Mechanism of success
Atonik is a unique, plant biostimulant based on 3 synthetic nitrophenols (naturally occurring compounds in living cells). Plants treated with Atonik show better growth and generative development, improved biomass accumulation, and higher photosynthetic efficiency, improved water status, membrane integrity and cell wall lignification. Atonik reduces the negative impact of stress and increases tolerance of unfavourable crop growth conditions. Applied in the field, Atonik increases the yield and yield quality of arable crops, fruits, greenhouse and field vegetables.

Atonik is produced and developed by Asahi Chemical Manufacturing, located in Nara, Japan. Over 50 years of research and development in co-operation with more than 100 Universities and Scientific Institutions has resulted in 10 global patents, over 500 trials and more than 200 scientific papers.

The product is commercialized in Europe, Asia, Africa, the Middle East and the Americas for the treatment of various annual and perennial crops including oilseed rape, potato, sugar beet, sunflower, cereals, rice, maize, soybean, fruit trees, berries, olives, grapes, citrus, cucurbits, solanaceous, leafy and root vegetables.

Active substances of Atonik are registered as Plant Protection Products in EU (Annex I, Directive 2009/11/EC). Since 2009 intensive work on Post Inclusion Maintenance has been in progress in Poland, Slovakia, the Czech Republic, Hungary, Bulgaria, Romania, Greece and Spain.
### Toxicological information

#### Acute toxicity
- **Ingestion (rat)**: LD50 > 2000 mg/kg
- **Skin contact (rat)**: LD50 > 2000 mg/kg b.w
- **Inhalation (rat)**: LC50 (4 h) > 6.7 mg/l
- **Skin irritation (rabbit)**: Not irritant
- **Eye irritation (rabbit)**: Not irritant
- **Skin sensitization (guinea-pig)**: Not a skin sensitizer (M&K)

#### Chronic toxicity
- **Carcinogenicity**: No suspected carcinogenic effects
- **Mutagenicity effects**: No suspected mutagenic effects

### Active substances

<table>
<thead>
<tr>
<th>Common name</th>
<th>Sodium 5-nitroguaiacolate</th>
<th>Sodium o-nitrophenolate</th>
<th>Sodium p-nitrophenolate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical name</td>
<td>Sodium 2-methoxy-5-nitrophenolate</td>
<td>Sodium 2-nitrophenolate</td>
<td>Sodium 4-nitrophenolate</td>
</tr>
<tr>
<td>CAS No</td>
<td>67233-85-6</td>
<td>824-39-5</td>
<td>824-78-2</td>
</tr>
<tr>
<td>Molecular formula</td>
<td>C7H6NNaO4</td>
<td>C6H4NNaO3</td>
<td>C6H4NNaO3</td>
</tr>
<tr>
<td>Molecular mass</td>
<td>191.1 g/mol</td>
<td>161.1 g/mol</td>
<td>161.1 g/mol</td>
</tr>
</tbody>
</table>

### Structural formula

![Structural formula](image)

### Physical and Chemical properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Brown yellow liquid</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>8.36 at 21°C</td>
</tr>
<tr>
<td><strong>Explosives properties</strong></td>
<td>Risks of explosion almost none in the recommended conditions of storage. Real risk in case of fire or accumulation of the emanations</td>
</tr>
<tr>
<td><strong>Relative density</strong></td>
<td>1 about</td>
</tr>
<tr>
<td><strong>- Water</strong></td>
<td>Miscible with water in all proportions. Gives limpid solution. Non miscible with almost all organic solvents.</td>
</tr>
<tr>
<td><strong>- Organic solvents</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Ecological information

#### Aquatic organisms
- **Fish**
  - LC50 (96 h): Cyprinus carpio > 100 mg/l
  - NOEL (96h): Cyprinus carpio > 100 mg/l
- **Daphnids**
  - EC50 (48 h): daphnia > 100 mg/l
  - NOEC (48 h): daphnia > 100 mg/l
- **Algae**
  - EC50 and EC100 (72 h): Scenedesmus subspicatus > 100 mg/l
  - NOEC (72 h): Scenedesmus subspicatus: 100 mg/l
- **Aquatic plants**
  - Acute (7d): Lemna EC50 > 100 mg/l

#### Terrestrial organisms
- **Birds**
  - LD50 bird > 2000 mg/kg bw (pNP)
  - LD50 bird = 1046 mg/kg bw (oNP)
  - LD50 bird = 2067 mg/kg bw (5-NG)
- **Bees**
  - LD50 oral = 61.2 μg/bee (pNP)
  - LD50 oral = 123.2 μg/bee (oNP)
  - LD50 oral = 131.6 μg/bee (5-NG)
  - LD50 contact = 111 μg/bee (pNP)
  - LD50 contact > 100 μg/bee (oNP)
  - LD50 contact > 100 μg/bee (5-NG)
- **Earthworms**
  - Earthworms (Eisenia fetida)
  - LC50 = 310 mg/kg soil
  - 8 weeks NOEC = 37.0 mg/kg soil

