ECONOMICS OF VARIABLE RATE

PLANTING FOR CORN

by

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Abstract

This analysis works out the economic implications for variable rate seeding of the corn population response curves estimated by Pioneer Hi-Bred agronomists. Examples are developed for various mixes of low, medium and high yield potential soil, as well as for a range of seed costs and variable rate equipment costs. The strategies analyzed were: variable rate planting using agronomic recommendations for each yield potential zone, variable rate planting using an economic decision rule for each yield potential zone, an information strategy which sets the uniform planting rate at the highest population indicated by agronomic recommendations for any part of the field and a second information strategy which uses an economic decision rule for the whole field based on potential in each yield zone. The economic decision rule sets the value of additional yield produced by adding a few more plants equal to the cost of planting a few extra seeds.

Major assumptions of the analysis include: only corn is considered for variable rate planting, 1000 acres of corn are planted annually, the yield potential zones are small, irregularly shaped and interspersed so that changing population by field is ineffective, the zones are accurately mapped and corn price at harvest is $3/bu. The analysis does not include risk, alternative uses for low yield potential soil or the benefits of variable rate planting other than seed cost savings and matching population to the yield potential of the soil.

The general conclusion is that variable rate seeding has profit potential only for farmers with some low yield potential land(<100 bu./a). Farmers with mix of medium and high potential land are better off with uniform rate seeding. The surprise is that variable rate seeding is potentially profitable when the proportion of low yield land is small. In the example, the farm with 10% low yield potential soil shows positive returns to variable rate planting. The results are not particularly sensitive to seed cost or variable rate investment cost.

Keywords: precision farming, variable rate, corn, GPS, production economics

Economics of Variable Rate Planting for Corn

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Introduction

Varying plant populations within fields is an old idea that has been given new life by the availability of GPS technology. Intuitively, it makes sense to reduce plant populations on soils that have lower yield potential. From the investment cost perspective, variable rate planting is relatively inexpensive, especially for a producer who already has invested in GPS. A variable rate planter controller sells for about $3500-$4000. But intuitive appeal and low investment cost do not necessarily generate profit. The objective of this analysis is to examine the profitability of variable rate planting for corn given available information on crop response to plant populations. This will be done using crop responses estimated by Pioneer Hi-Bred agronomists (Pioneer Hi-Bred International, 1997) and a simple spreadsheet model.

Operator managed variable rate planting systems have been around for about 20 years, but failed to catch on because they depended on the alertness of the operator. Farmers who used manual systems often say that they worked when the operator was fresh, but as fatigue crept in operators would often forget to switch populations. All the gains from lower populations for the low yield potential areas could be lost if a few rounds were made at the lower population in higher yield areas. Precision technology automates the process and reduces switching errors.

Numerous agronomic studies have considered variable rate planting. Doerge (1997) summarizes the results of several Pioneer Hi-Bred studies by saying that optimum seeding rates do not vary much across a wide range of soil and yield conditions in the Corn Belt. He also states that while seeding rates below the optimum can reduce yields; higher than optimum seeding rates carry little penalty. He

concluded that variable rate seeding may be profitable on farms with some areas with yield potential below 100 bu./a. Barnhisel et al. (1996) provide data from a three year study in Kentucky which indicates a modest return to variable rate planting on fields which include some soils with below 100 bu./a yield averages. Kinsella reported a soybean response to higher populations on lighter, lower yield potential soils. Some farmers have reported success in variable rate planting by soil type, instead of by yield potential.

This analysis will address the following specific questions for variable rate planting based on yield potential:

1) What proportion of corn area must be below 100 bu./a yield potential to justify variable rate planting?
2) Does the profitability of variable rate planting depend on the productivity of the better soils in the mix? Is variable rate planting profitable for only a mix of low and high productivity soils or also for a mix of medium and low productivity land?
3) How sensitive are returns to variable planting to seed and equipment costs?

This analysis will not deal with the risk considerations related to seeding rate decisions, interaction of row width and variable rate planting, or use of variable rate planting to increase populations in low germination areas. These are important issues, but beyond the scope of this analysis and of the data available. This analysis assumes that the low yield potential land will be farmed. It does not deal with alternate uses for that land in forage, forestry or other crops.

