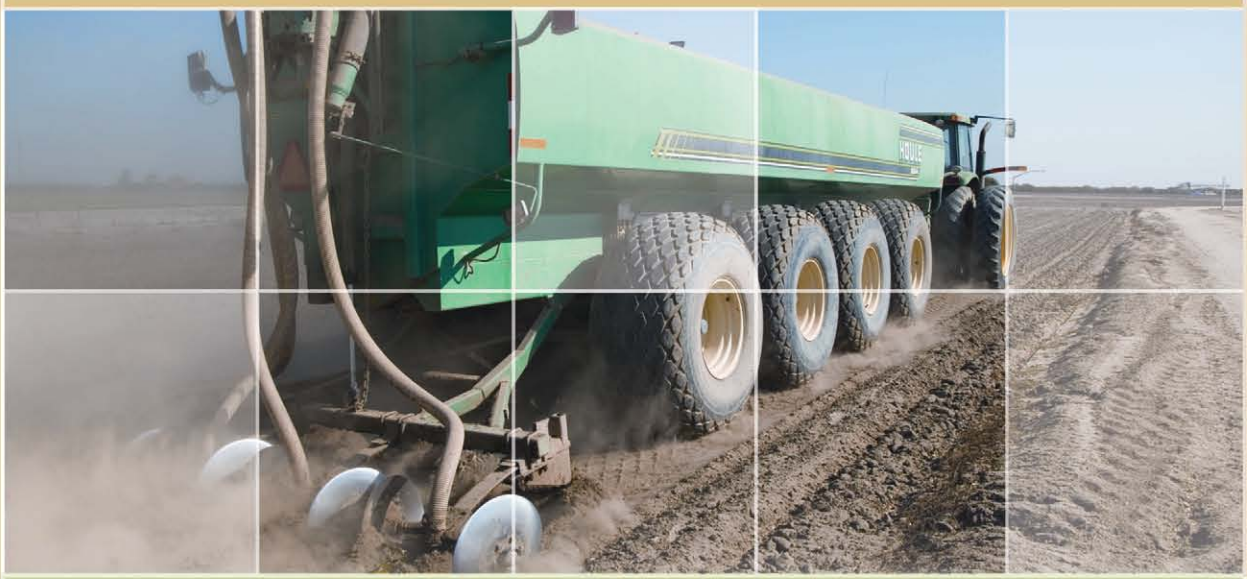
United States Department of Agriculture
Economic Research Service

Nitrogen Management on U.S. Corn Acres, 2001-10

Marc Ribaudo
Michael Livingston
James Williamson

ECONOMIC BRIEF NUMBER 20 • November 2012



Nitrogen is a critical input in agriculture, enabling farmers to produce high crop yields profitably. However, nitrogen compounds released into the environment can also be a source of environmental problems, including eutrophication and hypoxia in aquatic ecosystems, visibility-impairing haze, and the loss of biodiversity.

Improved nitrogen management on cropland has been a longstanding goal of USDA conservation policy. Technical and financial assistance through programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program has promoted best management practices like applying nitrogen at agronomic rates or injecting it directly into the soil. For some sectors, such as large animal feeding operations, and in some States, nutrient management planning is mandatory.

Despite such regulatory measures and government assistance, a large share of cropland does not follow nitrogen best management practices: in 2006, 65 percent of cropland (producing eight major field crops) did not follow what are considered to be nitrogen best management practices (Ribaudo et al., 2011). USDA's Natural Resources Conservation Service (NRCS) found that improvements in at least one aspect of nitrogen management (see box, "Criteria for Good Nitrogen Management") were needed on 86 percent of cropland rotations in the Upper Mississippi Basin, 87 percent of cropland rotations in the Chesapeake Bay watershed, 82 percent of cropland rotations in the Great Lakes watershed, and 93 percent of cropland rotations in the Ohio-Tennessee Basin (USDA, NRCS, 2010, 2011a, 2011b, 2011c). Failling to apply best management practices increaases the risk that excess nitrogen can move from the field to water resources or the atmosphere.

