RESEARCH FOCUS

By Amir Sadeghpour, Karl Czymmek, and Quirine Ketterings

Nitrous oxide emissions in corn are related to nitrogen inputs

Dairy consumers are increasingly interested in sustainable and healthy products. The dairy industry's challenge is to meet this interest by decreasing the environmental footprint, such as greenhouse gas (GHG) emissions, while remaining profitable. This becomes even more challenging as world population increases and the global market demand for dairy products continues to grow. The main GHGs of concern for dairy, and all agriculture, are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). GHGs are characterized by their "global warming potential" (GWP), a measure of how much heat each gas can trap over a 100 year period relative to CO_2. The GWP of CO_2 is 1, the GWP of CH_4 is 24, and the GWP of N_2O is 298, which makes N_2O a gas of particular interest for agriculture. On a GWP weighted basis, N_2O emissions is estimated to represent 44% of the annual GHG emissions from US agriculture, and this is primarily driven by soil and fertilizer management. Thus, finding management practices that reduce N_2O emission related to corn production can help reduce GHG emissions from dairy farming.

Managing for, and achieving high yields, reduces emissions on a per bushel basis.

We quantified how much N_2O per bushel of corn was produced after corn was grown with two rates each of liquid dairy manure and semi-composted dairy solids (the separated solids were piled and aged, but not routinely mixed), as well as N fertilizer treatments. The main question was: How do the fertility sources compare in terms of corn yield and N_2O emissions?

In 2014, we measured N_2O emissions in an experiment that had a prior history of five years of silage corn (2001-2005), five years of alfalfa/grass (2006-2010) and three years grain corn. Manure, compost, and fertilizer nitrogen (N) were applied during the corn but not the alfalfa years. Treatments were spring applied liquid dairy manure, surface applied at 17,000 gallons/acre (designed to meet N needs with a surface application of manure), and 10,000 gallons per acre incorporated immediately (designed to meet N needs and approximately match P removal); separated dairy solids at 40 tons (designed to meet N needs) and 15 tons (designed to meet P removal) per acre. Fertilizer N plots with no manure or compost history had a small rate of starter N and then were sidedressed with either 0 or 100 pounds N per acre. The fertilizer N plots received 25 lbs N-P_2O_5-K_2O per acre as banded starter fertilizer while 10 lbs N-P_2O_5-K_2O per acre were banded in organic fertility treatments. Nitrous oxide was measured on 32 dates in 2014 on days when highest emissions were expected (right after rainfall). To assess N_2O-N emission per unit of corn yield, we divided N_2O-N emission (lbs N_2O-N/acre/yr) by corn grain yield (bu/acre). Also, each lb of N_2O-N captured was divided by estimate lbs of N available to the crop, based on applications and source, to estimate N losses from emissions for each fertility source.

Nitrous oxide emission per bushel of corn

Evaluating N_2O emission per bushel of corn yield can be a helpful way to determine which fertility source produces the least N_2O per bushel of corn. At this site, the crop in 2014 was modest, where corn yields ranged from 124 bu/acre (zero N control) to 159 bu/acre (high rate of manure and inorganic N fertilizer), slightly exceeding the statewide corn grain yield average (148 bu/acre). N_2O emissions are normal and unavoidable in corn production, regardless of inputs. All treatments generated N_2O emissions, regardless of yield, N source and management. However, N_2O emissions (and also yield) increased at the higher N input levels. For example, the zero N control and lower

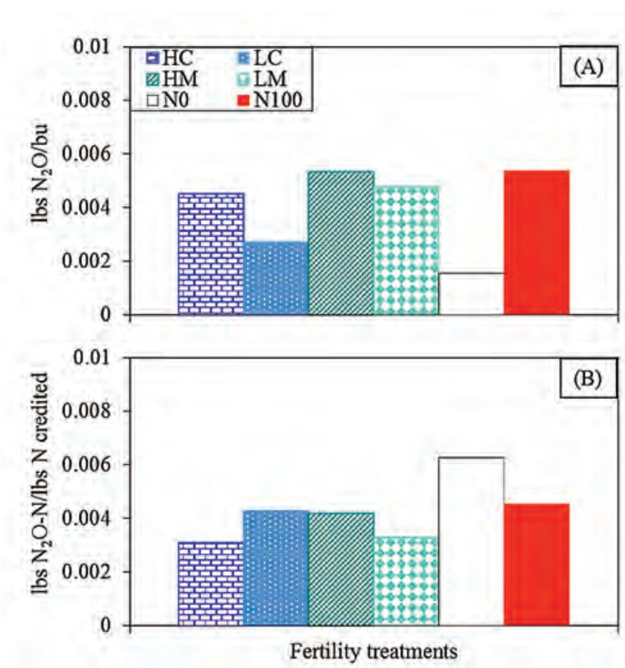

Fig. 1. Soil N_2O-N emission per bushel of corn (A) and N_2O-N emission per lbs of N credited (B) for two rates of liquid dairy manure, separated dairy solids, and fertilizer N in the 2014 growing season.

