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OPMC Ontario Pest Management Conference 2025

Agricultural robots for weed management in beets and carrots on muck and mineral soils

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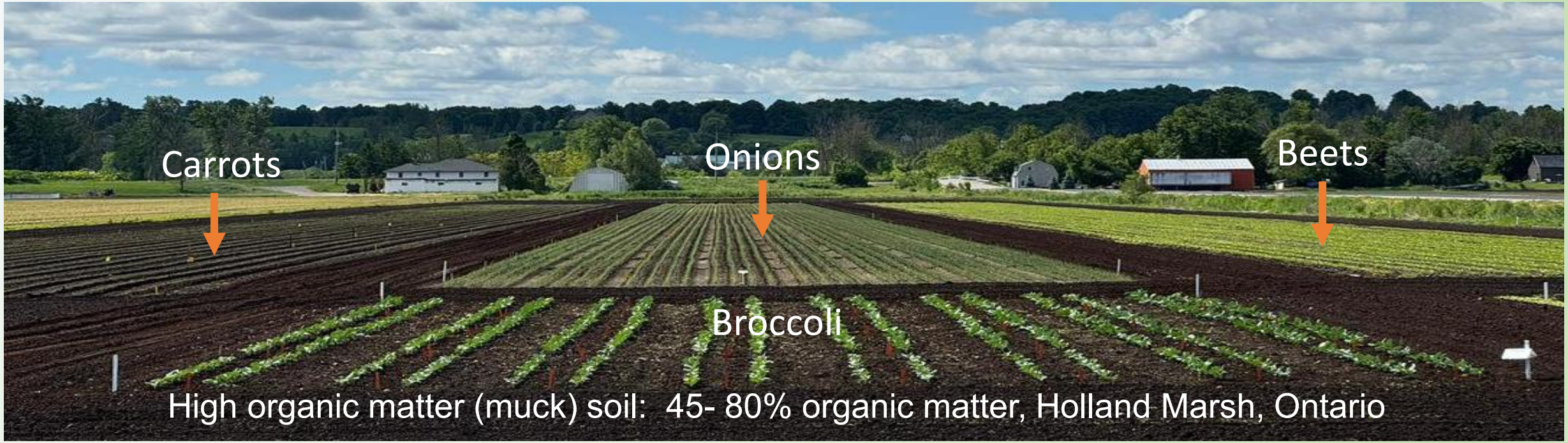
Introduction: Why agricultural robots?



- Intensive vegetable production
- Few effective herbicides and growing resistance (Davies et al., 2019).
- Labour shortages and high cost
- Need for an alternative approach

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Meet the Naïo Orio robot

- Autonomous electric robot
- 10 hours per day/ 9 ha
- RTK GPS and camera-guided systems
- Safety: LiDAR sensors, wheel bumpers, and geofencing
- Turns at the end of the row
- Cultivates and sprays
- Automatic sprayer and cultivator regulation

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Pixelfarming Laser One-I prototype

- AI-Powered weed recognition
- Precision laser modules include integrated targeting and cooling systems
- Semi-autonomous operation
- Universal mounting plate allows integration with custom tools
- Chemical-free weed control

Tractor-mounted Laser One-I

Carrots

Carrots (*Daucus carota* L.)

- Carrot: 2nd most valuable field vegetable in Canada. Valued at $163.8 million in 2024.
- Ontario accounts for 45% of Canada's fresh carrots. (Statistics Canada, 2024)
- Holland Marsh region – 60% of Ontario's fresh market carrots.

Table beet

- Table beets: A notable field vegetable in Canada, valued at $27.6 million in 2024.
- Ontario accounts for 29% of Canada's production. (Statistics Canada, 2024)
- Holland Marsh – commercial production.

