

SITE-SPECIFIC FARMING INFORMATION: ASSESSING WEED AND SOIL PROPERTY EFFECTS ON CROPS

Stuart Pettygrove, Lee Jackson, Richard Plant, Ford Denison, and Julie Young¹

INTRODUCTION

The development of yield monitor/GPS systems for grain harvesters has raised hopes that growers, as well as researchers, could quantitatively relate crop yield variation within individual fields to variations in soil properties, pests, irrigation, etc. In the past, it has been possible to monitor the extent of nutrient deficiencies or pests in fields by use of plant and soil sampling or by remote sensing, but it was not possible to relate such variations to yield without the use of small plots or other intensive measuring procedures. An example is the use of color infrared aerial (CIR) photography to map the advance of phylloxera in individual grape vineyards. The photographs have been useful in informing growers how rapidly the pest is advancing, but there is no practical, direct method for relating the appearance of the vines in the aerial photographs to fruit yield and quality. Where yield impacts can be assessed, remotely sensed information could aid management decisions, such as whether to replant, apply an expensive pesticide, abandon a crop, etc. In grain crops, and a few other crops such as sugarbeet for which yield monitors have been developed, it is now possible to do such evaluations.

In this paper, we describe a project in which wheat yield and related soil and plant characteristics were measured in three irrigated farm fields in the Sacramento Valley. The fields are in a wheat-tomato-corn-sunflower or wheat-tomato-alfalfa rotation. In 1996 all three fields were in wheat. Within one field, grain yield was related to soil texture, weeds, and N fertilizer non-uniformity. Within a second field, weeds were the dominant factor in yield variability. One of our goals is to determine quantitatively the yield loss attributable to the weeds. The weed impact must be separated from the other factors that contributed to yield variability. The lessons learned from this research should have applicability to other crops for which yield monitors are now available or under development, such as alfalfa and cotton.

PROJECT DESCRIPTION

In the fall of 1995, a team of University of California faculty and Cooperative Extension specialists and advisors began working with a Sacramento Valley grower to attempt to relate within-field variation of crop yield and quality to variations in soil, pest pressures, plant tissue nutrient content, etc. A wheat-tomato rotation was chosen due to its economic importance in both the Sacramento and San Joaquin Valleys. The team's intent is to relate environmental variables (such as soil drainage class) and manageable factors (irrigation, fertilizer) to crop yield and quality using relatively low-cost information obtained through aerial photography and yield mapping. A key question is:

¹ Stuart Pettygrove, Extension Specialist, LAWR; Lee Jackson, Extension Specialist; Richard Plant and Ford Denison, Professors; Julie Young, Staff Research Associate, Dept. of Agronomy and Range Science, University of California, Davis.

Can variability and its causes be mapped without over-reliance on more expensive information such as grid soil and plant sampling?

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PROCEDURES

We are monitoring the performance of crops in three commercial fields of 77, 78, and 108 acres in the lower Sacramento Valley. The soil textures are mainly clay loam, silty clay loam, and silty clay, and the fields generally are difficult to irrigate uniformly. The fields were cropped to wheat in 1995-96 and to tomatoes in 1997. Tomato yields were measured in July-August 1997 using a prototype load cell/GPS yield monitor mounted on one of the grower's harvesters.

'Express' spring wheat was planted in early December, 1995. In June 1996, wheat yield was measured continuously with an Ag Leader™ yield monitor/GPS combination retrofitted on the grower's harvester. Yield and grain moisture content were recorded in a data logger once per second, corresponding to two to four feet of travel by the combine. Color infrared aerial photographs were taken before crop emergence in December 1995, at early jointing in March, and during grain fill in May. Photographs were digitized (1 pixel = 1.8 x 1.8 meters), and a vegetation index was derived for the growing season images. Soil properties, plant nutrient status, and crop/weed/disease visual ratings were collected on a 200 x 200 ft grid – about one sample per acre. To relate aerial photographic pixel values to the plant and soil sample data, several pixels closest to each grid sampling point were averaged. For the weed analysis, pixels within a 50-ft radius of each grid point were averaged, representing approximately the area visually observed for the weed ratings. All data were compiled and color yield maps were generated using ArcView® (ESRI) and Surfer® (Golden Software) software.

