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BIOCHEMICAL EVALUATION OF TWO OIL-YIELDING CULTIVARS OF HELIANTHUS ANNUUS L. TOWARDS SULPHUR DIOXIDE POLLUTION

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ABSTRACT

Sulphur dioxide is a potent phytotoxic gas and its toxic effect to plants is well documented as plants's response towards changing climatic conditions is often more evident before it can affect humans or animals. Present study deals with the biochemical evaluation of two oil-yielding cultivars of sunflower i.e., *Helianthus annuus* L.cv.PAC-36 and cv. MSFH-55 (family Asteraceae) on fumigation with four cumulative doses 2612, 3265, 3918 and 4571µg m^{-3} of SO_2 at different plant age i.e.30d and 90d along with a control set. The biochemical parameters i.e., photosynthetic pigments chlorophyll **a**, **b** and carotenoids were found to be decreasing with increased SO_2 concentration in both the oil-yielding cultivars of *Helianthus annuus* L. indicating the adverse effect of SO_2 pollution. However, among the two cultivars, cv. PAC-36 was found to be resistant in comparison to cv. MSFH-55.

Keywords: biochemical, chlorophyll, *Helianthus*, SO_2

INTRODUCTION

Nature has provided resources to fulfill the needs of every living organism but, the greed of humankind coupled with a strong desire to raise our standards of living has subsequently led to environmental degradation through various forms and one such form is air pollution. Among the various air pollutants, sulphur dioxide (SO_2) is one of the major contaminants emerging out of the industrial development and human activities. 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). In order to perform the essential phenomenon of photosynthesis, plants require chlorophyll pigments which provide light energy to photosystem I and photosystem II. SO_2 pollution affect these pigments (chlorophyll **a** and chlorophyll **b**) and this directly influences the photosynthetic ability of the plants. A decrease in chlorophyll content can be considered as an indicator of air pollution injury mainly SO_2 (Gilbert, 1968). The present biochemical evaluation deals with the study of the effects of different concentrations of SO_2 on photosynthetic pigments (chlorophyll **a**, **b** and carotenoids) of *Helianthus annuus* L.cv.PAC-36 and cv. MSFH-55 (family – Asteraceae), the two oil-yielding cultivars of sunflower.

MATERIAL AND METHODS

Seeds of *Helianthus annuus* cv.PAC-36 and cv. MSFH-55 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 and 90th day for biochemical parameters (chlorophyll **a**, **b** and carotenoids).

The amount of chlorophyll **a** and **b** was calculated according to Arnon (1949) using the following formula:

Chlorophyll **a** (mg.g^{-1} fwt) = 12.7 (A_{663}) – 2.69 (A_{645}) $\times \frac{V}{1000 \times W}$

Chlorophyll **b** (mg.g^{-1} fwt) = 22.9 (A_{645}) – 4.68 (A_{633}) $\times \frac{V}{1000 \times W}$

Where A = Absorbance at specific wavelength

V = Final volume of chlorophyll extract in 80% acetone

W= Fresh weight of tissue extracted

The amount of carotenoids was determined according to Maclachlan and Zalik (1963) using the following formula:

Carotenoids (mg.g^{-1} fwt) = $\frac{7.6\,(A_{480}) - 1.96\,(A_{510})\,V}{1000 \times W}$

Where, V = Volume (ml) of acetone used
W = Fresh weight (g) of leaves

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

RESULTS

The biochemical components (chlorophyll **a**, **b** and carotenoids) in the leaves of studied two oil-yielding cultivars of *Helianthus annuus* L. were affected considerably on exposure with four concentrations of sulphur dioxide. The phytotoxic effect of SO_2 was found to be more on exposure with higher concentrations of SO_2 as against the lower concentrations. Comparing the effect of the highest concentration i.e., 4571 µg m^{-3} of SO_2, it can be delineated that it had reduced both chlorophyll **a** and **b.** However, the degradation of chlorophyll **b** was more than that of chlorophyll **a** at all plant ages (Table - 1). The amount of carotenoids, the accessory pigments, was also found to be reduced with increasing concentration of sulphur dioxide and plant age in cv. PAC-36 and cv. MSFH-55 (Table - 2).

