CLEMSON
PRECISION AGRICULTURE

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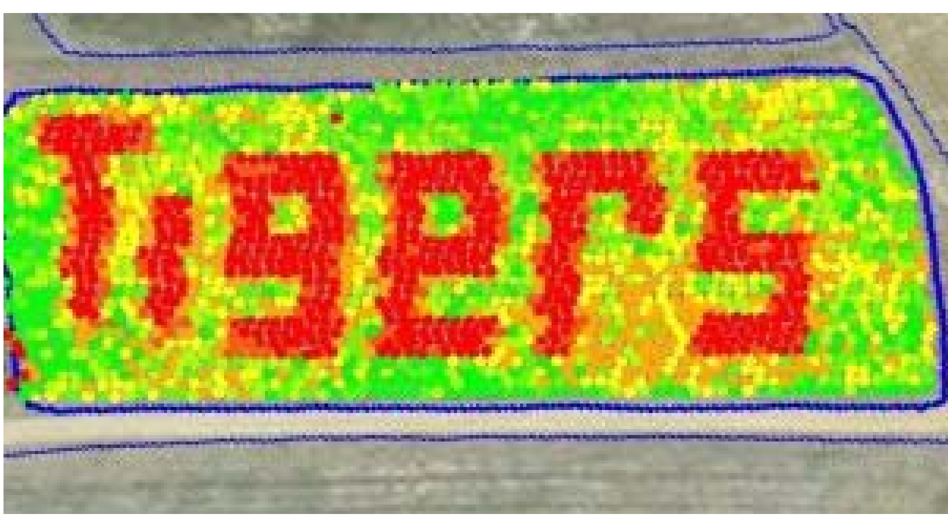
“Directed R_X” for Variable Rate Prescription Development

Dr. Kendall Kirk—Precision Ag Engineer

Variable rate application capabilities exist for most of today’s inputs used in row crop production. The underlying goal of variable rate application is to improve use of crop inputs to increase profitability; in some cases this is accomplished by reducing input costs and in some cases this is accomplished by increasing yields, but in all cases increasing profitability equates to maximizing revenue with respect to input costs. The prescription plan is the map used by the rate controller, which spatially defines the rates and/or products to be applied. An in-cab computer uses GPS position along with the prescription plan to communicate with the rate controller for any given position in the field. Variable nutrient application rates other than nitrogen are generally dictated by results of zone or grid soil samples, sometimes coupled with yield goals. However, other rates and products such as nitrogen, seeding rate, or hybrid selection are generally less scientifically defined. Several methods exist for assigning these rates, the most common of which involves assignment of a product type or rate of product by zone on the producer’s or consultant’s expected performance of that zone.

Introduction to Directed R_X

Directed R_X is a system being developed by Clemson researchers in an effort to improve these variable rate prescriptions. The central concept of the Directed R_X system is to integrate yield data and soils data from a field to optimize the prescribed inputs for that specific field. A unique feature of the Directed R_X system is that it does not use generalized test results from other sites; it uses only the yield response data generated from the field in question. In conventional prescription plan development the rates and products assigned to these zones are often based on data generated from tests conducted elsewhere or they are based on grower/consultant speculation of what might be best in each area of the field. Check strips or blocks in conventional prescription assessment allow for assessment of rates within zones but are not valuable for zone boundary refinement.



In This Issue

"Directed R_X" cont.

How Directed R_X works

The Directed R_X system uses strip tests to integrate yield and therefore profitability effects with site-specific foundation (e.g. soil EC, elevation, irrigation) polygons, seeking to optimize prescriptions, specific to a field and input. The method allows for layering of multiple datasets for zone foundation and is applicable to prescription development for any input where yield data is available. The Directed R_X system involves application of fixed rate input strips and yield data collection across these strips. Soil property data (e.g. soil electrical conductivity, elevation, texture, etc.) is collected and contoured to divide the field into soil foundation zones. The yield for each input rate/product is then averaged as a function of each soil property. This method allows for determination of the rate/product that maximizes profitability within each soil property division, which defines the prescription to be applied in the subsequent year.

