The Effect of Feedgrain Program Participation on Chemical Use

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Economic incentives created by the commodity programs are hypothesized to cause program participants to apply agrichemicals at greater rates than nonparticipants. Corn producers who participate in the USDA feedgrain program are shown to apply nitrogen, herbicides, and insecticides at statistically greater rates than those who do not participate.

The design of U.S. commodity programs creates economic incentives and conditions that result in higher per-acre chemical use on commodity crops than would occur under free-market conditions. In this analysis, cross-sectional data from the 1991 and 1992 Cropping Practices Surveys are used to test for differences in chemical use in corn production between participants in the feed grain program and nonparticipants (NASS/ERS). Corn is the most important U.S. crop in terms of chemical use. Over half of all pesticides applied to field crops are applied to corn, and more than 60 percent of nitrogen fertilizer.

Background

U.S. commodity programs are designed primarily to provide price and income protection for farmers, to assure the nation an abundant and low-cost supply of food and fiber (Langley et al). One justification for government intervention includes the perception that farmers are an economically hard-pressed group that would be subject to intolerable instability in commodity markets without government intervention (Langley et al). Income support is achieved by government intervention in the market to raise prices received by producers. Several mechanisms are used. For feedgrains a combination of loan rates and target prices raise the effective market price a participant in the program can expect to receive. To limit the accumulation of surplus stocks, deficiency payments are usually contingent on setting aside a percentage of the program base acres. Participation in the deficiency payment program is voluntary and therefore the program needs to be sufficiently generous to induce participation. A consequence of the program provisions is the creation of distortions in farm production. These distortions are a source of the intensification of input use.

The distortions can be shown by comparing the firm optimization decisions with and without farm programs. Our illustrative model assumes a single-product firm using two variable inputs, land and nonland, denoted A and X respectively. Output is produced by a neoclassical production function defined as $F(A,X)$ with the usual properties, $F_i > 0$ and $F_{ii} < 0$, where $i = A, X$ and subscripts denote derivatives. The firm maximizes profits in perfectly competitive product and factor markets. The firm's maximization problem and optimality conditions are:[1]

$$\pi = pF(A,X) - wX - vA \tag{1}$$

$$\pi_A = pF_A - v = 0 \tag{2a}$$

$$\pi_X = pF_X - w = 0 \tag{2b}$$

where p is the commodity price and v and w are the market prices of land (rental) and nonland inputs. From (2a) and (2b) the usual first-best efficiency condition is:

$$\frac{F_A}{F_X} = \frac{v}{w} \tag{3}$$

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[1] This simple model treats land essentially as a variable input, abstracting from the issues of land investment and adjustment cost making this is a long-run comparative static model. The efficiency effects of commodity programs have been examined elsewhere, (Shoemaker 1993), in a model with land and durable capital investment with adjustment costs and finds the similar results to the ones in this simpler model.

where the marginal rate of substitution equals the market factor price ratio.

The deficiency payment programs have been the primary income transfer mechanism in U.S. farm policy. As such, it is the instrument through which most agricultural policy oriented distortions occur. The deficiency payment provisions also involve cropland set-asides. Deficiency payments are the product of the deficiency rate and program production. The deficiency rate is the difference between the target price, $\bar{p}$, and the higher of the five-month weighted national average market price or the loan rate. (For brevity's sake we will assume that the market price is greater than the loan rate throughout the paper). The level of production used for calculating program payments is determined as the product of the program yield and allowable planted acres (base acres minus set-aside). Of course, if the market price exceeds the target price, there is no deficiency payment.

Over the years the formula for calculating program payments has changed. Prior to 1981, deficiency payments were based on proven yields and payment acres (base acres net of set-asides), where proven yields are the average products of effective land in production. Noting that payment yields were average products, the deficiency payment can be expressed as,

$$(4)\quad DP = (\bar{p} - p)\frac{F(A(1-\theta),X)}{(A(1-\theta))}(A(1-\theta))$$

indicating that payments were based on actual production. Since deficiency payments were determined by the payment yield (actual production) and acres, payment yields were endogenous. That is, producers had the direct incentive to increase yields and their payment rate by adjusting variable inputs, such as fertilizers and pesticides to enhance yields. In this case, the profit and first-order conditions are:

$$(5)\quad \pi = pF(A(1-\theta),X) + (\bar{p} - p)\,F(A(1-\theta),X) - wX - vA$$

$$(6a)\quad \pi_A = \bar{p}F_A(1-\theta) - v = 0$$

$$(6b)\quad \pi_X = \bar{p}F_X - w = 0$$

where θ is the set-aside rate.

