Design of a Mechanical Harvester for Sea Buckthorn Berries

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Outline

- Sea Buckthorn Background
- Harvesting Methods
- Shaking Harvesters
- Typical Harvesting Problems
- Prototypes
- Conclusions
- Questions

Sea Buckthorn Background

- Multi-branched, thorny shrub
- Reaches 2-4 m in height
- Soft, tightly-clustered berries
- Berries difficult to harvest

Harvesting Methods

- Direct Harvesters
  - Mechanical devices that have direct contact with fruit
- Indirect Harvesters
  - Mechanical devices that cause the fruit to be removed without actually touching it
    - Shaking
    - Vacuum suction
    - Quick freezing
    - Whole-branch removal

Harvesting Methods

- Battery-powered Shaker
- Vacuum Harvester

Harvesting Methods

- Whole-branch Removal
- Over-crop Sway Harvester

Shaking Harvesters

A number of experiments have been conducted to determine adequate parameters for berry removal by shaking

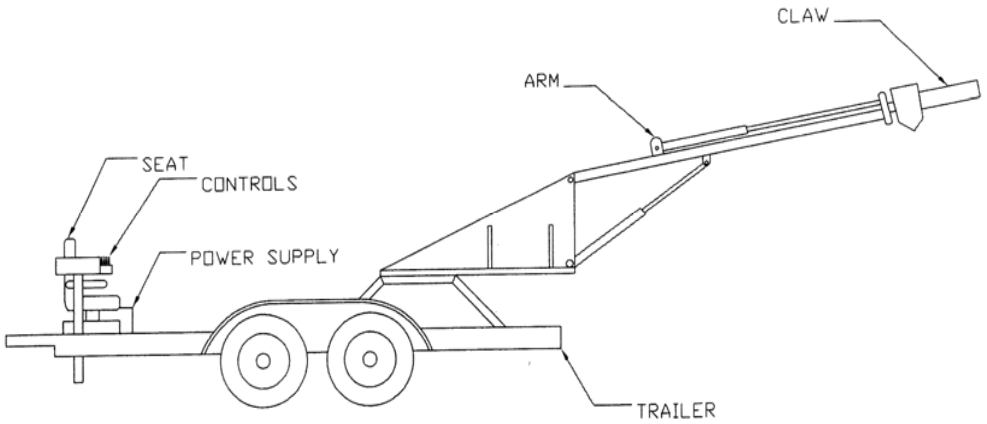
- According to Stan et al. (1985)
  - Amplitude: 25 mm
  - Frequency: 25 Hz
- According to Mann et al. (2001)
  - Amplitude: 32 mm
  - Frequency: 25 Hz

Typical Harvesting Problems

- Fruit damage and loss
- Shrub and bark damage
- Low efficiency
- Maneuverability

Mark I Prototype

- Hydraulically-operated arm mounted on trailer
- Clamping device used to attach the shaker to the shrub
- Oscillations created by cam mechanism



Evaluation of Prototypes

- 5 year old, un-pruned, Sea Buckthorn shrubs were used for evaluation
- Combinations of different amplitudes and frequencies were selected for testing
- Damage to the shrub and berries were qualitatively assessed

Evaluation of Mark I Prototype

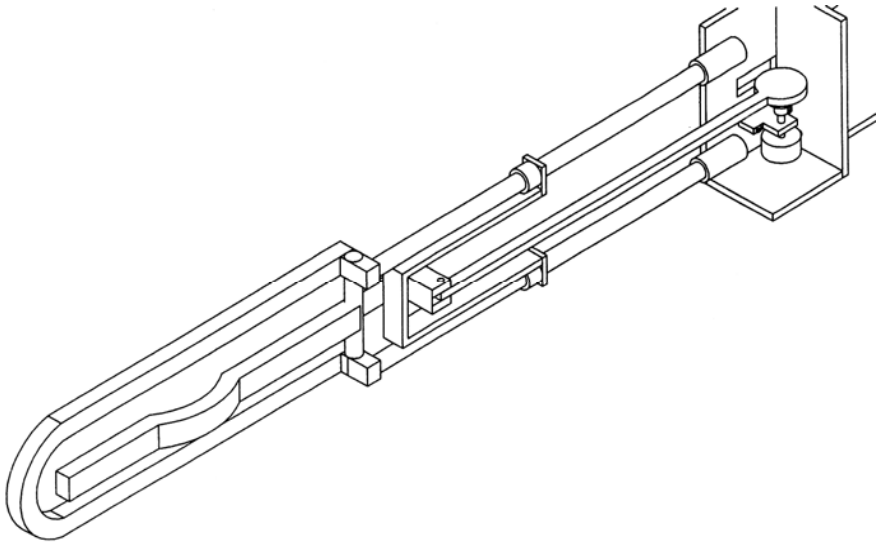
- Determined that the optimum amplitude and frequency for shaking were 25 mm and 23 Hz
- Caused extensive damage where clamp was attached to shrub

