METRICS

THE AGRI-FOOD COMPETITION FOR ROBOT EVALUATION (ACRE)

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www.metricsproject.eu

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METRICS PROJECT

Matching supply and demand in AI and Robotics through competitions

METRICS objectives:

- Development of the Evaluation Framework
- Organization of 4 competitions: Healthcare, **Agri-food**, Inspection & Maintenance, Agile production
- Consolidation of the European Robotics and AI community

Evaluation Campaigns organization

- Two types of Campaigns

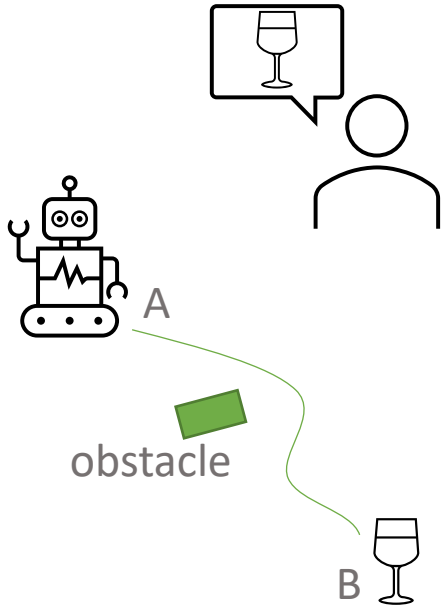
Field Campaigns

Cascade Campaigns

Functionality and Task Benchmarks

Task Benchmarks (TBM)

TBM-1: To fetch for a glass of water when asked



Functionality Benchmarks (FBM)

FBM-1: To understand fetching orders
FMB-2: To detect obstacles
…
FBM-n: To grab a drink

ACRE Competition

Agri-Food Competition for Robot Evaluation focuses on **autonomous weeding robots to reduce/eliminate the use of pesticides**

- Politecnico di Milano
- National Research Institute for Agriculture, Food and the Environment (INRAE)
- Università degli Studi di Milano
- National Laboratory of Metrology and Testing (LNE)

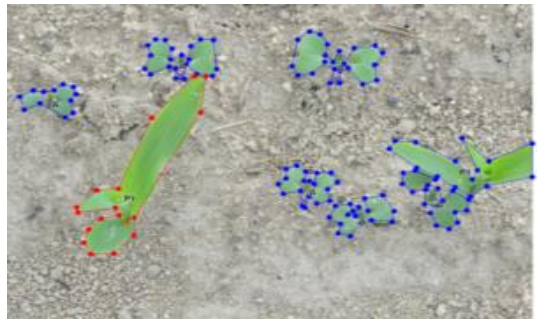
Why

Automatic **weed recognition** for:

- Precise pesticides treatments
- Mechanical or electrical

The ACRE Challenges (FBM & TBM)

- Robot **perception**
  - Plant Discrimination (FBM)
  - Leaf area estimation (FBM)
  - Biomass estimation (FBM)
- Robot **navigation**
  - Field Navigation (FBM)
  - Crop Mapping (TBM)
- Robot **actuation**
  - Weed destruction (FBM)
  - Intra-row Weeding (TBM)



