THE EFFECT OF VIBRATION AS A SPACE FLIGHT FACTOR ON WHEAT PLANTS GROWTH AND DEVELOPMENT

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Effect of vibration on plant organisms

- Changes of ethylene synthesis velocity and cell wall peroxidase activity; changes of biochemical state of the cell walls and growth stimulation (Delone et al., 1968; Siegel S.M. and Siegel B.Z., 1983)
- Activization of callusoginesis and rhizogenesis (Chekmarev, 1986)
- Dependence of gravitropic reaction of plants on frequency and amplitude of vibration. In addition, it has been established the hypersensitivity of plants to mechanical impacts at insufficient light or in the dark (Mitchell C., 1992; Zhong Ma and Karl H., 2007)
- Dependence of seeds germination on frequency and amplitude of vibration (Takahashi H. et.al., 1991; Uchida H.A., Yamamoto K.T., 2002)
The aim of the work

Studying the influence of vibration on ontogenetic characteristics and grain productivity structures of wheat plants (*Triticum aestivum* L.).
MATERIALS AND METHODS

We tested two wheat cultivars: Inna (winter wheat) and Lada (spring wheat). The seeds have been vibrated at 70 Hz and an amplitude of 0.5 mm on vibration bed B&K 4809 (power amplifier B&K 2705 and signal generator B&K 1049) at Rocket and Space Corporation “Energia”. The seeds were sown in 6 hours after the end of vibration.
## Regims of vibration

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Object influenced by vibration</th>
<th>Time of exposure, hour</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Inna</em> (winter wheat)</td>
<td>Germinated seeds</td>
<td>12</td>
</tr>
<tr>
<td><em>Lada</em> (spring wheat)</td>
<td>Germinated seeds</td>
<td>12, 14</td>
</tr>
</tbody>
</table>
Plant growth method in light culture

Object: *Triticum aestivum* L.
*Cultivar: Inna* (winter wheat); *Lada* (spring wheat)

Time of exposure, hour: 12

- **Object:** winter wheat, cultivar Inna
- **Cultivation method:** hydroponic
- **Mineral nutrition:** Chesnokov solution ½ normal dose with microelements (Hogland)
- **Water potential in root zone:** (–1,0) ± 0,05 kP
- **Air temperature:** 29 ± 1 °C
- **Air humidity:** 30 ± 5 %
- **Photoperiod:** 24-hours
- **PPF, µM/(m²·s):** 700 ± 50

- **Object:** spring wheat, cultivar Lada
- **Cultivation method:** soil culture
- **Mineral nutrition:** soil with Chesnokov solution ½ normal dose with microelements (Hogland)
- **Soil humidity:** 70%
- **Air temperature:** 32 ± 3 °C
- **Air humidity:** 20 ± 5 %
- **PPF, µM/(m²·s):** 450 ± 20
- **Photoperiod:** 24-hours
Plant growth method in field experiments

Object: *Triticum aestivum L.* Cultivar: *Lada* (spring wheat)

**Experiment 2008**

- Time of exposure, hour: 12
- Cultivation method: standard technique of cultivation of grain plants in Non-Chernosem zone of Russian Federation
- The norm of sowing: **70 seeds – length of the line 1 m**
- Total amount of sown seeds for each variant: **420**

Experiment was conducted at the Research Institute of Non-Chernosem Grain Farming

**Experiment 2008**

- Time of exposure, hour: 14
- Cultivation method: standard technique of cultivation of grain plants in Non-Chernosem zone of Russian Federation
- The norm of sowing: **70 seeds – length of the line 1 m**
- Total amount of sown seeds for each variant: **3500**

Experiment was conducted at the Russian State Agrarian University
Methods of cytogenetic studies

**Objects:**
Germinated seeds after vibration ending;
Primary roots of 2 days old plants

**Fixation procedure:** Carnoy's solution

**Study of metaphase plates:** squash method using Dapy colorant

**Analazing:** fluorescent microscope Axioskop 40 (×40)
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Variant</th>
<th>II (seedlings)</th>
<th>III – IV (tillering)</th>
<th>V (nearing the heading stage)</th>
<th>VIII (heading)</th>
<th>IX (blossoming)</th>
<th>XII (full-ripe stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter wheat</td>
<td>Control</td>
<td>27</td>
<td>52</td>
<td>Not marked</td>
<td>Not marked</td>
<td>Not marked</td>
<td>Not marked</td>
</tr>
<tr>
<td>Experiment</td>
<td></td>
<td>25</td>
<td>55</td>
<td>Not marked</td>
<td>Not marked</td>
<td>Not marked</td>
<td>Not marked</td>
</tr>
</tbody>
</table>
Vibration effect on growth and development of winter wheat in artificial lighting conditions