Criteria for Good Nitrogen Management

The basic practices for improving nitrogen use efficiency are agronomic application rate, appropriate timing of applications, and proper application method (USDA, NRCS, 2006):

- ***Rate***. Applying no more nitrogen (commercial and manure) than 40 percent more than that removed with the crop at harvest, based on the stated yield goal, including any carryover from the previous crop. This agronomic rate accounts for unavoidable environmental losses that prevent some of the nitrogen that is applied from actually reaching crops.
- ***Timing***. Not applying nitrogen in the fall for a crop planted in the spring.
- ***Method***. Injecting (placing fertilizer directly into the soil) or incorporating (applying to the surface and then discing the fertilizer into the soil) nitrogen rather than broadcasting on the surface without incorporation.

Trends in Nitrogen Management

Farmers adjust the management of their crops for a variety of reasons. As input or output prices change, farmers' motivation to conserve nitrogen fertilizer may change too. Other factors—such as conservation program benefits, yield or revenue risk, and environmental regulations (ongoing or anticipated)—also affect the level of nitrogen management observed on U.S. farms. An examination of nitrogen management on U.S. corn acres in 2001-10 indicates that farmers might be adjusting to changing economic conditions.

Corn is the most widely planted crop in the United States and the largest user of nitrogen in terms of application rates per acre, total acres treated, and total applications. Over 97 percent of planted corn acres receive nitrogen (commercial and manure). Data from the Agricultural Resource Management Survey (ARMS) indicate that corn acreage treated with nitrogen increased 18 percent between 2001 and 2010, as farmers planted more corn in response to higher prices.

During 2001-10, corn acres with nitrogen applied above agronomic rates declined from 41 percent to 31 percent (table 1). This more efficient use of nitrogen is consistent with findings that application rates per unit of output have been declining in recent years (Turner et al., 2007). However, similar improvements in nitrogen management were not observed for application timing or application method (table 1). While limiting application rates is probably the most important factor in terms of reducing environmental impacts, inappropriate application methods or timing still increases the risk of nitrogen losses to the environment. Overall, corn acres meeting all three management criteria increased from 28 percent to 34 percent between 2001 and 2010. Despite the increase in corn acres receiving nitrogen, the total number of corn acres not meeting the three criteria declined by almost 10 percent between 2001 and 2010.

Higher nitrogen prices are likely a factor in the reduction in corn acres receiving excess application. Nitrogen fertilizer prices nearly doubled from 2000 to 2008 (fig. 1). By 2005, nearly one in four farmers indicated that they had reduced application rates in response to higher prices (table 2). In contrast, the price of nitrogen and the nitrogen/corn price ratio have fallen since 2008, making nitrogen fertilizer cheaper to use. By 2010, fewer farmers (relative to 2005) indicated that they reduced application rates or were more carefully managing nitrogen. Lower nitrogen prices relative to crop prices could perpetuate this trend.

Observed changes in nitrogen management vary, depending on whether nitrogen comes from synthetic fertilizer or animal waste. Corn acreage receiving only commercial fertilizer dropped from 84 to 82 percent between 2005 and 2010, while corn acreage receiving manure increased from 16 to 18 percent. Between 2005 and 2010, management improved for farms using only commercial fertilizer: the share of corn acres not meeting the rate/timing/method criteria declined from 65 percent to 60 percent (table 3). However, no improvement in nitrogen management was observed on corn acres that received manure as a source of nitrogen. On farms where manure is produced and used as a nitrogen source, an increase in nitrogen fertilizer prices typically results in a substitution of manure nitrogen for commercial fertilizer

Recommended citation format for this publication:

Ribaudo, Marc, Michael Livingston, and James Williamson. *Nitrogen Management on U.S. Corn Acres, 2001-10*, EB-20. U.S. Dept. of Agriculture, Economic Research Service, November 2012.