Assuming the target price, $\bar{p}$, exceeds the market price, the target price becomes the operational marginal price, i.e., the price at which producers make decisions at the margin. The marginal value product of both inputs are increased by the target price. The willingness-to-pay for land and nonland inputs are expressed as:

$$(7a)\quad \bar{p}F_A = \frac{v}{(1-\theta)}$$

$$(7b)\quad \bar{p}F_X = w$$

Equations (7*a*)–(7*b*) indicate that the first-best efficiency conditions are violated. The MRS/effective price ratio for this case is:

$$(8)\quad \frac{F_A}{F_X} = \frac{v}{w(1-\theta)}$$

The user cost of land is increased because the market price v is divided by $(1 - \theta)$. The increase in the user cost of land reflects the opportunity cost of the set-aside requirement. For the producer that is willing to participate in the program, the opportunity cost of the set-aside is compensated at the margin by the target price. The important point to note is that the effective cost of the nonland input falls relative to the rental cost of land, resulting in an intensification in the use of non-land inputs (chemicals, for example).

In the 1985 Farm Bill, in an attempt to reduce budget exposure and to reduce the direct incentive effects of deficiency payments on production, the yield basis for payments was frozen at the average 1981–1985 level.[2] It has been suggested that by fixing the payment yield, the distortionary effects of the program are eliminated. From the first order conditions below we see that while the more overt incentive effects have been reduced, distortions still remain. The firm's optimization problem and first-order conditions are,

$$(9)\quad \pi = pF(A(1-\theta),X) + (\bar{p} - p)\,\bar{y}(1-\theta)A - wX - vA$$

$$(10a)\quad \pi_A = (1-\theta)\{pF_A + (\bar{p} - p)\bar{y}\} - v = 0$$

$$(10b)\quad \pi_X = pF_X - w = 0$$

where $\bar{y}$ is the fixed program yield and θ is the acreage set-aside rate.

The MRS/effective price ratio for this case is expressed as,

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[2] Between 1981 and 1986, the payment yield was based on a five-year moving average of actual yields. Shoemaker (1992) examined this payment scheme and found the distortionary effects as an intermediate case between payments based on actual production and fixed (exogenous) payment yields.

$$(11) \qquad \frac{F_A}{F_X} = \frac{v(1-\theta)^{-1} - (\bar{p} - p)\bar{y}}{w}$$

The MRS shows that program-induced distortions are not eliminated. Equation (10*a*) can be rewritten as,

$$(10a') \quad pF_A(1-\theta) = v - (\bar{p} - p)\bar{y}(1-\theta)$$

The term on the left-hand-side is the willingness-to-pay for land or the marginal value product of land in production where value is determined by the commodity market price. The willingness to pay for land is equal to the two components that are on the right hand side. The first is the market rental price of land which is reduced by the second component, the marginal deficiency payment. The marginal deficiency payment is that component which drives a wedge between the market price for land services, v, and the effective price participants pay, $v - (\bar{p} - p)\bar{y}(1-\theta)$. The marginal deficiency payment, or wedge, reduces the user cost of land, which again violates the Pareto tangency conditions. Therefore, the program still creates production distortions.[3]

The evolution of the deficiency payment schemes over the past several decades has resulted in removing the direct incentive effects of having payments based directly on endogenous yields. Although the current deficiency payment is "decoupled" from production in the sense that there are no endogenous variables within the deficiency payment calculation, it still distorts relative factor (and commodity) prices. The current scheme also provides indirect incentives or opportunities to increase the use of variable inputs by providing additional income which reduces capital constraints and increases the availability of credit. However, the set-aside requirements limit producers' ability to expand land inputs to the same degree as non-land inputs, therefore producers may use more variable inputs per acre.