Directed R_X Example: Variable Rate Corn Seeding

The example provided here is from a Directed R_X test that was conducted in 2016 to develop a prescription plan for corn (DKC62-05) seeding rate in a 24 ac field in Barnwell, SC. The steps demonstrated here are similar to what would be used for application of the Directed R_X system to any type of prescription plan development:

1. Establish soil foundation zones (Figure 1a). In this example the deep EC, measured with a Veris cart, was contoured to seven divisions for establishment of these zones. It should be noted that this number of divisions is higher (finer resolution) than that which is normally employed in conventional zone management.
2. Lay out strips for variable rate input to be tested (Figure 1b). Although the Directed R_X system is for development of a variable rate prescription, those rates are actually determined through application of fixed or blanket rate/product strips. Take care here to consider the width of the harvester and the width of the planter. The strips do not need to canvas the entire field, but they do need to span the soil foundation zones as best possible.
3. Collect yield data from strips (Figure 1c). If profit analyses are to be conducted, a good yield monitor calibration is important. Note that the yield data shown here is overlaid on the deep EC data. The next step involves averaging the yield response as a function of EC within each seeding rate.

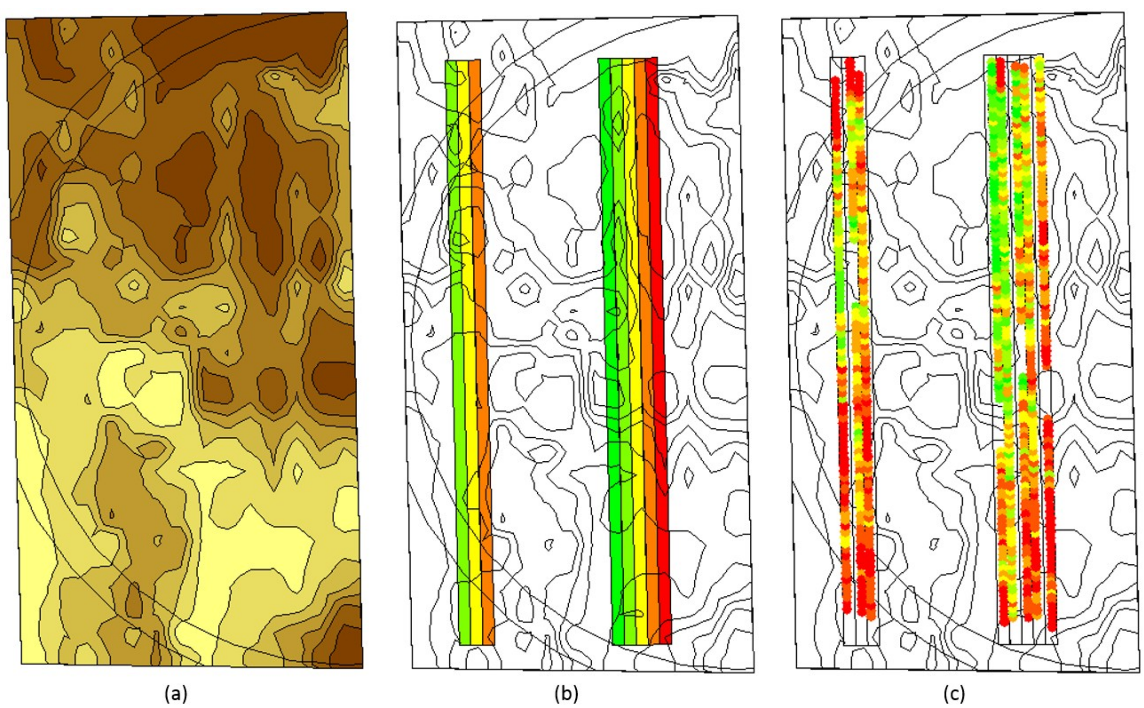


Figure 1. Seven division contour map of deep EC (a) with darker colors representing higher EC values and semi-circular lines representing end tower and endgun boundaries; layout of blanket seeding rate strips (b) from 27,000 seed/ac (red) to 39,000 seed/ac (green) in 3,000 seed/ac steps; and yield data collected from strips (c) from about 220 bu/ac (red) to about 290 bu/ac (green).

