RESEARCH INSTITUTE OF HORTICULTURE
Agriculture Engineering Department
SKIERNIEWICE - Poland

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)

Poland

- Skierniewice – population 50.000

Research Institute of Horticulture

- 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

DIVSION OF POMOLOGY | DIVSION OF VEGETABLE CROPS | DIVSION OF FLORICULTURE | DIVSION OF APICULTURE

437 researches and technicians
120 maintenance staff and field workers

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





Research Institute of Horticulture

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





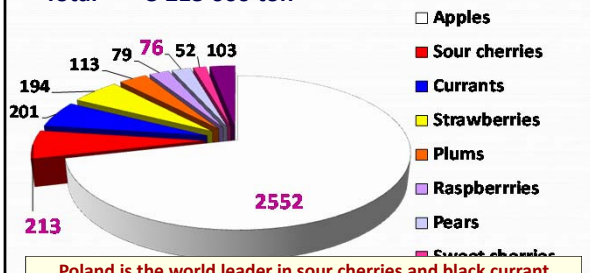
Horticultural Engineering Dept.

- 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



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

Plant production - horticulture



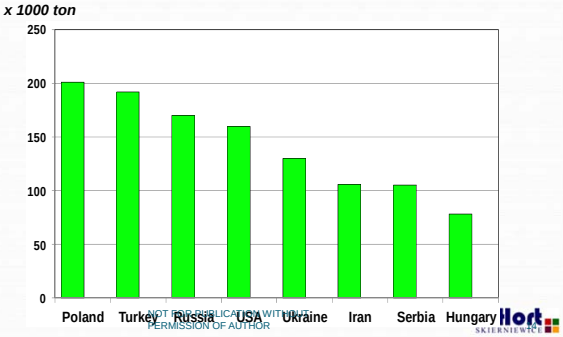

Horticulture	area (%)	value (%)
Vegetables	1,3	16,1
Fruits	2,1	13,8
Ornamental plants	0,04	19,1
	3,4	49,0
Plant production		
Cereals	63,5	24,8
Potatoes	6,1	7,3
(Jabłońska, 2005)	69,6	32,1

Horticulture in Netherlands– 75% of plant production

TART CHERRY PRODUCTION IN POLAND

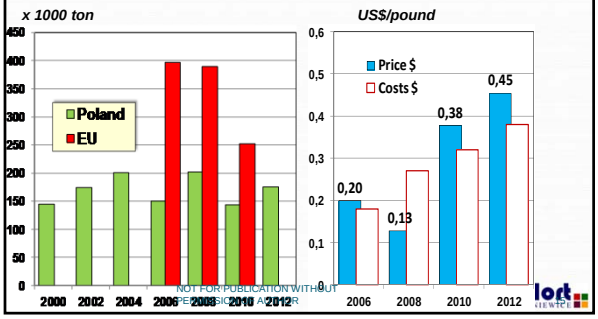
Sour cherry

- **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%)

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

Machine	Capcity (tree/hour)	Staff	Description
Tractor shaker	120	7 - 10	Hand operated catching frames
One side machine	30 - 60	2 - 4	Tractor or self-propelled
Double side machine	80 - 200	3 - 6	Self-propelled, automatic trunk shaker
Harvester	300 - 500	3 - 5	Self-propelled, shaking directly on shoots

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

(foldnig - hand/mechanical)

- **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

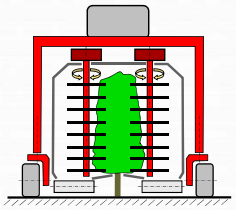
- **English Morello is the main variety** (75%)
- **How to train ?**
  - **The central leader**
  - **Trunk** (50-60 cm; 4 years)
- **Weak propagation of vibration**

New concept of tart cherries harvesting was necessary

- **Problem**
  - **Bark and wood diseases**
  - **Training and pruninig system**
  - **Harvester**

Tart cherries harvester - concept

- **First tests** (Pecco – raspberry harvester) **1992 - 97**
  - **Parameters**
  - **New orchard type**



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

Tart cherries harvester - concept

- **First tests** (Pecco – raspberry harvester)
  - **Parameters** (amplitude, frequency)

Any excessive bark and limbs damages were not observed

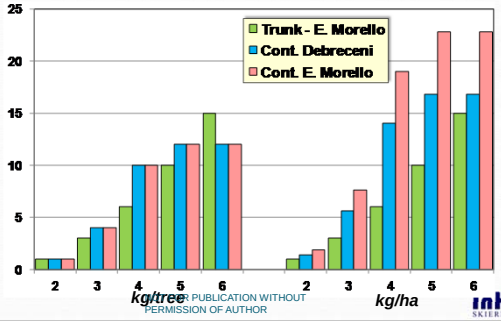
Tart cherries harvester - concept

- **First tests** (Pecco – raspberry harvester)
  - **New orchard type**

Harvesting efficacy and fruit quality were acceptable

New orchard type - advantages

- **Higher yield**
- **Eearlier full yield**



First tests - conclussions

- **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

- **New harvester** **2003 - 05**
  - **Self-propelled harvester prototype**

A new cherry harvester

- Self-propelled harvester prototype

2003 - 05

First ever built cherry combine harvester
A new possibilities – 500 trees/h

A new cherry harvester

- New harvester
  - Hydraulically driven
  - Higher and wider working area
  - The slot for tree trunk was decreased
  - The driver's seat was moved
  - Crates or bins ?
- **Problems** (extension)
  - Growers had no trust in new technique
  - Fruit processing plants – had no trust in fruit quality

