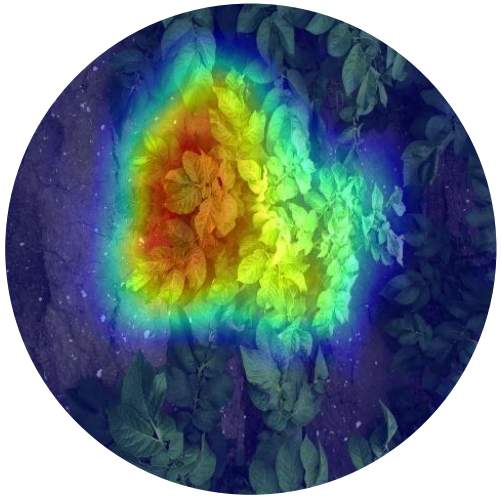
AGROS Smart Disease detection seed potatoes

Jan Kamp – WUR Open Teelten

2024-04-24 – AGROS End Event



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Introduction

- Seed potato sector NL: 40.000 ha → 1.500.000ton
- Export all over the world: total 750.000 ton
- Companies: Agrico, HZPC, Europlant, Meyer Potatoes
- Disease selection in fields:
    - virusses –potato Yn-virus
    - Erwinia – Dickeya solani / Pectobacterium atrosepticum / P. carotovorum subsp. Brasiliense
- Effect of sick plants: strong yield reduction!

Disease traits:

Y virus:

Erwinia:

What developments can we expect?

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Business case is there!

- Acreage: 40.000 ha
- “Financial loss” due to lowering in class or rejection: 20-25M€
  (=ca. 6%)
- Cost of manual selection: 8 – 10M€

- Estimated loss (lower value + selection cost)
  - 40 ha seed potatoes on farm → €30-35.000

Objectives project

- Detection of sick plants: both virus and Erwinia
- High quality– as good as the NA
- Fair speed of working → econor

Implementation:

- vision + AI (Deep learning) → b
  - RGB camera's (cheap)
  - additional light for good con
  - High processing speed possi

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What did we do?

- 4 years of data collection → 46000 annotated images
- 3yr Lelystad; 1yr several locations
  - 6 varieties: Erwinia inoculated
  - virus sick batches (Bintje, Innovator, Fontane, Vogue, Agria)
- 3 camera's: 1 vertically / 2 under angle 30^0
- System upgraded to run algorithms in practise

Variety	D. solani	P. atroscepticum	P. Brasiliense	water
Agria	14	54	82	1
Esmee	57	38	100	0
Fontane	36	83	159	0
Kuras	6	32	50	1
Kuroda	15	37	36	1
Riviera	12	58	166	2

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Some outcomes - 1

Net 1: getraind obv. Kuras, Kuroda, Riviera & Esmee

- Resultaten:
  - **Performance test set:** $\mathbf{R}_{\boldsymbol{erwinia}} = \mathbf{0.86}, \boldsymbol{P}_{\boldsymbol{erwinia}} = \mathbf{0.96}$
  - Performance Agria 2021: $\mathrm{R}_{erwinia} = 0.87,\ P_{erwinia} = 0.81$
  - Performance Agria 2022: $\mathrm{R}_{erwinia} = 0.83,\ P_{erwinia} = 0.96$
  - Performance Esmee 2021: $\mathrm{R}_{erwinia} = 0.81,\ P_{erwinia} = 0.73$
  - Performance Fontane 2021: $\mathrm{R}_{erwinia} = 0.82,\ P_{erwinia} = 0.73$
  - Performance Fontane 2022: $\mathrm{R}_{erwinia} = 0.86,\ P_{erwinia} = 0.86$

Some outcomes - 2

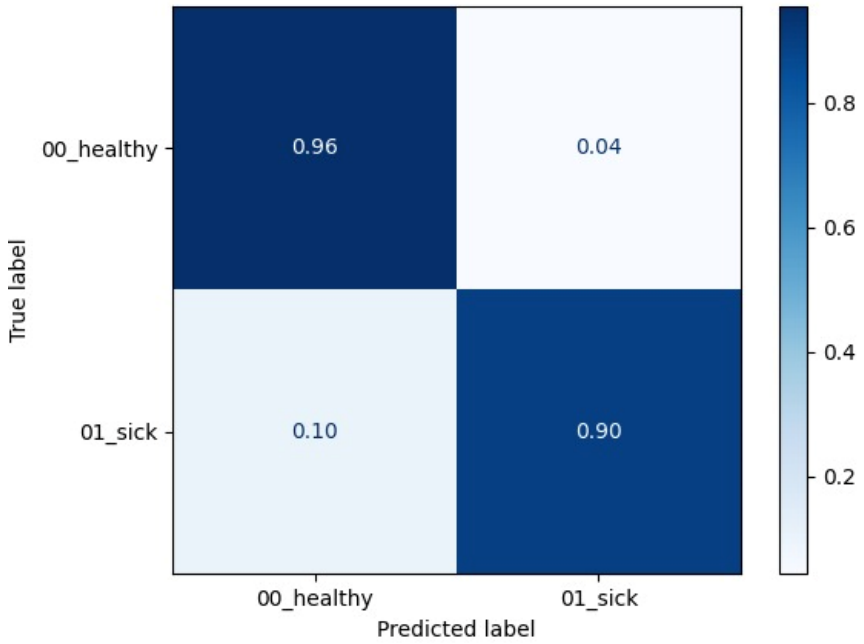
- What happens when retraining with limited number of annotated images of the current year?
- Results with extra 200 images:
  - Performance Agria 2021: $\mathrm{R}_{erwinia} = 0.95,\ P_{erwinia} = 0.83$
  - Performance Agria 2022: $\mathrm{R}_{erwinia} = 0.95,\ P_{erwinia} = 0.83$
  - Performance Fontane 2022: $\mathrm{R}_{erwinia} = 0.90,\ P_{erwinia} = 1.00$

- Could be part of the introduction strategy of a new application.

Sometimes ~ hidden symptoms /
- testing under practical conditions!!

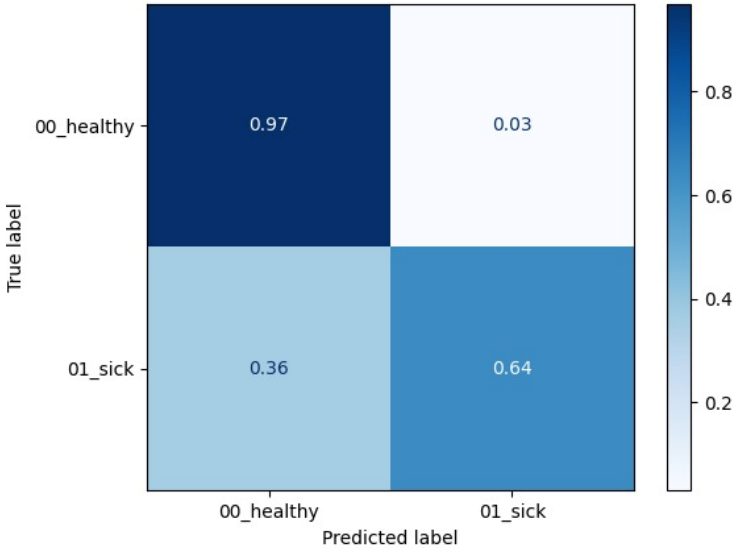
Results 2023 so far

- Based on images t/m 2022
- Randomly splitting into (13000 afbeeldingen):
  - 90% train
  - 10% test
  - Confidence threshold 50%



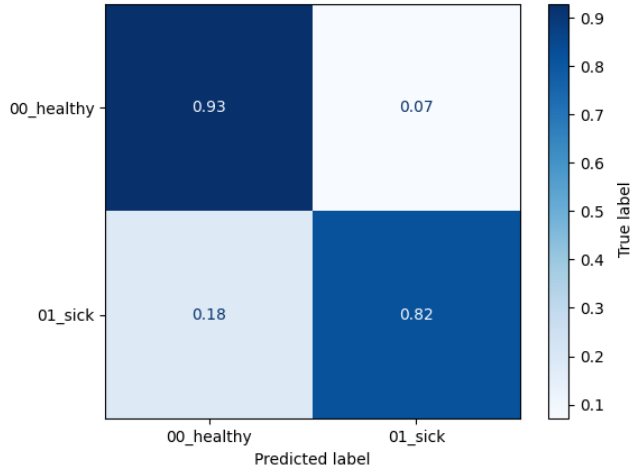
Results 2022 algorithm tested on “NAK field”

