Texas
Precision Agriculture

The Texas A&M University System – Agriculture Program

Annual Reports – 2000

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and Texas Agricultural Extension Service

Project Title: Precision Farming - Site Specific Production Systems:
Economics of Precision Farming Practices in the Texas High Plains
(cotton, grain sorghum, corn, and peanuts).

Reporting Period: September, 1997 - December, 2000

Project Objectives:

The overall objective of this project is to derive precision farming optimal decision rules of input use (irrigation water, fertilizers, herbicides and insecticides) and evaluate the economic impacts of precision farming practices in cotton, grain sorghum, corn, and peanut production in the Texas High Plains.

A. Summary of Progress:

Increased use of fertilizers, pesticides, and other chemicals have contributed to the enhancement of agriculture's productivity in recent decades. Currently, production agriculture is facing many challenges such as increasing cost of production, shortage of irrigation water, and increased public concern on the impacts of agricultural production on the environment. To survive in the highly competitive world market of agricultural commodities, agricultural producers must produce high quality products at low prices while using environmentally sound practices. A way to address these objectives is to adopt precision farming technology. Traditionally, input use in agriculture has assumed field homogeneity with respect to soil fertility, soil moisture, pest populations, and crop characteristics. That is, optimal decision rules of input use do not account for differences

of those characteristics within fields. Precision farming, precision agriculture, or site-specific management recognizes the variability of such factors within fields and seeks to optimize variable input use under these conditions.

It has been said that precision farming is an advanced information-technology-based management system designed to identify, analyze and manage site-soil spatial and temporal variability within fields for optimum profitability, sustainability, and protection of the environment. The development of precision farming practices is closely related to the many new technologies that have been utilized in agricultural production in recent years. These new technologies involve microcomputers, microprocessor based control systems, satellite positioning technologies, and many kinds of sensors. With the help of these technologies, variable rate application of fertilizers and spraying of weeds, spatial soil testing, and yield mapping are becoming available.

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The general approach followed in the derivation of precision farming economically optimal decision rules of input use of all the crops analyzed has been as follows. First, statistical estimation of site specific production functions are derived to evaluate spatial crop responses across a specific field. In some cases equations of motion related to the dynamics associated with the spatial nature of soil fertility and residual levels of nitrate are also estimated. Once these functions are estimated, either static of dynamic mathematical optimization models are formulated to derive site-specific precision farming optimal decision rules of input use under alternative input and output price scenarios. Then, these decision rules and their associated levels of economic profitability are compared to those that would have been derived under conventional (i.e., “average”) production practices.

Sophisticated mapping computer software such as MapInfo and Vertical Mapper are used to graphically depict the results obtained. These mapping procedures facilitate the visualization of results and clearly convey the spatial details of what, within the field being analyzed, specific locations are the most or least profitable.

To date, precision farming optimal decision rules of input use have already been derived for cotton, grain sorghum, and corn production. Overall, these results indicate that: (1) precision farming practices are economically beneficial as compared to conventional practices in cotton, corn and grain sorghum production, but widespread use of these practices will critically dependent on their adoption cost; (2) the economic benefits of precision farming practices are not evenly distributed across fields - in fact, spatial variability of both yields and profits across fields are magnified under precision farming practices as compared to conventional production practices; and (3) precision farming can effectively be used to identify “management zones” within fields where the potential for significant improvements in profits are possible.

This research could have significant impacts on well over 5.0 million acres of cropland in the production of corn, grain sorghum, peanuts and cotton in the Texas High Plains. Results for corn, grain sorghum, and cotton production have been released to professional and agricultural producers audiences. Peanut production work is ongoing. It is anticipated that next year, results applicable to peanut production will be available. Also, precision farming optimal decision rules of input use refinements for the other crops will be made.

B. Educational/technology transfer:

Several presentations addressing the economics of precision farming production practices have been made to professional (peer and non-peer), agricultural producers, and college students audiences. The overall message conveyed has been: precision farming can be economically enhancing for producers in the Texas High Plains, if adoption costs are reasonably low. Depending on the specific location, the crop being analyzed, and input and output price scenarios, net increases of profits of 2 to 5 percent per acre could be expected from the adoption of precision farming practices. However, there could be instances where net increases in profits could be higher. Also, precision farming practices could contribute to the "improved placement" of chemicals on fields, thereby enhancing the environment.