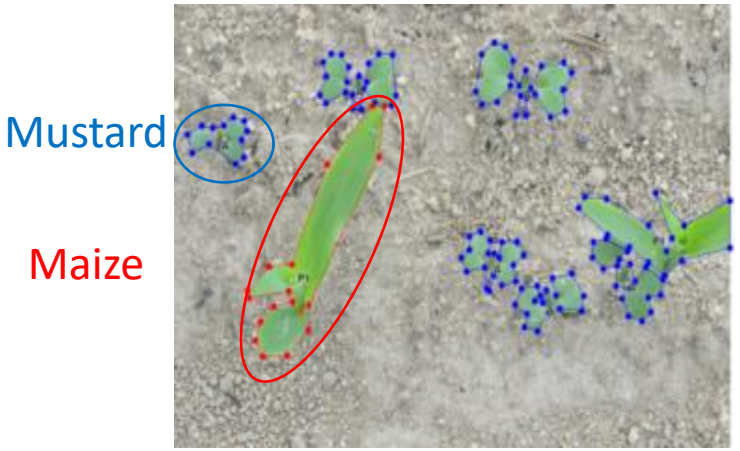
Manual annotation

Hypothesis : Mask return

Crops & weeds markers

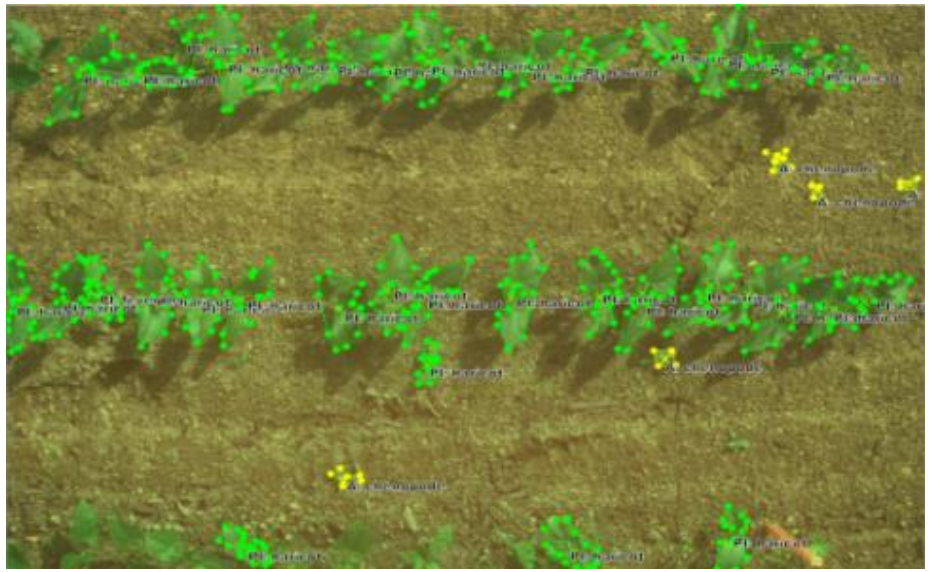
Plant Discrimination (FBM)

Goal: Detect which plants of an intra-row are weeds and which are crops.



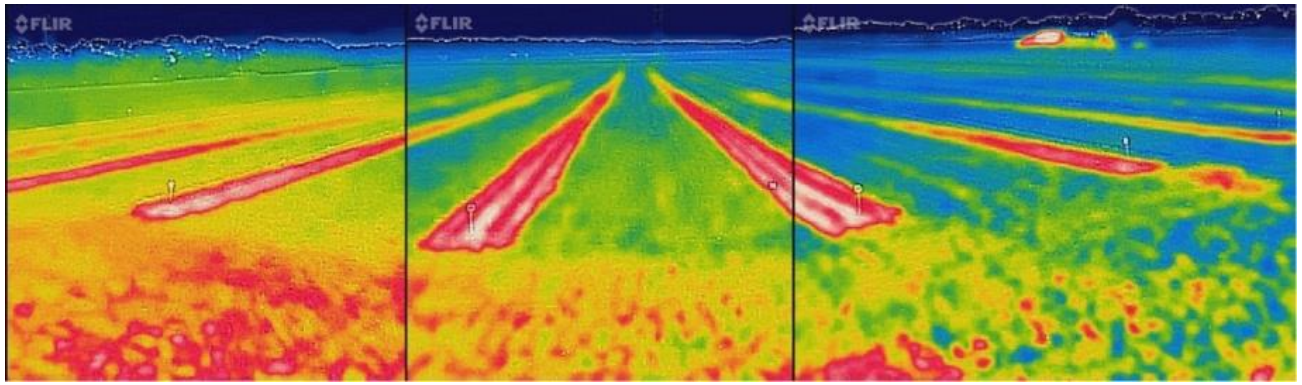
Leaf Area Estimation (FBM)

Goal: Estimate the Leaf Area of plants along a cultivated row.



