

A close-up view of an automated weeder machine in a vegetable field. The machine's metal legs and sensors are positioned over rows of young green vegetable plants. The soil is dark and appears to be in the process of being worked. The background shows more of the machine's complex mechanical structure.

# **Automated Weeders for Controlling Weeds in High Density Vegetables**

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# **Weed Control in Onions**

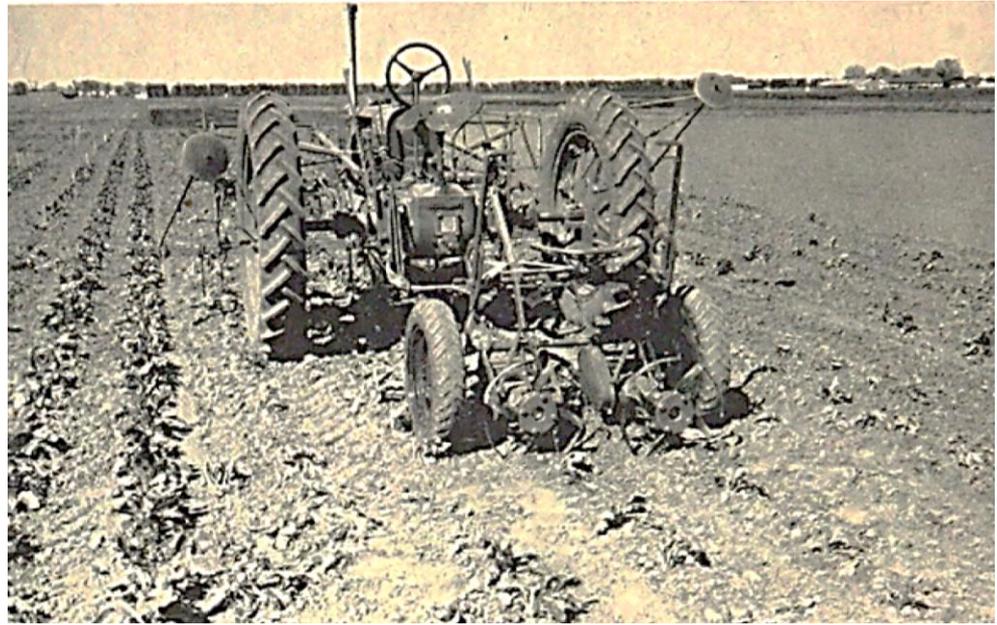
- **EPA cancellation of the Dacthal registration**
  - **Registered since 1958**
  - **The fate of the registration could be in the political arena**
- **Has been taken off the market before**
  - **Spurred research into creative use of Goal and eventual 1st true leaf registration of Goal Tender**
- **If the loss of Dacthal is upheld by the EPA, what are the current solutions available to address critical weed control issues?**
  - **Can the currently registered materials fill the gap?**
  - **Can an autoweeder play a role?**

# **Weed Control in Onions**

- As I prepared this talk, I realized that the situation with Dacthal had to be woven into the discussion**
- I am not familiar with the weeds and production practices of this area. My comments are based on my experience in my area**
- Also, we have not used the laser weeder technology on onions yet – as I understand, that has been done here**
- I have left time for discussion at the end so someone can comment about that if you would like**

# The Quest for Automated Weeders and Thinners

- There has been interest in the development of mechanical thinners for sugar beets for many years
- Early machines used a straightforward spinning blade that blocked out the stand in a rote fashion
- John Deere continued to make innovations on beet thinners into the 1970's using plant detection technologies available at the time (primitive by current standards)



Colorado State University  
1940's beet thinner

# Cultivation Technology

- Improvements in cultivation have made steady progress following improved precision in making beds and planting
- Now has progressed greatly with GPS guidance of making beds and camera guidance of cultivators
- Leaving the uncultivated seedline as the challenge



Manual 1930's



Sled guided



Camera Guidance 2005

# First Attempt at Reaching into the Seedline - Finger Weeders



# The Modern Age Camera/Computer Based

In 2007 the first automated weeder came to Salinas

- The first machines had a camera which captured the image, computer processor and a kill mechanism
- The Garford (England) machine used a blade with a notch in it where the keeper plant was placed and then the blade spun around it



# The Use of a Spray Kill Mechanism was First Used on Lettuce

Less inertia, more precision





Carbon Robotics (USA)



FarmWise (USA)



Naio (France)

# Auto Weeders



Ferrari (Italy)



Garford (England)