- Algorithm trained on data 2022
- tested on 2023 NAK field (200 varieties)
  - most varieties are unknown
  - Confidence interval 50%

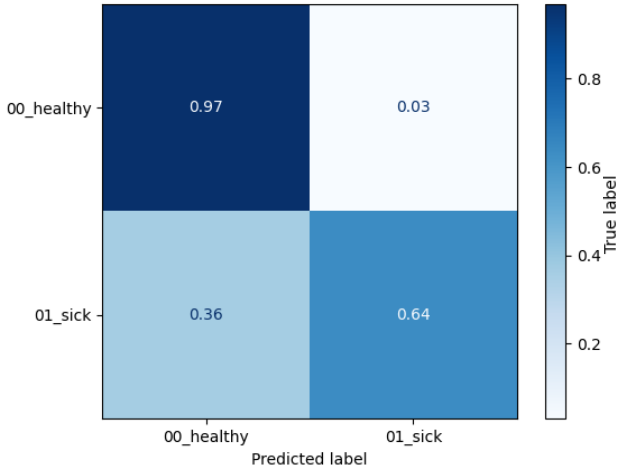


Effect confidence threshold op results

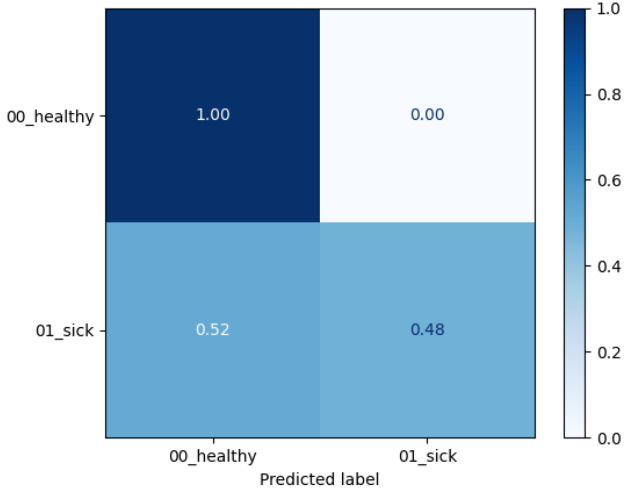
- farmer can change the settings.... Data NAK 2023