Table 1

Nitrogen use on corn: nitrogen-treated acres and the share of treated acres that did not meet the rate, timing, or method criteria[1], by region, 2001, 2005, and 2010

Region	Treated acres			Did not meet rate		
	2001	2005	2010	2001	2005	2010
	1,000			*Percent of treated acres*		
Appalachia	1,925	2,118	2,433	52	66	56
Corn Belt	35,087	39,145	41,100	46	38	30
Lake States	12,965	13,958	14,488	46	34	29
Mountain	1,243	1,018	1,361	18	14	29
Northeast	2,696	2,477	2,559	42	32	53
Northern Plains	16,962	18,293	21,677	27	28	29
Southeast	280	286	311	39	50	62
Southern Plains	1,708	2,109	2,510	31	32	28
Total	72,868	79,404	86,439	41	35	31

Region	Did not meet timing			Did not meet method			Did not meet rate, timing, and method criteria		
	2001	2005	2010	2001	2005	2010	2001	2005	2010
	Percent of treated acres								
Appalachia	12	16	7	56	78	47	82	90	75
Corn Belt	41	41	44	39	34	37	77	70	68
Lake States	37	41	41	36	30	34	77	67	67
Mountain	9	20	20	33	50	26	48	62	53
Northeast	39	40	35	54	53	72	70	74	89
Northern Plains	10	15	19	36	45	39	56	67	63
Southeast	27	29	17	41	55	57	78	77	78
Southern Plains	45	38	23	33	18	19	70	74	46
Total	32	34	35	38	37	38	72	70	66

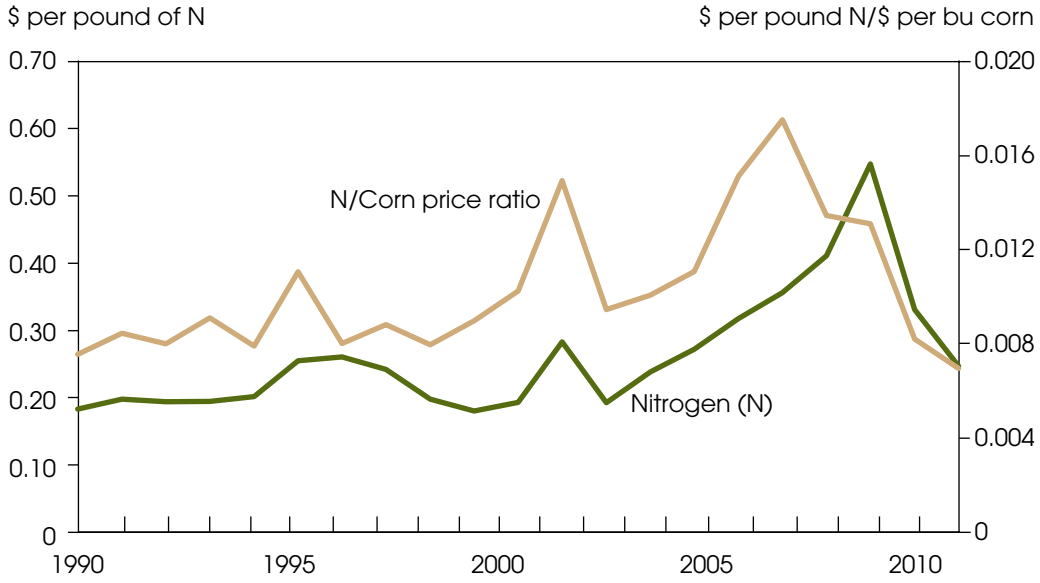
Source: USDA, Economic Research Service, using data from USDA's Agricultural Resource Management Survey (2001, 2005, 2010), Phase II.
[1]Rate, timing, and method criteria are met when nitrogen is applied at an agronomic rate, not applied in the fall, and injected or incorporated into the soil.

(Ribaudo et al., 2011). This substitution effect is likely the reason that nitrogen management did not improve on farms using manure, since most farms using manure also produced it. The share of farmers indicating that they substitute manure for commercial fertilizer in response to higher fertilizer prices increased between 2001 and 2010 (table 2), as did the percentage of corn acres receiving manure.

