Simulation-based Logistics and Economic Analysis of Grafting Propagation Operations

Sponsor: USDA SCRI PROJECT NO. 2011-51181-30963

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Vegetable Grafting Symposium, November 7th, 2012
Project Team at UA

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Simulation Scope: Grafting Types

- Manual grafting
- Semi-Automated Grafting
- Fully Automated Grafting
Case study with A Real Nursery in Canada: Systems of Systems Simulation

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Simulation Demo: Major Mobile and Static Objects

- Root Stock Tray Before Cutting
- Root Stock Tray After Cutting
- Small Scion Tray
- Trash Can
- Worker
- Scion Tray Before Cutting
- Scion Tray After Cutting
- Tray Shelf Cart
- Table
- Grafted Plant Tray
- Empty Tray
- Conveyor
Simulator of Real Grafting Department

1. **Work table**
2. **Conveyor for rootstock**
3. **Out-going conveyor**
4. **Conveyor for scion**
5. **Conveyor for rootstock**
6. **Transplant small scions to empty tray**
7. **Put grafted trays to shelf**

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**Model Statistics**

- Total Grafted Plants (Trays) = 16
- Total Labor Cost (Dollars) = 106
- Average Labor Cost (Dollars/Plant) = 0.08
- Total Small Scions Transplanted (Plants) = 279
- Total Small Scions Back To Greenhouse (Trays) = 2

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2D and 3D Simulation Demos

- 2D Grafting
- 3D Grafting
- Growing
- Seeding
3D Simulation Demos
(Flexible) Simulation Inputs and Outputs

**Inputs**

- Number of grafting workers
- Number of grafting machines (semi/fully-automated)
- Grafting speed (manual and semi/fully automated grafting)
- Grafting success rate (manual and semi/fully automated grafting)
- Grafting worker salary rate
- Electricity price
- Grafting machine electricity consumption rate

**Outputs**

- Grafting worker and machine utilization
- Total production by manual and automated grafting (semi/fully)
- Variable cost by manual and automated grafting (semi/fully)
- Total electricity consumption
- Seedling cycle time
- Capital expenses
- Percentage of order fulfilled in time with acceptable quality

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Sample Output Analysis

Plants grafted by manual grafting

Number of plants

Grafting success rate

50% 60% 70% 80% 90% 100%

173 186 195 210 225 241
(On-Going) Case study with A Real Nursery in Canada

• Analyzing the sensitivity of system outputs to factors:
  ▪ Uniformity of scion trays
  ▪ Scion/rootstock tray process time
  ▪ Worker skill distribution (distribution of process time)

• Comparing logistics patterns for manual grafting (island/line operation)

• Modeling other processes in propagator operations and supply chain involving
  ▪ Germination, order scheduling, sorting & transplant, healing
  ▪ Seeds/plants shipping & transportation, inventory control
Systems of Systems Simulation: Distributed Simulation

- Systems of systems **within a propagator** (potential computational complexity)
- Extension to **supply chain** (allow integration without sharing proprietary information)
- **Demo** (manufacturing supply chain simulation)
Simulation-based Decision Support Services for Propagators

Simulation-based Decision Support Services for Propagators

• Manufacturing system; Coal mine (demo)

Acknowledgements

- USDA SCRI (Specialty Crop Research Initiative)  
  PROJECT NO. 2011-51181-30963
Questions or Discussions

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