South Carolina Soybean Board
Final Report

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Project Title: Variable Rate Seeding Prescription Development for Soybeans
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Abstract

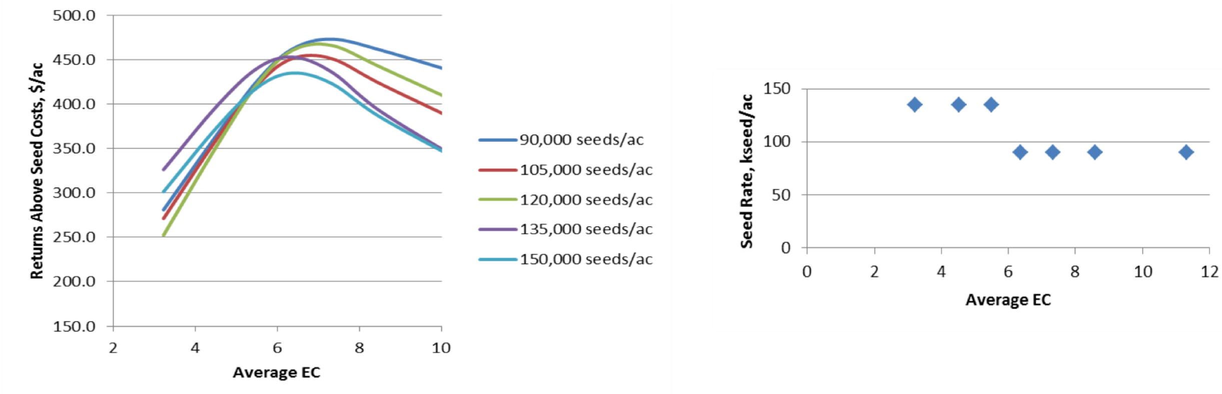
This report summarizes the results of the second year of a soybean seeding rate test conducted at Edisto REC in Blackville, SC. The test was designed to evaluate the potential benefits of variable rate seeding in soybean and to also evaluate Clemson's Directed Prescription (D-R_X) system for soybean seeding rate prescription. Year 1 (2016) evaluated five seeding rates (90, 105, 120, 135, and 150 kseed/ac); the trial was planted in 8-row uniform rate strips. Analysis of the Year 1 data resulted in projection of a $10/ac potential benefit from variable rate soybean seeding, with optimum seeding rates for maximizing yield and for maximizing profit being similar: higher rates in lower EC zones and lower rates in higher EC zones. Year 2 evaluated a D-R_X prescription based on 2016 results and six seeding rates (75, 90, 105, 120, 135, and 150 kseed/ac) planted and uniform-rate strips. The D-R_X treatment in 2017 demonstrated greater yield and profit than the best performing uniform rate treatment but the two were not significantly different. Observed profit benefit from D-R_X in 2017 using the prescription applied from 2016 data was $3.4/ac with a potential variable rate seeding profit benefit of $8.4/ac, had the prescription matched the best performing combination of rates observed.

Introduction

Several studies have been conducted on variable rate seeding for corn and cereal grains, but there have been very few studies that describe best practices for or evaluate profitability of variable rate seeding in soybean. In many cases, growers have variable rate seeding capabilities but only utilize these technologies on a subset of the crops that they grow. Statewide, or even nationally, we do not have sufficient data to support recommendations for variable rate seeding prescriptions in soybean; nor do we even have sufficient data to evaluate whether or not it is a worthwhile practice.

This study utilized Clemson's Directed Prescription (D-R_X) system to develop and test a variable rate prescription for soybean. The D-R_X system uses uniform rate strips in year one and integrates the yield data from these strips with polygons representing other in-field variability, such as soil electrical conductivity (EC), to "direct" a prescription plan for year two. In the D-R_X system, the resulting prescription plan selects the best performing seeding rate (or other variable input) on the basis of profit for each of several spatial classifications (e.g., seven contoured divisions of EC). For this study the average of the shallow and deep EC was used along with the Year 1 (2016) data for direction of Year 2 (2017) seeding rates. This general concept is demonstrated in Figure 1a, where returns above seed costs

($/ac) are shown as a function of EC for Year 1; it can be observed for Year 1 that the most profitable seed rate at low EC values was 135 kseed/ac and the most profitable seed rate at high EC values was 90 kseed/ac. These observations from Year 1 are summarized in Figure 1b, which was used to set the D-R_X seeding rates applied in Year 2. Tests for this two-year study were conducted on an a 13 ac irrigated field in Barnwell County, SC. Results from 2016 suggested that seeding rate for maximizing profit was inversely proportional to EC, with higher seeding rates recommended for the more marginal land.