Table beets (*Beta vulgaris subsp. vulgaris Conditiva*)

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Hypothesis

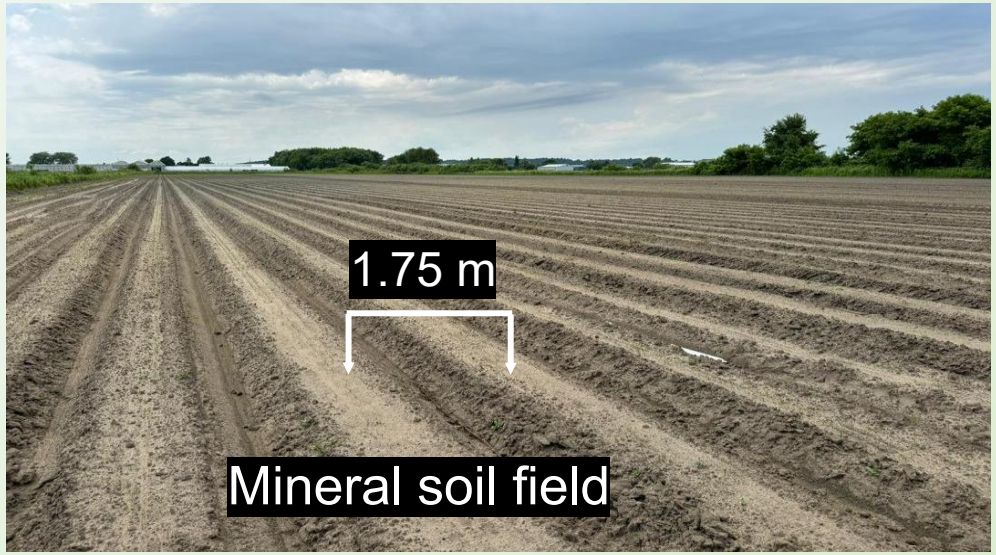
- The weed control efficiency of the Naïo Orio robot is comparable to conventional methods in carrot and beet crops across muck and mineral soils.
- Laser weeding reduces weed density over time in table beets grown on muck soil.

Objectives

- Evaluate the effectiveness of Naïo Orio for weed management in table beet and carrot on muck and mineral soils, and compare to that of a tractor.
- Assess if soil type influences the performance of Naïo Orio compared to conventional weed management.
- Assess herbicide application with the Orio on mineral soil compared to a non-treated check
- Evaluate Pixel Farming Laser One-I systems for weed management in beets

2024 Experimental design

a. Direct-seeded on hills, 1.75 m centers
b. Four rows of hills per rep in a completely randomized design: 2 reps on muck soil and 3 reps on mineral soil.
a. Mineral field 175 m rows; muck soil 300 m rows



