EFFECT OF SULFUR DIOXIDE ON TWO WHEAT CULTIVARS

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ABSTRACT

The effect of sulfur dioxide was studied on the two wheat cultivars developed by Chandra Shekhar Azad Agriculture University, Kanpur (Triticum aestivum K-7410 and K-816). The two crop varieties of control and exposed plants of wheat were analyzed for various biochemicals like starch, sugar, pigments, proline, ribulose bis phosphate carboxylase (rubisco), pH etc. RUBISCO activity was decreased in K-816 whereas in K-7410 it was nearly constant. Whereas nonstructural carbohydrate increased in K-816 and decreased or remain constant in K-7410. However the original pH of K-7410 was more basic than K-816. More basic pH provides more protection towards sulfur dioxide. However the buffering capacity for K-7410 was nearly constant but it reduced in K-816. Exposure to SO$_2$ caused increase in proline content in two varieties but increase was very less, say nearly equal in K-816. Stomatal conductance and transpiration increased in K-816 but decreased or remained constant in K-7410. From all the above studies and as assessed by various earlier studies conducted in the lab, cultivar K-7410 was found more tolerant than K-816 to be grown in sulfur dioxide exposed area.

Key Words: Sulphur di oxide, Wheat, RUBISCO, Biochemicals, K-7410, K-816.

INTRODUCTION

Air pollution is causing concern due to increased vegetation effect and crop yield losses$^1$. Air pollution has become major threat to the survival of plants in industrial areas$^2$. Ecosystem is altering due to rapid industrialization and also due to addition of toxic substances in the atmosphere$^3$. Pollution stress can alter plant growth and quality$^4,5$. Sulfur dioxide is the common air pollutant in India. In urban and rural environment low concentration of sulfur dioxide can interfere with various physiological and biochemical processes of plants without any visible foliar injury symptoms$^6$. Studies have been focused on lichens, bryophytes; metabolic alterations can increase or decrease the levels of specific metabolites which can further alter the quality and quantity of the yield. The response varies from species to species depending on genetic make up, growth stages, concentration and duration of pollutants and prevailing ecological conditions. Hence this study was conducted to determine the sensitivity of two wheat varieties at 0.05 µl litre$^{-1}$ SO$_2$ through biochemical and other responses to select the variety which can be effectively grown in sulfur dioxide environment. This study will also help to know the correlation if any that
exists between the cultivar sensitivity and various metabolites.

MATERIAL AND METHODS

Healthy seeds of 2 wheat varieties, namely K-7410 and K-816 were procured from C.S Azad University of agriculture and technology, Kanpur, (India).

The seeds were surface sterilized by soaking for 10 minutes in 0.1% (w/v) calcium hypochlorite solution, washed, imbibed and germinated on moist filter papers in sterilized petri dishes. Then eight germinated seeds were embedded on agar gel surface (1%w/v) with radicle piercing the gel. The plants were maintained in controlled environment chamber before and after exposure at light and dark cycle of 16/8 hours 25ºC.

Three day old seedling were fumigated to 0.05 ul litre-1 SO₂ for 4 hours daily for 10 days in a Perspex continuous flow exposure chamber (28x32x45 cm) with overhead reflectorized light and small fan. Dynacal SO₂ permeation tube (VICI, Metronics California, USA) and Meloy labs calibrator (model CS 10-2 Columbia, scientific industries, Virginia, USA) were employed for continuous flow of standard SO₂ gas of desired concentration. The concentration of SO₂ in the exposure chamber was determined by sucking the air from the middle of the chamber in 0.1 M sodium tetrachloromercurate solution and estimated colorimetrically. The control plants were also exposed similarly but without SO₂ gas in the incoming air. The ambient SO₂ concentration was negligible.

Leaves from exposed and unexposed plants are collected separately, cut into pieces and weighed. Then tissues were analysed for chlorophyll, carotenoid, protein, amino acid, starch, free sugars, proline, buffering capacity and Ribulose bis phosphate carboxylate activity by radioactive method.

RESULTS AND DISCUSSION

Sulfur dioxide had a significant effect on the growth of plants. Plant response varies from one variety to next. Fumigation of two varieties of wheat seedlings K-7410 and K-816 to 0.05ul litre⁻¹ SO₂, 4 hours daily for 10 days produced no visible symptoms. However a great deal of morphological changes and variety of alterations in stomatal architecture, trichome length and density were noticed. A significant reduction in plant cover, height and number of leaves for Carissa carandus was observed. Effect was also observed in other plants which showed that cement dust has significant effect on plant growth.

Biochemical studies provide opportunity to assess the hidden injury and therefore the two crop varieties of control and exposed plants of wheat were analyzed for various biochemicals like starch, sugar, pigments, proline, ribulose bis phosphate carboxylase, pH etc. Sulfur dioxide can influence the chlorophyll by various mechanisms including increased acidity, forming complexes and conversion to pheophytin by splitting Mg²⁺. Decrease of chlorophyll is the earliest finding and variety K 7410 depicted the same (Table 1). The cement dust kiln also showed reduction in protein content, starch, yield and phytomass in ground nuts. Photosynthetic rate, stomatal conductance, and water loss were reduced by all stress treatments. Most parameters recovered when the stress treatments were discontinued. However, photosynthesis in salt-stressed plants did not recover indicating a toxic effect of salt on the photosynthetic apparatus.
Table 1: Effect of SO$_2$ exposure on chlorophyll and carotenoids. All values are average of four replicates. Unit= mg/g dry weight

