ELECTRON PROBE ANALYSIS OF SAP EXUDATES OF TWO VARIETIES OF WHEAT (TRITICUM AESTIVUM L.)

S. Gartner, N. Roinel, N. Paris-Pireyre

To cite this version:

HAL Id: jpa-00223785
https://hal.archives-ouvertes.fr/jpa-00223785
Submitted on 1 Jan 1984

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
ELECTRON PROBE ANALYSIS OF SAP EXUDATES OF TWO VARIETIES OF WHEAT (TRITICUM AESTIVUM L.)

S. Gartner, N. Roinel* and N. Paris-Pireyre

Laboratoire de Physiologie Végétale, Université des Sciences et Techniques du Languedoc, Place E. Bartillon, 34060 Montpellier Cedex, France

*Département de Biologie, Laboratoire de Physiologie Physico-Chimique, C.E.N. Saclay, 91191 Gif-sur-Yvette Cedex, France

Résumé - La composition de la sève du blé a été déterminée par analyse à la microsonde électronique. Cette technique a permis d'analyser quantitativement les éléments K, Si, P, Cl, S, Mg, Ca et Na contenus dans les exsudats.

Abstract - The sap composition was determined by electron probe analysis. With this technique, it has been possible to make the quantitative analysis of the following elements: K, Si, P, Cl, S, Mg, Ca and Na contained in the exudates.

In spite of exudation experiments usually made, it is very difficult to reach the real concentration of sap elements, for exudate volumes are very small and exudation times cannot be too long.

As shown here, the sap composition was determined by electron probe analysis (1).

The exudates were collected under water saturated paraffin oil. The concentration of the following elements: K, Si, P, Cl, S, Mg, Ca and Na were measured, from 0.2 nl microdrops, with a Cameca MBX electron probe analyser (12 kV, 50-100 nA, beam diameter: 90-100 μm). Concentrations are expressed in mmol.l⁻¹ (mM). Those measures constitute a first experimentation in the case of plant material.

1 - Comparison between culture solution and sap. Evolution with time.

A first experiment was made with the "521" variety, during which the sap was collected every hour during 5 hours. The wheat seedlings, two weeks old, are grown in the Knop's culture solution, to which is added 0.2 (mM) sodium silicate. The exudation process is then started in the same solution (which has a pH of 5.5).

<table>
<thead>
<tr>
<th>H</th>
<th>vol</th>
<th>K</th>
<th>Si</th>
<th>P</th>
<th>Cl</th>
<th>S</th>
<th>Mg</th>
<th>Ca</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>8</td>
<td>33.8</td>
<td>2.7</td>
<td>3.8</td>
<td>2.7</td>
<td>1.0</td>
<td>0.73</td>
<td>1.0</td>
<td>0.32</td>
</tr>
<tr>
<td>2nd</td>
<td>11</td>
<td>32.3</td>
<td>2.7</td>
<td>4.6</td>
<td>2.1</td>
<td>1.1</td>
<td>0.70</td>
<td>1.0</td>
<td>0.30</td>
</tr>
<tr>
<td>3rd</td>
<td>7</td>
<td>36.3</td>
<td>3.2</td>
<td>6.3</td>
<td>1.8</td>
<td>1.2</td>
<td>0.70</td>
<td>1.0</td>
<td>0.35</td>
</tr>
<tr>
<td>4th</td>
<td>7</td>
<td>39.8</td>
<td>3.2</td>
<td>7.5</td>
<td>2.2</td>
<td>1.4</td>
<td>0.83</td>
<td>1.0</td>
<td>0.37</td>
</tr>
<tr>
<td>5th</td>
<td>4.5</td>
<td>45.4</td>
<td>3.2</td>
<td>8.7</td>
<td>3.0</td>
<td>1.9</td>
<td>1.0</td>
<td>1.4</td>
<td>0.54</td>
</tr>
<tr>
<td>1st</td>
<td>270</td>
<td>21.6</td>
<td>30.4</td>
<td>21.6</td>
<td>8</td>
<td>5.8</td>
<td>8</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>355</td>
<td>29.7</td>
<td>50.6</td>
<td>23.1</td>
<td>12.1</td>
<td>7.7</td>
<td>11</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>254</td>
<td>22.4</td>
<td>44.1</td>
<td>12.6</td>
<td>8.4</td>
<td>4.9</td>
<td>7</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>278</td>
<td>22.4</td>
<td>52.5</td>
<td>15.4</td>
<td>9.8</td>
<td>5.8</td>
<td>7</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>204</td>
<td>14.4</td>
<td>39.1</td>
<td>13.5</td>
<td>8.55</td>
<td>4.5</td>
<td>6.3</td>
<td>2.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Sap concentration C (mM) and amount Q (mmol.h⁻¹) of exudate elements.

H indicate at what time the sap was collected
vol is the volume (ul) of hourly exudates.

C x10⁻⁶

Q x10⁻⁶

http://dx.doi.org/10.1051/jphyscol:19842117
Some elements are found in the sap at higher concentration than in the culture solution, for example potassium: 30-45 (mM), phosphorus, silicon and chlorine: 3 to 8 mM. Concentrations of sodium, sulfur and magnesium are very close to those of the culture solution, and therefore presumably follow the water flow in the roots. On the contrary, calcium is found at a lower concentration in the sap than in the solution (table 1).