RESULTS AND DISCUSSION

A large amount of data (yield, photographic, and plant/soil sample) was obtained during the wheat crop in the project's first year. Analysis of this information is in progress. Collected information from two of the fields will be used here to show the potential for obtaining useful results.

Field 5

In this field, the grain yield of 2,940 lb/acre was about half the county average; however, some areas of the field yielded above 6,000 lb/acre. The great variability of the yield across the field is seen in Figure 1.

The main reason for low yield was the effect of heavy rains during the 1995-96 winter on the aeration status of the slow-draining Capay silty clay – the predominant soil in the northern two-thirds of the field. In the higher-yielding part of the field, the predominant soils (Brentwood and Yolo) have a lower silt and clay content and lack the impervious subsoil of the Capay (Fig. 2). In the areas with Capay soil, plants were small and poorly

tillered. It is likely that wheat in the areas with saturated soil was not able to obtain sufficient N due to a smaller root system and a greater loss of N from the soil.

Yields were also influenced by the presence of grassy weeds in some areas of the field. The main weeds were canarygrass, annual ryegrass, and wild oats. The herbicide that is normally used to control canarygrass was considered "off-label" at the time it was needed due to the stressed condition of the crop growing in the saturated soils. The weeds in some areas of the field overtopped the wheat and after heading out were easily seen in the aerial photograph. A visual weed rating map made by Lee Jackson is shown in Figure 3. An area of several acres with a heavy infestation of canarygrass on the west-center of the field can be seen in both the yield map and the weed rating map. In that area, grain yields were approximately one ton/acre lower than the wheat in adjacent areas. Other smaller areas of weeds are visible in the aerial photograph but are not as obvious in the yield map.

Field 58

In a second field, average yields were higher than in field 5, though at 4,055 lb/acre were still somewhat lower than the county average. In two large areas in the south and west part of the field, grassy weeds, mainly canarygrass, overtopped the wheat and depressed yields to below 3,000 lb/acre. In some areas in the east-central part of the field, yields exceeded 7,000 lb/acre (Fig. 4). In the color infrared (CIR) photo taken at early grain fill, weedy areas in the western part of the field appeared lighter red than the wheat and gave higher IR band and red minus green (R-G) band values in the digitized image. In Figure 5, it can be seen that the two large areas with weed ratings = 5 and low yields (as seen in Fig. 4) also had higher IR values shown in the contours. Normalized Difference Vegetation Index (NDVI), a commonly used index derived from the CIR photo did not reveal the large weedy areas. High weed ratings were recorded for some areas in the eastern part of the field, but there were not corresponding reduced yields or increased aerial image IR or (R-G) values. Therefore, over the entire field, the aerial photograph color values were poorly matched with the 1-5 visual ratings made on the ground (Fig. 6), although it was possible to distinguish areas with a "5" rating with an error of about 20 percent. Possibly differences in weed species (wild oats vs canarygrass) along with other factors (soil texture) affected the aerial photograph. It may be possible to remove the effect of soil texture by using the bare soil aerial photograph.

SUMMARY

Weed impacts on yield have traditionally been determined with small plots by researchers. We are assessing the potential for a grower or consultant evaluating weed impacts within whole fields by using yield monitor records and color infrared aerial photography combined with a limited amount of ground truth data. Obviously, where weeds are not as visible in the aerial photography, a greater number of ground observations would be required. However, it may be possible to exploit more subtle effects of weeds due to differences in plant development timing, as for example when weeds grow between crop rows early in the season.

