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Guidelines for Recommending Precision Agriculture in Southern Crops

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Guidelines for Recommending Precision Agriculture in Southern Crops

Abstract
Technology has tremendous implications for Extension agents working with producers, agribusinesses, and youth. Four southern crops, including cotton, corn, grain sorghum, and peanuts, were evaluated under current agricultural management practices and precision farming technology. Yield, profit, and fertilizer application levels are compared across the two management practices. Field characteristics for the most profitable locations are outlined as a reference for producers in determining whether they would likely be good candidates for this technology. Results are commodity specific and suggest maximum bounds on investment levels that would be profitable to producers.

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Introduction

Precision agriculture technology is paving the way for agricultural producers by allowing for precise management of inputs. Precision farming involves the sampling, mapping, analysis, and management of specific areas within fields in recognition of spatial and temporal variability with respect to soil fertility, pest population, and crop characteristics (Weiss, 1996; Nemenyi, Mesterhazi, Pecze, & Stepan, 2003). Traditionally, farming practices have assumed that fields are homogeneous in nature, and management practices seek to determine input application rates based on what is best for the field as a whole (Isik & Khanna, 2003). However, all locations do not have the same characteristics, indicating a uniform application prescription for agricultural inputs may not result in maximum yields or profits (Onken & Sunderman, 1972).

Precision application has several potential advantages over traditional farming practices:

1. Higher average yields,
2. Lower inputs costs, and
3. Environmental benefits from precise application (Isik & Khanna, 2003; Thrikawala, Weersink, Kachnoski, & Fox, 1999; Wang, Prato, Qiu, Kitchen, & Sudduth, 2003; Winter-Nelson, 2002).

As agricultural producers continue to face increasing costs of production, foreign subsidies far larger than current U.S. subsidies, and increased environmental regulations, technology is seen as the key for increasing productivity per unit of input. Many producers and Extension agents could undoubtedly benefit from guidelines on crop and field characteristics more likely to be conducive to precision farming technology. Therefore, four crops, including cotton, corn, grain sorghum, and peanuts, were analyzed to determine changes in yield, fertilizer application levels, and profit when using precision farming technology as opposed to current farm management practices. The results can serve as a guide for determining whether a particular producer would be a good candidate for exploring further, their likelihood of successfully implementing precision farming technology.

Methodology

With precision farming practices, potentially there are as many optimal applications as there are Global Positioning System (GPS) points in the field. GPS technology allows site-specific information to be collected through interface with satellites that is sufficiently accurate to be used for determining precision farming input use. GPS is a constellation of satellites that was developed by the U.S. Department of Defense and can be used 24 hours a day anywhere on Earth. GPS has military, industrial, commercial, and civilian uses.

The GPS system allows producers to identify locations in the field by latitude and longitude so that inputs can be applied based on performance and previous input applications. A GPS receiver can be attached to farm machinery to measure within-field variability. For example, converting the raw data gathered with the satellite with GPS software can produce a yield map.

Many of these site-specific technologies are commercially available as separate components. This allows individual producers to assemble a package of technologies specifically tailored to their operation. Basic technologies include aerial photography and soil survey maps. Other advanced technology includes optical sensors that collect, process, and dispense inputs according to a decision rule as a tractor moves through the field, and variable rate application, which is the ability to apply various amounts of inputs while moving across the field (Khanna & Randal, 1997). The GPS technology required for this analysis assumes using a one-input variable rate applicator for nitrogen fertilizer.

Every location in the field can be evaluated according to its specific characteristics and assigned an optimal input application rate unique to that location. Thus, there can be many different application rates across the field.

For example, suppose we have three GPS locations in the field, (locations a, b, and c) and two soil characteristics, pH (7.0 average) and sand percentage in the soil (75% average). Also, assume that the producer wants to optimize nitrogen fertilizer (input) use in his/her production practices.

Whole-field farming would use the average pH level, 7.0, and the average sand percentage in the soil, 75%, to determine the optimal nitrogen application level to use for all three locations. Precision farming would use the actual pH level for each location, (7.1 at location a, 7.0 at location b, and 6.9 at location c), and actual sand percentage in the soil unique to each location (70% at location a, 75% at location b, and 80% at location c). Optimal nitrogen application may be 70 lbs./acre for locations a, b, and c for the whole field farming scenario and 67 lbs./acre for location a, 100 lbs./acre for location b, and 47 lbs./acre for location c under the precision farming practice scenario.

Data for each of the four crops selected for study were gathered in the Southern High Plains of Texas. The objective of the study was to determine the profitability of precision farming in the Southern High Plains of Texas for cotton, corn, grain sorghum, and peanuts. Specific objectives were to determine the biological relationship between yield and production inputs by estimated production functions using SAS (SAS, 1982). Nitrogen behavior over time was also estimated to forecast nitrogen residual availability for future years.

The estimated models were used in a dynamic optimization framework to maximize net present value of returns above nitrogen and water costs (NPVR), which is a measure of profitability. The optimization model then determined the optimal level of nitrogen application, yield, and NPVR for both whole-field and precision farming technology using GAMS (General Algebraic Modeling System) software. This modeling framework allowed for the effects of changes in the field over time to be captured in addition to the spatial changes from each GPS location to compare the two technologies.

Findings

Results for precision farming were found to be commodity specific, which is consistent with findings from Heermann et al. (2002) and English, Mahajanashetti, and Roberts (2001). Yield and nitrogen fertilizer application levels are compared in both whole-field and precision farming technology and reported in the following sections. Net present value of returns above nitrogen and water costs (NPVR), used as an indicator of profitability is also determined in each crop under the two technologies and reported in the sections that follow.