(a) (b)

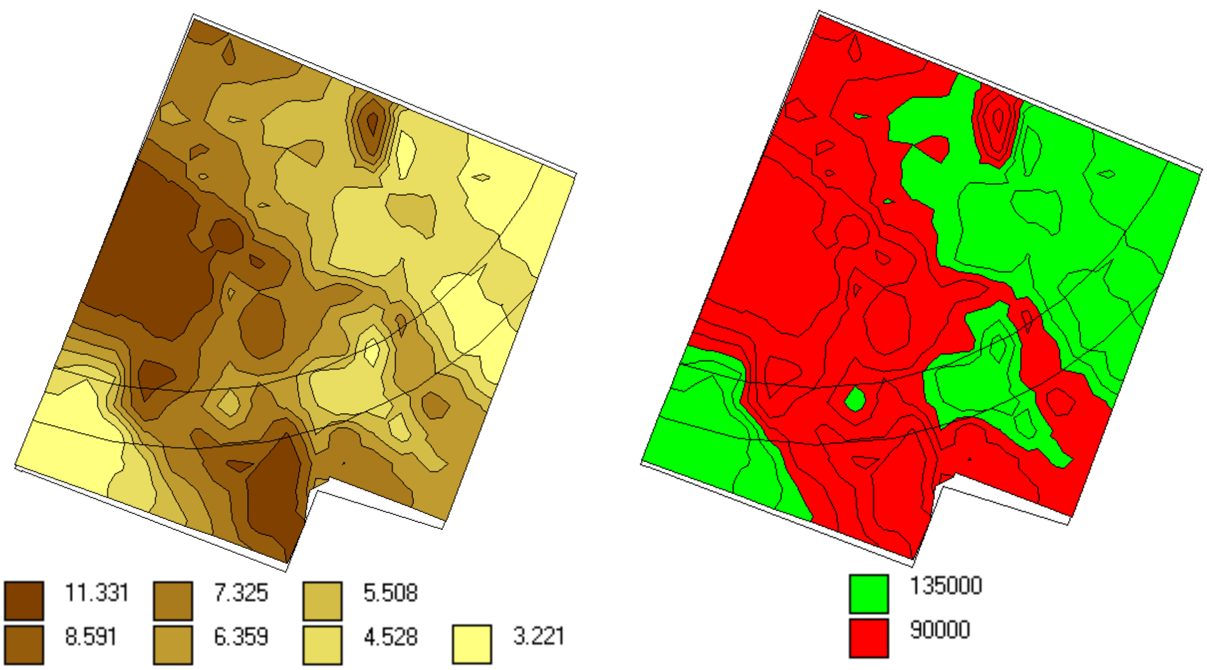
Figure 1. Results from Year 1 uniform rate strip trial used to direct Year 2 D-R_X seeding rates. Figure (a) represents returns above seed costs ($/ac) observed as a function of Average EC across five seeding rates. Figure (b) demonstrates the optimum seeding rates to maximize profit in Year 1 as a function of Average EC.

The challenge in applying variable rate technologies for any input on any crop is consistently getting the prescription right; this test sought to provide evidence to better understand variable rate seeding for soybean. Specific project objectives included:

- Compare profitability of variable rate seeding to uniform rate seeding for soybean
- Evaluate Directed R_X system for VR seeding prescription development in soybean
- Develop recommendations for best management practices for soybean seeding rates

Materials and Methods

The test was conducted in B6B, a 13 ac field located at Edisto REC in Barnwell County, SC with approximately 7 ac under irrigation. Soil texture subclasses present in B6B are sand and loamy sand, with sand contents ranging from 83% to 96.5%. The average sand content of the field is 93.2% (st. dev. = 3.18%); the sand texture subclass dominates, covering about 93% of the field. Both years of the test were conducted in the same field, which allowed for the seeding rate prescription developed as a function of Year 1 (2016) results to be applied during the Year 2 (2017) season. The D-R_X system for variable rate prescription development by design seeks to maximize profitability using results specific to a field. For variable rate seeding, the system requires that strips are planted in Year 1 at several different uniform rates, centered on the typically assigned rates. Taking into account variable input costs, yield data collected from Year 1 was analyzed by seeding rate and by soil division (e.g. soil EC) to identify the most profitable seeding rate from Year 1 within each soil characteristic division, as discussed for Figure 1, above. These seeding rates were then assigned in Year 2 to each soil characteristic division as the variable rate (D-R_X) prescription. In Year 1, the soil characteristic identified as most profitable for D-R_X soybean seeding rate prescription in the field used was average soil EC, which was calculated as the average of the shallow (0-12") and deep (0-36") EC values. Generally, higher seeding rates were more profitable at lower EC values and lower seeding rates were more profitable at higher EC values. The average EC map for the field is shown in Figure 2a and the D-R_X prescription developed from Year 1 testing for application in Year 2 can be seen in Figure 2b, from the rates demonstrated in Figure 1b.

