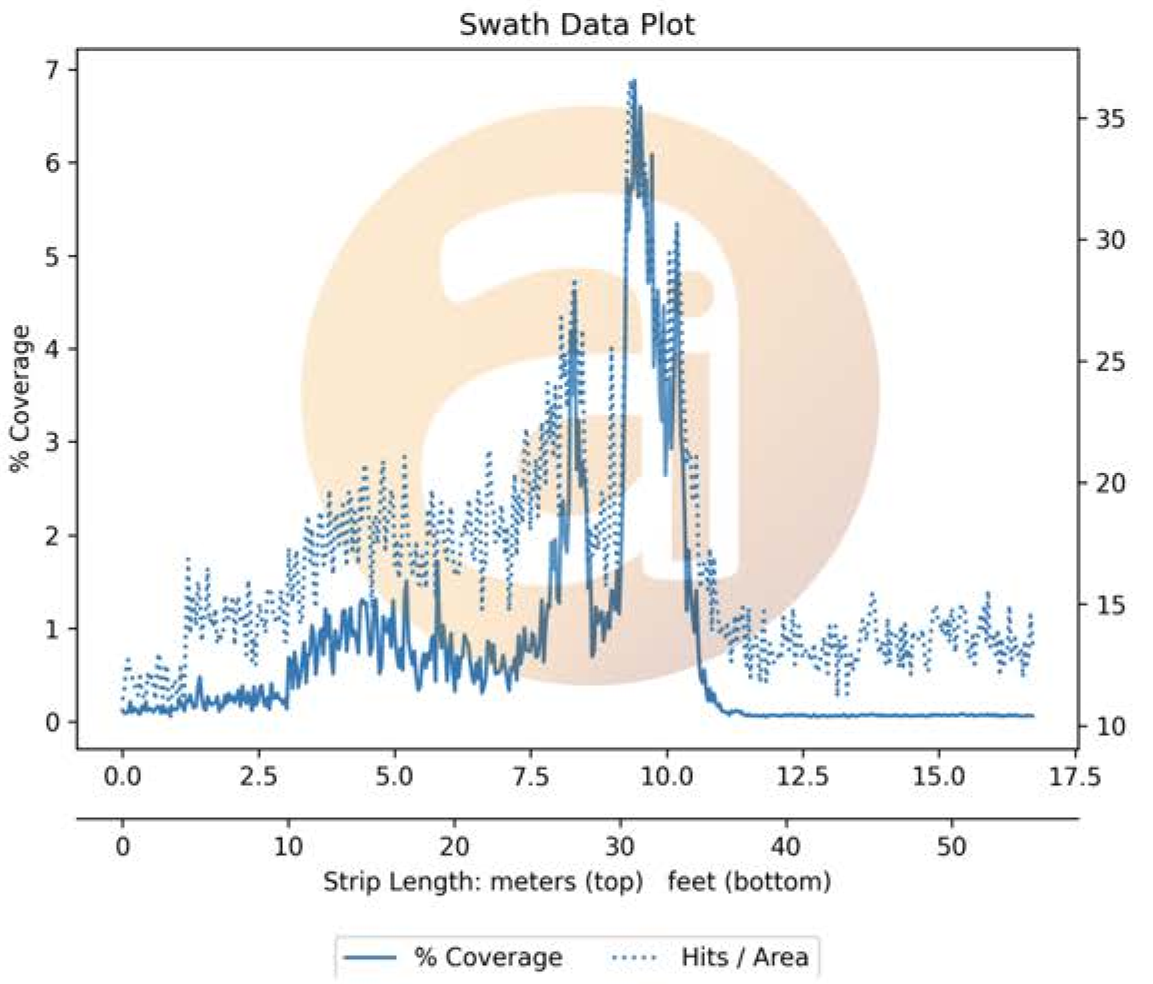
Drone with 16 nozzles of 110 01

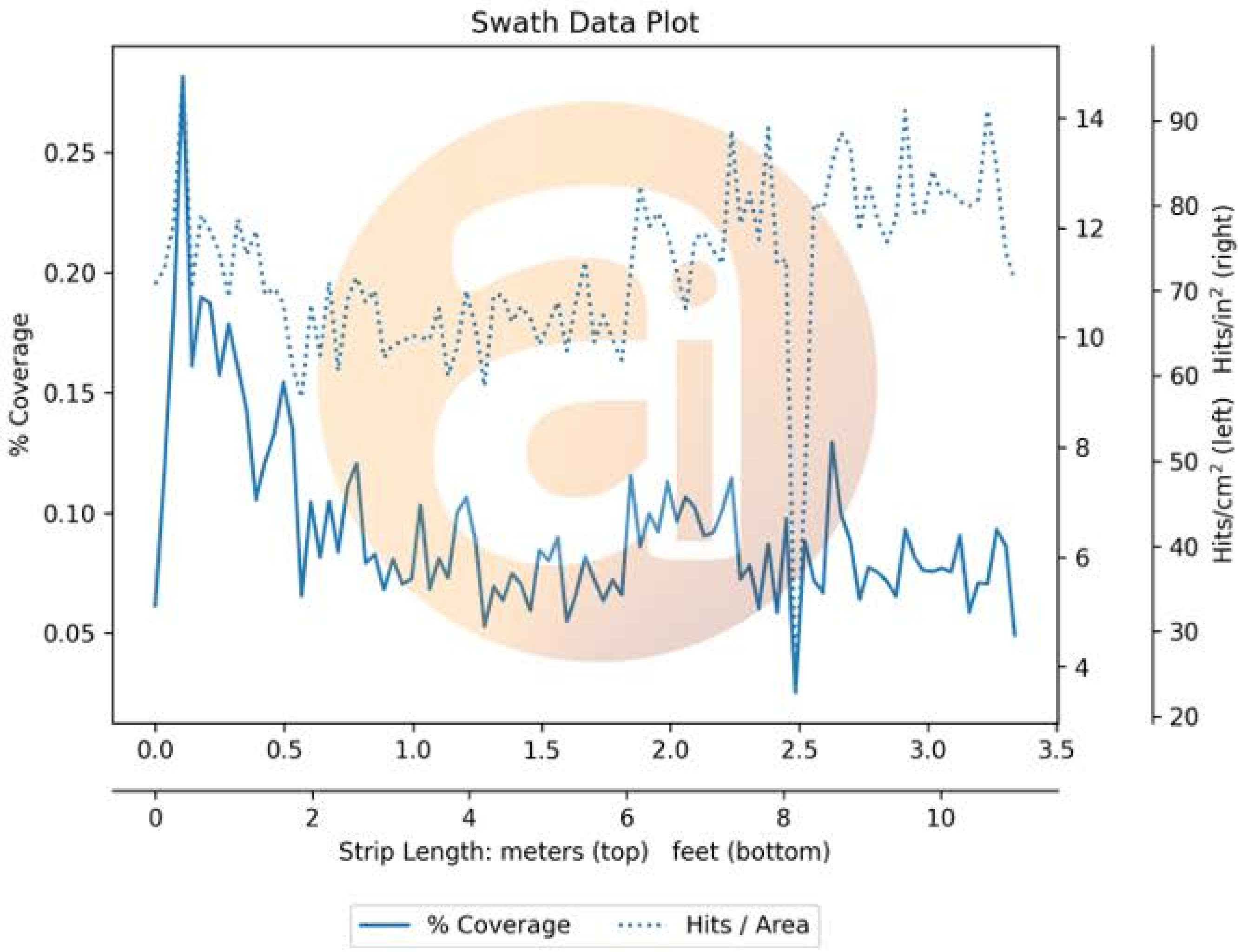
Application Insight, LLC
SWATH GOBBLER

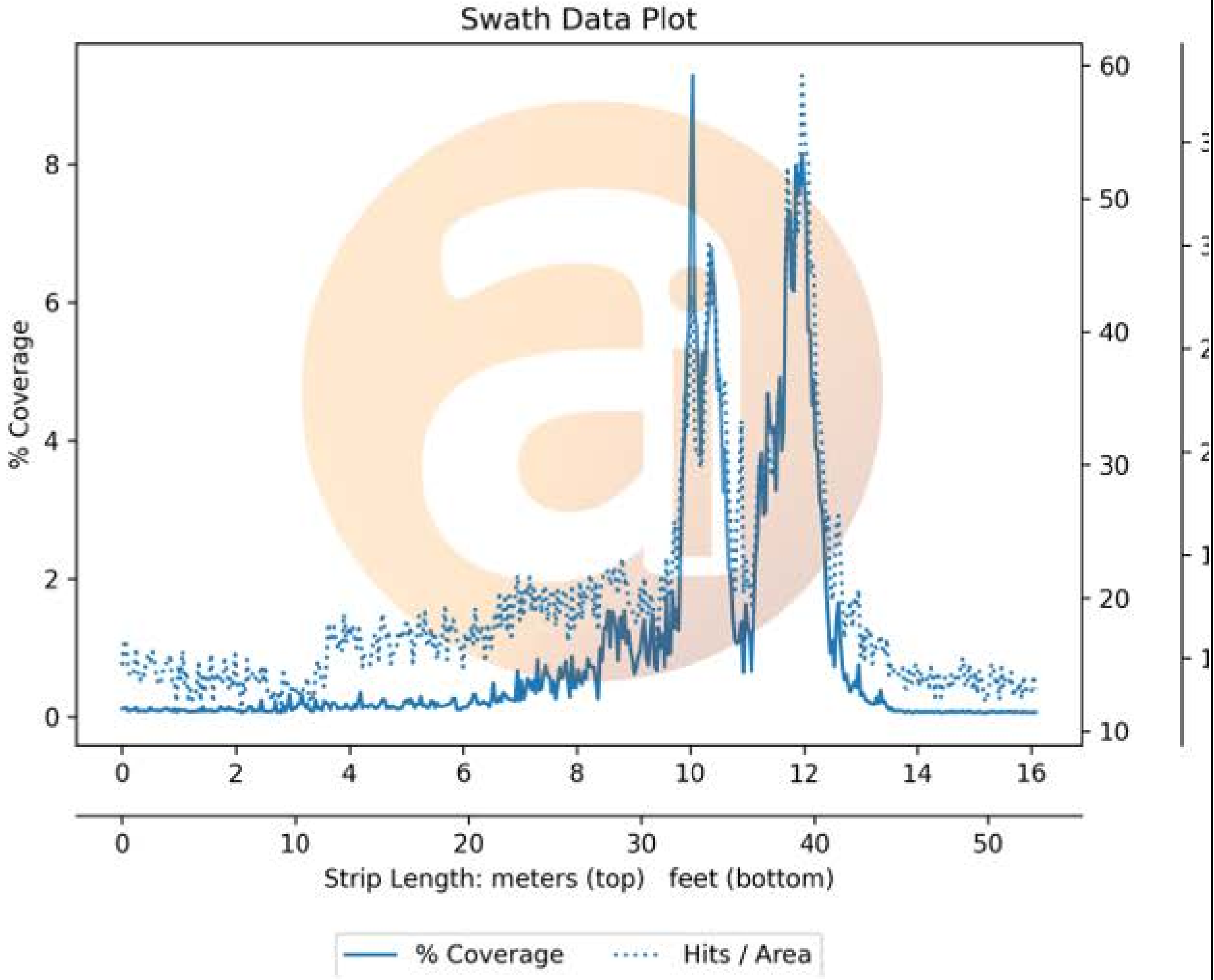
Horisontal_1.zip
Swath Data Plot

Agras T30 with 16 x 110 01 nozzles

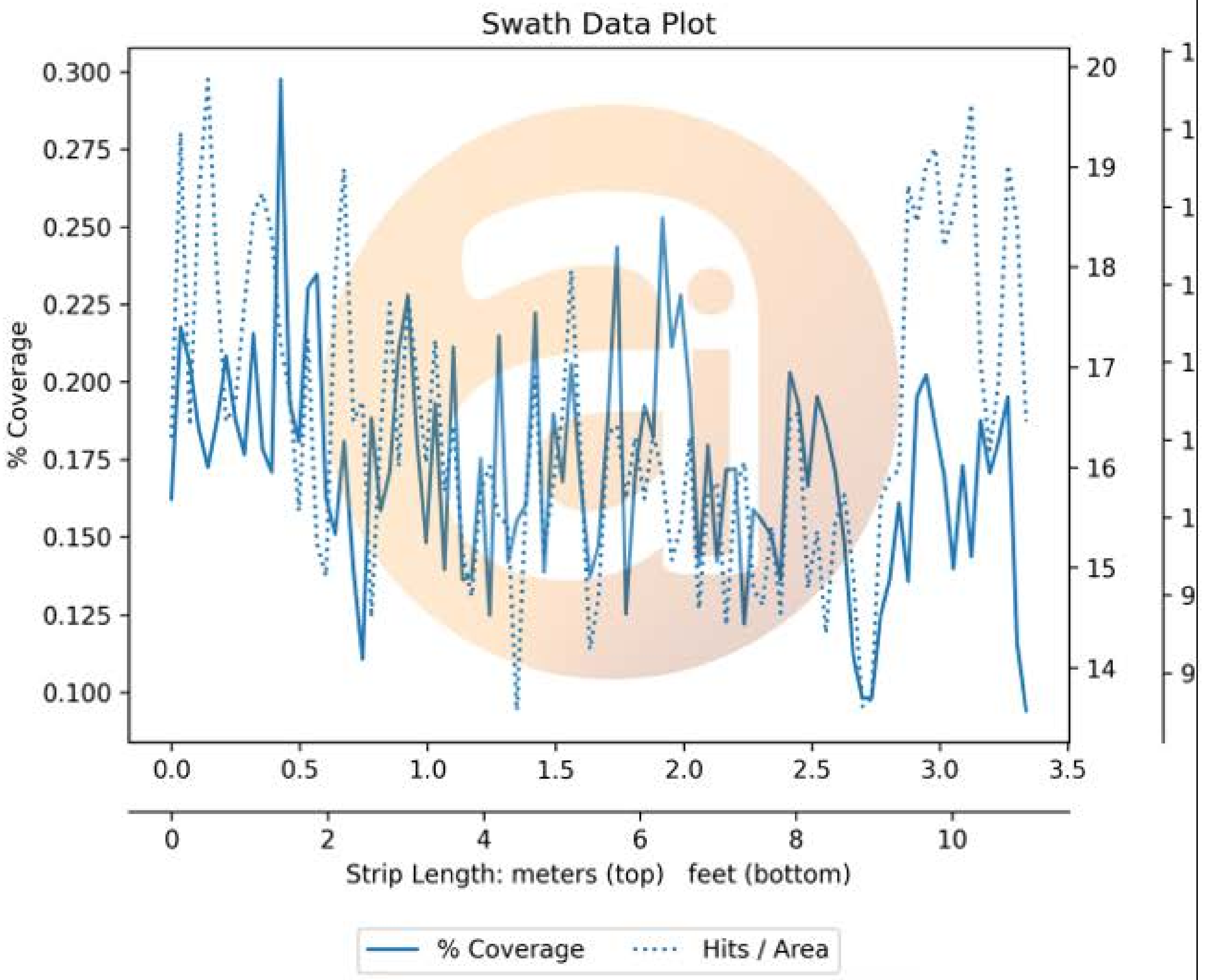
Trial	Wind m/s	Temp.	RH	Height m	Working Width m	Speed km/h	L/ha
3	3.7	18.6	44.8	3 .0	2.8	22.3	15
4	3.9	19.5	44.0	1.5	2.8	22.3	15
5	3.4	19.5	43.2	3.0	2.8	14.8	22
6	3.9	19.6	47.7	1.5	2.8	14.8	22
7	3.1	18.1	55.2	3.0	2.8	22.3	15


Swath Data Plot
% Coverage
Strip Length: meters (top) feet (bottom)
% Coverage
Hits / Area

