollutants, sulphur dioxide (SO_2) is one of the principal contaminants and is also associated with climate change. SO_2 emissions from burning of coal and oil react with water and oxygen in the air to form sulphate aerosols – that fall to the Earth in the form of acid rain. Sulphate aerosols are known to reflect sunlight back into the space thus counterbalancing the global warming. But in order to solve one environmental problem another problem can't be enhanced as SO_2 affects the plants adversely (Shahare, 1995). Sulphur dioxide cause severe damage to vegetation under natural and control conditions (Verma and Agarwal,1996). Acute and chronic exposure to SO_2 can result in the general disruption of photosynthesis, respiration, as well as, other metabolic and fundamental cellular processes (Ewald and Schlee,1983).Sensitivity of SO_2 depends upon the plant age, its development and various ecological conditions like solar radiation, temperature, humidity and edaphic factors (Heck and Dunning,1978). A decrease in chlorophyll content can be considered as an indicator of air pollution injury (mainly SO_2) because SO_2 pollution affect these pigments (chlorophyll **a**& **b**) and this directly influences the photosynthetic ability of the plants. The present paper deals with the study of the effects of different concentrations of SO_2 on photosynthetic pigments (chlorophyll **a**, **b** and carotenoids) and leaf extract pH of *Helianthus annuus*L.cv. Single Miniature (family – Asteraceae), an ornamental cultivar of sunflower.

MATERIAL AND METHODS

Seeds of *Helianthus annuus* cv. Single Miniature were procured from IARI, New Delhi. The seeds were sown in polythene bags filled with sandy loam soil. The plants were treated with 2612, 3265, 3918 and 4571 µg m^{-3} SO_2 for 2h daily from 11th day to maturity of the crop using 1m^3 polythene chambers in which circulation of air was maintained by a small fan to facilitate thorough mixing of air inside the chambers. The SO_2 gas was prepared chemically by reacting sodium sulphite with concentrated sulphuric acid. A control set was also run in identical conditions but without exposure to SO_2.The plant samples were studied at 30th, 50th, 70th and 90th day for various biochemical parameters (chlorophyll **a**, **b**, carotenoids and leaf extract pH (Table-1). The amount of chlorophyll **a** and **b** were measured according to Arnon (1949). The amount of carotenoids was determined by using formula of Maclachlan and Zalik (1963). Leaf extract pH was measured with the help of digital electronics pH meter by homogenizing 5g fresh leaves with 25ml double distilled water. The data obtained for various attributes in treated set and control both were subjected to statistical analysis.

RESULTS AND DISCUSSION

The accumulation of biochemical components in the leaves of studied cultivar of *Helianthus annuus* L. were affected to a great extent on exposure with different concentrations of sulphur dioxide. The higher concentration of SO_2 proved more toxic as against the lower concentrations. Degradation of chlorophyll **a** was more than that of chlorophyll **b**.The concentration 4571 µg m^{-3} of SO_2 had reduced chlorophyll **a** and **b**up to 43.75 and 38.93 percent (Figure 1). Carotenoids are the accessory pigments provided for photoprotection. Its amount was reduced upto 74.78 percent on exposure with 4571µg m^{-3} SO_2. Exposures with all concentrations of SO_2 had declined the leaf extract pH appreciably. 4571 µg m^{-3} SO_2 exposures reduced the pH by 27.87 percent (Figure 2). However, upto the plant age of 50d, exposure of 2612 µg m^{-3} of SO_2 did not induce any considerable reduction but its content was observed to be substantially lowered at higher concentrations and resulted in highly significant reduction (significant at 1% level).

The present investigation revealed that sulphur dioxide act as a kind of stress to plants and its fumigation caused considerable reduction in different biochemical attributes. Damage in plants is correlated with chlorophyll reduction. The decreased content of chlorophyll **a**, **b** and carotenoids of leaves on treatment with SO_2 could be due to disturbances in chloroplast ultrastructure and chlorophyll **a** was found to be more susceptible than chlorophyll **b**(Gupta, 1992). High sensitivity of chlorophyll **a** hampers the plant growth as it plays significant role in the process of photosynthesis. Reduced photosynthetic ability of chlorophyll molecule is associated with the formation of sulphurous (H_2SO_3) and sulphuric acid (H_2SO_4) formed by the reaction of water and absorbed SO_2 by plant tissues .These then dissociate to form toxic ions(H^+,$H_2SO_3^-$,SO_3^-,and SO_4^{-2})which cause degradation of chlorophyll molecule to phaeophytin and Mg^{+2} ions(Rao and Le Blanc,1966). Higher concentrations of SO_2 may cause total senescence by inhibiting chlorophyllase activity, RUBISCO and PEP carboxylase (Ziegler,1972). Carotenoid pigments serve a dual function of collecting energy for photosynthesis and protecting chlorophyll against photodestruction in times of excess light. Its significantly reduced content indicates inhibited photosynthetic capacity of the plant (Verma and Aggarwal, 2001).