Carrot field

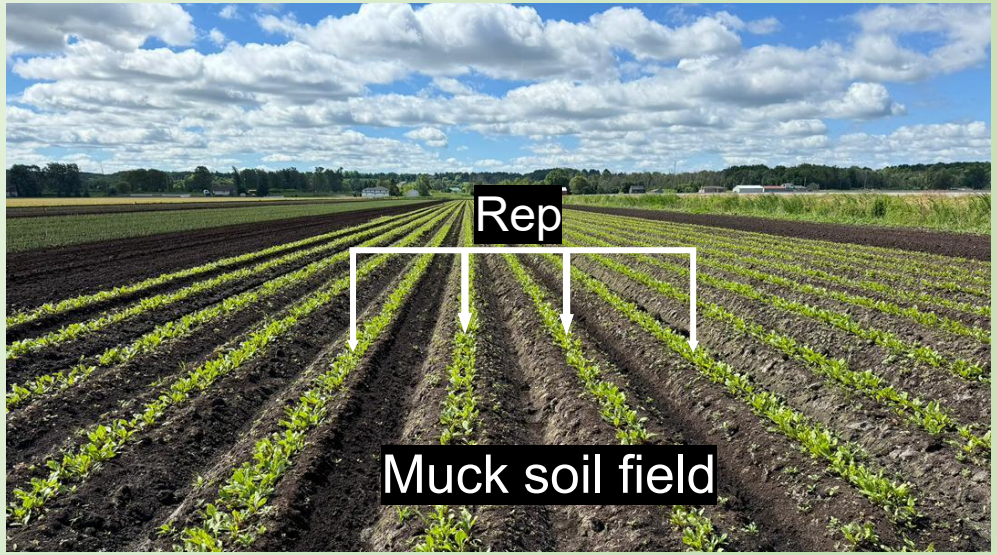


Table beet field

Cultivators

Naïo Orio fitted with the rolling gang cultivator with spider spikes

Naïo Orio used the S-Tine cultivator early season in beets

Spraying Setup -2024

Naïo Orio with band sprayer and two 55-gallon tanks

2024 weed management routine

Date	Stage	Muck soil	Mineral soil
Table beets			
13 – 20 June	Early post-emergence	BETAMIX EC (*desmedipham, phenmedipham*) on both soils	
		Mechanical control with S-tine	none
		BETAMIX EC	none