Finally, a monetary value per acre is given for each commodity estimating the approximate amount of money one could justify spending on implementing precision farming technology. This is done because technology prices change over time, and, if one commodity is not determined to be feasible under precision farming due to implementation costs today, it may be in the future. Currently, implementation costs are approximately $15 per acre.

Cotton

In cotton production, several fields were tested in Lamesa, Texas. A combination of cotton, fertilizer, and water prices were used. Results were not particularly sensitive to the variations. Therefore, recommendations provided will cover ranges for yield, NPVR, and fertilizer application.

- Precision farming yields increased approximately 0.16 - 4.00%.
- Precision farming NPVR increased approximately 0.19 - 4.5%.
- Precision farming fertilizer average application did not change. However, specific location recommendations decreased by as much as 42.71% and increased by as much as 57.38%, depending on yield potential.

Producers could afford to pay between $0.36 and $9.33 per acre to implement precision farming practices. The cotton studies did not appear to have a lot of potential in precision farming. However, if more than fertilizer was precisely applied, efficiencies might be gained, justifying the new technology.

The averages reported do not tell the whole story. A more detailed look at specific characteristics is necessary to determine locations within the field with the greatest potential for profit. Identifying these could help cotton producers determine if their specific field conditions would be appropriate for exploring precision farming possibilities. Agronomists ran the field trials and determined the characteristics of importance based on soil conditions and the specific crop in question. When looking at the most profitable locations, the locations had the following characteristics in common.

- Higher Altitude,
- More Nitrogen Residual in the soil from 0-12 inches,
- More Clay and Silt in the soil, and
- Less Sand in the soil.

Corn

Precision farming in corn production was found to be more receptive to the new technology than cotton. This is largely due to the responsiveness of corn to nitrogen fertilizer. Specifically, yields, NPVR, and fertilizer application under precision farming outpaced traditional whole-field farming by the following magnitudes:

- Average yield changes ranged from an increase of 7.68% to 15.38%,
- NPVR changes ranged from 13.69% to 60.51% on the average, and
- Nitrogen application increased from 69.58% to 191.23% on the average.

The averages indicate that, although precision farming used more fertilizer, it was used more efficiently. This means that the additional costs incurred from the fertilizer were more than justified by the increase in revenues. A producer could justify spending approximately $33.72 to $58.28 per acre to implement precision farming practices.

Characteristics of the most profitable locations included the following similarities:

- Higher Altitude,

- Higher Clay content in the soil, and
- Less Nitrogen Residual in the soil from 0-12 inches.

Grain Sorghum

Grain sorghum was also found to be responsive to precision farming, although not as much as corn. On the average:

- Precision farming yields increased approximately 6.79% over traditional whole-field farming,
- NPVR increased 7.86% when using precision farming management practices, and
- Nitrogen fertilizer application was not different among the two management practices. However, optimal nitrogen application levels for precision farming were as high as 58.61% more and as low as 95.60% less with individual locations within the field when precision farming management practices were used.

Grain sorghum producers could justify spending $11.49 per acre to implement this new technology. Specific location characteristics found be common to locations with the most profit potential include:

- Higher Altitude and
- Higher Clay content.

Peanuts

Peanuts production under precision farming technology showed a modest response to precision farming technology. Yields and NPVR did increase, however only slightly. Specifically:

- Yields increased by 2.32% on the average when precision farming technology was used,
- NPVR increased by 2.54% over traditional whole-field farming, and
- Nitrogen fertilizer application was not different on the average. However, some locations did use as much as 42.13% more fertilizer than whole-field farming, while other locations used as much as 80.63% less, depending on yield and profit potential.

A peanut producer could justify spending $11.67 per acre to implement precision farming practices on their farm. Specific characteristics more receptive to this technology include:

- More Manganese in the soil from 0-6 inches,
- More Potassium in the soil from 0-12 inches, and
- More Sodium in the soil from 0-12 inches.

Conclusions and Recommendations

The conclusions drawn from these studies indicate that the potential for precision farming can be drastically different for various crops. In this study, corn was the most receptive crop to precision farming when controlling for the variable input nitrogen fertilizer. The results for cotton were not nearly as favorable for implementing this new technology. In fact, it is not clear that precision farming is better than whole-field farming when factoring in the cost of implementing precision farming practices in any crop except corn. However, we would expect that to change as technology prices continue to decrease.

Precision farming would be more feasible with producers who could either spread the technology costs over a large number of acres or could control production practices for more than one input. Also, soils with much variability seemed to be more responsive to precision farming practices. Most of the soil in this study was fairly homogeneous, indicating a conservative estimate of the gains from using precision farming technology.

Implications for Extension

Technology has tremendous implications for Extension agents working with producers, agribusinesses, and youth. As technology improves and costs decrease, it is useful to understand the magnitude of possibilities associated with cutting-edge agriculture. With guidelines for understanding yield and profit potential in specific crops, producers can evaluate whether their fields would likely be adaptable to precision farming technology. Also, specific field characteristics can help agents and producers identify management zones within fields.

Agribusinesses with large operations can also benefit from an understanding of which commodities and field conditions are necessary for maximum profit potential. Environmental consideration with nitrogen fertilizer levels can also be evaluated with this new technology.

Finally, youth, who are the future of the technology-revolution in agriculture, can gain a practical understanding of the realm of possibility with precision farming management practices. Applying concepts and relationships obtained in this study can help increase the understanding and awareness of both agricultural and non-agricultural citizens to further educate our public on the potential that technology has to offer the agricultural industry.

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