The yield freeze was intended to be only temporary, for 2 years. The freeze initially had little affect on producers, since program yields always lagged behind expected actual yield (Hertel, Tsigas, and Preckel). However, as the freeze was maintained beyond 2 years, and appeared to become permanent, producer decisions should have become based on market prices. However, if there is any expectation that Congress might lift the ban or that the Secretary of Agriculture might exercise his/her authority to update the payment yields, then the incentive exists for maintaining high yields (Thayer, Zulauf, Schnitke, and Forster). Effective price is determined partially by the target price.

Another possible consequence of the programs are disincentives to adopt rotations. Program payments are linked to the quantity of base acreage a farmer maintains. The consequence of this is a loss of flexibility in cropping decisions (Reichelderfer and Phipps). Planting a different crop on program base acreage, even if it is a part of a rotation, results in the loss of the opportunity to collect future deficiency payments. Rotations are an important measure for breaking pest cycles and providing carryover nitrogen. Failure to rotate could therefore be linked to higher use of purchased chemical inputs.

Previous research has looked for program impacts on chemical use with time series data on aggregate chemical expenditures or aggregate chemical applications. In general, changes in chemical use patterns over time were evaluated in relation to changes in commodity programs. Osteen and Szmedra could not support an argument for the deficiency payment program having an impact on pesticide use with the time-series data available in 1988. However, they argued, based on non-statistical analysis, that target prices apparently have little effect on pesticide use. Carlson reported small but statistically significant increases in pesticide use in corn and cotton due to the 1981 farm program. Richardson found some evidence that acreage restrictions increase pesticide use based on elasticities of substitution believed to apply in the late 1960's. Offutt and Shoemaker, in examining the impacts of technology and policies over time on the share of land in the value of agricultural production, found that set-asides result in an increase in the value share of land and a subsequent increase in use of material inputs.

While the above studies were able to make some assessment on the possible impacts on commodity programs on chemical use, the aggregate data did not allow a direct comparison of participants and nonparticipants, nor for evaluating those resource and technology factors that might also lead to differences in chemical application rates. A great many factors have to be accounted for in explaining chemical expenditures or use over time, including changes in commodity programs, weather, output and input prices, and chemical products on the market. The cross-section data available since

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[3] The introduction of normal flex in the 1990 Farm Bill has not changed the basic result. Normal flex reduces the acre payment rate by the normal flex rate, currently set a 15 percent. The normal flex reduces the marginal deficiency payment by the flex acre rate, i.e., the marginal deficiency payment becomes, $(\bar{p} - p)\bar{y}(1 - \theta - \delta)$, where δ is the flex acre rate.

1990 makes it easier to directly compare program participants and nonparticipants, and virtually reduces the need to control for differences in prices.

In 1991 the loan rate for corn was $1.62, the target price $2.75, and the set-aside requirement 7.5 percent. Average market price over the 1991 crop year was $2.37. In 1992 the loan rate was $1.72, the target price $2.75, and the set-aside requirement 5 percent. Average market price was $2.10. In both years, those who participated in the program received a deficiency payment and had to set aside a portion of their productive land.

Model

If program participants are applying chemicals more intensively than nonparticipants, then this should be revealed by their respective derived demand functions for chemicals. Demand for chemicals for an individual producer can be defined as:

$$X_i = f(w_i, \ldots w_n, p, z_i, \ldots Z_{in})$$

where:

X_i = input use per acre

w_{xi} = input prices

p_y = output price

Z_i = yield-influencing factors related to the resource base and technology.

The latter variables define such resource related factors such as climate, soil quality, and water availability. They also include technology-related factors such as adoption of irrigation technology, use of conservation tillage, and use of soil nutrient testing.

Since cross-section data are being used to estimate the model, prices can be assumed to be the same for all producers. This leaves differences in chemical use to be explained by resource characteristics, technology, and participation in the program.

Data

The data for this analysis come from the 1991 and 1992 Cropping Practices Surveys conducted by NASS and ERS. The Cropping Practices Survey collects data on nutrient and pesticide usage and other related practices on major field crops. The survey does not represent the total U.S. acreage of each crop, but does represent a major portion. A random sample of fields was selected for each crop so that the probability of selecting a particular field was directly proportional to the total acres planted to that crop. Results from the survey can be used to make state-level estimates about each crop. The surveys did not collect financial or production cost data.