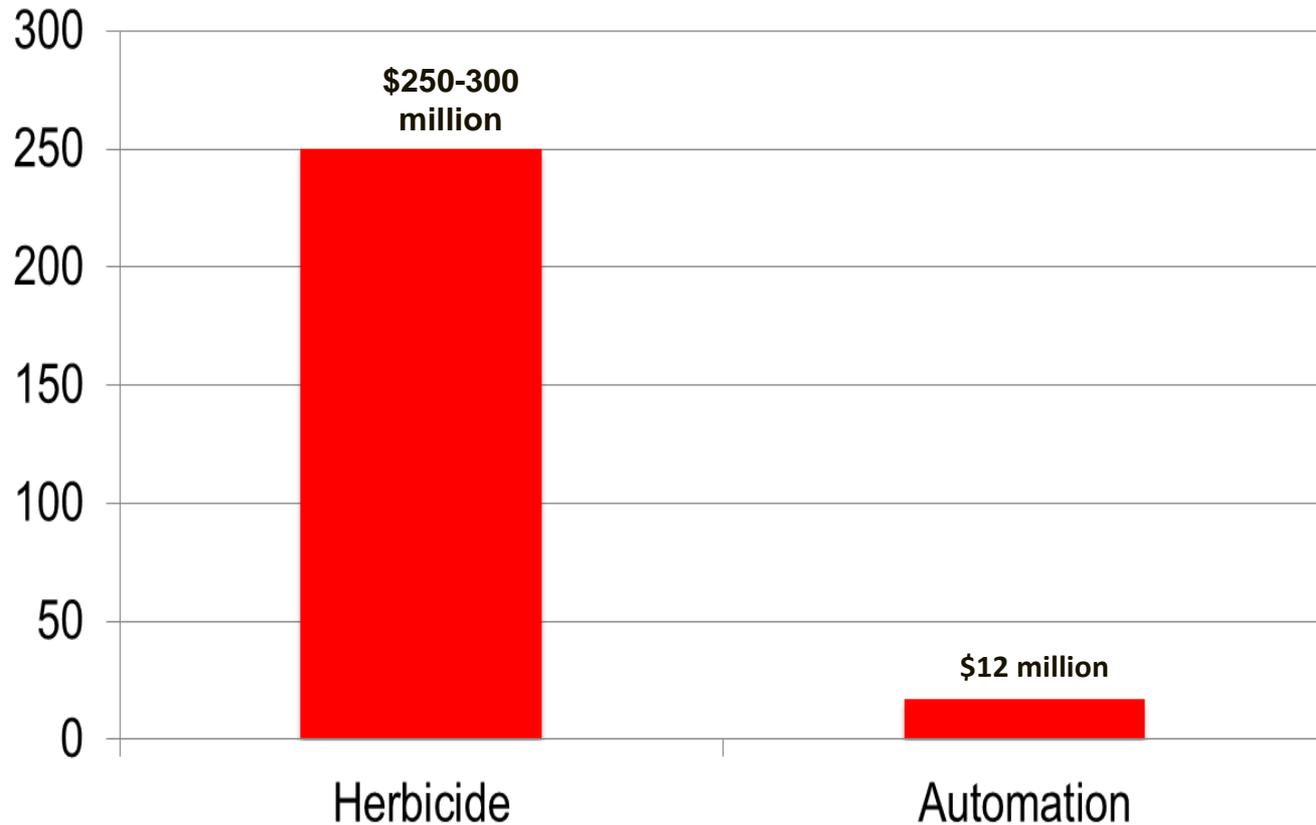
Robovator (Denmark)



Stout (USA)