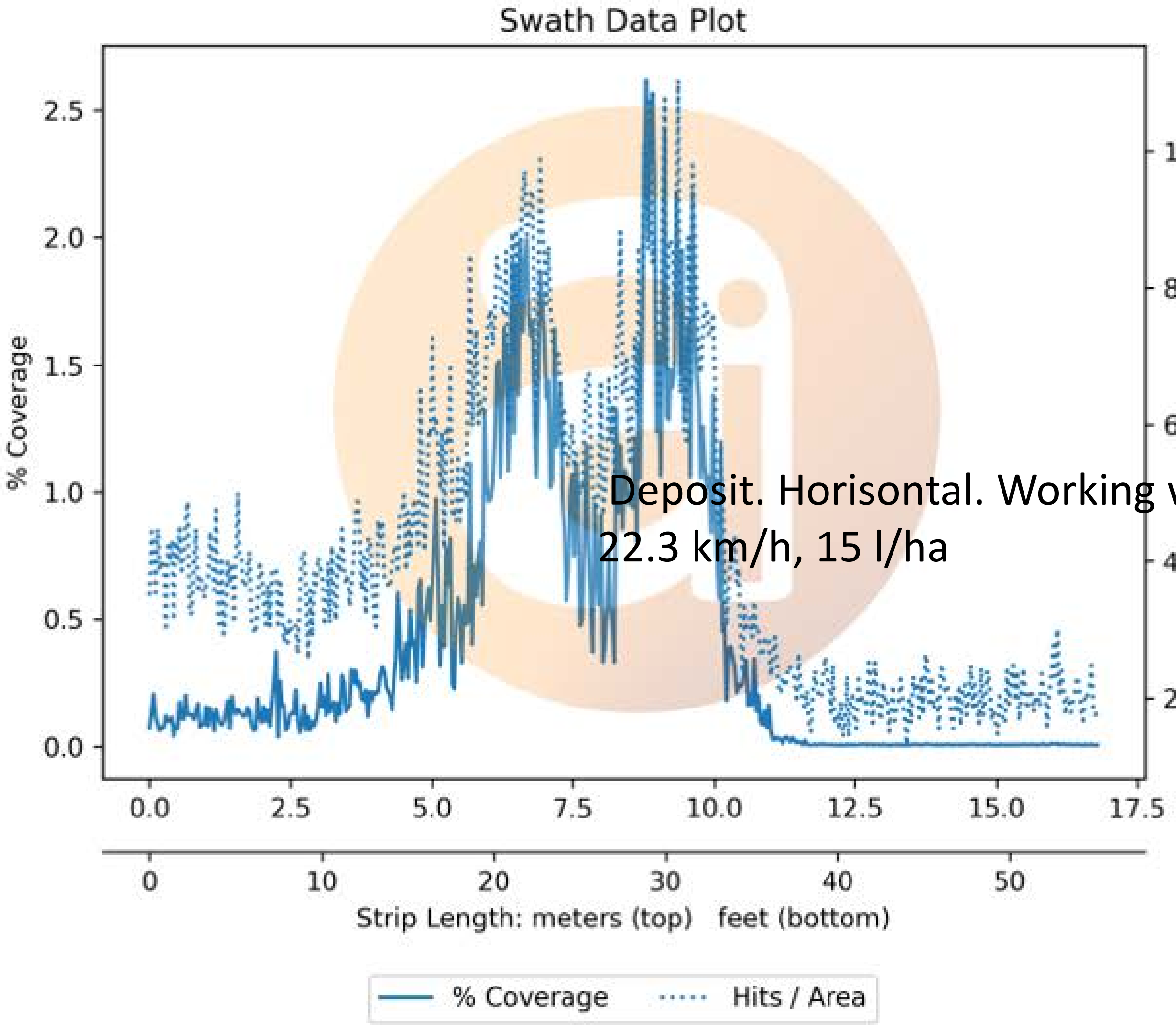

Swath Data Plot
% Coverage
Hits/cm² (left) Hits/in² (right)
Strip Length: meters (top) feet (bottom)
% Coverage
Hits / Area

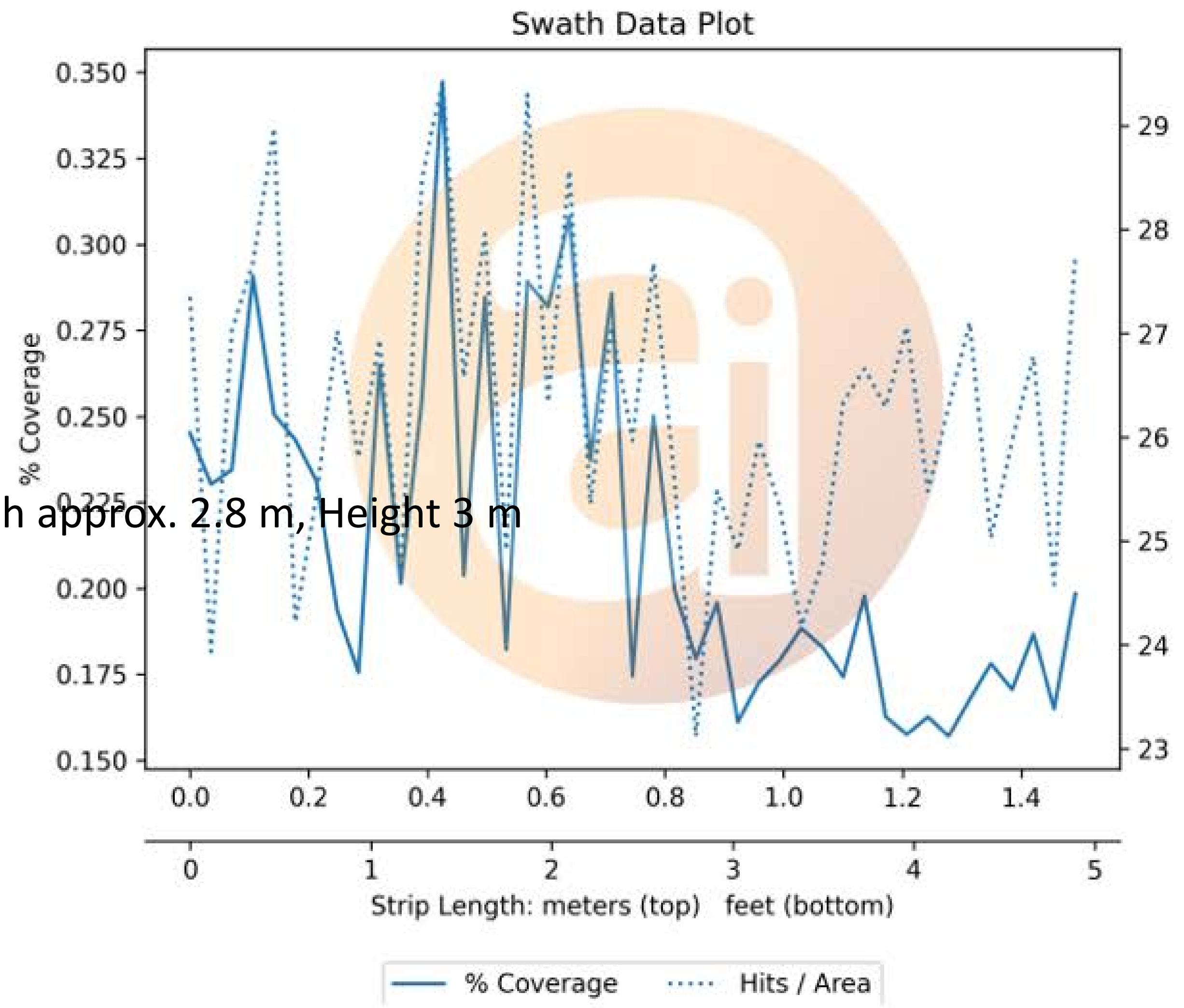


Swath Data Plot
% Coverage
Strip Length: meters (top) feet (bottom)
% Coverage
Hits / Area



Swath Data Plot
% Coverage
Strip Length: meters (top) feet (bottom)
% Coverage
Hits / Area





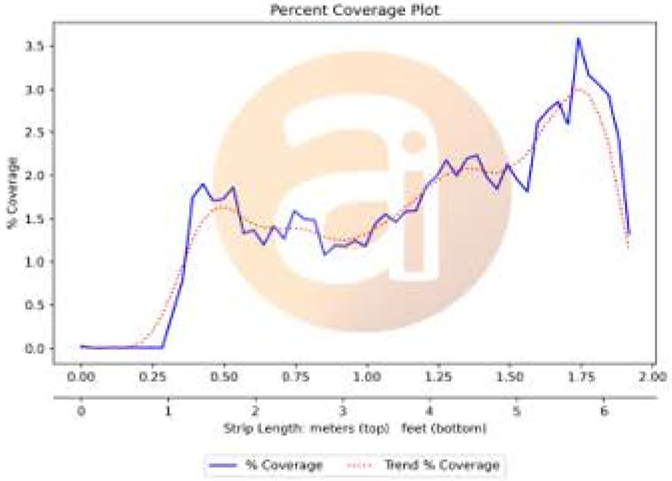
Deposit. Horisontal. Working width approx. 2.8 m, Height 3 m
22.3 km/h, 15 l/ha

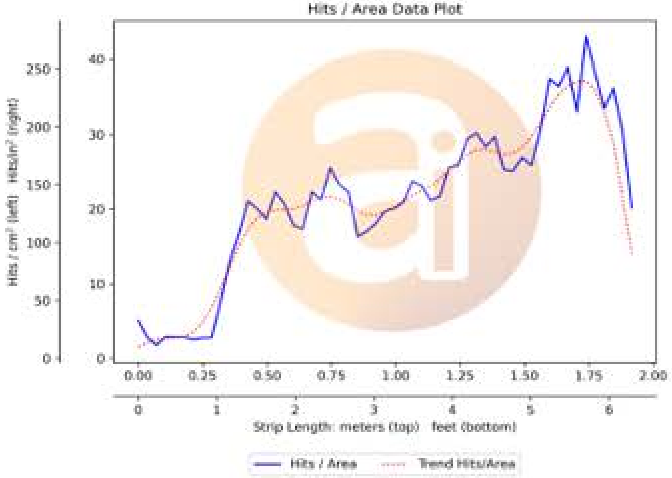
Spray drone with rotating discs

Agras T30 with rotating discs

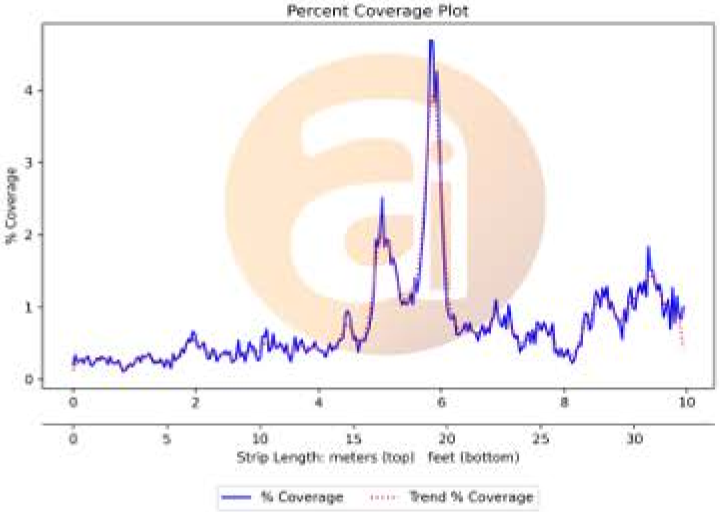
Trial	Wind m/s	Temp.	RH	Height m	Work. Width m	VMD µm	Speed	With betw. vert. m	L/min	L/ha
1.1	0	26.5	44.8	3 .0	3	320	18	10	2.64	30
1.2	0	24.8	52.3	2.5	3	320	18	10	2.64	30
1.4	1.6	26.6	38	2.5	3	100	18	10	2.64	30
2.1	2.8	21.2	61.5	2.5	3	100	18	12.7	2.64	30
2.2	1.8	20.1	65.3	2.5	3	320	18	12.7	2.64	30
2.3				2	3	500	18	12.7	2.64	30

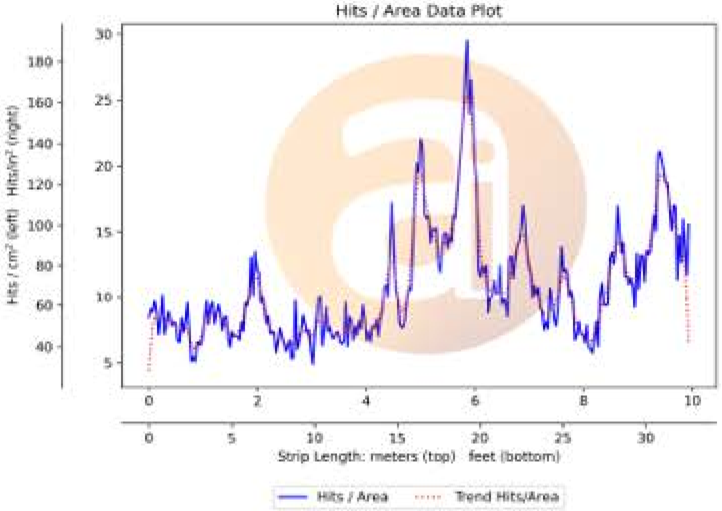
Swath Gobbler Report: SG-106-2024-08-11T0852



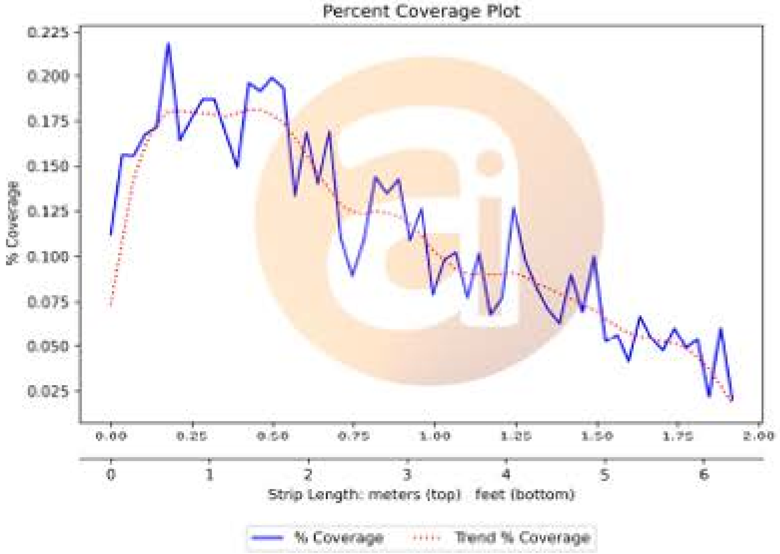


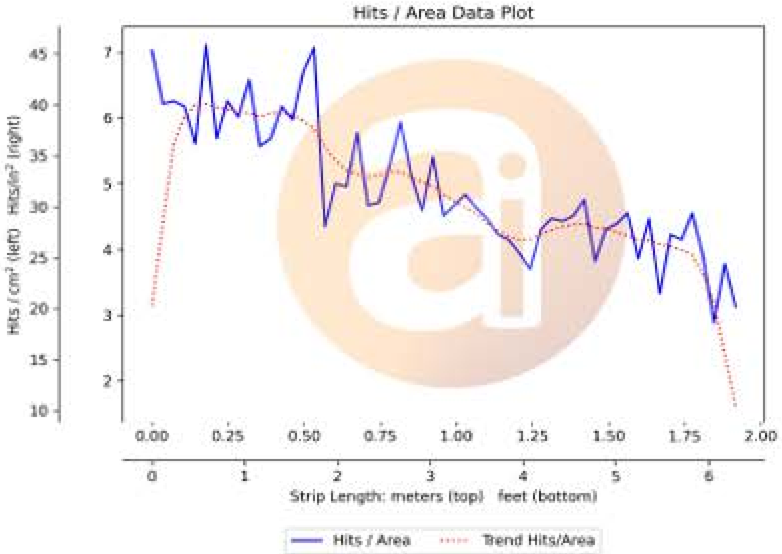
Swath Gobbler Report: SG-106-2024-08-11T0852



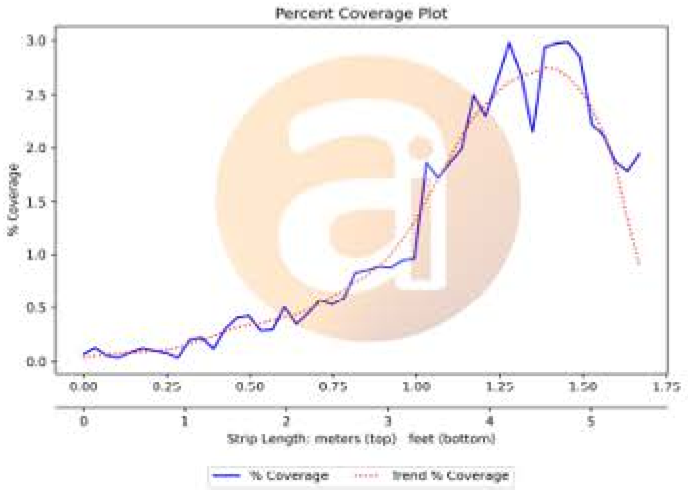


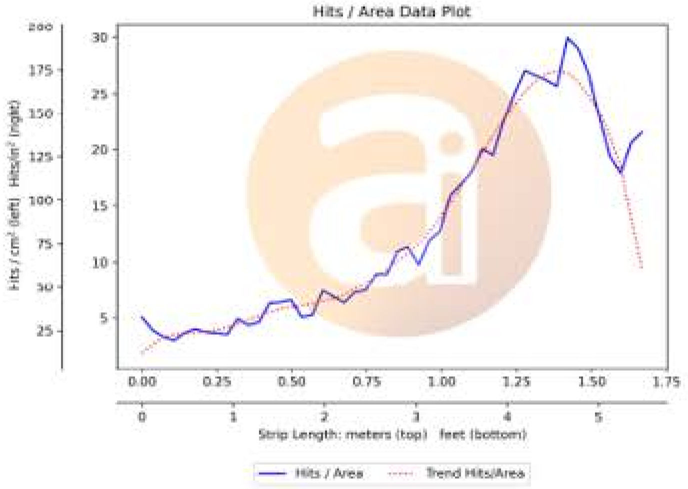
Swath Gobbler Report: SG-106-2024-08-11T0852



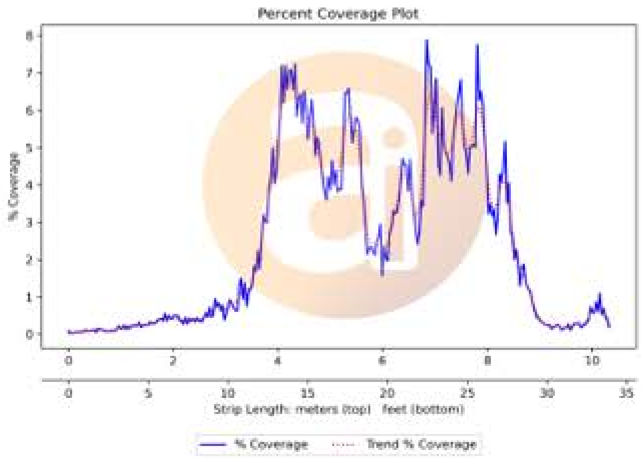


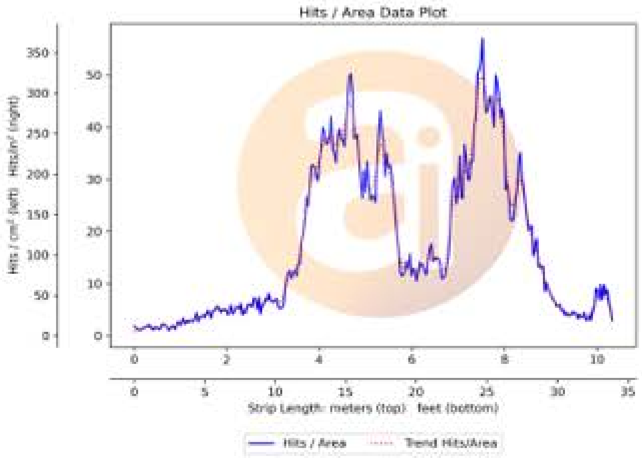
Swath Gobbler Report: SG-11B-2024-08-11T1310