The exuded volumes are large during the first, and mainly, the second hour, and then seem to stabilize, or even to decrease slightly so that, in spite of the variations of concentrations with time, the hourly exuded amount remain comparable, particularly after the third hour.

2 - Effect of cultivation conditions on sap concentration in the case of "521" and "Tarasque" varieties.

In this series of experiments, the 2-week old plants are grown and exuded in Knop's solution, with or without addition of sodium silicate at various concentrations. After two hours and a half, the exudate is collected and discarded. Then, the exudate of the following 30 minutes is collected for analysis. In that way, the exudation has most likely reached the stabilized stage.

2.1 - Influence of the silicon of the culture solution

The silicon content in the sap increases with the silicon content in the solution (fig. 1).

Plants grown without silicon show a small amount of it in their sap (0.2 mM), which is probably coming from either the silicon of the plant itself, or a polluted culture solution (dust, impurities in bidistilled water).

The silicon amount is greater in the "521" sap than in the "Tarasque" sap. The difference increases with the Si concentration of the culture solution.

The silicon content of the exudation solution has an importante influence on that of the sap within the three hours process studied here:

- increase in the case of plants grown without silicon and exuded in a solution containing 0.05 mM silicon, or
- decrease when the exudation solution contains no silicon, in the case of plants grown on a + 0.05 mM Si solution.

These phenomena are observed in both wheat varieties.
2.2 - Variations of elements concentrations with the age of the plants

Figure 2. Elements concentrations in the sap of 2-and 4-week old plants (Means values ± s e m, n=3)

Table II. Concentration and amount of silicon exuded by 2 and 4 week old plants (means values ± s e m).

<table>
<thead>
<tr>
<th></th>
<th>521</th>
<th>4 week</th>
<th>2 week</th>
<th>4 week</th>
<th>Tarasque</th>
<th>2 week</th>
<th>4 week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration (mM)</td>
<td>3.83 ±1.14</td>
<td>1.96 ±1.0</td>
<td>3.56 ±0.51</td>
<td>2.03 ±0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>amount (mmol)</td>
<td>1.43 ±0.88</td>
<td>10.08 ±4.12</td>
<td>0.89 ±0.55</td>
<td>9.12 ±4.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>exudate volumes (μl)</td>
<td>0.35 ±0.21</td>
<td>4.7 ±0.43</td>
<td>0.25 ±0.21</td>
<td>4.5 ±1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 shows that the K,P and Cl concentrations increase with the age of the plants. In the 2-week old plants, the three elements are more concentrated in the sap than in the solution, and this phenomenon is more evident with the 4-week old plants. The water flow rates are greater at 4 week than at 2 week and the transport is more important in older plants. With respect to the culture solution, an over-concentration in the sap is reached with time (table II and fig. 2).

The silicon, which is also over-concentrated in the sap of 2-week old plants, remains more concentrated in the 4-week old plants, but with a sap concentration almost divided in half. However, table II shows that its exuded amount is nevertheless greater at 4 week than at 2 week.

In the case of sulfur, its concentration is close to that of the culture solution in 2-week old plants, while it seems to over-concentrate in comparison to the culture solution in the 4-week old plants.

Lastly, the results are more variable in the case of calcium, sodium and magnesium.

2.3. Influence of the pH of the culture solution.

Two-week old plants of the "521" variety are grown and exsuded in half diluted Knop's solution, containing 1mM sodium silicate, pH of which is set at 6, or at 7.5.

The silicon concentration is the only one to be greater in the pH 7.5 solution than in the pH 6 one (fig. 3). The concentrations of the other elements remain unchanged (P, S, Mg), or decrease (K, Cl, Ca, Na).
2.4 Influence of silicon on phosphorus absorption

When there is silicon in the culture solution, the P concentration of the sap increases (fig 4). But it should be noted that the addition of silicate brings more sodium in the solution. In the case of fig. 4-B (experiments on "521" variety only), the culture solutions without silicate receive sodium sulfite in such an amount that the Na concentration is the same in the solutions with or without silicon. It can be noticed that the wheat grown without silicon takes more phosphorus than if grown with silica. However, this discrepancy is less clear than that of fig 4. Therefore, Na can be thought to play a greater role than Si in the increase of P concentration when culture solution contains sodium silicate.

3. Conclusion

With our techniques, it has been possible to make, on each sample, the quantitative analysis of the main elements contained in the sap. These experiments have principally demonstrated that microsamplings are quite feasible and that the elements they contain are in adequate concentration to be determined with the electron probe analyser.

Although the values are rather variable due to the low number of tested samples, those first experiments show that it is consequently possible to study the appearance in the sap, and hence, the absorption and the conveyance, of a rather large number of elements in a given sample, according to different parameters: age of plants, varieties, conditions of culture ....

Finally, the ability to analyse very small volumes of liquids opens the way to sampling exudates collected within a very short time. This would allow to reduce the way the roots are affected by both excision and lack of aerial parts. It would also make it possible to reach a sap composition as close as possible to that of the whole plant.