An increase in cropland receiving manure—which is generally more difficult to manage than commercial fertilizer—may heighten the need for improved nutrient management. A shift to manure in response to higher commercial fertilizer prices could lead to a greater demand for assistance from conservation programs, and greater scrutiny from resource management agencies dealing with nitrogen-related environmental issues.

Figure 1

U.S. April nominal prices of fertilizer nutrients and nitrogen/corn price ratio



Source: ERS and USDA National Agricultural Statistics Service, Agricultural Prices; and USDA, World Agricultural Outlook Board, World Supply and Demand.

Table 2

Reported changes in commercial nitrogen fertilizer management on corn due to price

	2001	2005	2010
Farmer reported actions		*Percent*	
Reduced nitrogen application rate	11	24*	14#
By how much	21	17*	28#
Increased manure	2	3*	5#
Changed the type of N	2	5*	6#
Managed N more carefully	8	21*	16#

Source: 2001, 2005, and 2010 ARMS, Phase II, Cost of Production Practices and Costs Report.
Notes: Data are weighted and the standard errors are calculated using the jackknife delete-a-group method.
* 2005 means are statistically different from 2001 at the 1% level.
# 2010 means are statistically different from 2005 and 2001 at the 1% level.

Table 3

Share of treated corn acres that did not meet the rate, timing, and method criteria, by nitrogen (N) source, 2005 and 2010

		Acres treated with commercial N only		Acres treated with commercial and manure N		Acres treated with manure N only	
Year	Acres treated with N (1,000)	Percent of all treated acres	Percent not meeting criteria	Percent of all treated acres	Percent not meeting criteria	Percent of all treated acres	Percent not meeting criteria
2005	79,404	84	65	14	96	2	91
2010	86,439	82	60	15	96	3	92

Source: USDA, Economic Research Service using data from the USDA's Agricultural Resource Management Survey (2005, 2010), Phase II.

Conclusions

Between 2001 and 2010, the share of corn acres meeting an application rate criterion increased, suggesting that corn producers are applying less excess nitrogen. A combination of higher fertilizer prices, heightened awareness, and concerns over environmental quality may all be contributing to this trend. Similar improvements have not been shown in application method and application timing, most likely because of perceived costs of changing management. Despite improvements in nitrogen application rates, about 66 percent of corn acreage does not achieve the rate, timing, and method criteria that minimize environmental losses of nitrogen. As a result, improved nitrogen management on cropland continues to be a major conservation policy goal.

Surveyed corn acres receiving manure did not show any improvement in nitrogen management between 2001 and 2010. Since 92 percent of corn acres receiving manure do not meet the rate, timing, and method criteria, a continued policy focus on improved manure management may be warranted, especially if higher commercial fertilizer prices increase the use of manure as a source of nutrients.

References

Ribaudo, M., J. Delgado, L. Hansen, M. Livingston, R. Mosheim, and J. Williamson. 2011. *Nitrogen in Agricultural Systems: Implications for Conservation Policy*. Economic Research Report 127, U.S. Department of Agriculture, Economic Research Service.

Turner, R.E., N.N. Rabalais, D. Scavia, and G.F. McIsaac. 2007. "Corn Belt Landscapes and Hypoxia of the Gulf of Mexico," in J.I. Nassauer, M.V. Santelmann, and D. Scavia (eds.), *From the Corn Belt to the Gulf: Societal and Environmental Implication of Alternative Agricultural Futures*, Resources for the Future.

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA, NRCS). 2006. "Natural Resources Conservation Service Conservation Practice Standard: Nutrient Management," *National Handbook of Conservation Practice*.

USDA, NRCS. 2010. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Upper Mississippi River Basin*.

USDA, NRCS. 2011a. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Great Lakes Regions*.

USDA, NRCS. 2011b. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Chesapeake Bay*.

USDA, NRCS. 2011c. *Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Ohio-Tennessee River Basin*.

Photo credit: USDA/NRCS