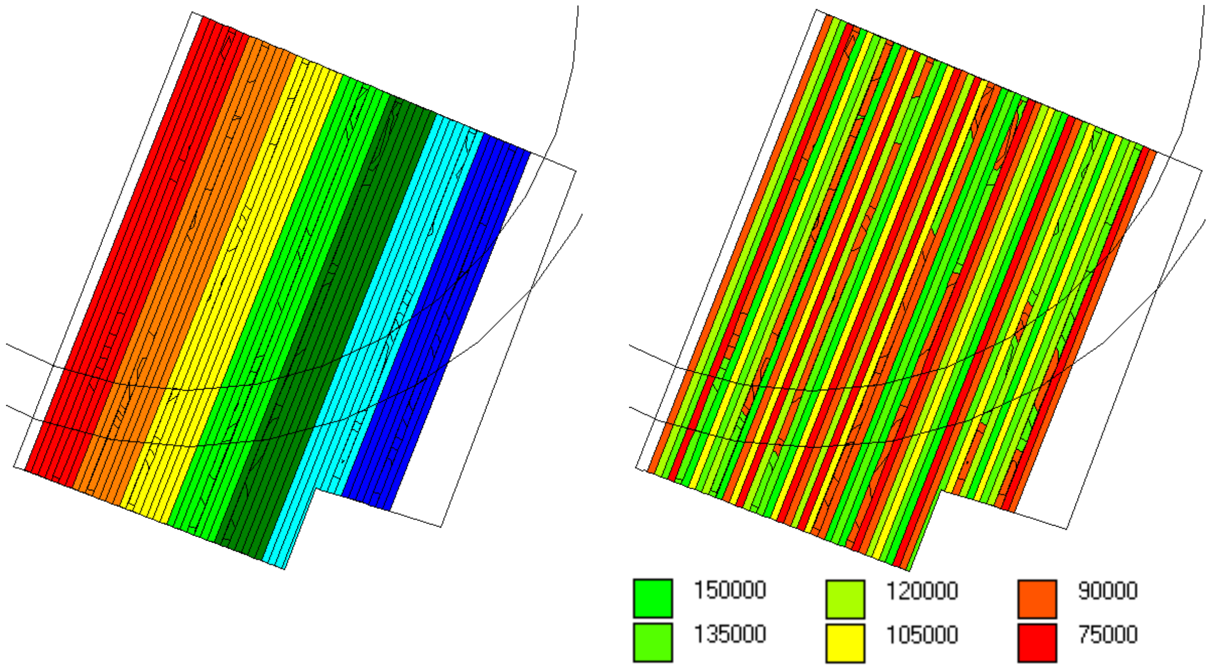


(a) Average EC

(b) D-R_X Prescription Applied in Year 2

Figure 2. Average EC map for B6B (b) with legend units of dS/m, and D-R_X variable rate seeding prescription (b) with legend units of seed/ac. Figure (b) was developed from Year 1 strip test data for application in Year 2. The two circular arcs in each map represent pivot tower and endgun boundaries.

The field was planted with Asgrow 69X6 (Group VI, the same variety as that used in Year 1) on May 17, 2017, applying seven replications of seven 4-row strip treatments assigned in a randomized block design (Figure 3). Row spacing in both years was 38 in. Year 2 of the test comprised about 11.5 ac of field B6B. The treatments included six uniform seeding rates (75, 90, 105, 120, 135, and 150 kseed/ac) and the D-R_X prescription shown in Figure 2b. The crop was routinely scouted for pests and weeds. Herbicide, fungicide, and pyrethroid applications were performed in order to maintain a healthy crop in an effort to maintain seeding rate and soil variability as the primary yield-limiting variables across the field. Irrigation was maintained at regular intervals to make up for precipitation deficits. Hurricane Irma caused some wind damage to crops in the area (mostly cotton), but the field used for this test had no obvious signs of damage from the storm.