C. Milestones achieved:

The most significant milestone achieved to date has been the establishment of the overall methodology to follow in the derivation of precision farming economically optimal decision rules of input use for the crops being analyzed.

D. Publications:

Yu, M., E. Segarra, and A. B. Onken. 1998. The Economics of Soil Fertility Under Precision Agriculture: The Case of Phosphorus. Proceedings of the 1998 Beltwide Cotton Conferences, pg. 289-292.

Yu, M., E. Segarra, and D. Nesmith. 1999. Spatial Utilization of Phosphorous: Implications for Precision Agriculture Practices. Proceedings of the 1999 Beltwide Cotton Conferences, pg. 299-302.

Machado, S., E. D. Bynum, Jr., D. T. Rosenow, G. C. Peterson, T. L. Archer, R. J. Lascano, K. Bronson, E. Segarra, and L. T. Wilson. 1999. Spatial Variability of Sorghum Yield: Site-Specific Interactions of Soil, Water, and Pests. Abstract in Proceedings of the 21st. Biennial Grain Sorghum Research and Utilization Conference, pg. 13-14.

Machado, S., E. D. Bynum, Jr., T. L. Archer, R. J. Lascano, M. Yu, E. Segarra, K. Bronson and D. Nesmith. 1999. Spatial and Economic Variability of Corn Yield: Site-Specific Interactions of Soil, Water, Pests, and Diseases. Abstract in Proceedings of the 1999 ASA, CSSA, and SSSA Annual Meetings, pg. 58.

Yu, M., E. Segarra, H. Li, R. J. Lascano, C. Chilcutt, L. T. Wilson, K. Bronson, and S. Searcy. 2000. The Economics of Precision Agricultural Practices in Cotton Production. Proceedings of the 2000 Beltwide Cotton Conferences, pg. 369-374.

Machado, S., E. D. Bynum, Jr., T. L. Archer, R. J. Lascano, L. T. Wilson, J. Bordovsky, K. Bronson, D. M. Nesmith, E. Segarra, D. T. Rosenow, G. C. Peterson, and W. Xu. 2000. Spatial and Temporal Variability of Sorghum and Corn Yield: Interactions of Biotic and Abiotic Factors. Proceedings of the International Conference on Precision Agriculture, in press.

Yu, M., E. Segarra, H. Li, R. J. Lascano, and S. Watson. 2001. Precision Farming Practices in Irrigated Cotton Production in the Texas High Plains. Proceedings of the 2001 Beltwide Cotton Conferences, in press.

Li, H., R. J. Lascano, J. Booker, L. T. Wilson, K. F. Bronson, and E. Segarra. 2001. Water and Nitrogen Balance of Cotton as Affected by Soil Texture and Topography. Proceedings of the 2001 Beltwide Cotton Conferences, in press.

Li, H., R. J. Lascano, E. M. Barnes, J. Booker, L. T. Wilson, and E. Segarra. 2001. Cotton Reflectance Characterization and NDVI-days Lint Yield Modeling. Proceedings of the 2001 Beltwide Cotton Conferences, in press.

Watson, S., E. Segarra, M. Yu, E. Bynum, S. Machado, T. Archer, and L. T. Wilson. 2001. The Economics of Precision Farming in Grain Sorghum. Abstract in Journal of Agricultural and Applied Economics, in press.

Yu, M., and E. Segarra. 2001. Economic Impacts of Precision Farming in Cotton Production. Abstract in Journal of Agricultural and Applied Economics, in press.