Table 1.Biochemical response of *Helianthus annuus*L.cv.Single Miniature on exposure to different concentrations of SO_2.

Plant age,d	SO_2 (µg m^{-3})	Attribute			
		Chlorophyll a	Chlorophyll b	Carotenoids	Leaf extract pH
30	0	0.384	0.226	0.115	6.221
	2612	0.268	0.209	0.097*	6.184
	3265	0.255	0.178*	0.069**	6.082*
	3918	0.235**	0.159**	0.043**	5.968**
	4571	0.216**	0.138**	0.029**	5.655**
	CD5%	0.131	0.036	0.015	0.133
	CD1%	0.143	0.051	0.021	0.144
50	0	0.498	0.301	0.177	6.287
	2612	0.383	0.282	0.167	6.091
	3265	0.367	0.234**	0.121**	5.978**
	3918	0.344**	0.216**	0.101**	5.716**
	4571	0.323**	0.198**	0.085**	5.446**
	CD5%	0.139	0.046	0.018	0.211
	CD1%	0.151	0.064	0.025	0.309
70	0	0.621	0.284	0.252	6.355
	2612	0.494	0.244*	0.227	5.984*
	3265	0.462**	0.219**	0.202**	5.805**
	3918	0.435**	0.202**	0.173**	5.473**
	4571	0.410**	0.191**	0.143**	5.051**
	CD5%	0.133	0.030	0.036	0.271
	CD1%	0.147	0.043	0.051	0.388
90	0	0.887	0.311	0.293	6.468
	2612	0.672*	0.290*	0.277*	5.765*
	3265	0.638**	0.254**	0.236**	5.688**
	3918	0.609**	0.227**	0.217**	5.249**
	4571	0.581**	0.206**	0.175**	4.665**
	CD5%	0.212	0.017	0.015	0.511
	CD1%	0.231	0.034	0.021	0.717

CD – Critical difference *Significant at 5% level **Significant at 1% level.