(a) Block Locations (b) Treatment Strip Assignments

Figure 3. Block layout applied for B6B showing seven blocks of 4-row strips (a); and target seeding rates assigned randomly by strip within each block (b, legend units are seeds/ac). Seven strip treatments were applied within each block: six seeding rates and one D-R_X variable rate prescription.

The field was harvested on November 25, 2017 and yield data was collected using an Ag Leader grain yield monitor. Yield data was cleaned to eliminate the following: data collected across terrace ridges, data collected at row ends, and statistical yield outliers by treatment (using Tukey's method). Remaining yield data points were adjusted to a 13% moisture content to represent marketed yield for revenue and profit analyis. For profit analysis, revenue was set at $10/bu and seed cost was set at $58 per 140 kseed. Return above variable input cost (RAVIC, $/ac) is used here to represent profit response and was calculated for each yield data point as revenue minus seed cost. Only the irrigated yield data was used for analysis in this study. Means comparisons shown in the results used students t-tests ($\alpha = 0.05$).

Results

The yield data for the test can be seen in Figure 4; only yield data from the irrigated portion of the field was used for the analysis here. The regions of yield data points removed represent areas where terraces are located in the field. Figure 5 shows that the D-R_X prescription resulted in the greatest yield and RAVIC, although neither yield nor RAVIC for D-R_X was significantly greater than that for the best performing uniform seeding rate. Yield benefit from D-R_X was 0.1 bu/ac and profit benefit from D-R_X was $3.40/ac. The Year 1 test resulted in a D-R_X prescription for maximizing profit and a D-R_X prescription for maximizing yield; the prescription applied in Year 2 was the one that would have maximized profit in Year 1. The

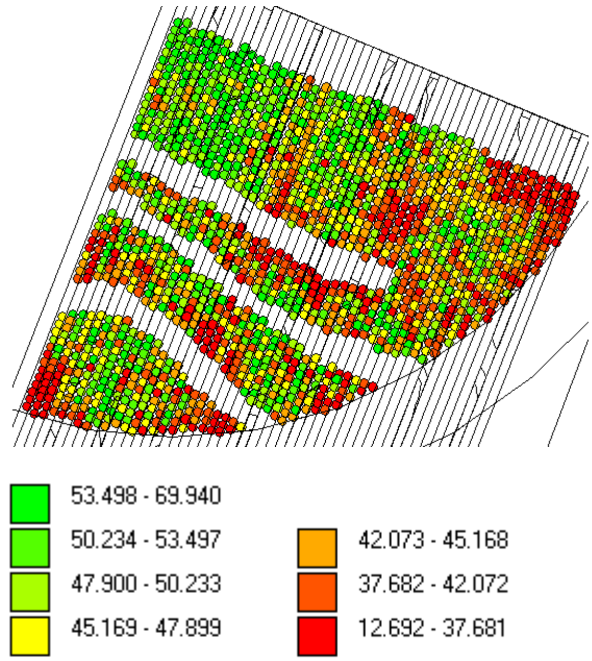
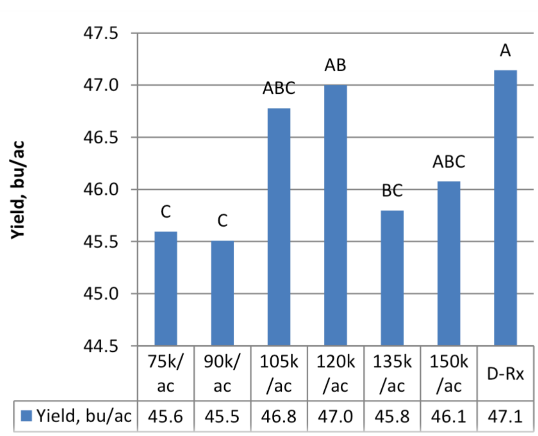
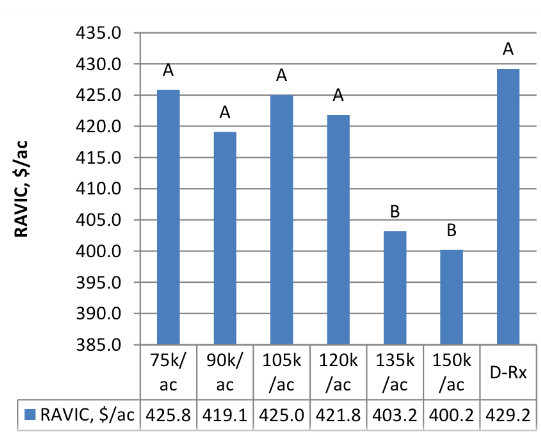


Figure 4. Trimmed 2017 soybean yield data from field B6B at Edisto REC (legend units = dry bu/ac). Circular lines represent pivot end tower and endgun boundaries. Sections of missing yield data at interior of field represent terrace ridges.