For corn, the 17 major corn producing states containing 90 percent of the corn acres planted in 1991 and 1992 were surveyed. Over 5700 useable surveys were obtained in 1991, and over 5600 in 1992. Approximately seventy-percent of the fields surveyed were enrolled in the feed grain program each year.

A simple comparison of participants and nonparticipants revealed some important similarities and differences that tend to support the hypothesis that the participation in commodity programs results in production intensification (Table 1). Note

Table 1. Comparison on Participants and Nonparticipants in the Feedgrain Program

	1991		1992	
	Part.	Non-part.	Part.	Non-Part.
Irrigate (%)	17	4***	17	5***
Use manure (%)	15	22***	13	18***
Nitrogen test (%)	44	32***	46	35***
Rotate (%)	74	78***	76	83***
HEL (%)	24	15***	20	17***
Residue (% cover)	23	19	27	20***
Seeding rate (kernels/acre)	24993	24090***	25344	24268***
Yield (bus/acre)	116	111	146	141**
Own land (%)	44	46***	45	45
Nitrogen rate (lbs/acre)	128.7	115.4***	129.8	116.4***
Herbicide rate (lbs/acre)	2.81	2.68***	2.88	2.74***

***Significant difference at 1 percent level.
**Significant difference at 5 percent level.

Table 2. Nitrogen Application Rate on Corn for Grain by State and Feedgrain Program Participation

	Application Rate (lbs/acre)			
	1991		1992	
State	Participant	Non-part.	Participant	Non-part.
Georgia	135.1	145.6	127.4	156.4***
Illinois	159.6	151.1	157.4	141.2***
Indiana	136.2	127.0	140.4	140.6
Iowa	119.6	109.9	113.9	114.2
Kansas	152.2	93.5***	149.7	111.0***
Kentucky	156.4	113.8***	143.8	134.9
Michigan	126.1	97.5***	123.7	101.7***
Minnesota	110.3	101.8	111.4	97.1***
Missouri	139.2	123.8**	137.0	124.4**
Nebraska	137.2	111.9***	137.8	100.4***
North Carolina	98.1	115.2	146.6	149.9
Ohio	159.3	138.6***	162.3	131.7***
Pennsylvania	81.0	79.3	104.9	67.1***
South Carolina	137.4	146.1	135.6	132.0
South Dakota	64.0	65.4	68.7	69.3
Texas	112.6	53.8***	168.8	111.3***
Wisconsin	90.8	76.7**	97.1	83.7**
US	128.7	115.4***	129.8	116.4***

***Significant at 1 percent level.
**Significant at 5 percent level.

that differences are reported only if statistically different at the 5% level, using either Chi-square or t test. Observations were weighted by the weighting factors provided by NASS.

For both 1991 and 1992 participants were found to apply nitrogen and herbicides at greater rates than nonparticipants. Participants also seeded at a higher rate and used soil nutrient testing more frequently. Fields operated by participants were more likely to be irrigated, and less likely to have manure applied. Fields operated by participants were more likely to be labeled HEL by the SCS. There was no difference in crop yields in 1991, but participants did have significantly higher yields in 1992. Significantly less of the corn acreage operated by participants was in a rotation, although most participants did have corn in a rotation.

The result on HEL supports the findings of Shoemaker that a deficiency payment is a subsidy on land, and thus allows more marginal, less productive land to be put into production, assuming that HEL is a measure of land quality.[4] Acreage control provisions also favor enrollment of marginal land, as the opportunity cost of setting aside a portion of such land is less than for higher yielding land. One would therefore expect participants' land to be of generally poorer quality than nonparticipants'. The higher amounts of crop residue left on fields operated by participants is further indication of the greater erosivity of participants' land.

Nitrogen Use

Nitrogen fertilizer was applied to 96 percent of the corn acreage in the states surveyed in 1991, and to 97 percent of the corn acreage in 1992. Participants applied significantly more nitrogen per acre than non-participants on corn grown for grain (as opposed to seed, silage, or sweet corn) in each year, based on a two-tailed t-test of the difference in mean application rates (Table 2). A state-by-state analysis has a similar result. Only in Georgia in 1992 did non-participants apply significantly more nitrogen than participants.

