Improving Site-Specific Nutrient Management in the Southeastern US: Variable-Rate Fertilization Based on Yield Goal by Management Zone

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Abstract.

High in-field variability of primary macronutrients is a leading cause of yield variability within the Southeastern United States. Over- and under-application of fertilizer is often a cause of this issue. The recent advancement in precision application technology has allowed for variable rate (VR) application to be implemented in order to mitigate this problem. Current applications of VR fertilization have been limited to only applying fertilizer rates based on single yield goal across the whole field. A study was conducted over two fields in the Southeastern United States that evaluated and compared the VR fertilization based on a single versus varied yield goal by management zone. Grid soil sampling was conducted to get an estimate of the nutrient variability within each field. The samples were analyzed using Mehlich 1 extraction and interpolated in SMS using inverse weighted distance (IDW) interpolation. VR prescription maps were calculated from the UGA fertilization recommendations for 840, 1120, and 1400 kg ha^{-1} yield goals for cotton. The total required application was then used to calculate the costs per acre for the application of phosphorus (P) and potassium (K) nutrients. Zone creation was based on one year of historical yield coupled with NDVI imagery to improve zone smoothness. For field 1, yield goals of 1120 and 1400 kg ha^{-1} lint yield were determined based on the yield monitor data. Field 2 had yield goals of 840 and 1120 kg ha^{-1}. For each field, the higher yield goal was used when determining the VR fertilization based on the single yield goal. The study found that the benefit of VR application for phosphorus was lower for fields with the majority of P levels over 67 kg ha^{-1}, given the lower amounts of product applied*. VR application under these conditions saved $1.98 per ha for field 1, and $0.86 per ha for field 2. For VR applications of K, application costs were reduced by $5.71 per ha in field 1 and $6.20 per ha in field 2. While the*

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savings achieved through this study were varied, it has provided a basis for studying the VR fertilization based on different yield goals within a field based on yield potential.

Keywords.
Management zones, variable rate application, fertility, yield goal

The increased availability of precision application technology has allowed growers in the southeastern US to reduce their input costs, especially in cotton. Several studies have been conducted on variable-rate (VR) application of fertilizers such as nitrogen, phosphorus, and potassium, as well as PGR applications in cotton. The VR fertilization rates are often determined from soil analysis, with no considerations of variations in productivity across the field. Arable land in the Southeast often has significant variability not only between fields but also within the same field. This variability can result in a reduction in yield that is often unrelated to fertility, such as lower elevation causing excess moisture, high erosion areas, or biological issues such as nematodes. In order to address this variability, 4R's of nutrient management is even more critical as applying the right amount of fertilizer at the right place can help in maximizing nutrient efficiency as well as profitability. The availability of in-season data along with spatial yield can be used to delineate management zones, which can be used to vary fertilizer rates based on a varied yield goal by each zone contrary to the single yield goal based fertilization. . The objective of this study was to compare single-yield goal versus yield by management zone fertilization (specifically for Phosphorus and Potassium) in cotton with the goal to measure the economic benefit that occurred when pre-plant fertilizer applications of phosphorus and potassium were reduced to match the yield potential of the field more closely.

The study was conducted in two fields in Southeast Georgia, with a total area of 47 hectares. Cotton was the previous crop grown in both fields. To capture the actual spatial variability of the field, grid soil samples were taken on the recommended 0.1 ha grid size (Coleman, 2021). The samples were analyzed at the University of Georgia Soil, Plant, and Water Laboratory, which uses Mehlich 1 extraction to measure nutrient levels. To determine the fertilizer rates, the UGA Fertex tool equations for P and K were used . Accufield software was used to create the management zones using yield data and aerial imagery. The 2021 cotton yield data (the most recent available) was used at a weight of 1 and 2021 NDVI data was added with a weight of 0.5 to smooth the yield data. Two different zones were created for both fields, which created around a 280 kg ha^{-1} yield difference between the zones. Field 1 (30 ha) had zones with an average yield of 1400 kg ha^{-1} and 1120 kg ha^{-1} . Field 2 (17 hectares) yield averages were 1120 kg ha^{-1} and 840 kg ha^{-1} . For each field, the higher yield average was used when calculating the fertilizer rates based on a single yield goal without considering management zones. For fertilization by yield goal by management zone, the equation was adjusted based on the yield goals, and was applied to the P and K measurements in MS Excel. This data was then imported into the AgLeader SMS program and interpolated using IDW interpolation. The prescription maps were then created using computed P and K rates for both single- and zone-based yield goals.

Field 1 required a total of 1178 kgs of P when based on the single yield goal of 1400 kg ha^{-1} (Table 1). The multi-yield goal required a total of 1138 kgs. When using the UGA Cotton Enterprise Budget, this resulted in a savings of $1.98 per ha, or a total field savings of $56.55 using the yield by management zone approach. For VR K application, the single yield goal required 2,359 total kgs, while the yield-by-zone strategy required 2,207 kgs. This resulted in a $5.71 per ha savings, and a total field savings of $167. Field 2 required a total of 108 kgs of P for the 1400 kg ha^{-1} yield goal, and 228 kgs of P for the multi-yield goal. This resulted in a savings of $0.86 per ha. For K applications, the single yield goal required 855 kgs, and the multi-yield goal required 759 kgs. This resulted in a savings of $6.20 per ha, and a total savings of $7.06 per ha for field 2. The savings average between both fields was $7.36 per ha. While this number is small compared to total fertilizer input costs, this study has shown that savings can occur but may vary between fields depending upon size and previous fertility management. High P levels such as in the fields used here may not justify VR applications based on varied yield goals in some fields but the potential to benefit from this approach would be greater in fields with higher P (and K) variability.