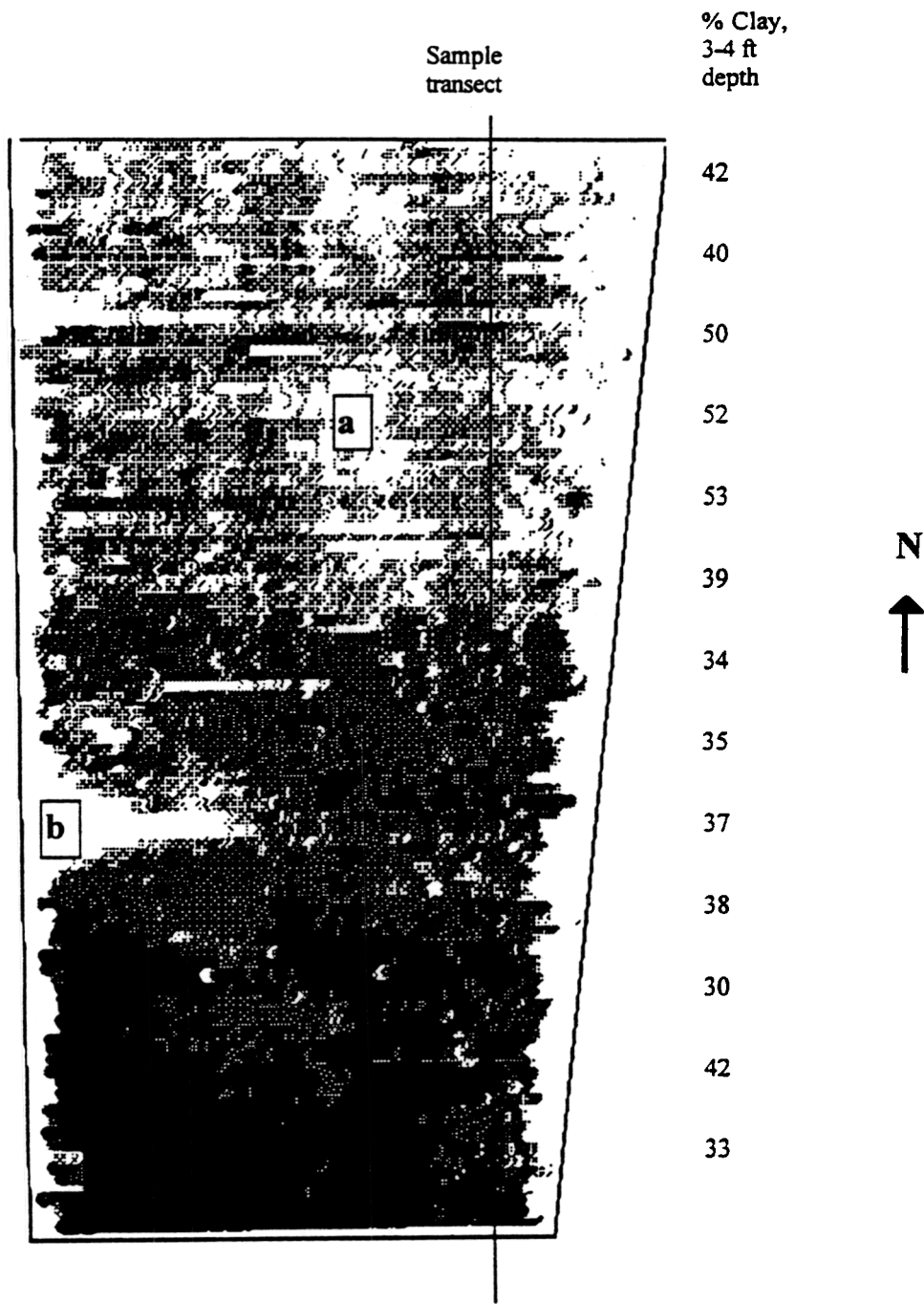


Fig. 1. Wheat yield in a 77-acre field. Higher yield = darker shade. a = area with poor drainage. b = severe grassy weed infestation, mainly canarygrass and wild oats. Areas with high clay contents (3-4 ft depth) that restricts drainage are shown for samples taken along a north-south transect shown by the solid line.

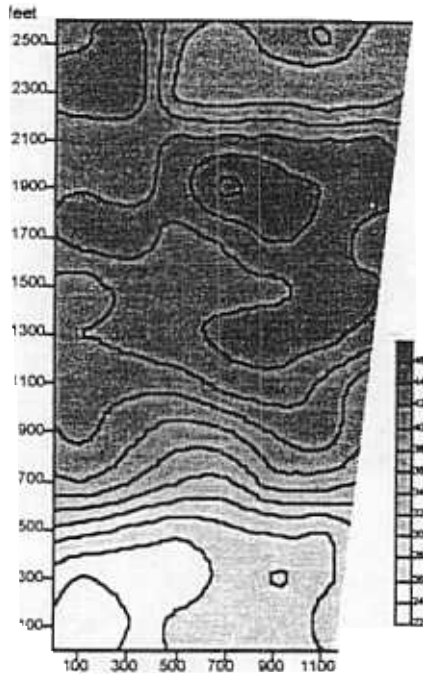


Fig. 2. Silt content, 0-6 inch depth.

