RESEARCH ARTICLE

# OXIDATIVE STRESS RESPONSES IN LEGUMINOUS CROPS IN RESPONSE TO SULPHUR DIOXIDE: A MAJOR AIR POLLUTANT

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**Abstract**: Present study is an attempt to evaluate and compare the oxidative stress response in *Vigna mungo* L. cv.T-9, *Pisum sativum* L. cv. Arkil, *Cajanus cajan* L. cv. UPAS – 120 and *Cicer arietinum* L. cv. Avrodhi on exposure to four different concentrations of sulphur dioxide, viz. 653, 1306, 2612 and 3918 µg $m^{-3}$ at different plant ages. Observations were made and results incurred at 40 and 80 d of plant age. Oxidative stress was observed in the form of Ascorbic acid content which was evaluated, tabulated and statistically analysed. An initial enhancement in the ascorbic acid content was observed upon fumigation with $SO_2$in the four cultivarswhich was followed by a gradual reduction in the ascorbic acid level with increasing age. Increased level of ascorbic acid has been related with the tolerance of plant to the pollutant. *Cajanus cajan* exhibited highest degree of tolerance.

**Keywords**: Air pollution, Sulphur dioxide, Oxidative stress, Ascorbic acid, Legumes

## INTRODUCTION

In India, pollution has become a great topic of debate at all levels and especially the air pollution because of the enhanced anthropogenic activities such as burning fossil fuels, i.e. natural gas, coal and oil-to power industrial processes and motor vehicles(Khan and Khan, 2011).Among the most common and poisonous air pollutants is sulphur dioxide ($SO_2$) which is formed when fossil fuels such as coal, gas and oil are used for power generation (Ahmed, 1999). In addition to the health impacts, $SO_2$ leads to acid deposition in the environment. This deposition causes acidification of lakes and streams and damage to tree foliage and agricultural crops(Alias *et al*., 2007).

Sulphur dioxide is a colourless, non-flammable gas with a penetrating odour that irritates the eyes and air passages and is noticeable at 3-5ppm. It is soluble in water and can be oxidised within air borne water droplets. It is the gas released from burning of coal, high sulphur coal and diesel fuel.In dry, unpolluted atmospheric conditions, it is estimated that the average $SO_2$ concentration ranges from 0.03 to 0.3µg/cu-m (0.01 to 0.1 parts per billion or ppb). In remote areas, itrangesfrom 0.13 to 0.31µg/cu-m (0.05 to 0.12 ppb). In urban and industrialized areas, $SO_2$ concentrations range from 2.6 to 2600 µg/cu-m (1 to 1000 ppb). A survey by the World Health Organization (WHO) of urban areas showed annual mean $SO_2$ concentrations ranging from 20 to 60 µg/cu-m (7 to 21 ppb) and daily means rarely exceeding 125µg/cu-m (44 ppb) (WHO, 2003). IARC (1992) presents data for ambient air concentrations of $SO_2$ in different parts of the world (WBK and Associates, 2003).

At low concentration, sulphur dioxide can stimulate physiology and growth of plants, especially in plants growing in sulphur deficient soil (Darrall, 1989) where the sulphate might be metabolized to fulfil the demand for sulphur as nutrient (DeKok, 1990). Increased uptake of $SO_2$ can cause toxicity and reduce growth and productivity of plants due to accumulation of sulphite and sulphate ions in excess (Agarwal *et al*., 2003). The work focuses on the relationship between $SO_2$ exposures and physiological effects in the plantsin relation to ascorbic acidand impact of $SO_2$ pollution on it.Ascorbic acid maintains the stability of cell membrane during pollution stress (Dhindsa *et al*., 1982)

## MATERIAL AND METHOD

The undertaken research was carried out on four widely grown leguminous crops in western UP, viz.*Vigna mungo* L. cv.T-9, *Pisum sativum* L. cv. Arkil,*Cajanus cajan* L. cv. UPAS – 120 and *Cicer arietinum* L. cv. Avrodhi. The plants were fumigated with four different concentrations of sulphur dioxide, viz. 653, 1306, 2612 and 3918 µg $m^{-3}$daily for 2hrs. The fumigation was carried out in covered portable aluminium chambers of size $1m^3$. Ascorbic acid content was analysed for oxidative stress response (Keller and Schwager, 1977). The effect was studied at 40d and 80d of the plant age. Observations were tabulated and statistically analysed.

## OBSERVATION AND RESULT

Ascorbic acid is a biochemical component indicative of stress. It was found to increase initially at 40d age for all doses of $SO_2$ while at later age of 80d a considerable decrease was observed in all the four plant species(Table 1 and 2). The increase was 8.55, 41.31, 25.67 and 12.61 % in *Vigna mungo*, *Pisum sativum*, *Cajanus cajan and Cicer arietinum* respectively at 40d age under 3918 µg $m^{-3}$.