Methods

The basic approach was to develop spreadsheet budget examples that estimate returns to various seeding rate strategies and then to vary certain parameters parametrically to determine the sensitivity

of results to baseline assumptions. The population response functions by yield potential estimated by Doerge (personal communication, 1998) were used to estimate corn yields because they are the best available for Corn Belt conditions. The focus is on corn because no soybean population response functions are available.

One of the key questions raised by Doerge and others is that if planting rates are varied, how will the changes be determined. Accurately mapping yield potential is in itself a major problem. It is assumed that the yield potential zones are relatively small, irregularly shaped and interspersed, so that management by field or other unit would be difficult. It is assumed that yield potential zones are accurately mapped. For simplicity this study assumes that we know the proportion of the corn area that has high, medium and low yield potential and that variable rate equipment can accurately change populations given a map of the zones.. The zones are defined as:

High: over 180 bu./a expected yields

Medium: between 120 and 140 bu./a expected yields

Low: under 100 bu./a expected yields

Five strategies were evaluated based on approaches suggested in the literature for managing variable rate inputs (Lowenberg-DeBoer and Boehlje, 1996):

- **Uniform seeding** to achieve a population of 28,000 plants/a at harvest - this is the control to which other strategies are compared.
- **VRT, agronomic rule** - Variable rate seeding based on Pioneer agronomic recommendations.
- **VRT, economic rule** - Variable rate seeding based on the economic criteria that the marginal value of the additional product be equal to the marginal cost of the additional input in every management zone.

- **Information strategy, agronomic rule** - An "information strategy" based on agronomic recommendations, which identifies the highest optimal plant population for any site in the field and plants all the corn acres uniformly at that rate.
- **Information strategy, economic rule** - An information strategy which uses site specific yield potential information to determine the population at which the marginal value equals marginal cost criteria for all the corn acres.

The plant populations for each management strategy are listed in Table 1. Because the crop response functions were estimated on a limited range of populations, no populations below 18,000 were used.

Price assumptions are listed in Table 2. The $67/bag seed price is the average price for 1997 with all relevant quantity and other discounts. The "Other Costs" include hired labor, chemicals, fertilizer, equipment, interest, crop insurance, machinery, drying equipment and storage for average soils from Doster et al. (1996). Other assumptions include: 1000 acres of corn planted, to allow for germination and other problems the planted populations should 10% higher than desired population at harvest and the useful life of the planter controller is 5 years. The 10% discount rate is used to estimate an annualized cost for the VRT equipment.

In the examples, only the seeding rate was influenced by the site specific information. All other inputs were held constant. Larger gains are to be expected in an integrated system which manages several inputs site specifically.

To keep the example simple the baseline farm was assumed to have only two yield potential zones: 50% high yield potential land and 50% low yield potential land. Scenarios were also developed with a 50/50 mix of high and low yield potential land and a 50/50 mix of medium and low yield potential soil. Other scenarios include:

- varying seed price from $50 to $110 per 80000 kernel bag and
- changing the variable rate equipment cost from $2000 to $8000 per farm.

The baseline scenario assumes that the producer's only investment is the variable rate planter controller and monitor. The sensitivity testing considers the case of producers who must also purchase GPS units, computers or other equipment to implement variable rate planting.

Results and Discussion

Consistent with the agronomic studies variable rate planting shows economic advantage on farms with some land with under 100 bu./a yield potential (Table 3). The benefits vary with the proportion of low potential soil, but are of similar magnitude for mixes of high and low or medium and low potential land. Surprisingly, benefits occur for a very modest proportion of low yield land. Both variable rate strategies show small positive returns at 10% of land being low yielding.

The benefits are highest when a small part of the farm has high potential soil. In the baseline example, when 95% of the farm is low yield potential (5% high yield potential), the gain from variable rate is over $4/a for both variable rate strategies. This large benefit when a high proportion of the land is low yielding, depends on the assumption that under a uniform rate strategy producers would maintain a desired harvest population of 28,000.

With the variable rate strategies, the source of economic benefits depends on the proportion of low yield land. When proportion of low yield land is small, yield gains provide most of the benefits and seed savings are small. When the proportion of low yield land is large, the largest source of benefits is seed savings.

