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Digital tools to support in-field assessments of efficacy trials

Case study: assessment of foliar disease in cereals

EPPO Workshop, Ede, NLs, June 2022

Digital Assessments in R&D Field Trials

What

- Increase accuracy of the assessments & reduce subjectivity of human assessments
- Enable higher assessment frequency & faster reporting
- Gain information before appearance of visual symptoms & establish new assessments

How

- "Robust" algorithms
- Digital tools:
  Efficient system to capture, pre-process images, hosting models and reporting
  Integrated in the execution of field trials
- Easy-to-use multi spectral cameras

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Algorithm portfolio

Examples

Counting Insects at leaf level

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Target: Organism: BEMITA (adults IV-IV), FRANOC (adults), FRANOC (nymphs), MYZUPE & APHIGO Part of the plant: Leaf (BX, BU) Crops Validated crops: SOLME & LYPES Other crops: available, but to be validated Sensor Handheld device: Smartphone or digita...

Weed Assessment

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Target: Organism: Broad leaf weeds & Grasses Part: Plot level Assessment: % coverage & % herbicide injury by organism. Crops Validated crops: Soybean (GLXMA) Corn (ZEAMX), Sunflower (HELAN) Other crops: available, but to be validated Sensor Handheld...

Diseases Assessment at leaf level (Handheld device)

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Target: Organism: several diseases (SEPTTR, PUCCC, etc) Part: Leaf level (B1, B2, B3, BX, BU) Assessment: % infection by disease. Crops Validated crops: Wheat, Barley, Cucumber, grapes, corn Other crops: available (rice, OSR), but to be validated Se...

Wheat Diseases (Drone)

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Target: Organism: SEPPTR, PUCCRT, PUCCST Part of the plant: B1, B2, B3, BX. Prediction of leaf layers per plot Crops Validated crops: Wheat TRZAW Sensor Multispectral sensor (Micasense RedEdge MX) in a multicopter drone Deployed in: iQarus Status Al...

LEPTMA in OSR

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Target: Prediction of % infection of LEPTMA at stem / root neck (transversal cut) Organism: LEPTMA Leptosphaeria maculans ; anamorph : Phoma lingam : Part of the plant: HS (stem), WC (root neck) Crops Oil Seed Rape / Canola BRSNW, BRSNS... Se...

LAI. Leaf Area Index using multi-spectral cameras with drones

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Prediction of Leaf Area Index using multispectral cameras from drones Target: Organism: NNNNN (crop) Part of the plant: TPLOT (Plot) Assessment: Assessment Method: LEPTMA / YPFFRA / P%INF / HS or WC / UNIT Crops All Sensor Multispectral camera (Mica...

PHYEVI Feeding damage Flea Beetle in OSR

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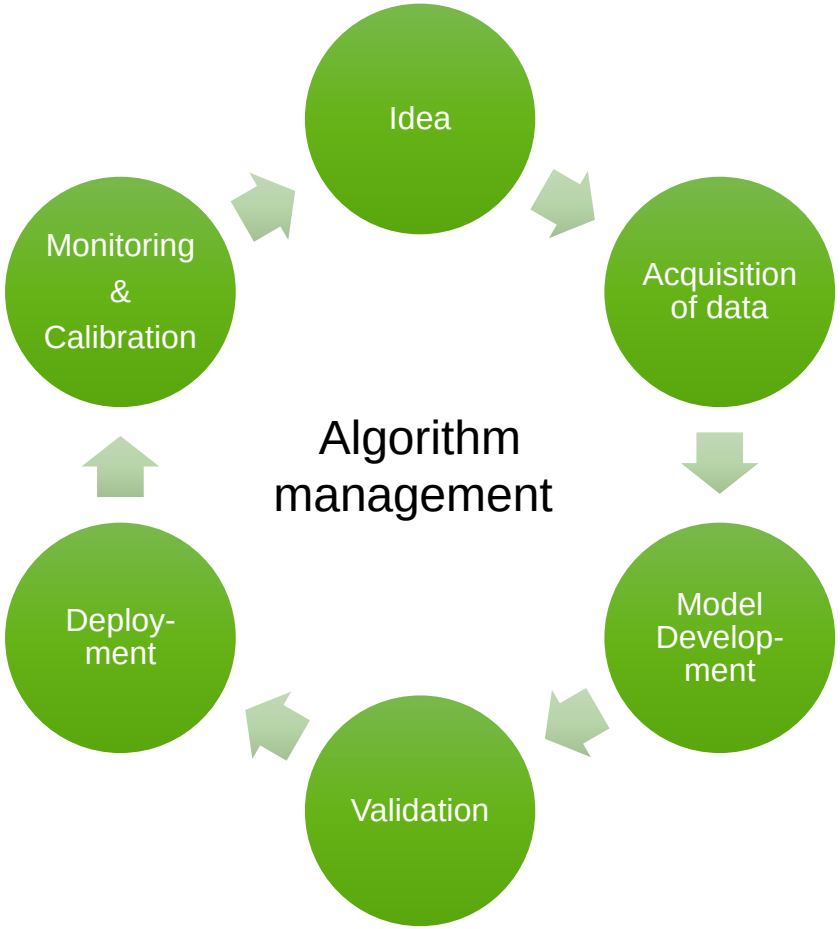
Prediction of % of Feeding damage produced by PHYEVI in OSR at early stages of the crop. Plot pictures Target: Organism: PHYEVI Part of the plant: PX (Plant) Assessment: % infection by HS / WC. Crops Oil Seed Rape / Canola BRSNW, BRSNS, Growth stage...