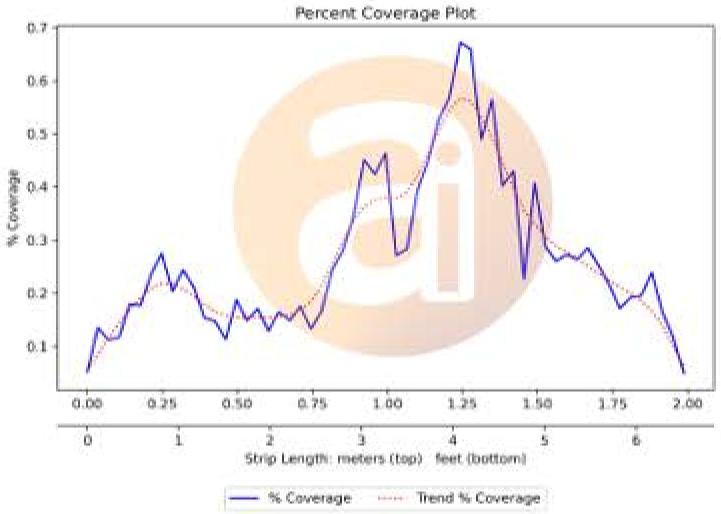


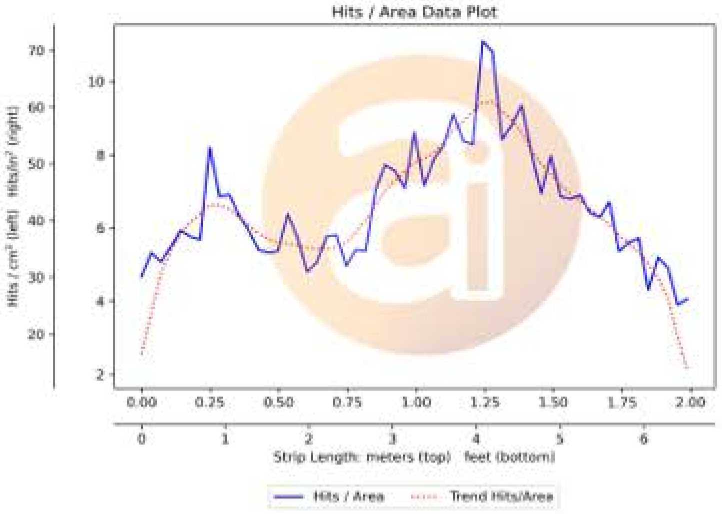
Swath Gobbler Report: SG-106-2024-08-11T0852





Swath Gobbler Report: SG-106-2024-08-11T0852





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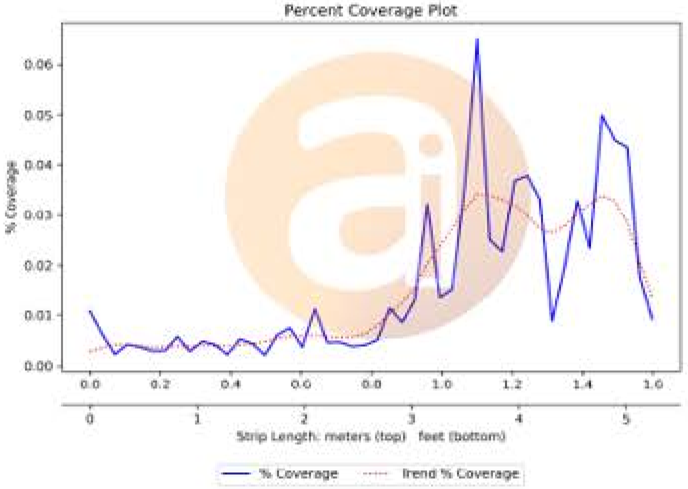
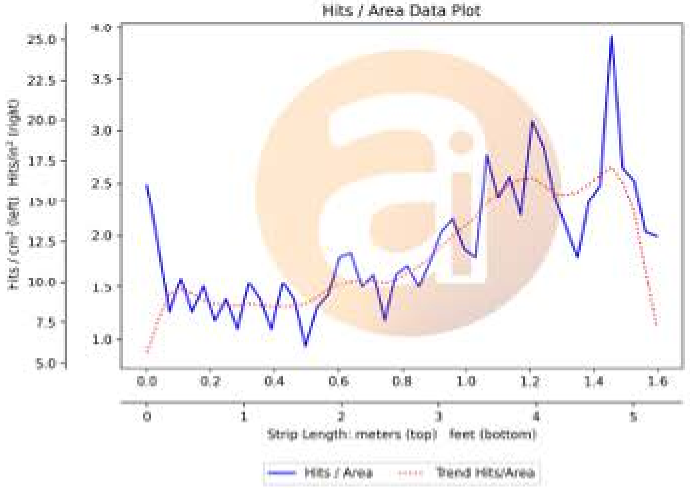
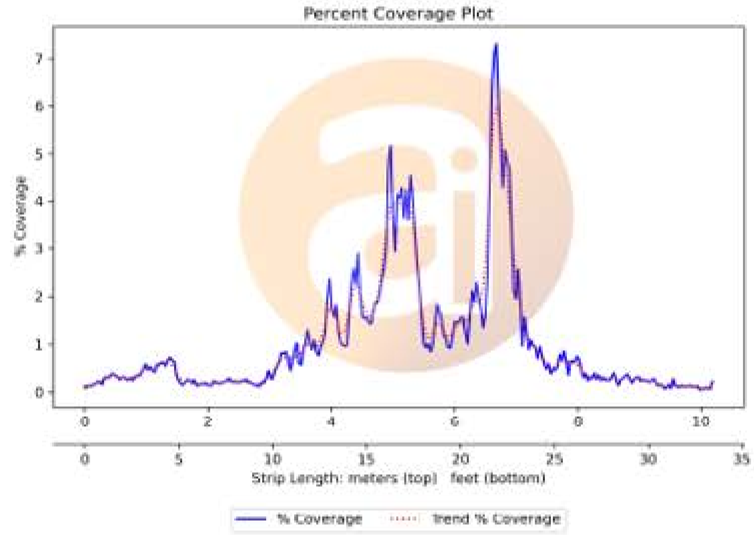
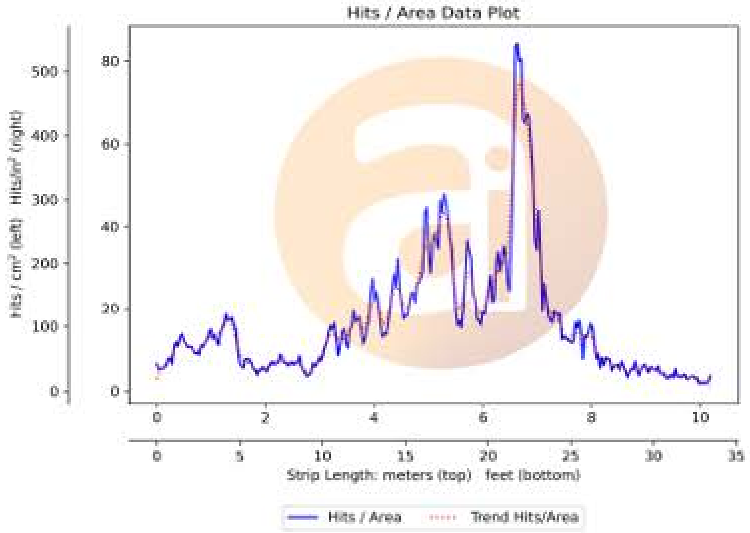


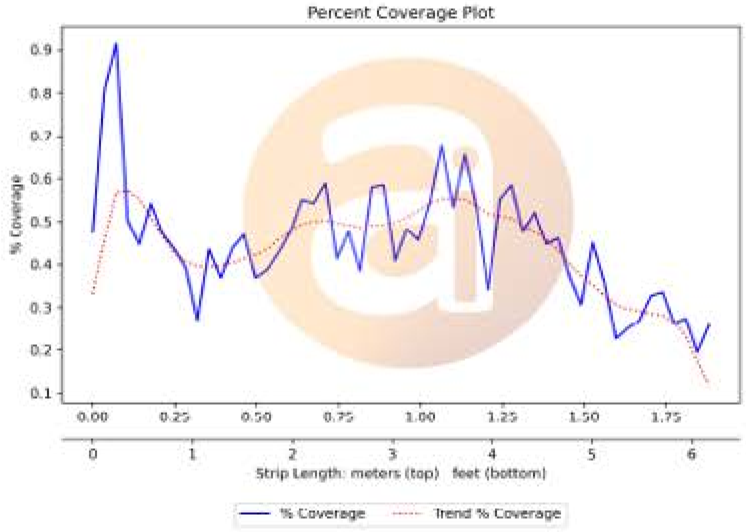


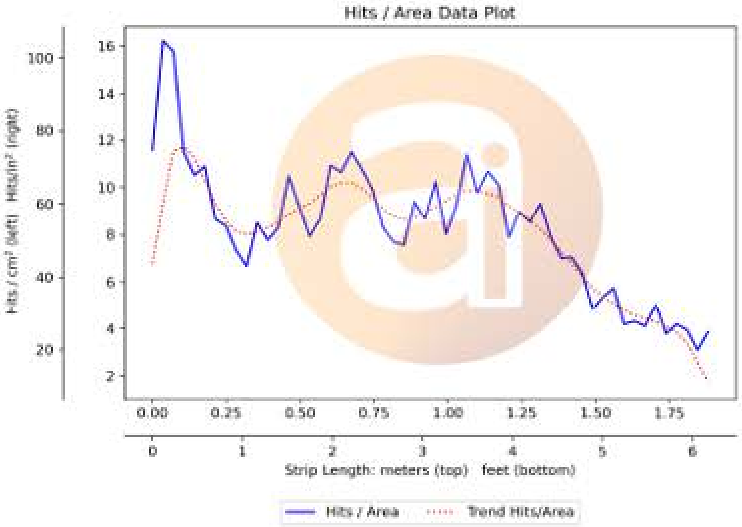
Swath Gobbler Report: SG-106-2024-08-11T0852