- changing means a shift in the precision: see FP en FN
- 25%



50%



75%



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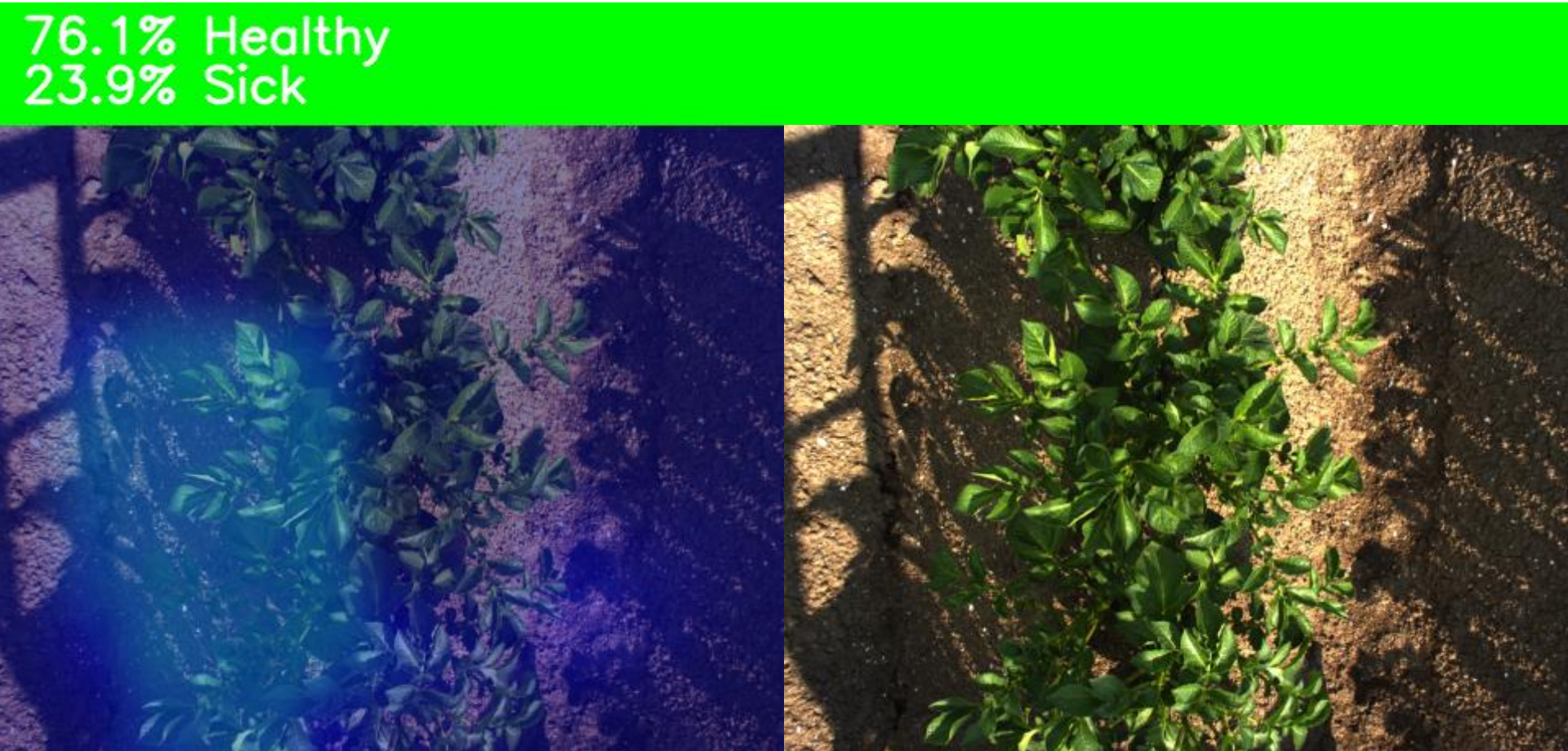
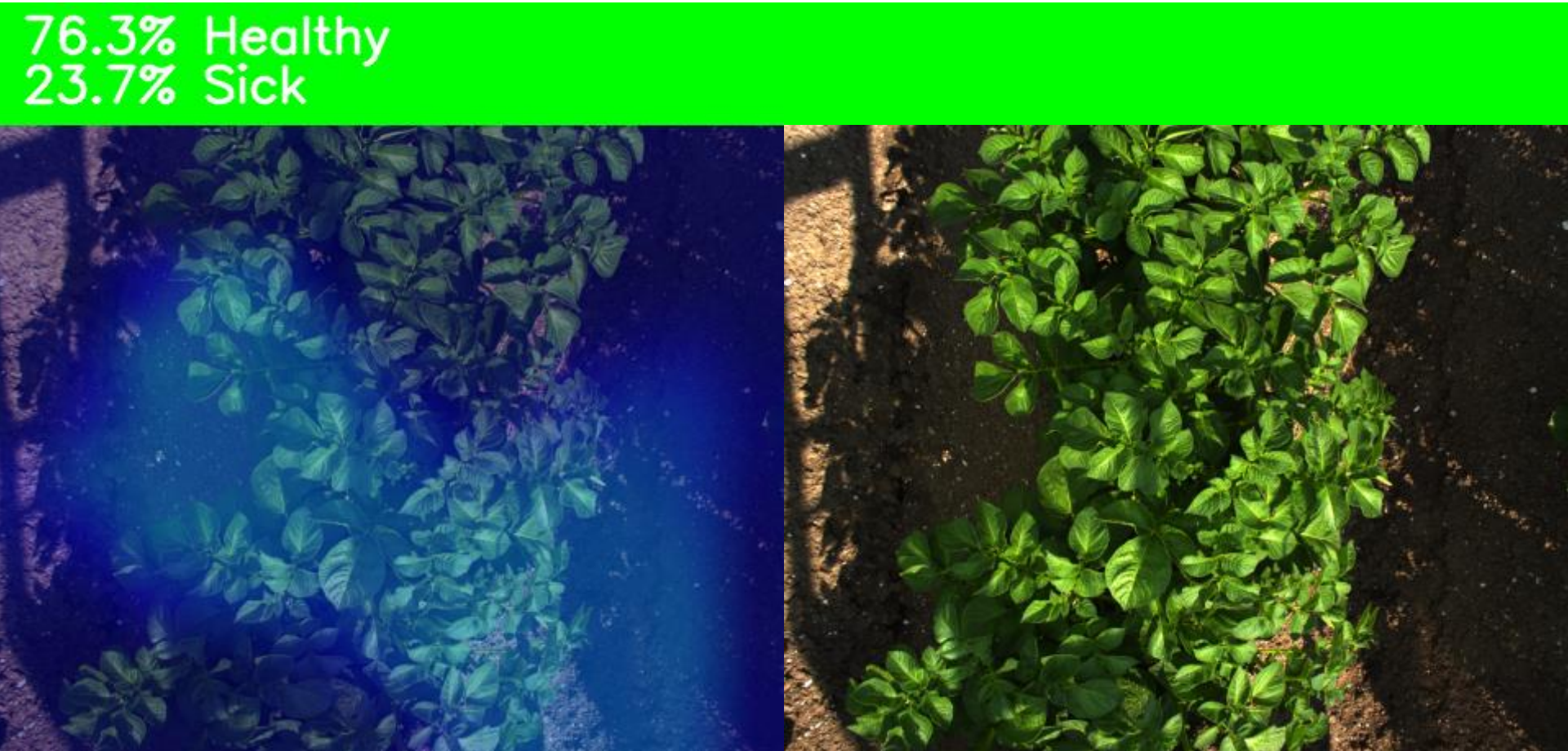
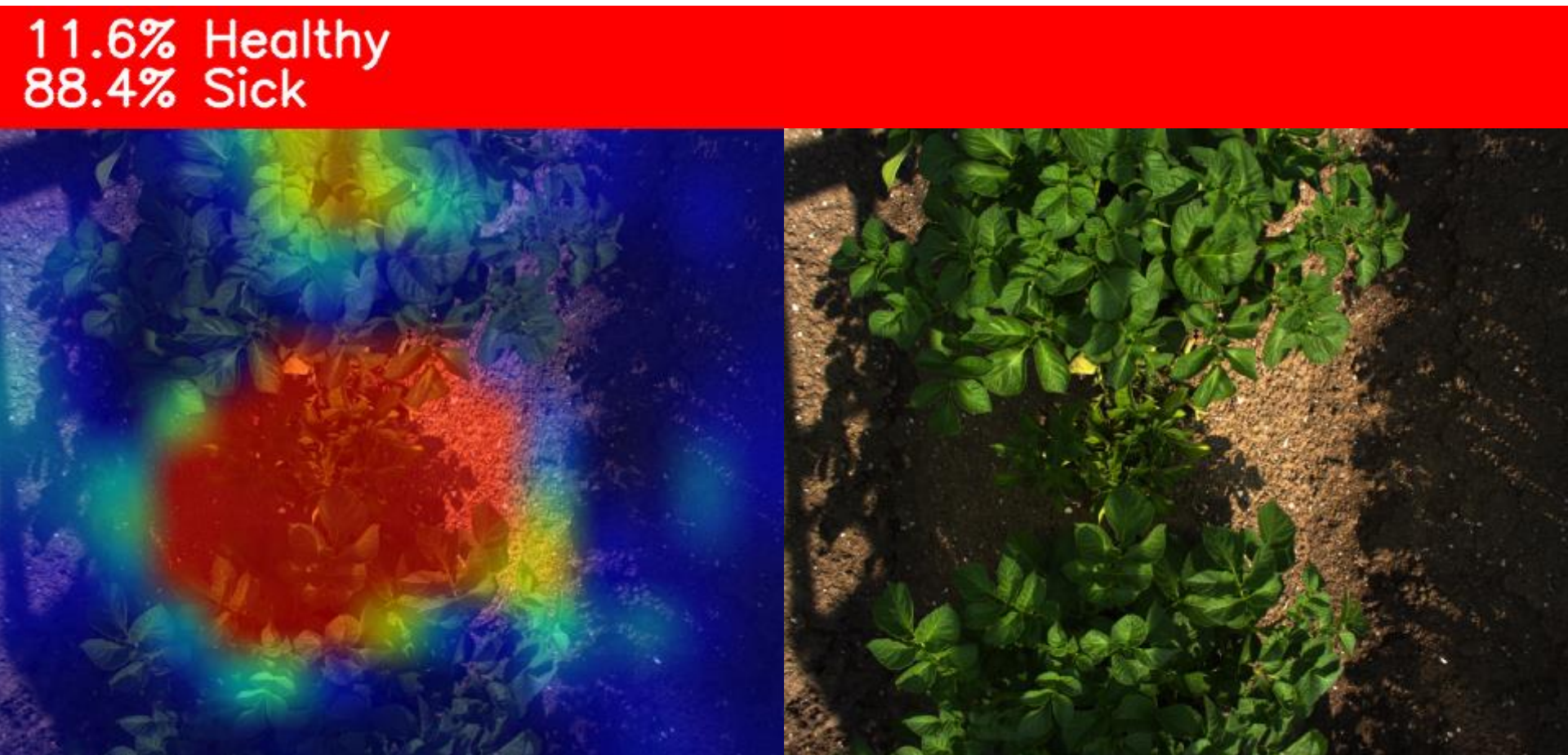
Detection demo



