COOPERATIVE EXTENSION SERVICE
University of Kentucky – College of Agriculture

Site Specific Issues

A Precision Agriculture Newsletter

Winter Planning 2002

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GPS Accuracy

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There have been many innovations in GPS technology in recent years that have caused the accuracy of available equipment to be dramatically increased and the prices to drop. The bottom line for most people when purchasing receivers is to get a unit with good accuracy at the lowest price possible. The problem is that it can be difficult to determine just how accurate a receiver will be, given the numbers on a specification sheet. There are actually two things to consider when evaluating GPS accuracy: 1). how was the accuracy reported, and 2). how was the receiver tested?

Accuracy Reporting

There are several different ways that manufacturers publish accuracy data, most of which are based on different statistical inferences. The following table shows some different accuracy reporting methods.

To illustrate, consider a GPS receiver that specifies 3 ft. rms accuracy. From the second line of the table, this means that the receiver will give you accuracy within 3 ft. about 67% of the time. This is quite typical of many receiver specifications. Now consider a second receiver with a 5 ft. R95 accuracy. To compare the receivers, you must convert the specifications to the same basis using one of the conversion factors from the table. In this case, multiply the 3 ft. rms specification by 1.7 to convert to the equivalent R95 specification of 5.1 ft. The conclusion is that the second receiver is more accurate than the first.

Testing Method

Most receivers are tested using a static accuracy test. This means that the manufacturer places the receiver in a known location for a fixed period of time and collects position data. Most of the time, the static test duration is 24 hours. Unfortunately, the static test is not always indicative of the dynamic performance of the receiver. Different manufacturers are using a variety of techniques to report dynamic or pass-to-pass accuracy of the receiver. Be aware that many of these tests are conducted for very short time durations. This means that the GPS receiver will perform well as long as you make subsequent trips across the field within a couple minutes of the previous. You may notice a degradation of performance if you take extended breaks for refills or repairs.

Researchers at UK are actively involved in testing GPS equipment to determine how they really perform. In addition, there is a national effort underway to standardize testing and reporting methods for GPS receivers. Until then, make sure to ask tough questions about testing and reporting methods.

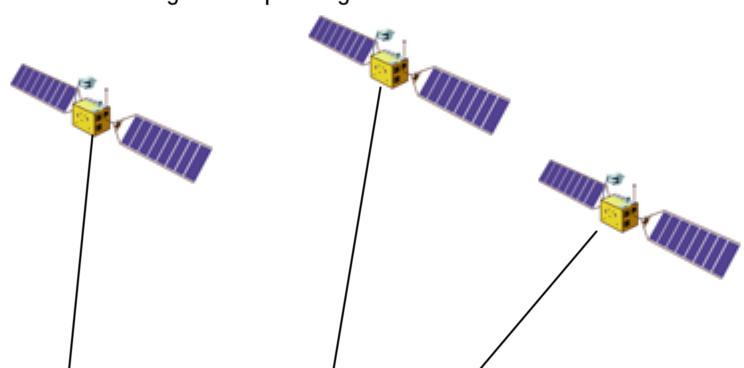


Table 1: Conversion to different units of accuracy.

Accuracy Description	Probability (%)	Conversion Factors			
		CEP	**rms**	**R95**	**2drms**
CEP – Circular Error Probable	50	1	1.2	2.1	2.4
rms or 1 Sigma – 1 standard deviation	63-68		1	1.7	2
R95 – horizontal 95% accuracy	95			1	1.2
2drms or 2 Sigma – 2 standard deviations	95-98				1

Also in this Issue...

