MANURE ON PERENNIAL FORAGES: BENEFITS AND CHALLENGES

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Introduction

Why apply manure on alfalfa and other perennial forage crops? There are several benefits, but also some concerns or challenges to be considered.

Alfalfa and other forages have a large nutrient need – potassium, phosphorus, sulfur, micronutrients, and for grass forages, nitrogen. Manure is a good source of these nutrients and can produce yield increases if nutrients are deficient. Application of manure to forage crops increases the acreage base, which may be important to meet nutrient management plan requirements and avoid over application of P. And applying manure after harvest during the growing season opens up windows of time for manure application not available with most annual crops. While alfalfa and other legumes don't benefit from nitrogen in manure, applied N reduces the amount of symbiotic N fixation, helping to buffer N availability and reducing the risk of nitrate leaching due to N application from manure. And the deep rooting pattern of alfalfa can capture nitrate that leached beneath the root zone other crops from excessive manure or fertilizer N application. (See Russelle and Jokela, 2013, for more detail.)

There are also some challenges or limitations associated with manure application on forages – smothering and leaf coating, soil compaction and crown damage from wheel traffic, pathogens and feed contamination, surface runoff of nutrients, and odor and ammonia emission. Most of these concerns are associated with broadcast application after harvest and will be discussed in a later section.

There are three general manure application strategies or times of application: preplant (before forage seeding), following last harvest at termination of the stand, and after harvest during the season.

Manure Application before Seeding

Before planting is a good time to apply manure, especially on medium- to fine-textured soils deficient in P and/or K, so that the manure can be incorporated. Manure applied at this time must be thoroughly mixed with the soil to avoid seedling damage from manure-seed contact.

Research has shown yield benefits from preplant application. Liquid dairy manure was applied before seeding of alfalfa at three sites in Minnesota (Rosemount and Waseca) and Wisconsin (Marshfield) (Kelling and Schmitt, 2003). Seeding year yields were greater or equal to those from the treatment with P and K fertilizer and the no-fertilizer control at two of the sites. At the Waseca location manure did not increase yields because of severe compaction with the large equipment. During the first full production year yields from manure were greater than both control and fertilizer treatments at all sites. The yield benefit from manure compared to that from P and K fertilizer was attributed to some combination of other nutrients (e.g., S, B), soil physical and/or microbial effects, and possibly N in the seeding year.

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Application before Stand Termination or Plowdown

Manure application after the last harvest just before termination of alfalfa or other perennial forage is a favored time of manure application because it avoids any potential damage to the forage stand and provides N for the following crop (e.g., corn). However, N mineralization after alfalfa termination often meets or exceeds the need of the following crop, resulting in high levels of soil N and increased risk of nitrate leaching. The extent of this phenomenon depends on soil texture, the characteristics of the manure and how much is applied, as well as the density and quality of legume in the forage crop. A summary of research results from 61 sites in Iowa, Wisconsin, Minnesota, and Pennsylvania showed only seven sites showed any corn yield response to fertilizer N the first year following alfalfa plowdown (Kelling and Schmitt, 2003). A comprehensive review of recent research in Minnesota, as well as many other published results (Yost et al., 2015: 259 trials total) also concluded that first-year corn after alfalfa is not likely to respond to N application on medium textured soils, but the response depends on specific factors such as length of alfalfa stand and early season soil conditions.

Topdress Application after Harvest during the Season

Surface broadcast is the dominant method of manure application for alfalfa and other perennial forages in North America. The wide spreading pattern of broadcast application reduces wheel traffic over the field and increases the speed of application. Broadcast slurry can also increase yields of forages, especially grasses. Much of the research on manure application on grass forages has been done in Europe, where most of the forage production is grasses, but there has been some work done in North America.

