Research Update on Automated Weeder Technology

- **Richard Smith, Vegetable Crop and Weed Science Farm Advisor, Monterey County**

Automated Weeders

- There are commercially available automated weeders on the market
- Some growers are using these machines and others are evaluating their use
- They use a variety of techniques to distinguish the crop from the weeds (e.g. difference in size, spectral reflectance)
- Utilizing these machines in transplanted crops enables them to use size differences between the crop and the weeds
- Use of preemergent herbicides is generally helpful to reduce confusion by the machine

Automated Weeders

Split Knife Kill Mechanism

Robovator
Frank Poulsen Engineering
Denmark

IC Steketee
Netherlands


Island of undisturbed soil is left around the plant; this undisturbed area can be adjusted to be more aggressive or less

Automated Weeder

Summary of Four Evaluations

Pre vs Post weeding	Lettuce plants 1000/A	No. of Weeds 1000/A
Pre weeding	37.3	13.5
Post weeding	35.2	6.6

Removed about 50% of the weeds in seedline

Weeds butting against the plant are not removed

Automated Weeder

Summary of Four Evaluations

Treatment	Hand Weed Hrs/A
Mechanical weeder	6.1
No mechanical weeder	9.7

Reduced time of subsequent hand weeding by 35%

Automated Weeders
Spray Kill Mechanism

- **Blue River Technology* has developed an automated weeder that uses a spray mechanism to kill the weeds**
- **They are building several production machines to pursue the cotton market**
- **They have plans to bring the machine to the lettuce market at some point in the future (2 – 3 years??)**

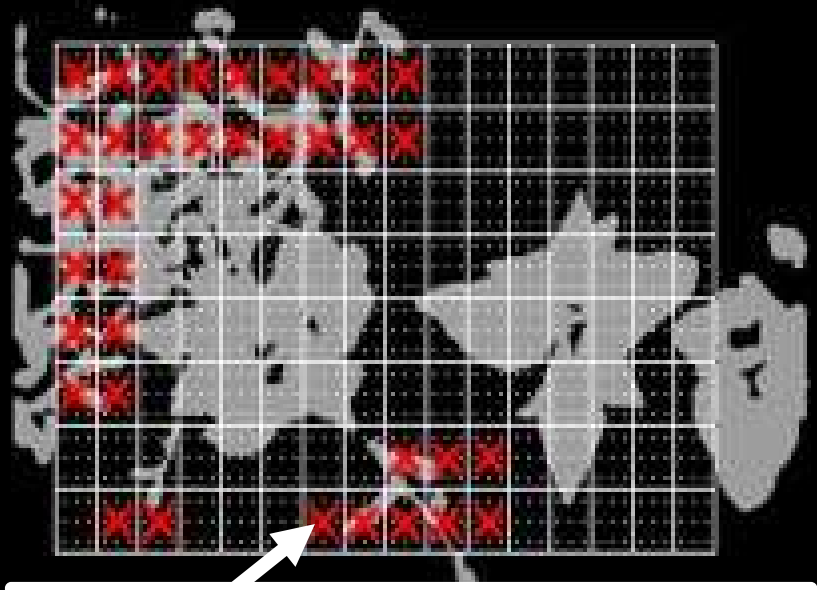
*** Recently merged with John Deere**

Spray Kill Mechanism

- The spray kill mechanism has advantages and disadvantages
- They can perform more pin point weed removal
- Depending on the material being used to kill the weeds, the potential for collateral damage
- They cannot reach under the leaves of the crop plant as effectively as the mechanical method

Machine Vision Spot Spray Mapping of Morning Glory in Beans

Original Image



Map showing ½" by ⅜" Microjet spray cells

Cells with a red X are mapped to be sprayed.