Regression analysis was used to determine whether program participation was a significant explanatory variable of the derived demand for nitrogen fertilizer. The derived demand function for nitrogen, with prices assumed to be constant across producers, was specified as:

$$\text{RATE} = f(\text{PART, IRR, MAN, TEST, INHIBIT, RESIDUE, ROTATE, TYPE, OWN, HEL, DRY})$$

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[4] HEL is probably a poor measure of soil quality. Soil depth, type, water holding capacity and other physical factors are also important determinant of soil quality, but these data are not available for the Cropping Practices Survey, nor is it possible to link these data with other soils databases.

where:

RATE = nitrogen fertilizer application rate in lbs/acre on corn for grain
PART = dummy variable for participation in the feed grain program
IRR = dummy variable for whether the field was irrigated
MAN = dummy variable for whether manure was applied to the field
TEST = dummy variable for whether a soil nutrient test was conducted
INHIBIT = dummy variable for whether a soil inhibitor was used to increase the efficiency of fertilizer application
RESIDUE = percent of previous crop residue at planting
ROTATE = dummy variable for whether a legume was grown on the field in either of the previous two years
TYPE = dummy variable for maturity length of corn (full or otherwise)
OWN = whether the field was owned by the operator
HEL = whether the field was designated as being highly erodible (soil quality)
DRY = whether the state was affected by dry conditions at planting time.

All variables but DRY were obtained from the cropping practices survey. DRY was based on the Palmer drought index, and was obtained from ERS. Participation, irrigation, HEL, residue, and full season maturity were hypothesized to have a positive influence on application rate. Irrigated agriculture generally uses inputs more intensively, primarily because of higher yields. A field designated HEL has higher erosion and runoff than fields without this designation. Higher runoff and erosion implies greater nutrient losses that must be replaced through fertilizer applications. Higher residue left on the field results in cooler and wetter soil conditions, and higher organic matter content in the soil. These condition result in less nitrogen being available for plant uptake (Duffy and Hanthorn). Full season corn has a longer growing season and therefore requires nitrogen to be present for a longer period of time than shorter season varieties. Higher application rates are required to assure that adequate nitrogen is present throughout the growing season.

Using manure, using a soil test, using soil inhibitors, being an owner-operator, and rotating a legume were expected to have a negative influence on application rate. Animal manure is a substitute for inorganic nitrogen. Those who use manure as a source of nitrogen would require less inorganic fertilizer. Soil tests and use of soil inhibitors can increase the efficiency of nitrogen applications, if properly used. Owner-operators were expected to apply nitrogen more efficiently than non-owner operators. Owner-operators are hypothesized to have a greater level of concern over the long-term impacts of their activities on the local environment, including groundwater, and are therefore quicker to adopt more efficient chemical management practices (Lynne, Shonkwiler, and Rola). Owner-operators might also have more flexibility in making changes to farm management practices than non-owners, who must often get approval from the owner before making management changes.

About 3 percent of the fields surveyed were not treated with nitrogen fertilizer, resulting in a data set that is left censored around 0. The model was therefore estimated as a tobit. Each year was estimated separately because a likelihood ratio test indicated that the data could not be pooled.

A potential problem with any cross-section data set is heteroscedasticity. If left uncorrected, the tobit models would be inefficient and inconsistent (Maddala). Given the specification of the nitrogen model, the only variable for which heteroscedasticity is expected to be a problem is TEST. One would expect that the application rates of those who conduct a soil test would have a smaller variance around the recommendation than those who do not have as good information about soil fertility.

The Goldfeld-Quandt test was used to test the null hypothesis of homoscedasticity (Pindyck and Rubinfeld). The data have a natural break around the variable TEST, which is a dummy variable. The resulting F test could not reject the null hypothesis, so no correction for heteroscedasticity was necessary.