Algorithm development

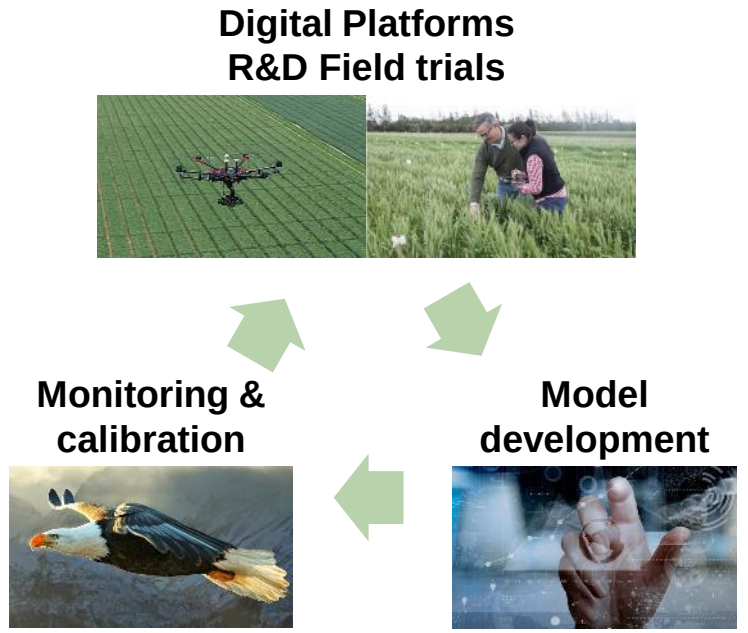
Process



Multi disciplinary team

- Agronomic expertise
- Capabilities on deep learning (internal & external)
- IT & Hardware (Sensor & equipment)

Tools



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Disease assessment at foliar level – Idea

Define the use case: prediction's outcome, part of the plant rated, accuracy / benchmark

- Prediction of % infection at foliar level by disease
- Target:
  - Organisms & Crops (selected list) Wheat, Cucumber, Grapes
  - Part of plant rated: Leaf
  - Assessment: % Infection
- Sensor:
  - Smartphone & Digital Camera
  - Drone (another project)

Examples

Step	Crop	Disease	Name Scientific	Plant Part
First Step: Cereals	TRZAW	SEPTTR	*Zymoseptoria tritici*	Leaf (BX, B1, B2, B3)
	TRZAW	LEPTNO	*Septoria nodorum (Parastagonospora nodorum)*	Leaf (BX, B1, B2, B3)
	TRZAW	PUCCST	*Puccinia striiformis*	Leaf (BX, B1, B2, B3)
	TRZAW	PUCCRT	*Puccinia recondita*	Leaf (BX, B1, B2, B3)
	TRZAW	PYRNTR	*Drechslera tritici-repentis*	Leaf (BX, B1, B2, B3)
Second Step: Specialty crops	CUMSA	SPHRFU	*Sphaerotheca fuliginea*	Leaf (BX)
	VITVI	PLASVI	*Plasmopara viticola*	Leaf (BX)
	VITVI	GUIGBI	*Guignardia bidwellii*	Leaf (BX)

Disease assessment at foliar level – Data acquisition

Selection sensor / equipment / Describe SOP / Creation of a data set

- Standard Operation Procedure (SOP) to take the picture
  - Adjust Field of View (FoV) to the leaf area
  - Try to maintain the leaf as flat as possible
  - Search for homogeneous illumination
  - Search for right focus
- Assessments / Ground Truth
  - Align assessment method with the target
- Ensure quality
  - Variability: Pictures from different sites / technicians which should represent the reality
  - Balanced data sets: having a balanced data representing low – medium – high disease

Disease assessment at foliar level – Model development

Data set preparation (annotation) / Selection of algorithm type / Target accuracy