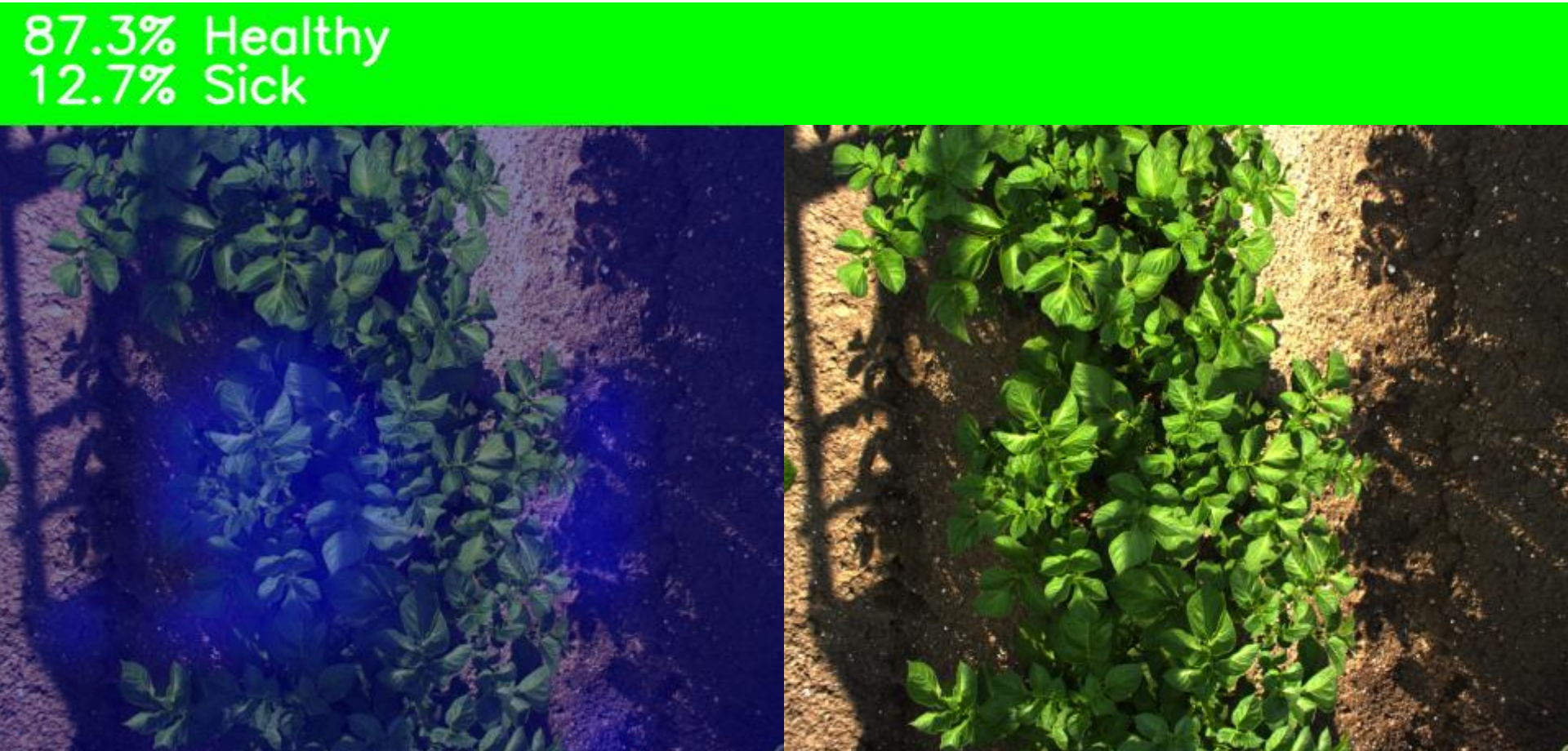
Detection demo



Detection demo



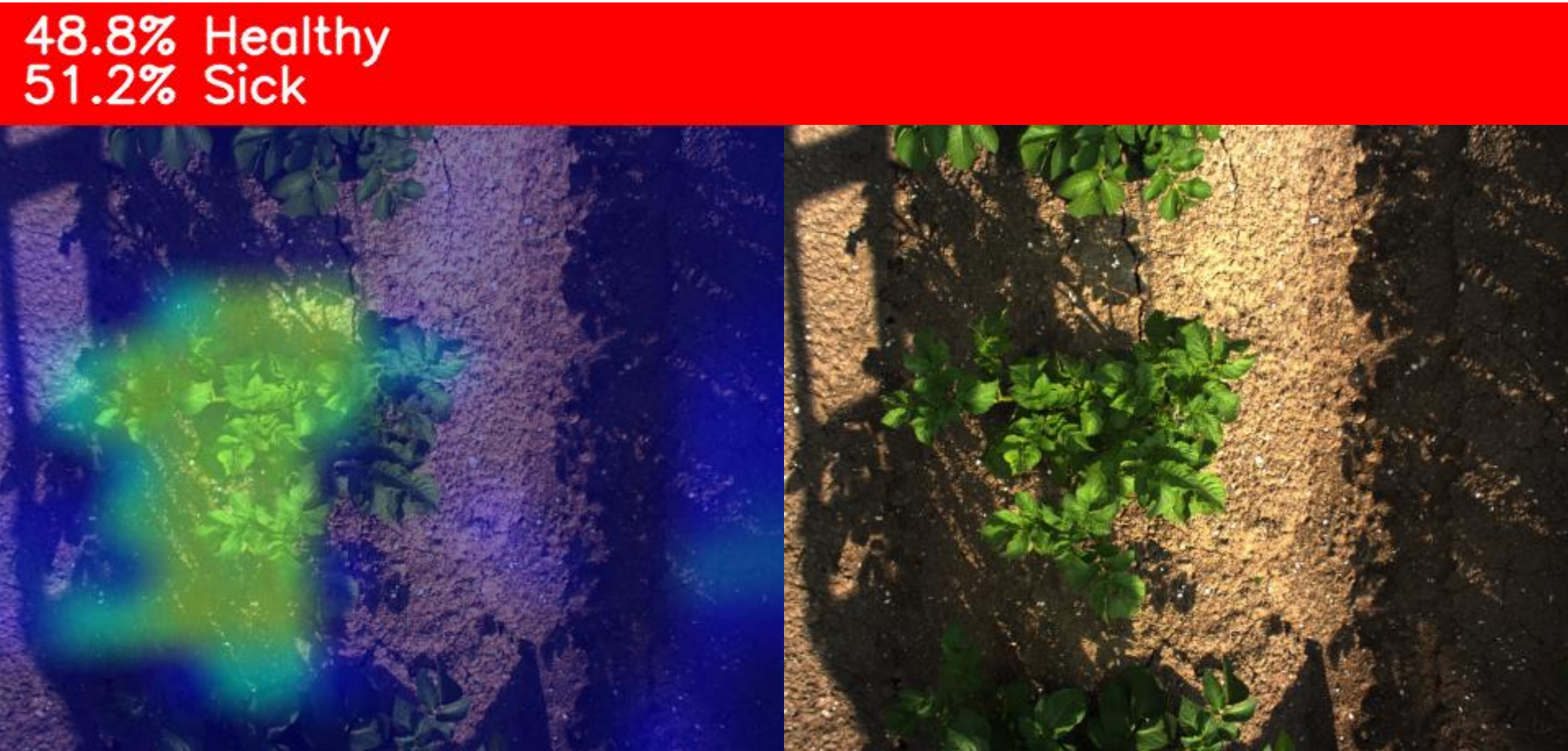
Detection demo



Detection demo

Detection demo

Detection demo



Detection demo

Detection demo

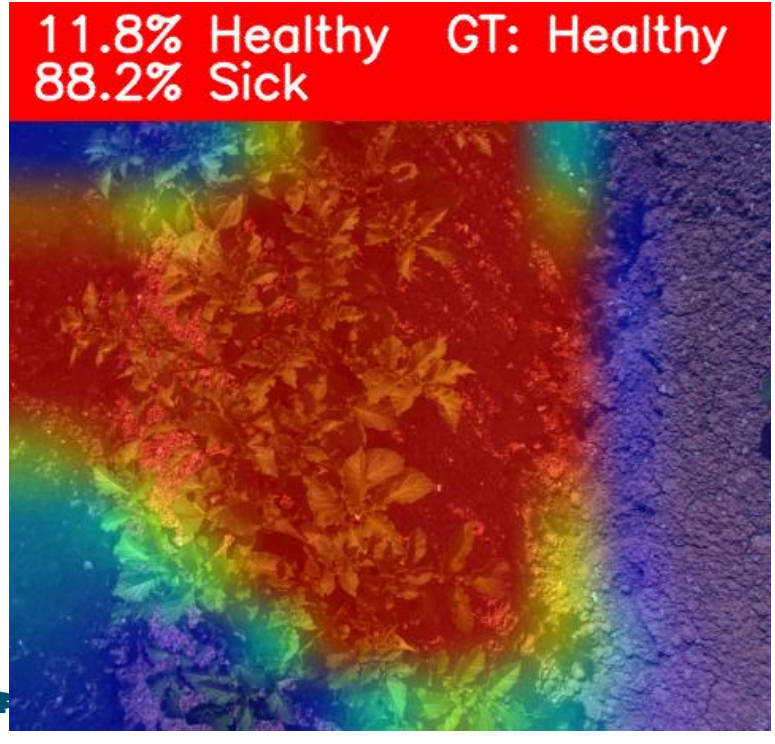
Detection demo

Results 2023 – live detection

- Correctly classified as Healthy

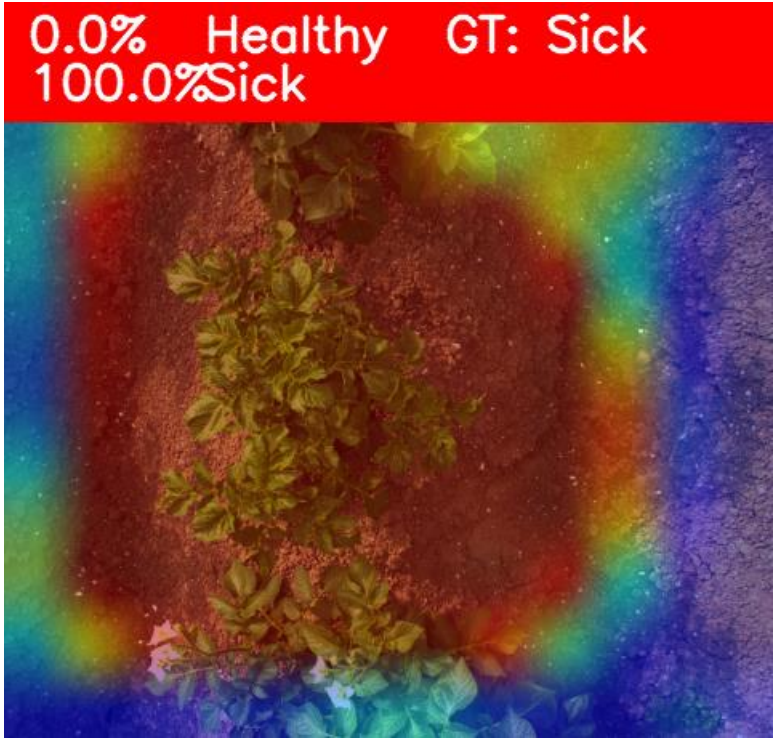
Resultats 2023

- Healthy plant classified as sick
- due to curly leaves (not sick according to inspector)



Results 2023 – field test

- Correctly classified as sick



Conclusions and how to continue?

- Good results BUT, we have still some challenges:
  - Generalization needs improvement
  - Early detection of sick plants
  - How to deal with varieties that hardly show symptoms?
- Next steps:
  - Continuation of cooperation in AGROS-II
  - Kverneland is going to develop a robot solution
  - Close involvement of HZPC, Agrico, Meijer Potato en NAK

The End

- Thanks for your attention!
- Questions??