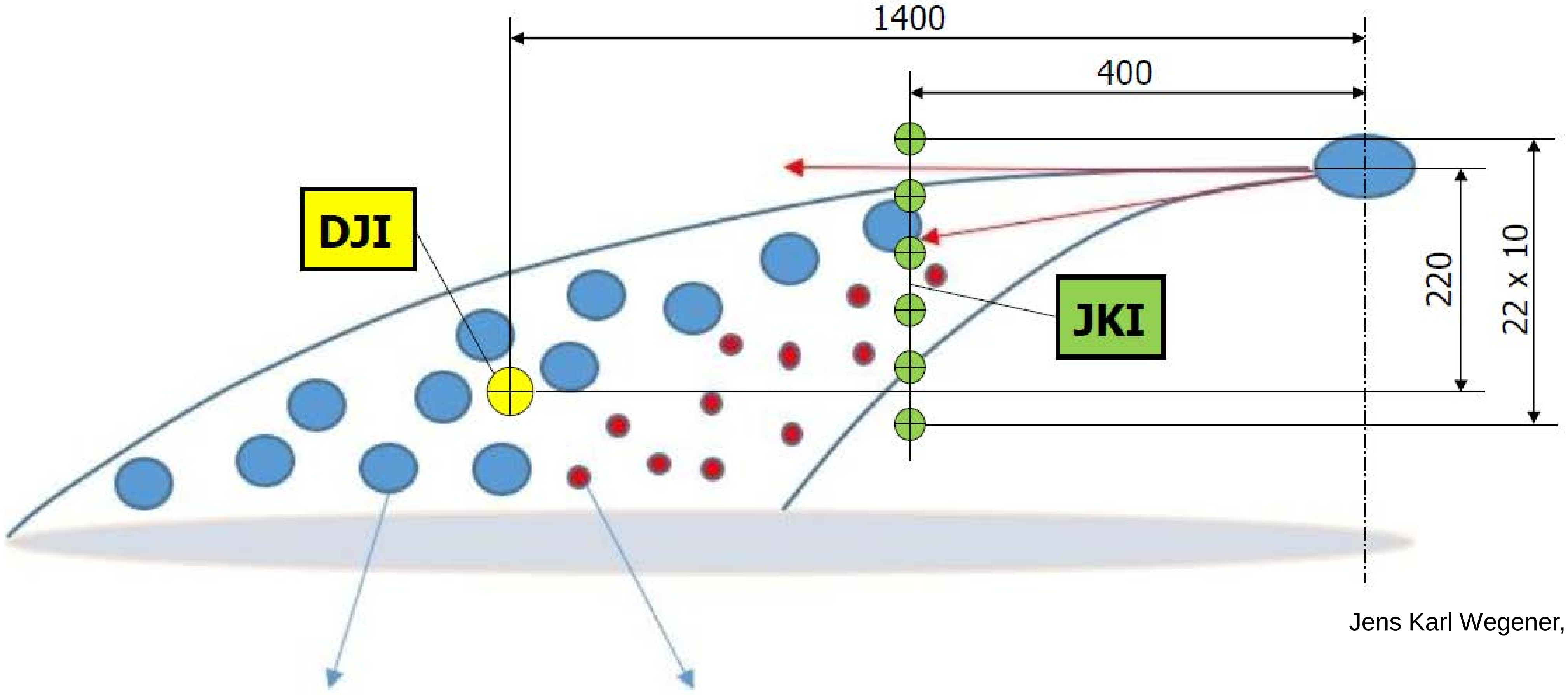


Swath Gobbler Report: SG-106-2024-08-11T0852





Drop size masurements

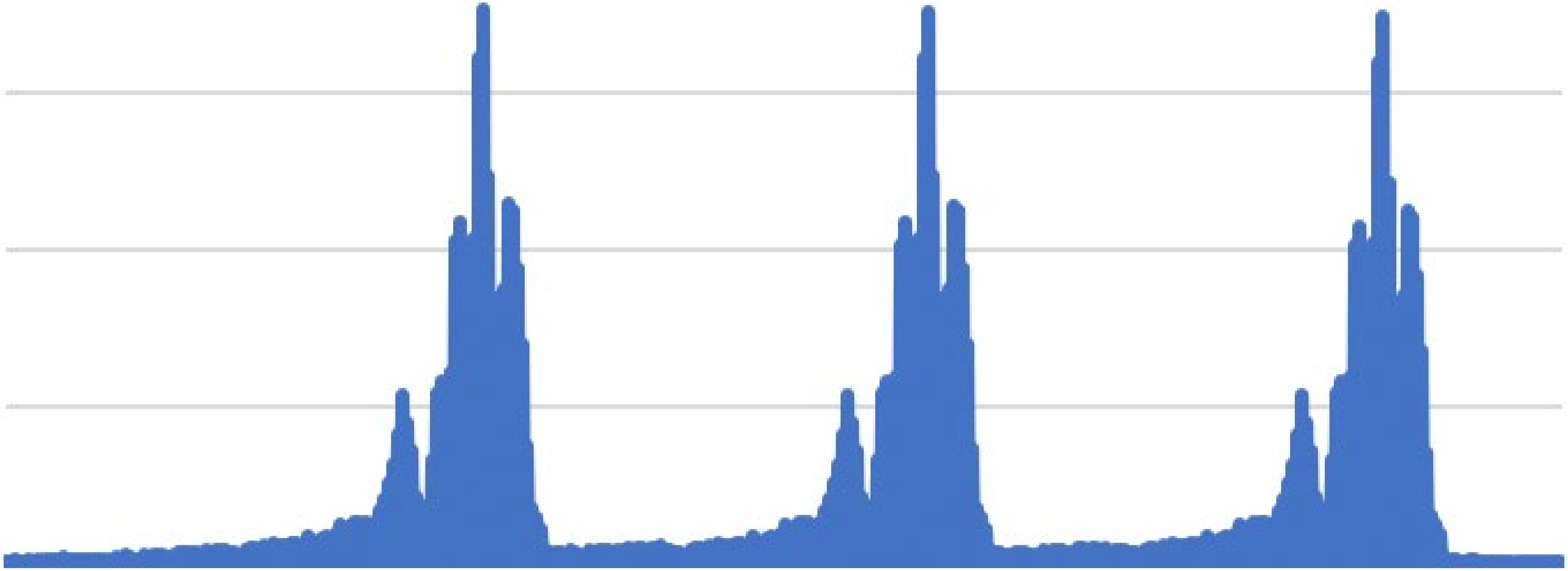


Jens Karl Wegener, JKI, 2024

Drone vs field crop sprayer

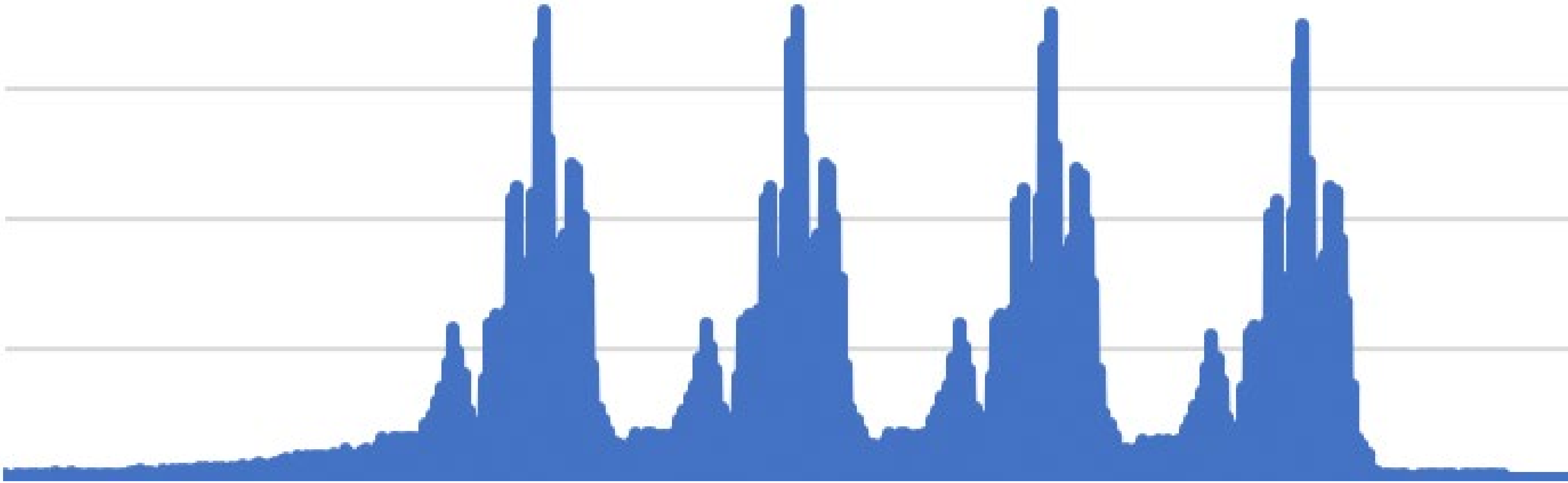
Distribution of multiply swaths

Working width 10 m, CV 150%



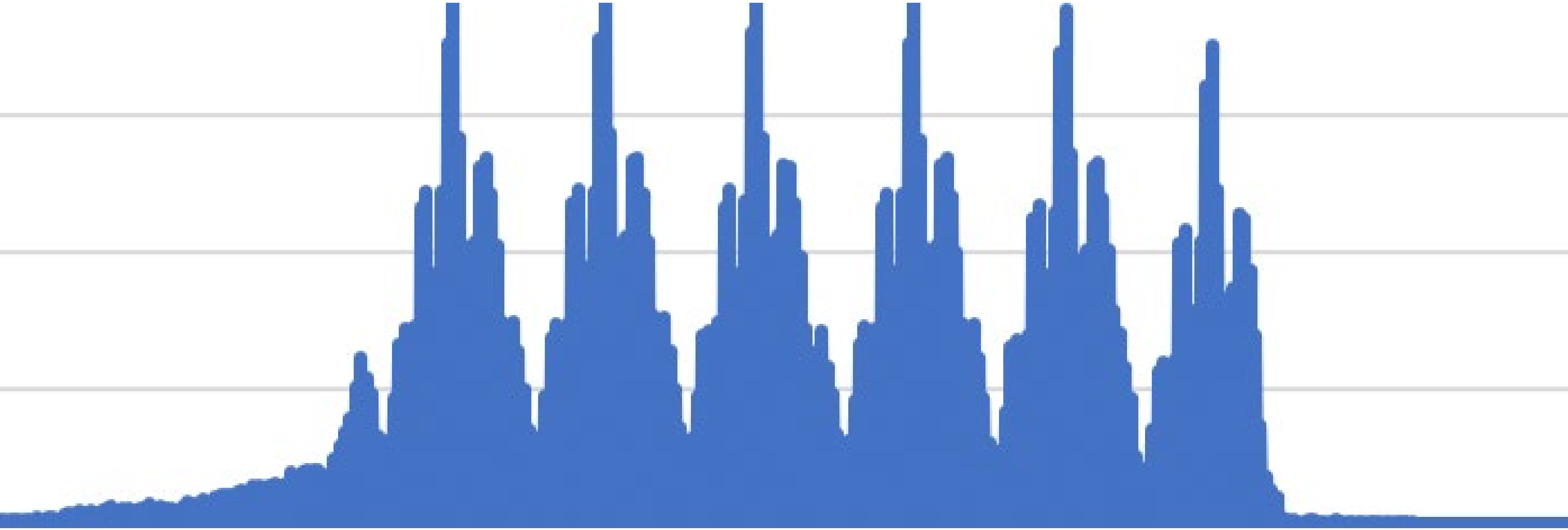
Distribution of multiply swaths

Working width 5 m, CV 130%

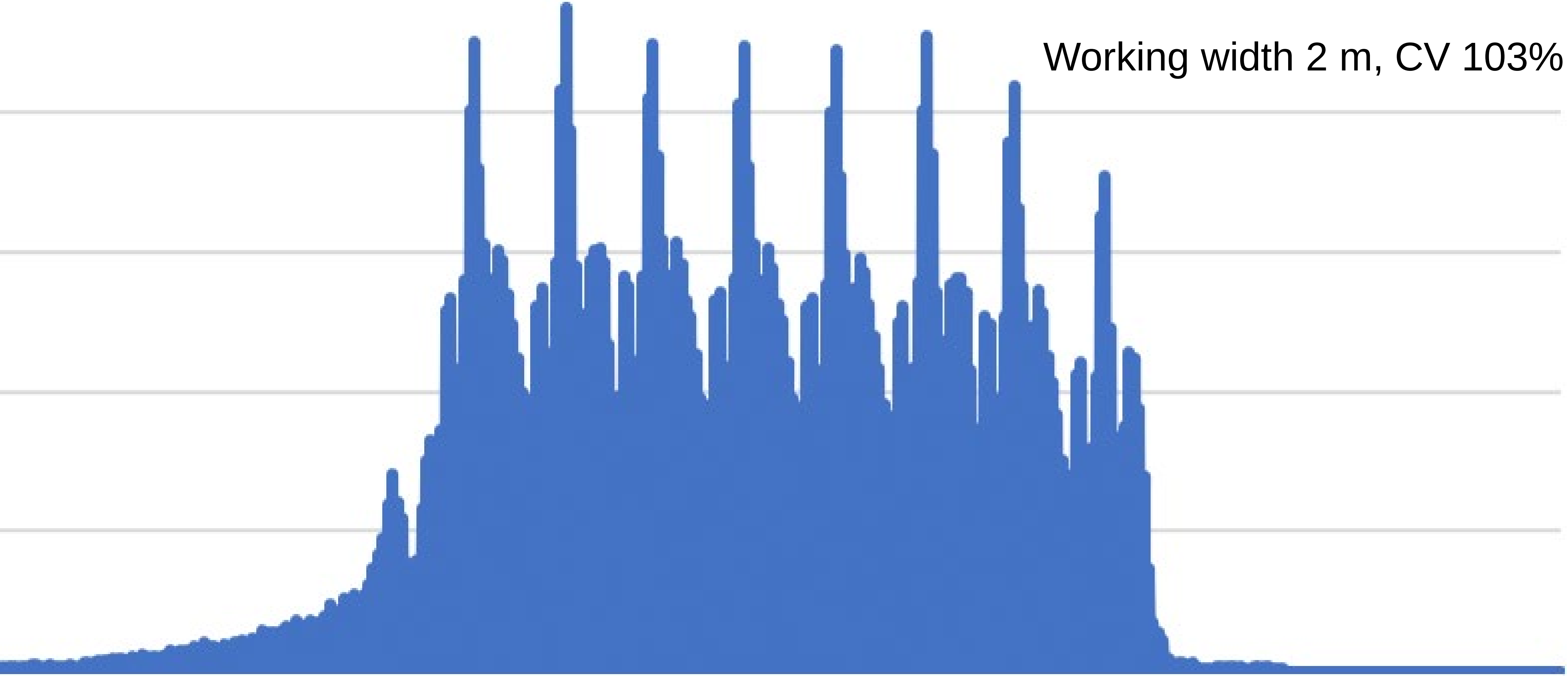


Distribution of multiply swaths

Working width 3 m, CV 107%



Distribution of multiply swaths



Spray drone vs Field crop sprayer

CONS

- Lower volume rate
- Poorer coverage
- Poorer distribution
- Higher nozzle height
- Higher speed
- More prone to drift
- Costs & licence & availability

PROS

- No soil compaction
- Independant of topography or soil conditions
- Easier spot spraying
- Easier to treat small, irregular fields
- Easier in hilly areas & safety
- Low operator exposure
- For spot spraying
  - Less use of PPP
  - Less drift
- CO2 friendly

Conclusions

- Spray drone cannot obtain so even distribution as field crop sprayers
- Areas where spray drones may have benefits in Norway;
  - In fields; potential for spot spraying e.g. against weeds
  - In hilly terrain due to operator safety and application
  - In orchards at early stage without leaves in steep fields
  - Areas where only knap sack sprayers are possible e.g. difficult grazing areas
  - Special situations, e.g. due to soil compaction and none existing access to field with ground based equipment

New Project SUSDOCK

Sustainable control of docks (Rumex spp.)

Synergies of detection, mapping, and innovative weed control

NMBU Sustainable Arena

Smart Farming and Green Innovation

Funding– «Smart farming and green innovation»

Year	2021	2022	2023	2021-2024
NOK	700.000	700.000	700.000	2.800.000
EUR	60.000	60.000	60.000	240.000




Research groups within, robotics, drones, precision agriculture, GIS and GNSS, sensors, image analysis, computer science, phenotyping, plant sciences, fertilizer sciences and soil sciences are included in the group, which can also be expanded as needed.

DEVELOPMENT OF AGRICULTURE

TECHNOLOGICAL REVOLUTIONS

1.0 WORK-INTENSIVE

- Work intensive
- Low productivity
- 1/3rd of population involved-required

2.0 GREEN REVOLUTION

- Artificial fertilizers
- pesticides
- More efficient equipment
- Productivity dramatically increased

3.0 PRECISION AGRICULTURE

- Precision operations within crops
- Individual treatment of animals vs total flock
- Automatic steering with 10mm precision
- Sensors and controls

4.0 SMART FARMING

- Internal and external network integration of agricultural operations
- Cloud service usage, large data sets processed
- Cheap and advanced sensors
- Big data analytics
- New algorhythms that transform raw data into insight

5.0 ROBOT FARMING

- Operations without human presence
- Artificial intelligence, self-learning systems
- Production systems adapted to plant/animal needs
- Food production, consumer needs fulfilled
- Controls of ingredients/ internal components

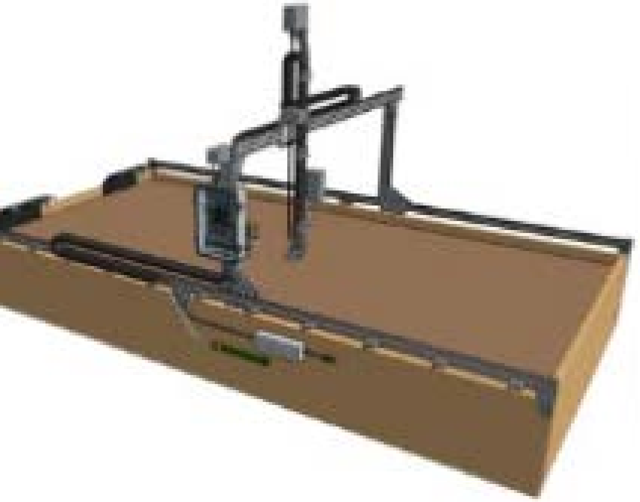
Research groups and topics at NMBU

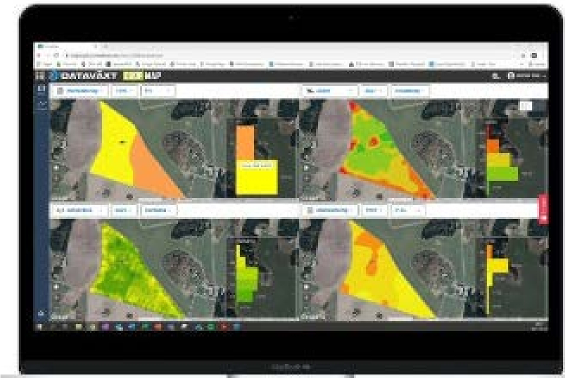
REALTEK | BIOVIT and MINA

SKP – Centre for Plant Research in Controlled Climate (senter forklimaregulert planteforskning)

SHF – The lifestock Production Research Centre (senter for husdyrforsøk)

Smart Farming & infrastructure





PheNo - Norwegian Plant Phenotyping Infrastructure

Coordinator

Norges miljø- og biovitenskapelige universitet (NMBU) — **Ås**

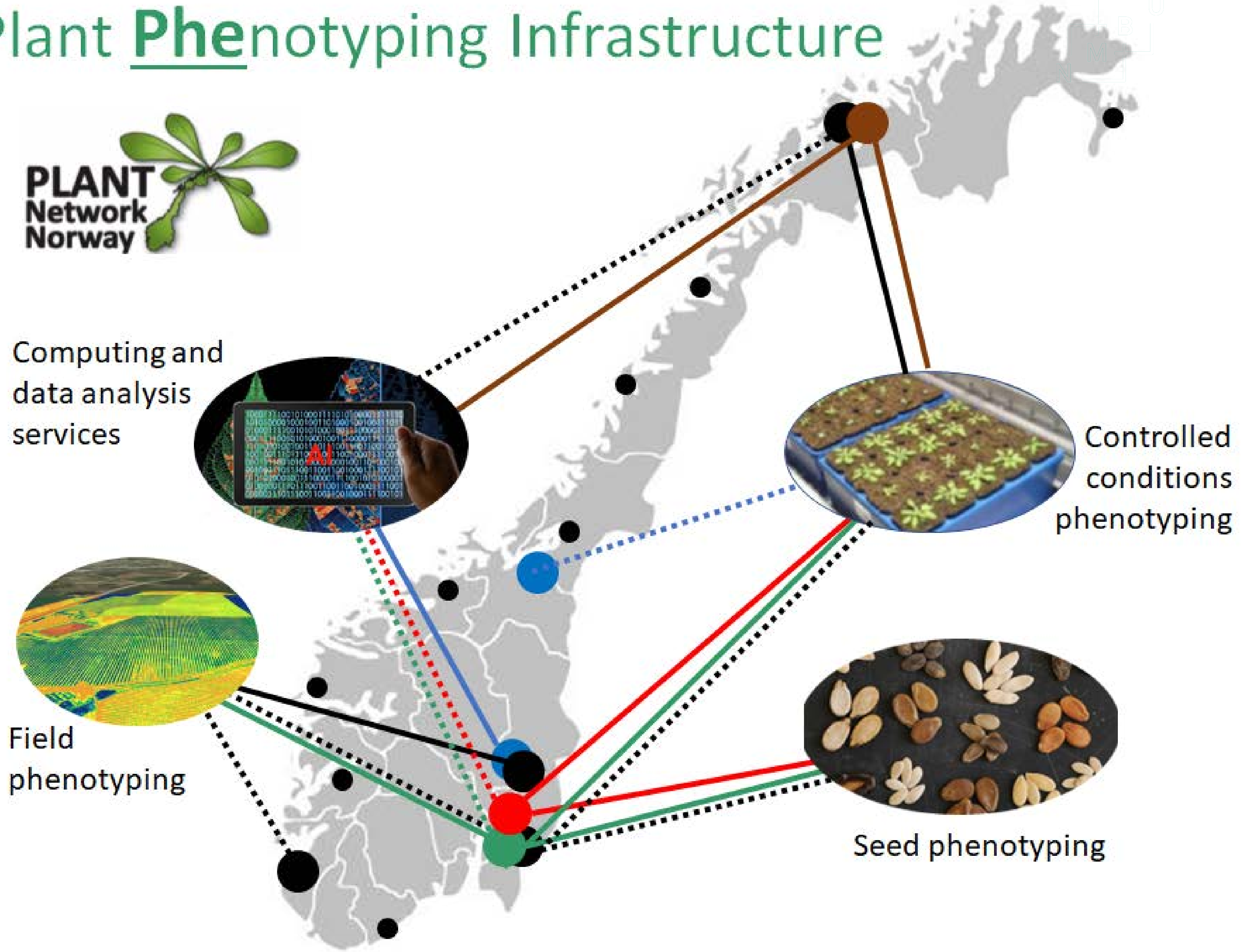
Consortium partners

UiO — **Oslo**

NIBIO — NORSK INSTITUTT FOR BIOØKONOMI — **Tromsø**, **Apelsvoll**, **Særheim**, Ås

NTNU — **Gjøvik**, Trondheim

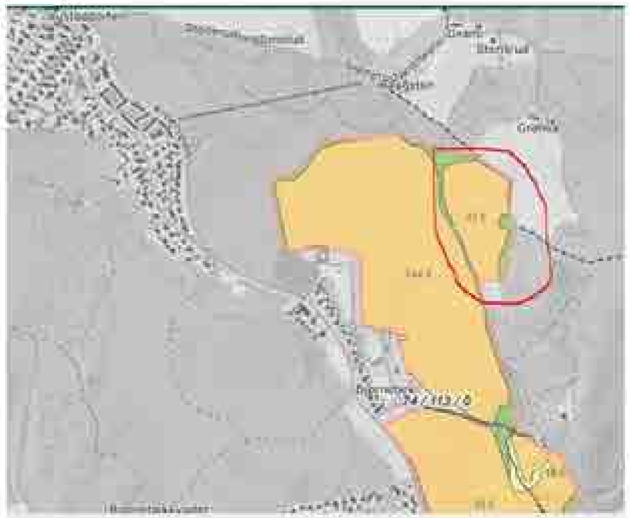
UiT — NORGES ARKTISKE UNIVERSITET — **Tromsø**