- Data set preparation:
  - Field trial researchers to label with the ground truth (%INF at leaf level)
  - Check the quality of the data
    - Data set shows variability
    - Balanced data set
    - Annotation quality: to determine the quality of the technician
- The label / annotation quality has a high impact on the accuracy of the algorithm

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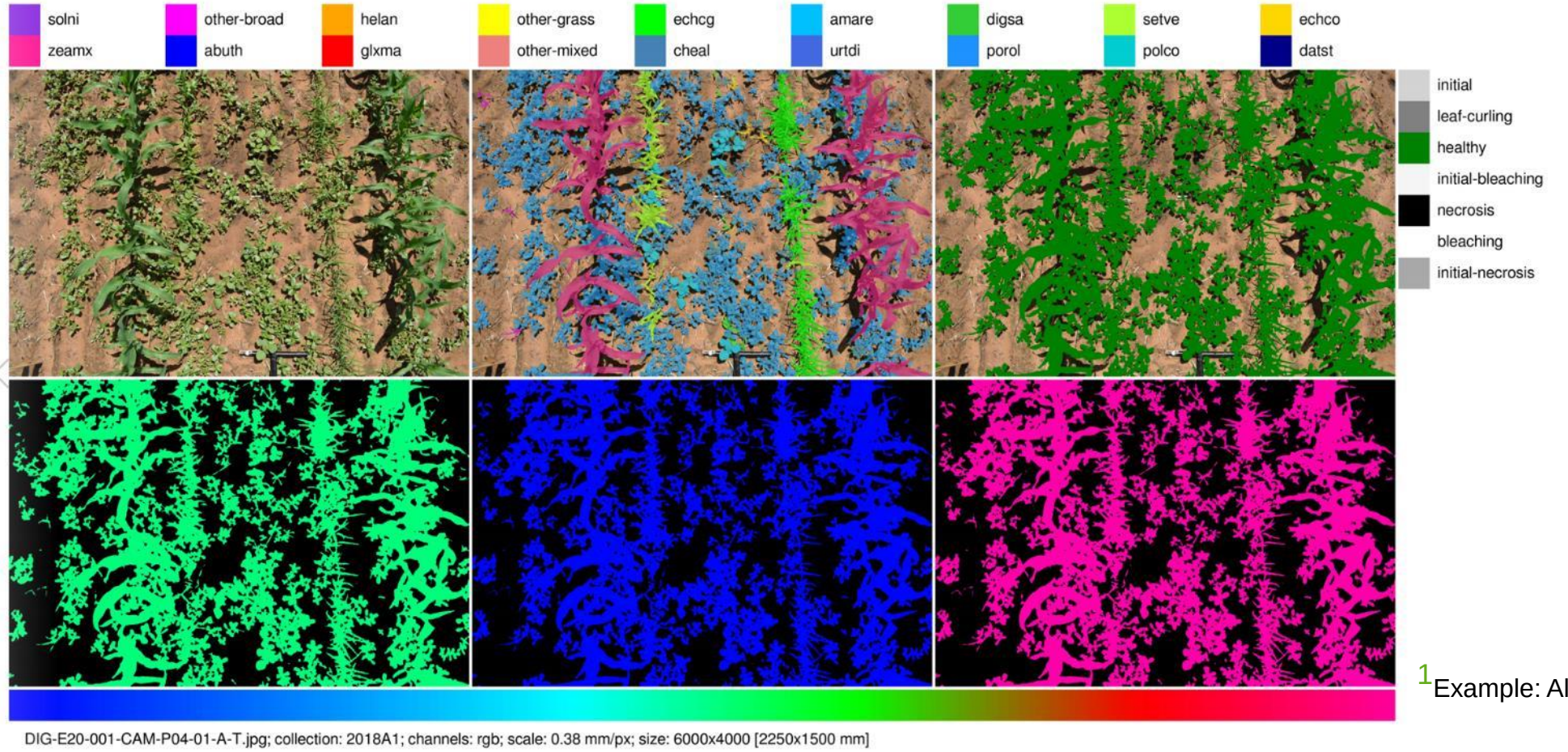
Disease assessment at foliar level – Model development

Annotation can be a time intensive task which requires a high agronomic knowledge[1]



[1]Example: Algorithm for herbicide trials

Disease assessment at foliar level – Model development

Data set preparation (annotation) / Selection of algorithm type / Target accuracy

The case requests 3 different models

- Identify the leaves → Segmentation model
- Classify the disease in the leaf → Classification model
- Quantify the disease → Regression model

Phase 1

Phase 2

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Model approaches Scientific paper

- Part of the work performed during the development of the algorithm supported the publication of a scientific paper in “**frontiers** in Plant Science”

frontiers in Plant Science

ORIGINAL RESEARCH
published: 07 March 2022
doi: 10.3389/fpls.2022.813237

Analysis of Few-Shot Techniques for Fungal Plant Disease Classification and Evaluation of Clustering Capabilities Over Real Datasets

