High-Throughput Greenhouse Imaging for Basal Stalk Rot Phenotyping in Sunflower

Srushtideep Angidi [1], Anup kumar Das [2], Julie S. Pasche[1], Paulo Flores [2] and William Underwood[3].
[1] Department of Plant Pathology, North Dakota State University, Fargo, ND, USA.
[2]Department of Agricultural and Biosystems Engineering, North Dakota State University, Fargo, ND, USA
[3] USDA-ARS, Sunflower & Plant Biology Research Unit, Fargo, ND, USA.

Introduction

Sclerotinia basal stalk rot (BSR), caused by *Sclerotinia sclerotiorum*, is a destructive soilborne disease of sunflower that compromises vascular function, resulting in rapid wilting, progressive whole-plant desiccation, and eventual mortality. Greenhouse-based resistance screening is challenging because symptom expression is primarily wilting, and reliable evaluation often requires repeated visual scoring of thousands of plants. This manual workflow is highly labor-intensive, time-consuming, and susceptible to rater subjectivity, limiting throughput and reproducibility in breeding programs. To address these constraints, this study develops an automated RGB imaging and deep learning (YOLOv12) pipeline to detect and quantify terminal wilting and mortality under controlled greenhouse conditions.

Objectives

1. Develop a standardized RGB imaging workflow to monitor sunflower responses to BSR in the greenhouse.
2. Train and validate YOLOv12 models to detect terminal wilting and mortality from image datasets.
3. Validate automated disease scoring against manual ratings for accuracy, repeatability, and efficiency.

BSR Symptoms

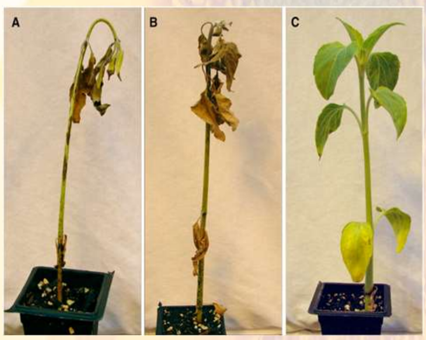

Figure 1: Sunflower BSR symptoms observed in the greenhouse.
A. Plant exhibiting terminal wilt at 14 days post inoculation (dpi). **B.** Plant exhibiting desiccation at 14 dpi. **C.** Plant exhibiting few or no symptoms at 14 dpi.

Material and Method

Table 1. List of genotypes with known BSR response

Genotype	Response to BSR
Cabure 1004	Susceptible
HA 89	Moderately Susceptible
RHA 801	Moderately Resistant
HA 124	Highly Resistant

Fig. 2. Dronwer 2.0 RGB imaging platform. A downward-facing RGB camera mounted on the Dronwer 2.0 gantry captured time-series images of sunflower trays at fixed positions. Imaging and video capture were conducted regularly for 28 days post-inoculation to monitor BSR wilting, whole-plant desiccation, and mortality for image based scoring.

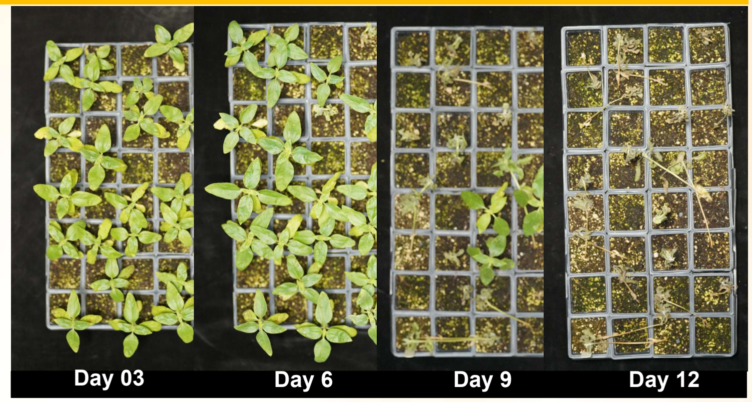

Fig. 3. **Image extraction and Model development:** Images were split into training and validation sets, with augmentation applied to training only. Multiple YOLO versions were trained and the best model was selected based on detection performance This figure is a representative example of a susceptible variety, illustrating how the phenotyping output appears after image separation and time-wise organization.

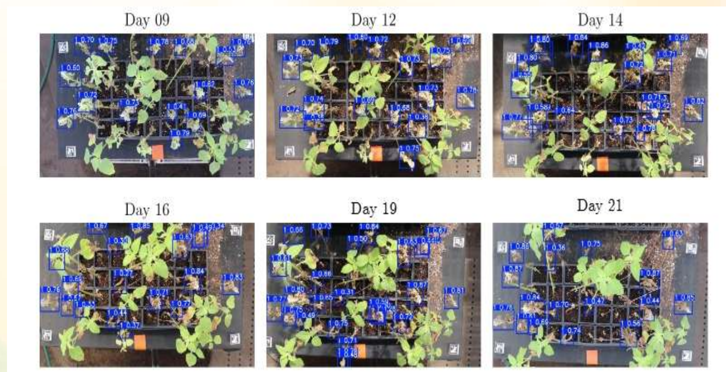

Fig. 4. **Representative YOLOv12 detection outputs on separated tray images across the disease time course (Day 9–21).** The separated tray images were then used to develop a YOLOv12 detection model for identifying BSR symptom targets. Blue bounding boxes show detected regions, and the numbers indicate the model confidence score for each detection at each time point (Day 9, 12, 14, 16, 19, and 21).

Results and Limitations

•**Model outcome:** The developed YOLOv12 model successfully detected BSR symptom targets from separated tray images.
•**Detection performance:** Across the disease time course, YOLOv12 achieved ~90% detection accuracy, producing clear bounding boxes with confidence scores for symptomatic regions.
•**Time-course consistency:** The model generated reliable detections across multiple days post inoculation (e.g., Day 9–21), supporting visual tracking of disease progression in greenhouse phenotyping.

Limitations

•**Cell-based detection failed -** when plants/leaves overlapped across cells, leaned into neighboring wells.
•The model detects only one genotype per tray.

Future work

Multi-genotype validation: Evaluate performance across diverse sunflower genotypes (susceptible to resistant) to ensure robustness of the model

References

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Underwood, W., Misar, C. G., Block, C. C., Gulya, T. J., Talukder, Z. I., Hulke, B. S., & Markell, S. G. (2021). *A greenhouse method to evaluate sunflower quantitative resistance to basal stalk rot caused by Sclerotinia sclerotiorum*. Plant Disease, 105(2),

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