

Using Remote Sensing to Differentiate Weeds in Mint

Mary Gumz and Stephen C. Weller
Purdue University

Introduction

Remote sensing has the potential for simplifying weed detection, producing site specific herbicide maps, and decreasing weed control costs in peppermint and spearmint. Mint is an ideal candidate for site-specific weed management as it has a low growth habit and patchy weed infestations. Highly accurate maps of mint crop health and weed infestations can be developed using supervised classification techniques; however, the accuracy of these techniques relies on extensive ground referencing. In order to make remote sensing a practical on-farm technology, our research is currently focusing on techniques to analyze remotely sensed images and convert them into weed maps with a minimal amount of ground referencing.

Spectral vegetation indices have been shown to be useful in discriminating between different vegetation types but are not effective for all crops. Spectral vegetation indices (SVIs) are usually ratios of reflectance values at different wavelengths but may be other functions of reflectance (e.g. average reflectance over a range of wavelengths). If SVIs prove to be accurate in mint for differentiating between weeds and mint crop conditions, analysis of remote sensing images would not require extensive ground referencing. Such technique development would allow remote sensing-based site-specific weed management to become a practical, effective and economical on-farm technology.

The objective of this experiment was to evaluate the use of SVIs to differentiate between peppermint and problem weed species and their utility in analysis of remotely sensed images.

Data Collection

Hyperspectral reflectance data were collected from small flats of mint and weeds using a spectroradiometer. All measurements were replicated 9 times. SVIs were calculated from reflectance data.

A hyperspectral image of a 40 acre Indiana peppermint field was acquired on September 10, 2004, using a hyperspectral camera. Natural field weed populations and variation in peppermint crop health were mapped using ArcPad 6.0.2 on a Dell Axim handheld computer equipped with a WAAS-enabled DGPS receiver. Digital number (DN) values were obtained for pixels located in weedy and weed-free patches. Border pixels were excluded. DN values were converted to reflectance and used to calculate spectral vegetation indices.

Results

Index Evaluation

Spectral response curves differed for monocultures of peppermint, spearmint, and weeds (Figure 1). Peppermint and spearmint had greater reflectance at wavelengths of 670 nm and above (near-infrared (NIR) region) as well as a steeper slope from 640 to 740 nm (the “red edge”) followed in order by giant foxtail, white cockle, waterhemp alone, the mixture of waterhemp, Powell amaranth, and smooth pigweed, and the mixture of Powell amaranth and smooth pigweed. These separations in spectral response between

crops and the various weed monocultures (both dicot and monocot) indicate that NIR reflectance was useful in distinguishing the mint crop from monoculture weed patches. Our results were consistent with previous studies showing differences in NIR reflectance between plant species with different leaf morphology, and suggest this technique could be useful for site-specific herbicide application.