Something to Think About

Some Editorial Thoughts on PA topics from Researchers at UK

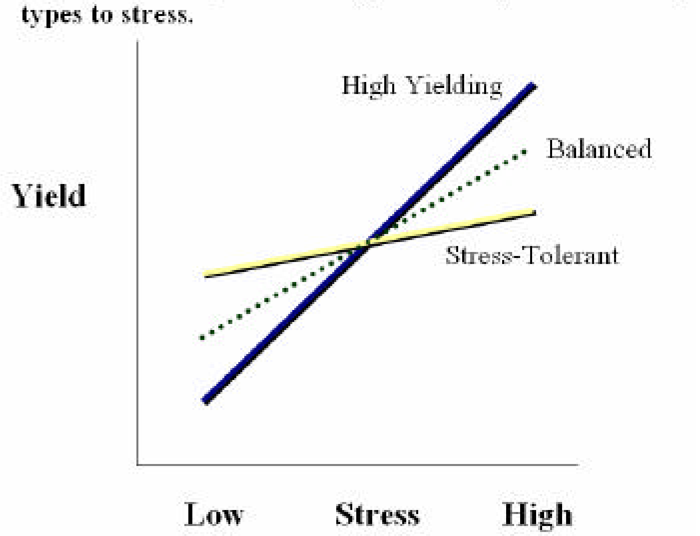
Highlights of the Agronomy Meetings

*Dennis Hancock**

The American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America held their joint annual national meeting in Indianapolis in November. There were several presentations made on topics related to site-specific management, generally revolving around three main themes: variety selection and population management, long and short-term yield data analysis, and fertilizer response curves within management zones. Though this is just three examples of current research, and an over-simplification of their work, there is some tremendous work going on in other parts of the country, not to mention the studies ongoing here at UK.

Variety Selection and Population Management – One common variable rate technology (VRT) is that of varying seeding rate within a given field. This has been done with significant success in many instances, particularly when differences in water holding capacity of the soil are considered. Researchers in North Carolina are evaluating the use of stress-tolerant varieties in consistently droughty areas and high yielding varieties in areas with higher water holding capacity. This is based on the principle that varieties range from stress-tolerant (yields decline very little with increased stress, but similarly will not increase much with good conditions) to record-yielding varieties (which have outstanding yields in good conditions, but decline quickly with stress (Figure 1). Because varieties with a balance between stress-tolerance and high yields are what show consistent results, most companies promote varieties that are somewhere in-between. The point of their research, and the point of other presentations made later, was that the balanced varieties are, by definition, intended to show little variability between zones in a field. Differences that have been observed in VRT seeding rate studies are likely only an indication of the possibilities. A statement of summary from one project pointed out that broadly adapted varieties are generally poorly adapted to site-specific management. However, we've found that many things in Precision Agriculture work in theory, but fail to consistently work in "the real world." Proceeding cautiously with on-farm experimentation and careful plot research is prudent despite these possibilities.

Figure 1: Conceptual viewing of the response of variety types to stress.



Long and Short-Term Yield Data Analysis – Another area that was mentioned often was how to properly utilize yield data. Some work out of South Dakota suggests a way to make sense of your yield data. Of course, to do this you must first "clean" the yield map data. Their suggestions were to pay particular attention to locations with down head positions and very low flow, rapid changes in speed, excessively slow speed, unreasonably low flow, and yields exceed +/- 3 standard deviations of the mean. I would add to this by cautioning you to examine the data before you delete it. Though these are indications that the data points are errant, it doesn't always mean that they are. Some data points that look off may actually be correct. Once the data is "cleaned," it should give a more meaningful picture of the field.

With multiple years of data, a standardization of the information (even across different crops) can be achieved. See the accompanying equation. Such a standardization can show areas that consistently yield high (high yields – low standard deviation), consistently yield low (low yields – low standard deviation), and unstable areas in the field (low or high yields – high standard deviation). This may not give a complete picture of the field, because it doesn't include factors such as random weed patches, insect damage, or other yield limiting events. However, if one uses scouting records in conjunction with them, standardized yield maps give a good look at a field.

$$Yield_{std} = \frac{Yield_i - Yield_{min}}{Yield_{max} - Yield_{min}}$$

Where

$Yield_{max}$ = maximum yield
$Yield_{min}$ = minimum yield
$Yield_i$ = yield at point i

Fertilizer Response Curves Within Management Zones – Response curves are generated by varying the soil fertility and measuring the resulting yield (Figure 2). As soil fertility increases (or more fertilizer is added), yield usually increases (Yield **A** < Yield **B** < Yield **C**) and then

Figure 2: Conceptual viewing of yield response to fertilizer input.