New project coordinator:

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AGROS Weed Control

Technology for Smart Weed Control

April 24th, 2024, Bram Veldhuisen

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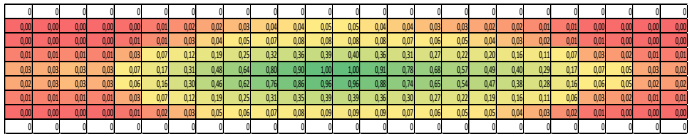
Goal

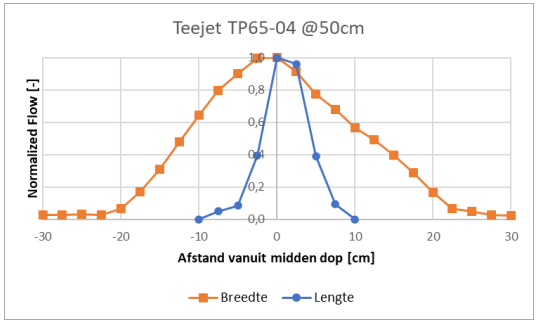
- Show potential of spotspray technology in relation to weed control
- In Farm of the Future: “Mechanical where possible, chemical where needed”
- Develop and demonstrate technology which will enable this
    - Spot sprayers,
    - AI Detection algorithms

What do farmers want from a model?

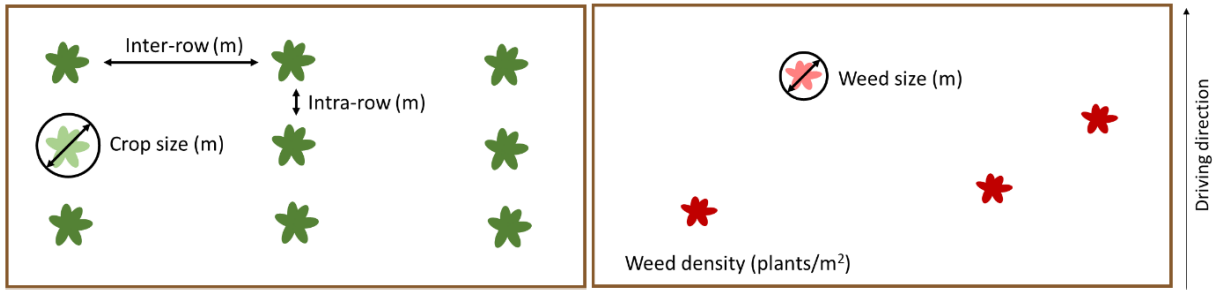
- Predict reduced chemical use
- Predict crop damage
- Spot sprayers are complex,
    - Test setting, like safe margins

Depostion model



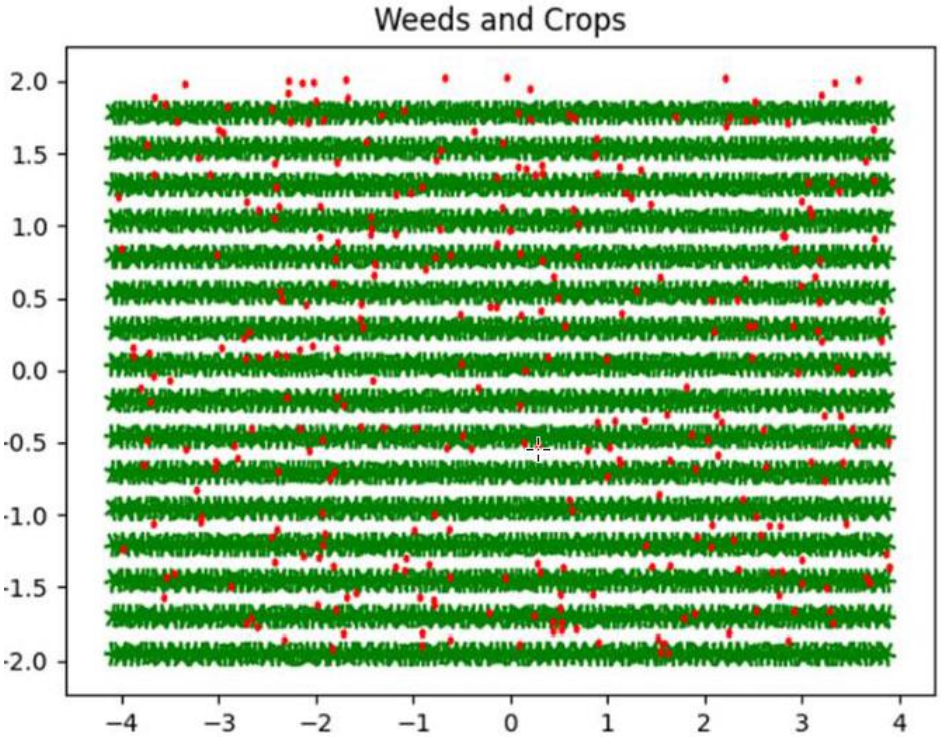


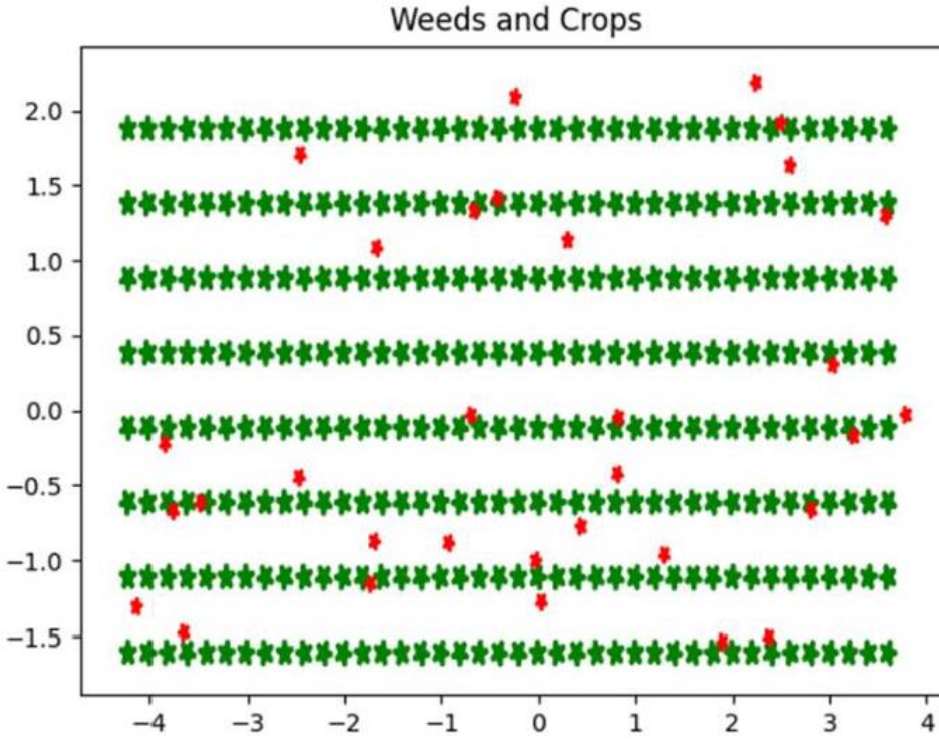
Scenarios



Group	Parameters	Sugar beet + volunteer potato	Onion+ Low weed pressure	Onion+ High weed pressure
Field	Length (m)	20	6	6
	Width (m)	5	1,5	1,5
Weed	Size (m)	0.10	0.03	0.03
	Shape	"plant"	"plant"	"plant"
	Density (plants / m2)	1	10	200
Crop	Size (m)	0.15	0.20	0.20
	Shape	"plant"	"onion"	"onion"
	Inter row (m)	0.50	0.25	0.25
	Intra row (m)	0.20	0.05	0.05