Table 1. Total application amounts of phosphorus and potassium, in kilograms. The total costs were calculated using the UGA cotton enterprise budgets.

Location	Single Yield Goal Rec.		Yield-by-Zone Rec.		Reduction in Application cost (savings/ha)		
	P (kg ha^{-1})	K (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	P	K	Total Savings
Field 1	239	856	229	760	$0.86	$6.20	$7.06
Field 2	1178	2359	1138	2207	$1.98	$5.71	$7.64

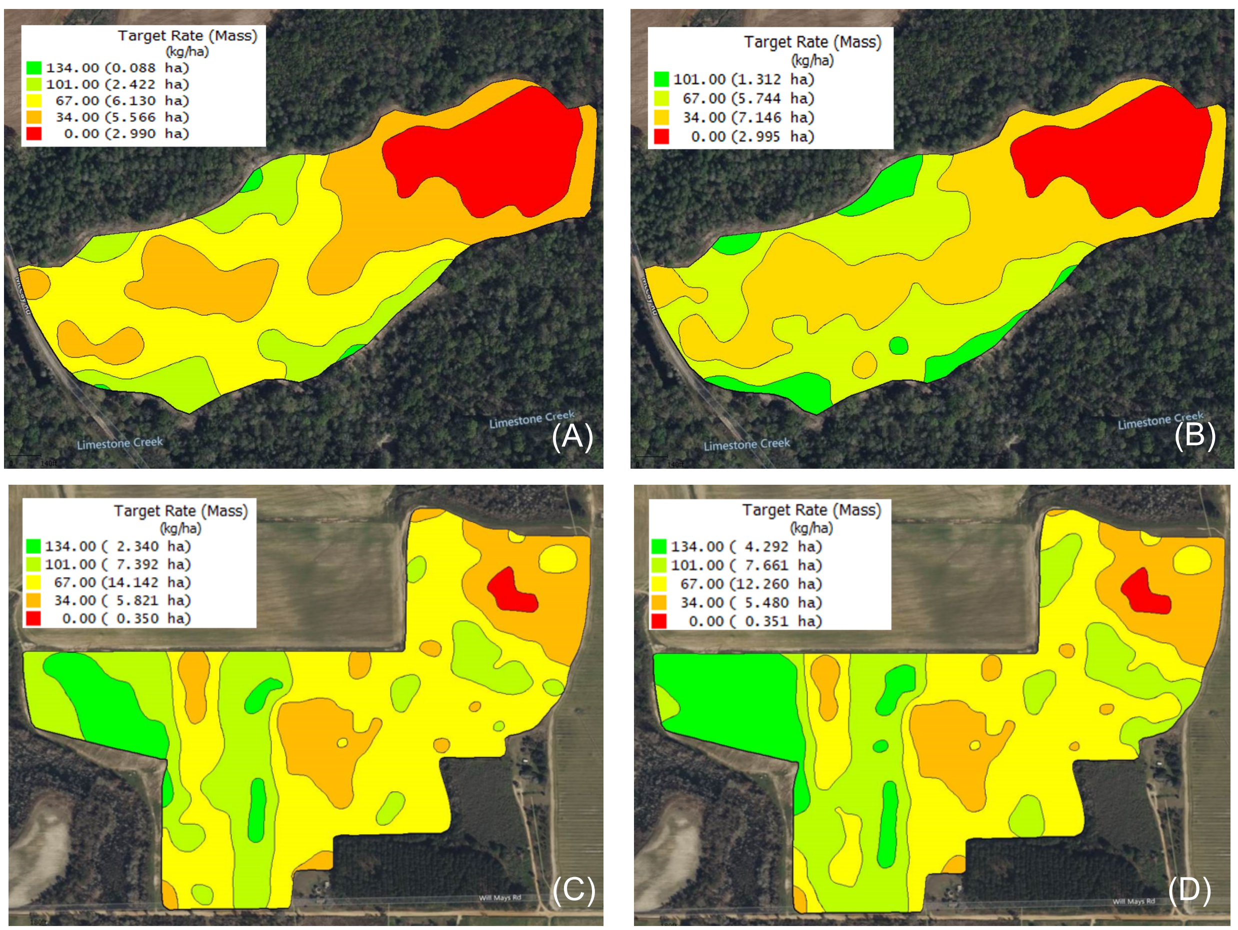

Fig 1. (a) Prescription K map from field 2 based on a 1120 kg ha^{-1} yield goal and (b) a prescription K map based on both 1120 and 840 kg ha^{-1} yield goal. (c) Prescription K map for Field 1 based on both a 1400 kg ha^{-1} and 1120 kg ha^{-1} yg. (d) Prescription K map based only on the 1400 kg ha^{-1} yg.

This study has shown promise in the ability for yield-based management zones to reduce pre-plant fertilizer application costs for cotton. While the reduction in costs were low, other fields with higher P and/or K variability may show greater savings. Future research efforts should be focused on larger fields with higher variability and that also have significant areas with lower levels of fertility. Future efforts should also consider carrying out this study through the growing season, to ensure that yield data is as expected when the VR fertilization is implemented.

References

Coleman, A. M. (2021). Development of a Management Zone Scoring Index & Economic Returns of Grid & Management Zone Soil Sampling in Coastal Plain Soils of the Southeastern United States.