

PHOTOGRAPHIC ANALYSIS TO HELP DEFINE OPTIMUM NITROGEN FERTILIZATION PRACTICES FOR GRASS SEED PRODUCTION SYSTEMS

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Introduction

A study to define optimum nitrogen fertilization practices for perennial ryegrass and tall fescue seed production systems in the Willamette Valley has been underway since fall 1998. The study has involved measuring seed production, yield components to help explain yield differences, and plant tissue and soil nitrogen levels. During 2000, we tested aerial and ground-truth verification photography to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on plant growth and plant survival as a function of nitrogen application rates.

Procedure

Large-scale on-farm plots were established prior to fertilizer applications. Field trials were conducted with perennial ryegrass (*Lolium perenne*) variety SR 4200. The field was established in 1997. Plots were approximately 22 ft wide by 300 ft long. Spring fertilizer treatment rates of 0, 45, 90, 135, 180, 225, and 270 lb N/a were used. The seven treatments were replicated three times in a randomized complete block. The plots were managed the same as the rest of the field for all other cultural management practices by the grower-cooperator.

In order to visualize, manipulate, analyze and display spatial data we used Geographical Information Systems (GIS). GIS data can be derived from various sources including field sampling, digitized paper maps, remote sensing, and aerial photography. Each data set represents a single layer. These layers of information have to be geo-referenced to be linked together. This can be done by geo-rectifying (common points in each layer are positioned on top of each other) each layer through the use of Global positioning systems (GPS). The next paragraphs explain the tools we used in our study.

Global Positioning Data

We mapped treatment plots boundaries using a Trimble® Pathfinder Pro® XL GPS equipped with a data logger. Positions were differentially corrected (accurately positioned) using a local base station (Portland, OR) and averaged using Trimble® navigation software (Trimble, 1996).

Color Aerial Photography

We photographed the research plots eight months after the spring fertilizer. The flight was taken on December 19, 1999. We used Kodak® Royal Gold® ISO 400 film in a 35-mm camera fitted with a 28-mm wide-angle lens, mounted on a single-engine, fixed-wing aircraft. A mosaic of the images was scanned and saved as 24-bit tagged image format (TIF) files.

These images were imported into Picture Publisher® software and converted into red, green, and blue digital images. Each of these images were then imported into IDRISI®, an image processing/GIS software package (Eastman, 1997).

Image Rectification and Classification

Images were rectified using a minimum of 10 ground-control points and a linear, nearest-neighbor algorithm (Richards, 1986). Pixels were resized to 1 m and UTM zone 10 North, WGS84 Datum coordinate system. UTM is Universal Transverse Mercator, which is a standard coordinate system used to locate positions on the earth's surface. WGS84 is World Geodetic System of 1984, which is the most recently developed information used in defining a geographic coordinate system. The root mean square error (Richards, 1986) for this operation was kept at less than one meter, which means the position on the map is accurate to within one meter of where it actually exists on the earth's surface.

Image classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to that criteria.

In our procedure, we used unsupervised classification, which is a technique for the computer-assisted interpretation of remotely sensed imagery. The computer routine does this by identifying patterns in the reflectance data. The patterns are usually referred to as clusters or classes. The procedure we used generated three classes. These classes are then identified by looking side by side at the computer classification (screen) and color photographs (print) plus the knowledge from the site visits and ground truthing to determine their interpretation.

Ground level Photography

To obtain higher resolution information at known locations within the field, we used a light-weight platform of polyvinyl chloride (PVC) tubing on which we mounted a 35-mm camera fitted with a 28-mm, wide-angle lens (Louhaichi, 1999). The camera was pointed vertically downward 5.6 ft. above the ground. A 1-m² frame was central in the photograph, which provided an estimate of scale and allowed us to measure objects and calculate surface areas in the photo. Photographs taken with this camera arrangement were scanned and converted to digital format.

Three uniformly spaced ground-level photographs were taken for each treatment on or close to the day of overflight. At each photographic location we recorded the following information: (1) plant height, (2) any unusual circumstances such as flooding and rodent activity, and (3) GPS location.

Ground Level Image Analysis

We were interested in determining the percent green leaf cover of perennial ryegrass. Cover is defined as the vertical projection of the crown and shoot areas of a plant species on the

ground surface, expressed in percent or fraction of the area measured (Stoddart *et al.*, 1975). We measured cover in 1-m² quadrats at ground level by analyzing digital, color images. Pixels in the digital RGB (red, green, blue) images of plant leaves and stems had higher green digital numbers than red or blue. Soil, rocks, litter, and dead leaves tended to have lower values for green than for red or blue. This is to be expected since chlorophyll absorbs red and blue light and reflects green. We therefore classified images by determining if the average of red and blue digital numbers were greater or less than the green digital number.

The resultant image had pixel values between -1 and +1. Negative values tended to be soil/nonliving while positive values were green leaves and stems. We calculated percentage leaf cover. The classification process was programmed in Visual Basic[®] software so classification of 63 photographs can be completed in about 30 minutes.