### Persistence and degradability
- **Soil**
  - DT50 in soil = 3.3 days (pNP)
  - DT50 in soil = 5.5 days (oNP)
  - DT50 in soil = 6.6 days (5-NG)

Atonik has a very good profile regarding end user, consumer and environnement.
Mechanism
of plant gene expression

After application, Atonik constituents penetrate quickly and easily into plant cells and are immediately metabolized into compounds occurring naturally in plants and perform similar functions. The first changes, clearly seen already after 24 h, are noted on a molecular level. Experiments on model plant Arabidopsis thaliana L., in which the most advanced microarray technology was employed, showed that the biostimulant causes considerable changes in gene expression. Among genes with a changed expression level, the vast majority (over 90%) are genes with higher expression, which means that those genes are more “efficient” in plants treated with the biostimulant. In other words, the genes are active only after application of Atonik. Those induced are involved, in plant growth and development, both vegetative and generative, photosynthesis, plant hormone, transport and defence response against various stresses. It can be assumed that processes regulated by genes with a higher expression level are more effective.
Mechanism of influence on plant life processes at cell level

Numerous studies show that biostimulant treatment affects most of life processes of the plants at the cell level. The data presented below was obtained during basic studies on Arabidopsis thaliana as a model plant grown in controlled conditions.

Atonik positively affects:

a) photosynthetic apparatus by:
   - higher leaf assimilation area
   - total chlorophyll content
   - intensity of photosynthesis

b) enhanced water management by:
   - lower stomatal resistance
   - higher intensity of transpiration
   - higher water uptake by roots

c) chemical content of:
   - plant hormones
   - lignin content
   - protein content
   - carbohydrates
   - mineral elements

d) improvement of membrane integrity

e) enzyme activity

f) cytoplasmic streaming

All results on Arabidopsis thaliana as a model plant.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Atonik</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf assimilation area cm²/plant</td>
<td>191</td>
<td>164</td>
</tr>
<tr>
<td>Intensity of photosynthesis μmol CO₂/m²/s</td>
<td>8.98</td>
<td>7.33</td>
</tr>
<tr>
<td>Stomatal resistance s/cm</td>
<td>0.86</td>
<td>4.85</td>
</tr>
<tr>
<td>Transpiration μmol H₂O/m²/s</td>
<td>5.55</td>
<td>2.36</td>
</tr>
<tr>
<td>Activity of glutathione reductase n cat/g f.w.</td>
<td>1.16</td>
<td>1.02</td>
</tr>
<tr>
<td>Activity of catalase n cat/g f.w.</td>
<td>0.32</td>
<td>0.03</td>
</tr>
<tr>
<td>Proline content mg/g f.w.</td>
<td>3.07</td>
<td>2.43</td>
</tr>
</tbody>
</table>

ABA content affected by drought level and Atonik application

MWC – Maximum Water Capacity
Mechanism of effect on plant growth and development

Atonik treatment affects all developmental stages of plants. Basic studies show positive effect on:

a) vegetative growth of
- seedlings
- shoots
- roots
- branches

b) generative growth
- number of flowers
- number of fruits, siliques, ears
- seed germination
- pollen Tube growth

c) biomass accumulation and yield
Application of biostimulant usually causes increase of biomass accumulation, both fresh weight and dry matter.

All results on *Arabidopsis thaliana* as a model plant.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Atonik</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry mass weight</td>
<td>g/plant</td>
<td>2.58</td>
</tr>
<tr>
<td>Fresh mass weight</td>
<td>g/plant</td>
<td>23.97</td>
</tr>
<tr>
<td>Number of flowering shoots</td>
<td>nb/plant</td>
<td>43</td>
</tr>
<tr>
<td>Number of siliques</td>
<td>nb/plant</td>
<td>41.5</td>
</tr>
<tr>
<td>Height of the plant</td>
<td>cm</td>
<td>42.92</td>
</tr>
<tr>
<td>Number of flowers</td>
<td>nb/plant</td>
<td>43</td>
</tr>
</tbody>
</table>
**OSR Sugar Beet**

**Rate:** 0.6 l/ha  
**Nb of treatments:** 1-2  
**Timing:** BBCH 29-31, BBCH 51-55, BBCH 61-65  
**Benefits:**  
- regeneration after winter 
- stronger roots 
- branching 
- more pods 
- more seeds/pod 
- higher MTS 
- lignification 
- less Dasyneura damages 
- lower seed shattering 
- longer vegetation/later harvest 

