MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT 68-2015 (YEAR 1)
2015 Final Report

TITLE: Detection of glyphosate-resistant and susceptible Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot) using plant hyperspectral reflectance imagery in soybean field.

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BACKGROUND AND OBJECTIVES

Although Glyphosate [*N*-(phosphonomethyl) glycine] is the most widely used herbicide in fields planted with glyphosate-resistant (GR) soybean, repeated and intensive use of glyphosate has exerted a high selection pressure on weed populations, resulting in evolution of GR weeds.

GR Italian ryegrass (*Lolium perenne* L. ssp. *multiflorum* (Lam.) Husnot) is a troublesome weed in soybean. Italian ryegrass is an erect winter annual with a biennial-like growth habit. It grows vigorously in winter and early spring and is highly competitive. GR Italian ryegrass populations could seriously jeopardize preplant burndown options and planting operations in reduced-tillage soybean crop production systems of Mississippi. Use of glyphosate cannot control Italian ryegrass field populations which are resistant to glyphosate. The GR and glyphosate-susceptible (GS) Italian ryegrass plants look alike, and visually, it is impossible to distinguish GR plants from GS plants.

The objective of this project is to develop hyperspectral imagery-based remote sensing technology for rapid, consistent, and accurate differentiation between GR and GS Italian ryegrass plants in soybean fields. The results of this project will provide guideline data to allow soybean producers and consultants to effectively deal with Italian ryegrass and other GR weeds in soybean fields.

The results from this project in the past year indicated that the spectral reflectance of field-grown GR Italian ryegrass was significantly different from the spectral reflectance of field-grown GS Italian ryegrass, and the overall classification accuracy between greenhouse-grown GR and GS Italian ryegrass was equal to or higher than 75%. Therefore, we are ready to start the 2016-2017 project to see if the positive results from GR Italian ryegrass are transferrable to other GR weed species such as Palmer amaranth and Johnsongrass.

Objectives

1. To characterize the hyperspectral reflectance properties of GR and GS Italian ryegrass plants.
2. To assess classification accuracy of an unknown set of GR and GS plants (test set) using the model built from a known set of GR and GS plants (training set).
3. Evaluate the results from the experiments to optimize the number of bands and to determine consistent principal wave bands.

PROGRESS

Objective 1. The results of data analysis of the field experiment indicated that the spectral reflectance of GR Italian ryegrass wAS significantly different from the spectral reflectance of GS Italian ryegrass. In the visible spectral range of 450 – 680 nm, regardless of the age of the plants (i.e. WAP (weeks after field planting), the spectral reflectance of the GR Italian ryegrass was paired up with and different from the spectral reflectance of GS Italian ryegrass.