Incorporation of Geographic Information Systems

Our objective was to evaluate photographic analysis as a potential technique for assessing residual nitrogen influence on plant growth and plant survival as a function of nitrogen application rates. We combined information in aerial photographs with platform photography and ground-truth data within a GIS to classify the response of each treatment. There are three main steps that summarize our methodology. In step 1, we scanned, rectified, and classified color aerial photography. This separated treatments into units with similar reflectance (usually two to four classes). In step 2, image processing of platform photography generated percent leaf cover in each treatment. Since all themes were geo-referenced, this allowed us to overlay ground-truth data points on the color aerial image and double check our output in step 3. In addition, we are able to seek relationships between computer classification of aerial photography and ground level platform photography.

Results and Discussion

The most remarkable result was that, based on aerial photography, class 1 (greener) decreased as N rates increased (Figure 1). It went up from 50% at 0 lb/a N to reach a peak of 84 % at 90 lb/a N and then decreased to about 30 % at 270 lb/a N.

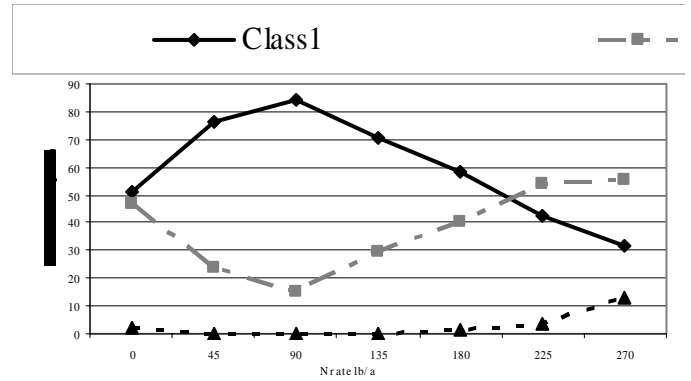


Figure 1. Computer classification of aerial photography. Class 1 is green leaf, class 2 is litter, class 3 is soil/non-living.

The image processing of the 1-m² platform images illustrated similar trends. The overall response across three replications indicated that the lowest percent leaf cover coincided with the highest N rate application of 270 lb/a (Figure 2).

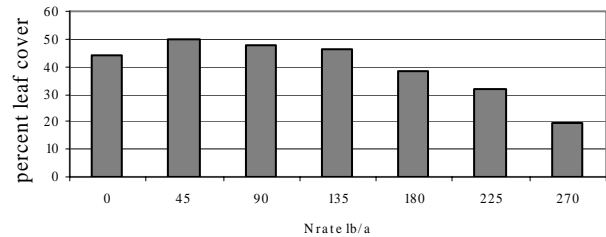


Figure 2. Overall percent leaf cover based on platform photograph analysis.

When comparing the response of percent leaf cover taken by the platform photography and computer classification of aerial photography, there was a correlation of 90 % (Figure 3). This would suggest that for large area we can use aerial photography and computer classification to stratify field into classes based on the amount of green cover.

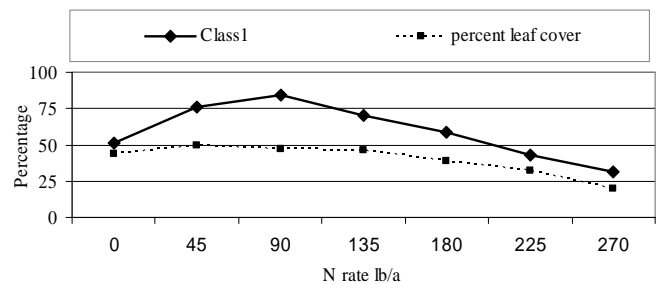


Figure 3. Comparison between percent leaf cover and class 1. Class 1 is green leaf classification from aerial photograph analysis. Percent leaf cover was calculated from platform photographs.

The platform photography will be used for collecting ground truth that should help calibrate aerial photographs and their interpretation.

Conclusion

Our research demonstrates that using GPS-located ground photographs, geo-positioned field observations, and ortho-rectified aerial photography in concert, we were able to map the response of nitrogen application in grass seed production fields. This approach could provide farmers and researchers with reliable information to optimize nitrogen application.

References

- Eastman, J.R. 1997. IDRISI for Windows, User's Guide, Version 2. Clark Labs for Cartographic Technology and Geographic Analysis, Worcester, Mass. 386p.
- Louhaichi, Mounir. 1999. Assessment of impacts of Canada geese on wheat production. M.S. thesis, Oregon State University, Corvallis. 104p.
- Richards, J.A. 1986. Remote Sensing Digital Image Analysis: An Introduction. Springer-Verlag, New York. 281p.
- Stoddart, L.A., A.D. Smith, and T.W. Box. 1975. Range Management. McGraw-Hill Book Company, New York. 532p.
- Trimble Navigation. 1996. Trimble Pathfinder Office Software Reference Guide. Trimble Navigation, Ltd., Sunnyvale, CA. 432p.