Are Midwest Corn Farmers Over-Applying Fertilizer N?

By C.S. Snyder

U.S. corn yield (Zea mays L.) and fertilizer N consumption data are briefly reviewed, and selected Land Grant university research-based recommended N rates for corn in the U.S. are compared with public data on actual N rates used by farmers in leading corn-producing states to determine if farmers may currently be over-applying N. Contrary to popular belief, U.S. corn farmers in leading corn-producing states do not appear to be applying N at rates in excess of profit-maximizing university recommendations.

Federal and state agencies have reported increased groundwater nitrate contamination and eutrophication of lake, stream, river and coastal water resources by agricultural nutrients that escape our fields and farms (Dubrovsky et al., 2010; EPA, 2012a). Resource areas in the U.S. like the Chesapeake Bay watershed, the Mississippi River Basin watershed and the northern Gulf of Mexico have garnered considerable political and nutrient loss mitigation attention during the last two decades. The effects of N_2O emissions derived from soil management activities (which include fertilizer N use) have also been a key issue in climate change and global warming policy discussions during the last decade (EPA, 2012b; Grassini and Casman, 2012).

In the U.S., corn is often the target of environmental impact policies, perhaps because it is the crop that accounts for the largest fraction (37 to 51%) of total fertilizer N consumed annually (**Figure 1**). Although Grassini and Cassman (2012) showed that high yield and high input-use efficiencies, together with low greenhouse gas (GHG) emissions per unit of crop output (GHG intensity), are not conflicting goals in well-managed commercial-scale production fields, there is a growing fear that increases in corn acreage and fertilizer N consumption will automatically exacerbate these environmental resource challenges.

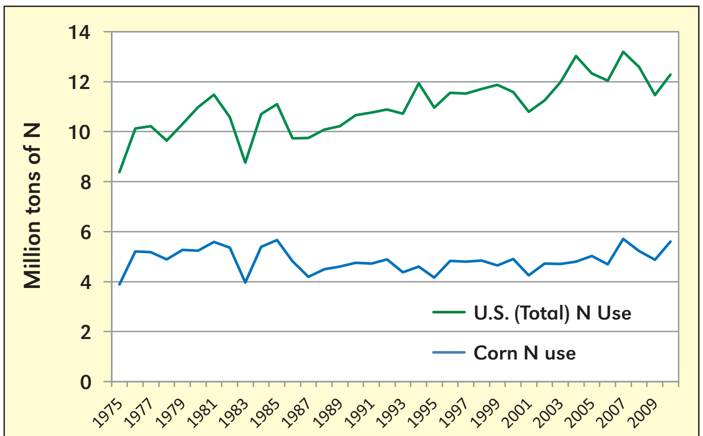

Figure 1. U.S. total fertilizer N consumption, and N used on corn. Sources: AAPFCO, TFI; http://www.ers.usda.gov/data/fertilizeruse

Modern corn production systems may take up more than 200 lbs of N/A (grain + above-ground plant residue) in achieving yields above 200 to 225 bu/A (12 to 14 t/ha). At harvest, approximately 0.7 lbs of N are removed per bushel of grain (0.0125 kg N/kg of grain). Much of the public often assumes that farmers commonly over-apply fertilizer N as they hedge their N management rates against a perceived risk of insufficient N (Millar et al., 2010). Research has shown that roughly 40 to 60% of the N applied to corn is taken up by the crop in its growing season. Much of the remaining N is stored on soil exchange sites and in soil organic matter, while a similar to smaller fraction is subject to potential environmental losses (i.e. volatilization of NH_3, NO_3^- leaching/runoff, N_2O emissions during nitrification and denitrification, and N_2 cycling back to the atmosphere during denitrification).

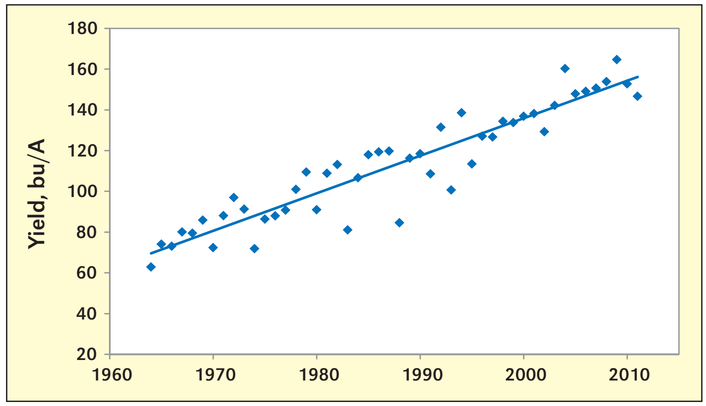

Figure 2. Yield trend of U.S. corn. Source: USDA NASS

Corn yields in the U.S. have trended steadily upward since 1975 (**Figure 2**), which has concurrently resulted in increased removal of N in the harvested grain. Fertilizer N rates applied to corn rose until the mid-1980s, declined and then rose again to approach rates used in the mid-1980s (**Figure 3**).

There has been a perception (*misperception*), which may be based in part on older reports, that N rates used by farmers on corn in the U.S. were generally higher than Land Grant University research-based recommendations (Yadav et al., 1997; Trachtenberg and Ogg, 1994).