Compared to the variable rate approaches, the information strategy using the economic rule appears to offer some promise. For a mix of low and high yield potential land, the net gains

compared to uniform planting are slightly greater than those of the variable rate strategies for small areas of low yield and slight less for a higher proportion of low yield (Table 3). The information strategy might have consistently greater return if the costs of installing variable rate equipment, learning to operate it, mapping yield potential zones and additional field time are factored in. With a mix of high and medium yield potential land, the information strategy with the economic rule shows small gains relative to uniform planting for situations in which variable rate planting shows losses (Table 4). The populations for the information strategy with the economic rule drop to near 20,000 when a high proportion of the land is low yielding, and rise to near 30,000 when most of the farm is in high yield potential zones.

The information strategy with the agronomic rule seems to offer small benefits compared to either uniform or variable rate planting when small parts of the farm are in low yield potential zones (Tables 3 & 4). When the farm has some high yield potential land, this strategy sets plant populations at the high yield potential rate of 30,000. When over 50% of the farm is in the lower yielding zones, uniform planting is preferred to either the variable rate or the information strategy with the agronomic criteria.

Results for the information strategies appears to be quite sensitive to the exact population response functions used. Early response function estimates reported by Doerge (1997) show less favorable results for the information strategy.

If the farm has a mix of medium and high productivity land, the cost of variable rate planting is greater than the yield or seed savings benefits (Table 4). For the mix of medium and high yield soils, the information strategy which uses the highest agronomic rate shows consistently lower returns than the uniform rate strategy. For that soil mix, the information strategy with the economic decision rule shows very modest positive returns; probably too modest to justify a change in equipment.

Seed cost increases augment the value of site-specific variable rate management (Table 5), but they do not change the general management advice. Farmers with a mix of high and low productivity land may benefit from variable rate seeding at any seed cost in the range from $50 to $110 per bag. Farmers with a mix of medium and high yield potential soil are better off with uniform rate planting.

Similarly, a higher investment cost for variable rate equipment reduces the benefit (Table 6), but the farmer with a mix of low and high yield potential soil still shows positive returns even with an $8000 investment on 1000 acres of corn. The farmer with a mix of medium and high potential soils does not show positive returns from variable rate even at a $2000 investment cost.

Conclusions & Implications

The general conclusion is that variable rate seeding has profit potential only for farmers with some low yield potential land (<100 bu./a). The examples indicate that profitability does not depend on the productivity of the other land in the mix, as long as it is substantial higher than that of the low productivity soil. Variable rate seeding can be profitable for mixes of high and low or of medium and low yield potential soils. Farmers with a mix of medium and high potential land are better off with uniform rate seeding.

Sensitivity tests indicate that variable rate seeding is potentially profitable when the proportion of low yield land is small. In the example, the farm with 10% low yield potential soil shows positive returns to variable rate planting. The results are not particularly sensitive to seed cost or variable rate investment cost. This result suggests that variable rate seeding may be most valuable in areas on the fringe of the Corn Belt where some of the low yield potential soils are farmed.

The information strategies appear to offer some promise, especially for farms with small areas of low yield potential. This is especially true if the time and effort required to implement variable rate

planting is factored in. The information strategies have the advantage of being simpler to implement and do not require special variable rate equipment.

This analysis is only as good as the corn population response functions used. The functions used in this analysis were estimated with pooled data from around the Corn Belt. Site- specific population response functions would probably improve the performance of both the variable rate and information strategies. This type of function could be estimated with yield monitor data.

References

Barnhisel, R.I., M.J. Bitzer, J.H.Grove and S.A. Shearer, "Agronomic Benefits of Varying Corn Seed Populations: A Central Kentucky Study," in Proceedings of the Third International Conference on Precision Agriculture, P.C. Robert, R.H. Rust and W.E. Larson eds, ASA/CSSA/SSSA, Madison, WI, 1996.

Doerge, Tom, "Variable Rate Seeding of Corn," Crop Insights, Pioneer Hi-Bred International, http://www.pioneer.com, 1997.

Doster, D.H., S.D. Parsons, E.P. Christmas, D.B. Mengel and R. L. Nielsen, "1997 Purdue Crop Guide," ID-166, Purdue University, West Lafayette, IN, 1996.

