MECHANICAL HARVESTING OF TART CHERRIES AND OTHER FRUITS IN POLAND

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Mechanical harvesting ...

- Research Institute of Horticulture
- Fruit production (Poland, Europe)
- Cherry production in Poland
- Research studies on mechanical harvesting
- Continuously moving harvesters
  - Berry fruits
  - Stone fruits
- Harvesting of other fruits
- Manufactures of hort. machines in Poland

Poland
- Population 38 mln
- Area slightly smaller than New Mexico
- Annual precipitation 600 mm (23.6 in)
- Temperature -20 °C (-4 °F) 35°C (95°F)

Skierniewice – population 50,000
- 1136 - as a rural settlement belonging to Gniezno archbishops
- 1457 - official foundation of the town
- The birthplace of Polish composer Fryderyk Chopin (1810 – 02.22)

Research Institute of Horticulture
- 1620 -1918 Warsaw bishops residence
Research Institute of Horticulture

- Research area
  - Fruit plants’ genetics and breeding
  - Molecular biology and biotechnology
  - Physiology and biochemistry of horticultural plants
  - Orchard management
  - Sustainable production of horticultural plants
  - Organic farming
  - Fruit storage and processing
  - Plant protection
  - Product quality and pesticide residue analysis
  - Irrigation and fertigation
  - Horticultural engineering

- The biggest successes
  - Apple varieties Ligol, Ligolina, Gold Milenium
  - Black currants Tisel, Ruben, Tiben, Gofert, Polares
  - Rootstock for apples P60, P2, P22
  - Raspberry P60, P2, P22
  - Plant protection Integrated Pest Management
  - Mechanical harvesting
  - Spray application tunnel sprayers, navigated sprayers
testing sprayers in use currants, sour cherries

Horticultural Engineering Dept.

- Spray Application Lab.
  - SDRT (Spray Drift Reduction Technologies)
  - Target oriented and tunnel sprayers
  - Precision Agriculture in spray application
  - Bioremediation of PPP residues

- Hort. Engineering Lab.
  - Machine harvest of fruit
  - Non chemical weed control methods
  - Application of bio-products in organic farming

- Centre of Education on Spray Application
  - Trainings for the staff of Sprayer Test Stations

Fruit production in Poland 2011

- Total 3 213 000 ton
  - Apples 76
  - Sour cherries 52
  - Currants 103
  - Strawberries 201
  - Plums 113
  - Raspberries 79
  - Pears 194
  - Sweet cherries 2552

Plant production - horticulture

- Horticulture
  - Area % 16.1
  - Value % 19.1
- Vegetables
  - Area % 1.3
  - Value % 16.1
- Fruits
  - Area % 2.1
  - Value % 13.8
- Ornamental plants
  - Area % 0.04
  - Value % 19.1
- Cereals
  - Area % 63.5
  - Value % 24.8
- Potatoes
  - Area % 6.1
  - Value % 7.3

Poland is the world leader in sour cherries and black currant production, world leading exporter of concentrated apple juice and European leader in apple, raspberry and blueberry production.

Horticulture in Netherlands - 75% of plant production

NOT FOR PUBLICATION WITHOUT PERMISSION OF AUTHOR
TART CHERRY PRODUCTION IN POLAND

SOUR CHERRY
- World production – 2011 (1,358,000 ton; 260,000 ha)

Sour cherry
- Production Poland – European Union
- Prices - Poland

Tart cherry in Poland
- Additional crop
  - First new money on the farm (to pay for the workers)
  - Apples is the main crop
- Main problems
  - Shortage of workers (1000 working hours/ha)
  - Labor costs ($4/h)
  - Increasing production costs ($0.4/pound)
  - Low prices ($0.45/pound)
  - Processing fruit (value of fruit does not exceed 7-10%)

MECHANICAL HARVESTING OF STONE FRUITS

SOUR CHERRY
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70% of Polish sour cherries are exported

MECHANICAL HARVESTING OF STONE FRUITS

Methods
- Tractor shaker (stop & go)
- By trunk or limbs
- Hand operated catching frame (plastic, canvas)
- Fully mechanized
  - Automatic trunk shaker
  - Catching & handling system
  - Cleaning & filling of containers
- Continuous moving harvester
  - Shaking directly on shoots
  - Catching & handling system
  - Cleaning & filling of containers
### Methods - capacity