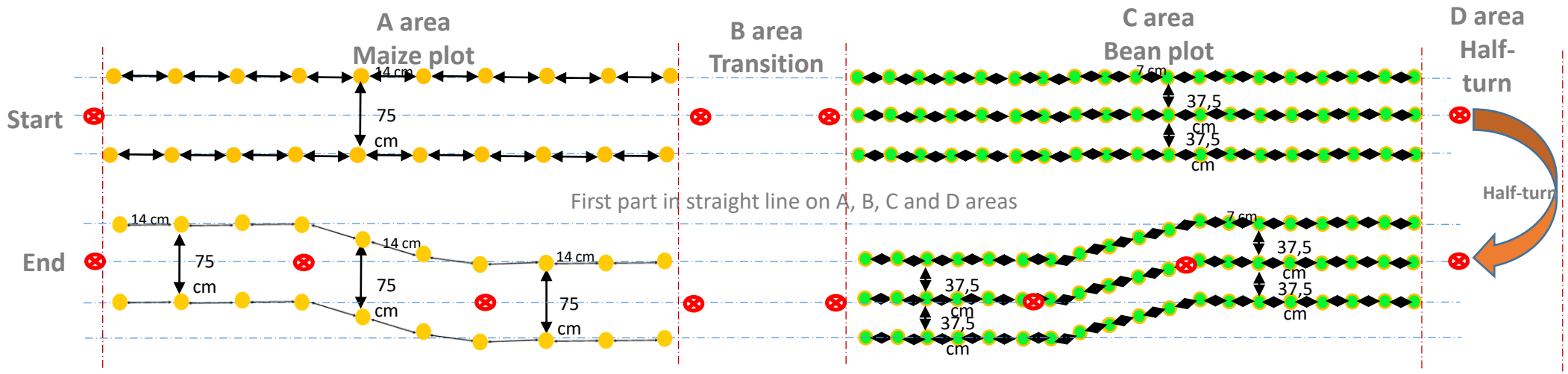
Biomass Estimation (FBM)

Goal: Estimation of the above-ground crop biomass



Field Navigation (FBM)

Goal: being able to navigate through rows of crops in a field, or other cultivated area without causing damage to the crop.

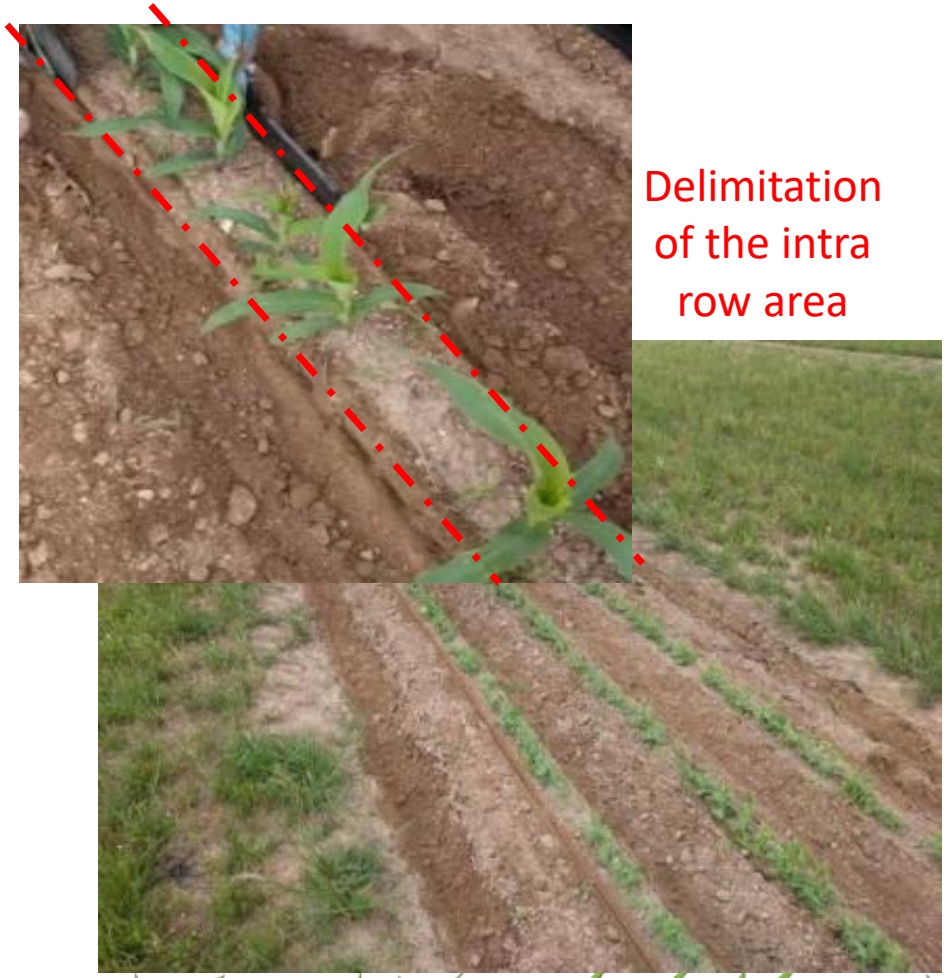


Weed Destruction (FBM)

Goal: Using intelligent weeding robots or smart implements to destroy intra-row weeds while not damaging the crop plants.