Itziar Egusquiza[1,2], Artzai Picon[1,2], Unai Irusta[2], Arantza Bereciartua-Perez[1], Till Eggers[3], Christian Klukas[3], Elisabete Aramendi[2] and Ramon Navarra-Mestre[3]*

[1] TECNALIA, Basque Research and Technology Alliance (BRTA), Parque Tecnológico de Bizkaia, Derio, Spain, [2] University of the Basque Country, Bilbao, Spain, [3] BASF SE, Limburgerhof, Germany

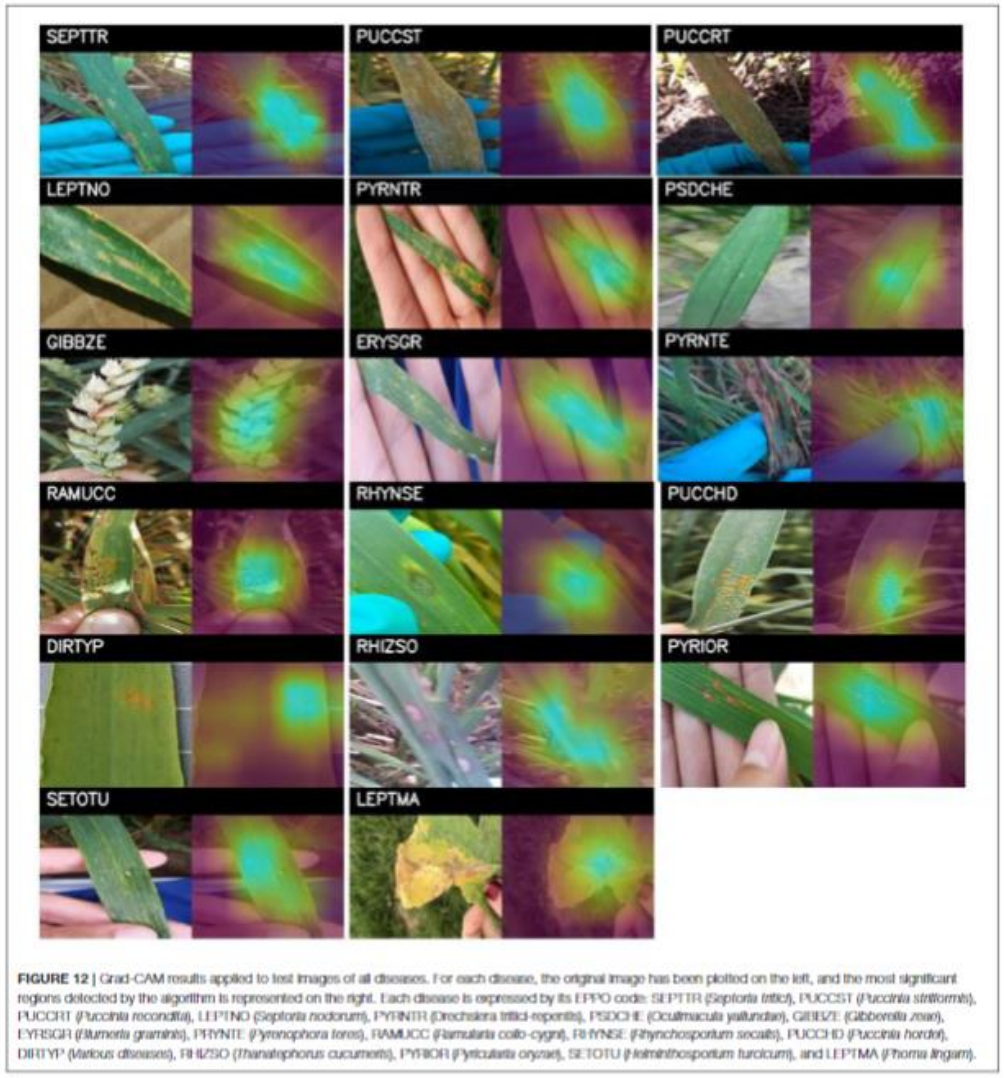
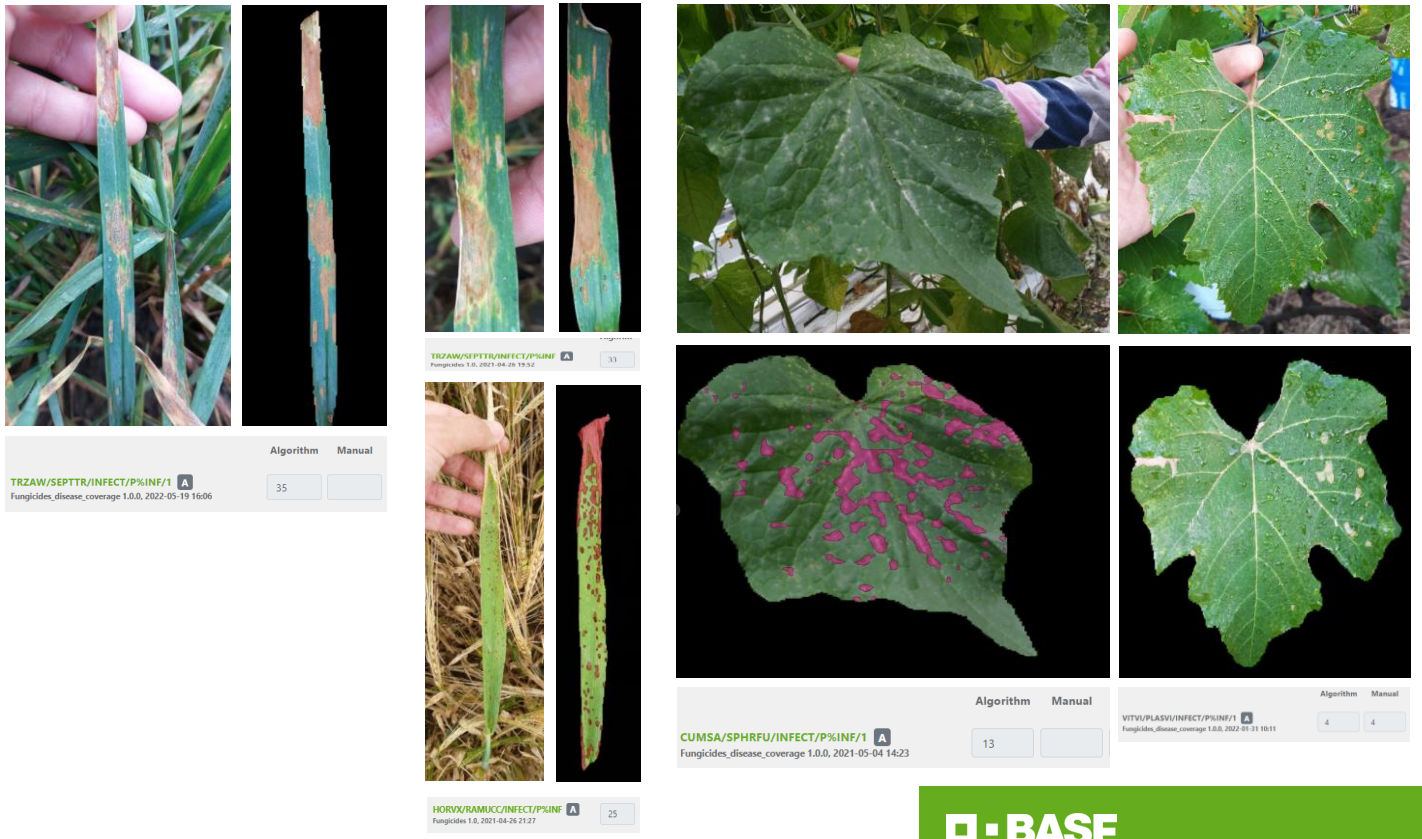


