Image Classification of Sugarcane Aphid Densities Using Deep Convolutional Neural Networks

Ivan Grijalva, Brian J. Spiesman, and Brian McCornack
Department of Entomology, Kansas State University

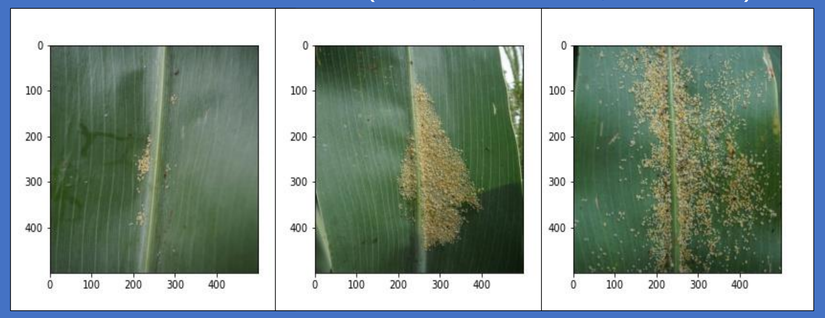
Background and Purpose

- Since 2013, sugarcane aphid (SCA) *Melanaphis sacchari* (Zehntner) has caused significant yield loss across the sorghum growing region in the U.S. (Bowling et al., 2016).
- Scouting this pest under field conditions is time-consuming and inefficient.
- Deep learning techniques, such as convolutional neural networks (CNN), are a type of computer vision model that can analyze visual imagery and excel at various tasks such as image classification and object detection.
- To assist pest monitoring, we propose using computer vision models to automatically classify SCA's infestation levels on leaves according to images of aphids on leaves at varied densities and composition.

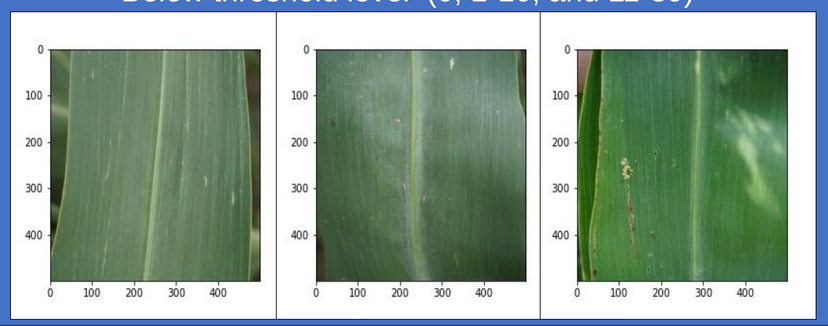
Methods

- We used 5,048 images collected from production fields and evaluated the performance of four models: Inception v3, DenseNet 121, Resnet 50, and Xception.
- Input SCA images downscaled to 500 x 500 pixels and categories weighted by sample size. We trained the models to classify aphid densities into 6 classes (SCA/leaf) based on established standard threshold levels used for spraying insecticides:

Above threshold level (40-125, 126-500, and >500)

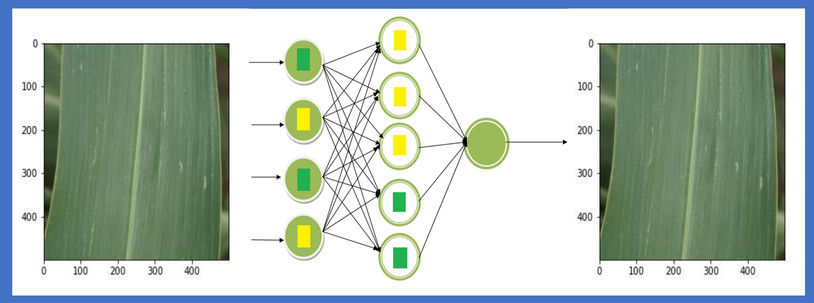


Below threshold level (0, 1-10, and 11-39)



Results

Convolutional neural network:



Input | Feature extraction + Classification | Output (0 SCA/leaf)

Inception v3 model:

Confusion matrix, where highlighted numbers correspond to correct predicted image classification in each category.

True (SCA/leaf)	Categories (SCA/leaf)	Predicted (SCA/leaf) 0	1-10	11-39	40-125	126-500	>500	Total number of tested images
	0	**211**	15	1	0	0	0	227
	1-10	19	**77**	13	1	0	0	110
	11-39	0	11	**127**	23	1	0	162
	40-125	0	0	6	**128**	15	0	149
	126-500	0	0	1	8	**282**	26	317
	>500	0	0	0	0	4	**41**	45

Percentage of correct classification of tested images above and below threshold level using Inception v3 model.

	Total images correctly classified	Percentage of correctly classified images
Above threshold	504	98.63
Below threshold	474	94.99

Conclusions

- This study developed a framework and one model capable of automatically categorizing leaf-level SCA infestations using digital images, which can renovate pest monitoring by standardizing sampling and decreasing human error in estimates.
- The Inception v3 model was able to classify SCA densities at 6 infestation levels, including no aphids (0 SCA/leaf) and (1-10, 11-39, 40-125, 126-500, and >500 SCA/leaf) with a classification accuracy of 86%.
- CNNs are deep learning techniques that can potentially classify other agricultural pests and beneficial insects, thus making incorporating biological control into decision-making for growers.

Next steps

- We are developing models for classification of common natural enemies and detection models for SCA wingless found in sorghum.

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- Reference cited: Bowling, R. D., Brewer, M. J., Kerns, D. L., Gordy, J., Seiter, N., Elliott, N. E., Buntin, G. D., Way, M. O., Royer, T. A., Biles, S., & Maxson, E. (2016). Sugarcane aphid (Hemiptera: Aphididae): A new pest on sorghum in North America. *Journal of Integrated Pest Management*, *7*(1). https://doi.org/10.1093/jipm/pmw011.