Pilot areas for education and research at NMBU

20 daa Kjærringjordet

14 daa Vollebekk



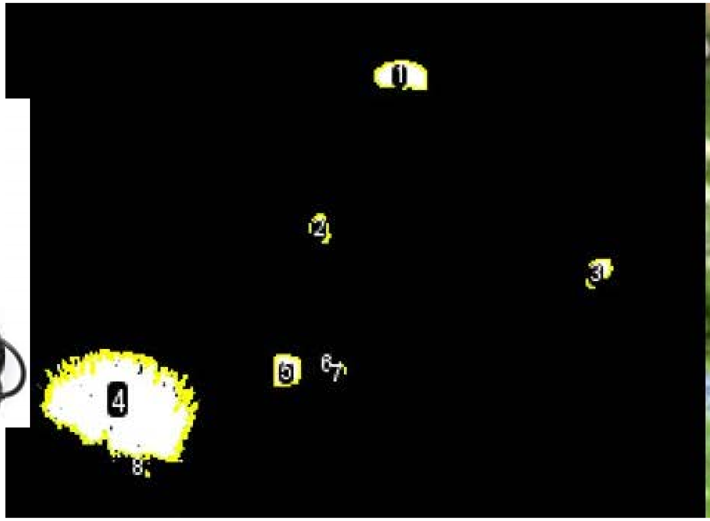
Grønnlia – 42 daa

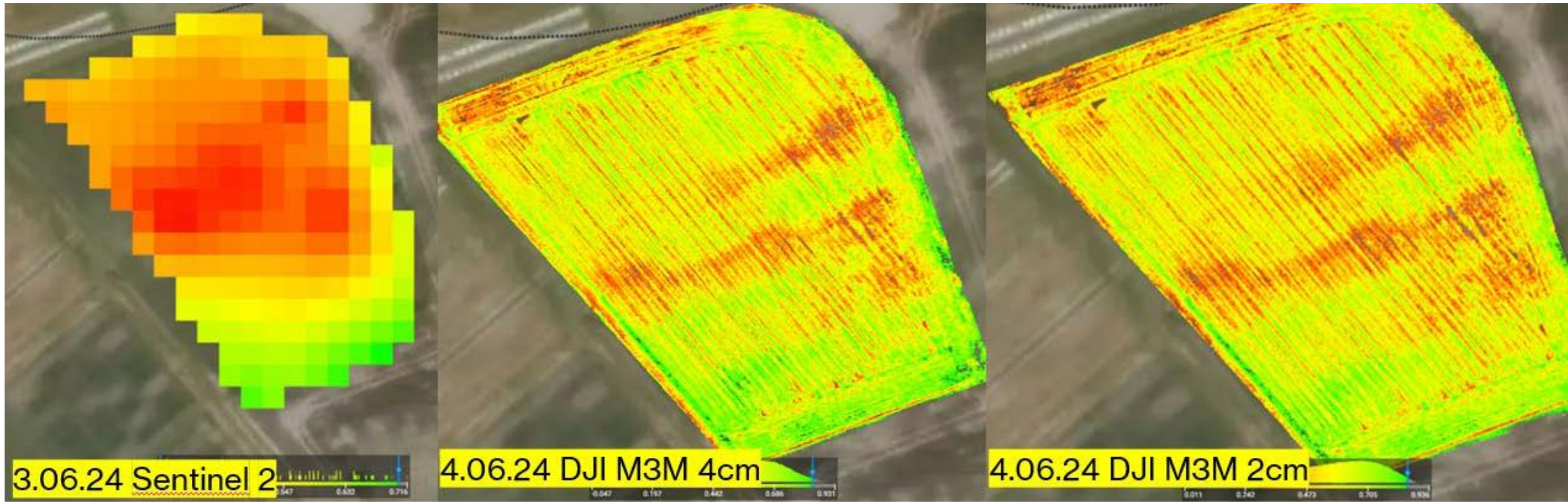
Høybråtan – 20 daa

Høybråtan – Sørås – 42 - 1

NMBU

BootCamp 2024 - student innovation





Autonomous grass harvesting

Projects -Smart Farming

ProteinBar

Projects -Smart Farming

Drone svever over forsøksfelt for å samle informasjon om hveteplantens vekst og helse.Foto: Thomasz Mroz

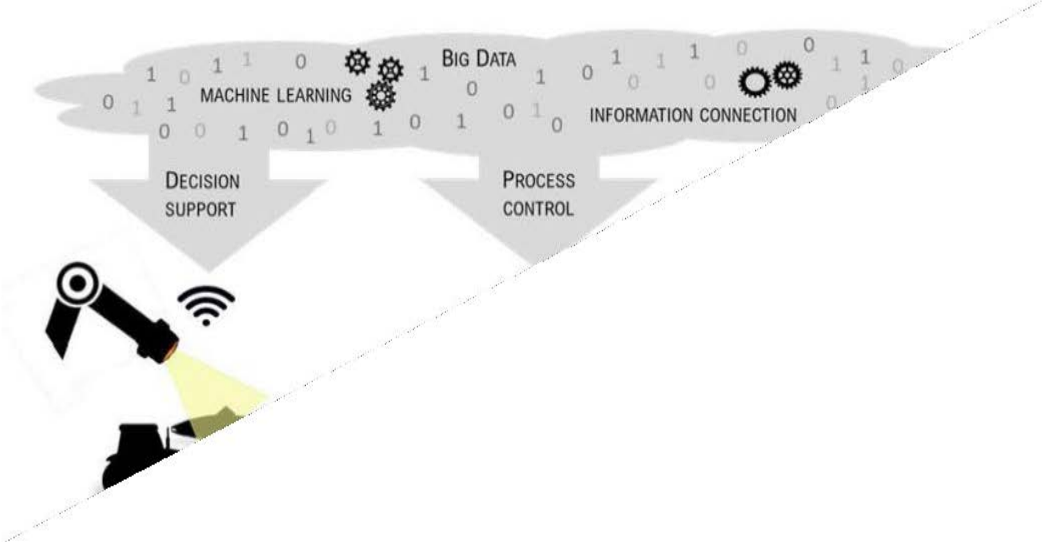
Projects -Smart Farming

AgriSol

Some projects within Smart Farming

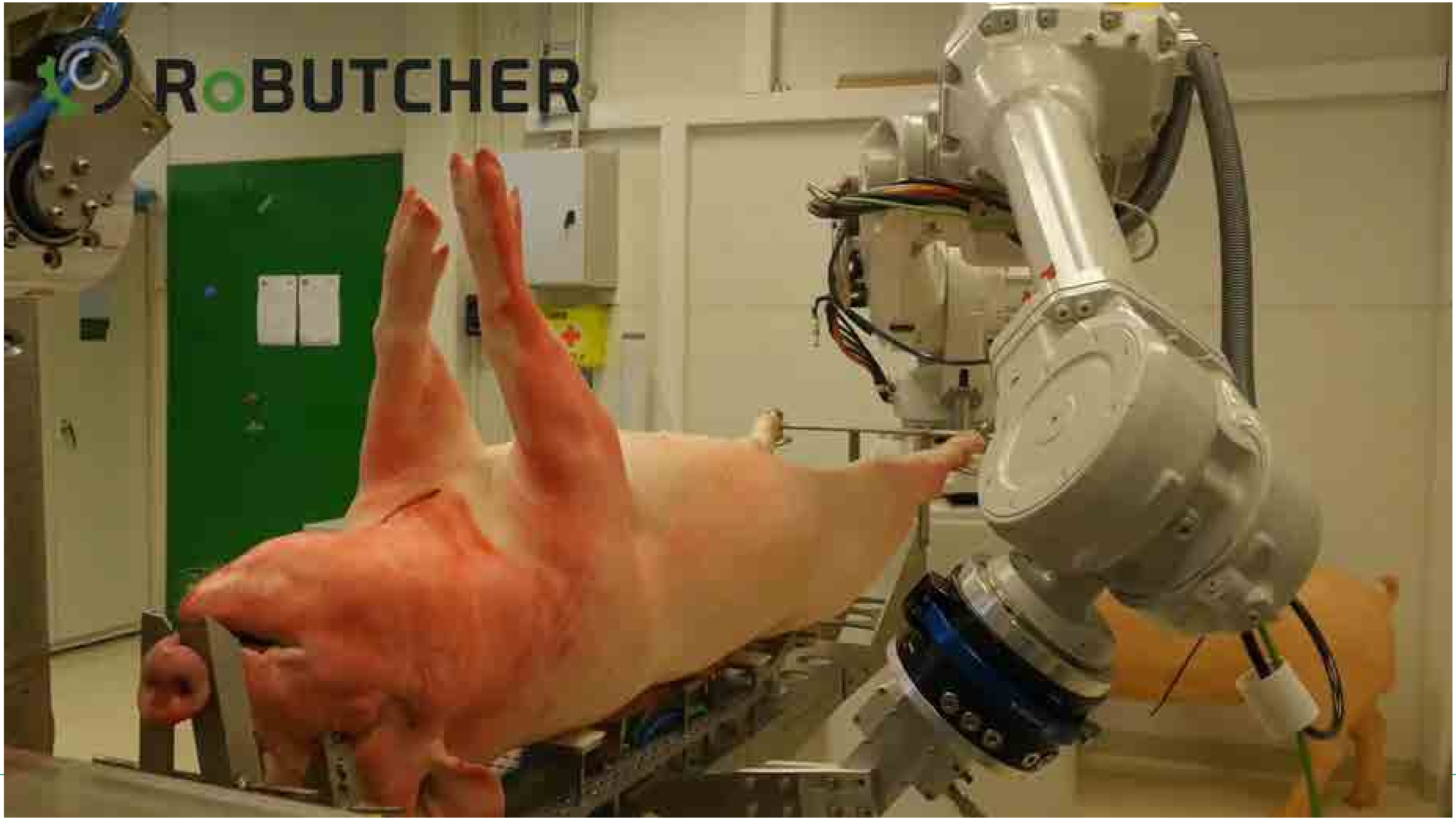
- RoboFarmer - Safe and reliable sensing, learning and control of an autonomous multi-arm agri-robot platform
- DLT farming Data-Led Transformation Solution for Sustainable Forage Grass Farming using Robotics, Energy-Efficient Sensors and Genomics
- ProteinBar and soil sensors
- Spray drones and drift measurements (2024-)
- SUSDOCK: Sustainable control of dock (Rumex spp.) (2025-)
- AgriSol (2025-)
- Smart farming – green production – long time learning digital modules
- SmartWeat (2025-2028) Harnessing AI models for climate-resilient wheat varieties in sustainable agriculture

RoboSense



Digifoods

RoBUTCHER




FIELD
ROBOT
EVENT
AMAZONE
KRONE
CLAAS

Center application AgriFoodTech

NMBU

Consortium:

NMBU Norwegian University of Life Sciences
BI Norwegian Business School
NORSUS Norsk Institutt for bærekraftsforskning
SINTEF
Veterinærinstituttet Norwegian Veterinary Institute
Nofima
NR Norsk Regnesentral Norwegian Computing Center
RI. SE Research Institutes of Sweden
University of Lincoln
Aalto University
Helsingin Yliopisto

sensonomic
AGRISENZE
monil
AgroSense
ANIMALIA Norwegian Meat and Poultry Research Centre
Grilstad
JÆDER
tks AGRI
DigiFarm
Klosser Innovasjon
Norsk Kylling
THORVALD
YARA
NORDIC EDGE
AVISOMO
Fatland
ULLENSVANG FRUKTLAGER
Grøntprodusentenes Samarbeidsråd
Nortura
Graminor
skala robotech
Telefrukt
7Sense
MOVING FLOOR CONCEPT
BioControl Technology for biology
NORGES BONDELAG
ard Innovation


Thank you for your attention!
Bærekraftsarena
Smart Farming
Smart Farming | Grønn Innovasjon
Green Innovation Student LAB
Norges miljø- og
biovitenskapelige
universitet
NMBU.no

Robotic and AI solutions for field Phenotyping

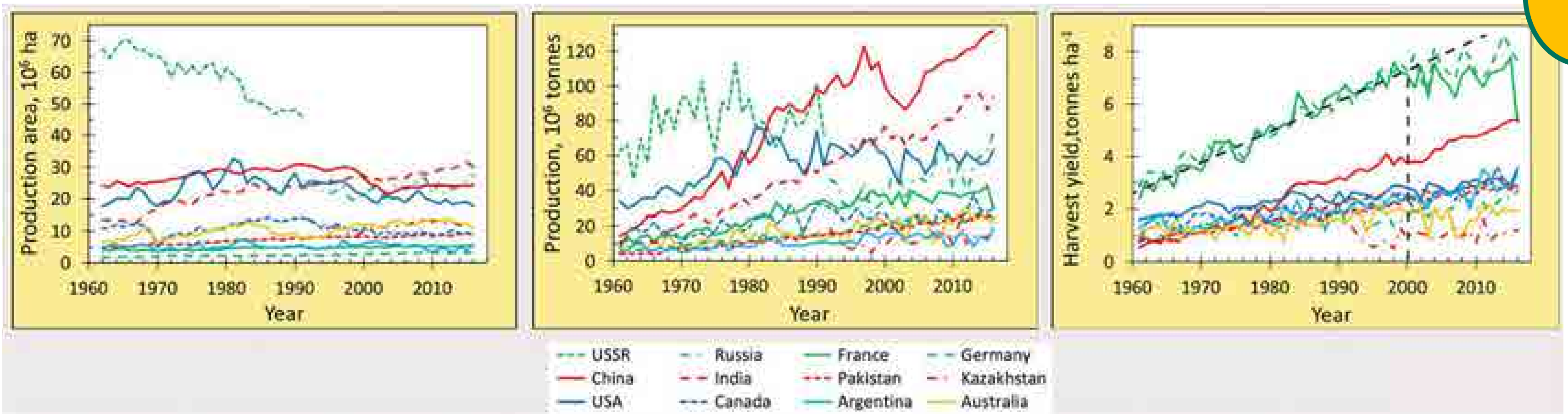
Sahameh Shafiee
Department of plant science
Norwegian University of Life Sciences (NMBU)

Current Challenges in Crop Breeding

- The yearly increase of yield in major crops is flattening from 2000
- Climate Change:

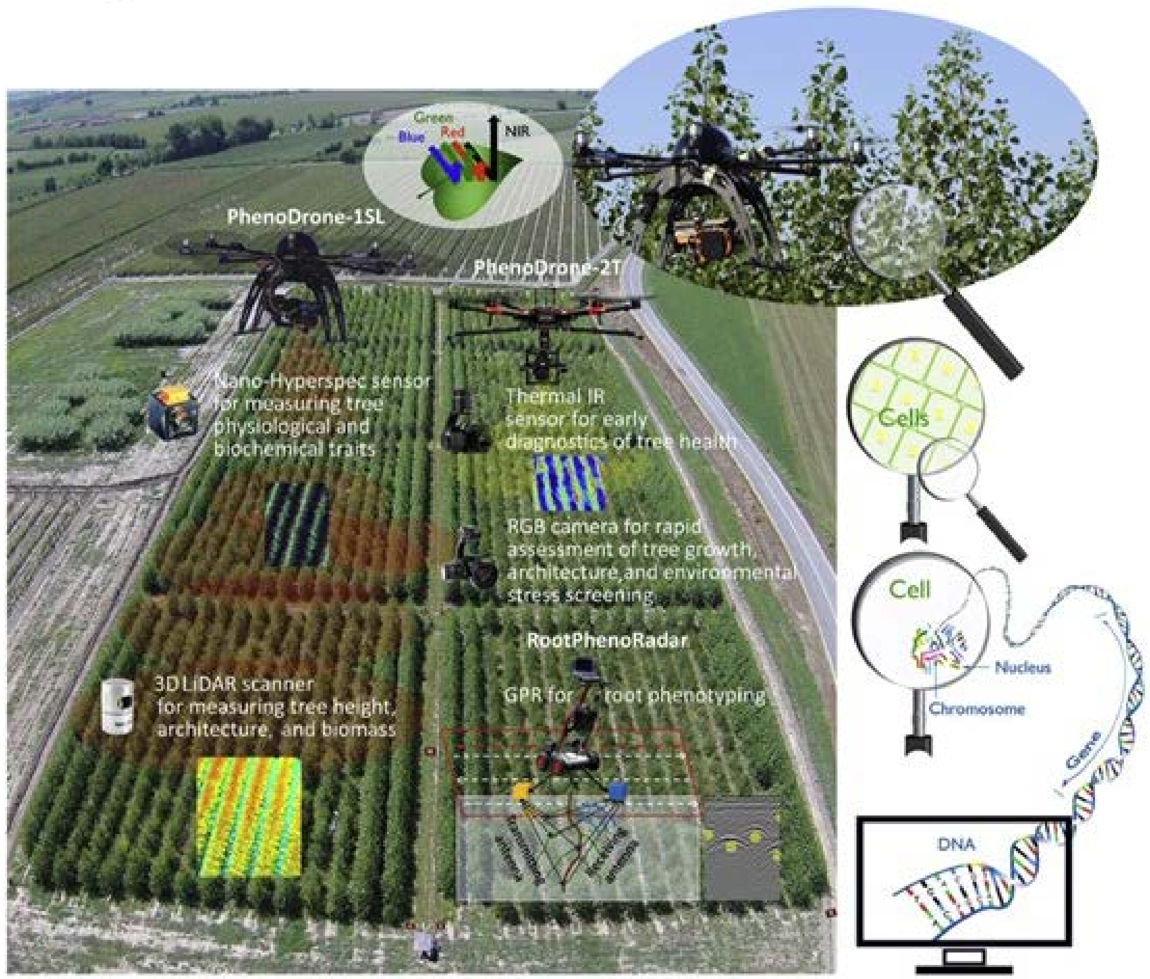
1. More extreme weather
2. Heat and drought stress (reduced yield)
3. Disease and pest pressure

Emphasizing the need for breeding for multiple stress resilience.