Scenarios





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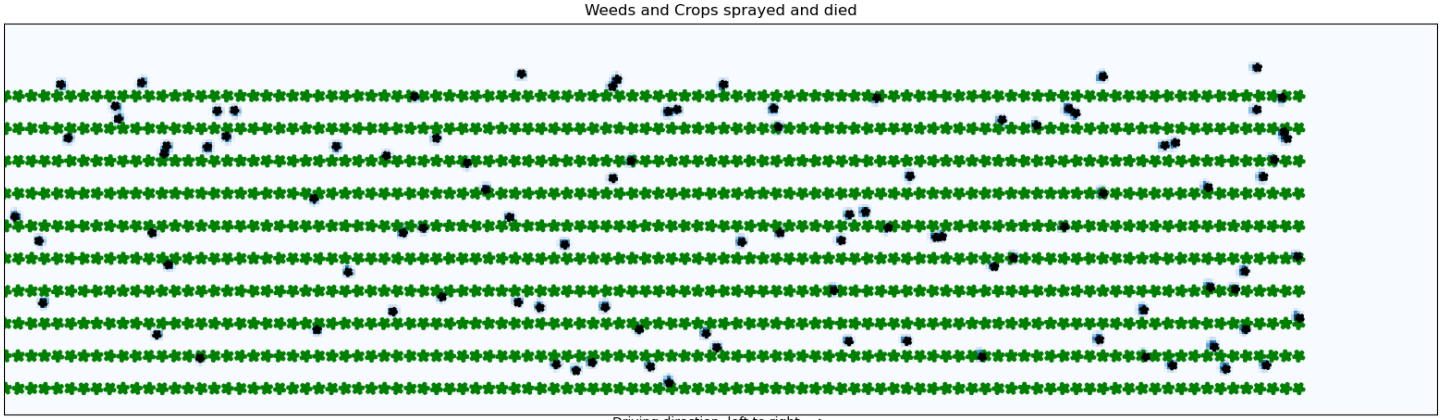
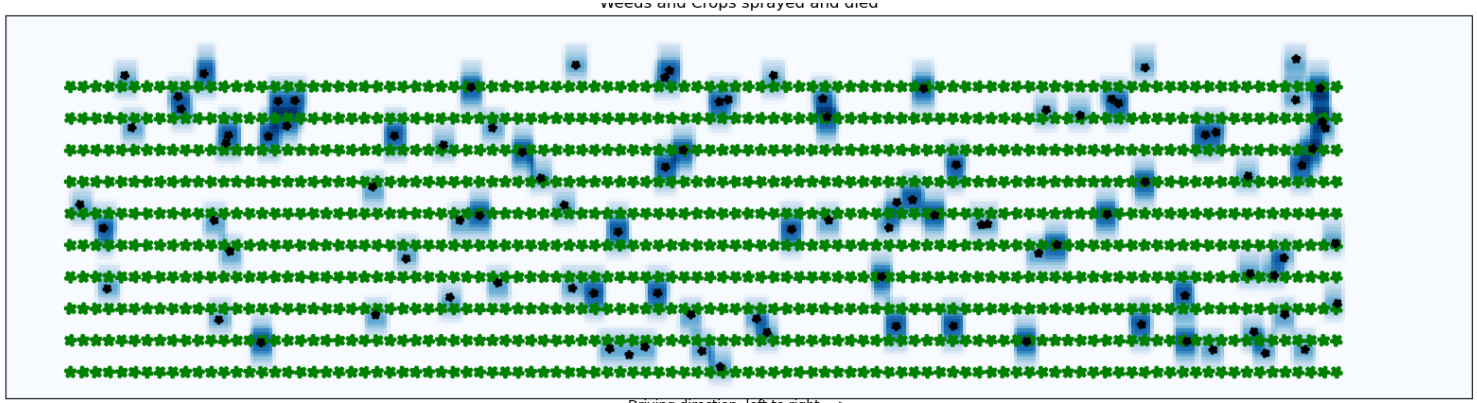
Sugar beets



	Sprayed	D
Weeds	100.0 %	1
Crops	7.4 %	0

- Crop
- Died crop
- Weed
- Died weed

	Spot s
Sprayed in field	
Sprayed per hecta	
Percentage liquid	

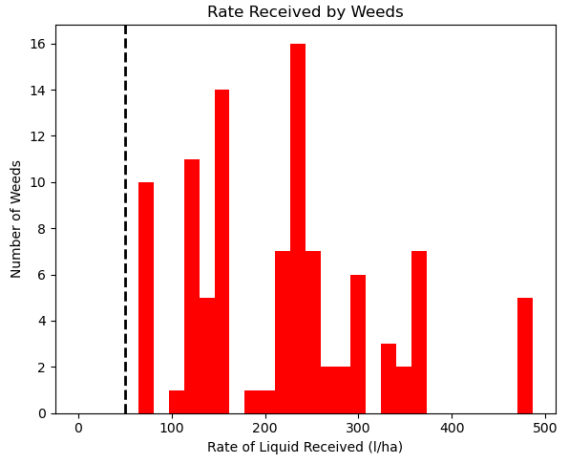


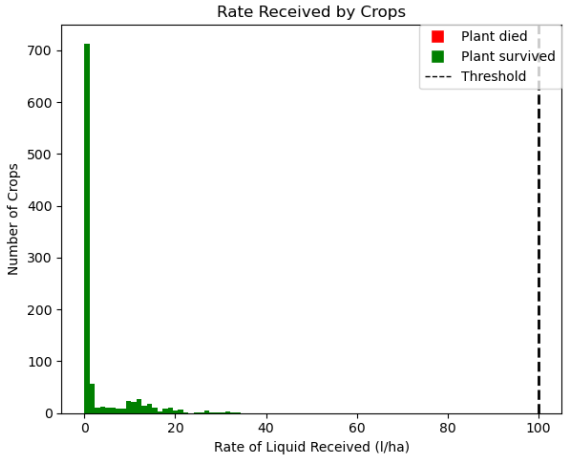
	Sprayed	Died
Weeds	100.0 %	100.0 %
Crops	47.3 %	0.0 %

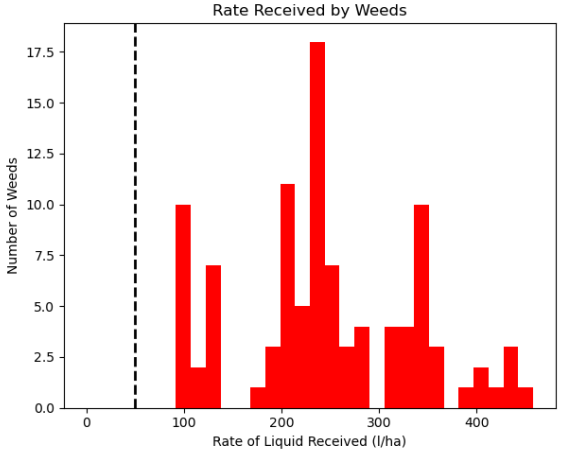
- Crop
- Died crop
- Weed
- Died weed

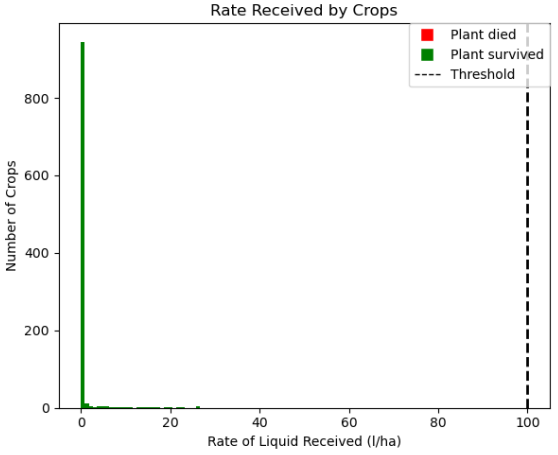
	Spot spraying	Whole field spraying
Sprayed in field	0.35 L	3.72 L
Sprayed per hectare	28 L/ha	300 L/ha
Percentage liquid used	9.3 %	100 %

