

IMPACT OF SULPHUR DIOXIDE EXPOSURE ON PHOTOSYNTHETIC PIGMENTS IN *VIGNA MUNGO*

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ABSTRACT

The present studies carried out on *Vigna mungo* regarding impacts of SO₂ exposure on photosynthetic pigments clearly revealed that sulphur dioxide has deleterious effects on different photosynthetic pigments. These effects had become more significant when the plants were exposed to higher doses of sulphur dioxide. During the present investigation four concentrations, i.e. 0.1, 0.3, 0.5 and 0.7 ppm of sulphur dioxide were taken in consideration and their impact on biochemical contents i.e chlorophyll 'a', chlorophyll 'b', total chlorophyll and carotenoids in *Vigna mungo* was studied. The observations obtained clearly revealed that a significant reduction was observed in photosynthetic pigments of *Vigna mungo*. This impact was of great extent in such plants which were exposed to 0.7 ppm of sulphur dioxide as compared to those exposed to lower concentration of sulphur dioxide. It was also observed that the impact was not only dose dependent but also age dependent.

KEY WORDS : Photosynthetic pigments, Sulphur dioxide, Exposure, *Vigna mungo*, Variable Concentrations.

INTRODUCTION

Unfavourable change in any component of biosphere is pollution and it is harmful for all living organisms including plants (Odigire, 1999). In the last four decades the problem of pollution increased at an alarming rate. Air quality has been ruined and became unfit for survival of human beings (Selgrade, 2000). Out of different types of pollution air pollution has an important key position. When air becomes unsuitable for survival of living organisms it is said to be polluted. Out of all air pollutants sulphur dioxide is reported to be very hazardous for plants. According to Krupa (1977), the SO₂ even present in lower concentrations is able to damage the crops. According to Zahn, (1963) 0.15 ppm of sulphur dioxide has been widely accepted as threshold level below which plants would not be affected. Out of different causes of pollution industrialization and urbanization are two main causes of pollution (Sharma *et al.*, 2005). According to most of the pollutants originate from automobile

exhaust (Javed *et al.*, 2009). Javed *et al.* (2009), revealed the fact that about 20 to 30% of pollutants comes from industries and 10% of pollutants is emitted through combustion of fossil fuels (Wagh *et al.*, 2006). Thermal Power are also equally responsible for sulphur dioxide emissions (Ramadan *et al.*, 2008).

Besides anthropogenic activities the sulphur dioxide also enters into environment through natural sources. The main natural sources of sulphur dioxide are volcanoes (Rennenberg *et al.*, 1990). Sulphur dioxide enters into leaves through stomata and reaches up to mesophyll cells where it reacts with water to form sulphurous acid and sulphate resulting in the accumulation of sulphur contents in leaves (Majernik and Mansfield, 1970, Zeiger, 1976). Keeping hazardous nature of SO₂ in mind the present study was undertaken to analyse the impact of a sulphur dioxide exposure on *Vigna mungo* which is an important pulse crop of India.

Sulphur dioxide is an important phytotoxicant and is more hazardous gaseous pollutant. It is now

well established that sulphur dioxide affects agricultural crops. A lot of work has been done on impact of sulphur dioxide on biochemical components in different plants by different workers. Malhotra, (1977) reported that sulphur dioxide inhibits an enzyme known as chlorophyllase which is necessary for chlorophyll synthesis. A significant reduction was reported by Pandey, (1978) in wheat. Similar results were revealed by Singh *et al.*, (1985) in *Calendula officinalis* by Kumar and Yadav, (1986) in *Solanum tuberosum*. Panigrahi *et al.* (1992) reported decreased chlorophyll contents in *Melilotus indica*. Similarly Agrawal, *et al.*, (1991) studied the impact of sulphur dioxide stress on chlorophyll contents in *Vicia faba* and reported decreased photosynthetic pigments. Mishra and Mishra (2007), reported a significant decrease in chlorophyll contents in *Aegle marmelos* under air pollution. Bushra Ali, *et al.* (2004), reported a significant decrease in chlorophyll 'a' and chlorophyll 'b' contents. Sharma and Tripathi (2009) revealed a significant decline in chlorophyll 'a' and chlorophyll 'b' contents when plants were exposed to coal smoke. Zhang Jiu Heng, *et al.* (2010), reported a reduction in chlorophyll concentration. Similar findings were reported by Bhardwaj *et al.* (2009) in *Tegetes erecta*. Carotenoids are isoprenoid derived pigments. They are important photosynthetic pigments and they protect chlorophyll. Singh *et al.* (1985) revealed a significant reduction in carotenoids contents in SO₂ treated *Calendula officinalis*, they also revealed that carotenoids are less sensitive to sulphur dioxide in comparison to chlorophyll Khan and Khan (1993) and Krishnamurthy (1994) also observed similar results. Niyogi (1999), reported a significant decrease in carotenoid contents in plants.