E. Precision agriculture proposals:

Since September 1997, funding for four projects addressing the economics of Precision Agriculture has been secured. Two of these projects (one in the 1997-99 biennium and one in the 1999-2001 biennium) were funded under the Texas A&M University - Precision Agriculture Initiative. The two other projects (one in the 1997-99 biennium and one in Fiscal Year 1999-2000) were funded by the College of Agricultural Sciences and Natural Resources, Texas Tech University through the Cotton Economics Research Institute in the Department of Agricultural and Applied Economics. The total level of funding generated under these four projects was $126,100 ($78,600 through Texas A&M and $47,500 through Texas Tech). Given these levels of funding, leveraging of Texas A&M University research funds is 0.6:1.0. That is, for every dollar of funding received from the Texas A&M - Precision Agriculture Initiative, an additional $0.60 of funding was generated in support of Precision Agriculture economics related research.

The specific projects funded were: (a) **Texas A&M projects** - 1) Title: Precision Farming - Site Specific Production Systems: Economics of Precision Farming Practices in Cotton Production. Source: Precision Agriculture Initiative - Texas A&M University. September 1997 - August 1999. Amount $28,600 (through Texas A&M University); and

2) Title: Precision Farming - Site Specific Production Systems: Economics of Precision Farming Practices in the Texas High Plains (cotton, grain sorghum, corn, and peanuts). Source: Precision Agriculture Initiative - Texas A&M University. September 1999 - August 2001. Amount $50,000 (through Texas A&M University); and

(b) **Texas Tech projects** - 1) Title: The Economics of Precision Farming in Cotton Production. Source: Department of Agricultural and Applied Economics, College of Agricultural Sciences and Natural Resources, Texas Tech University. September 1997 - August 1999. Amount $29,000 (through Texas Tech University); and 2) Title: The Economics of Precision Farming in Cotton Production. Source: Department of Agricultural and Applied Economics, College of Agricultural Sciences and Natural Resources, Texas Tech University. September 1999 - August 2000. Amount $ 18,500 (through Texas Tech University).

These four projects have supported the research of two Ph.D. students [Man Yu and Susan Watson (Bondurant)] in the Department of Agricultural and Applied Economics at Texas Tech University. Man Yu has finished all the requirements for his Ph.D. degree and will be graduating this month (December, 2000). The title of his dissertation is: "Economic and Environmental Evaluation of Precision Farming Practices in Irrigated Cotton Production."

Other proposals submitted which were not funded include:

(1) Onken, A. B., W. Keeling, and E. Segarra. 1998. Interaction Effects of Cropping System, Water, Level, and Fertilizer Rate on Profitability of Cotton Production. Submitted to the Cotton State Support Committee;
(2) Several TAES Personnel. 1998. Precision Cotton Production at AG-CARES: Yield Variability Management. Submitted to the Cotton State Support Committee;
(3) Bronson, K., W. Keeling, R. Bowman, T. Provin, and E. Segarra. 1999. Innovative Nutrient Management Practices for High Plains Cotton Production and Profit. Submitted to Cotton Incorporated - Texas State Support Committee;
(4) Archer, T., R. Lascano, K. Bronson, and E. Segarra. 1999. Optimizing Plan Productivity Using Integrated Crop Management in a Precision Agricultural System. Submitted to USDA - NRI program;
(5) Trostle, C., B. Bean, O. Moore, K. Bronson, K. Gregory, E. Segarra, J. Elzner, and T. Marek. 2000. On-Farm Precision Farming Corn Research and Demonstrations for the Texas High Plains. Submitted to the Texas Corn Producers Board;
(6) Archer, T., R. Lascano, J. Bordovsky, B. Payne, L.T. Wilson, Wenwei Xu, and E. Segarra. 2000. Optimizing Plan Productivity Using Integrated Crop Management in a Precision Agricultural System. Submitted to USDA - NRI program; and
(7) Larson, D., P. Mirchandani, P. Waller, and E. Segarra. 2000. Decision Support System for Site-Specific Management of Irrigated Crops. Submitted to USDA - IFAFS program.

F. Precision agriculture meetings attended/papers (posters) presented:

Yu, M., E. Segarra, and A. B. Onken. 1998. The Economics of Soil Fertility Under Precision Agriculture: The Case of Phosphorus. Selected for presentation, 1998

Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 5-9, 1998, San Diego, California.