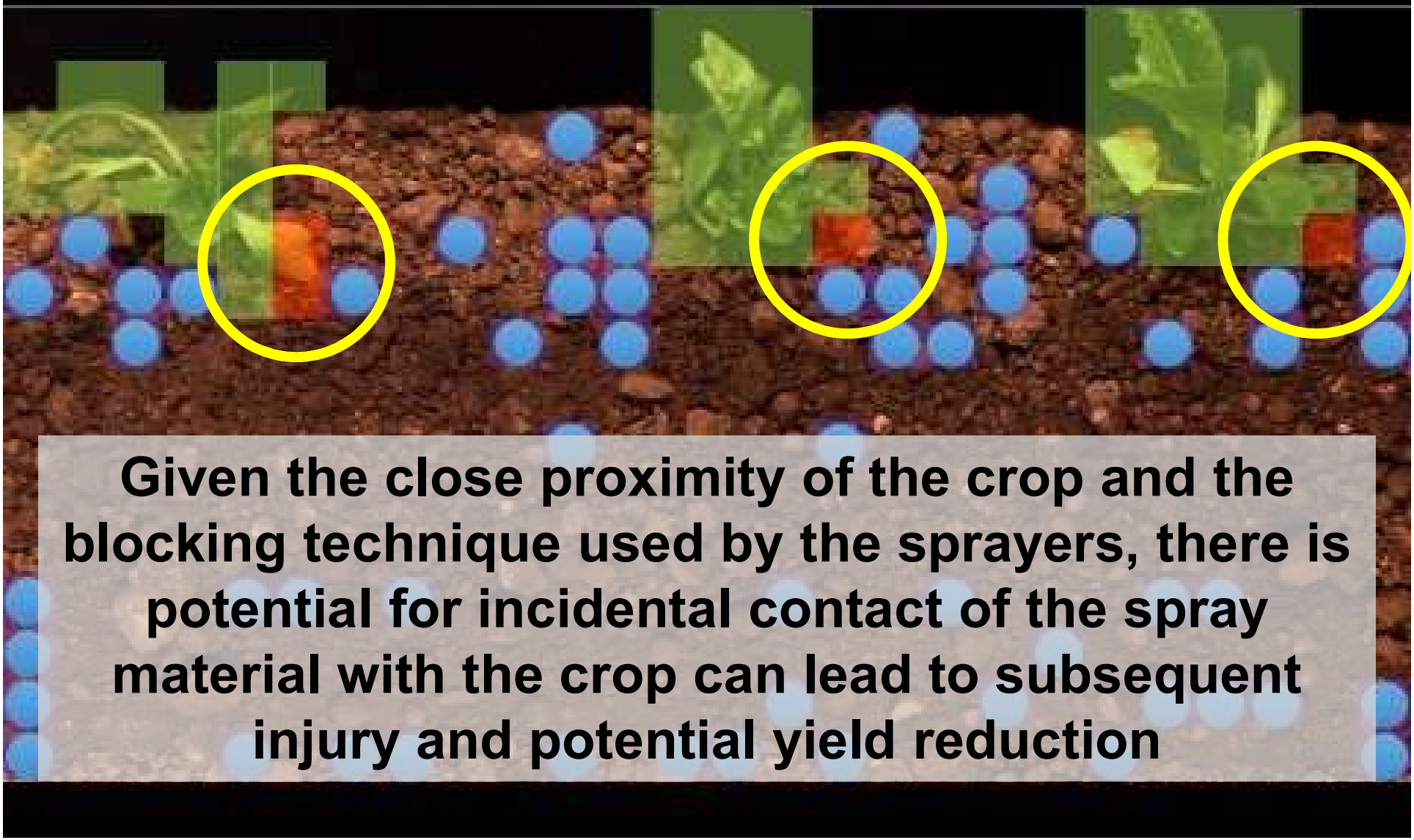
Micro-Jet Application Results

- Field results: 89% of weeds sprayed,
- 79% of cotton plants not sprayed.

Note the "guard" regions


Original Image of Lettuce Plants and Weeds

UC Davis Robotic Precision Spot Weed Spray Map for Univ. of AZ High-speed Spot Sprayer



Given the close proximity of the crop and the blocking technique used by the sprayers, there is potential for incidental contact of the spray material with the crop can lead to subsequent injury and potential yield reduction

Slides from Blue River Technology:

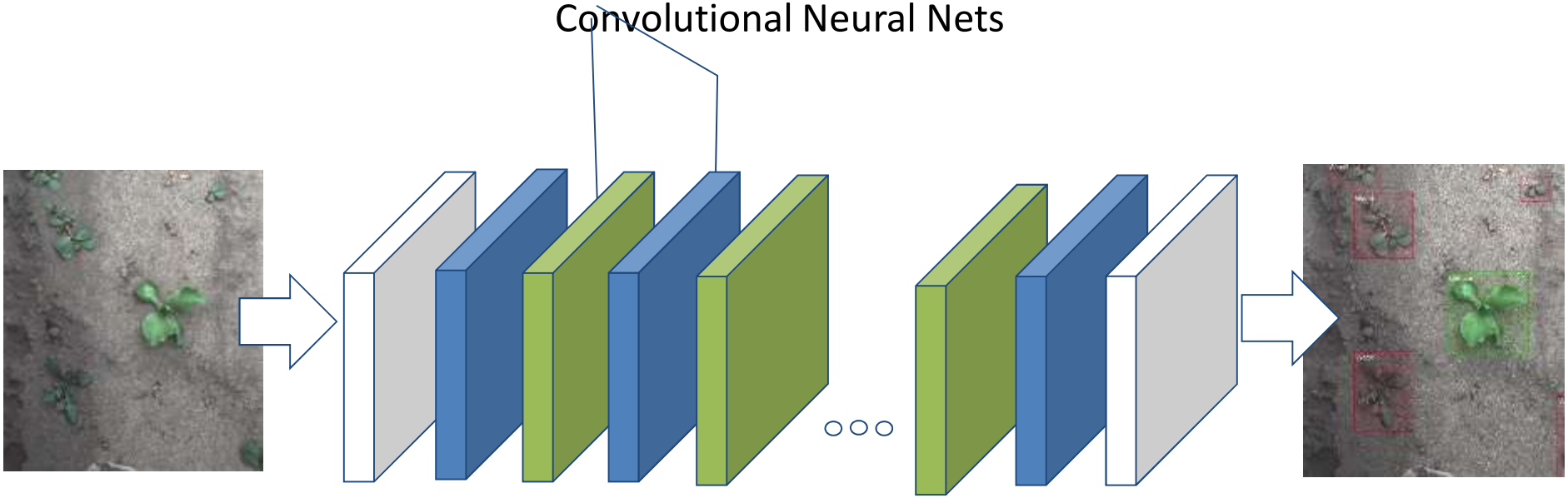
See & Spray uses artificial intelligence to identify and spray individual plants in milliseconds