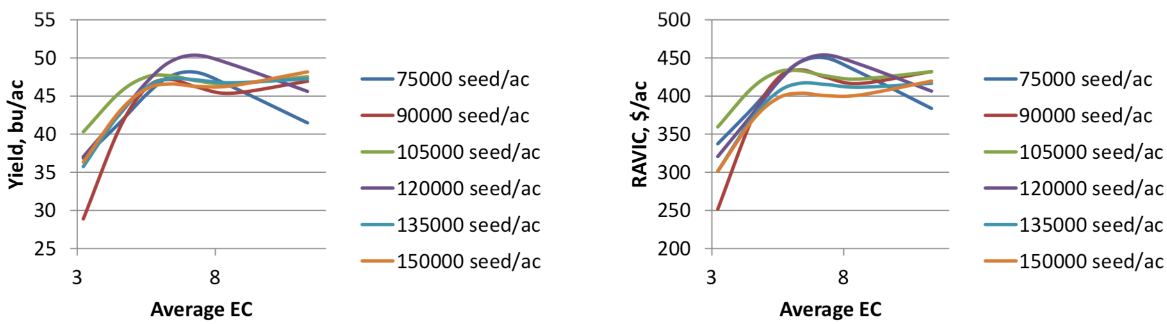
(a) Year 2: Yield by Treatment



(b) Returns by Treatment

Figure 5. Yield (a) and return above variable input cost (RAVIC, b) as a function of treatment, where yields are reported at 13 %MC basis to best represent market value. Columns within each chart with different letters are significantly different ($p<0.05$).

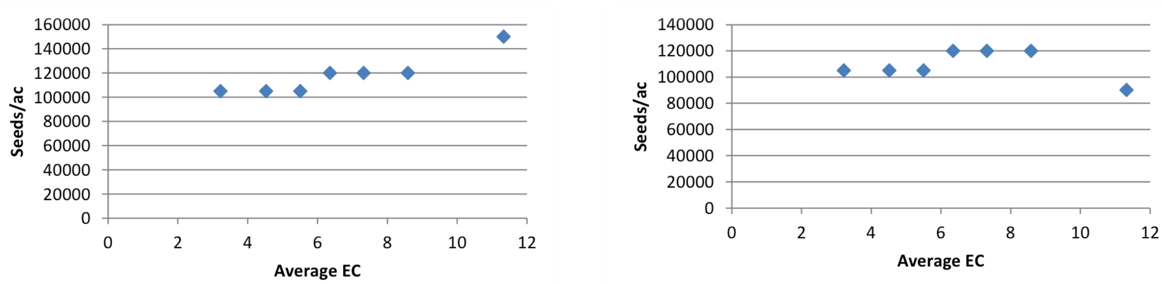
Figure 7 shows Year 2 yield- and profit-response of the seeding rates tested as a function of average soil EC. This is the basis for development of the D-R_X method. From these figures, yield or profit is sought to be objectively maximized by prescribing seeding rates as a function of EC, which represent the highest yield- or profit-response. The results of the $D\text{-}R_X$ prescription from Year 2 are shown in Figure 8; these are the seeding rates that maximized yield and profit in Year 2. For comparison, she same plots for Year 1 are shown in Figure 9. It can be seen that the general trends in seeding rate to maximize yield were not the same between the two years. In Year 1, optimum seeding rates generally decreased as a function of Average EC (Figure 9a) and in Year 2 they generally increased as a function of Average EC (Figure 8a). Although surprisingly little work has been done in variable rate soybean seeding, the trend demonstrated in Year 1 is generally consistent with other observations—that higher seeding rates should generally be applied on more marginal (sandier) ground and lower seeding rates can be used on better (heavier) ground.