DISCUSSION

The present investigation revealed that sulphur dioxide caused considerable reduction in different biochemical attributes in the two studied oil-yielding cultivars of *Helianthus annuus* L. in order to perform the essential phenomenon of photosynthesis, plants require chlorophyll pigments which provide light energy to photosystem I and II. Damage in plants is correlated with reduction in chlorophyll pigments. The decreased content of chlorophyll **a**, **b** and carotenoids in leaves on treatment with SO_2 could be due to disturbances in chloroplast ultrastructure (Gupta, 1992). Sulphur dioxide binds irreversibly with the iron in the chloroplast found in ferredoxin and cytochrome, interfering its catalytic properties, thus causing secondary photo-oxidative processes which lead to decomposition of the chlorophyll and ultimately death of the cells. 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 is also responsible for the reduced photosynthetic ability of chlorophyll molecule. The same 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). The low concentrations of aqueous SO_2 had very little effect on either chlorophyll a or b, but high concentrations had destructive effects (Malhotra, 1977). Higher concentrations of SO_2 may cause total senescence by inhibiting chlorophyllase activity, RUBISCO and PEP carboxylase (Ziegler,1972). Appreciable reductions in chlorophyll content was found in *Oryza sativa* and *Phaseolus aureus* (Panigrahi et al., 1992). Carotenoid pigments serve a dual function of collecting energy for photosynthesis and protecting chlorophyll against photo-destruction in times of excess light. It's significantly reduced content indicate inhibited photosynthetic capacity of the plant (Verma and Aggarwal,2001).

From the present biochemical evaluation of two oil-yielding cultivars of sunflower, it can be delineated that sulphur dioxide, as a pollutant had adversely affected the studied crop. However, the magnitude of damage caused by 2612, 3265 µg m^{-3} of SO_2 were lesser in comparison to 3918

and 4571 µg m^{-3} SO_2 and the pollutant affected 90d old plants more than 30d old plants that indicate the relationship between plant age and sulphur dioxide effect. Such effects of SO_2 with increasing age of the plants have also been reported by Bell (1982) in grasses; Prasad and Rao (1982) in legumes and cereals and Padhi et. al. (2013) in tomato. Moreover, considering the comparative response of two studied oil-yielding cultivars of sunflower to sulphur dioxide, it can be manifested that cv.PAC-36 showed resistance towards sulphur dioxide in comparison to cv. MSFH-55.

Table 1 : Biochemical response of *Helianthus annuus* L.cv.PAC-36 and cv. MSFH-55 on exposure to different concentrations of SO_2.

Plant age, d	SO_2 (µg m^{-3})	cv. PAC-36		cv. MSFH-55	
		Chlorophyll a	Chlorophyll b	Chlorophyll a	Chlorophyll b
30	0	0.692	0.515	0.690	0.466
	2612	0.631	0.498	0.581	0.444
	3265	0.603*	0.467*	0.559*	0.424
	3918	0.579**	0.436**	0.543*	0.390*
	4571	0.532**	0.403**	0.526**	0.368**
	CD5%	0.067	0.036	0.110	0.055
	CD1%	0.095	0.051	0.155	0.077
90	0	1.619	1.311	1.320	1.084
	2612	1.291*	1.199	1.196	1.003*
	3265	1.237**	1.146**	1.098**	0.996*
	3918	1.201**	1.101**	1.058*	0.972**
	4571	1.155**	1.028**	1.040**	0.933**
	CD5%	0.271	0.117	0.123	0.073
	CD1%	0.380	0.164	0.172	0.103

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

Table 2 : Biochemical response of *Helianthus annuus* L.cv.PAC-36 and cv. MSFH-55 on exposure to different concentrations of SO_2.

Plant age,d	SO_2 ($\mu g\ m^{-3}$)	cv. PAC-36	cv. MSFH-55
		Carotenoids	Carotenoids
30	0	0.480	0.448
	2612	0.465	0.430
	3265	0.447*	0.411
	3918	0.424**	0.379**
	4571	0.391**	0.356**
	CD5%	0.030	0.046
	CD1%	0.043	0.064
90	0	1.291	1.065
	2612	1.169*	0.981*
	3265	1.124**	0.969*
	3918	1.079**	0.950**
	4571	0.997**	0.919**
	CD5%	0.110	0.077
	CD1%	0.155	0.107

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

CONCLUSION

After investigating the crop following SO_2 exposure, it can be deduced that sulphur dioxide, as a pollutant had affected the studied cultivars adversely and acted on the plant as stress and caused appreciable reductions in biochemical parameters. However, comparison between the biochemical evaluation of the two studied cultivars indicate cv.PAC-36 to be resistant over cv. MSFH-55.

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