Segarra, E. 1998. Economics of Precision Agriculture. AG-CARES Field Day, September 15, Lamesa, Texas.

Yu, M., E. Segarra, and D. Nesmith. 1999. Spatial Utilization of Phosphorous: Implications for Precision Agriculture Practices. Selected for presentation, 1999 Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 3-7, 1999, Orlando, Florida.

Machado, S., E. D. Bynum, Jr., D. T. Rosenow, G. C. Peterson, T. L. Archer, R. J. Lascano, K. Bronson, E. Segarra, and L. T. Wilson. 1999. Spatial Variability of Sorghum Yield: Site-Specific Interactions of Soil, Water, and Pests. Selected for presentation at the 1999 Sorghum Production Conference - Blazing New Trails, February 21-23, 1999, Tucson, Arizona.

Machado, S., E. D. Bynum, Jr., T. L. Archer, R. J. Lascano, M. Yu, E. Segarra, K. Bronson and D. Nesmith. 1999. Spatial and Economic Variability of Corn Yield: Site-Specific Interactions of Soil, Water, Pests, and Diseases. Selected for presentation at the 1999 ASA, CSSA, and SSSA Annual Meetings, October 31-November 4, 1999, Salt Lake City, Utah.

Yu, M., E. Segarra, H. Li, R. J. Lascano, C. Chilcutt, L. T. Wilson, K. Bronson, and S. Searcy. 2000. The Economics of Precision Agricultural Practices in Cotton Production. Selected for presentation, 2000 Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 4-8, 2000, San Antonio, Texas.

Bynum, E., Jr., S. Machado, T. Archer, R. Lascano, E. Segarra, L. T. Wilson, and J. Bordovsky. 2000. Optimizing Integrated Pest Management Using Integrated Crop Management in a Precision Agricultural System. Selected for presentation at the 48th meeting of the Southwestern Branch of the Entomological Society of America, February 8-11, 2000, Forth Worth, Texas.

Segarra, E., and S. Bondurant. 2000. Economic Feasibility of Precision Agriculture: The Case of Grain Sorghum. Presented to the Precision Agriculture Industry Advisory Panel, June 15, Plainview, Texas.

Machado, S., E. D. Bynum, Jr., T. L. Archer, R. J. Lascano, L. T. Wilson, J. Bordovsky, K. Bronson, D. M. Nesmith, E. Segarra, D. T. Rosenow, G. C. Peterson, and W. Xu. 2000. Spatial and Temporal Variability of Sorghum and Corn Yield: Interactions of Biotic and Abiotic Factors. Selected for presentation at the International Conference on Precision Agriculture, July, 2000, Bloomington, Minnesota.

Yu, M., E. Segarra, H. Li, R. J. Lascano, and S. Watson. 2001. Precision Farming Practices in Irrigated Cotton Production in the Texas High Plains. Selected for

presentation, 2001 Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 9-13, Anaheim, California.

Li, H., R. J. Lascano, J. Booker, L. T. Wilson, K. F. Bronson, and E. Segarra. 2001. Water and Nitrogen Balance of Cotton as Affected by Soil Texture and Topography. Selected for presentation, 2001 Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 9-13, Anaheim, California.

Li, H., R. J. Lascano, E. M. Barnes, J. Booker, L. T. Wilson, and E. Segarra. 2001. Cotton Reflectance Characterization and NDVI-days Lint Yield Modeling. Selected for presentation, 2001 Beltwide Cotton Conferences. Co-sponsored by the National Cotton Council and the Cotton Foundation, January 9-13, Anaheim, California.

Watson, S., E. Segarra, M. Yu, E. Bynum, S. Machado, T. Archer, and L. T. Wilson. 2001. The Economics of Precision Farming in Grain Sorghum. Selected for presentation at the annual meeting of the Southern Agricultural Economics Association, January 27-31, Fort Worth, Texas.

Yu, M., and E. Segarra. 2001. Economic Impacts of Precision Farming in Cotton Production. Selected for presentation at the annual meeting of the Southern Agricultural Economics Association, January 27-31, Fort Worth, Texas.

G. Other developments: None.