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Maximum increase was found in *Pisum sativum* followed by *Cajanus cajan*, *Cicer arietinum* and *Vigna mungo*. A reduction was observed later with an increase in the age of the plant for higher $SO_2$ concentrations (Table 2). Maximum reduction was observed at 3918µg $m^{-3}$ of $SO_2$ by 30.33, 30.88, 19.17 and 20.87 % in *Vigna mungo, Pisum sativum, Cajanus cajan* and *Cicer arietinum* respectively at 80d, indicating the sensitivity of the plant to higher concentrations of $SO_2$. Maximum decline in the level of ascorbic acid was found in *Pisum sativum* and *Vigna mungo* followed by *Cicer arietinum* and *Cajanus cajan*. Plants under control exhibited a regular increasing trend.

**Table 1.** Ascorbic acid content (mg/g f.wt.) in $SO_2$fumigated leavesof leguminous crops at 40d plant

| PLANT NAME | $SO_2$Concentration (µg $m^{-3}$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 653 | 1306 | 2612 | 3918 | CD 5% | CD 1% |
| *Vigna mungo* L. | 3.273 | 3.060 | 3.236 | 3.673 | 3.553 | 0.781 | 1.111 |
| *Pisum sativum* L. | 4.236 | 4.973** | 4.426 | 5.890** | 5.986** | 0.672 | 0.956 |
| *Cajanus cajan* L. | 2.586 | 2.511 | 2.656 | 3.106 | 3.250* | 0.615 | 0.875 |
| *Cicer arietinum* L. | 3.733 | 3.810 | 4.723** | 4.773** | 4.187* | 0.384 | 0.547 |

* Significant at 5% level, ** Significant at 1% level

**Table 2.** Ascorbic acid content (mg/g f.wt.) in $SO_2$ fumigated leaves of leguminous crops at 80d plant

| PLANT NAME | $SO_2$Concentration (µg $m^{-3}$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 653 | 1306 | 2612 | 3918 | CD 5% | CD 1% |
| *Vigna mungo* L. | 5.473 | 4.170** | 3.043** | 3.240** | 3.813** | 0.781 | 1.111 |
| *Pisum sativum* L. | 6.993 | 5.613** | 4.853** | 5.573** | 4.833** | 0.390 | 0.554 |
| *Cajanus cajan* L. | 4.680 | 5.100 | 5.446 | 4.346 | 3.796 | 1.192 | 1.696 |
| *Cicer arietinum* L. | 6.580 | 6.446 | 5.846* | 5.710** | 5.310** | 0.524 | 0.745 |

* Significant at 5% level, ** Significant at 1% level

## DISCUSSION

Ascorbic acid was identified as the antiscorbutic factor, Vitamin C (Davis *et al.*, 1991) and act as an antioxidant (Halliwell, 1994; Podomore *et al*., 1998). Being a powerful reductant, it maintains the stability of cell membrane during pollution stress (Dhindsa *et al*., 1982) and scavenges cytotoxic free radicals (Halliwell and Gutteridge,1989). A direct relationship between endogenous level of ascorbic acid and plant susceptibility to pollutant has been established by Lee *et al*. (1984). Shahare (1995) explained that SO2 pollution stress even for comparatively shorter duration and low concentrations affect the ascorbic acid content.

In the above study, the ascorbic acid content was found to slightly enhance initially for all doses of $SO_2$, but reduced later in all four plant species.*Pisum sativum* showed maximum tolerance initially but later succumbed to the fumigation stress. A high value of decrease in *Pisum sativum* and *Vigna mungo* at 80d might be attributed to relatively short life span and early senescence under the effect of $SO_2$ fumigation.Untreated plants exhibited a regular increasing trend throughout the life span. Varshney and Varshney (1984) established a correlation between ascorbic acid content and resistance of plants. Heath (1994) reported that $SO_2$ dissolves in extracellular fluid and reacts with biological compounds producing free radicals. These free radicals interact with protein and lipids in the cell wall and cell membrane leading to production of more free radicals which increase the cell permeability (Pell and Dann, 1991). These antioxidants are developed by plants as a defence against the free radical formation. Chaudhary and

Rao (1977) related pollution tolerance of plants with ascorbic acid levels and concluded that resistant plants contain high amount of ascorbic acid while sensitive plants possess low levels of ascorbic acid. The results are in accordance to Dalmia and Sawhney (2004) and Falus *et al.* (2016). In the present case, ascorbic acid was reduced to a greater extent in *Vigna mungo* at 3918 µg $m^{-3}$. In the present study, the regeneration of ascorbic acid might be low compared to its utilization for scavenging cytotoxic oxy-radicals. A positive correlation has been reported between ascorbic acid content and cell division and expansion.

## CONCLUSION

The results obtained from this study revealed that there was an enhanced reduction in the ascorbic acid contents whichis indicative of stress. It was found to increase initially at an early age, but lowers later, close to senescence. The reductions following the enhanced level of ascorbic acidcontent observed could be attributed to the deposition of air pollutant on the four plant species and its penetration through the stomatal openings and surface of leaves. Maximum decline in the level of ascorbic acid was found in *Pisum sativum* and *Vigna mungo* followed by *Cicer arietinum* and *Cajanus cajan*.

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