Ergonomics in Agriculture: Blueberry Harvesting

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Blueberries

- Annual harvest of 79,000 tons
- Farm gate value of $130.9 million
- BC, Que and NS sell 86% of crop
- Production has not reached a plateau

Two Varieties

- **High bush**
- **Low bush**
  - Unique to Atlantic Canada
  - 6-8” tall

**Harvesting:**
- 70% machine harvest
- 30% manual
General thoughts

Machine harvest:
- More cost effective
- Increased production has reduced labour market
- Quality is improving

Manual harvest:
- Provides better quality
- Important for fresh market sales
Common concerns

Balance between productivity & safety

- Maximize yield
  - Short harvest season
- Machine human interaction
  - Moving parts
- Minimize WRMD’s
  - Low back pain
  - Wrist and hand injuries
  - Falls
Principles of Ergonomics/Human Factors Engineering

Process:

• The systematic application of relevant information about human capabilities, limitations, characteristics and their interaction with products, equipment, facilities, procedures and environments in work and everyday living.
Ergonomics Objectives

- To enhance the effectiveness and efficiency of work.
- Change the machines, environments and procedures people use to better match their characteristics to the system.
What is a system?

- A system is a set of elements developed to achieve an objective.
- Considers the relations amongst the elements and the boundaries around the elements.
- Usually has a defined input, a process and a defined output.
Main components of a system?

The system consists of all of the elements that may influence the work. Most systems consist of 3 main elements which are:

- Human
- Machine
- Environment
Areas which use HE/Ergonomics

- Appliances
- Office Machines
- Automobiles
- Aircraft
- Weapons
- Command Control
- Space Systems
- Hand Tools
- Tractors
- Processing Systems
Types of Human-Machine Systems

**Manual Systems**
- A human operator using hand tools and other aids powered by their own physical energy

**Mechanical Systems**
- A system consisting of a human operator who acts as a control device interacting with a self-powered machine

**Automated Systems**
- A system that functions with little or no human intervention. Humans are necessary to install, program and maintain/monitor these systems
A H-M-E Chart for this meeting
(list at least 3 items under each category)

<table>
<thead>
<tr>
<th>Human</th>
<th>Machine</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sex</td>
<td>• Laptop</td>
<td>• Lighting</td>
</tr>
<tr>
<td>• Age</td>
<td>• Projectors</td>
<td>• Noise</td>
</tr>
<tr>
<td>• Height</td>
<td>• Chairs</td>
<td>• Temperature</td>
</tr>
</tbody>
</table>

Now consider the “range” of possible scores for these items

Identify those items that are adjustable

Now draw lines between the items that may interact with each other
The Human

- Anatomy
- Physiology
- Biomechanics
Low Back Pain - Anatomy
The “Healthy” spinal unit
The Passive System

- Vertebrae
- Facet Joints
- Intervertebral Disc
- Ligaments
The Active System

- Musculature of the Spine
- Tendons

Figure 12
Physical Demands, Work Practices & Understanding Injury Mechanisms

Loss of Function
Discomfort
Pain

Enhanced Function
Growth
Pain/Pleasure

TISSUE TOLERANCE

TISSUE RESPONSE

Posture/Structure
Flexed Wrist
Grip Size

Force
Increased Force
Requirement

Exposure/Repetition
Shift Duration
High Repetitions

Norman & Wells, 1990
Mechanisms of Injury:  
Single load

Figure 1.1  (a) A margin of safety is observed in the first cycle of subfailure load. In the second loading cycle, the applied load increases in magnitude, simultaneously decreasing the margin of safety to zero, at which point an injury occurs. (b) The Canadian snowmobile driver (the author in this case who should know better) is about to experience an axial compressive impact load to a fully flexed spine. A one-time application of load can reduce the margin of safety to zero as the applied load exceeds the strength or failure tolerance of the supporting tissues.

Mechanisms of Injury:
Repetitive low loads

Figure 1.2  (a) Repeated subfailure loads lead to tissue fatigue, reducing the failure tolerance, leading to failure on the Nth repetition of load, or box lift in this example (b).

Mechanisms of Injury:  
**Constant low loads**

**Figure 1.3**  
(a) These rodmen with fully flexed lumbar spines are loading posterior passive tissues for a long duration, (b) reducing the failure tolerance leading to failure at the Nth% of tissue strain.
Can the tissue tolerance change?

Figure 1.4 Loading is necessary for optimal tissue health. When loading and the subsequent degradation of tolerance are followed by a period of rest, an adaptive tissue response increases tolerance. Tissue “training” results from the optimal blend of art and science in medicine and tissue biomechanics.

McGill 2002
Spinal loads and injury risk

LBP incidence (# / 200K man hr)

Predicted Compressive forces L5/S1 (Kg)
Spine Instability
Stability
Shear forces and injury risk
Compressive and shear forces (L4/L5)

Compression and Shear Force

Force (N)

Compression

Shear
Manual harvesting equipment

Hand rakes:

• Size
• Handle size
• Weight
• Handle angles
Manual harvesting equipment
Machine harvesters

- Large scale
Machine harvesters

- Smaller scale
So what is the problem and what is the solution?

- Many complex systems have moved beyond Human Factors Engineering
- Now Human Factors is integrated into the early design phase of a new “system”
What is Human Systems Integration?
Solutions

Build safety and ergonomics into the design

Many ‘new’ designs are in small businesses which lack R&D for things other than the PRIMARY OBJECTIVE

- Guarding
- Loads
Life cycle of a new product/system

Product Design

Product Development

Field Testing

Product Support
Design priorities

- Product goals
- Usability
- Human performance/error
- Emergency conditions
Cost of Design Change

- Concept: 1X
- Design: 10X
- Tooling: 100X
- Testing: 1,000X
- Release: 10,000X
Delayed input vs costs
How can Human Factors be used?

**Actions**
- Review and/or establish system goals
- Understand human limitations and design to minimize their effects

**How**
- Review existing systems (design, policies, etc)
- Model and evaluate proposed systems (early)
- High interaction with users.
- Ask for a review of new products before purchase!
How – By carefully moving upstream