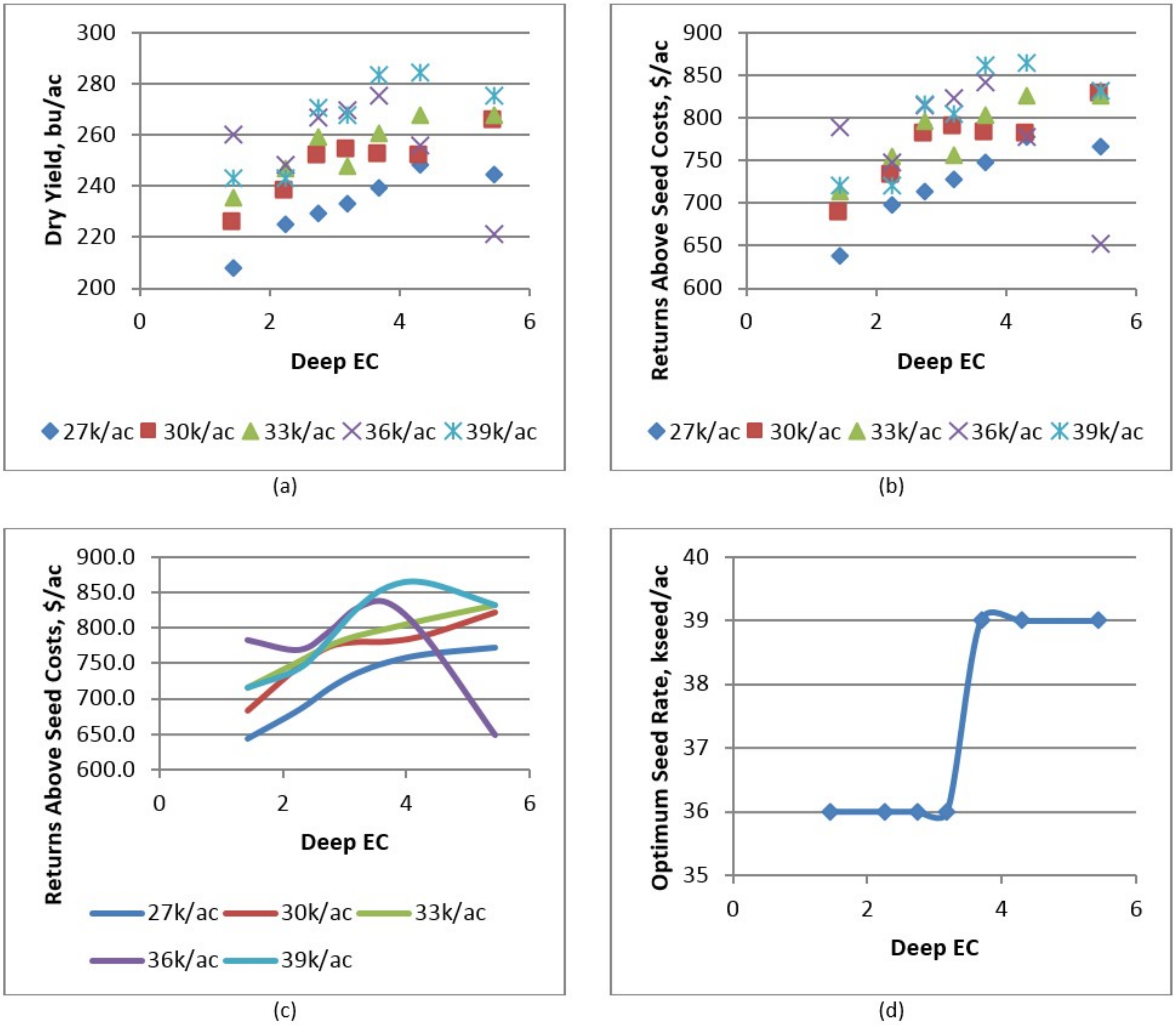


Figure 2. Yield as a function of deep EC for each seeding rate (a); cash returns above seed costs, $/ac, as a function of deep EC for each seeding rate (b); trendlines for cash returns above seed costs, $/ac, as a function of deep EC for each seeding rate (c); and optimum seeding rate as a function of deep EC.

"Directed R_X" cont.

The next steps involve averaging the yield data for each input rate/product (in this case seeding rate) as a function of soil foundation basis (in this case deep EC), as shown in Figure 2a. Using the market price of the commodity, the input costs per unit, and the input rate by strip, returns above input costs ($/ac) can be calculated (Figure 2b). While this calculation is not equal to profit, the differences between the returns are representative a differences in profit, assuming all other inputs between the strips are equal. To make it easier to compare returns as a function of deep EC across seeding rates, trendlines are calculated for each seeding rate (Figure 2c). It can be observed in Figure 2c that the 36,000 seed/ac rate was the most profitable at low EC values and the 39,000 seed/ac rate was the most profitable at high EC values; information from Figure 2c can therefore be used to develop Figure 2d, providing optimum, or most profitable seeding rates as a function of deep EC.