Mark II Prototype

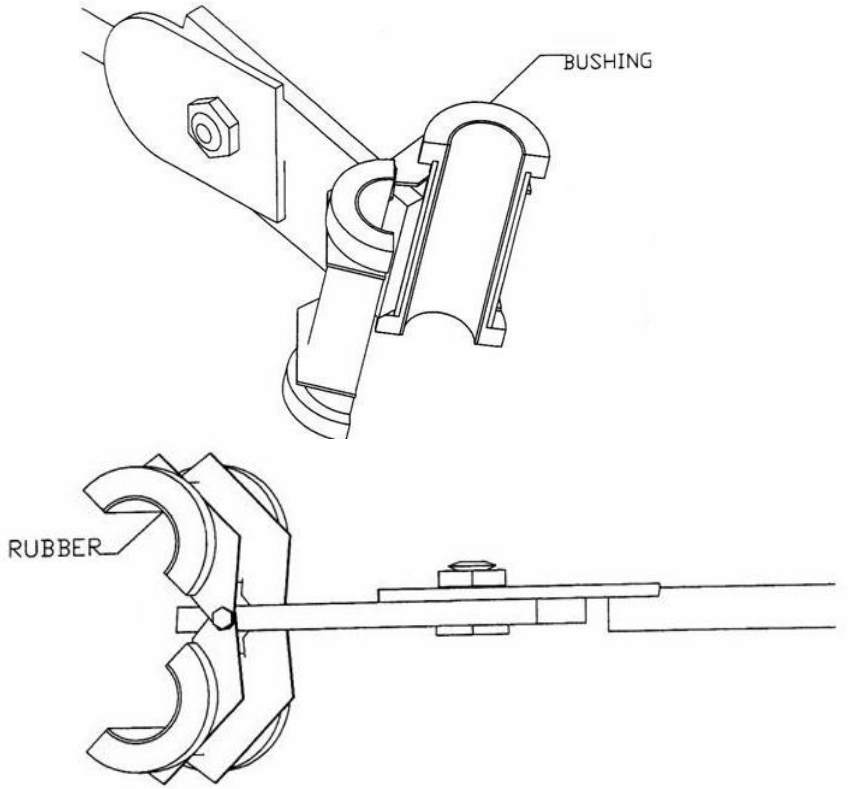
- Minimized damage to the bark of the shrub by altering the clamping mechanism:
  - Reduced angle of shaking arm with respect to the trailer
    - Clamping device intercepted shrub at right angle
  - Increased contact area with the shrub
  - Coated with rubber material

Prototype Comparison

- Mark I Prototype



- Mark II Prototype



Evaluation of Mark II Prototype

A “damage key” ranking system was used to evaluate the level of damage sustained

- Initial assessment performed immediately after harvest in the fall; second assessment performed the following spring

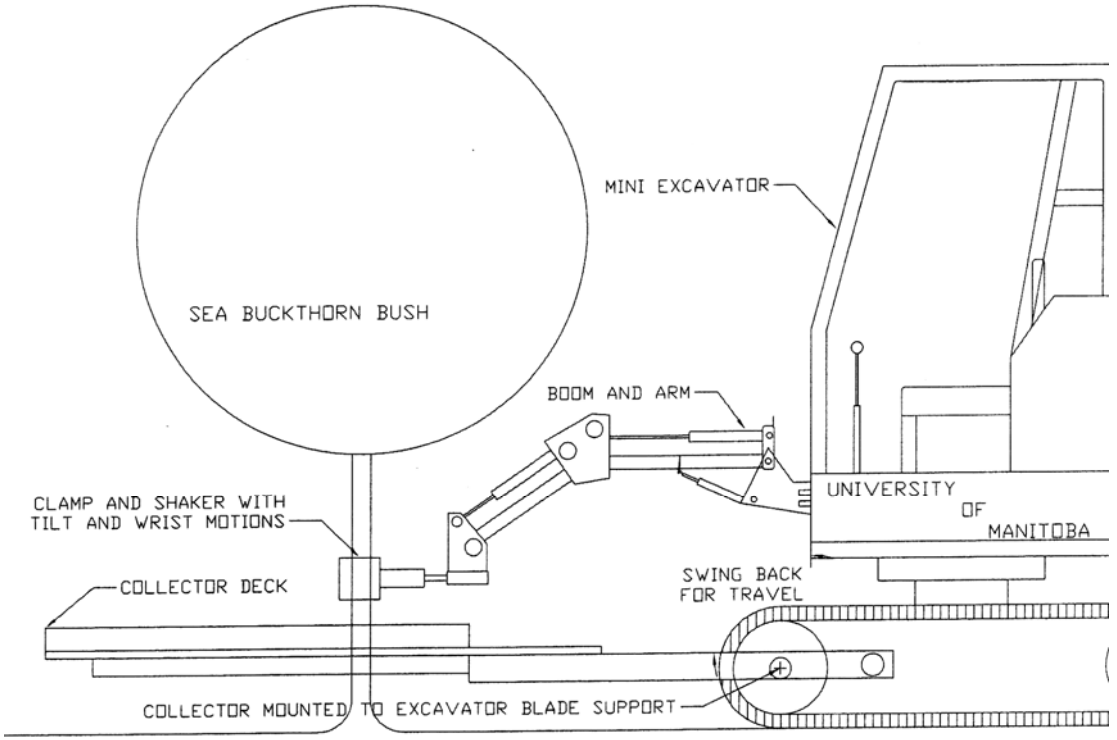
- Determined that the optimum amplitude and frequency for shaking were 25 mm and 25 Hz