Research in the Upper Midwest (MN, WI, IA) showed grass forage yield increases of 150% or more from broadcast manure compared to a no N control (Schmitt et., 1999). In research from Vermont (Carter et al., 2010) and British Columbia (Bittman et al., 2007) liquid dairy manure increased grass yields 90 to 100%, approximately equal to that from fertilizer N

Application of liquid manure on established stands of alfalfa has had mixed results, showing yields with topdressed slurry increasing, decreasing, or having no effect in research in Minnesota and Wisconsin (Kelling and Schmitt, 2003; Coblentz et al., 2014), Italy (Ceotto and Spallacci, 2006), and Maryland (Min et al., 1999). Probably the most comprehensive study was one in Ontario, in which liquid dairy manure was band-applied using drop-hoses with fan nozzles twice annually to 49 alfalfa cultivars at 4500 gal/acre for three years (Bowley et al., 2009). Average alfalfa yields were increased 14% with manure compared to the no-manure control, with some cultivars showing much larger yield responses to manure than others.

While topdress application of manure may increase forage yields and provide other benefits, there are a number of challenges or concerns associated with broadcast application after harvest. Excessive manure rates can cause smothering and coating of plants that can result in leaf scorching and clogging of pores. Wheel traffic from loaded spreaders can damage crowns and compact soil, especially under wet soil conditions. This can sometimes result in stand loss and yield decline. Manure often contains pathogens, so there is a risk of feed contamination and aerial or runoff transport. Odor from broadcast application is a nuisance issue that may affect neighbors in the vicinity of manured fields. Ammonia emission can represent a significant economic loss for grass forage production, and is a growing environmental concern because of potential adverse effects on air quality, specifically fine particulate formation, and re-deposition onto nitrogen-sensitive water or land areas. And transport of nutrients via surface runoff can contribute to eutrophication of lakes and streams, especially with late fall and winter applications. While these are very real concerns, their impact can be minimized by careful management, including use of alternative methods of application, since most of these are the most serious with surface broadcast application.

Alternatives to Broadcast Application

Concerns about odor, gaseous emissions, feed contamination, smothering of plants, and runoff of nutrients and pathogens from broadcast manure have led to development of alternative application methods. These include shallow injection, surface banding above the canopy, banding on the soil surface with drag-shoe or trailing-foot, and band application with tine aeration. These methods can reduce the potential for pathogen contamination and plant damage from smothering or leaf burn because manure is applied in narrow bands directly into the soil or on the soil surface, often underneath crop canopy, thereby limiting direct contact of foliage with manure. Other possible benefits are reduced odor, nutrient runoff, and gaseous emissions. These benefits need to be balanced against the potential for stand or yield loss from soil disturbance and mechanical damage to plants.

Grass forage yields in British Columbia were increased by an average of 7% by banding dairy slurry with a drag-shoe compared to broadcast application, but were increased even more by banding manure with tine aeration (Bittman et al., 2005). Banded manure/tine aeration also reduced ammonia emission by almost 50% and runoff N and P loss by 50 to 90% (Bittman et al., 2005; van Vliet, 2006). Band application of liquid dairy manure in Vermont reduced ammonia emission by 27 to 46% (depending on rate) and increased yields in two of four site-years compared to broadcast application (Pfluke et al., 2011; Carter et al., 2010).

There has been only limited research with alternative application methods on alfalfa. The research from Ontario discussed earlier (Bowley et al., 2009) that showed a 14% yield increase from surface-banded dairy slurry compared to a no-manure control, showed only a 10% yield increase from banded manure following tine-aeration. The authors suggested that this may have been the result of increased manure-root contact by infiltration of manure into the aerator slots. In another study in Saskatchewan (PAMI, 2001) injection of manure increased alfalfa yields on a low fertility site but decreased yields on a high fertility site due to stand damage, suggesting that the yield effect depended on the balance between yield response to manure nutrients and mechanical damage from injection.

