Chromosomal Aberrations Induced by Electroplating Waste Water

R. K. Somashekar and Govindappa D. Arekal

Department of Botany, University of Mysore, Mysore-570 006, India

Received November 8, 1981

Chromosomal abnormalities induced in plant cells by industrial effluents are not very well understood. Especially the effect of heavy metals on plant cell chromosomes has not attracted the attention of many biologists. The heavy metals in many cases are proved to be potential carcinogens and mutagens (Goyer and Mehlman 1977, Nagao 1978). The cytological and genetic effects of some of the heavy metals like cadmium, chromium and lead in animal cells have been studied by Paton and Allison (1972), Shiraishi et al. (1972), Bauchinger et al. (1976), Bigaliev et al. (1976), Ruposhev and Garina (1976), Sunderman (1976) and Verschaeve (1979). The effects of heavy metal salts on plant cells have been worked out by Kihlman (1957), Mukherji and Maitra (1976) and Ruposhev (1976). Amoore (1961a, b and 1962) in Pisum sativum and Lilly and Thoday (1956) in Vicia faba have studied the effects of cyanide salts. The presence of heavy metals such as zinc and magnesium in chromosomes has also been proved (Yakusizi 1936, Mazia 1954 and Stefansen 1955). Cytological and genetical effects of these heavy metals have not been studied so far. In view of this the present work was undertaken to examine the cytological abnormalities induced by a mixture of heavy metals and cyanides present in the waste waters of an electroplating industry near Mysore, Karnataka, India.

Materials and methods

Standard methods (Apha 1976) were employed during the analysis of effluents. A Perkin Elmer model 403 atomic absorption spectrophotometer was used during the estimation of metals.

Cytological investigations were carried out to evaluate the effect of electroplating waste waters on healthy onion bulbs (Allium cepa). The bulbs were grown in this waste water at 10 to 80 per cent concentrations at room temperature for about 3 to 72 hrs. duration in order to study the transitory or permanent nature of cytological abnormalities. Recovery experiments were also carried out. Controls were maintained in all experiments by growing the bulbs in distilled water for the same duration.

Roots from treated and control bulbs were washed thoroughly in running water. They were cut and fixed in ethanol and glacial acetic acid solution (3:1). The root tips were processed and stained with haematoxylin. Chromosome preparations were made by squash technique. Qualitative and quantitative observations were made by scoring a minimum of 4000 cells from different root tips in
control and treated bulbs.

Results and discussion

The results of heavy metal analysis and cyanide contents of the effluents are given in Table 1. The pH of the effluents is in the alkaline side. From Table 1 it is clear that metal ions such as nickel, copper and chromium are present in high concentrations compared to the others. The cyanides in this case are present in the form of sodium cyanide.

Different types of abnormalities observed after treatment are given in Table 2. Lilly and Thoday (1956), and Swanson (1957) have shown that potassium cyanide is an effective chromosome breaking agent. Kihlman (1957) has studied the ability of