Fresh biomass dynamic of shoots and tillers

<table>
<thead>
<tr>
<th>Characters</th>
<th>Plant age, days</th>
<th>Control</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh shoot biomass, g/plant</td>
<td>27</td>
<td>1,6 ± 0,5</td>
<td>1,8 ± 0,8</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>5,1 ± 1,4</td>
<td>5,3 ± 1,5</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>6,9 ± 1,5</td>
<td>15,9 ± 7,0</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>15,2 ± 5,5</td>
<td>18,6 ± 4,7</td>
</tr>
<tr>
<td>Number of tillers, num/plant</td>
<td>27</td>
<td>3,0 ± 0,0</td>
<td>2,7 ± 0,8</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>4,7 ± 0,7</td>
<td>5,0 ± 1,8</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>7,0 ± 2,1</td>
<td>14,3 ± 6,6</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>10,5 ± 3,1</td>
<td>9,1 ± 2,4</td>
</tr>
</tbody>
</table>

Shoot structure of 70 days old plants

<table>
<thead>
<tr>
<th>Variants</th>
<th>Fresh biomass of main shoot, g/plant</th>
<th>Fresh biomass of all tillers</th>
<th>Part of tillers that fresh biomass similar main shoot, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2,8 ± 0,8</td>
<td>11,0 ± 4,1</td>
<td>14</td>
</tr>
<tr>
<td>Experiment</td>
<td>3,8 ± 0,3</td>
<td>13,4 ± 4,1</td>
<td>39</td>
</tr>
</tbody>
</table>
Date of organogenesis stages of spring wheat in artificial lighting conditions, days after sowing

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Variant</th>
<th>Organogenesis stage / phase of development</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>II (seedling)</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>control</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>experiment</td>
<td>9</td>
</tr>
</tbody>
</table>
Vibration effect on plant structure and grain productivity of spring wheat under cultivation in artificial lighting conditions

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry mass of the whole plant, g</td>
<td>6.62 ± 0.64</td>
<td>7.38 ± 0.61</td>
</tr>
<tr>
<td>Seed’s dry mass from the main shoot, g/plant</td>
<td>0.48 ± 0.04</td>
<td>0.49 ± 0.05</td>
</tr>
<tr>
<td>Seed’s dry mass from the tillers, g/plant</td>
<td>0.56 ± 0.07</td>
<td>0.69 ± 0.16</td>
</tr>
<tr>
<td>Root part in total plant mass, %</td>
<td>11.0 ± 1.4</td>
<td>10.4 ± 1.1</td>
</tr>
<tr>
<td>Grain part in total plant mass, %</td>
<td>15.7 ± 0.9</td>
<td>15.9 ± 1.7</td>
</tr>
</tbody>
</table>
Vibration effect on seeds germination of spring wheat in field experiments

- Time of exposure, hour: 12

Number of plants per sowing line

- Time of exposure, hour: 14

Number of plant per m²

Seeds, sown without vibration

Seeds, sown after vibration
Growth and productivity of spring wheat at the field experiment, Time of exposure, hour: 12.

- There were no distinctions between control and experiment plants in ontogenetic development.

![Graph showing grain weight comparison between control and experiment plants.](image)
There was raising of ontogenetic development at the experiment at the time of IV-IX stages. There are appearing of number of spikles, number of flowers in the spikle, and the part of fertile flowers.
Conclusion

- Influence of vertical vibration on seeds can influence on growth and development of plants in future.

- Vibration effect on:
  - Dynamic of ontogenesis development of spring wheat, the time of exposure was 14 hours;
  - Raising biological and grain productivity, the time of exposure was 12 hours.
  - Vibration stimulated tillering and not effected on ontogenetic development winter wheat under 12-hours vibration.