FIGURE 12 | Grad-CAM results applied to test images of all diseases. For each disease, the original image has been plotted on the left, and the most significant regions detected by the algorithm is represented on the right. Each disease is expressed by its EPPO code: SEPTTR (*Septoria tritici*), PUCCST (*Puccinia striiformis*), PUCCRT (*Puccinia recondita*), LEPTNO (*Septoria nodorum*), PYRNTR (*Drechslera tritici-repentis*), PSDCHE (*Oculimacula yallundae*), GIBBZE (*Gibberella zeae*), ERYSGR (*Blumeria graminis*), PRYNTE (*Pyrenophora teres*), RAMUCC (*Ramularia collo-cygni*), RHYNSE (*Rhynchosporium secalis*), PUCCHD (*Puccinia hordei*), DIRTYP (*Various diseases*), RHIZSO (*Thanatephorus cucumeris*), PYRIOR (*Pyricularia oryzae*), SETOTU (*Helminthosporium turcicum*), and LEPTMA (*Phoma lingam*).

Disease assessment at foliar level – Validation

Defining KPIs to validate / Validation of the algorithm with new data sets

- New data sets from other users & locations
- To check that the acquisition of data is efficient, and SOP is scalable
- To check the robustness of model: accuracy should be maintained
- If not reached, new data sets should be included
- To communicate / involve the biology project leads in the evaluation



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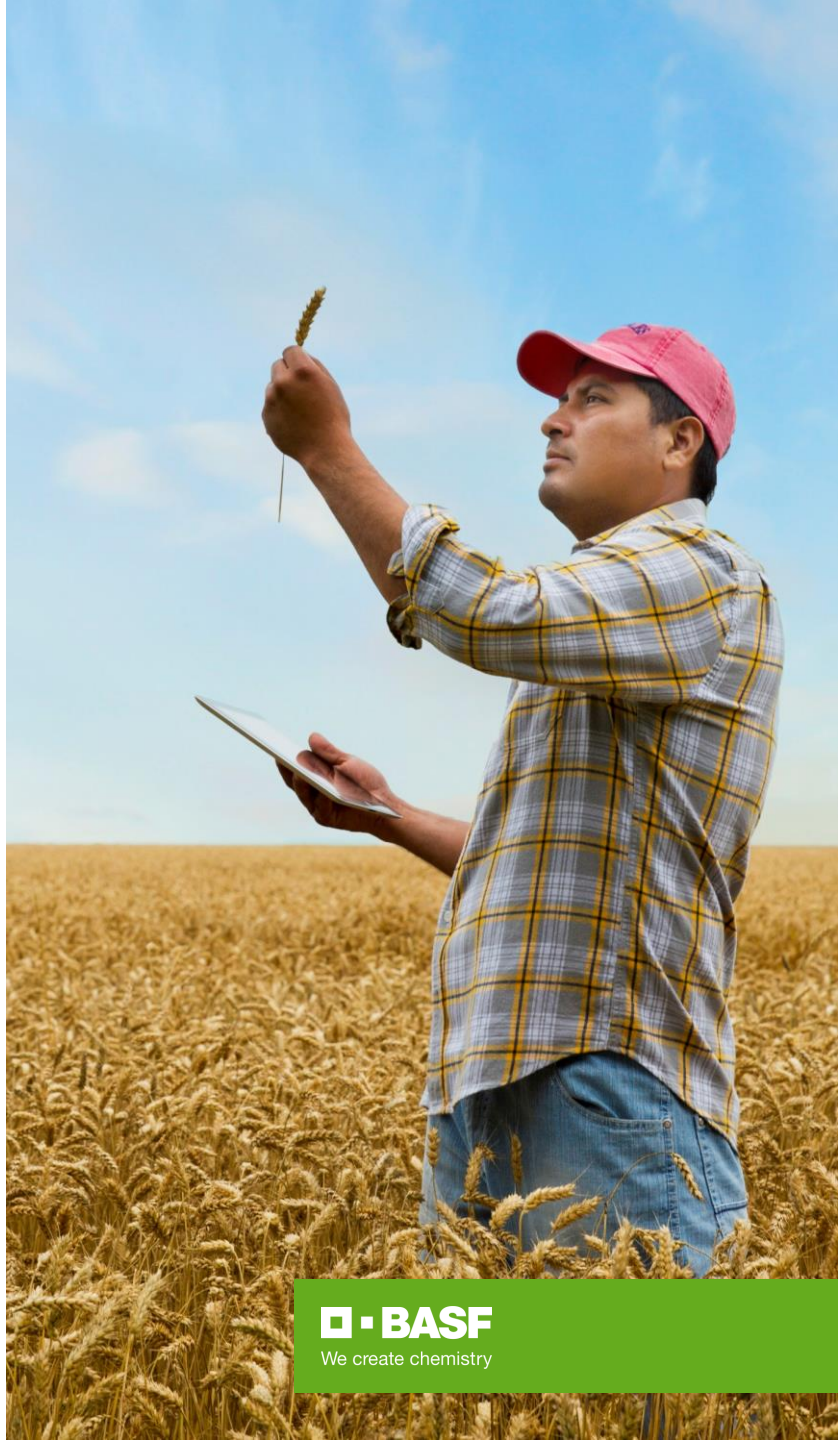
Disease assessment at foliar level – Deployment

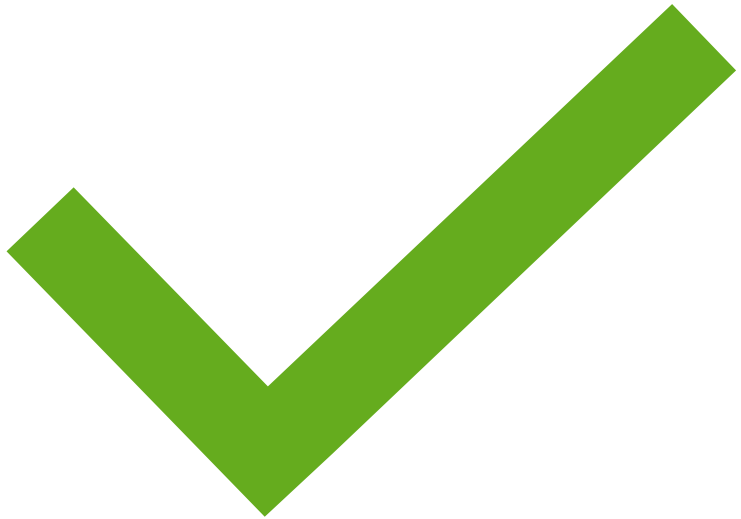
Ensuring deployments does not affect algorithm's performance