Once the optimum seeding rate as a function of deep EC is determined, the Directed R_X prescription map can be generated (Figure 3). This is done by simply assigning the optimum seeding rate for each EC value to the polygons represented for that EC value. This prescription can then be exported as a shapefile and uploaded to the rate controller. While the system allows for subdivision of contours on the basis of irrigation (or any other spatially defined factor), independent non-irrigated rates were not developed in this example because this field did not have enough area outside of irrigation.

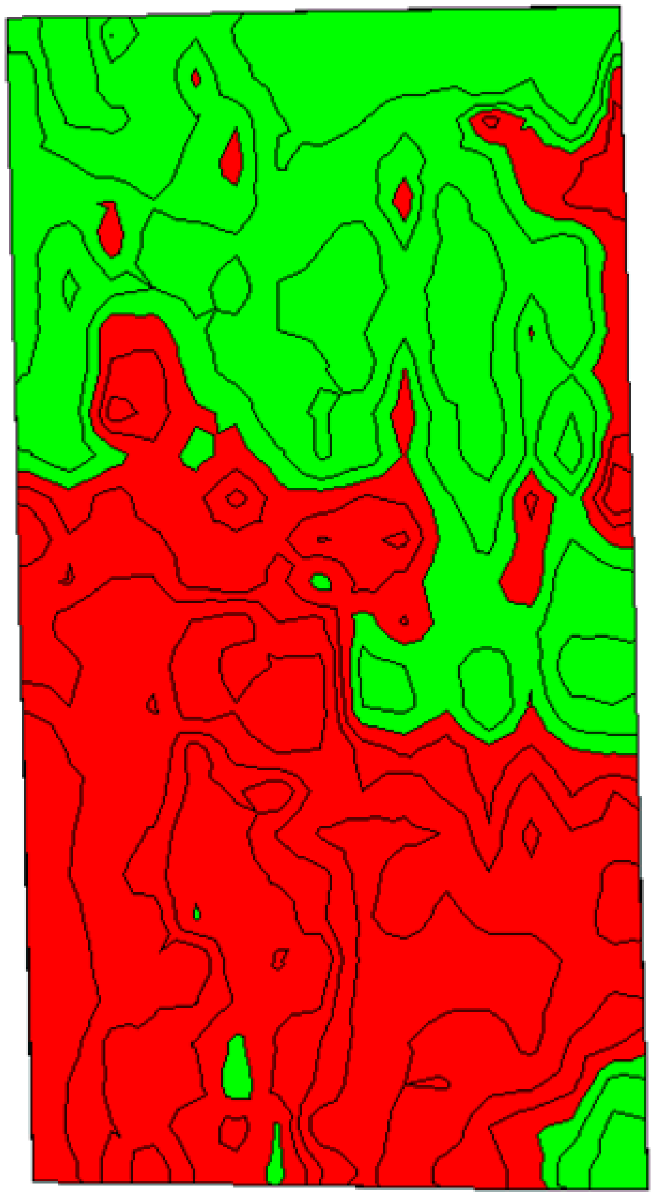


Figure 3. Directed R_X seeding rate prescription plan for field demonstrated in example with seeding rates of 36,000 seed/ac (red) and 39,000 seed/ac (green).

"Directed R_X" cont.

Software to facilitate implementation of the Directed R_X system has been developed by Clemson researchers with hopes of being available for public release within the next year. Studies are underway to evaluate the best soil properties to use for zone development, to evaluate profit value of method, and to evaluate weather effects on prescriptions. One obvious drawback of the system is that the strip test in place this year will be used for next year's prescription. For this reason, tests currently in place focus on irrigated land, somewhat reducing year to year weather effects. Not all fields are good candidates for all variable rate applications; if you are considering developing variable rate prescriptions for your fields it is generally most profitable to start with the fields demonstrating the highest degree of soil or yield variability. Even if a field proves to be a poor candidate for variable rate application, the Directed R_X system will still demonstrate the most optimum rate for the field. Clemson Precision Agriculture is interested in helping South Carolina growers set up Directed R_X tests on their fields. If you have a yield monitor for a given crop and are interested in optimizing your prescriptions using the Directed R_X system please contact Kendall Kirk (kirk2@clemson.edu) or Hollens Free (free@clemson.edu) and we will help you get started.