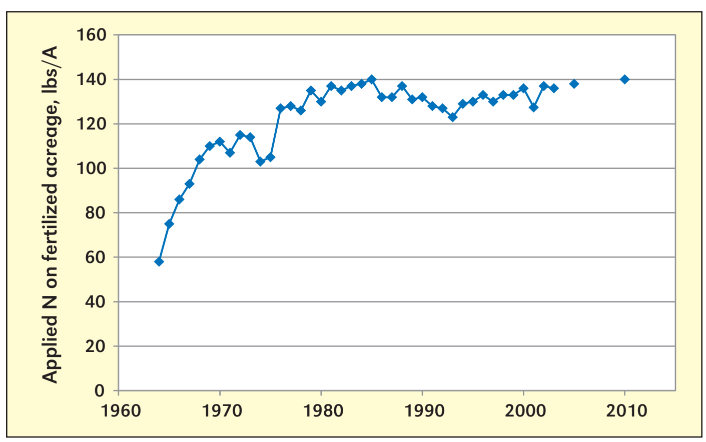

Figure 3. Fertilizer N applied to corn acres receiving fertilizer. Source: http://www.ers.usda.gov/data/fertilizeruse

Common abbreviations and notes: N = nitrogen; N_2O = nitrous oxide; NH_3 = ammonia; NO_3^- = nitrate; N_2 = nitrogen gas; $ = U.S. dollar.

To evaluate more current U.S. corn system N rate management, we used publicly available USDA survey data (Agricultural Resource Management Survey and Agrichemical Usage Data) on N rates applied to corn in 2000, 2005, and 2010 and compared them with the N rates recommended via the 'Corn Nitrogen Rate Calculator' (CNRC, 2012) to achieve profit maximization, or the maximum economic return to N (MRTN) for the same years. The MRTN data were from seven leading corn-producing states (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin) that have submitted their N rate field response data to the 'Corn Nitrogen Rate Calculator' website maintained by Iowa State University. Data for anhydrous NH_3 prices paid by farmers between March and April 2000, 2005, and 2010 ($227, $416, and $499/ton or $0.14, $0.25, and $0.30/lb of N, respectively) and average corn prices received by farmers between August to October in the same years ($1.69. $1.82, $4.02/bu, respectively), were used as input data for the 'Corn Nitrogen Rate Calculator'. The MRTN calculation for corn following soybean, excluding nonresponsive site data, was chosen, as opposed to corn following corn for the purposes of this article. Corn N fertilization needs are usually less when corn follows forage legumes or soybean than when corn follows corn (CNRC, 2012).

The results of these N rate comparisons for leading corn-producing states in the U.S. are shown in **Table 1**. Averaged within and across years, USDA survey data and agricultural statistics indicate that farmers applied N for corn in these states at rates that were frequently lower than the MRTN rates (see last three columns in Table 1) prescribed by some of the leading Land Grant Universities in 2000, 2005, and 2010.

Clearly, much of the current focus on "excess N rates" and calls for nutrient use reductions by Midwest U.S. farmers may be misplaced. Robertson and Vitousek (2009) recognized that appropriate crop N management is not all about N rate and stated, "Mismatched timing of N availability with crop need is probably the single greatest contributor to excess N loss in annual cropping systems."

Based on the results in this brief article and other published reports, more emphasis should be placed on all 4Rs of Nutrient Stewardship: right source at the right rate, right time, and right place; to achieve more sustainable crop production, improved nutrient use efficiency, and environmental resource protection. BC

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Table 1. Rates for maximum return to N as prescribed by the 'Corn Nitrogen Rate Calculator' compared with USDA survey data on N rates actually applied by farmers in 2000, 2005, and 2010 in the respective states.

	N rate prescribed by 'Corn Nitrogen Rate Calculator' for MRTN[1]			USDA-surveyed state fertilizer N rate on corn acres receiving N			Difference (surveyed state rate minus MRTN)		
State (region of state)	2000	2005	2010	2000	2005	2010	2000	2005	2010
	lbs of N/A								
Iowa	139	122	143	131	141	142	-8	19	-1
Illinois (north)	150	134	155						
Illionis (central)	174	155	180	161	146	167	-13	-9	-13
Illinois (south)	179	158	186						
Indiana (west and northwest)	171	158	175	153	147	178	-18	-11	3
Indiana (east and central)	207	193	210						
Indiana (remainder)	181	162	187						
Michigan	135	124	139	110	128	122	-25	4	-17
Minnesota	113	103	120	114	139	125	1	36	5
Ohio	181	161	188	162	161	141	-19	0	-47
Wisconsin (VH/HYP soils)	125	107	130	133	138	92	8	31	-38
Wisconsin (M/LYP soils)	98	94	105						
Wisconsin (irrigated sands)	209	200	209						
Wisconsin (nonirrig. sands)	130	124	130						
Ave. of white colored rows	**148**	**133**	**154**	**138**	**143**	**138**	**-11**	**10**	**-15**

[1]MRTN is maximum return to N, using the 'Corn Nitrogen Rate Calculator' found at: http://extension.agron.iastate.edu/soilfertility/nrate.aspx