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Towards high-throughput phenotyping of multiple stresses in soybean using a DCNN framework

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Biotic and abiotic stresses are threatening the soybean production sector by reducing seed quality and yield. Conventionally, mitigating potential yield losses relies on subjective and tedious symptom-based assessments by agricultural scouts to assist farmers in making preemptive action and proper management decisions in the field. Machine learning technologies utilizing readily available sensors and smartphone cameras have become a primary focus in the plant sciences for the detection and classification of plant stresses and could have a transformative impact in assisting soybean farmers and scouts with managing stresses. The goal of this study is to develop an automated framework to identify a/biotic stresses on soybean [*Glycine max* (L.) Merr.] under field conditions based on image classification using Deep Convolutional Neural Networks (DCNN). Over 25,000 leaflet images were collected from IA (USA) fields for five biotic stresses (bacterial leaf blight, bacterial pustule, frogeye leaf spot, septoria brown spot and sudden death syndrome) and three abiotic stresses (iron deficiency chlorosis, potassium deficiency and herbicide injury) as well as healthy leaflets on soybean using a standard imaging protocol. After initial image processing, a dataset comprised of 16,210 leaflet images was used to develop the DCNN model. The model was trained based on a training set of 11,345 images, which was then validated on 3,242 images and finally tested on 1,630 images. Preliminary results show that the trained model can efficiently differentiate between the eight different soybean stresses under consideration as well as healthy leaflets. The trained DCNN model can be used to create a mobile application for automatic diagnosis of soybean stresses in real time for Midwestern farmers as an alternative or supplement to traditional continuous disease monitoring services currently offered.