Industry Spotlight

Veris: Soil EC and so much more

Since Veris Technologies developed the first soil mapping machine over 20 years ago, the name Veris® has become synonymous with soil electrical conductivity—or soil EC mapping. Growers commonly describe having their fields 'Verised'. Soil EC is a simple yet powerful way of mapping soil variability. Soil EC measurements correlate with soil properties that affect crop productivity, including soil texture, cation exchange capacity, drainage conditions, salinity and subsoil characteristics. The electrical signal penetrates up to three feet into the soil, collecting data from throughout the crop rooting depth. It's like an MRI for your field! With this information, precision growers are improving their soil sampling strategies, varying seed rates and even varieties and hybrids, improving irrigation, and fine-tuning nitrogen applications. Veris soil EC machines are mapping soils across North America and in over 50 countries. Researchers at Clemson University were among the very first to recognize the value of precise soil mapping. In fact, Veris serial #1 was tested extensively throughout South Carolina in 1997-1998 by Clemson researchers.

Today, soil EC technology is the backbone of every Veris system. But Veris is not just EC anymore. Over the past two decades Veris has developed and commercialized sensors that map other important soil properties such as soil OM and soil pH. On-the-go soil optical mapping became commercially available in 2010 with the Veris OpticMapper which uses a soil reflectance sensor to map organic matter. Soil OM affects the chemical and physical properties of the soil and its overall health. It is a key component of productivity, affecting moisture holding capacity and nitrogen availability. While OM levels in the southeast US are lower than in the northern US, even in low amounts OM can be a key indicator and driver of productivity. On-the-go soil pH sensing was commercialized nearly a decade ago with the introduction of the Veris pH Manager. Soil pH is an important factor in crop production. Nutrient usage, crop growth, legume nodulation, and herbicide activity are all affected by the pH of the soil.

Veris Technologies produces two multi-sensor platforms that record soil EC, optical, and pH along with topography data. The MSP3 and U3 systems generate highly detailed soil maps of these critical soil properties and the sensor readings are calibrated with lab-analyzed organic matter and cation exchange capacity, along with pH buffer/lime requirement. The result is a calibrated and validated map of CEC/texture, OM, pH/buffer pH, and field topography at a scale that would be impossible to affordably collect using conventional soil testing. These are crucial soil properties that affect productive potential and they form the foundation of an effective precision program.

In 2013, Veris introduced FieldFusion®, a cloud-based software program that assembles the soil data and fuses multiple layers into single specific maps for different applications. For example, the iNseason Sampling fusion layers combines soil EC, OM, and field topography to identify areas of possible nitrogen loss due to leaching or denitrification. Another fusion delineates both unique and representative water-holding areas to aid in moisture probe placement.

Veris Technologies engineers continue to innovate, with several new sensors and module configurations along with exciting software solutions underway in 2017. Keep checking out www.veristech.com for more information.

Veris MSP3 and U3 models that map soil EC, OM, and pH.

Faculty Member Spotlight

Dr. Kendall Kirk started working at Clemson University's Edisto Research & Education Center in Blackville, SC as the Precision Agriculture Engineer in May 2014. Prior to that, he was a faculty member of the Agricultural Mechanization & Business Program at Clemson University for about 10 years. His current work focuses primarily on development and testing of new technologies, software tools, and management strategies for implementation of precision agriculture. Dr. Kirk is an inventor on four technologies with patents pending and software copyright in precision agriculture. He focuses on development of practical, commercializable technologies and software and works closely with regional farmers for testing and evaluation. Some of his current projects include work on the following: peanut yield monitor, hay yield monitor, on-baler hay bale weighing technologies, automated depth peanut digger, spatial image digitization software, crop yield data processing software, variable rate prescription strategies, and plant vigor analysis sensing and software.

Team Member Spotlight

Alex Coleman is the Feed Grains technician and began working at the Edisto REC in January of 2016. He assists David Gunter in the production of corn, sorghum, soybeans, and small grains, as well as, the Official Variety Trials. Along with this responsibility, he is also enrolled in graduate school at Clemson University in Plant & Environmental Sciences working to determine the best method for developing yield management zones with Dr. Kirk. Alex obtained his undergraduate degree from Clemson in December of 2015 where his major was Agricultural Mechanization and Business.

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