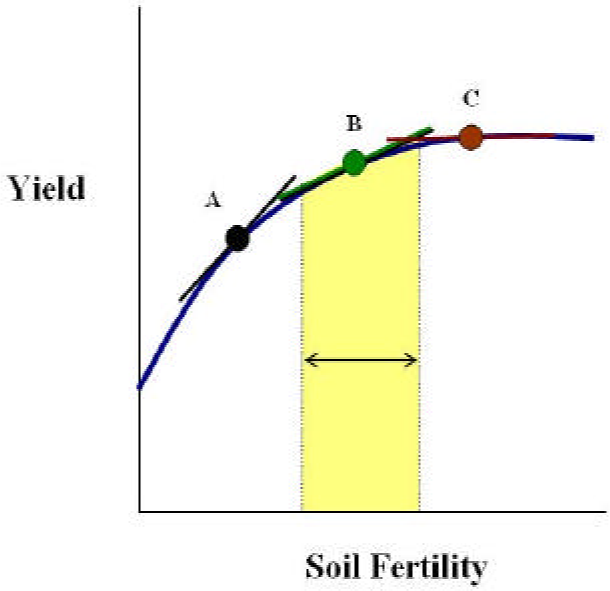
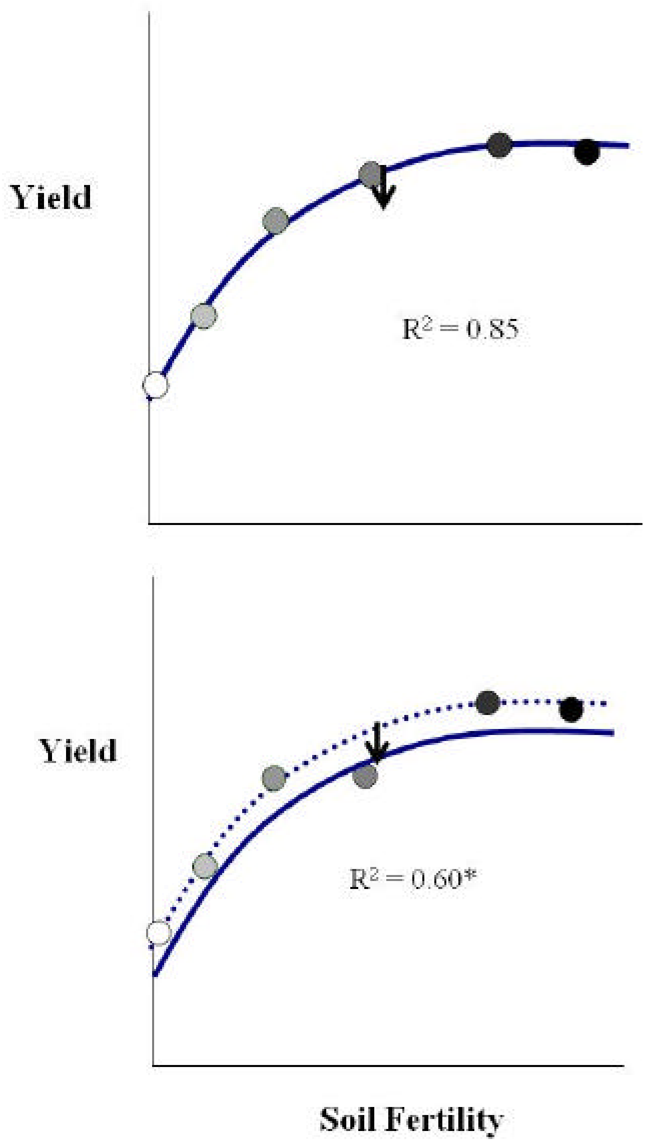


Figure 3: Theoretical change in predictive ability of site-specific response to fertilizer input.



reaches a maximum at a certain point (**C**). After that point, additional fertility doesn't increase yields. Fertilizer recommendations from UK (AGR-1) are based on response curves for different soil test levels and have been developed from several years of research, over many locations, and conditions. However, their recommendations aren't to fertilize to achieve maximum yield (**C**). Their recommendations are based on the fact that at some point (**B**), the cost of an extra pound of fertilizer will equal the value of the increase in yield. The recommendation is for point **B**, given a certain soil test level, aeration/drainage, and cropping history. Such a recommendation should be viewed as just that: a recommendation. Because of their basis on unspecified sites, these are guidelines and not absolutes.