Fruit quality is acceptable for processing. The period between the harvest and processing time was shortened

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)
	5	(crates 10 kg)

Cherry harvester is very heavy and expensive machine

Self-propelled cherry harvester

- 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

2005 - 07

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)

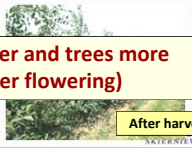


Field tests

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

Field tests

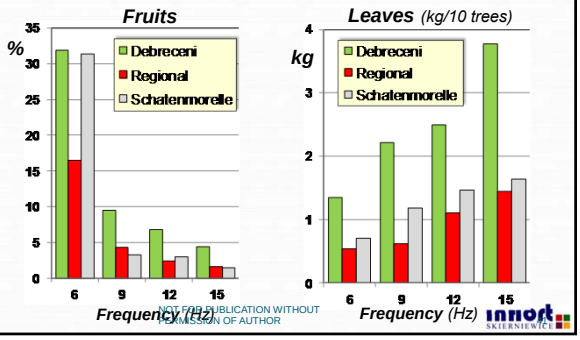
- **Harvest** (leaves loss)
  - Leaves/tree 15 000
  - Harvested leaves 600 (5%)

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

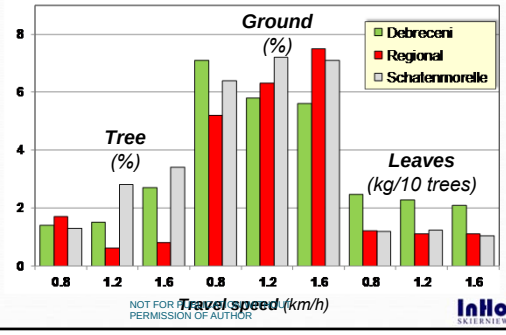
Field tests

- **Fruit/leaves loss** (Białkowski at al., 2011)
  - Frequency of shakers (Hz)



Field tests

- **Fruit/leaves loss** (Białkowski at al., 2011)
  - Travel speed



Optimal parameters

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

(Białkowski at al., 2011)

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

Stone fruits - parameters

(Wawrzyńczak at al., 2008)

Parameters	Units	Species	
		Tart cherries	Plums
Amplitudes	mm	90*	90*
Frequence	Hz	12 - 15	6 - 10
Detachment force**	N	<2.5 - 3.0	<6.5 - 8.0

(*) - 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	%
	on ground	5.3	3.5	%
Harvest efficiency		0.28	0.22	ha/h
		380 - 550	300 – 500	tree/h
U-turn		8 – 10		m

(Białkowski at 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

Varietes

- Cacanska Rana
- Cacanska Najbolia
- 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

1981-90

Black currant

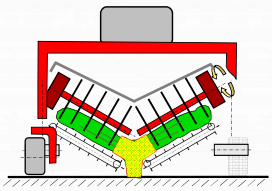
- Over the row harvester 0.35-0.40 ha/h

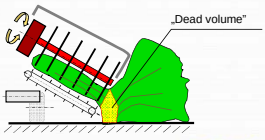
2005-07

Black currant

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

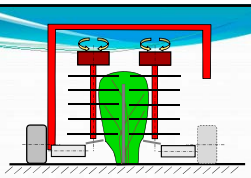
1981-90





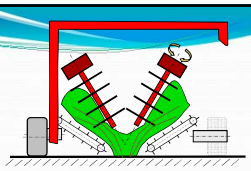
Raspberry

- On 2 year shoots



Raspberry

- On 1 year shoots



2009 - 11

OTHER FRUITS

Other fruits

- *Rosa rugosa*
- *Amelanchier* (juneberry, saskatoon),

2012

Other fruits

- Apples
  - Hand picking

1890

1938

1965

2013

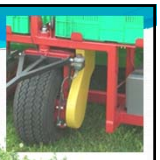
Any signifficant changes in harvesting of apples were not observed within last 100 years

Other fruits

- Apples
  - Harvest aid

Other fruits

- Apples
  - Harvest aid

Extension

- Conferences
- Field demonstration
- Books
- Booklets



Machine makers – Poland

- **All machines are produced in Poland** (except tractors)
  - Sprayers — 6 manufactures
  - Black curant 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 & catchnig frames)
  - Big areas or common use of machines (continuos 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

We still have many original ideas on mechanical harvesting of fruits

THANKS A LOT

FOR YOUR KIND ATTENTION