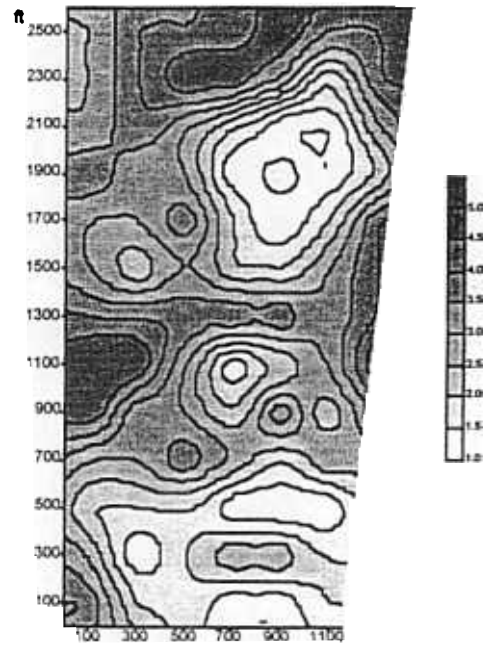
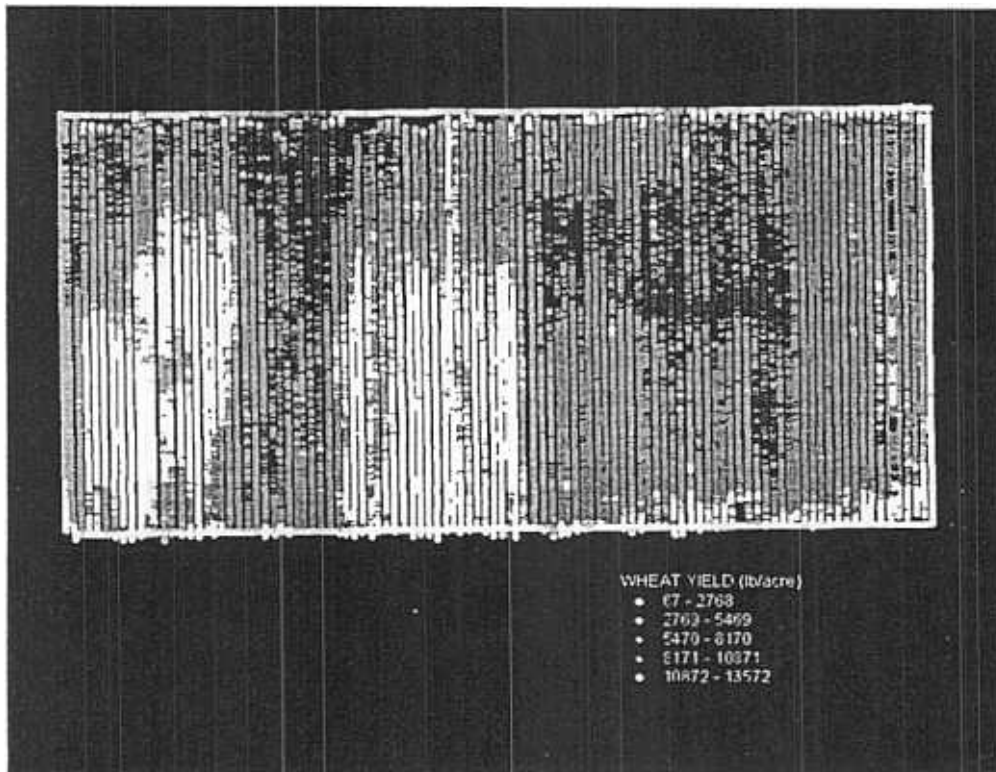