MATERIALS AND METHODS

For the present experimental work seeds were purchased from a certified agency and were sown in polythene bags of appropriate sizes. These polythene bags were filled with sandy loam soil and organic manure. After germination, except one seedling rests were uprooted. After 20 days of germination fumigation of seedling was carried out with different concentrations of sulphur dioxide. For the present study four concentrations, i.e. 0.1, 0.3, 0.5 and 0.7 ppm were used. The fumigation of plants was carried out in fumigation chambers. All chambers were of same size, i.e. one cubic meter. The desired concentrations of sulphur dioxide were

made following Singh and Rao (1979) method. Sulphur dioxide was produced by using Rao and Le Blanc (1966). For evaluation of chlorophyll contents in plants Arnon (1949), method was followed and for carotenoids Maclachlan and Zalik (1963), method was used. To assess the impact of different concentrations of sulphur dioxide 5 sets of plants were made out of them one was kept as control set and other 4 sets were treated with respective concentrations of sulphur dioxide. The plants were exposed 5 hours a day to different concentrations of sulphur dioxide and continued up to 45 days of age.

RESULTS

It is clear from the observations that sulphur dioxide is hazardous to plants and it affects the plants growth severely. The observations revealed a significant decline in photosynthetic pigments under sulphur dioxide exposure. The decline in chlorophyll contents were progressive with age of plants. When observations were made at the age of 15 days of fumigation, 5.79% reduction was recorded in chlorophyll 'a' contents with exposure of 0.1 ppm of sulphur dioxide and it was reached up to 12.04 % when similar aged plants were exposed to 0.7 ppm of sulphur dioxide. At the age of 30 days the maximum reduction in chlorophyll 'a' content was 15.7 % while at the age of 45 days it increased up to 21.50% as compared with control set. The decline in chlorophyll 'b' content was found to be similar as in chlorophyll 'a'. The minimum deduction was observed at the age of 15 days which was recorded as 5.63% while maximum reduction was recorded at the age of 45 days when these plants were exposed to higher doses of sulphur dioxide, i.e 0.7 ppm and it was a mounted upto 20.8 9%. As far as the total chlorophyll content is concerned maximum reduction was observed in plants of 45 days when they were treated with 0.7 ppm of sulphur dioxide and was recorded 21.50%.

The carotenoids are important photosynthetic components and they help in harvesting light energy. They protect the chlorophyll from harmful UV rays. Generally in plants the carotenoids contents show an increase when chlorophyll contents decrease. However in the present case the contents of carotenoids were found to be decreased with decreased chlorophyll contents when the plants are exposed to higher doses of sulphur dioxide. These findings are attributed to the hazardous nature of sulphur dioxide which

Table 1. Showing the effect of variable concentrations of SO₂ on photosynthetic pigments in *Vigna mungo*.