The estimated models are significant at the 1 percent level. A goodness-of-fit test gave values between .09 and .11 (Table 4).[5] These values are

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[5] Goodness of fit measure is sum of squared residuals divided by total

Table 3. Herbicide Application Rate on Corn for Grain by State and Feedgrain Program Participation

	Application Rate (lbs/acre)			
	1991		1992	
State	Participant	Non-part.	Participant	Non-part.
Georgia	1.64	0.62***	1.74	1.39
Illinois	3.23	3.01	3.44	3.37
Indiana	3.21	3.10	3.48	3.28
Iowa	3.13	2.94	3.22	3.17
Kansas	2.07	1.59	1.93	1.79
Kentucky	4.30	3.13***	3.46	2.94**
Michigan	2.92	2.71	3.02	2.63**
Minnesota	2.60	2.91	2.62	2.26**
Missouri	2.92	3.26	2.96	2.81
Nebraska	2.23	1.98	2.18	2.03
North Carolina	2.70	2.43	2.78	2.41
Ohio	3.49	3.13***	3.46	3.05***
Pennsylvania	3.19	2.45***	3.19	2.73
South Carolina	2.49	1.72**	2.70	1.80***
South Dakota	2.14	2.04	2.22	1.77
Texas	1.12	1.01	1.46	1.07
Wisconsin	2.51	2.10**	2.56	2.24**
US	2.81	2.68***	2.88	2.74**

***Significant at 1 percent level.
**Significant at 5 percent level.

low, even for cross-section data. Therefore, emphasis is placed on significant factors and unexpected insignificant variables. Most variables are significant at the 1 percent level and had the expected sign. There was a great deal of consistency between the two years.

One interesting result is that using a soil nitrogen test was associated with *higher* application rates. Three possible reasons for this are that the recommendations based on the test were geared to maximizing yields, that the recommendations were not followed by the farmer, or that farmers had been underapplying nitrogen.

Program participation is positive and significant at the 1 percent level, even after accounting for the other factors. This result suggests that economic conditions created by the program increase fertilizer application rates on corn.

Herbicides

Over 97 percent of fields surveyed were treated with at least one herbicide. Twenty-seven herbicides were found to be used in corn production. An analytic approach similar to the one used for nutrients was carried out to test whether total herbicide application rates are higher for program participants than for nonparticipants.

Nationally, the application rate for participants was statistically greater than for nonparticipants at the 1 percent level in both 1991 and 1992 (table 3). In most states, participants applied herbicides at greater rates than non-participants. Participants applied at statistically greater rates in 6 states in 1991 and 1992 (at the 5 percent level).

A tobit model was specified to determine whether factors other than participation were the reason for the differences in application rates. The following model was estimated:

$$\text{RATE} = f(\text{PART, IRR, CULT, RESIDUE, ROTATE, TYPE, OWN, HEL})$$

where

RATE = total herbicide application for 1992 crop year, in lbs of active ingredient per acre.
PART = dummy variable for participation in feed grain program
IRR = dummy variable for whether field was irrigated
CULT = number of times field was cultivated for weed control

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sum of squares. There is no commonly recognized goodness of fit measure for the tobit.

Table 4. Model Estimation Results

	Nitrogen model		Herbicide model	
	1991	1992	1991	1992
INTERCEPT	115.76***	114.62***	3.04***	3.22***
PART	6.87***	9.93***	0.28***	0.27***
IRR	34.40***	32.61***	−0.38***	−0.60***
MANURE	−23.62***	−21.79***	—	—
TEST	8.10***	7.03***	—	—
INHIBIT	29.25***	19.27***	—	—
RESIDUE	5.97***	0.19	0.51***	0.15***
ROTATE	−4.09***	−5.60***	−0.02	−0.10**
TYPE	3.27***	13.48***	0.07***	−0.18**
OWN	−3.78***	−6.93***	−0.20***	−0.19***
HEL	5.42***	−1.99	0.15***	0.10***
DRY	−26.91***	18.87***	−0.94***	0.22***
CULT	—	—	−0.55***	−0.45***
Fit	0.09	0.11	0.14	0.11

Nitrogen and herbicide models estimated as a tobit.
***Significant at 1 percent level.
**Significant at 5 percent level.