Sense & Decide: Blue River's artificial intelligence identifies subtle differences between crops (green) and weeds (red)

Act: Only weeds are sprayed, reducing chemicals by >90%

We've pushed the state of the art on plant identification

Convolutional Neural Nets

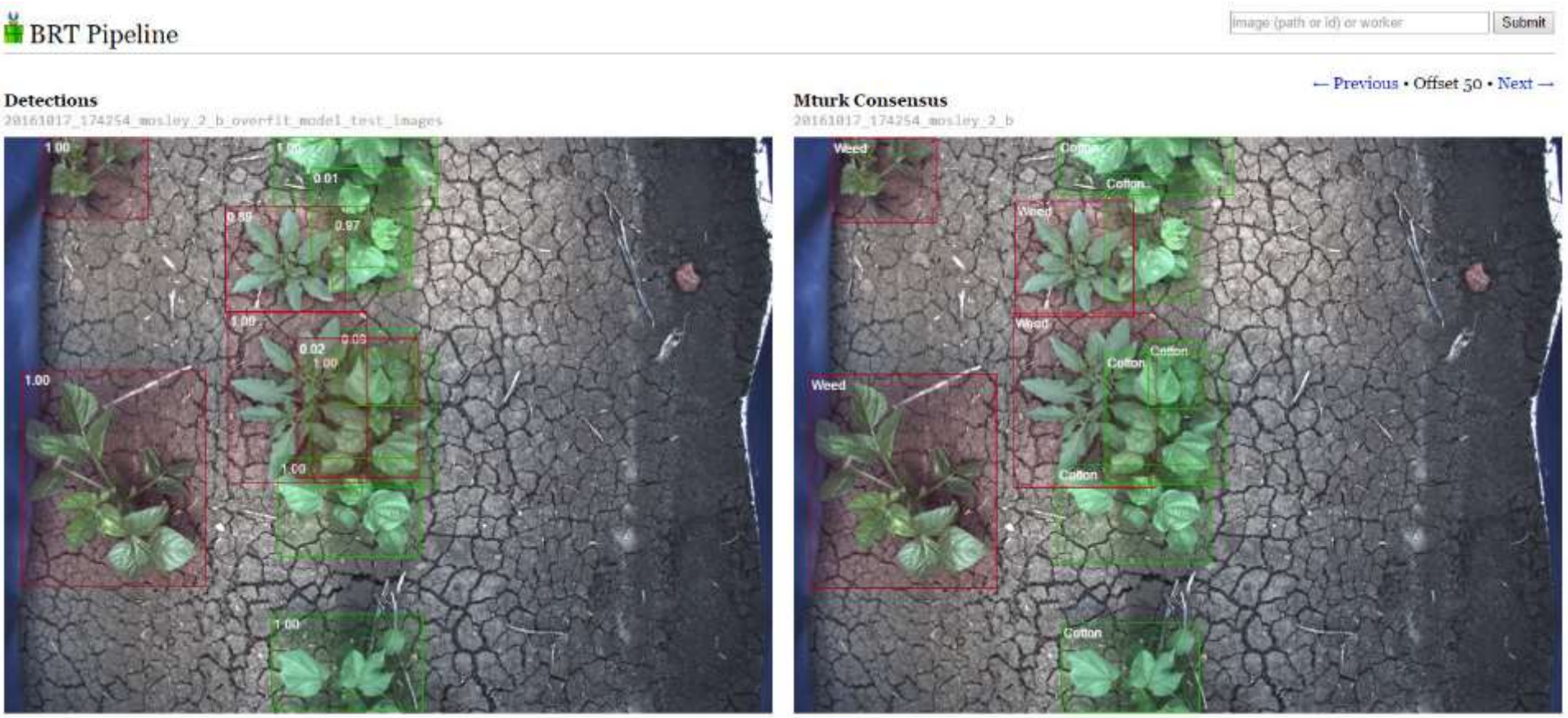


Millions of weights, millions of training images

train for hours; identify in milliseconds

Complicated case – cotton

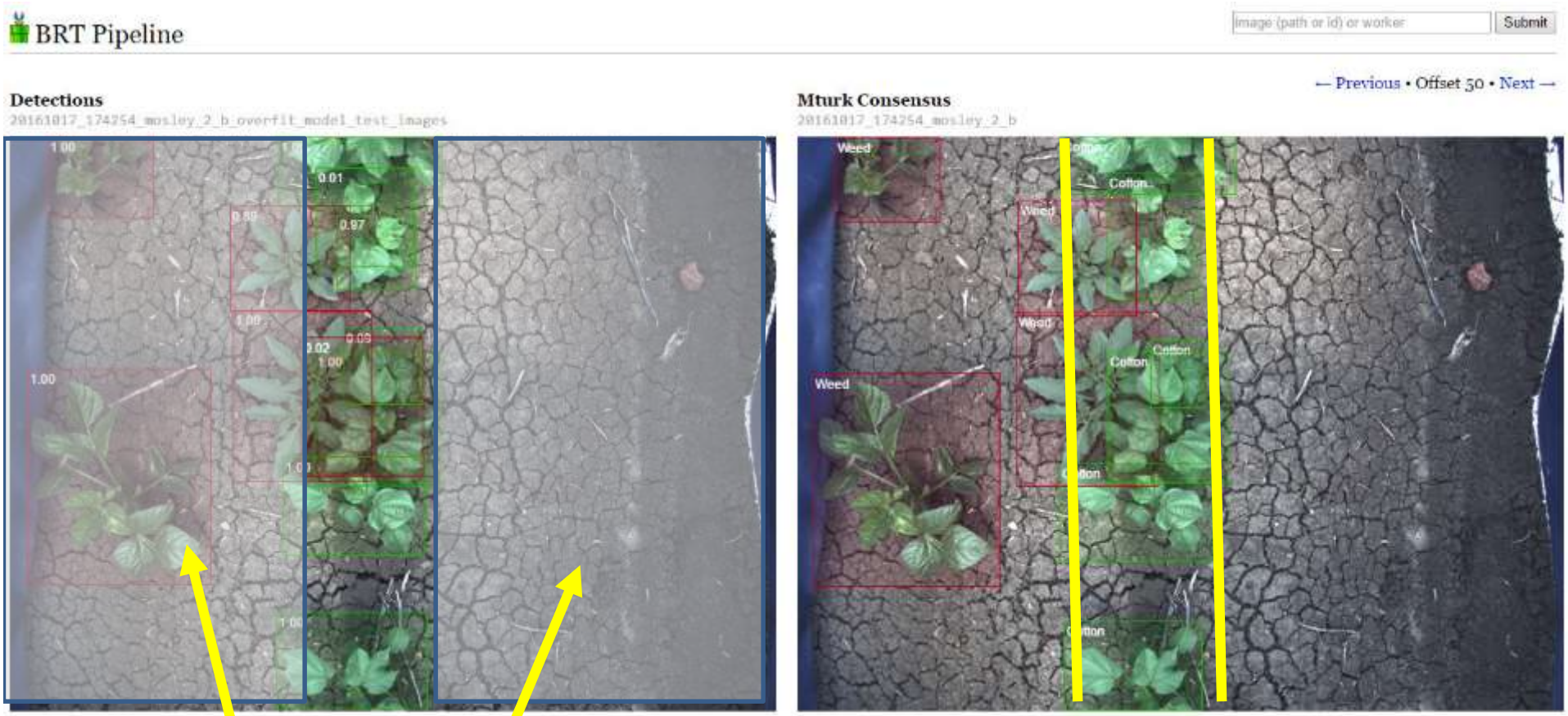
We do pretty well detecting too



Vision system output

Labeled image (truth)

Salinas Valley Context



Weeds here will be cultivated out
No need to spray these weeds in the Salinas Valley

Weed removal from the seedline is of <u>tremendous value</u>

Ultimately, we are interested in an autoweeding system that can remove weeds from high density crops