<table>
<thead>
<tr>
<th>Variety</th>
<th>Chlorophyll</th>
<th></th>
<th>Carotenoid</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>E</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>K-7410</td>
<td>7.5</td>
<td>6.6</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>K-816</td>
<td>5.9</td>
<td>5.9</td>
<td>1.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Variety K-7410 also showed decrease in protein content (Table 2). Whereas variety K-816 neither showed depletion in pigment nor in protein. Rather both increased. It was found that protein increased in the sensitive cultivars of pea exposed to sulfur dioxide gas$^{13}$. RUBISCO activity was decreased in the K-816 whereas in K-7410 it was nearly constant (Table 4). Whereas nonstructural carbohydrate increased in K-816 and slightly decreased or say remained constant in K-7410 (Table 2). Similar results were noticed when plants were exposed to ozone$^{14}$. Carbohydrate accumulation may be postulated as a positive signal for reduction of Rubisco gene expression$^{15}$. Trees in polluted regions have lower concentration of starch, total and soluble sugars than trees in the unpolluted area$^{16}$. However dry biomass of total plant/seedling remained nearly constant in K-7410 and slightly decreased in K-816 whereas fresh biomass followed the starch response. Increased accumulation of carbohydrates in rice cultivars exposed to air pollution was indicated as sensitive cultivar only$^{17}$.

Table 2: Effect of SO$_2$ exposure on starch, free sugars, protein and amino acid contents in varieties of wheat leaves. All values are average of four replicates. Unit: mg/g dry weight

<table>
<thead>
<tr>
<th>Content</th>
<th>K-7410 C</th>
<th>E</th>
<th>K-816 C</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>134.1</td>
<td>110.5</td>
<td>129.1</td>
<td>163.2</td>
</tr>
<tr>
<td>Total free sugars</td>
<td>50.4</td>
<td>53.9</td>
<td>44.7</td>
<td>62.1</td>
</tr>
<tr>
<td>Protein</td>
<td>125.1</td>
<td>105.6</td>
<td>111.2</td>
<td>124.6</td>
</tr>
<tr>
<td>Amino acid</td>
<td>12.8</td>
<td>10.3</td>
<td>19.2</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Table 3: Effect of SO$_2$ exposure on stomatal conductance, transpiration rate and dry wt/plant in wheat cultivars. All values are average of four replicates

<table>
<thead>
<tr>
<th>Content</th>
<th>K-7410 C</th>
<th>E</th>
<th>K-816 C</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomatal conductance (mMol/M2/S)</td>
<td>108.0</td>
<td>84.0</td>
<td>107.25</td>
<td>115.0</td>
</tr>
<tr>
<td>Transpiration rate (mMol/M2/S)</td>
<td>4.4</td>
<td>3.91</td>
<td>4.23</td>
<td>4.71</td>
</tr>
<tr>
<td>Dry wt/plant (g)</td>
<td>0.027</td>
<td>0.027</td>
<td>0.026</td>
<td>0.025</td>
</tr>
</tbody>
</table>
However the original pH of K-7410 was more basic than K-816 (Fig 1). More basic pH provides more protection towards sulfur dioxide. However the buffering capacity for K-7410 was nearly constant but it reduced in K-816. This study indicates that variety K-7410 is more tolerant than K-816.

Proline is a stress indicator. Exposure to SO\textsubscript{2} caused increase in proline content in two varieties but increase was very less, say nearly equal in K-816 (Table 4). Accumulation of proline has been reported due to osmotic stress and salinity\textsuperscript{18,19}. Accumulation of proline was also noticed in wheat cultivars exposed to ultraviolet light. Proline can protect plants against damage by ultraviolet rays\textsuperscript{20}. Praline accumulation can be associated with protein depletion\textsuperscript{21}. Stomatal conductance and transpiration increased in K-816 but decreased or remained constant in K-7410 (Table 3). Kondo and Sugahara (1978) found decrease in transpiration rate in SO\textsubscript{2} resistant plants.

**Table 4 :** RUBISCO activity, pH and Proline content in controlled and SO\textsubscript{2} exposed plants. All values are average of four replicates

<table>
<thead>
<tr>
<th>Content</th>
<th>K-7410</th>
<th>K-816</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUBISCO activity (counts/min/mg protein)</td>
<td>1190</td>
<td>1168</td>
</tr>
<tr>
<td>pH</td>
<td>8.46</td>
<td>8.3</td>
</tr>
<tr>
<td>Buffering capacity (ml HCl /pH unit change/g dry weight)</td>
<td>90.0</td>
<td>90.0</td>
</tr>
<tr>
<td>Proline content (mg/g dry wt.)</td>
<td>0.58</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In the previous paper the twenty wheat varieties were categorized in two groups on the basis of various biochemical and morphological changes. In group I, K-7410 was kept and in group II K-816 was kept\textsuperscript{23}. Group I was categorized tolerant and group II was categorized sensitive to SO\textsubscript{2}. Further experiments followed the same path as
previous studies. It indicates that plants belonging to group I like K-7410 are better equipped to deal with SO$_2$ since they had better capability to allocate the amount of carbon towards biomass accumulation. To deal with pollutant either the plant should possess some inherent characters or a metabolic adjustment to suit the conditions may provide a temporary resistance to plant till the pollutant is excreted out.

REFERENCES


