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Research Article

LEAF RESPONSE OF *HELIANTHUS ANNUUS* L. TOWARDS SULPHUR DIOXIDE POLLUTION

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ABSTRACT
Air is a resource not confined by political or geographical boundaries and as a resource, it carries many social, economic and environmental significance. But pollution of air creates various problems related to environmental quality, public health and economic problem directly affecting not only the agriculture but industry also. However, industrialization can be considered as the major contributor to air pollution emitting various chemical and noxious gases in the atmosphere. Sulphur dioxide is one such gas found to be responsible for acidification of water bodies and affects plants causing damage to vegetation under natural and controlled condition. The present study indicated the adverse effect of SO_2, as a pollutant, on foliar response of *Helianthus annuus* L. cv. KBSH-1 (Family Asteraceae), an oil-yielding cultivar of sunflower on exposure with four cumulative doses of sulphur dioxide i.e. 2612, 3265, 3918 and 4571 µg m^{-3} at different plant age along with a control set. Both the parameters i.e. leaf number $plant^{-1}$ and single leaf area (cm^2) were found to be decreased with increasing concentrations of sulphur dioxide.

Keywords*: Air pollution, SO_2, Foliar response, Leaf number, Leaf area*

INTRODUCTION
The pollution may be described as "any direct or indirect alteration of the physical, thermal, biological or radioactive properties of any part of the environment by discharging, emitting or depositing wastes or substances so as to affect any beneficial use adversely, to cause a condition which is hazardous to public health safety or welfare of the animals, birds, wildlife, fish or aquatic life or to plants" (Alan, 1974). Pollution may be classified on the basis of habitats into air, water, soil and noise pollution. Industrialization coupled with ever demanding growing population has contributed to air pollution emitting various chemical and noxious gases in the atmosphere polluting the air that is not confined by political or geographical boundaries. Among the various air pollutants, the oxides of sulphur are probably the most widespread and intensively studied. Sulphur dioxide is one such oxide of sulphur that is found to be one of the principal contaminants of air.

The environmental effects of SO_2 not only include acidification of soils, lakes and rivers but also causes injuries and devastating damage to vegetation under natural and controlled conditions. The injuries caused by SO_2 in plants may have visible and invisible effect on vegetation. Leaves are the primary route for the uptake which is controlled by the stomatal aperture and conductance to the gas diffusion (Tingey and Tailor, 1982). The extend of visible damage (chlorosis and necrosis) greatly varies among plant species even if the exposure to SO_2 is performed under same conditions. Necrotic lesions appear due to sulphur accumulation in leaves on exposure to high concentration of SO_2 (Mishra, 1980). The foliar injury increased with increasing SO_2 concentration (Lalman et al., 1990). The present study deals with the effect of four cumulative dose of sulphur dioxide i.e.,

2612, 3265, 3918 and 4571 µg m^{-3} on the leaf of *Helianthus annuus* L. cv. KBSH-1 (Family Asteraceae), an oil-yielding cultivar of sunflower at plant age 30, 50, 70 and 90d.

MATERIALS AND METHODS

Seeds of *Helianthus annuus* cv. KBSH-1 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 11^{th} day to maturity of the crop using $1m^3$ framed and portable polythene fumigation chambers in which circulation of air was maintained by a small fan to facilitate thorough mixing of air. The SO_2 gas was produced in the chamber by the reaction of anhydrous 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 30^{th}, 50^{th}, 70^{th} and 90^{th} day for the following foliar response:

a) Leaf number $plant^{-1}$ – The leaf number $plant^{-1}$ was counted in different cultivars at different plant ages. The senescent leaves (completely yellow or very close to shedding) were not included for the counting.

b) Leaf area (cm^2) – For leaf area determination, the leaf outline was drawn on a graph paper and its area was determined with manual planimeter.

The data obtained for various attributes in treated set and control, both were subjected to statistical analysis.

RESULTS

In the present investigation, fumigation of *Helianthus annuus* L. cv. KBSH-1 with 2612, 3265, 3918 and 4571 µg m^{-3} of sulphur dioxide showed inhibitory effect on the leaf parameters. Decline in the number of leaves was exhibited by the studied plant after subsequent exposure with different concentrations of sulphur dioxide. Lower concentration of the pollutant i.e. 2612 and 3265 µg m^{-3} had little effect initially but prolonged exposure resulted in a sharp decrease in number of leaves (Table-1). Besides the reduction in leaf number, leaf area also got affected adversely and exhibited reduction in their surface areas in SO_2 exposed plants. The reduction enhanced with increasing concentration of sulphur dioxide.

DISCUSSION

In the present investigated plant, visible foliar injury appeared in the form of yellow chlorotic patches in interveinal areas later on turned into dark brown bifacial necrotic lesions in the leaves of treated plants. Plants exhibit acute injuries in advanced stages of growth with higher concentrations of sulphur dioxide (Farooq et al., 1988; Fulford and Murry,1990). The concentration of pollutant and duration of exposure measure the severity of injury in the fumigated plants and generally plants suffer with acute injury on exposure with high SO_2 concentrations for short duration and with chronic injury on exposure with lower concentration for long duration (Singh and Rao,1986; Briggs and Davis,1981; Goswami, 2016). The mature leaves found to be more susceptible than the younger leaves, may be due to the reason that the younger leaves being in synthetic phase can synthesize the metabolites against the pollutant stress and hence are resistant or less susceptible (Cracker and Starbuck, 1973; Giridhar, 1981). Leaf is an important part of the plant as it exposes a photosynthetic surface area to catch maximum sunlight as well as facilitate gaseous exchange. In the present study, the size of the leaf has reduced indicating adverse effect of sulphur dioxide. The reduced size of leaf can be regarded as an adaptive response, developed by the polluted plants against SO_2 stress so that less absorptive surface leads to lesser absorption

of SO_2 gas (Sharma and Rao, 1985). But inhibition of leaf expansion might also inhibit the process of photosynthesis in turn diminishing the distribution of photo assimilates leading to altered biochemical processes causing decrease in cell division resulting in leaf area reduction (Verma and Agarwal, 2001).

Table 1: Leaf number plant^{-1} of *Helianthus annuus* L. cv. KBSH – 1 on exposure to different concentrations of SO_2.

Plant Age (d)	SO_2 (µg m^{-3})						
	0	2612	3265	3918	4571	CD 5%	CD1%
30	15.20	12.40	11.00**	10.60**	9.600**	3.094	3.344
50	21.80	18.80	17.40**	13.80**	10.60**	3.145	3.399
70	26.40	21.80	19.20**	16.60**	14.00**	4.959	5.360
90	30.60	25.80	22.60**	20.60**	18.80**	5.681	7.965

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

Table 2: Single leaf area (cm^2) of *Helianthus annuus* L. cv. KBSH – 1 on exposure to different concentrations of SO_2.

Plant Age (d)	SO_2 (µg m^{-3})						
	0	2612	3265	3918	4571	CD 5%	CD1%
30	34.55	30.15	27.70	24.00**	22.45**	4.886	6.851
50	67.10	59.60	50.00**	44.15**	37.85**	9.542	13.37
70	151.50	138.65	121.75**	114.55**	102.00**	19.07	22.42
90	219.80	198.75	185.80**	172.50**	159.25**	23.07	32.34

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

CONCLUSION

The study undertaken to find out the impact of four cumulative doses of sulphur dioxide i.e. 2612, 3265, 3918 and 4571 µg m^{-3} had affected the oil-yielding cultivar of *Helianthus annuus* L. adversely in the form of reduced leaf number $plant^{-1}$ and reduced single leaf area (cm^2).

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