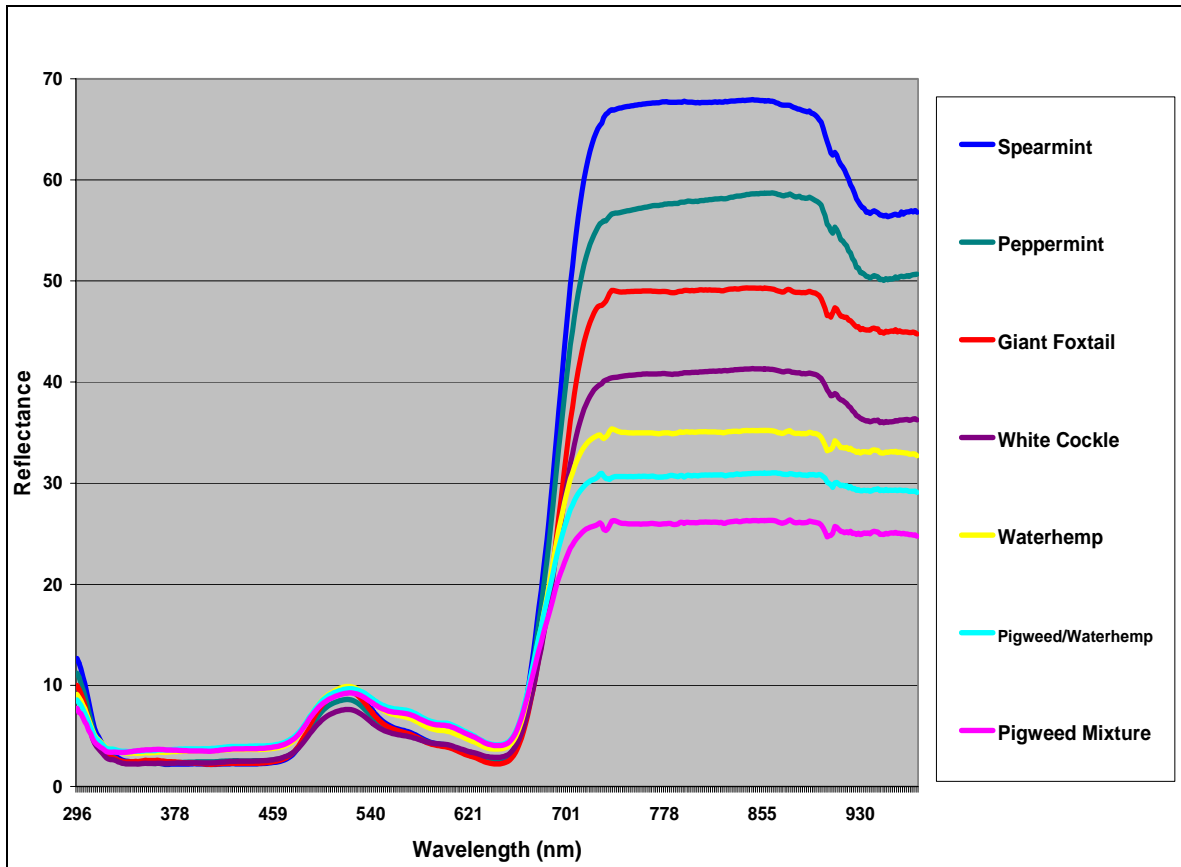


Figure 1. Spectral reflectance of peppermint, spearmint, and problem weed species.

Hyperspectral Image Evaluation

A hyperspectral image of a peppermint field for September 10 (Figure 2), showed weed and crop regrowth after crop harvest on July 22. Weed infestations were patchy and occurred where the mint crop was the weakest. Field scouting notes superimposed on the image show examples of locations where yellow nutsedge (1), mixed Powell amaranth and smooth pigweed (2), dead crabgrass (3) and weed-free peppermint (4) occurred. Differences in pixels of weed patches compared to healthy mint are obvious in the hyperspectral image. Spectral differences between weed free peppermint and weeds were used to locate weed patches in the hyperspectral image. Figure 3 shows actual peppermint and weed patches.