21 June – 25 July	Post-emergence to full canopy	Mechanical control with rolling cultivator gang on both soils	
Carrots			
21 – 26 June	Early post-emergence	LOROX L (linuron) on both soils	
		Mechanical control with rolling cultivator gang on both soils	
27 June – 25 July	Post-emergence to full canopy	LIBERTY 200 SN (*glufosinate ammonium*)	none
		Mechanical control with rolling cultivator gang on both soils	

Weed assessment

Carrot field

Weed parameters:

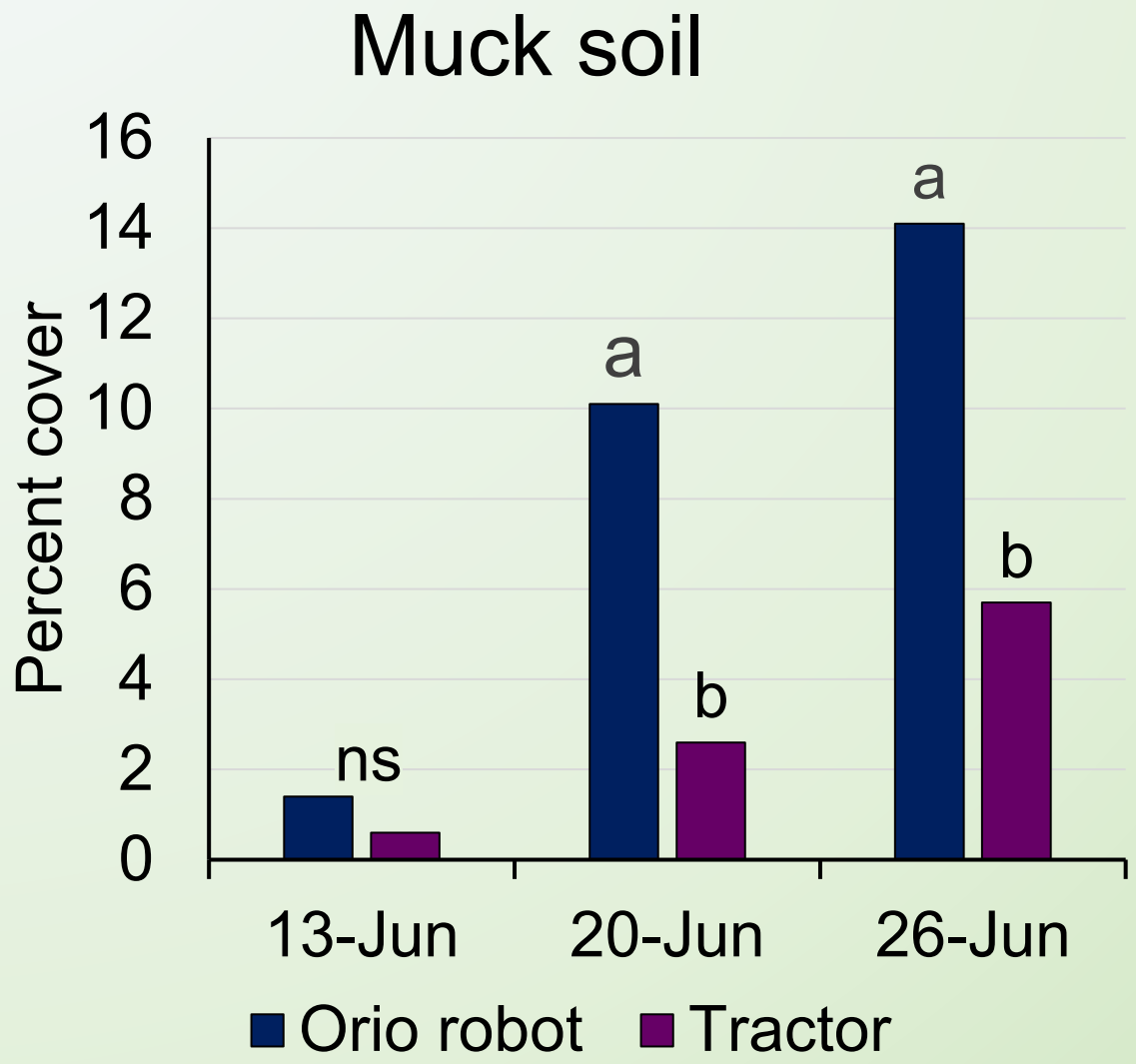
- Vegetative cover
- Weed count (density)
- Fresh biomass