High Density Crop: Baby Lettuce

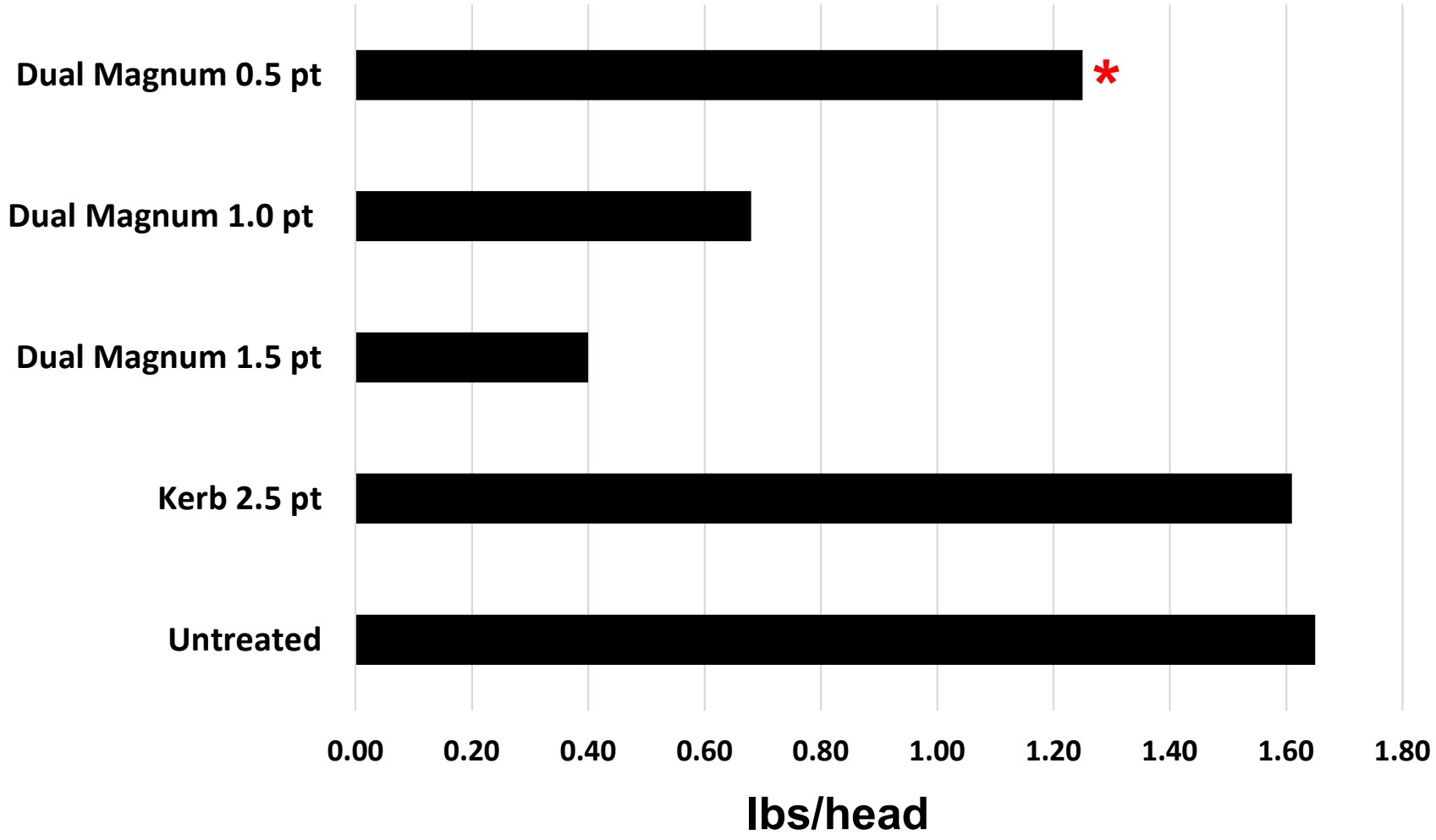
Impact of High Weed Pressure

- All the machines can be confused by the presence of too many weeds
- This often necessitates the use of a preemergent herbicide
- Currently, there are no new prospects for preemergent lettuce herbicides
- However, there Dual Magnum is being evaluated for transplanted lettuce