From an economic perspective, the ideal would then be, to develop a response curve for each site in the field. Though this is a possibility given the abilities of Precision Agriculture, it takes time, considerable effort, and is error-prone. Researchers from Missouri are working on just such an idea in selected fields. They staggered soil fertility consistently across a grid in the field to 6 levels of soil fertility and created a response curve in each field. Each year makes the response curve more accurate. But there are vulnerabilities to this system, particularly in the short term. Consider the accompanying figure. The researchers showed that if something caused just one point to shift (a weedy patch or drowned population, heavier than normal insect pressure, etc.), it would have a major impact on the accuracy of the response curve. Such an errant data point could reduce the predictive ability and accuracy of the curve. Only several years later with lots more data, would those events have less of an effect on the curve. This means one would have to stagger soil fertility across the grids in a field for several years to get good data. This obviously would not be economically feasible for most producers. However, from a research perspective it is intriguing, as such research may identify other parameters (soil characteristics, elevation changes, etc.) that have consistent affects on the shape of the curve.

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Precision @g

Check out some of the new additions to our website: www.bae.uky.edu/precag/

Research HIGHLIGHTS

Mapping Soil EC

Tom Mueller, Than Hartsock, Richard Barnhisel, Tasos Karathanasis, Scott Shearer, and Tim Stombaugh[1]

Soil electrical conductivity (EC) refers to the ease with which electrical current moves through the soil. Prior to our initial studies, we wondered why some farmers across the United States had been interested in mapping soil EC across agricultural fields. As we examined the literature, we found that Missouri researchers had related EC to claypan depth below the surface (soils with 50% or more clay below the topsoil) (Doolittle et al., 1994). Although most soils in Kentucky generally have < 35 % clay below the topsoil, topsoil thickness is of agronomic importance because clayey subsurface horizons may limit root growth. Work in Kentucky has demonstrated the importance of topsoil thickness (Barnhisel et al., 1996), including some work showing that topsoil thickness can explain 70 to 90% of yield variability (Murdock et al., 2002).

One initial question was whether it would be possible to predict topsoil thickness for soils in Kentucky using EC. Our findings showed good relationships for up to 18 or 19 inches of topsoil, although the slopes, intercepts, and strengths of these relationships varied across locations and over time (Fig. 1)(ECshallow and ECdeep refer to EC in the top 1 and 3 feet of soil, respectively). The variation of these relationships suggested that site and time specific calibration measurements would be necessary to predict topsoil thickness. Also, in some cases, prediction may not be possible for all fields such as Shelby Co. Field B, which had relatively little clay in surface samples. Often areas with higher EC and thinner topsoils tend to occur on more severely sloping and eroded soils in fields (Fig. 2). We also found that EC was related to the depth of fragipan and depth to bedrock. These factors also affect soil water storage.

Other work in Kentucky has shown that every additional inch of topsoil thickness contributes, on average, 10.1 bu/ac more corn up to an 8 inch depth (Murdock et al., 2002). Still other work has shown topsoil depth can be used as a basis for variable rate nitrogen and seeding (Barnhisel et al., 1996). Unfortunately, topsoil thickness is not known without intense sampling. If EC can be used to predict topsoil depth, EC may be useful for variable rate technologies. We are currently conducting variable rate nitrogen studies across Kentucky to relate nitrogen response to soil EC.

Our second interest was to study relationships between EC and grain yield. Other investigators have shown that boundary line relationships exist between EC and yield (Kitchen et al., 1999). Our initial work confirmed this relationship for Kentucky soils. With a boundary line relationship, the potential for high yield decreases as EC increases. Note how maximum yield decreases with increasing EC (Fig. 3). These relationships tend to be stronger in dryer than wetter years, and more consistent for corn than for soybeans or wheat.

Currently, we are developing a software package that uses boundary line analysis to calculate and develop yield potential maps. These maps are created by calculating the difference between potential and actual yield which could be indicative of yield opportunity. The quality and management adequacy of these maps is currently being assessed, but it is not clear the extent to which this approach will benefit Kentucky farmers.