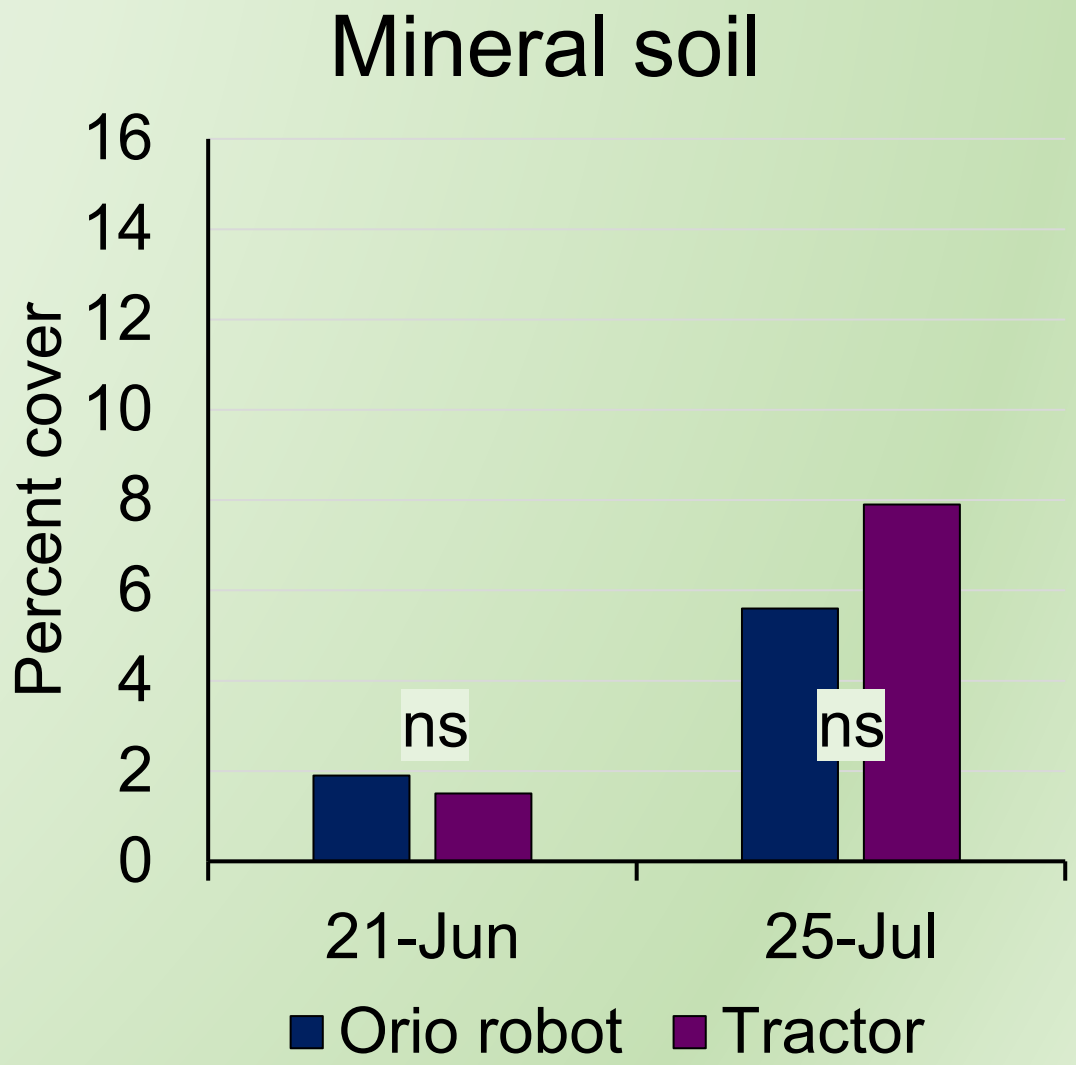
Table beet field

- 0.25 m^2 quadrat
- Middle row of a rep