Evaluation of Dual Magnum on Plant Tape Transplanted Field

Time to Weed Lettuce

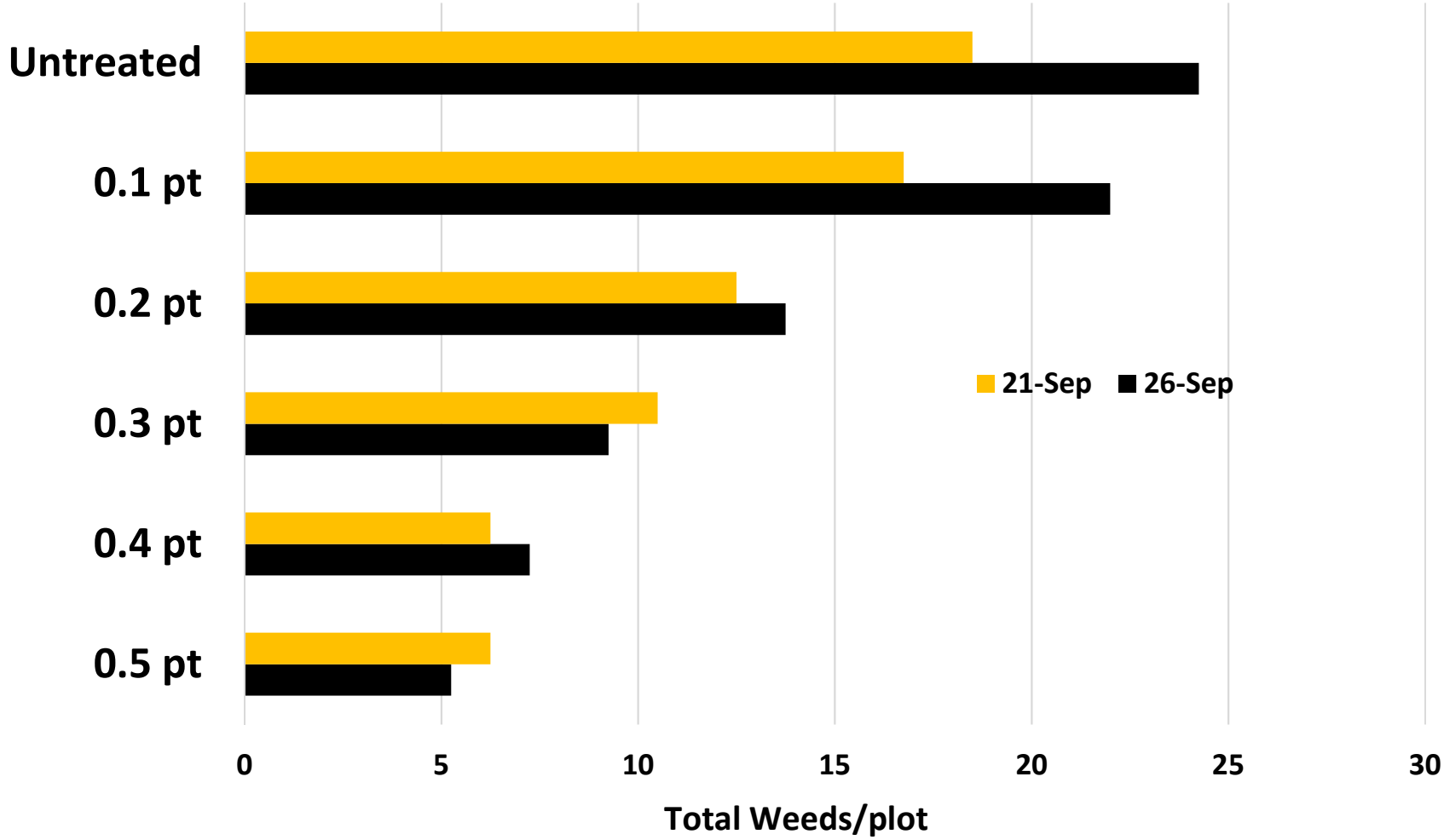
Lettuce Mean Head Weight



Ways to Make Dual Magnum work for Transplanted Lettuce

- It seems clear that on sandy soils, lower rates will be necessary to safeguard the crop
- Probably similar to the Dual Magnum label for spinach
- Conducted a trial looking at efficacy of low rates of Dual Magnum on weed control:
- 0.1, 0.2, 0.3, 0.4 and 0.5 pint/A

Impact of Low Rates of Dual Magnum on Number of Weeds



Selective Spray Material for use with Auto Weeder

- Ideally, we would use a spray material that is selective to the crop plant