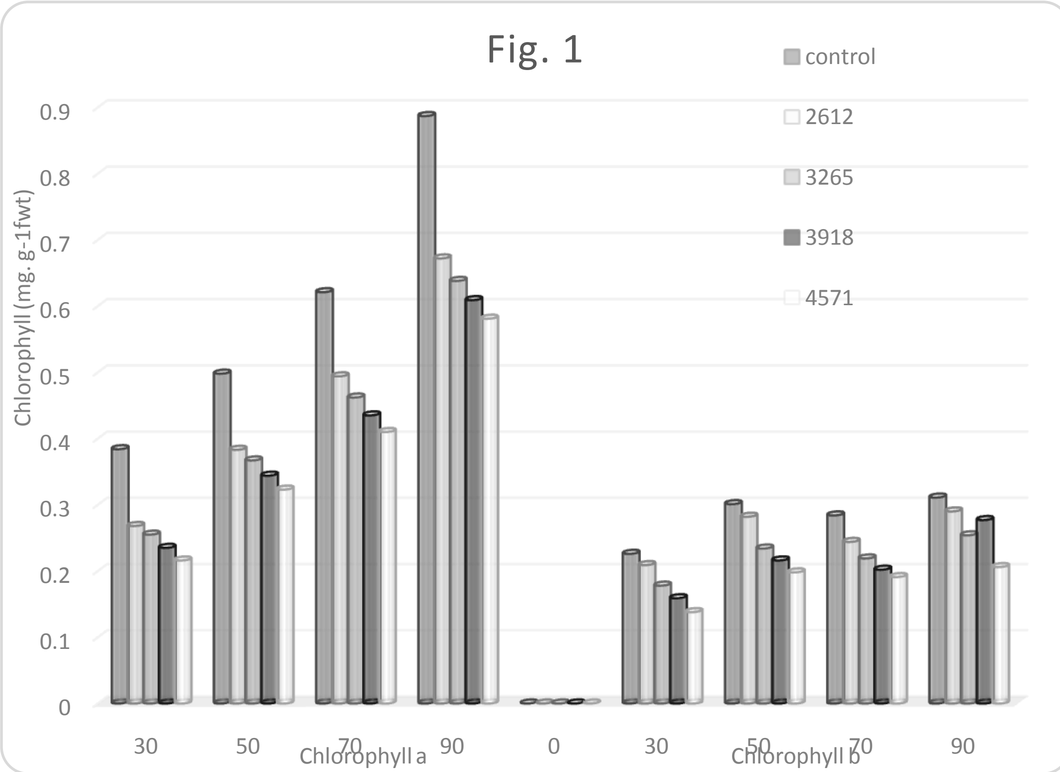

Figure 1.Response of Chlorophyll a & b (mg g^{-1}fwt) in *Helianthus annuus* L.cv. Single Miniature at different plant age (30d, 50d, 70d, 90d) on fumigation with various concentrations of SO_2 ((µg m^{-3}).

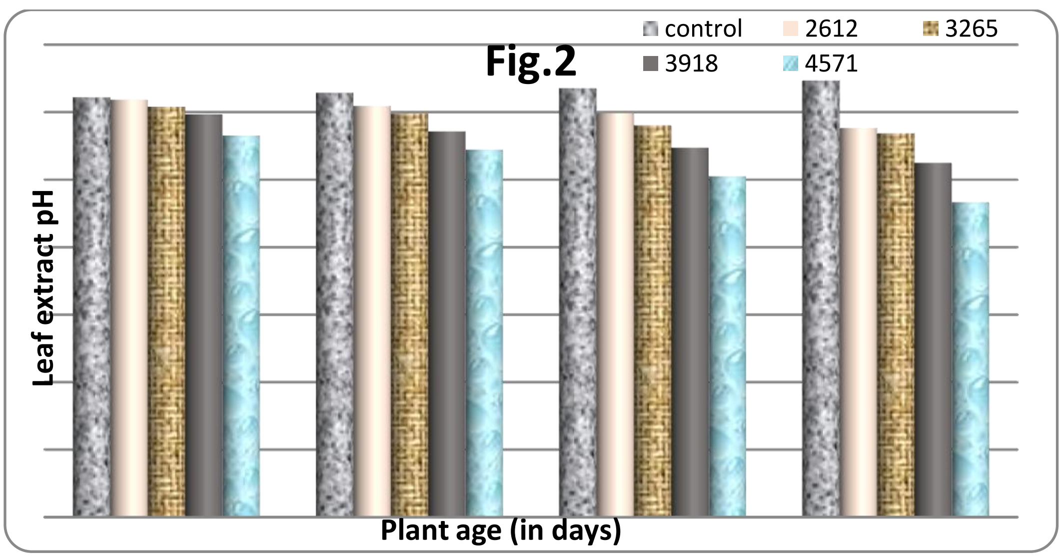

Figure 2. Response of leaf extract pH in *Helianthus annuus* L.cv. Single Miniature at different plant age (30d, 50d, 70d, 90d) on fumigation with various concentrations of SO_2 (µg m^{-3})

Sulphur dioxide enter the leaf via stomata and come in contact with water in leaf tissues forming H_2SO_3 and H_2SO_4 thus reducing the leaf extract pH. Several pH dependent enzymatic activities get altered by decline in leaf extract pH and this in turn affect the plant metabolism (McLean et al.,1968).It is quite clear from the observations that the magnitude of damage caused by 2612, 3265 µg m^{-3} of SO_2 were lesser in comparison to 3918, 4571 µg m^{-3} SO_2.Moreover,the pollutant produced more appreciable effects on 90d old plants than 70, 50 and 30d old plants. Such effects of SO_2 with increasing age of the plants have also been reported by Bell(1982) in grasses and Prasad and Rao (1982) in legumes and cereals.

CONCLUSION

After investigating the crop following SO_2 exposure, it can be deduced that sulphur dioxide, an external factor has exerted a disadvantageous influence on the plant as stress and cause appreciable reductions in biochemical response. We can correlate this to the fact that if air pollutants can cause such injuries to plants, then definitely, they affect the whole environment which comes to us in the form of climate change and then disasters.

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