**Others: Nexus; Verdant Technologies, many others**

# Development Costs: Herbicides vs Automation



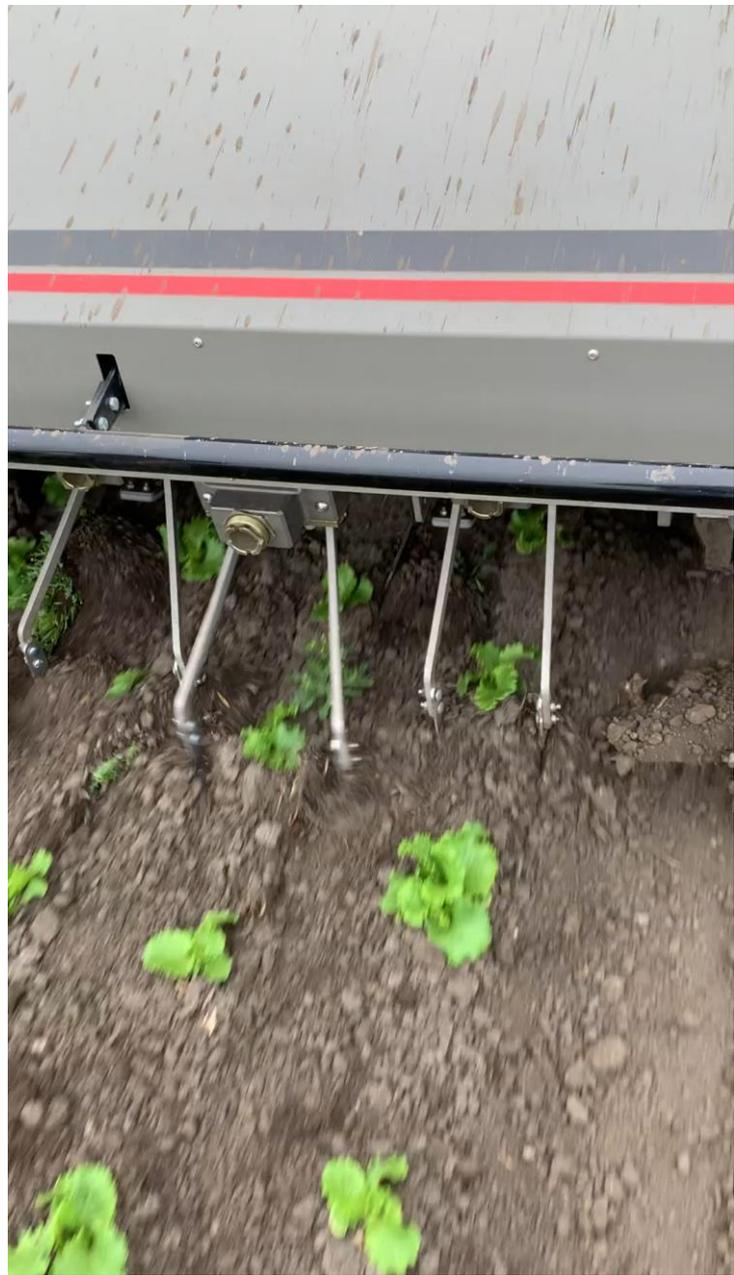
Rüegg et al. 2007

Polsen DK, Mol NL 2016

# AutoWeeder Split-blade Kill Mechanism

- The split blade closes between keeper plants and opens around keeper plants
- Widely used on vegetable crops grown in rows





# Island of undisturbed soil around the keeper plant left by split blade



# 2021 Evaluation of Split-Blade Auto Weeders

Response Variable	Auto Weeder	Standard Cultivation
Weeds Removed (%)	70.0	0.0*
Follow-up Hand Weeding (Hrs/A)	7.7	12.8*