Sugar beets









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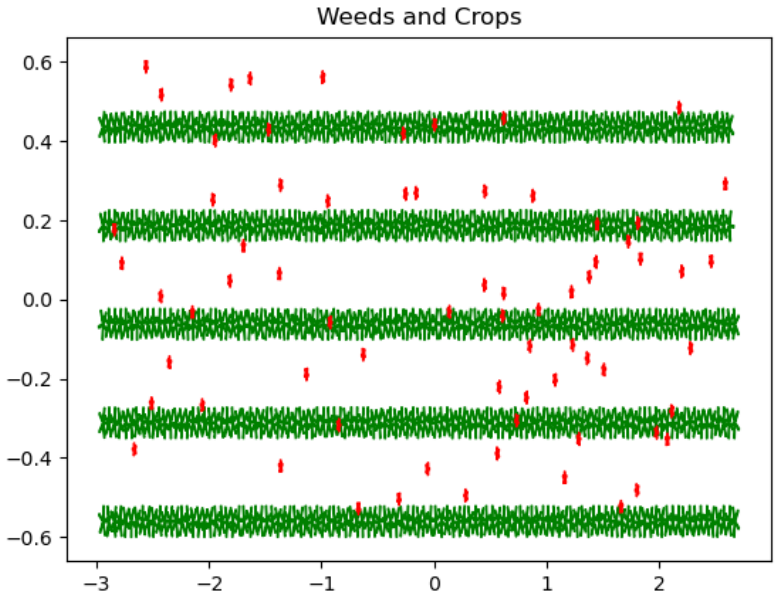
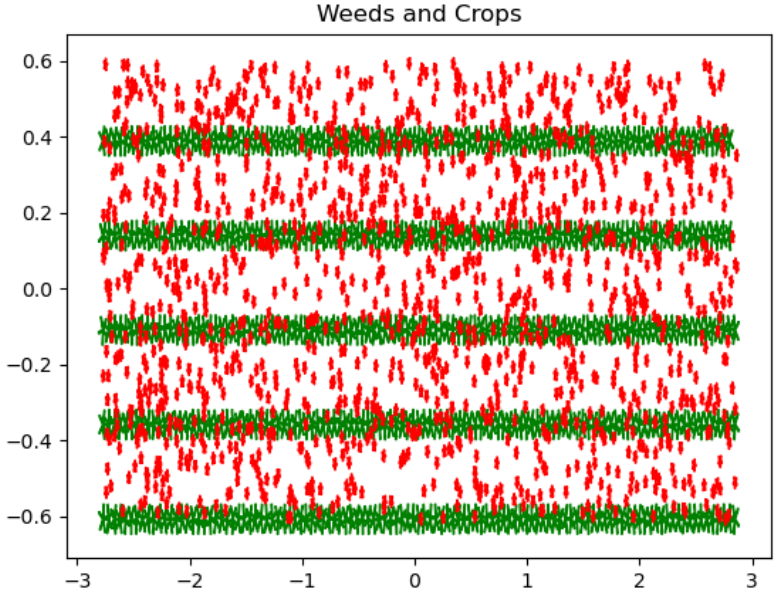
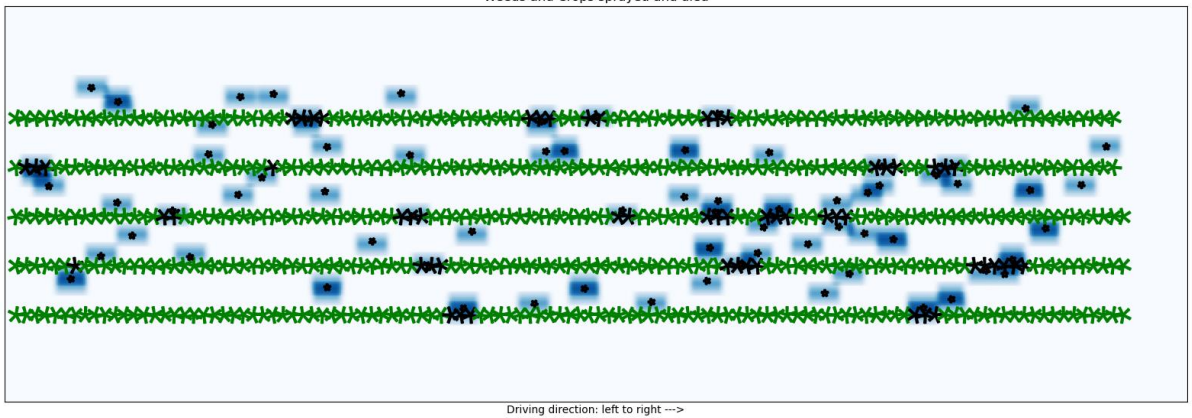
Onions


Weeds and Crops
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−3
−2
−1
0
1
2


Weeds and Crops
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−3
−2
−1
0
1
2
3

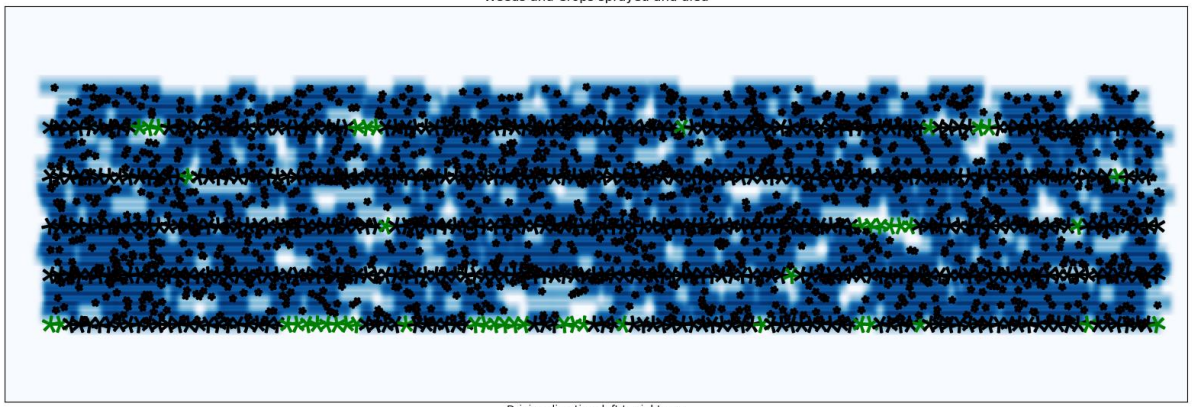
Onions



	Sprayed	Died
Weeds	100.0 %	100.0 %
Crops	36.4 %	10.3 %

Crop
Died crop
Weed
Died weed

	Spot spraying	Whole field spraying
Sprayed in field	0.02 L	0.22 L
Sprayed per hectare	18 L/ha	198 L/ha
Percentage liquid used	9.2 %	100 %

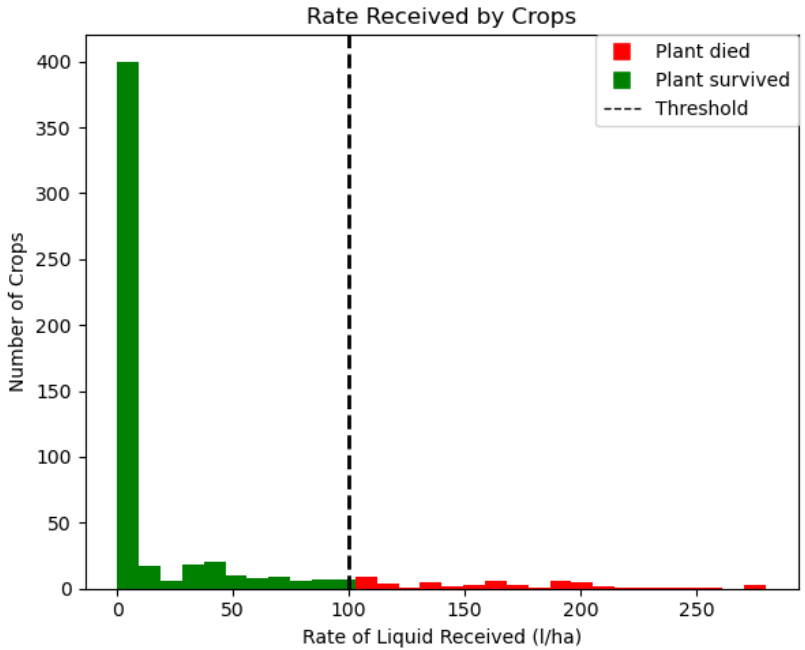


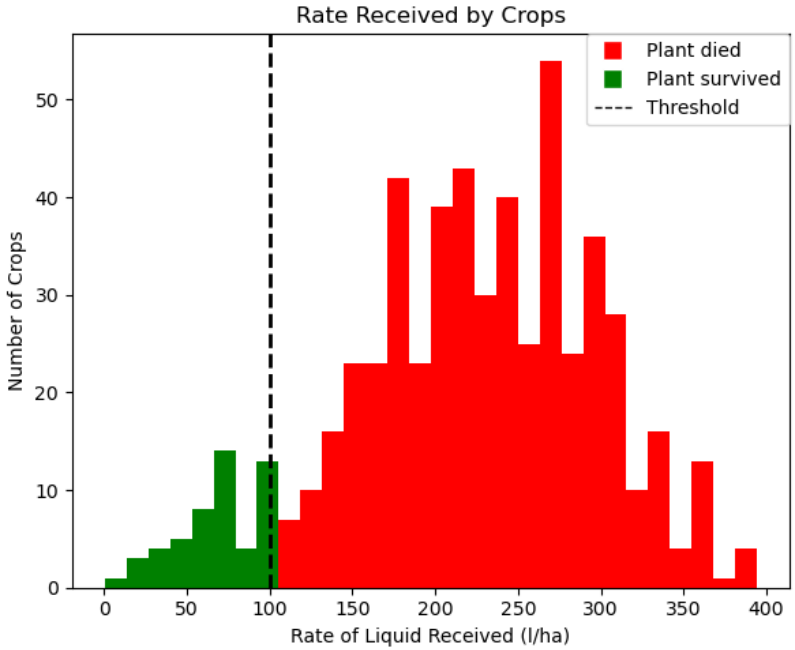
	Sprayed	Died
Weeds	100.0 %	100.0 %
Crops	100.0 %	91.5 %