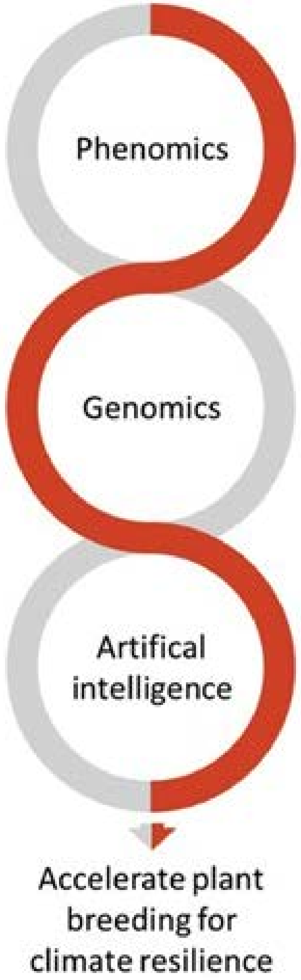


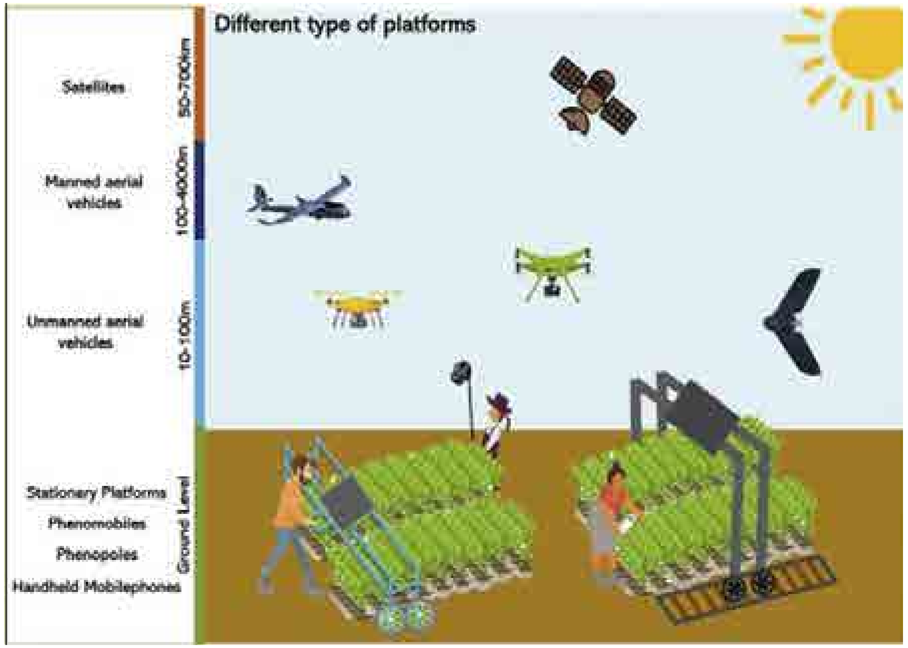
http://www.fao.org/faosata/en/#data/QC
Top 12 wheat producers by area

What we are really looking for?



PhenoBotix Lab: field high-throughput phenotyping is ready for a close-up

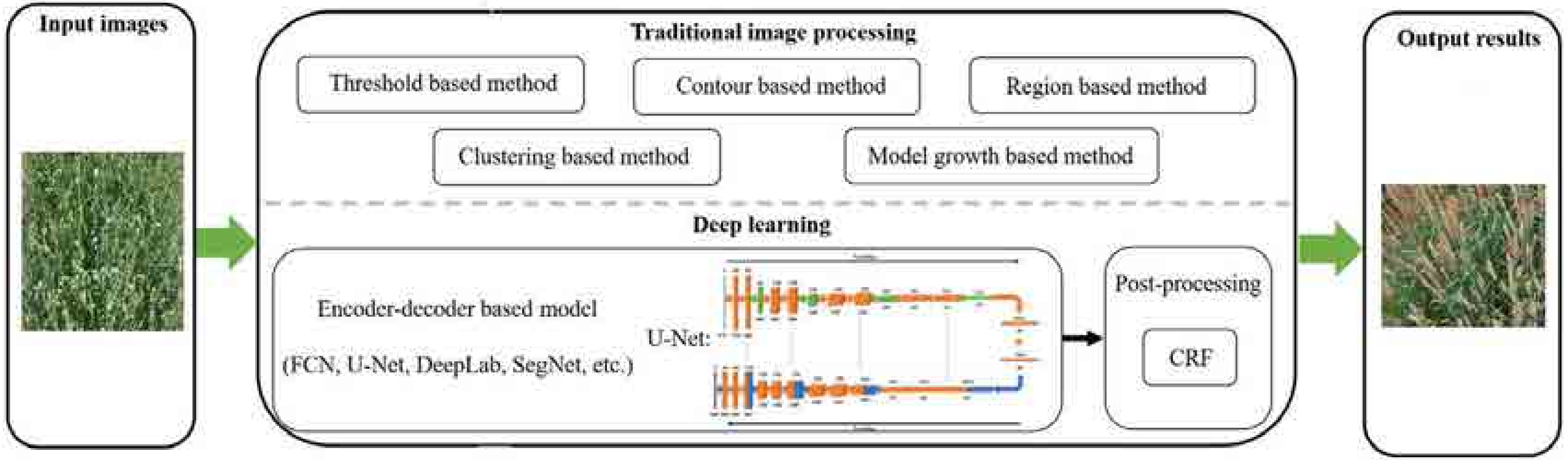




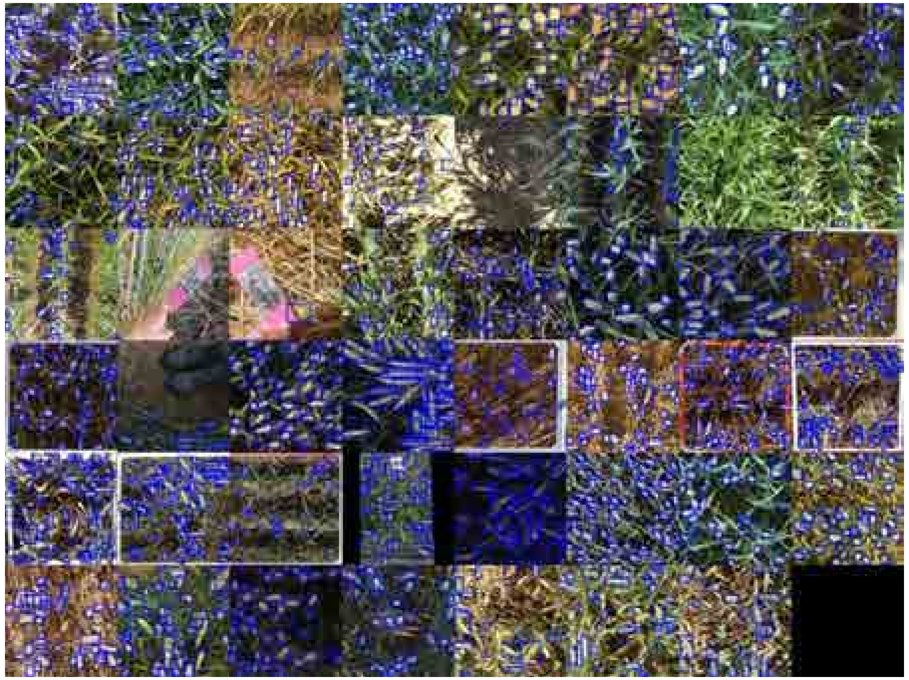
[Field Based High Throughput Phenotyping Rapidly Identifies Genomic - gn.racesociety.com]()

Case studies in Norwegian Wheat Breeding

Can we simplify some tasks using AI?

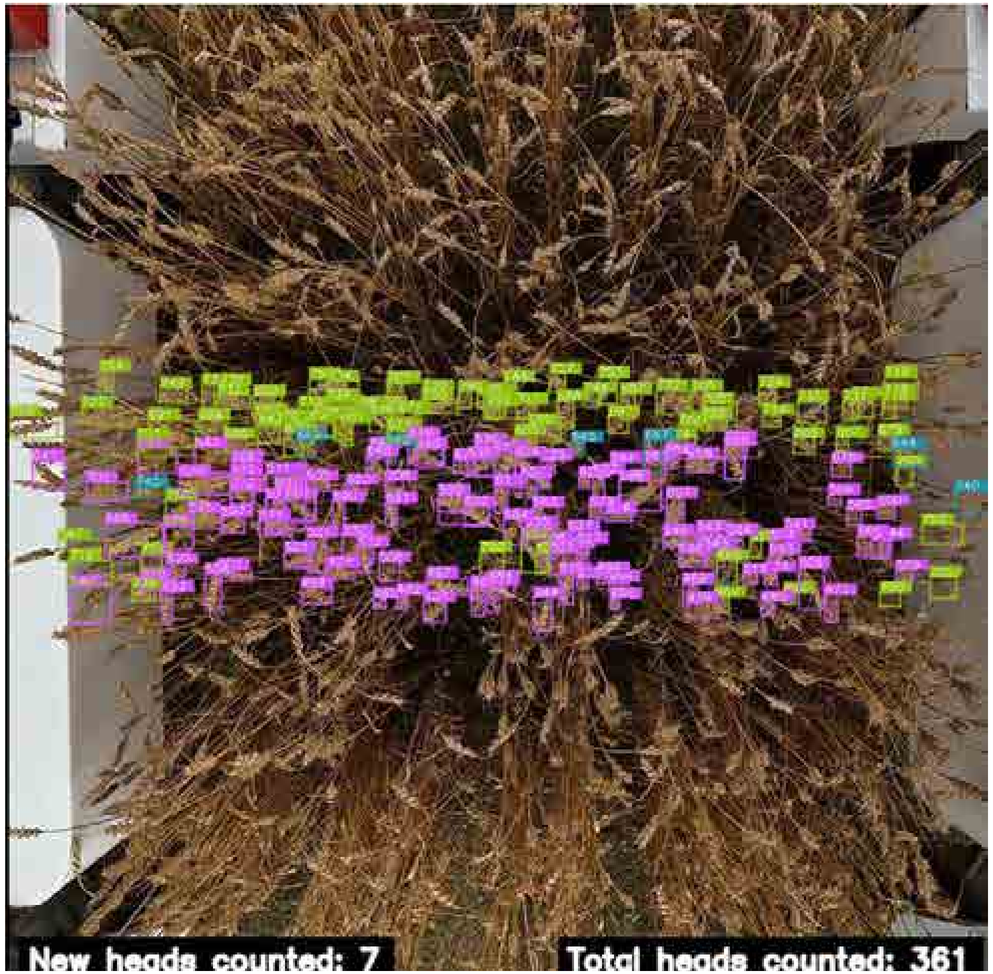


Global Wheat Head Dataset (GWHD)

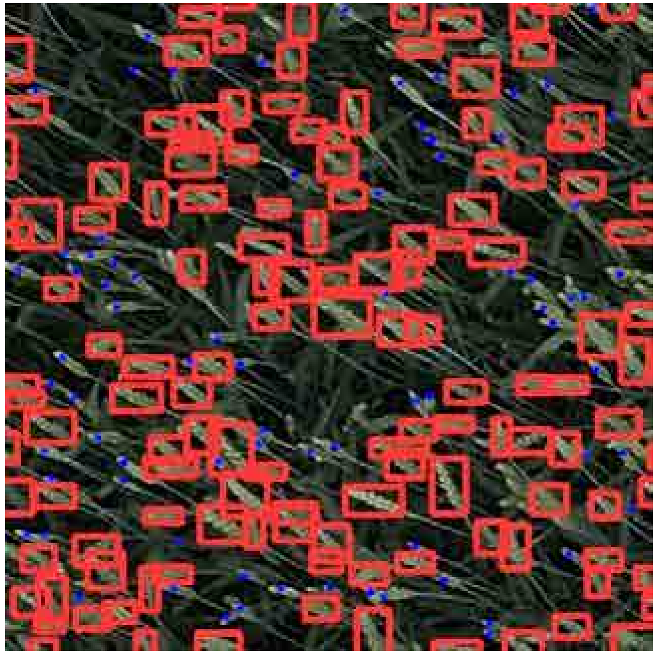


CNN and YOLO5

Can we make it on-the-og?



Applying YOLO5 model on drone images



Best Accuracy: 62%

Can we add another layer? FHB detection?

Data Collection & annotation

- Coco annotator to annotate the images
- Total of 700 images in the dataset

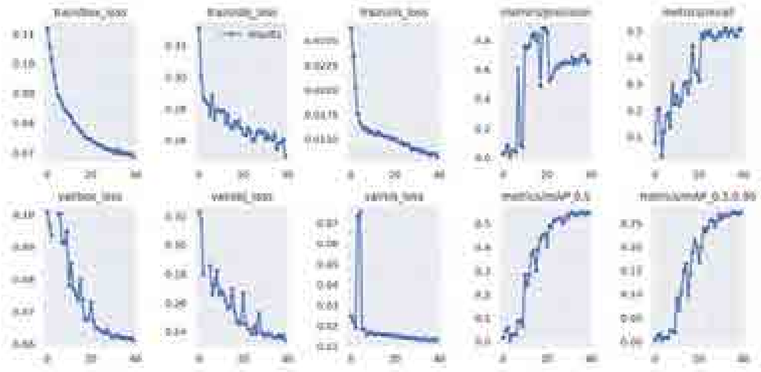
(25706 instance of wheat heads,

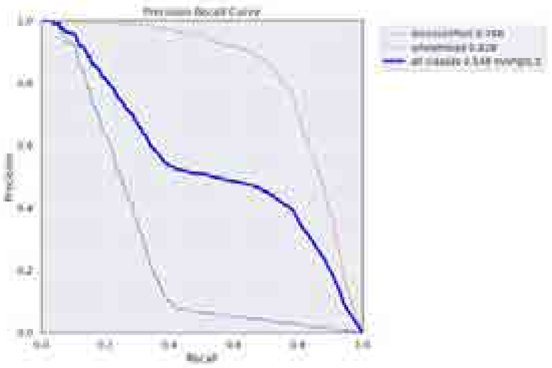
10866 instance of diseased parts)

- Splitting the dataset to train, validate and test (70%, 20%, 10%)