Effect of weed management on weed vegetative cover, 2024

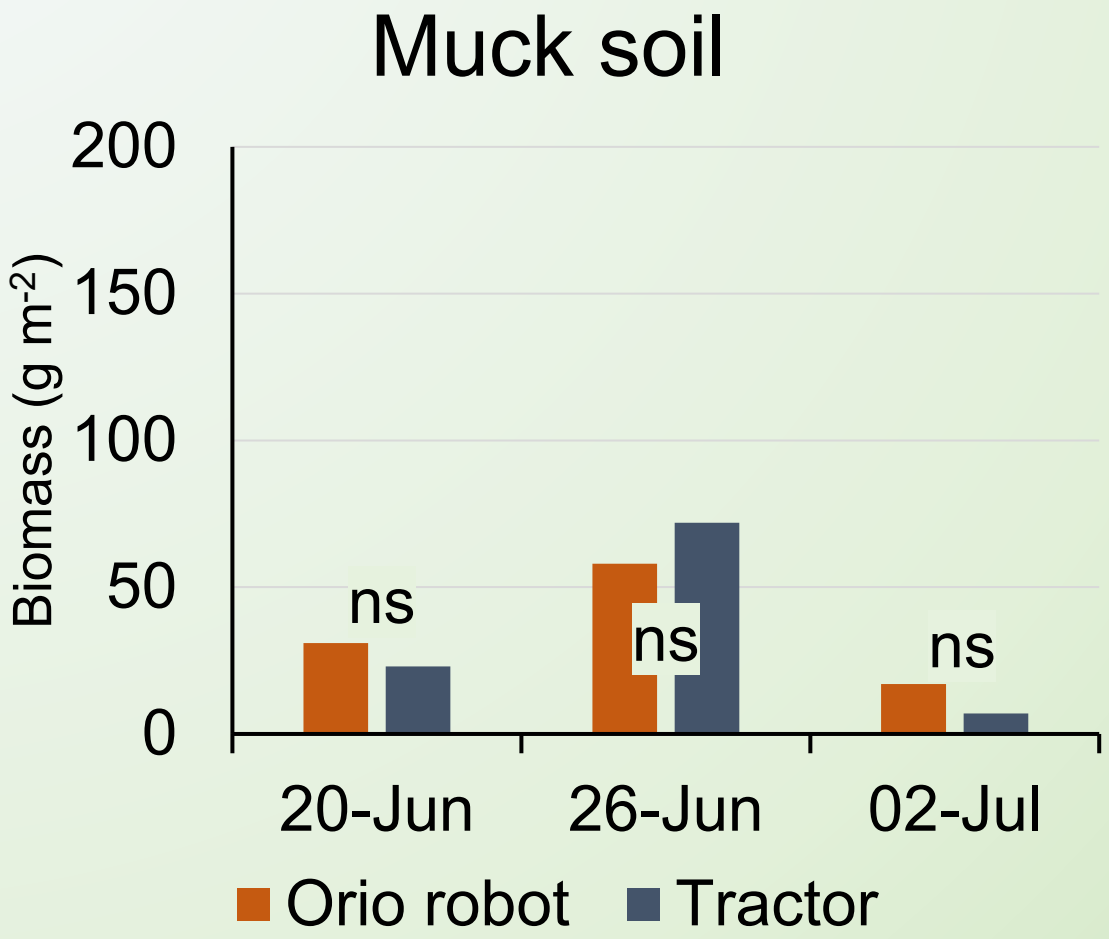
Table beet