Crop
Died crop
Weed
Died weed

	Spot spraying	Whole field spraying
Sprayed in field	0.18 L	0.24 L
Sprayed per hectare	162 L/ha	213 L/ha
Percentage liquid used	75.8 %	100 %

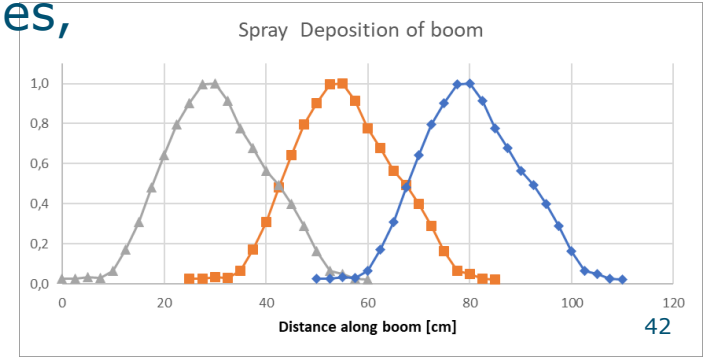
Onions


Rate Received by Crops
Plant died
Plant survived
Threshold
Number of Crops
Rate of Liquid Received (l/ha)
0
50
100
150
200
250
300
350
400

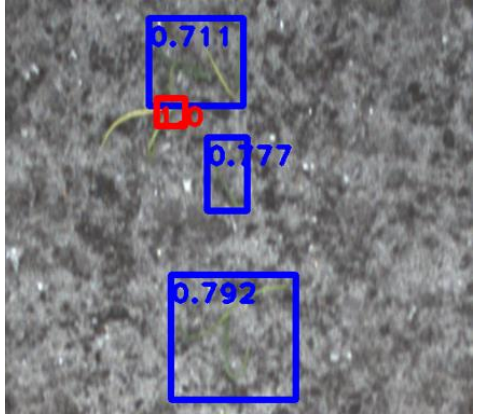

Rate Received by Crops
Plant died
Plant survived
Threshold
Number of Crops
Rate of Liquid Received (l/ha)
0
10
20
30
40
50
0
50
100
150
200
250
300
350
400

Conclusions model and scenarios

- Modeling of the deposition works,
- The higher the area sprayed, the less beneficial spots praying is,
- Smart nozzle selection could be beneficial,
- Further research with dose response curves needed,
- Accurate rate is difficult with current nozzles,

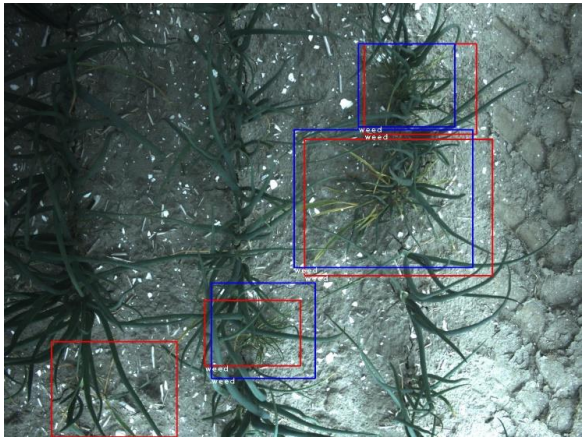


Algorithm Development



- For proof of principle any data is satisfactory,

- Crop detection with bounding boxes not feasible in onions,
- Pixel wise segmentation doesn’t work robust with long narrow objects (onions),
- Best results with ignoring crops, and only label weeds



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In practice

In the fields

Bayer Crop Science presents its Spotsprayer MagicSprayer 6000 at Agritechnica 2023. The spotsprayer is si
the well-known EcoRobotix ARA. - Photos: Mark Pasveer.

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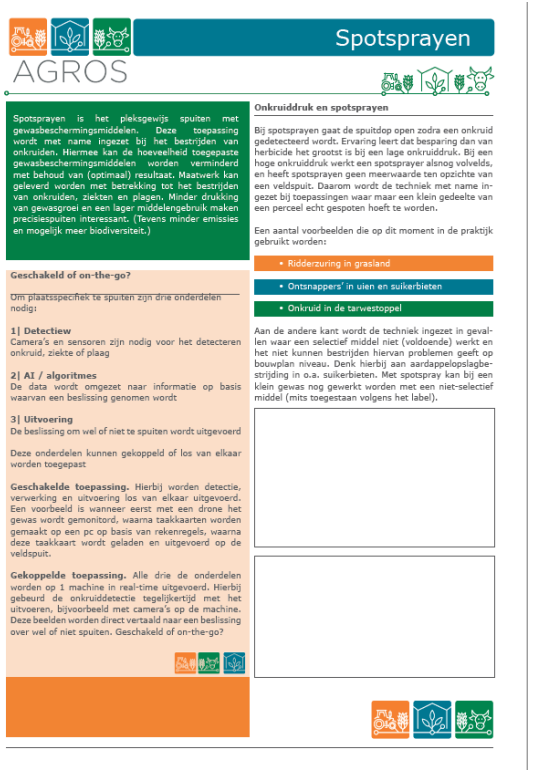
Spot Spray Fact sheet

- Two page guide for farmers
- Explaining principles
- Use cases
- Resolution
- Tips
- What’s on the market



Spotsprayen

AGROS

Spotsprayen is het pleksgewijs spuiten met gewasbeschermingsmiddelen. Deze toepassing wordt met name ingezet bij het bestrijden van onkruiden. Hiermee kan de hoeveelheid toegepaste gewasbeschermingsmiddelen worden verminderd met behoud van (optimaal) resultaat. Maatwerk kan geleverd worden met betrekking tot het bestrijden van onkruiden, ziekten en plagen. Minder drukking van gewasgroei en een lager middelengebruik maken precisiespuiten interessant. (Tevens minder emissies en mogelijk meer biodiversiteit.)

Geschakeld of on-the-go?

Om plaatsspecifiek te spuiten zijn drie onderdelen nodig:

1| Detectiew
Camera’s en sensoren zijn nodig voor het detecteren onkruid, ziekte of plaag

2| AI / algoritmes
De data wordt omgezet naar informatie op basis waarvan een beslissing genomen wordt

3| Uitvoering
De beslissing om wel of niet te spuiten wordt uitgevoerd

Deze onderdelen kunnen gekoppeld of los van elkaar worden toegepast

Geschakelde toepassing. Hierbij worden detectie, verwerking en uitvoering los van elkaar uitgevoerd. Een voorbeeld is wanneer eerst met een drone het gewas wordt gemonitord, waarna taakkaarten worden gemaakt op een pc op basis van rekenregels, waarna deze taakkaart wordt geladen en uitgevoerd op de veldspuit.

Gekoppelde toepassing. Alle drie de onderdelen worden op 1 machine in real-time uitgevoerd. Hierbij gebeurd de onkruiddetectie tegelijkertijd met het uitvoeren, bijvoorbeeld met camera’s op de machine. Deze beelden worden direct vertaald naar een beslissing over wel of niet spuiten. Geschakeld of on-the-go?

Onkruiddruk en spotsprayen

Bij spotsprayen gaat de spuitdop open zodra een onkruid gedetecteerd wordt. Ervaring leert dat besparing dan van herbicide het grootst is bij een lage onkruiddruk. Bij een hoge onkruiddruk werkt een spotsprayer alsnog volvelds, en heeft spotsprayen geen meerwaarde ten opzichte van een veldspuit. Daarom wordt de techniek met name ingezet bij toepassingen waar maar een klein gedeelte van een perceel echt gespoten hoeft te worden.

Een aantal voorbeelden die op dit moment in de praktijk gebruikt worden:

- Ridderzuring in grasland
- Ontsnappers’ in uien en suikerbieten
- Onkruid in de tarwestoppel

Aan de andere kant wordt de techniek ingezet in gevallen waar een selectief middel niet (voldoende) werkt en het niet kunnen bestrijden hiervan problemen geeft op bouwplan niveau. Denk hierbij aan aardappelopslagbestrijding in o.a. suikerbieten. Met spotspray kan bij een klein gewas nog gewerkt worden met een niet-selectief middel (mits toegestaan volgens het label).

Weed control

Questions?