(a) Year 2: Yield Response

(b) Year 2: Profit Response

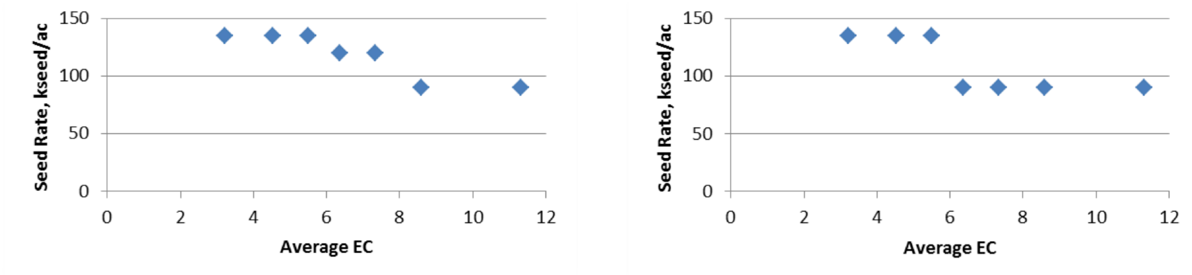
Figure 7. Year 2 yield (a) and profit, as RAVIC (b), as functions of Average EC across seeding rates.



(a) Year 2: Maximize Yield

(b) Year 2: Maximize Profit

Figure 8. Seeding rates in Year 2 to maximize yield (a) and profit (b) as a function of Average EC. The seeding rates shown here are those that produced the maximum response as a function of Average EC, from Figure 7.



(a) Year 1: Maximize Yield (b) Year 1: Maximize Profit

Figure 9. Seeding rates in Year 1 to maximize yield (a) and profit (b) as a function of Average EC. The seeding rates shown here are those that produced the maximum response as a function of Average EC, from Figure 7.

Confidently explaining the differences in optimum seeding rate trends that were observed between Year 1 and Year 2 can only be done with more research. There are a number of factors that may be responsible entirely or in part for the differences observed, including but certainly not limited to: precipitation (see Table 1, Year 2 was substantially wetter than Year 1), planting date (Year 1 soybeans were planted on June 30 due to requirement to replant, Year 2 soybeans were planted on May 17), rotation (Year 1 was soybeans after corn and Year 2 was soybeans after soybeans), and temperature (see Table 1, Year 2 was slightly cooler on average than Year 1). Prior to planting, had we been able to project the seeding rates providing the greatest yield or profit in each year, variable rate seeding in soybean shows good potential for increasing profitability as demonstrated by the projected D-R_X benefits. Projected yield- and profit-benefit from the D-R_X prescription were 1.9 bu/ac and $9.6/ac in Year 1, and 1.1 bu/ac and $8.4/ac in Year 2. These values are generally representative of what could have been achieved had the prescription applied in those years been optimized.

Table 1. General comarison of weather differences between Year 1 and Year 2. Data is for June 1 through August 31 each year from KBNL weather station in Blackville, SC.

Factor	Year 1 (2016)	Year 2 (2017)
Mean, Max Daily Temperature	95 °F	91 °F
Max Temperature	102 °F	98 °F
Mean, Min Temperature	73 °F	72 °F
Min Temperature	60 °F	60 °F
Mean, Mean Daily Temperature	84 °F	81 °F
Max, Daily Precipitation	1.34	2.3
Total Precipitation	3.42	9.56

Conclusions

Variable rate seeding in soybean showed good potential for yield- and profit-benefit (1.9 bu/ac, 1.1 bu/ac, $9.6/ac, and $8.4/ac) as compared to uniform rate seeding in both years on the field used for this test. The general trend in seeding rate to maximize yield or profit as a function of Average EC was not the same in both years but despite this a profit benefit was still observed in Year 2 when the findings from Year 1 were applied as the D-R_X treatment. The D-R_X treatment in Year 2 represented the seeding rates from Year 1 that maximized profit as a function of Average EC; cash returns of this treatment were $3.4 greater than those for the most profitable uniform seeding rate, although not significantly different.

More work needs to be done to better understand the driving factors of yield-response as a function of in-field variability and year-to-year differences; this small test at one site does not provide enough answers to confidently provide recommendations for variable rate soybean seeding. However, it is suggestive that S.C. soybean growers can profit from implementing the practice on their operation. The benefits may or may not be substantial enough to pay for the purchase of variable rate seeding technology in a short term. However, for the many growers who already utilize variable rate seeding in corn production, no additional investment would be required for them to use the same practice in soybean production. The challenge in variable rate seeding for any crop is consistently getting the prescription right; we hope to have the opportunity to continue this work to better understand best practices for developing consistently successful variable rate soybean seeding plans.