Kinsella, James, "What My Farm Plots Say," Presentation at the Top Farmer Crop Workshop, Purdue University, West Lafayette, IN, July 21, 1997

Lowenberg-DeBoer, J. and M. Boehlje, "Revolution, Evolution or Deadend: Economic Perspectives on Precision Agriculture," in Proceedings of the Third International Conference on Precision Agriculture, P.C. Robert, R.H. Rust and W.E. Larson eds, ASA/CSSA/SSSA, Madison, WI, 1996.

Pioneer Hi-Bred International, "Pioneer Agronomy Research Update," 1997.

Table 1. Plant Populations for Variable Rate and Information Strategies by Yield Potential Zone

Yield Potential Zone	Variable Rate, Agronomic Recommendation	Variable Rate Economic Rule	Information, Highest Agronomic Recommendation	Information, Economic Rule
----------plants/acre at harvest----------				
Low	18,000	20,000	30,000	28,000
Medium	28,000	26,000	30,000	28,000
High	30,000	30,000	30,000	28,000

Table 2. Price Assumptions for Estimation of Returns to Variable Rate Corn Planting

Item	Unit	Price
Corn at Harvest	bu.	$3.00
Corn Seed	bag, 80000 kernels	$67.00
Dryer Fuel	gal.	$0.50
Variable Rate Planter Controller & Monitor	controller & monitor	$3500
Discount Rate	year	10%
Other costs	acre	$168.55

Table 3. Gains From Using Site-Specific Information in Corn Plant Population Decisions for Farms With Varying Percentages of Low Yield Potential Land.

Percentage of Land With Low Yield Potential	Variable Rate Seeding, Agronomic Recommendations	Variable Rate Seeding, Economic Decision Rule	Information Strategy, Highest Agronomic Recommendations	Information Strategy, Economic Decision Rule
		$/a		
5%	0.26	0.28	0.77	0.82
10%	0.47	0.50	0.57	0.70
25%	1.10	1.19	-0.04	0.34
50'%	2.16	2.33	-1.06	0.00
75%	3.22	3.46	-2.08	0.66
90%	3.85	4.15	-2.69	2.44
95%	4.06	4.37	-2.89	3.68

Table 4. Gains From Using Site-Specific Information in Corn Plant Population Decisions for Farms With Varying Percentages of Medium Yield Potential Land

Percentage of Land With Medium Yield Potential	Variable Rate Seeding, Agronomic Recommendations	Variable Rate Seeding, Economic Decision Rule	Information Strategy, Highest Agronomic Recommendation	Information Strategy, Economic Decision Rule
		$/a		
5%	0.00	0.02	0.87	0.87
10%	-0.05	-0.00	0.77	0.80
25%	-0.19	-0.08	0.46	0.59
50%	-0.44	-0.22	-0.05	0.24
75%	-0.68	-0.35	-0.56	0.00
90%	-0.83	-0.43	-0.87	0.09
95%	-0.87	-0.46	-0.97	0.19

Table 5. Gains From Using Site-Specific Information in Corn Plant Population Decisions Over a Range of Seed Corn Prices for Farms with 50% Low Yield Potential Land.

Seed Corn Prices, $/bag	Variable Rate Seeding, Agronomic Recommendations	Variable Rate Seeding, Economic Decision Rule	Information Strategy, Highest Agronomic Recommendation	Information Strategy, Economic Decision Rule
		$/a		
50	1.23	1.70	-0.59	0.00
60	1.78	2.05	-0.87	0.00
70	2.33	2.45	-1.14	0.00
80	2.88	2.98	-1.42	0.00
90	3.43	3.57	-1.69	0.04
100	3.98	4.19	-1.97	0.18
110	4.53	4.81	-2.24	0.31

Table 6. Gains From Using Site-Specific Information in Corn Plant Population Decisions Over a Range of VRT Equipment Investment Levels for Farms with 50% Low Yield Potential Land.

Variable Rate Equipment Investment $/farm	Variable Rate Seeding, Agronomic Recommendations	Variable Rate Seeding, Economic Decision Rule	Information Strategy, Highest Agronomic Recommendation	Information Strategy Economic Decision Rule
		$/a		
2000	2.56	2.72	-1.06	0.00
3000	2.29	2.46	-1.06	0.00
4000	2.03	2.19	-1.06	0.00
5000	1.77	1.93	-1.06	0.00
6000	1.50	1.67	-1.06	0.00
7000	1.24	1.40	-1.06	0.00
8000	0.97	1.14	-1.06	0.00