[1] This material is based upon work supported by the Kentucky Corn Growers Association and the Cooperative State Research, Education and Extension Service, U. S. Department of Agriculture, under agreement no. 99-34408-7561 (any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U. S. Department of Agriculture or the Kentucky Corn Growers Association). We are grateful to Mike Ellis, Wayne McAtee, Rick Murdock, and Charlie Stuecker for providing access to their farms to conduct this research.

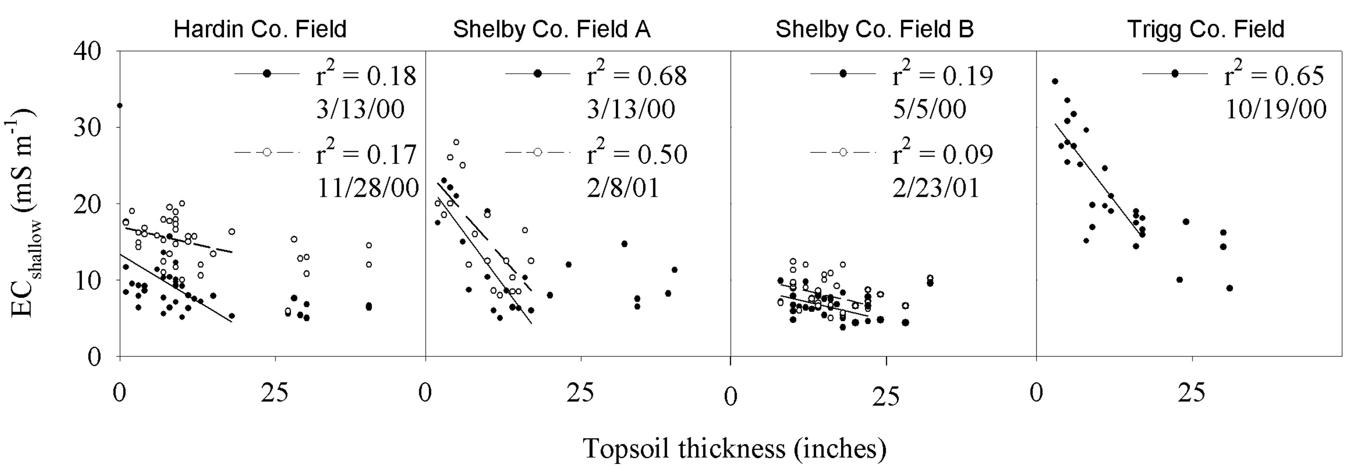

Fig. 1. Relationship between shallow soil EC and topsoil thickness for soils in Hardin, Shelby, and Trigg Co. Kentucky. Adapted from Mueller et al. (2003).

Our work suggests that EC mapping may have potential in other areas, such as in assessment of rental ground, CRP land enrollment, and detecting differences in historical management. This technology is promising for Kentucky farmers; however, site and time specific calibration is likely to be required to improve predictability.