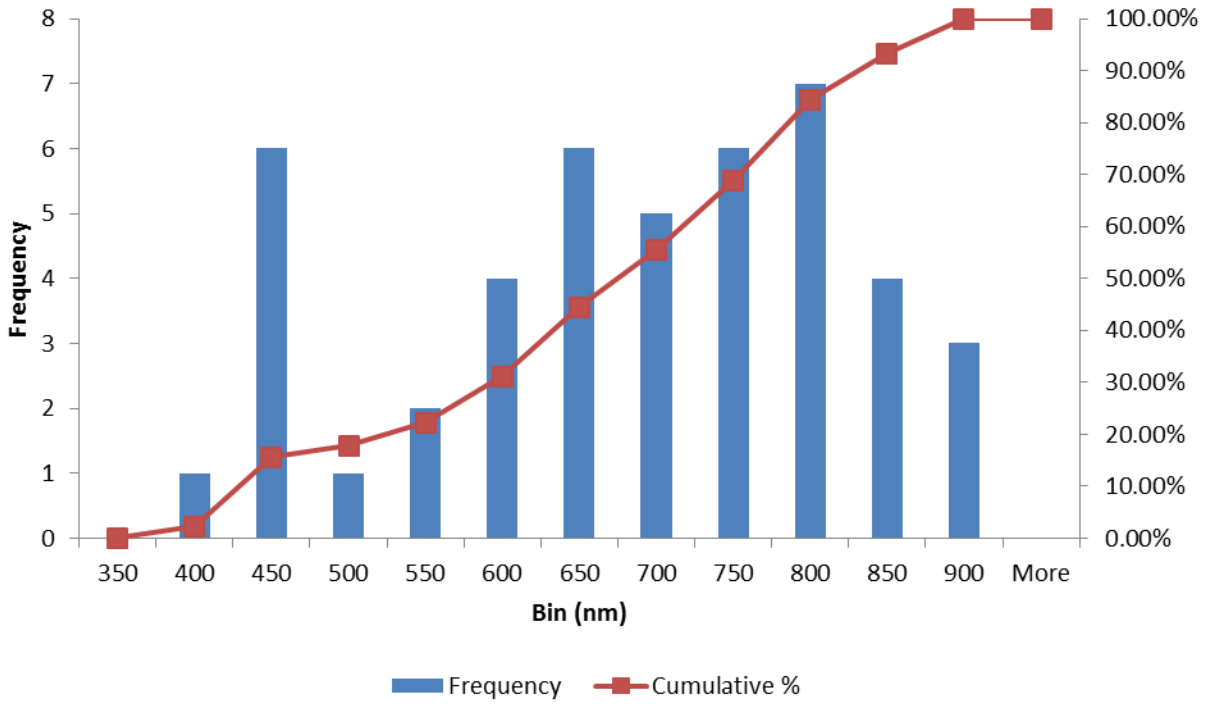
This finding determined that the pigments of GR and GS Italian ryegrass are differentiable, and these pigment differences can be one basis for remote sensing to detect GR and GS Italian ryegrass. In addition, in the NIR (near infrared) spectral range of 730-1,100 nm, the reflectance of GR and GS plants was significantly different at early stages such as 2 and 3 WAP, but they were no longer differentiable at 4 WAP.

The NIR spectra are typically a reflection of plant structure. These results illustrate that with WAP, the plant structures of GR and GS Italian ryegrass are more and more alike, but in early WAPs (2-3 WAP), their NIR spectra are differentiable for optical remote sensing to detect GR and GS Italian ryegrass. Overall, the combination of visible and NIR spectra of GR and GS Italian ryegrass were totally differentiable regardless of WAP.

Objective 2. The maximum likelihood classification was conducted for plant sample differentiation with 169 greenhouse-grown Italian ryegrass plants, including 89 GR and 80 GS plants. The results of validation with 57 greenhouse-grown Italian ryegrass plants, including 30 GR and 27 GS plant, showed that the overall classification accuracy was 75% and 80% for 3 WAE (weeks after emergence) and 4 WAE, respectively.

Objective 3. In validation of the classification model, it was determined that at 3 WAE, the mean overall accuracy was about 75% when 15 wavelength bands were used. At 4 WAE, the mean overall accuracy was about 80% when 15 bands were used.

To optimize the number of bands and to determine consistent principal wave bands, more classifications were run at other WAEs. With these data, cumulative percentage of the occurrence of the selected bands are shown as below.



The graphs show the wavelength distribution for detection of GR and GS Italian ryegrass and the principal bands are around 450 nm, 650 nm and 800 nm. This formation is important for us to simplify the sensor system to develop a portable device for farmers to use in the field, with further validation through meta-analysis of more band selection data.

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

We have been able to characterize hyperspectral reflectance properties of GR and GS Italian ryegrass plants, evaluated the accuracy of the classification model, and optimized the selected wavelengths to provide band information for further development. The positive results from this project allow us to start the new project to determine if the success on GR Italian ryegrass is transferrable to other GR weed species such as Palmer amaranth and Johnsongrass. The completion of this study will provide solid information for design and development of a portable optical device for farmers to use to rapidly detect populations of GR and GS weeds in soybean fields.

END PRODUCTS

A measuring protocol and selected and optimized wave band information for rapid differentiation of GR from GS Italian ryegrass in greenhouse and soybean field environments. Papers are being prepared to present in the coming weed science and agricultural engineer societies.