- Good alignment between
  - Algorithm developers
  - Product owners of digital tools
- Ensure a smooth deployment to the digital tool
  - Algorithm not only work in the development environment but in productive
  - Recommended to perform reality checks in productive environments

Digital platform for handheld devices & robots



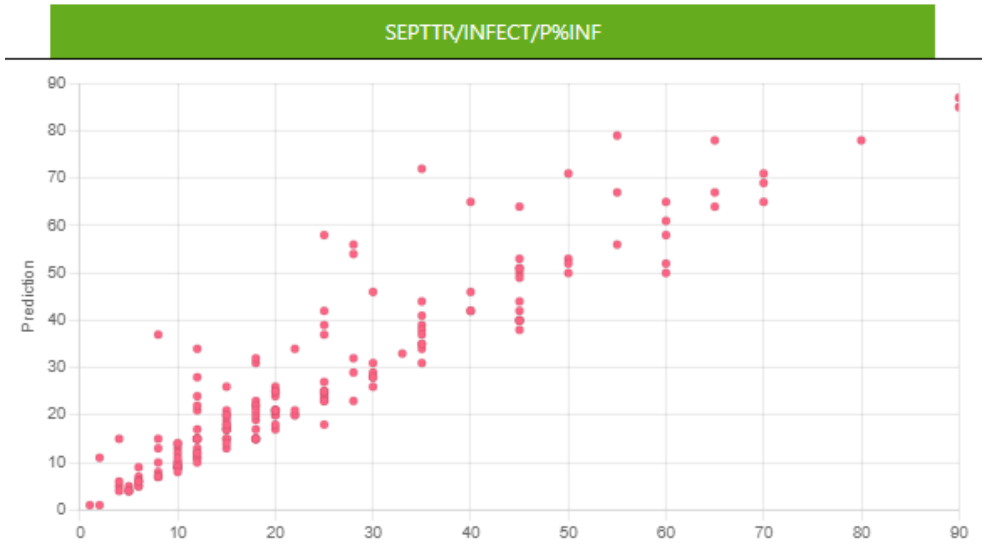
Algorithm in use



Disease assessment at foliar level – Monitoring & calibration

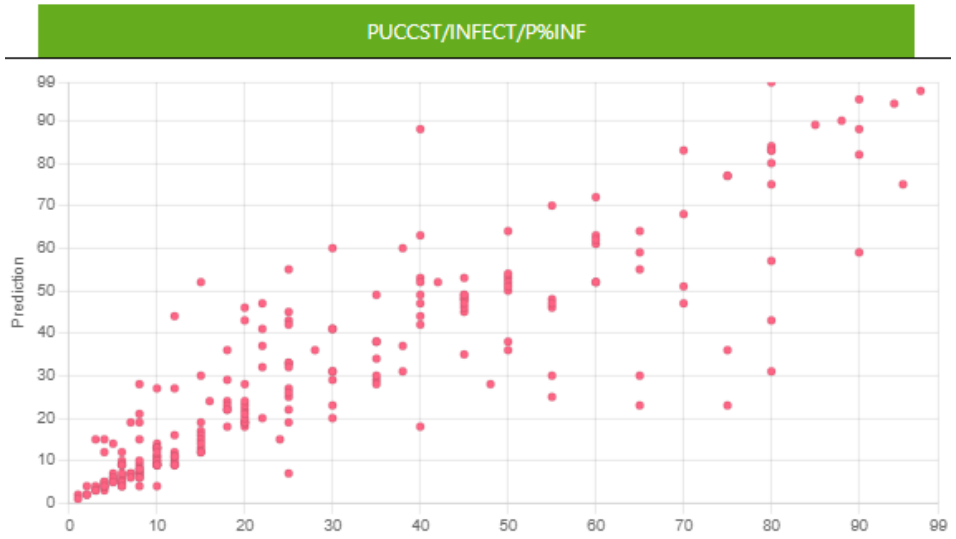
Calibration at image level: comparing visual & digital assessments in regular base (yearly)