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>1%</th>
<th>3%</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>40%</th>
<th>60%</th>
<th>80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitotic index</td>
<td>27.4</td>
<td>20.6</td>
<td>19.2</td>
<td>17.4</td>
<td>14.5</td>
<td>11.4</td>
<td>80.1</td>
<td>6.3</td>
<td>5.4</td>
</tr>
<tr>
<td>Lag chromosome</td>
<td>Nil</td>
<td>0.1</td>
<td>0.36</td>
<td>1.2</td>
<td>1.7</td>
<td>2.3</td>
<td>2.8</td>
<td>3.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Bridge</td>
<td>0.002</td>
<td>1.7</td>
<td>2.8</td>
<td>5.6</td>
<td>6.2</td>
<td>7.3</td>
<td>9.5</td>
<td>10.4</td>
<td>11.3</td>
</tr>
<tr>
<td>Binucleate cells</td>
<td>0.01</td>
<td>0.85</td>
<td>2.0</td>
<td>3.6</td>
<td>4.7</td>
<td>6.0</td>
<td>7.9</td>
<td>7.9</td>
<td>10.1</td>
</tr>
<tr>
<td>Dicentric chromosomes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>0.2</td>
<td>0.3</td>
<td>0.8</td>
<td>1.4</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Heterochromatin blocks</td>
<td>Nil</td>
<td>Nil</td>
<td>0.1</td>
<td>0.5</td>
<td>0.7</td>
<td>1.4</td>
<td>1.8</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Nuclear disintegration</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>0.2</td>
<td>0.6</td>
<td>1.1</td>
<td>1.5</td>
<td>2.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Cellular vacuolation and marginal nuclei</td>
<td>Nil</td>
<td>Nil</td>
<td>0.3</td>
<td>0.8</td>
<td>1.3</td>
<td>1.7</td>
<td>2.6</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Fragmentation</td>
<td>Nil</td>
<td>0.2</td>
<td>0.7</td>
<td>1.7</td>
<td>2.9</td>
<td>4.5</td>
<td>5.3</td>
<td>6.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Nuclear vacuolation</td>
<td>0.01</td>
<td>0.8</td>
<td>1.6</td>
<td>2.4</td>
<td>3.5</td>
<td>4.9</td>
<td>6.1</td>
<td>7.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Spindle deterioration</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>0.3</td>
<td>0.8</td>
<td>1.1</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Clumping</td>
<td>0.001</td>
<td>0.7</td>
<td>2.3</td>
<td>4.1</td>
<td>5.7</td>
<td>7.6</td>
<td>9.1</td>
<td>10.6</td>
<td>11.5</td>
</tr>
<tr>
<td>Chromatin erosion</td>
<td>0.01</td>
<td>2.0</td>
<td>2.6</td>
<td>5.0</td>
<td>7.2</td>
<td>10.1</td>
<td>13.5</td>
<td>17.3</td>
<td>19.1</td>
</tr>
<tr>
<td>Micronuclei formation</td>
<td>Nil</td>
<td>Nil</td>
<td>0.8</td>
<td>1.6</td>
<td>3.0</td>
<td>5.3</td>
<td>8.5</td>
<td>13.3</td>
<td>14.3</td>
</tr>
</tbody>
</table>

heavy metal complexing agents to induce chromosome abnormalities in case of *Vicia faba*. Such abnormalities were also recorded in the present study.

The data given in Table 2 shows that mitotic index is low in treated cells depending upon the concentration of effluents. Some of the common abnormalities observed are scattering of chromosomes at metaphase and anaphase, lagging chromosomes (Fig. B), dicentric chromosome, the binucleate cells (Fig. C) and the formation of anaphase bridge (Fig. A).

Some of the morphological changes observed are condensation, chromatin elimination (Fig. F), fragmentation (Fig. E), nuclear disintegration, cellular vacuolation (Fig. G) stickyness, micronuclei formation (Fig. D), clumping, nucleolar vacuolation (Fig. H) and erosion of chromatin material.

Ruposhev and Garina (1976) have established the fact that cadmium salts produce number of structural chromosome aberrations. Lead induced disturbed mitosis with a series of abnormalities has been recorded by Mukherji and Maitra (1976) in case of *Allium cepa*. Some of the common structural abnormalities recorded by these workers have also been observed in the present study (See Table 2).

**Summary**

It is established that heavy metal complex ions and cyanides induce chromosomal aberrations in *Allium cepa*. It is concluded that these pollutants present in the electroplating waste water increase mutation rates when they are present in high concentration. Further studies on the role of individual metal ions and cyanides may throw more light on their capacity in bringing about chromosomal aberrations.

**Acknowledgement**

One of us (RKS) is thankful to CSIR for financial assistance.

**References**

Kihlman, B. A. 1957. Experimentally induced chromosome aberrations in plants. I. The produc-