# Weed Removal in High-Density Planting Configurations



# Laser Weeder



**Carbon Robotics – Seattle based**  
**Started in 2018**  
**2022 first year of commercial application**

# Laser Technology Married with Artificial Intelligence to ID Weeds

## Lasers

150 Watt CO<sub>2</sub>

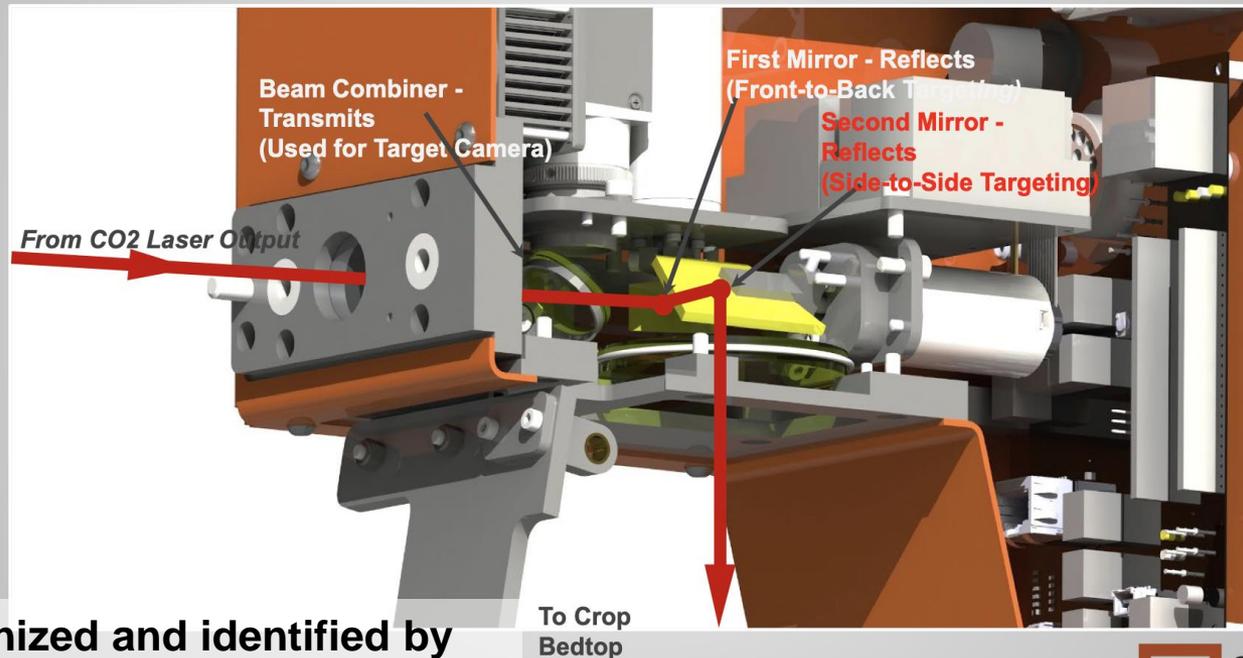
Multi-Season Tested

Easily Swappable (Consumable)



# Movable Mirrors Direct the Laser Beam

Scanner: Laser Beam Path



Weeds recognized and identified by artificial intelligence, then beam directed to remove them

# Ultra Precision Weed Removal





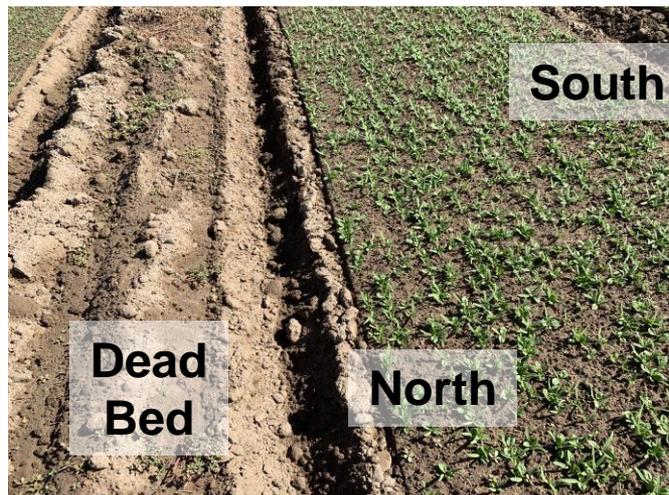


# Initial Weed Populations and Percent Killed with Laser Weeder

Location in field	Trial 1			Trial 2		
	Weeds/m <sup>2</sup>	% Killed weeds	% Live weeds	Weeds/m <sup>2</sup>	% Killed weeds	% Live weeds
North	86.4	90.6	9.4	33.2	80.5	19.5
South	44.0	69.3	30.7	104.2	85.3	14.7
Overall	65.2	79.9	20.1	68.6	82.9	17.1

# Weed Control and Follow-up Hand Weeding Time

Treat	North side of bed Next to 'dead bed'			South side of bed Away from 'dead bed'		
	Weeds per m <sup>2</sup>	Percent Killed	Weeding time hrs/A	Weeds per m <sup>2</sup>	Percent Killed	Weeding time hrs/A
Untreat.	41.9	---	69.0	6.2	---	25.9
Laser	14.3	65.8	24.8	0.3	95.9	11.9



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# Use of Laser Technology for Weeding Onions

- Clearly, this technology would be applicable to onions based on our experience with other high-density crops:
- Spinach and mizuna planted at 3-5 million seeds/A
- Onions are planted at lower seeding densities which may allow it to travel at faster speeds than we have seen
- It is used in a narrow window (e.g. 7-10 days) when the weeds are small enough for the machine to kill them – addressing the first wave of weeds
- Can it remove sufficient weeds to be equivalent to the action of a preemergent herbicide?

# **Use of Laser Technology for Weeding Onions**

- In the case of other crops, follow up hand weeding is usually necessary to remove weeds not killed by the autoweeder**
- In the case of onions, the laser weeder might remove enough weeds for the onions to get to the 2<sup>nd</sup> true leaf stage when post emergent herbicides can kill escaped weeds and get the crop through the remainder of the crop cycle**

# **Other AutoWeeders**

- The Nexus machine uses a mechanism to reach down and physically remove weeds**
- The Verdant machine uses a spot sprayer to treat individual weeds**
- Both of these machines may have an advantage of being able to remove weeds that are bigger and that have escaped prior weeding efforts**

# **Where do we go from here?**

- The autoweeder technology has legs and is being used on thousands of acres in the Salinas Valley**
- It comes at a fortuitous time when ag labor is in short supply**
- It is tricky for growers to make decisions to purchase a machine, given up front costs and complicated situations if follow-up hand weeding is necessary**