Fig. 3. Visual weed rating, 1=low, 5= high



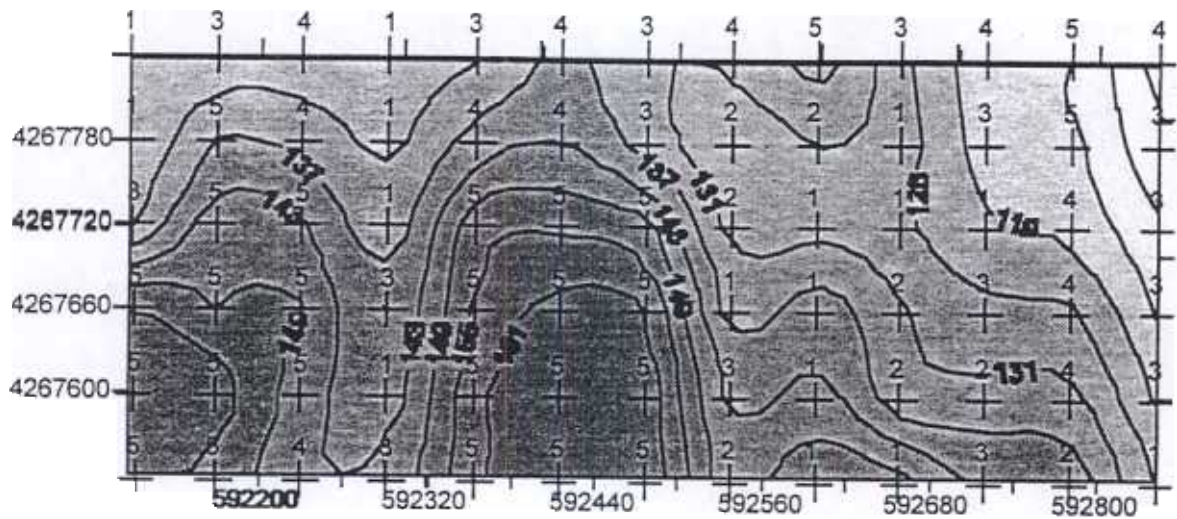


Figure 5. Weed ratings in field 58 shown at grid points are visual rating made by Lee Jackson at anthesis. 1= low density, 5= high. Canarygrass was most severe in the west and central parts of the field, wild oats were light to moderate in the eastern part of the field. Contours show May color infrared photo IR band value.

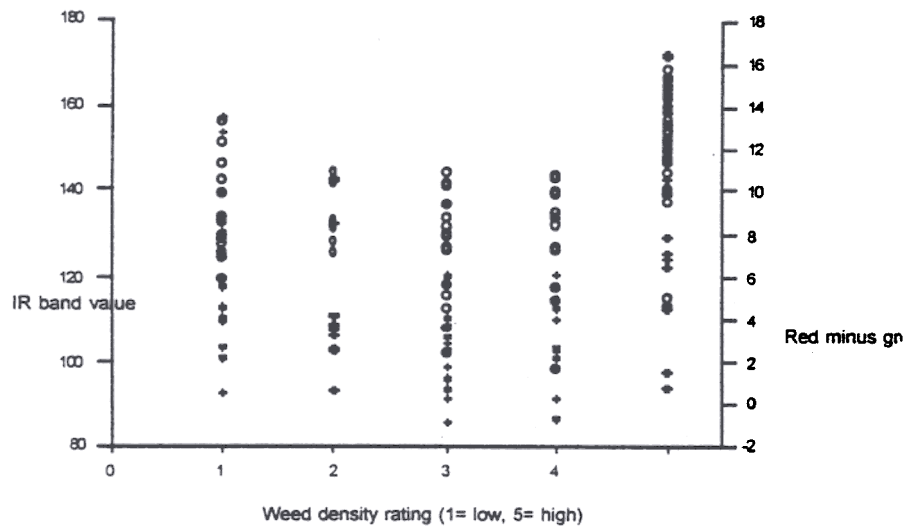


Figure 6. Relation of color aerial photo in field 58 at grain fill to visual weed ratings at anthesis. Color values on vertical axes determined from pixels within 50-ft radius of weed rating locations.