Age of Plants SO ₂ Concentrations (ppm)	15 Days				30 Days				45 days						
	0	0.1	0.3	0.5	0.7	0	0.1	0.3	0.5	0.7	0	0.1	0.3	0.5	0.7
Parameters															
Chlorophyll 'a' (mg g ⁻¹ f.w.)	0.504±	0.474±	0.459±	0.451±	0.443±	0.653±	0.588±	0.572±	0.561±	0.550±	0.625±	0.554±	0.531±	0.510±	0.490±
Chlorophyll 'b' (mg g ⁻¹ f.w.)	0.452	0.327	0.225	0.355	0.482	0.391	0.544	0.512	0.472	0.299	0.456	0.355	0.485	0.325	0.324
Chlorophyll (a+b)(mg g ⁻¹ f.w.)	0.433±	0.408±	0.395±	0.389±	0.384±	0.482±	0.438±	0.424±	0.414±	0.406±	0.440±	0.391±	0.374±	0.361±	0.348±
Carotenoids (mg g ⁻¹ f.w.)	0.545	0.217	0.325	0.311	0.242	0.321	0.247	0.322	0.367	0.452	0.155	0.178	0.281	0.186	0.241
	0.937±	0.882±	0.854±	0.841±	0.827±	1.135±	1.026±	0.996±	0.975±	0.956±	1.065±	0.945±	0.905±	0.871±	0.838±
	0.354	0.292	0.312	0.521	0.210	0.354	0.238	0.365	0.421	0.320	0.325	0.345	0.259	0.365	0.421
	0.488±	0.464±	0.454±	0.442±	0.434±	0.604±	0.555±	0.535±	0.528±	0.517±	0.544±	0.484±	0.470±	0.446±	0.432±
	0.052	0.023	0.087	0.048	0.083	0.027	0.034	0.057	0.064	0.084	0.025	0.041	0.053	0.074	0.025

completely destroyed the pigment system when they are exposed to higher dose of sulphur dioxide. The decrease in carotenoid contents was reported up to 20.50% at the age of 45 days when they were exposed to 0.7 ppm of sulphur dioxide.

DISCUSSION

Sulphur dioxide is an important phytotoxicant and very much hazardous for the plants. Sulphur dioxide impacts the plants in various ways for example anomalies in morphological and biochemical nature. Keeping this view in mind the present study was undertaken to assess the impact of sulphur dioxide on photosynthetic pigments in *Vigna mungo* under different concentrations of sulphur dioxide. When plants were fumigated with sulphur dioxide they resulted in simultaneous loss of chlorophyll 'a' and chlorophyll 'b'. The losses incurred in chlorophyll 'a' were more pronounced than chlorophyll 'b'. Loss in chlorophyll 'b' depends upon inhibition of chlorophyll 'a', since chlorophyll 'a' is precursor of chlorophyll 'b' (Bogoard, 1966). Sulphur dioxide results in lowering of pH therefore the internal environment of mesophyll cells becomes acidic which results in loss of chlorophyll (Gilbert, 1968). After entering into mesophyll cells the sulphur dioxide combines with water and forms sulphurous acid. This sulphurous acid dissociates into H⁺ and HSO₃⁻ ions. H⁺ ion replaces Mg⁺⁺ ions present in chlorophyll. Due to this replacement of Mg⁺⁺ from chlorophyll the phaeophytin is formed. This phaeophytin is inactive form of chlorophyll. Chlorophyll 'b' forms chlorophyllide through removal of phytol group of molecule (Rao and Le Blanc, 1966). Zeigler (2006), suggested the decreased photosynthetic activity is due to competition between SO₂ and CO₂ for the reaction site on RuBP carboxylase enzyme.

The main cause of phaeophytinization of chlorophyll is lower pH caused by sulphur dioxide (Malhotra, 1977). According to Ricks and William (1975), the excess of sulphite results into breakdown of chlorophyll.

Carotenoid pigments are important components of photosynthetic machinery. They act as photoprotectants and antioxidants. They also serve as precursor for abscissic acid synthesis (Niyogi, 1999; Havaux, 1998). Generally in plants the amount of carotenoids contents increases when chlorophyll contents decrease but in the present case the crop showed reduction in total chlorophyll as well as

carotenoid contents when the crop was exposed with sulphur dioxide. Similar findings were made by Lalman and Singh (1990); Mishra and Mishra (2007) Bhardwaj *et al.*, (2009); Bhardwaj *et al.* (2011) and Bhardwaj *et al.*, (2012). The findings are in conformity with earlier works. The carotenoids are least affected photosynthetic pigments and are more resistant in comparison to chlorophyll. Increased carotenoids could be regarded as an adaptive feature developed by plants in order to protect chlorophyll from phytooxidative destruction. Vranova (2002), reported the role of carotenoids as scavenger of reactive oxygen species.

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