RESIDUE = percent of previous crop residue at planting
ROTATE = dummy variable for whether any crop other than corn was grown in either of the previous two years
HEL = whether the field was designated as being highly erodible (soil quality)
OWN = whether the field was owned by the operator
TYPE = dummy variable for early or medium versus full season corn.

Participation, having an HEL designation, amount residue, and having full season corn are hypothesized to have positive effects on application rate. Assuming that the HEL designation is a proxy for soil quality, higher herbicide application rates are required to assure that expected yields are achieved. Leaving crop residue on fields increases soil moisture and reduces the number of cultivations, thus requiring greater reliance on herbicides to control weeds.

Rotations, ownership, irrigation, and cultivation were hypothesized to have negative effects on application rate. Rotating crops with other crops breaks pest cycles, thus reducing the amount of pesticides required. Applying herbicides in irrigation water increases efficiency, thereby minimizing the amounts required. Cultivation is a mechanical means of weed control that is a substitute for chemical controls.

The estimated models were significant at the 1 percent level, with goodness-of-fit measures ranging between .12 and .14 (Table 4) Most variables were significant at the 1 percent level, and most variables had the expected sign.

Participation had the expected positive effect on herbicide application rates and was significant at the 1 percent level in each year. Holding everything else constant, participants applied more herbicides per-acre than non-participants.

Conclusions

Commodity programs, in this case the feed grain program, appear to provide sufficient economic incentives to producers to apply more nitrogen fertilizer and herbicides than non-participants. Even after taking into account prices (by using cross-section data) and all the technology/resource variables available on the cropping practices survey, participants were found to apply both nitrogen fertilizer and herbicides at higher rates than non-participants, indicating a greater intensity of production. However, the exact cause or causes for this apparent intensification of production cannot be determined from the data. The higher application rates could be caused directly by the substitution of chemicals for land as a consequence of program set-aside requirements. While it is reasonable to assume that producers react to the market price because of the freeze on program yields, it is possible that an expectation that the freeze will be lifted or that program yields will be adjusted are incentives to maintain and officially record higher yields. A better understanding of the substitution between land and chemical inputs is needed in order to predict how set-aside requirements affect the use of chemical inputs.

The results indicate that those who rotate apply less chemicals, and program participants rotate less frequently than nonparticipants. Even though most program participants do rotate corn (over 70%), the fact that nonparticipants use rotations to an even greater degree could be a factor in the observed differences in chemical use. Planting flexibility options introduced in 1990, and likely to be continued or expanded in 1995, could reduce this effect over time. However, producer response has been poor to date (ERS).

Finally, the differences in application rates between participants and nonparticipants have a bearing on the debates leading up to the 1995 Farm Bill. We have shown that, for corn, the feedgrain program increases per-acre application rates of agricultural chemicals. Participants applied about 10 percent more nitrogen per acre and 5 percent more herbicides per acre than nonparticipants. One would expect to find similar results for the other program crops. Higher application rates could contribute to water quality and other environmental problems. However, the set-aside requirements may be offsetting these higher use rates. With set-aside rates between 5 percent and 7.5 percent, the total use of chemicals by corn producers in the feedgrain program may not be much different than if they were not in the program.

Any changes to the commodity programs that might be contemplated for the 1995 Farm Bill would have to be carefully examined for impacts on chemical use. Relaxing set-aside requirements, *ceteris paribus*, would certainly increase total chemical use, increasing the potential for environmental problems. Unfreezing or updating program yields would increase per-acre use, to the extent that producers have not already made some adjustments in anticipation of such a move. Eliminating the current program and moving towards a market-based system, supplemented with "green" payments or some other form of revenue assurance, would probably decrease per-acre application rates. However, the impact on total chemical use would depend on whether crop acreage increases or decreases. In the case of herbicides, where the difference in application rates between program participants and nonparticipants is relatively small, it is the changes in crop acreage which would be of the greatest interest.

All these potential impacts have important implications for the conservation portion of the Farm Bill, and for USDA's conservation programs in general. The environmental problems that would need to be addressed, the recommended farm management practices, and the appropriate incentive mechanisms for getting farmers to adopt improved management practices would all have to be reexamined if the structure of commodity programs is greatly altered.

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