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Technical Note

The Economics of Nutrient and Pest Management

Economics Series No. W-9

THE ECONOMICS OF NUTRIENT AND PESTICIDE MANAGEMENT

INTRODUCTION

Background

In the Soil Conservation Service, economics can play a major role in implementing our Nutrient Management and Pest Management standards. Economic principles and tools can be used together with other tools such as soil testing, nutrient source analysis, water budgets, leaching indices, site vulnerability assessments and pesticide solubility ratings, etc., to develop specific nutrient management plans or pest management plans. That is indeed fortunate as farmers and ranchers will need to rely more and more on economic principles and methodologies to help them make chemical application decisions. This paper is meant to serve as a catalyst towards more involvement by SCS economists in this area.

The two main principles examined here include optimization and economic thresholds. Specifically, this paper will explain the "what" and "how" of fertilizer optimization and economic thresholds in herbicide and insecticide application. It is hoped that from the methods described in this paper, a basis for technology transfer to the field can be established. With simple "spreadsheet" automation, these techniques can be made even more useful.

Optimization

Optimization is a term that can relate to various production situations. However, in the context of nutrient management, optimization means adding fertilizer up to the point where it no longer pays to do so. Why does it no longer pay? Because the income from the increase in yield caused by the last unit of fertilizer does not cover the cost of that fertilizer. It is as simple as that. However, the concept of optimization is sometimes ignored.

Economic Threshold

Farmers and ranchers must make decisions about pesticide application. Weeds and insects can cause injury to a crop. A little injury may be acceptable if it does not significantly affect profits. However, if injuries worsen, decisions about using pesticides must be made. The key becomes whether or not the cost of treating the crop problem is less than the cost of the problem itself.

The point at which an input starts to pay for itself is called the "economic threshold." This paper will discuss methods to estimate the economic threshold for two agricultural inputs, herbicide and insecticide.

NUTRIENT MANAGEMENT

Fertilizer Recommendations

Soil testing is being used more and more as a benchmark in fertilizer recommendations. A yield goal or "target yield" sometimes supplied by the farmer, is compared to the soil test benchmark to estimate fertilizer needs. This is superior to previous "trial and error" fertilization and new, more accurate soil testing methods are being developed all the time. However, if the estimated target yield is too high, over application will result and the crop will not be able to utilize all the available nutrients, leaving them as potential pollutants.

Hallberg (1986) reports that half of all farmers in Iowa and Nebraska over fertilize by 20 to 25 percent. In the Pacific Northwest, winter wheat in many locations shows little response to additional nitrogen because of previous over-fertilization (Papendick, et al, 1984). Another study shows that irrigated corn producers over-apply nitrogen at an average rate of 78 lbs/ac. (Schepus, 1982).

In addition to potential environmental problems, over-fertilization leads to loss of profit. Some farmers are applying fertilizer at a rate that simply does not pay. Why? They have not incorporated economics into their nutrient management decisions. Their equation does not include yield response, the price of fertilizer, nor the price of their crop. In fact, we in SCS have not included yield response sufficiently into our standards and assistance. Prices of fertilizer and crops are not considered at all. We flatly do not consider optimization in our nutrient management technical assistance.

As Iowa Attorney General Tom Miller explained at the Midwest Soil Testing Conference held in Des Moines last fall, "If fertilizers were applied only in the best economic interests of farmers, then the environmental problems would probably be eliminated."

Fertilizer Optimization

So how does one incorporate the principle of optimization? By developing a way to incorporate economics into the target yield estimation. Most noneconomists recommend a three- to five-year historical average. This is a good first step but can be improved upon by applying some simple economic logic, a few prices, and yield response data from the Extension Service - - - all readily available:

Data needed	Source
Target yield (3-5 year average)	Farmer's records
Yield response	Extension Service
Fertilizer price	Fertilizer Dealer
Crop price	
Realistic estimate	Hedged Price
Conservative estimate	Target Price

With this data, the following table can be filled out by hand, automated quite quickly in a spreadsheet, or compiled in an executable form. The result of the process is a "revised target yield," one which incorporates economics, specifically optimization, Table 1.

