THE ROLE OF COMBINE YIELD MONITORS IN NUTRIENT MANAGEMENT

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INTRODUCTION

A grain yield map is one of the key elements of site-specific crop management. Knowledge of spatial yield variations can serve three basic functions. First, a yield map can illuminate problems with drainage, fertility, diseases, or weed infestations that may have gone unnoticed by the producer. Secondly, a yield map is a feedback tool that will encourage a grain producer to compare different fertility treatments, planting rates, or other variations in cultural practices. Third, a yield map can define the spatial variation in the production potential within a given field, for use in prescribing spatially-variable crop inputs.

For some producers, the first two uses may justify the expense and effort of acquiring a yield map. However, it is the use of a yield map as a basis for site-specific crop management that is the subject of this discussion.

THE TECHNOLOGY

Four basic streams of data are needed to produce a yield map; combine location, combine width of cut, combine ground speed, and grain flow rate into the bin.

1. Location
Considerable effort has been expended in developing and evaluating different methods of navigation, but the consensus is settling on some form of the Global Positioning System. As long as selective availability is activated, autonomous GPS receivers will probably not produce sufficient accuracy for yield mapping, and some form of differential GPS (either real-time or post-processed) will be needed. Systems for real-time differential corrections may use uplink-downlink communications to make the differential corrections available to wide geographic areas.

2. Width of Cut
Width of cut can be treated as a constant by producers of row crops having regular field boundaries, but many producers will harvest grain in terraces having point rows and other irregular field shapes. Ultrasonic and optical sensors have been investigated for sensing the uncut grain boundary on a grain platform. However, if differential GPS fulfills the promise of "centimeter-level" accuracy, width of cut can be obtained by comparing the paths of adjacent combine swaths.

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3. Ground Speed
Most standard combine ground speed indicators are based on transmission speed, which neglects variations (sometimes significant variations) in slippage. "True" ground speed indicators generally use radar or ultrasonic sensors, and have been well accepted in the tractor market. A second source of true ground speed is the differential GPS.

4. Grain Flow Rate
A number of methods have been developed to determine grain yields in real time as the crop is harvested. Potential grain flow measurement concepts include volumetric paddle-wheel sensors (Searcy, et al., 1989), optical measurement of elevator content (Pfeiffer, et al., 1993), piezo-film impact (Pang and Zoerb, 1990), radiometric techniques (Auernhammer, et al. 1993), and a pivoted auger (Wagner and Schrock, 1989). Additional grain flow measurement concepts were reviewed by Borgelt (1992). Impact-type flow sensors are commercially available from at least two sources.

FIELD EXPERIENCES

The Biological and Agricultural Engineering Department at Kansas State University has been active in yield mapping since 1984, and has concentrated on the development of a grain flow sensor. Our current system uses post-processed differential GPS for location, constant width of cut, an ultrasonic sensor for true ground speed, and a triangular elevator for sensing grain flow (Pringle et al., 1993 and Howard et al., 1993). The system, illustrated in figure 1, has mapped over 2000 acres, primarily of wheat and corn. It is now being used by the KSU Department of Agronomy in a study of spatially-variable nitrogen management in irrigated corn.

The raw data from the flow sensor are correlated to differential GPS position signals and processed into grain yield maps (figure 2). Details of the procedure are contained in Pringle et al. (1993) and Howard et al. (1993). The grain flow sensor data were combined into blocks so that each field was represented by 1000 points, and variograms were developed for each field based on those points.

The influence of cultural practices on the degree of yield variability is difficult to determine from the 1000-point data sets, since the area represented by each data point varies somewhat for each field. The coefficients of variation for the yield of nine fields mapped during the summer and fall of 1992 are shown in table 1.

The dryland wheat yields showed the highest coefficients of variation, ranging from 19.98 to 32.57%. The highest coefficient of variation was for a field that had experienced winter-kill that varied across the field.

All of the corn fields shown in table 1 were irrigated, but the method and management of the irrigation varied from field to field. In general, the irrigated corn had lower coefficients of variation than the dryland wheat, and the variability appears to have been reduced as the level of irrigation was increased. The highest variation was evident in a field that experienced flooding and replanting.

CONCERNS

1. Yield Map Accuracy.

The relatively harsh operating environment on a combine requires that close attention be given to sensor calibration, mechanical and electrical shielding of cables, and protection from dust and vibration. Internal averaging of crop flow within the processing components of a combine can produce spurious yield spikes unless machine transients are handled correctly in the yield calculation process. A continuous real-time display of yield is a valuable feature that builds confidence in the integrity of the mapping system, even if the display is not fully corrected for grain moisture or other factors.

2. Validity and Intended Use

Even if one assumes that a yield map accurately reflects a field's yield on a given year, it is highly questionable whether a single year's map should be used as a basis for spatially varying fertilizer rates or other inputs. To qualify for use as a site specific input, a map should answer the question, "How does yield potential vary spatially within this field?" In the author's opinion, a map based on one year of spatial yield data is an inadequate answer to this question.

During a given year, many factors can intervene and distort productivity in a spatial manner, adding "noise" to a yield map. For example, rain may interrupt the planting of a field, or a fertilizer attachment may malfunction for a few planter swaths. It would seem that several (at least three?) years of yield maps should be averaged or otherwise combined in order to represent the spatial differences in productivity that underlie the annual "noise."

CONCLUSIONS

1. Coefficients of variation for grain yield have generally been in the range of 10 to 35%, when yield blocks of about .04 acre are compared. Coefficients of variation for irrigated crops have tended to be lower than dryland crops.

2. Caution should be applied when using yield maps as a basis for prescribing spatially-variable crop inputs. Because a single year's yield map contains annual "noise," it is suggested that several yield maps be consolidated to produce a more accurate representation of the spatial variations in a given field's productive potential.