Regression Plot



Visual assessment

Regression Plot

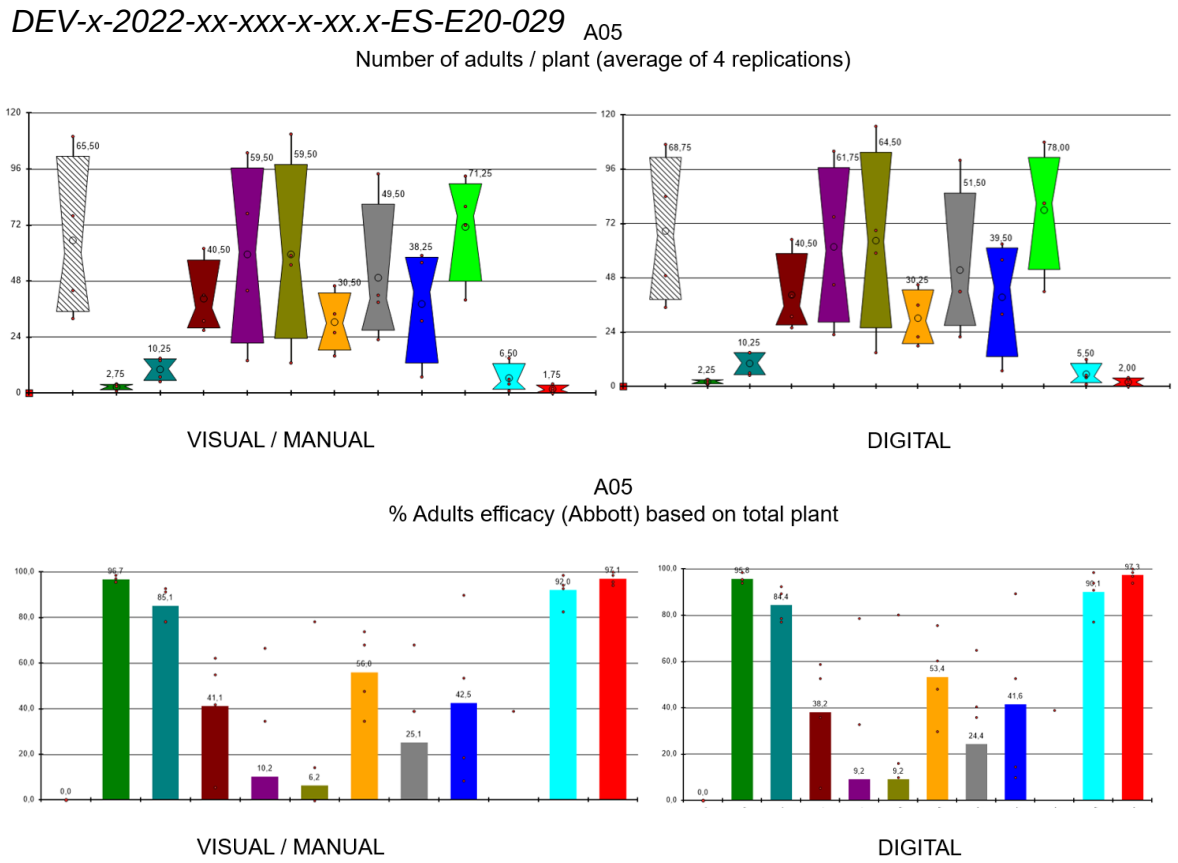


Visual assessment

Counting BEMITA adults alive at leaf level – Monitoring & calibration

Calibration in a trial: comparing visual & digital assessments in regular base (yearly)

- Algorithm
  - Counting alive BEMITA at leaf level
- Counting BEMITA adults alive at leaf level
  - DEV-x-2022-xx-xxx-x-xx.x-ES-E20-029
  - All evaluations by visual & digital method
- Result
  - Number of adults counted: slight differences
  - Efficacy analysis: same conclusions
- Conclusion
  - Algorithm can be further used



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Disease assessment at foliar level – Next steps & new ideas

From foliar level to plot level

Key success factors in developing a digital assessment

Good definition of each case

Starting any new case, the approach should be clearly defined including a good standard procedure on acquiring data & images, definition of sensors and equipment, creation of a divers and balanced dataset and considering the scaling up: it should improve **quality**, be **efficient** and **scalable**

Teamwork

Digital assessments are the result of a **multi-disciplinary** team covering agronomic, model development and IT expertise

Digital tools for users

Digital assessment platforms should be **user-friendly** for the field technicians, **integrated** in the established processes of executing trials and **connected** to existing R&D tools to allow for **visualization** of the data

Digital platforms for algorithm development:

It is essential that the model development platforms should be **transparent**, **traceable**, **reproductible** and **collaborative**

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Future

- Vision: In 5 years, **all R&D field trials** will be (partially) assessed with **digital tools**.
- Digital Tools for assessing trials

Satellites

Drones

Robots

Field vehicles

Smartphones

- Field Researchers will have the responsibility of **ensuring good field trialing** and **having digital skills**