Table 1. Calculating a Revised Target Yield

Fertilizer (N in lbs.) (Price = $.25/lb.)	Crop Yield (corn in bu.) (Price = $1.80/bu.)	Change in Cost ($)	Change in Return ($)	Net Change ($)
50	70	-	-	-
75	95	6.25	45.00	38.75
100	105	6.25	18.00	11.75
125	113 (Revised Target Yield)	6.25	14.40	8.15
150	116	6.25	5.40	-.85
175	118	6.25	3.60	-2.65
200	119	6.25	1.80	-4.45
225	120 (3-year Target Yield)	6.25	1.80	-4.45

Extension service data will show a relatively fixed relationship between quantity of fertilizer applied and expected yield. The first two columns of Table 1 can be constructed to show this relatively stable relationship.

Using this information and assuming the only cost change associated with increasing fertilizer application is the cost of the additional fertilizer, the remainder of Table 1 can be constructed when you move from one level of fertilizer to the next higher level. Columns 4 and 5 indicate the change in total and net revenue that occur because of the change in fertilizer application from column 1.

The revised target yield is obtained by increasing fertilizer application to a point where the last addition of fertilizer resulted in a positive change in net income. For this case, this occurred at a yield of 113 bu of corn and an application of 125# of N. If the data were more refined, it would be possible to show that the optimal N application would be somewhere between 125 and 150 lbs. of N and 113-166 bushels of corn.

For purposes of this procedure we will select 113 as the target yield.

If the farmer had used the three-year average target yield, he would over-applied by 100 pounds, causing increased hazard to the environment as well as lost profit. In fact, the over-application cost the farmer $12.40/ac. which is the sum of the negative net change between the three-year average target yield and the revised target yield.

HERBICIDE THRESHOLD

What Is It?

The herbicide threshold is the point where weed density is high enough that herbicide control costs equal the cost of the lost yield due to the weeds. That is, the point where applying herbicide is economically justified. If herbicide is applied on a field where the threshold is not reached, profits are lost. For example, if the lost yield due to weeds is $12 per acre, herbicide costs are $18 per acre, and herbicide is applied; $6 per acre lost profit results.

How Is It Calculated?

The following is one method to estimate the need to apply herbicide, (herbicide threshold), in corn or soybeans. Similar methods are available for small grain crops as well. To estimate, use the following steps:

1. Determine the expected yield.

2. Determine the crop price.

3. Determine densities of weeds by species and expected yield loss.

   a. Count weeds in 100 feet of row.

   b. Use following table to determine weed density and expected yield loss.

Economic Thresholds for Weeds

	% corn yield loss						% soybean yield loss					
	1	2	4	6	8	10	1	2	4	6	8	10
WEED	-----------number of weed clumps per 100 feet of row----------											
Cocklebur	4	8	16	28	34	40	1	2	4	6	8	10
Giant ragweed	4	8	16	28	34	40	1	2	4	6	8	10
Pigweed	12	25	50	100	125	150	2	4	6	10	15	20
Lambsquarters	12	25	50	100	125	150	2	4	6	10	15	20
Velvetleaf	--	--	--	---	---	---	8	16	24	32	40	50
Morningglory	--	--	--	---	---	---	8	16	24	32	40	50
Jimsonweed	--	--	--	---	---	---	8	16	24	32	40	50
Smartweed	--	--	--	---	---	---	8	16	24	32	40	50
Giant foxtail*	10	20	50	100	150	200	5	10	17	25	32	44
Shattercane**	6	12	25	50	75	100	2	5	8	11	14	18
Volunteer corn	--	--	--	---	---	---	1	2	3	4	5	6

*5 to 8 stems per clump **2 to 3 stems per clump
Source.--University of Illinois - Field Crop Scouting Manual, 1990

4. Add up the percentage of yield loss for all weeds and multiply by the expected yield to get yield loss in bushels per acre.