- Examples in vegetables are less common but include:
  - Prometryn for many celery family crops
  - Lorox for carrots
  - Spin Aid for spinach*
  - Sandea for peppers
  - Matrix for tomatoes

Spray Weeders

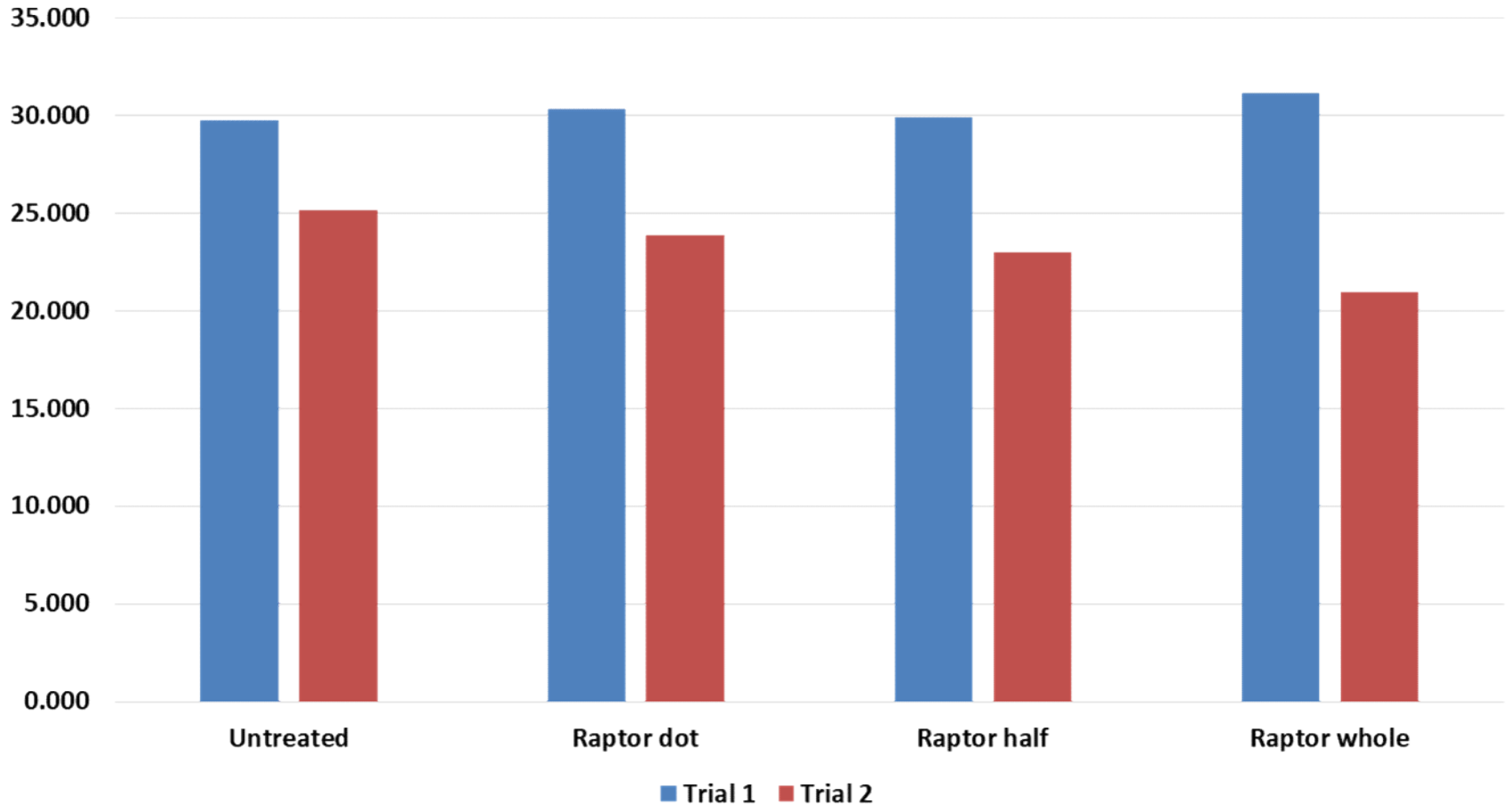
- Evaluated Raptor as a possible “selective” weed control material for lettuce
- Registered for post emergent use on chicory
- We have tested it for preemergent use on lettuce but not post emergence
- Given the blocking method of applying herbicides by auto weeders, we applied the Raptor as a drop, half leaf and full leaf application on lettuce plants at the 3 leaf stage