Damage Key

Descriptor	Key	Level	Meaning
Branch damage	Light	1	0-24% of branches damaged
	Medium	2	25-74% of branches damaged
	Heavy	3	75-100% branches damaged
Bark damage	Light	1	top layer of bark rubbed off
	Medium	2	outer layer removed
	Heavy	3	complete disruption of vascular tissue
Leaf bud damaged	Light	1	0-24% of leaf buds damaged
	Medium	2	25-74% of leaf buds damaged
	Heavy	3	75-100% leaf buds damaged
Overall condition of shrub	Good	1	shrub visibly vigorous, no appreciable change in condition compared to non-tested shrub
	Fair	2	shrub noticeably less vigorous than non-tested shrub but no serious damage visible
	Poor	3	shrub significantly less vigorous than non-tested shrub; serious damage present

Mark III Prototype

- Tractor-mounted to improve maneuverability
- Addition of rigid-platform, berry collector fitted around shrub
- Interlocking finger clamp, controlled by hydraulics, provided tilt and wrist motion



Evaluation of Mark III Prototype

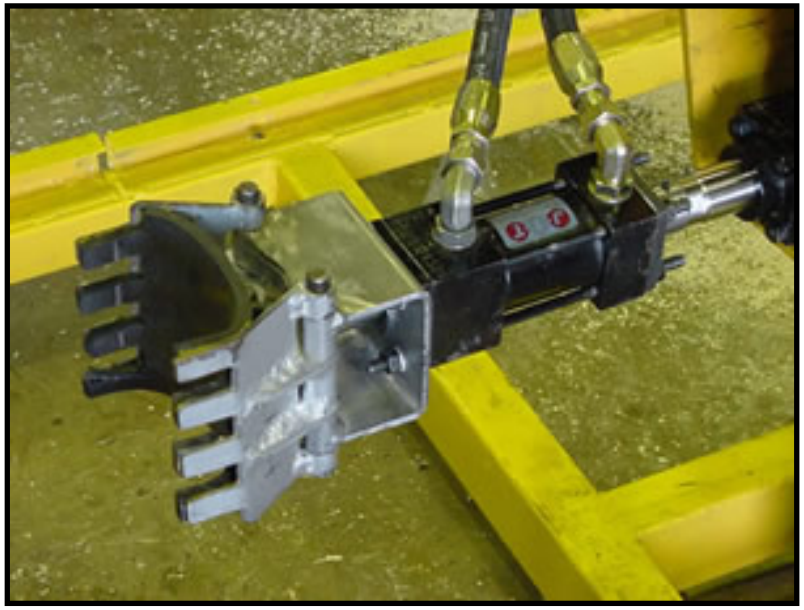
25 year old, un-pruned, Sea Buckthorn shrubs were used for evaluation

- Previous amplitude and frequency values could not be met
- Rigid platform contributed to berry damage
- Low claw height made alignment difficult, which led to shrub damage

Prototype Comparison

- Mark II Prototype

- Mark III Prototype



Mark IV Prototype

- Modifications made to accommodate 25 mm amplitude and 25 Hz frequency for shaking
- Side-mounted collector increased maneuverability
- Screen mesh on collector decreased berry damage

Evaluation of Mark IV Prototype

Used same evaluation procedure as Mark III Prototype

- Obtained 76% mean harvest efficiency
- Future improvement: mechanize the positioning of the collector

Conclusions

- Optimum amplitude and frequency are 25 mm and 25 Hz for berry removal by shaking
- Shaking mechanism mounted on tractor improves maneuverability
- Rubber-lined bushings and claw wrist motion decreases shrub damage
- Mesh collector decreases berry damage and loss

Questions?