<table>
<thead>
<tr>
<th>Machine</th>
<th>Capacity (trees/hour)</th>
<th>Staff</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractor shaker</td>
<td>120</td>
<td>7 - 10</td>
<td>Hand operated catching frames</td>
</tr>
<tr>
<td>One side machine</td>
<td>30 - 60</td>
<td>2 - 4</td>
<td>Tractor or self-propelled</td>
</tr>
<tr>
<td>Double side machine</td>
<td>80 - 200</td>
<td>3 - 6</td>
<td>Self-propelled, automatic trunk shaker</td>
</tr>
<tr>
<td>Harvester</td>
<td>300 - 500</td>
<td>3 - 5</td>
<td>Self-propelled, shaking directly on shoots</td>
</tr>
</tbody>
</table>

The purchase price of automatic shaking machine and the harvester are comparable, but the harvesting capacity is lower by 50%.

### Shakers + simple frames
- **Advantages**
  - Low investment cost
  - Low maintenance cost
  - High capacity (max. 120 trees/h)

- **Imperfection**
  - Fruits with leaves
  - Large number of workers (7-10)
  - Requires long trunk

### Shakers + catching frame
- **Advantages**
  - Low investment cost
  - Low maintenance cost
  - Clean fruits
  - 2-4 workers

- **Imperfection**
  - Low capacity (40 trees/h)
  - Requires long trunk

### Shakers + mechanical frame
- **Advantages**
  - Low investment cost
  - Low maintenance cost
  - Clean fruits
  - Only 2-3 workers

- **Imperfection**
  - Low capacity (50 trees/h)
  - Requires long trunk

### Automatic shaker
- **Advantages**
  - High capacity (200 trees/h)
  - Clean fruits
  - Only 3 workers

- **Imperfection**
  - Very high investment cost
  - High maintenance cost
  - Requires long trunk

### Not for English Morello
- **English Morello is the main variety (75%)**
- **How to train?**
  - The central leader
  - Trunk (50-60 cm; 4 years)
- **Weak propagation of vibration**

- **New concept of tart cherries harvesting was necessary**

- **Problem**
  - Bark and wood diseases
  - Training and pruning system
  - Harvester
First tests (Pecco – raspberry harvester) 1992 - 97

*New orchard type*

The results were very optimistic. However, a new machine and a new orchard type should be developed.

Any excessive bark and limbs damages were not observed.

Tart cherries harvester - concept

*Parameters (amplitude, frequency)*

New orchard type - advantages

*Higher yield*  *Earlirer full yield*

New orchard type - advantages

*New orchard type*

Before harvest  After harvest

Harvesting efficacy and fruit quality were acceptable.

First tests - conclusions

*New machine*

*Increased working width*

*More room for containers (higher yield)*

*Improved visibility from the driver’s seat*

*New orchard type*

*Smaller trees* (limited dimensions of the harvester)

*More dense planting system* (less gaps between trees)

*Central leader is necessary* (different pruning system)

*Exchanging old limbs*

The results were very optimistic. A new machine and orchard type had to be developed.

A new cherry harvester  2003 - 05

*New harvester*

*Self-propelled harvester prototype*
A new cherry harvester

- Self-propelled harvester prototype

First ever built cherry combine harvester

A new possibilities: 500 trees/h

Self-propelled cherry harvester

- Main parameters
  - Length: 7.0 m
  - Width: 3.1 (4.0) m
  - Clearance: 2.8 x 2.0 m
  - Diesel engine: 50 kW
  - Working speed: 0.6 – 1.5 km/h
  - No of shakers: 4
  - Frequency: 0 – 15 Hz
  - Amplitude: 65 – 80 mm
  - No of workers: 3 (bins)
  - (crates 10 kg)

Cherry harvester is very heavy and expensive machine

Advantages
- High efficiency: 500 trees/h
- High efficacy: 90 - 95 %
- Low harvest costs: 0.06 – 0.07 $/kg (0.027 – 0.031 $/pound)
- First harvest: 3rd leaf

Disadvantages
- High investment costs: 6 ton,
- Sophisticated machine: 14 pumps & hydraulic motors
- Difficult guidance for the driver
- Difficult highway transport

A new model of cherry harvester have to be developed

Harvester pulled by the tractor

Harvester pulled by the tractor
Harvester pulled by the tractor

- **Advantages**
  - Automatic guided steering wheels
  - More simple
  - Not so heavy
  - Cheaper