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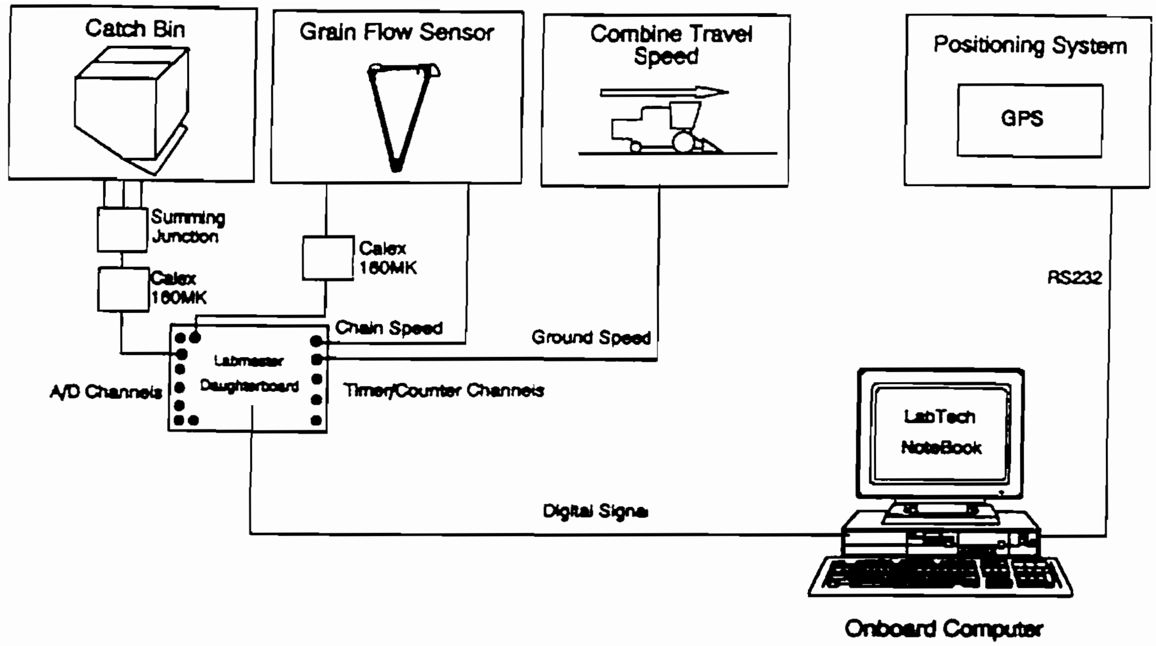

Figure 1: Schematic of data acquisition system for yield mapping and flow sensor development.

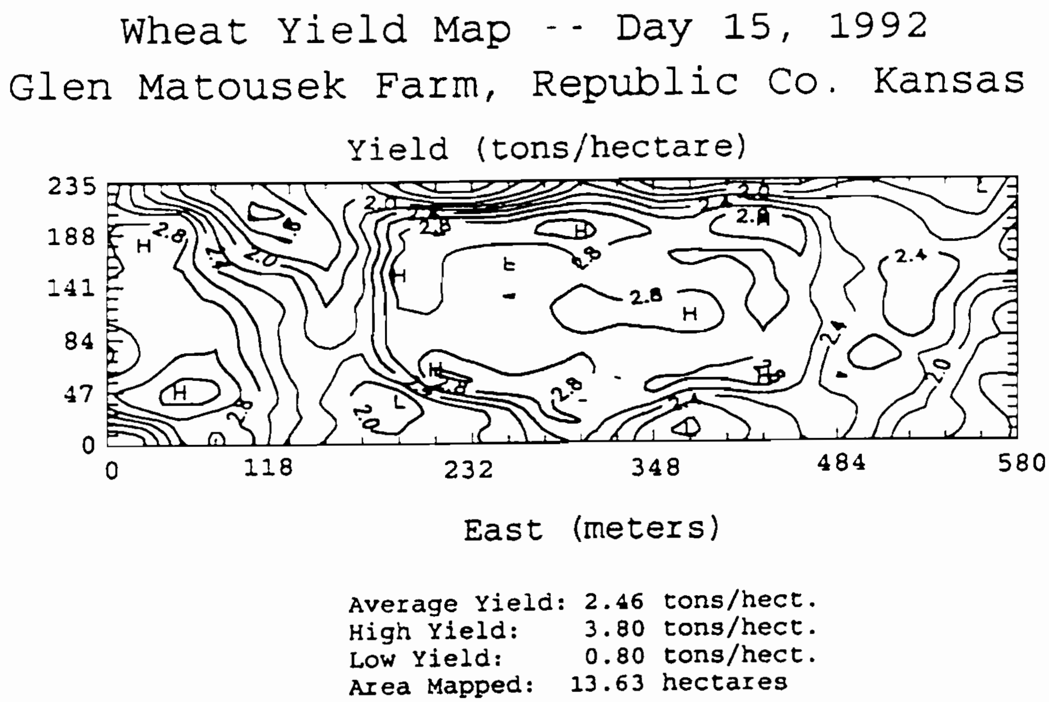

Figure 2: Example of yield map of dryland wheat.

Table 1: Coefficients of variation for 1992 harvest yield data.

Crop	Water Management	Coef. of Variation
Wheat	Dryland	19.98
Wheat	Dryland	26.40
Wheat	Dryland	32.57
Wheat	Dryland	20.32
Corn	Irrig. Moderate	15.42
Corn	Irrig. Limited	14.19
Corn	Irrig. Moderate	8.20
Corn	Irrig. Full	10.26
Corn	Irrig. (Replant)	22.58

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