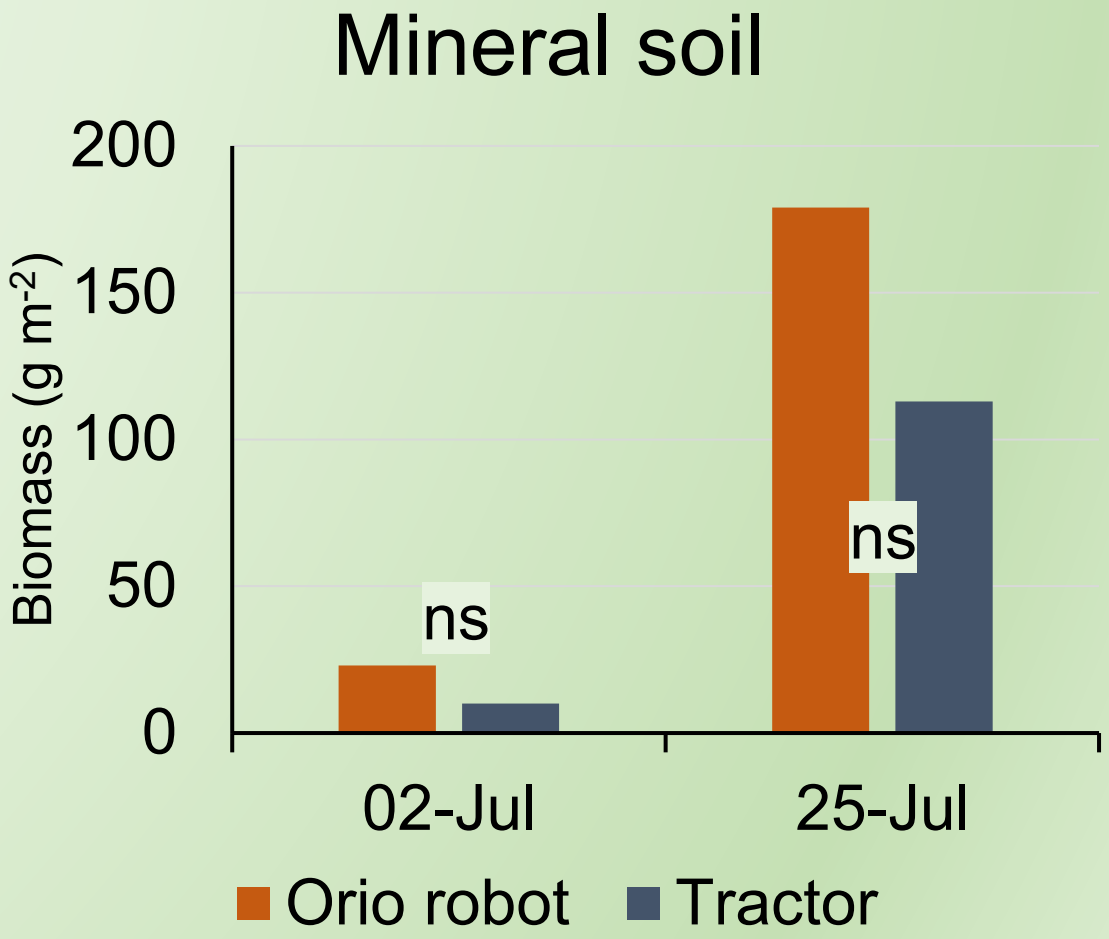




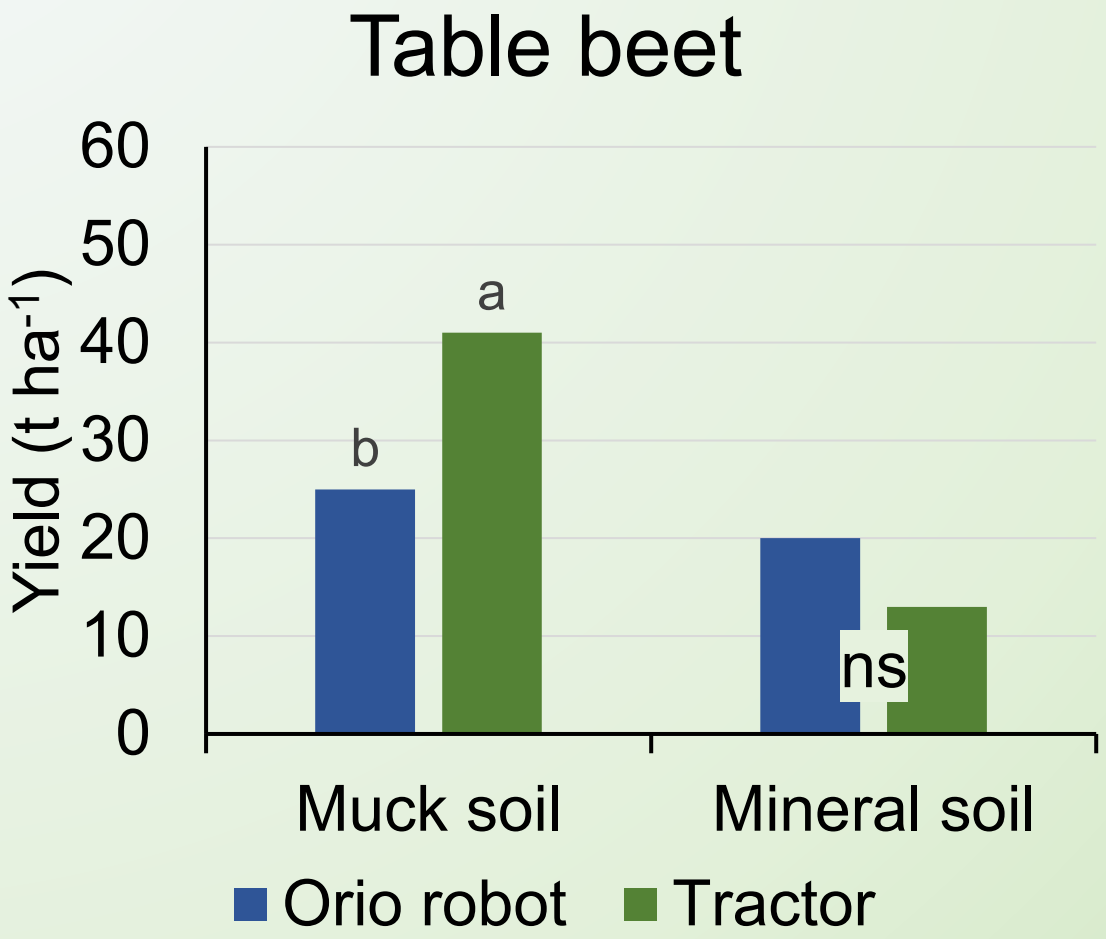
Effect of weed management on weed biomass, 2024