rate of compost treatments showed lower N_2O emission per bushel of corn (Fig. 1A), whereas the highest N_2O emission per bushel of corn was found in the highest rate of manure and optimum N rate (100 lbs sidedress N/acre) (Fig. 1A). Every farmer knows that corn must have adequate N to produce good yields and it will be necessary to explain this to consumers. Since N_2O emissions increase as N inputs increase, it will be increasingly important for all corn producers to hone in on optimal N rates so that the highest corn yield can be obtained without creating any more N_2O emission than necessary.

Nitrous oxide emission per pounds of N credited

While we targeted expected peaks of emissions for measurement, literature indicates emissions taper quickly as free water drains from the soil, so the majority of total emissions should have been captured. When lower fertility levels were used, and lower yields resulted, the N_2O-N emissions per pound of N credited to the crop were actually higher (Fig. 1B). This indicates lower efficiency of use of the applied N, and also a result to avoid if possible. No matter the N fertilization rate, the N_2O-N emission losses we measured are agronomically small (Fig. 1B) and represent a very small fraction of the applied N: less than 5 to 10 lbs/acre. This means that N_2O-N emissions from corn production is not much of an economic issue for farms. However, with tens of millions of acres of corn produced annually in the US, the small emissions per acre can play a big role in contributing to GHG emissions, and are starting to get increasing attention in some circles. For farm managers, honing N management practices has always been good advice, and managing GHG emissions is one more reason to continue to do so. ❐

__Amir Sadeghpour__ (as3289@cornell.edu) is a Post Doctoral Associate in the Cornell University Department of Animal Science. __Karl Czymmek__ (kjc12@cornell.edu) is a Senior Extension Associate with Cornell PRO-DAIRY. __Quirine Ketterings__ (qmk2@cornell.edu) is a Professor in the Cornell University Department of Animal Science.

Transition cow management characteristics in Northeast dairy herds

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present on each visit for the respective periods. Feeding frequency increased from the dry period to the lactating period (Table 1). Feed was pushed-up more frequently per day during the lactating period than the dry period (far-off: 7.2 ± 4.8×, close-up: 8.1 ± 4.2×, fresh: 8.4 ± 4.5×, high: 8.6 ± 4.6×). It was also more common to find dry cow pens with feed bunk walls (far-off visit: 15.6%, close-up visit: 16.5% of pens) than lactating pens (fresh visit: 8.1%, high visit: 4.2% of pens).

These results demonstrate the variability in current management practices and health related outcomes in large, progressive dairies in the Northeast and can be used for comparison and advisement purposes. Analysis is ongoing to identify associations that exist between these management factors and cow performance, including milk production, reproductive performance outcomes, health and culling, and energy metabolism and blood biomarkers. ❐

Table 1. Densities for stocking, water space, and feed bunk space, based on number of cows present on each visit in 72 herds (mean ± SD) and feeding frequency/day.

Item	Visit			
	Far-off (n pens)	Close-up (n pens)	Fresh (n pens)	High (n pens)
Stocking density (cows / stall), %	94.4 ± 21.4 (100)	92.7 ± 34.9 (79)	100.3 ± 22.5 (93)	116.6 ± 18.5 (211)
Bedded pack density, m2/cow	9.1 ± 7.1 (7)	12.3 ± 6.6 (17)	6.0 ± 5.5 (93)	–
Linear Water Space, cm/cow	6.7 ± 4.4 (107)	9.1 ± 6.2 (96)	10.3 ± 6.2 (98)	7.5 ± 3.0 (211)
Overall bunk density (cows/headlock spaces[1]), %	123.3 ± 41.4 (107)	96.4 ± 42.5 (96)	117.9 ± 37.2 (98)	153.0 ± 36.0 (211)
Feeding Frequency/day				
1×	91.7%	93.8%	68.7%	57.5%
2×	6.4%	5.2%	28.3%	35.1%
3×	-	-	-	1.4%
4×	-	-	3.0%	3.3%
Other	1.8%	1.0%	-	2.8%

[1] Headlock spaces = (length of neck rail (cm) / 60.96 cm) or 1 headlock (1 headlock = 60.96 cm of neck rail space)

__Allison Lawton__ is a Dairy Research Specialist and Ph.D. student.

__Buzz Burhans__ is a consultant with Dairy-Tech group and PRO-DAIRY. __Daryl Nydam__ is a Professor in the College of Veterinary Medicine at Cornell University. __Thomas Overton__ is a Professor in the College of Agriculture and Life Sciences at Cornell University and Director of PRO-DAIRY.