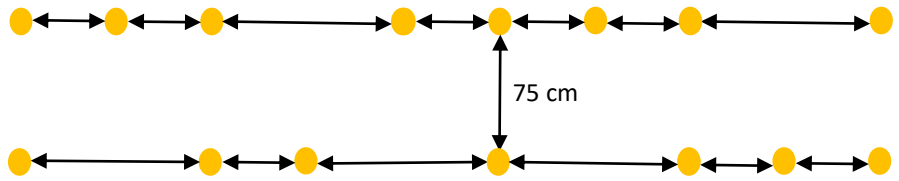
Intra-row Weeding (TBM)

Goal: Using intelligent weeding robots or smart implements, perform **fully autonomous** intra-row weeding to eliminate the weeds while not damaging the crop plants.

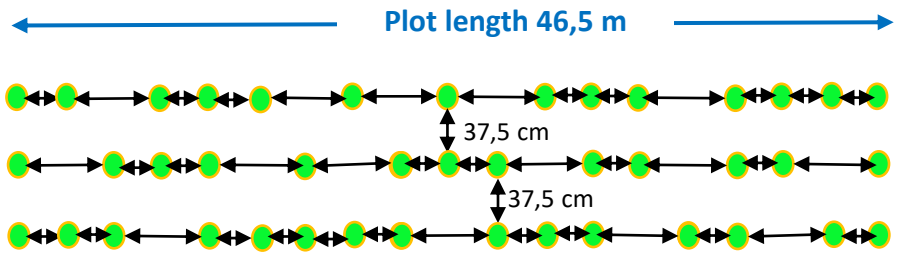


Crop Mapping (TBM)

Goal: Produce a map of a multi-row plot autonomously, by retrieving UTM coordinates of crop plants.



Maize plot with variable density



Bean plot with variable density

The ACRE First Field campaign

Open to teams from all around the world.

Focused on autonomous weeding robots to reduce or eliminate the use of pesticides.

Largest potential for environmental, societal and economic benefits.

Performance evaluation is based on objective benchmarks.

A Field Campaign in June 2022

(from June 6th to 10th)

More details and information on the benchmarks' execution in the Evaluation Plan online:
https://metricsproject.eu/agri-food/

The ACRE Field campaign

Organized from June 6th to 10th, 2022 (week 23)

On "AgroTechnoPôle" site of INRAE Montoldre (France)