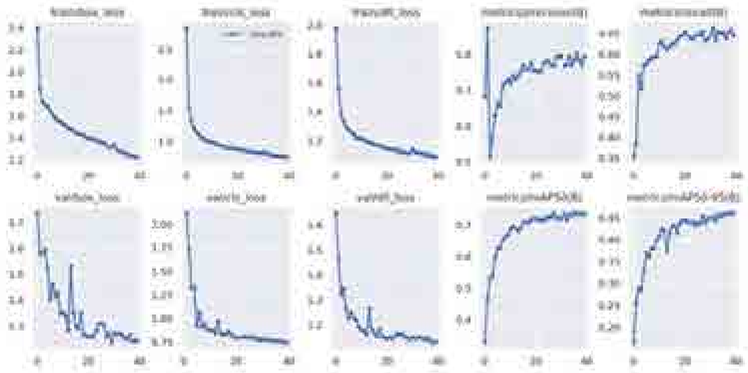
YOLOV5 and YOLOV8

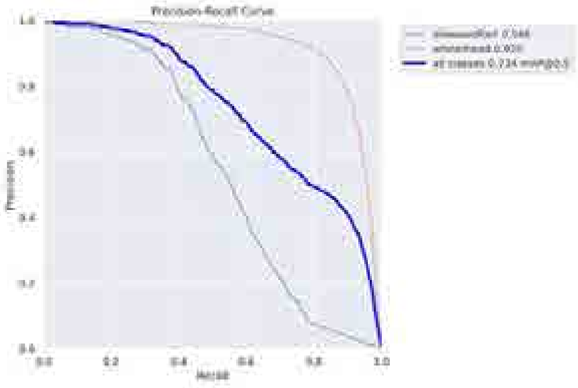




YOLOV 5

- 82% for wheat heads detection
- 26% for FHB detection

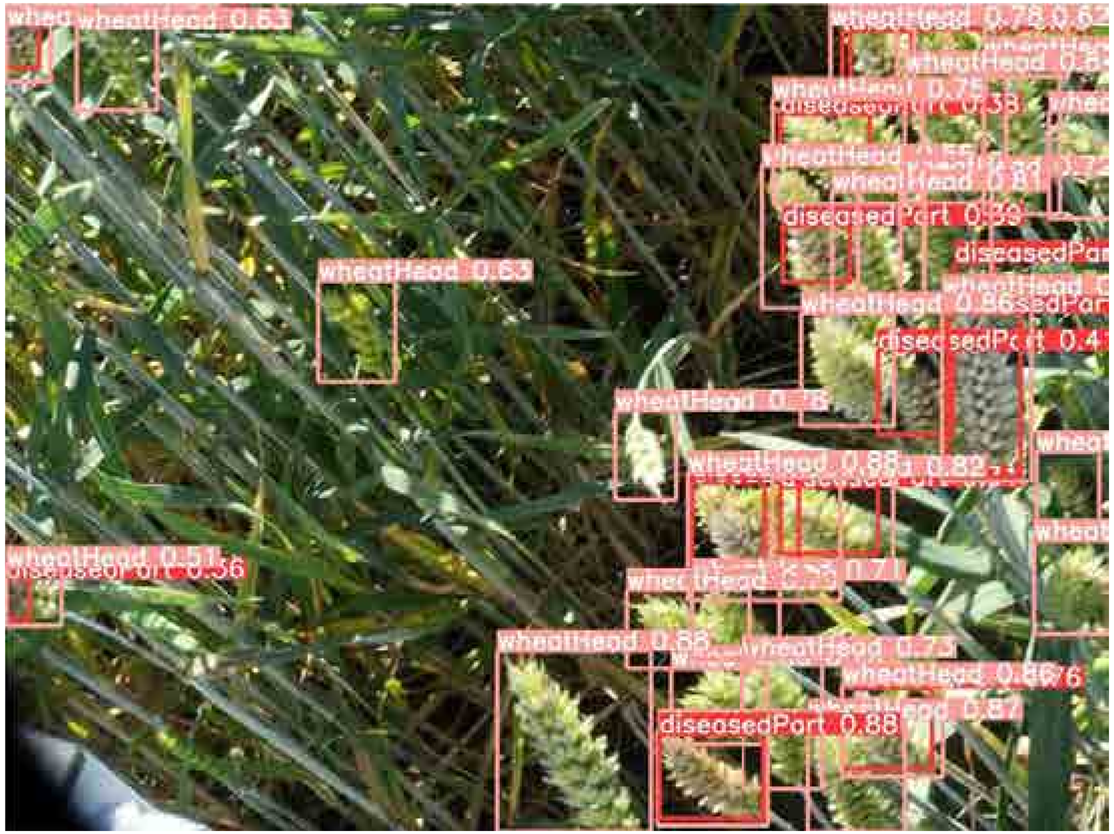




YOLOV 8

- 92% for wheat heads detection
- 54% for FHB detection

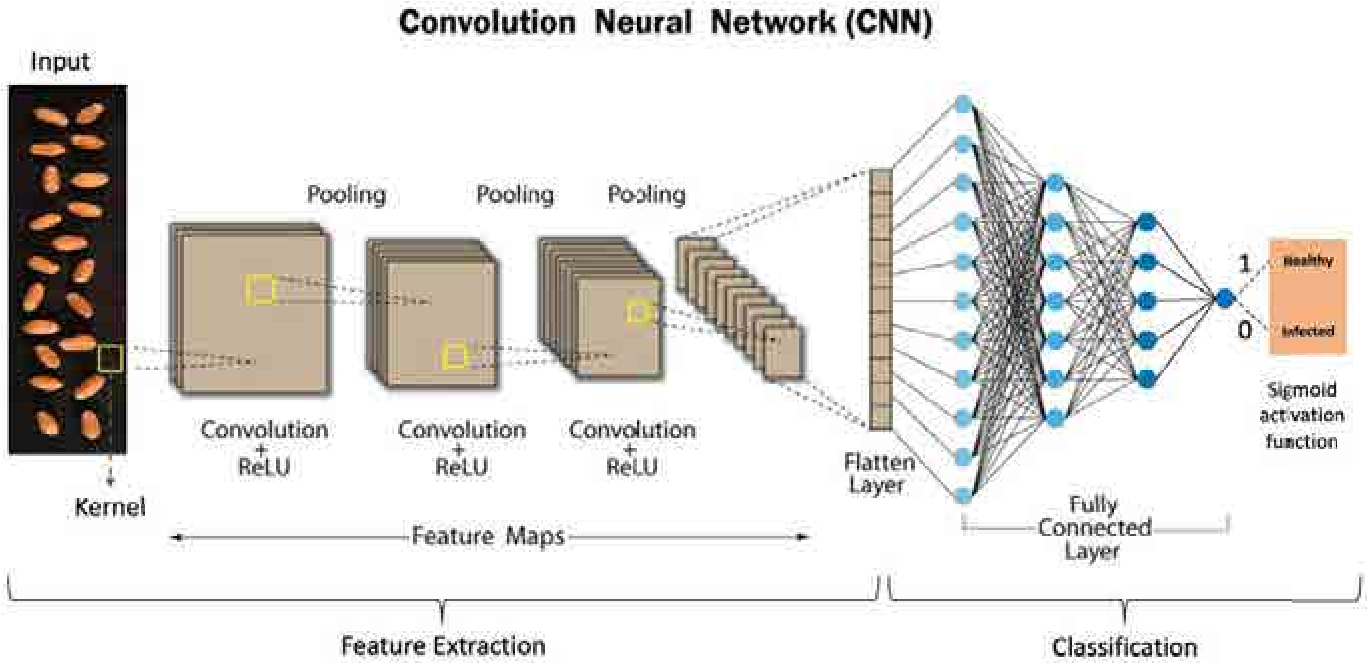
Testing both models' performance on the same image

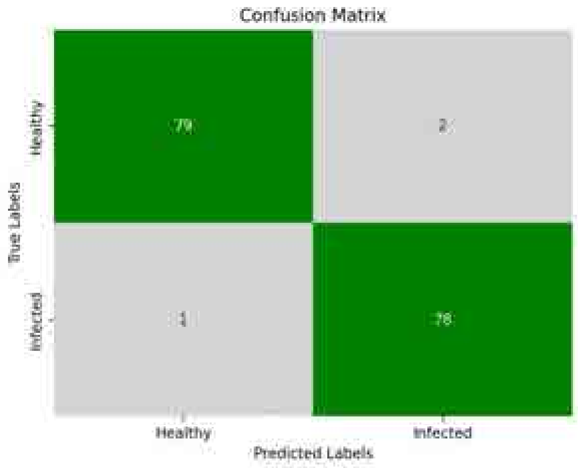


Yolov8

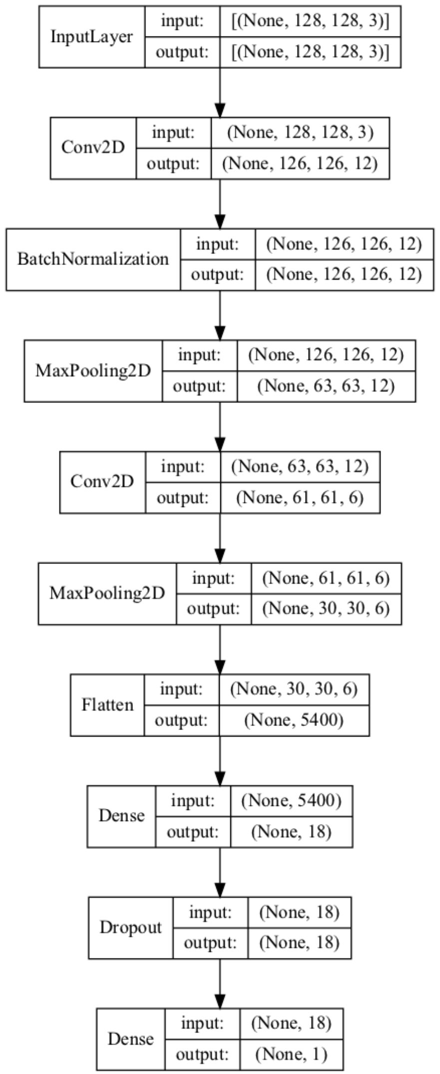
Yolov5

What about detection in seed level?

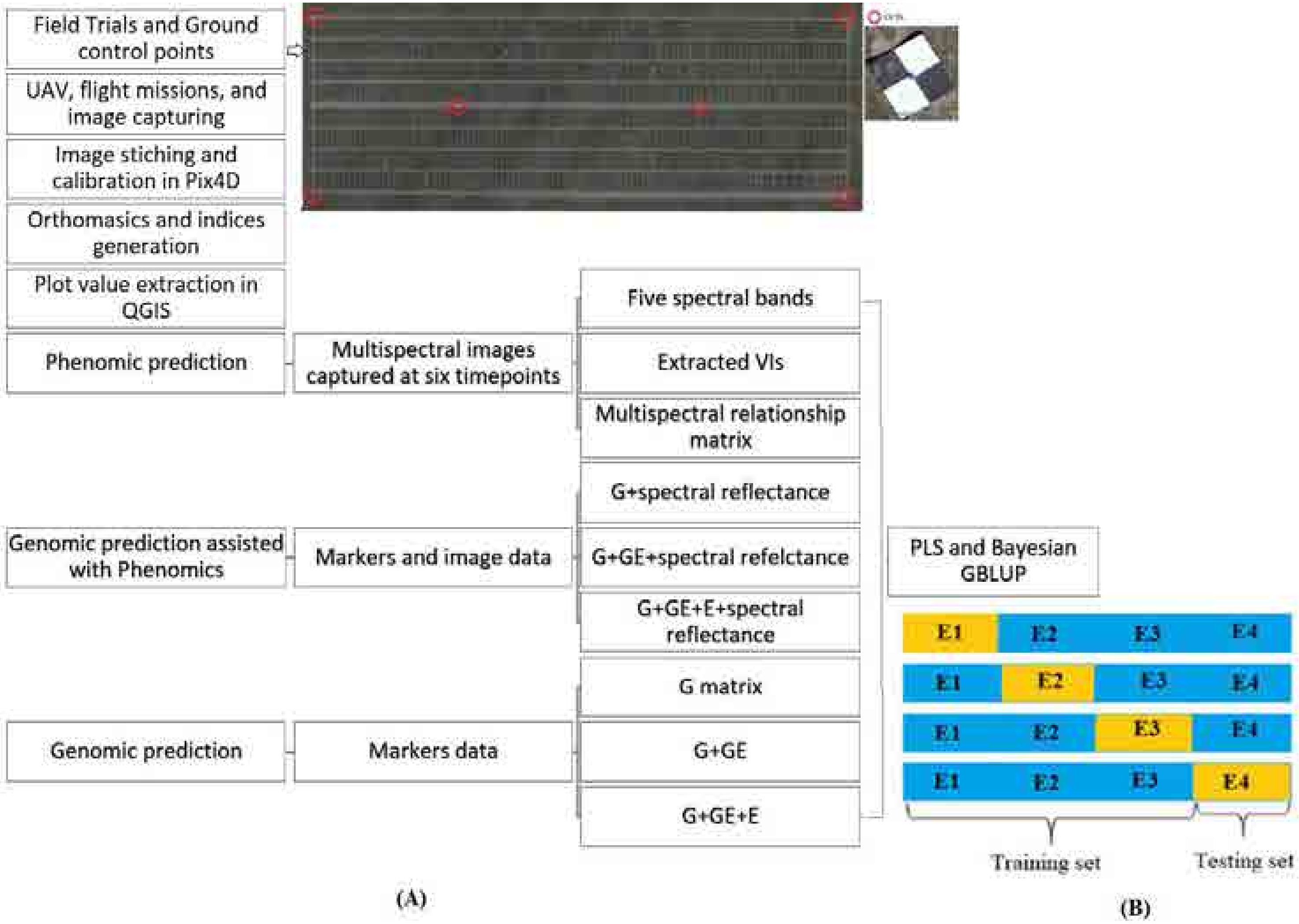




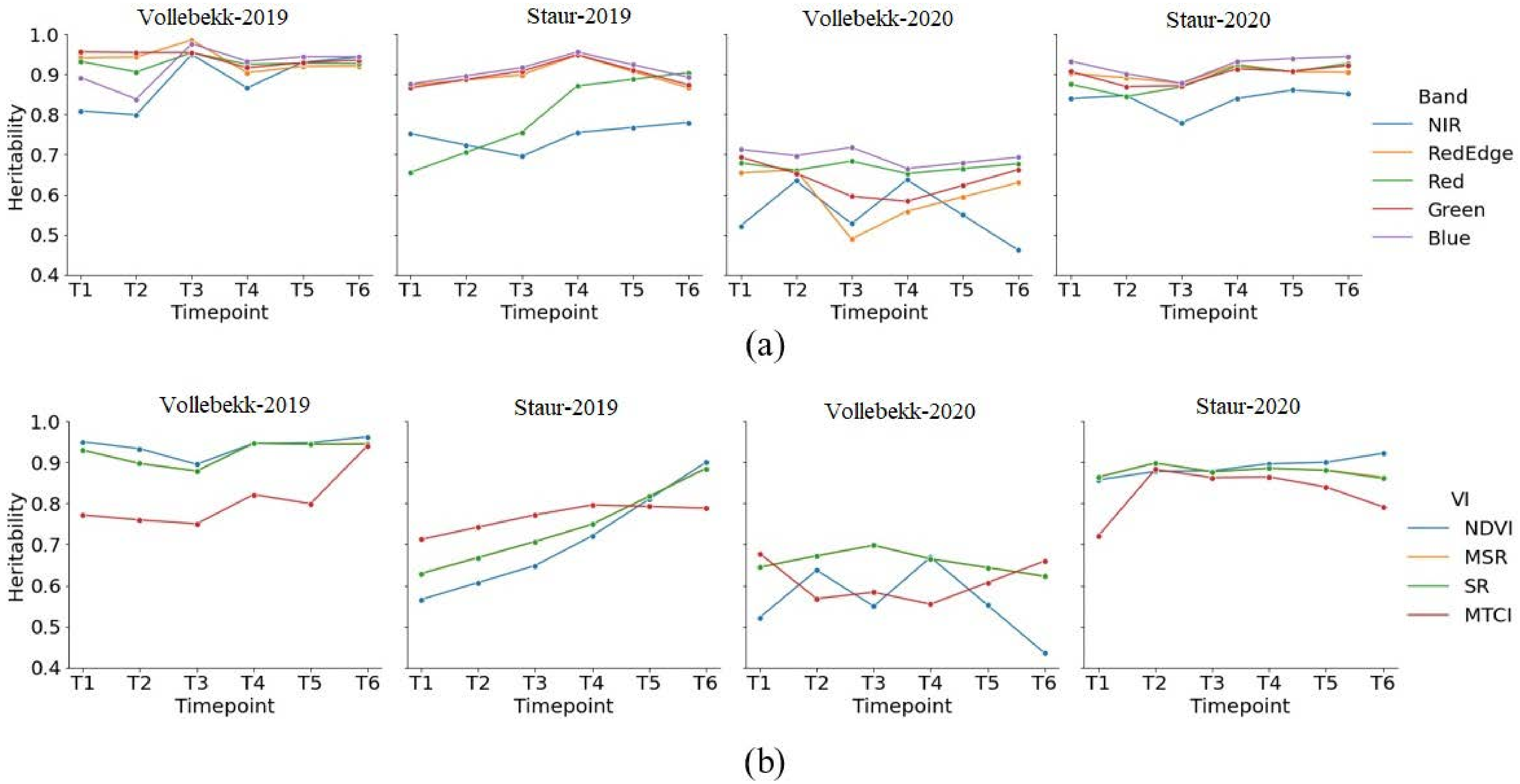
Condition	Precision	Recall	F1-score
Healthy	0.975	0.988	0.981
Infected	0.987	0.975	0.981

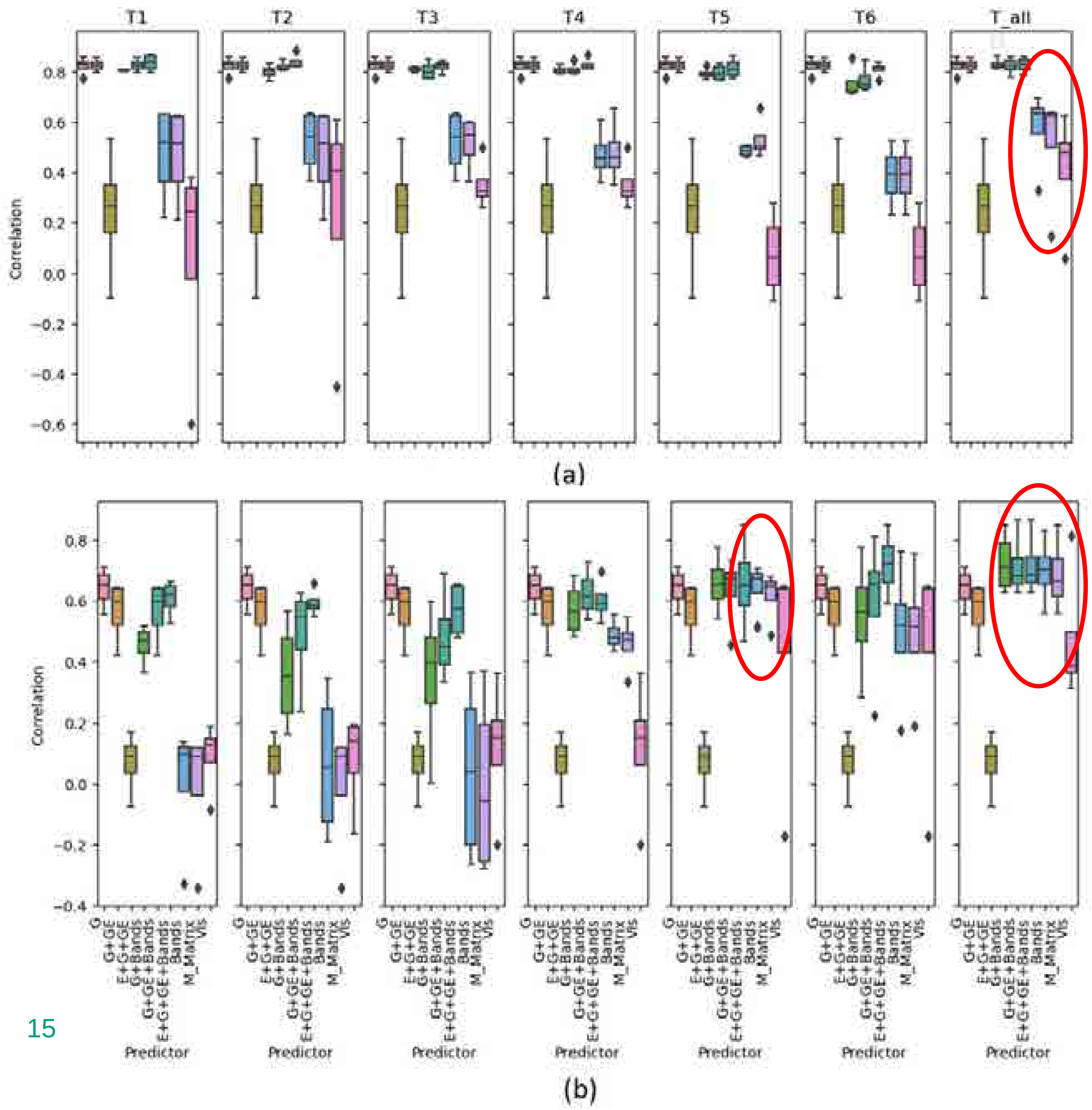


G2P? Genomic and Phenomic prediction



Looking into Herritability!