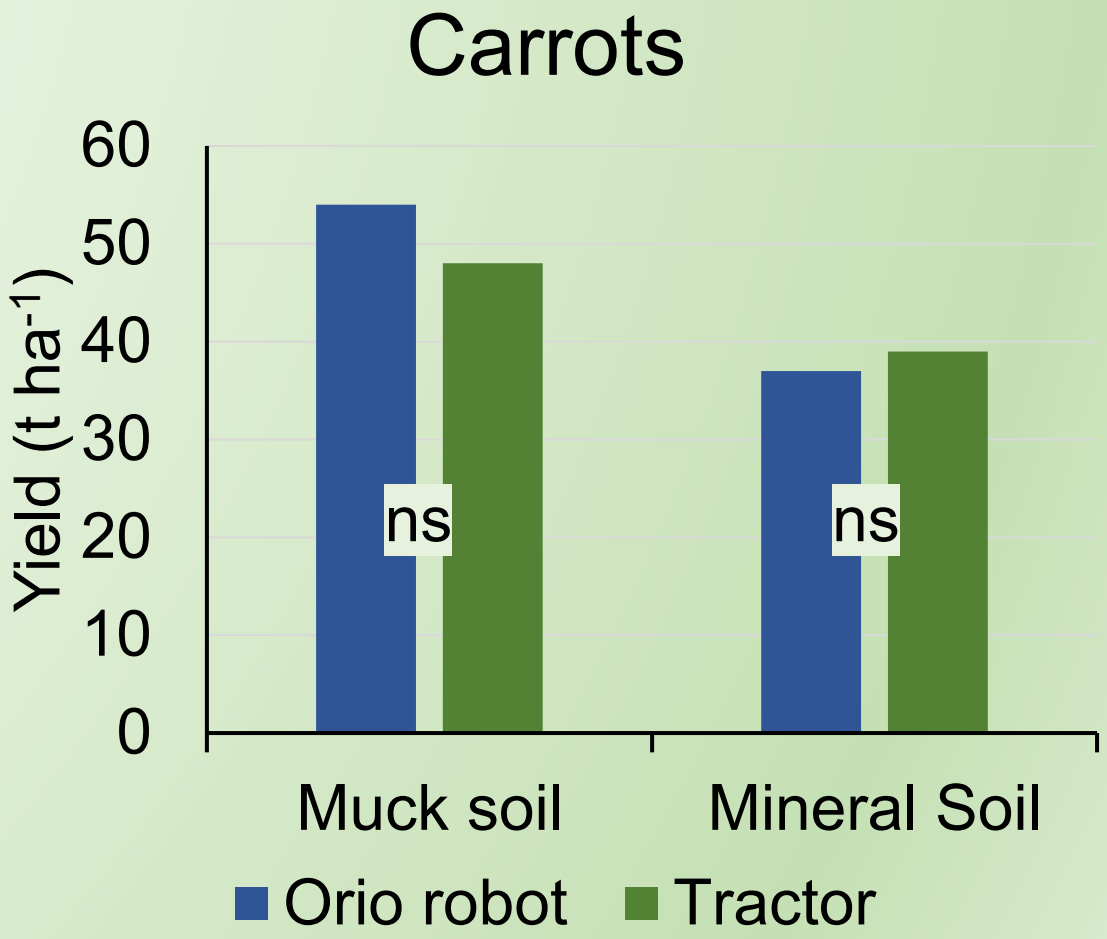
Carrot





Effect of weed management on marketable yield, 2024





Correlations

Weed biomass and total beet yield in 2024

Soil type	Yield (t ha^{-1})	Pearson correlation	20 - 21 June	26 June – 25 July
Muck	Total weight	r	**-0.75**	**-0.68**
		p-value	**0.005**	**0.015**
Mineral		r	-0.15	0.27
		p-value	0.54	0.29

Weed biomass and total carrot yield in 2024

Soil type	Yield (t ha^{-1})	Pearson correlation	26 June - 2 July	3 – 25 July
Muck	Total weight	r	-0.11	0.18
		p-value	0.66	0.48
Mineral		r	-0.01	0.26
		p-value	0.97	0.42

Summary of weed management effects 2024

- Weed parameters in carrot fields and table beet on mineral soil were comparable.
- Correlations with yield were weak and non-significant for both crops on mineral soil.
- Weed indicators had a strong effect on table beet yield in muck soil.
- Early implement setup issues led to weed escapes with the S-tine.
- No strong weed–yield relationship in carrot

2025 Naïo Orio herbicide application study

Objective: Compare herbicide-treated with nontreated check in carrot plots on mineral soil.

Date	Crop stage	Herbicide
August 21	Established carrot canopy and root bulking (BBCH 41–43)	LIBERTY 200 SN *(glufosinate ammonium)* – non-selective

- Pre-recorded RTK data
- Robot stopped every 20 to 25 seconds.
- Cones required continuous adjustments, causing crop injury
- Spray mode or speed showed no differences

2025 Naïo Orio herbicide application result

Effect of herbicide application on weed vegetative cover, density, and biomass in **carrots** on mineral soil 2025

Spraying mode	Speed (km h^{-1})	Weed density[1] (plant m^{-2})	Weed cover (%)	Relative crop injury (%)
Pre-herbicide		**10**	**3.0**	**-**
Automatic	2	13 ns[2]	0.3 ns	22 ns
Automatic	3	40	1.9	16
Manual	3	15	1.3	6

ns = no significant means in a column *(p = 0.05)* without the pre-herbicide treatment, as determined by the Tukey-Kramer test.

2025 Pixel Farming Laser One-I evaluation

- Takes time to train (600 images)
- Takes time to acquire targets in the field
- Requires consistent operating speed
- Shielded area for imaging would improve imaging

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Conclusions

- No differences between robot and tractor in mineral soil for weed control or yield.
- In muck soil, robot plots had higher weed pressure and lower beet yield linked to early-season equipment limitations in 2024
- 2025 Mechanical breakdown limited full assessment
- Laser One-I is not field-ready for Holland Marsh conditions

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Next Steps

- Orio is capable but needs improved GPS stability, better insulation for cables, and adaptable implement hitch adjustments
- Hood cones need improvement to prevent herbicide drip if working in larger canopies.
- Orio needs another full season to validate findings
- Costs/ROI needs to be compared
- LaserOne-I prototype needs pre-installed weed identification programs
- LaserOne-I would be more effective if fully autonomous

ACKNOWLEDGEMENTS

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Thank you for listening

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