5. Multiply bushels per acre yield loss times expected price.

This results in the expected dollar damage caused by weeds which can be compared to the cost of treatment. If the damage is higher than the cost of treatment, the herbicide threshold has been reached and application is economically justified. If not, profits will be higher if herbicide is not applied at this time.

Example: A soybean field has an average of six giant ragweed, 24 velvetleaf, and 10 giant foxtail clumps per 100 feet of row. According to the chart, yield losses for the weeds are 6 percent, 4 percent, and 2 percent, respectively, making total yield loss 12 percent. If the expected yield is 40 bushels per acre and beans are valued at $5 per bushel, the yield loss would be 4.8 bushel or $24 per acre. If the cost of treatment is $26 per acre, the net gain of treatment would be -$2 per acre. In this case, treatment would not be economically justified.

INSECTICIDE THRESHOLD

What Is It?*

Consistent with the herbicide threshold definition, the insecticide threshold is the point where insect density is high enough that insecticide control costs equal the cost of lost yield due to the insects.

*Integrated pest management (IPM) is one approach to lessen the application of insecticides through use of scouting and other monitoring techniques to more accurately estimate the insect problem. In fact, IPM was one of the first developments to popularize the use of economic threshold as an efficiency tool.

How Is It Calculated?

Insect scouting methods vary, but normally information is needed on many of the same factors as with weed scouting. Using the European Corn Borer as an example, the following steps are taken to determine the need for insecticide:

1. Determine the expected yield.

2. Determine the crop price.

3. Determine density of borers.

   a. Sample 25 plants in each of four locations counting the number of corn borers per stalk (borers are found in whorls on the stalk).

   b. Divide this number by 100 to get an average number of borers per stalk.

   c. Multiply the number of borers per stalk by 5 (percent damage caused by one borer per stalk) to get percent of yield damage to the crop.

4. Multiply crop price x expected yield x .75 x percent yield damage to get the dollar damage to the corn per acre from corn borers (75 percent control is assumed with corn borer insecticides).

If this amount is more than the cost of treatment, treatment is economically justified.

Example: An average of one borer cavity per plant is capable of causing an approximate 5 percent yield loss. In the example shown, from scouting you know that there are 2 worms per plant. Assume 75 percent control and $1.75 per bushel with a yield expectation of 125 bushels per acre.

		Example Field	Your Estimates
1.	Yield potential for this field.	125 Bu/A	____ Bu/A
2.	Potential yield loss (2 larvae/plant x 5% = 10% loss in yield, 10% x 125 Bu = 12.5 Bu loss/A).	12.5 Bu/A	____ Bu/A
3.	Dollar loss/A (12.5 Bu/A x $1.75 per Bu = $21.87 loss/A).	$ 21.87	$ ____
4.	Preventable loss (if chemical is 75% effective $21.87 x 75% = $16.41/A).	$ 16.41	$ ____
5.	Chemical ($8.00/A) and application cost ($4.00/A). (Estimate your own cost or call dealer/applicator.) TOTAL = $12/A.	$ 12.00	$ ____
6.	Compare preventable loss ($16.41/A) with treatment cost ($12.00): $16.41/A - $12.00/A = $4.41/A (dollars saved by treatment/A).	$ 4.41	$ ____

Source: Nebraska Cooperative Extension Service, 1989

In this case, the net gain from treatment would be $4.41 per acre and treatment would be economically justified.

SUMMARY

In order for farmers/ranchers to adequately analyze the nutrient and pesticide application decisions of today, they must understand the economic and environmental implications. This Technical Note discusses techniques that consider economics, which if adopted by overappliers, would go a long way in solving the negative environmental implications as well.

For we in SCS, the need to understand and be able to relate the economic implications of nutrient and pesticide management would be very complimentary to our environmental technical assistance. The use of the optimization concept for nutrient management and the concept of economic thresholds in pesticide management would increase our credibility at the field level.

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