The genomic prediction (GP) results
for grain yield (GY) (a)
and days to maturity (DM) (b)

Future work

- How can we make the models robust?
- Explainable AI
- Hybrid models
- Feature engineering
- SmartWheat: Harnessing Al Models for Climate-Resilient Wheat Varieties in Sustainable Agriculture





Thank you for your attention

Questions?

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→ Håkon Bråten & Mathias Johan Dyrén
→ Norwegian University of Life Sciences
→ 26. november 2024

On the Go Wheat Head Counting Using Robotics and AI

A robot autonomously navigates fields,

counting wheat heads to predict yield and quality

Agenda

- → Introduction
- → Methods
  - → Equipment
  - → Navigation
  - → Wheat Head Counting
- → Results
- → Future work

Research questions

Can a robot autonomously navigate a row of wheats without making crop damaging mistakes using only an RGB camera?

Is it possible to use YOLOv5 and a counting algorithm to recreate the results of a human count without deviating significantly?

Equipment

GoPro Hero 11

RealSense D435

ROS

Thorvald

Navigation

Navigation

Data Collection

- Drove Thorvald in field
- Capturing diverse scenarios
- Total of 550 images

Navigation

Preprocessing

What should the model do?

- Segmentation mask
- Reference line

Train/Test/Validation 70/15/15

Data augmentation

PATH

VEGETATION

GROUND

Navigation

Deep Learning Model

Convolutional Neural Network (CNN) model

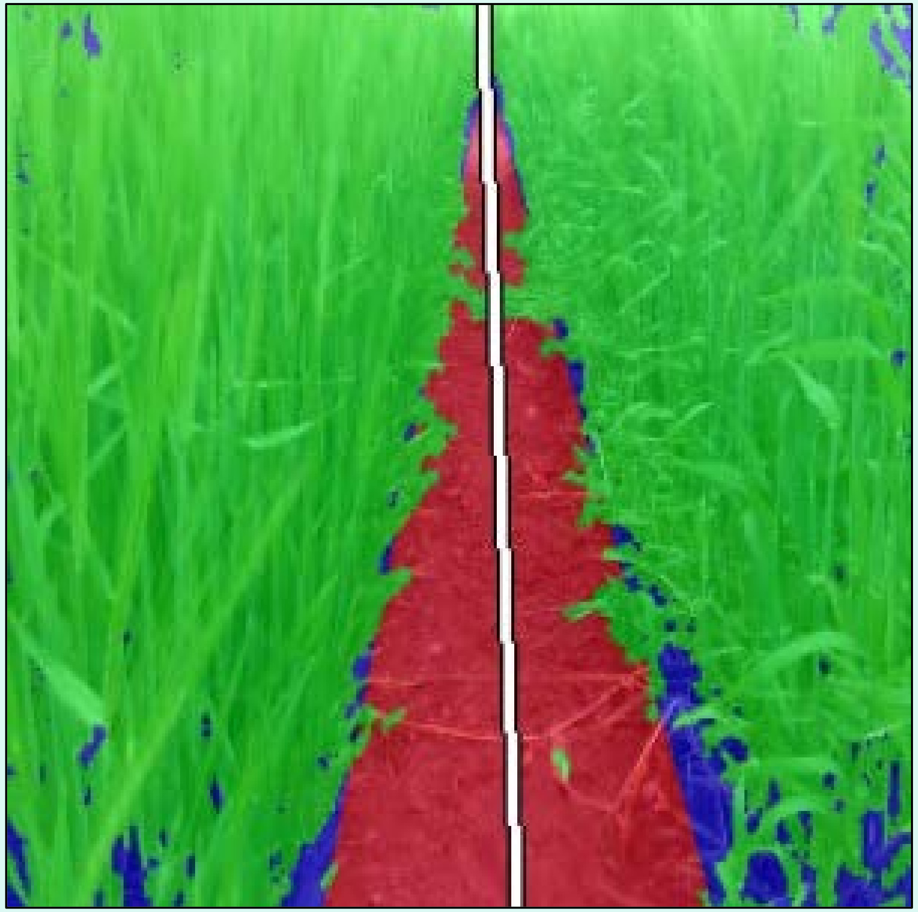
- DeepLabV3+ with ResNet50 backbone
- Atrous Convolutional Layer

Loss

- Sparse Categorical Crossentropy
- Mean Absolute Error (MAE)

Optimizer

- Adam (learning rate of 0.0001)



Goal of the model:

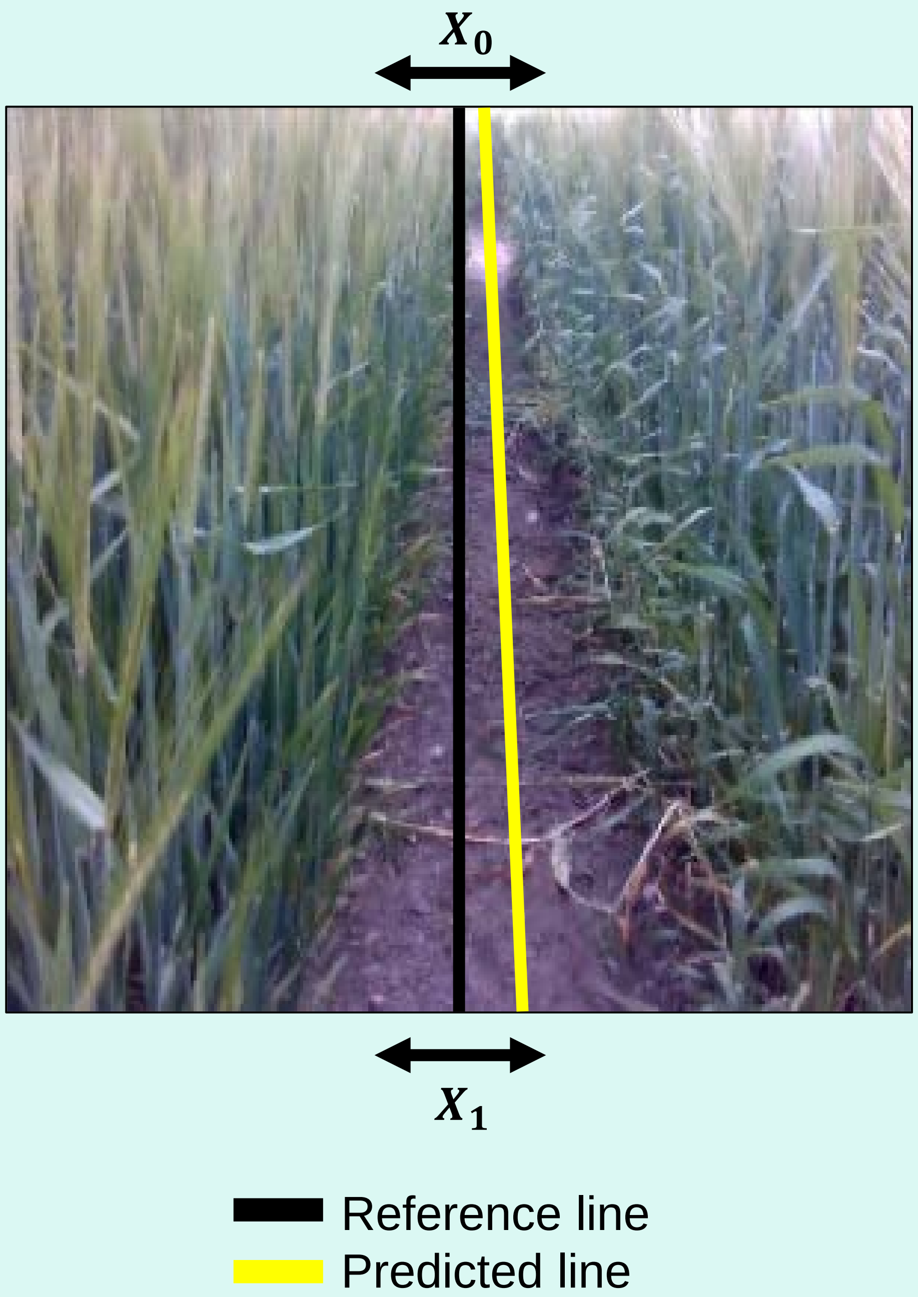
Predict reference line and segmentation mask to guide the robot's navigation

Navigation

Robot Controller

- Constant speed while adjusting turning angle
- X_0 and X_1 are the distances from the reference line to the predicted line at the top and bottom

Goal of the controller:
Adjust the robot's angular velocity to minimize these offsets, ensuring the robot stays on the detected path

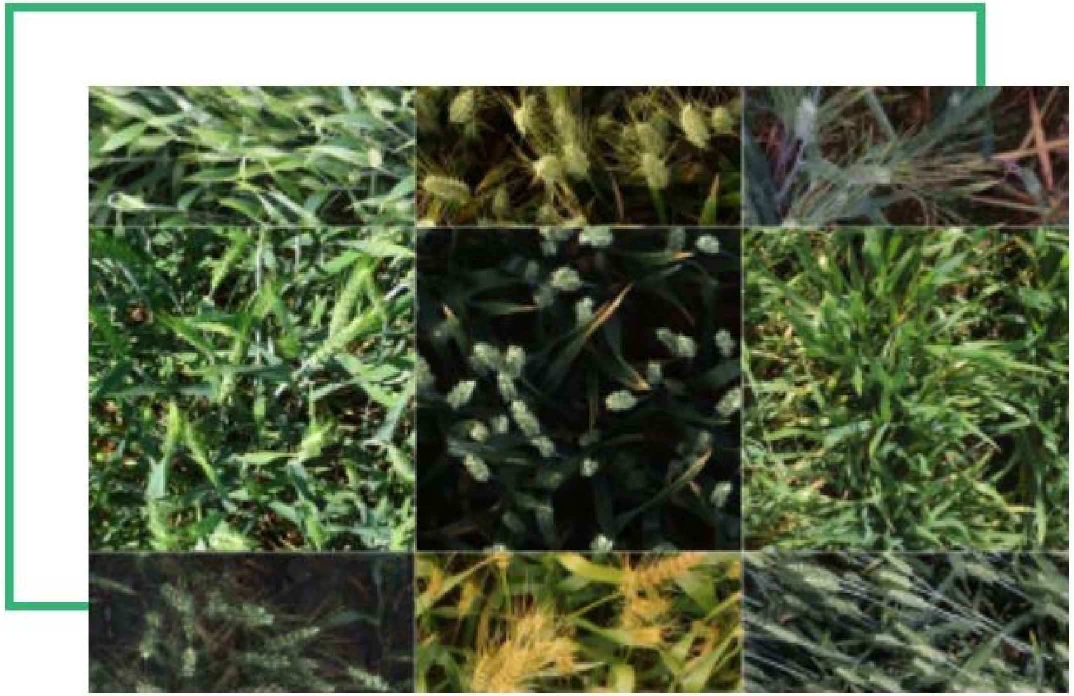


Wheat Head Counting

Wheat head counting

Detection

- **Global WHEAT Head Dataset 2021**
  - 6k+ images
  - 300k unique heads
  - Traning and test
- **Global WHEAT CHALLENGE 2021**
  - By University of Saskatchewan
  - Winning team: randomTeamName



GWHD 2021

Figure 1: Global Wheat Dataset, 2024, https://www.global-wheat.com/gwhd.html)

Global WHEAT CHALLENGE 2021

Figure 2: Global WHEAT CHALLENGE 2021, 2024, https://www.aicrowd.com/challenges/global-wheat-challenge-2021)

Location:
Vollebekk, Ås, Norway

- 96 plots (1.5 m × 6.5 m)
- 8 columns , 12 rows
- 24 spring wheat cultivars
- Different nitrogen fertilization levels

Wheat head counting

Algorithm

App: GoPro Quick

Start video when approaching plot

End once droven past

Video stored in camera and extracted afterwards

Wheat head counting

Algorithm

(3840x2160) resolution video

Cut to 2000x2000

Resize with max pooling

840x840

1000x1000

1200x1200

Wheat head counting

Algorithm

Detected

Tracking

Counting

Counted

Wheat head counting

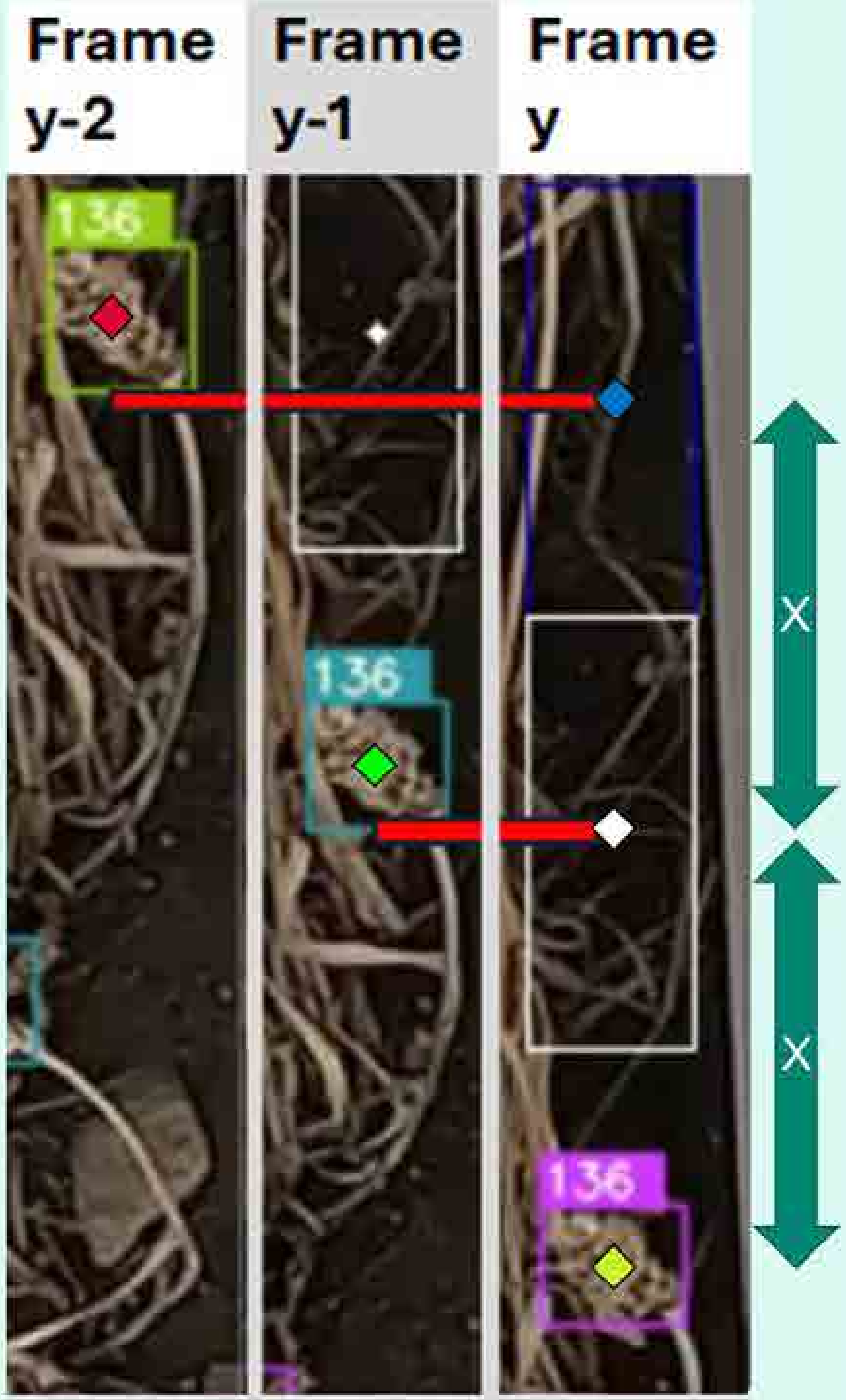
Algorithm

A new wheat is detected
Frame 0

In frame y – 1
DIST_Y1 =| ◆ - ◆ |
Goal:
Find wheat in frame Y-1
Within □ compare
With lowest DIFF

In frame y - 2
DIST_Y2 = | ◆ - ◆ |
Goal:
Find wheat in frame Y-2
Within □ compare
With lowest DIFF

Enherit ID
of wheat with lowest
DIST_Y1 + DIST_Y2



Wheat head counting

Algorithm – Special situations

No previous frame

No frame to check

Give ID won't count

Same ID given

Left get given ID 1 ,then right get given ID 1

Check which has the lowest distance to ID 1

Right was closest and gets given ID 1

Left will look for new ID except for 1

No wheat found in previous frame

No wheat is available within check zone

Gets a new ID