Manure Application Methods for Alfalfa: Ongoing Wisconsin Research[2]

We have completed 2 years of a 3-year study evaluating different methods for applying liquid dairy manure on alfalfa at the Marshfield Agricultural Research Station. The following treatments were applied to an established alfalfa site on a Withee silt loam (somewhat poorly drained, 1 to 3% slope): a) control (no manure; fertilizer based on need); b) broadcast liquid dairy manure; c) surface banded manure; d) aerator/banded

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manure (AerWay SSD); and e) shallow injection (Yetter Avenger) (see Fig. 1). Manure was applied annually after first (2015) or second (2014) harvest with an 1800-gallon research model spreader (Nuhn Industries, Ltd.; Sebringville, ON, Canada) with a quick-attach feature that allows changing of implements for different application treatments. Fifteen 24 x 42 ft plots were arranged in a randomized complete block design with three replicates. Target manure application rate was 4000 to 5000 gal/acre, but a flow meter equipment failure in 2014 resulted in an excessive rate that year (approximately 10,000 gal/acre).

Figure 1. Aerator/banded manure (Aerway SSD; left) and shallow injection (Yetter Avenger; right) application implements.

Alfalfa yields for individual harvests ranged from 1 to 1.5 ton/acre for third cut to over 3 ton/acre for first harvest with no significant yield differences in most cases (Table 1). There were no significant treatment effects on yields in the first harvest after the Aug 7, 2014, manure application, nor on the next harvest in June of 2015. This would suggest that there was little or no damage to the stand due to manure or mechanical effects of application equipment (despite the high application rate); neither was there a yield benefit from manure nutrients. However, yield from shallow injection was significantly lower than most other treatments in the first harvest (22 July) following the 2015 manure application. But the yield effect had disappeared by the next harvest in August.

Ammonia emission was greatly reduced (95% or more) by shallow injection compared to other manure application methods. Emission of N_2O, a potent greenhouse gas, was increased by manure application, that increase limited primarily to a few-week period following application. Treatment effects were somewhat variable, but in 2015 N_2O emission was significantly greater from the injection and aerator-band treatments.

In summary, preliminary results from the first 2 years of this study show minimal effects of manure application on yield compared to the no-manure control (optimum or higher soil test P and K); however, there was some indication of a short-term (one harvest) decrease in yield from the injection treatment. Injection greatly decreased ammonia emission, but there may be a trade-off with increased greenhouse gas (N_2O) emission.

Table 1. Alfalfa yield (DM basis) for individual harvests in 2014 and 2015. Manure treatments were applied after second harvest in 2014 (Aug 7) and after first harvest in 2015 (June 30).

	2014			2015		
Treatment	Jun 24	Aug 5	Sep 8	Jun 25	Jul 22	Aug 25
	ton/acre					
Control	2.89	2.03 c†	1.44	2.85	1.85 a	0.96
Broadcast	3.13	2.36 ab	1.39	2.93	1.84 a	1.00
Surface band	3.07	2.23 b	1.10	2.86	1.82 a	0.95
Aerator/band	3.10	2.46 a	1.46	3.03	1.76 ab	0.83
Shallow inject	3.14	2.29 ab	1.47	3.05	1.63 b	1.00
CV	6	4	5	7	5	25
P value	NS	0.01	NS	NS	0.06	NS

† In each column, least square means followed by the same letter are not statistically different at p-value=0.05.

Conclusion

There are potential benefits of applying manure on perennial forages, in particular, increasing acreage for manure application and more flexibility in timing. Yields may be increased, especially for grass forages and on sites in need of nutrients, but yields may be unaffected or even decreased in some cases. The potential advantages of manure application on forages need to be considered in the context of some concerns – plant damage from manure or wheel traffic, nutrient runoff, excessive N at stand termination, and others. Most of these risks can be minimized by careful management, for example by spreading soon after harvest, avoiding traffic on wet soils, and avoiding application at stand termination if the N credit from the forage is adequate for the next crop. Several innovative liquid manure application methods offer additional options to improve N utilization, minimize forage contamination, decrease nutrient runoff, and provide more uniform manure application. To a large extent, however, the success of manure application on alfalfa depends on the specific conditions at the site and good decision-making by the manager.

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