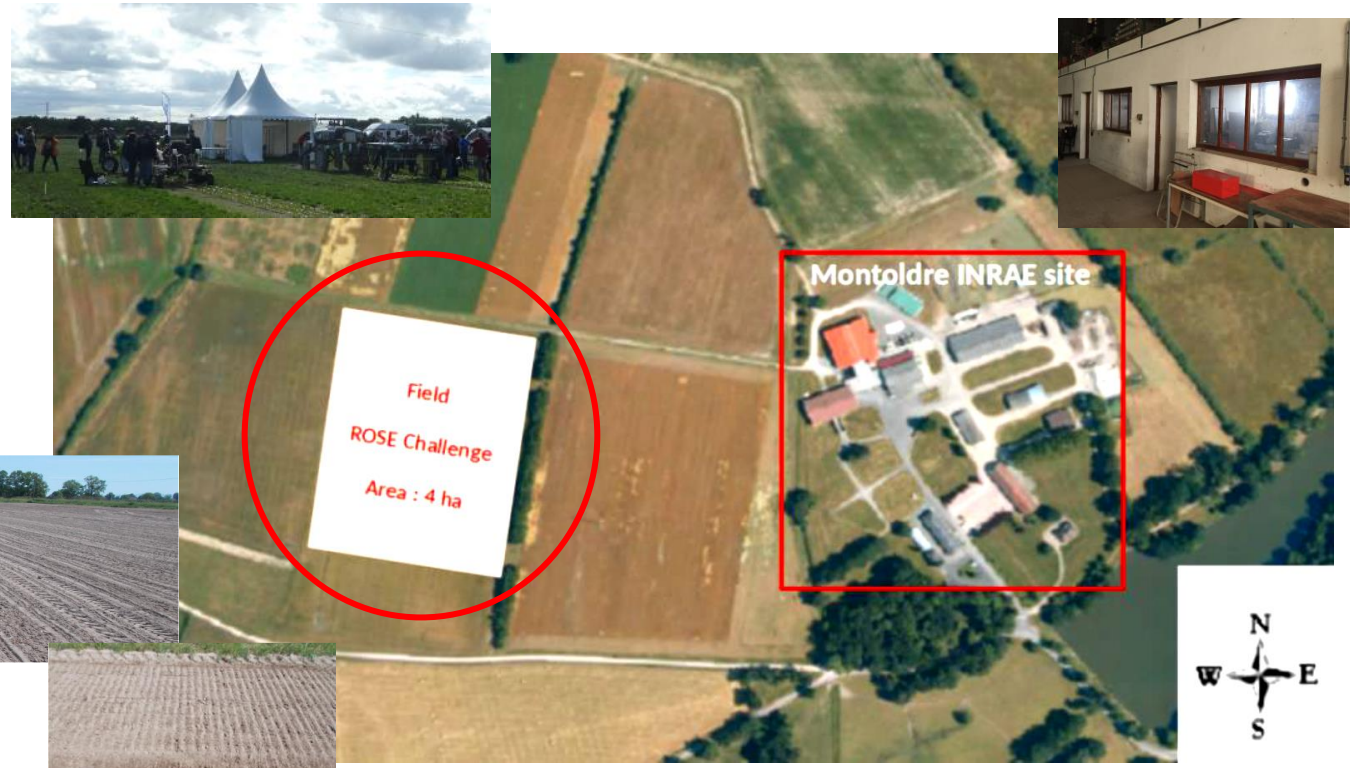
- **An experimental field** *(4 ha)*
  - conditions: sandy soil without stone
  - suitable for evaluation experiments in real conditions

  (testing new autonomous solutions: navigation, weeding, …)

- **Several technical buildings and halls**

  to welcome the participants with their equipment

  (prototype, autonomous solution, smart implement, robots, ...)



Aerial view of INRAE experimental field.

The ACRE Field campaign

The core: the experimental field

Soil work of the plot
(Homogeneity, aeration)

Preparation: a step with several important agricultural works to obtain optimal experimental conditions

Taking into account: agronomics and technical elements, weather conditions for a regularity, homogeneity and repeatability in the test plots

Plot leveling after sowing
(Surface uniformity)

Inter-rows weeding
(Intra row width adjust)

Seedbed preparation with heat treatment

Sowing of crops and weeds at the same time

Watering of the sown plots
(Emergence regularity of crops and weeds)

The ACRE Field campaign

A network of observation sensors: information about the actual conditions in the experimental field…

Observation measure point *(Copeeks)*

Scheduled image capture *(Timelapses, growing crops)*

Raspberry case *(INRAE)*

INRAE site (Davis)

In the field (Sencrop)

Weather stations

The ACRE Field campaign

An experimental field with crops and weeds sown

- **Two main crops:**
  - **Maize:** *(field great crop)*
    - inter-row spacing : 75 cm,
    - intra row spacing between plant : 15 cm
  - **Bean:** *(field vegetable crop)*
    - inter-rows : 37,5 cm
    - intra row spacing between plant : 7 cm
- **Four main weeds:**
  - **With horizontal development** *(spread out)*
    - Model weed: **mustard**
    - Natural weed: **matricaria**
  - **With vertical development** *(erected port)*
    - Model weed: **ryegrass**
    - Natural weed: **chenopodium**

Sowing density: - Model: take into account thousand grain weight, 27 seeds/ml
- Natural: preconisation of Arbiotech/100 ml or 10 m^2

Two main crops

Four main weeds

The ACRE First Cascade Campaign

The task: segment RGB images to distinguish between crop, weeds, and background.

The First Cascade Competition was focused on the use of **domain adaptation techniques**.