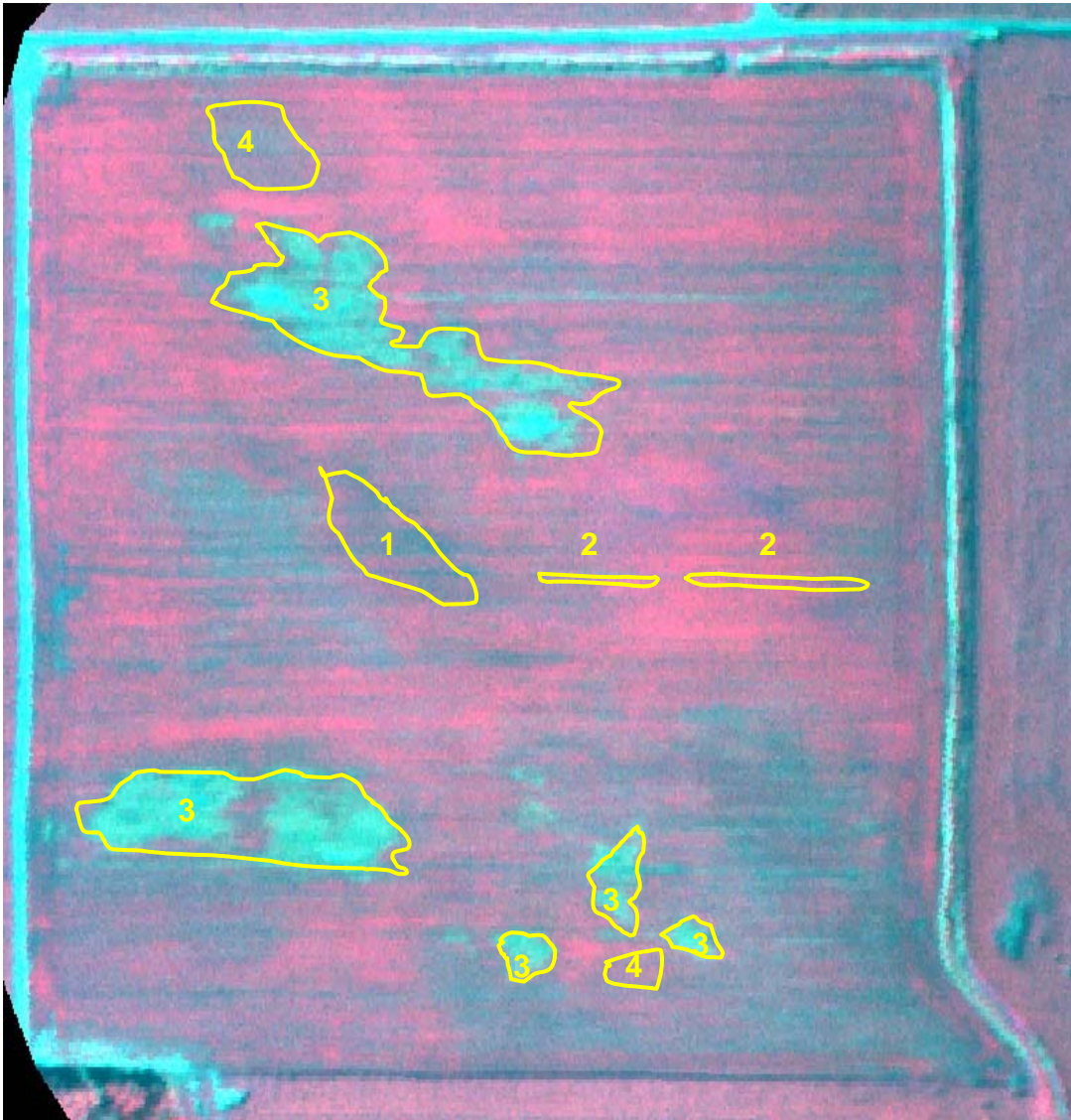


Figure 2. Hyperspectral Image of a Peppermint Field (Bands: 57, 27, 4).



Figure 3- Field conditions shown in hyperspectral image (A – weed free peppermint; B-Powell Amaranth; C-yellow nutsedge; D- dead crabgrass).

The SVIs useful in showing differences between mint and weed species in the greenhouse experiment were applied to reflectance data of the hyperspectral field image (Figure 2). Calculated reflectance values from weed-free mint, areas of *Amaranthus* spp., and yellow nutsedge were used to determine the SVI values (Table 1). Simple ratio (SR) 695/479, Red Edge Slope, and Average Reflectance (750 to 850 nm) differentiated between weeds and weed-free peppermint and identified weed patches within the field. Values for Average Reflectance (750 to 850 nm) and Red Edge Slope patterns were similar to those observed for greenhouse grown plants. Differences in the actual SVI values in the greenhouse and field study are likely due to variation in morphology, leaf arrangement and nutritional status of plants grown under different environmental conditions that affect actual spectral reflectance.

	SR 800/551	SR 750/551	SR 695/479	Average Reflectance 750-850	Red Edge Slope
Weed free-Peppermint	16.03a*	10.36a	1.77b	46.27b	0.26b
Pigweed Mix	15.80a	10.34a	2.32a	50.21a	0.29a
Yellow nutsedge	10.70b	6.45b	0.30c	35.45c	0.17c

Table 1. SVI values for natural field populations of peppermint and weeds.

Conclusions

- SVIs were useful for differentiating between mint and weeds grown under greenhouse or field conditions.
- SR 695/479, Average Reflectance (750 to 850nm), and Red Edge Slope accurately predicted specifics regarding weed species composition and location in a field image.
- SVIs obtained from greenhouse grown plants can be used to analyze field hyperspectral imagery.

SVIs represent a promising development towards automating the analysis of remote sensing images and the development of weed maps. Future research on this project will confirm the spectral response values using field grown plants and develop more indices specifically for differentiation between mint and weeds.

For More Information

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Smith, G.M. and E.J. Milton. 1999. The use of the empirical line method to calibrate remotely sensed data to reflectance. Int. J. of Rem. Sensing. 20:2653-2662.

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