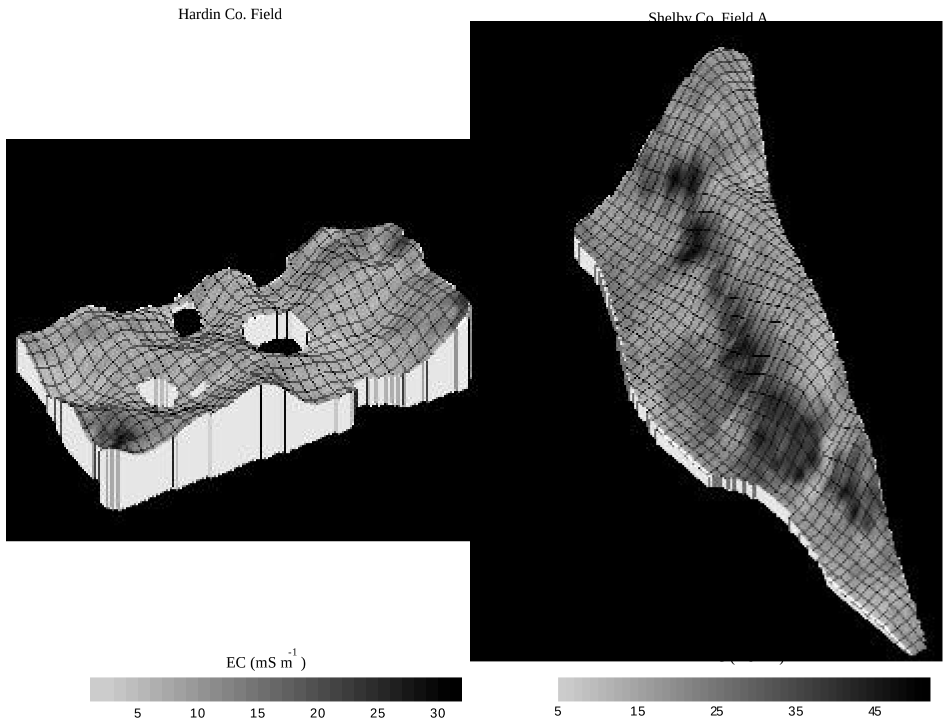

Fig. 2. Soil EC overlain on digital elevation model for fields in Hardin and Shelby Co. (13 times vertical exaggeration).

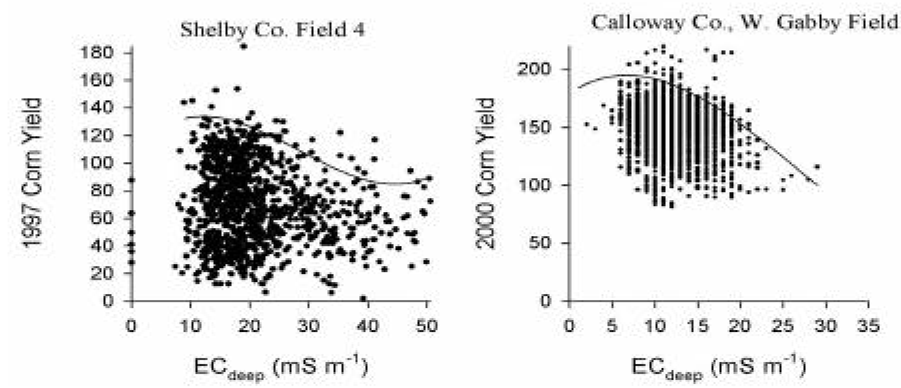

Fig. 3. Boundary line relationships between corn grain yield and EC.

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Hands-on Training Opportunities:

Kentucky Wheat Field Day

When: Mon., January 7: 8:30 a.m. - 2:30 p.m.
Where: Christian Co. Extension Service 2850 Pembroke Road, Hopkinsville

The University of Kentucky College of Agriculture Wheat Science Group's winter conference will highlight no-till production, disease control methods, and new varieties. In addition, Dr. Marvin Stone, an agriculture engineer from Oklahoma State University, will be discussing the successes they've had with variable rate nitrogen applications using real-time, site-specific sensing of crop needs. The Kentucky Small Grain Growers Association will be providing lunch and there will be 3 Certified Crop Advisor credit hours available (1 each in nutrient management, pest management and crop management). For more information, contact Jay Stone, Christian County Extension agent for agriculture and natural resources, at (270) 886-6328, or Dottie Call, Wheat Science Group coordinator, at (270) 365-7541 ext. 234.

Quotables:

"I'm not sure I understand all I know about that." – **Anonymous Farmer** upon looking at yield data that just didn't look right.

"Any technology used in an efficient operation will magnify the efficiency. Technology applied to an inefficient operation will magnify the inefficiency."

- Bill Gates, Founder of Microsoft

UK COOPERATIVE EXTENSION SERVICE
University of Kentucky – College of Agriculture

PRECISION AGRICULTURE

In Kentucky

Developing and Assessing Precision Agriculture Technologies for Kentucky Producers

1st Annual Conference

February 13, 2003 - 9 a.m. to 6 p.m.
South Wing – Rooms 109-110

Kentucky Fair & Exposition Center in Louisville, Ky
In conjunction with: The 38th National Farm Machinery Show

Conference Objective

To share results from University trial and on-farm research that assesses precision agriculture equipment and technologies that enhance profitability and improve environmental quality on Kentucky farms