Organized as a three-stage Competition

- **Development:** in this stage, participants are asked to perform semantic segmentation with a training/test set collected in 2019.
- **Generalization:** in this stage, participants are asked to submit predictions of the new unlabeled test set collected in 2021 by exploiting domain adaptation techniques.
- **Final:** in this stage, participants are required to submit predictions of the final test set with images collected in 2021.

Dataset

Data for the 1st ACRE Cascade Campaign was from ROSE Challenge where 4 teams competed with different robots.

	Development stage	Generalization stage	Final stage
Training_Dev_2019	• *448 Images* • *448 Masks*	• *448 Images* • *448 Masks*	• *448 Images* • *448 Masks*
Test_Dev_2019	• *52 Images*	• *52 Images* • *52 Masks*	• *52 Images* • *52 Masks*
Test_Gen_2021	• *16 Images*	• *246 Images*	• *246 Images*
Test_Final_2021	• *HIDDEN*	• *HIDDEN*	• *252 Images*

3 Winning categories: 1 global, 2 regarding crops (maize and bean)

SCORING

Participants evaluated on the Intersection over Union (IoU)

$$IoU_{crop} = \frac{TP_{crop}}{TP_{crop} + FP_{crop} + FN_{crop}}$$

$$IoU_{weed} = \frac{TP_{weed}}{TP_{weed} + FP_{weed} + FN_{weed}}$$

$$IoU = \frac{IoU_{crop} + IoU_{weed}}{2}$$

Development Phase Results

Results							
#	User	Entries	Date of Last Entry	Team Name	Global IoU ▲	Global IoU Bean ▲	Global IoU Maize ▲
1	ru_willow	8	04/02/22		0.83 (2)	0.82 (1)	0.83 (2)
2	Rich_Li	3	04/04/22		0.83 (1)	0.82 (2)	0.84 (1)
3	SoleMiao	5	04/04/22		0.83 (1)	0.82 (2)	0.84 (1)

Generalization Phase Results

Results							
#	User	Entries	Date of Last Entry	Team Name	Global IoU ▲	Global IoU Bean ▲	Global IoU Maize ▲
1	Rich_Li	1	04/30/22		0.68 (1)	0.67 (1)	0.69 (1)
2	ru_willow	3	05/17/22		0.63 (2)	0.60 (2)	0.66 (2)
3	xindima19980501	12	04/20/22		0.42 (3)	0.39 (3)	0.44 (4)
4	johnny_373	4	04/25/22		0.41 (4)	0.38 (4)	0.44 (3)

Final Phase Results

Results							
#	User	Entries	Date of Last Entry	Team Name	Global IoU ▲	Global IoU Bean ▲	Global IoU Maize ▲
1	ru_willow	3	05/20/22		0.69 (1)	0.69 (1)	0.68 (2)
2	Rich_Li	1	05/18/22		0.69 (2)	0.68 (2)	0.69 (1)
3	SoleMiao	1	05/20/22		0.62 (3)	0.54 (3)	0.68 (2)
4	johnny_373	3	05/19/22		0.42 (4)	0.40 (4)	0.43 (3)
5	xindima19980501	6	05/20/22		0.34 (5)	0.31 (5)	0.36 (4)

Global winner: ru_willow

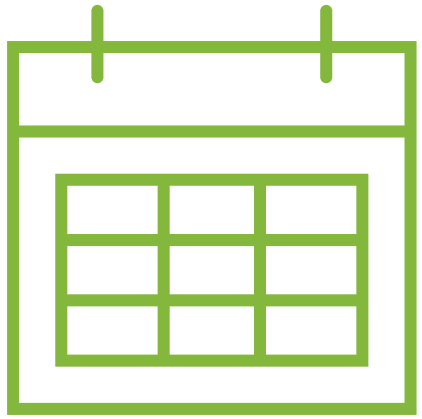
Bean winner: ru_willow

Maize winner: Rich_Li

What's Next?

The next **ACRE activities:**

- June '22: ACRE 1st Field Campaign @ Montoldre (France)
- Sep./Oct. '22: 2nd ACRE Cascade Campaign
- May '23: ACRE 2nd Field Campaign @ Cornaredo (Italy)



Drop us an **email to get updated**: acre@metricsproject.eu

Check **METRICS website**: https://metricsproject.eu/agri-food/

THANK YOU

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