Shark Drop

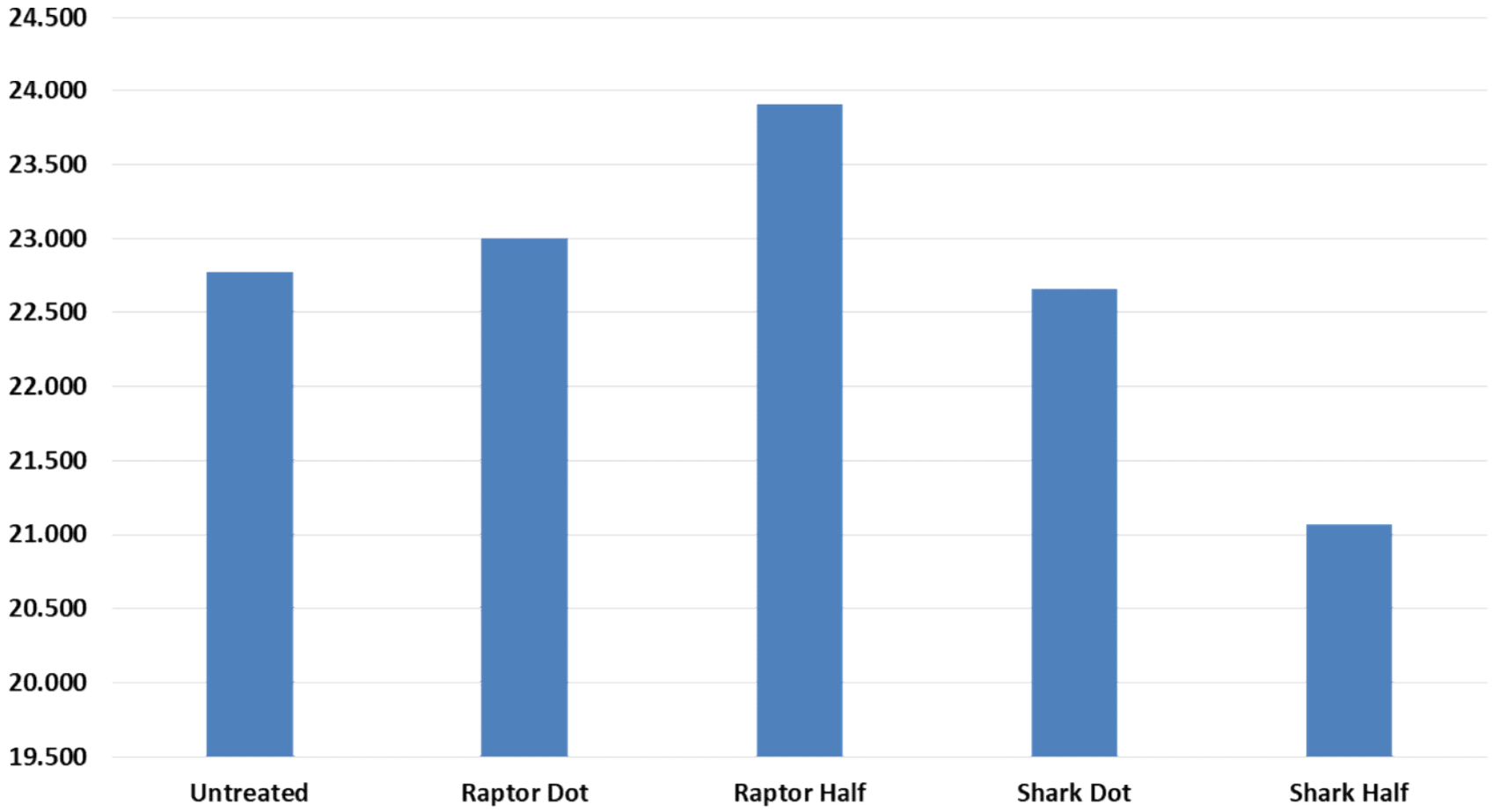
Shark half leaf

Raptor half leaf

Yield Evaluation of Raptor "Drift" onto Lettuce

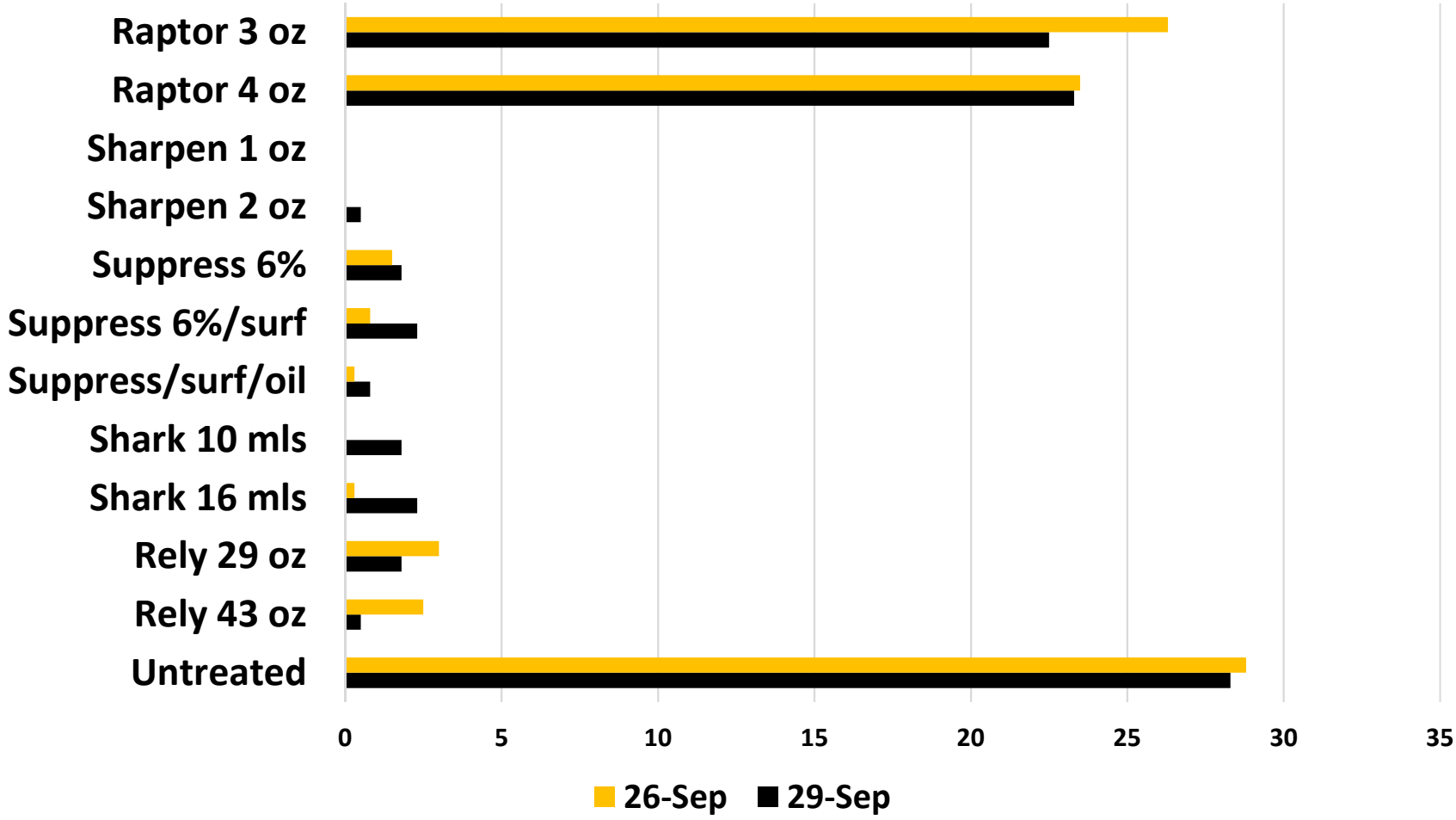


Yield Evaluation of Raptor and Shark “Drift” onto Lettuce



Treatment Applied at Thinning

No. weeds/2 ft^2



Summary

- **Automated weeders that use a mechanical kill step are commercially available in the Salinas Valley**
- **They provide a useful level of weed control that makes subsequent weeding operations more efficient**
- **Auto weeders that use a spray kill mechanism are still in the development phase**

Acknowledgements

- **Tricia Love, Bibiana Mendez and Jose Delgado**
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