**Remarks:** main target tank mix with Boron

---

**Sugar Beet**

**Rate:** 0.6 l/ha  
**Nb of treatments:** 2-3  
**Timing:** BBCH 12-18  
**Benefits:**  
- higher safety for the crop 
- higher mass of seedlings 
- root mass quicker recovery after herbic appl 
- sugar content 
- technological sugar yield increase 

**Remarks:** tank mix with herbicide

---

**Mechanism of success on the field**

- Yield growth (%)

- Average yield (dt/ha)

- Roots yield (t/ha)

- Sugar content (%)

- Technological sugar yield (t/ha)
### Winter wheat

**Rate:** 0.6 l/ha  
**Nb of treatments:** 1  
**Timing:** BBCH 28-30  
**Benefits:**  
- higher leaf area  
- higher number of tillers  
- higher gluten content  
- higher yield and quality  
**Remarks:** tank mix with fungicide or herbicide

---

### Sunflower

**Rate:** 0.6 l/ha  
**Nb of treatments:** 2  
**Timing:**  
- BBCH 14-18  
- BBCH 55-59  
**Benefits:**  
- post emergent herbicide stress regeneration  
- higher size of the head  
- higher oil content  
- higher biomass accumulation  
- higher yield and quality  
**Remarks:** 2nd application tank mix with fungicide

---

#### Yield (t/ha)

<table>
<thead>
<tr>
<th></th>
<th>control</th>
<th>Atonik</th>
<th>Average of 5 trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>var. Sakwa</td>
<td>5</td>
<td>5.5</td>
<td>5,5</td>
</tr>
<tr>
<td>var. Zyta</td>
<td>6</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>var. Sukow</td>
<td>7</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>var. Trend</td>
<td>8</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>var. Zyta</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Gluten content (%)

<table>
<thead>
<tr>
<th></th>
<th>control</th>
<th>Atonik</th>
<th>Average of 3 trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>var. Sakwa</td>
<td>0</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>var. Zyta</td>
<td>10</td>
<td>15</td>
<td>12.5</td>
</tr>
<tr>
<td>var. Sukow</td>
<td>15</td>
<td>20</td>
<td>17.5</td>
</tr>
<tr>
<td>var. Trend</td>
<td>20</td>
<td>25</td>
<td>22.5</td>
</tr>
<tr>
<td>var. Zyta</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Maize

<table>
<thead>
<tr>
<th>Rate:</th>
<th>0,6 l/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of treatments</td>
<td>2</td>
</tr>
<tr>
<td>Timing:</td>
<td>BBCH 14-65</td>
</tr>
<tr>
<td>Benefits:</td>
<td>post emergent herbicide stress regeneration, cold and drought stress at early stages, biomass accumulation, higher yield</td>
</tr>
</tbody>
</table>

#### Graphs

- **MTS (g)**
  - cv. Pelican
  - cv. Lemko
  - cv. Mucho
  - cv. Kanada

- **Yield (t/ha)**
  - cv. Pelican
  - cv. Lemko
  - cv. Mucho
  - cv. Kanada

### Tomato

<table>
<thead>
<tr>
<th>Rate:</th>
<th>0,6 l/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nb of treatments</td>
<td>4</td>
</tr>
<tr>
<td>Timing:</td>
<td>BBCH 12-14, BBCH 18-19, BBCH 60-69</td>
</tr>
<tr>
<td>Benefits:</td>
<td>flowering quality, fruit setting, higher yield and fruit quality</td>
</tr>
</tbody>
</table>

#### Graphs

- **Total yield (kg/plot, in greenhouse)**
  - cv. Formula
  - cv. Alliance
  - cv. Primadonna

- **Number of flowers/cluster (in greenhouse)**
  - cv. Formula
  - cv. Alliance
  - cv. Primadonna
**Apple**

Rate: 0.6 l/ha  
Nb of treatments: 4  
Timing: BBCH 57  
BBCH 65  
BBCH 69  
BBCH 71  
Benefits: higher resistance to spring frost  
better fruit setting  
better flower bud setting for next season  
higher efficiency of fruit thinning  
higher tolerance for low temperatures  
higher yield and quality

---

**Strawberry**

Rate: 0.5 l/ha  
Nb of treatments: 4  
Timing: BBCH 12-14  
BBCH 55-57  
BBCH 65-67  
Benefits: higher leaf area  
earlier harvest  
better fruit setting  
higher yield and fruit quality

---

Yield (t/ha)

<table>
<thead>
<tr>
<th>cv.</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gala Must</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jonagold</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average fruit weight (g)

<table>
<thead>
<tr>
<th>cv.</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jonagold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elstar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jonagold</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>