- **Disadvantages**
  - Lower working speed (only 2 shakers)
  - Difficult maneuvering (at the end of the row)

Field tests

- **Harvest efficacy (fruits - no leafs)**

<table>
<thead>
<tr>
<th>Fruit/leaves loss</th>
<th>Frequency of shakers (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td>20%</td>
</tr>
<tr>
<td><strong>Leaves</strong> (kg/10 trees)</td>
<td>1</td>
</tr>
</tbody>
</table>

Trees without leaves are weaker and trees more susceptible to frost (earlier flowering)

Field tests

- **Harvest (leaves loss)**
  - Leaves/tree 15 000
  - Harvested leaves 600 (5%)

Trees without leaves are weaker and trees more susceptible to frost (earlier flowering)

Field tests

- **Fruit/leaves loss**
  - Frequency of shakers (Hz)

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Field tests

- **Fruit/leaves loss**
  - Travel speed

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Trees without leaves are weaker and trees more susceptible to frost (earlier flowering)
Optimal parameters

- **Harvest parameters** (fruits no leafs)
  - Detachment force: 2.5 – 3.0 N
  - Frequency: 12 Hz
  - Amplitude: 80 mm

(Białkowski et al., 2011)

Detachment force is not a reliable indicator of harvest time and its parameters (frequency, amplitude)

Stone fruits - parameters

(Stawarskyć et al., 2008)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitudes</td>
<td>mm</td>
<td>Tart cherries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plums</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>12 – 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 – 10</td>
</tr>
<tr>
<td>Detachment force</td>
<td>N</td>
<td>&lt;2.5 – 3.0</td>
</tr>
</tbody>
</table>

(*) - shaking of the trunk requires twice bigger amplitudes
(**) - detachment force decide the harvest time

Results

- Harvest efficacy: 91.5 94.9 %
- Fruit loss on tree: 3.2 1.6 %
- Fruit loss on ground: 5.3 3.5 %
- Harvest efficiency: 0.28 0.22 ha/h
- U-turn: 8 – 10 m

(Białkowski et al., 2011)

An automatic harvester guidance system significantly decreased the fruit losses and tree trunk damages

MECHANICAL HARVESTING OF PLUMS

Field tests

- Plums
  - Harvest efficiency: 0.2 ha/h
  - Harvest efficacy: >90 %

Field tests

- Plums
  - Harvest efficiency: 0.2 ha/h
**Varieties**

- Cacanska Rana
- Cacanska Najbolja
- Katinka
- Valievka
- Sylvia
- Nektavit
- Diana
- Amers
- Jojo

**Mechanical Harvesting of Small Fruits**

**Mechanical harvesting**

- Black & red currant
- Gooseberry
- Aronia
- Raspberry

**Black currant**

- Over the row harvester
  - 0.25-0.30 ha/h

**Black currant**

- Over the row harvester
  - 0.35-0.40 ha/h

**Black currant**

- Over the row harvester
- Half row harvester
  - 0.12-0.15 ha/h
OTHER FRUITS

- On 2 year shoots
- On 1 year shoots

OTHER FRUITS

- Rosa rugosa
- Amelanchier (juneberry, saskatoon)

Any significant changes in harvesting of apples were not observed within last 100 years.

Hand picking
Harvest aid
Other fruits

- Apples
- Harvest aid

Conferences
- Field demonstration
- Books
- Booklets

Machine makers – Poland

- All machines are produced in Poland (except tractors)
  - Sprayers 6 manufactures
  - Black currant harvesters 5
  - Shakers – stone fruits 3
  - Rotary movers 6
  - Harvest aid, trailers 5

- Manufactures
  - SMEs & microenterprises
  - Ideas from our Institute
  - Close relationship (Institute, manufactures, growers)
  - System of supporting new developments
  - Monopolization of machines
  - Mainly Polish market

Conclusions

- Stone fruits
  - Small plantation <10 ha (simple trunk shakers & catching frames)
  - Big areas or common use of machines (continuous moving harvesters)

- Small fruits
  - Mechanical harvesting of new varieties
  - Simple and low-cost solutions are the most requested

- Harvesting of apples is the most challenging area
  - Harvest aids (trailers, platforms)
  - Mechanical harvesting for processing
  - Mechanical harvesting of fresh market apples

THANKS A LOT FOR YOUR KIND ATTENTION