Applying Manure to Alfalfa

Pros, Cons and Recommendations for Three Application Strategies

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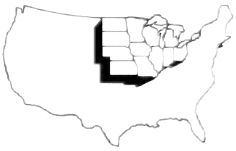

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K.A. Kelling and M.A. Schmitt[1]

It's becoming increasingly common for livestock producers to apply manure to alfalfa. This shift comes partly as a response to increased regulatory pressure designed to promote nutrient management planning. In the face of concern about pollution of groundwater and surface water due to runoff from row crops, farmers are searching for alternative crops on which to spread manure. In addition, many livestock producers simply don't have enough corn acres to accommodate all of their manure when spreading at proper agronomic rates.

Applying manure to alfalfa has several potential environmental, agronomic and management advantages. It allows more scheduling flexibility: a producer who applies manure to alfalfa has substantial cropland available for spreading throughout the summer months. It's good for the crop: alfalfa requires relatively high rates of nutrients and can benefit from the secondary and micronutrients as well as the nitrogen, phosphorus and potassium (NPK) contained in manure. Finally, alfalfa does an excellent job of recycling nitrogen (N) from the soil. Given the choice, alfalfa will take most of the nitrogen it needs from the soil (60–75 lb. N / ton of dry matter), rather than symbiotically fixing nitrogen from the atmosphere. Furthermore, alfalfa's deep root system can extract mobile nutrients (nitrogen, sulfur, and boron) at greater depths than corn.

To take advantage of these potential benefits of manure for alfalfa, producers need to think carefully about application timing. There are basically three strategies for successfully applying manure to alfalfa: 1) apply it immediately prior to alfalfa seeding; 2) topdress it on established alfalfa; and 3) apply it after the last alfalfa harvest and prior to preparing the land for a grain crop. Each of these choices offers some unique potential benefits and associated risks.

Strategy A: Applying Manure Before Establishing Alfalfa

Applying manure on land to be seeded to alfalfa is a relatively new approach. It wasn't recommended in the past because of potential inefficiencies in the use of the nitrogen provided by the manure.

Effect on Alfalfa Yields

Several recent studies have examined the usefulness of applying manure before establishing forage legumes (see selected reference list). Table 1 shows the results from Minnesota and Wisconsin studies where manure was broadcast and incorporated at three rates before the alfalfa stand was established. For comparison, commercial fertilizer was applied to other plots at rates equivalent to the phosphorus and potassium contained in the manure. A third set of plots received no added nutrients to serve as a control.

At Rosemount, adding manure resulted in significant increases in harvested forage yields over the controls. These increases tended to be larger than the increases associated with the comparable fertilizer treatments. This difference may be due to (1) the nitrogen applied with the manure; (2) the other "extra" nutrients such as

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sulfur and micronutrients applied with the manure; (3) the soil conditioning benefits associated with manure; (4) the stimulation of soil organisms, or (5) the slightly higher amounts of nutrients provided by manure compared to fertilizer. Similar results were seen in the Marshfield, Wisconsin experiments.

At Waseca, a site with low soil-test levels (Bray P_1 = 8 ppm, K = 94 ppm), the manure did not increase yields although increasing fertilizer rates did. The combination of applied manure and the large application equipment created a severe compaction problem. Almost no alfalfa grew in the wheel tracks.

At all locations, yields tended to be higher in the first full hay year where the preplant manure was applied compared to untreated controls. While the fertilizer treatments provided some benefit, especially at the low soil-testing Waseca site, the manure treatments provided a greater response.

Effect on Weed Competition

In the Waseca experiments, weediness was increased by addition of either manure or fertilizer, but it was most severe at the high rates of manure. Other researchers have reported increased weed competitiveness from nitrogen applications, although sometimes the enhanced weed growth was partly offset by additional alfalfa growth. The Wisconsin experiments also showed that adding manure or nitrogen-containing fertilizer enhanced weed growth, but this effect did not persist past the seeding year. Similarly, weed competition was not significantly different between treatments at Waseca after the first cutting. The additional weed seeds or stimulation of weeds caused by manure is the major agronomic problem associated with pre-seeding applications. Growers must be prepared to handle the extra weed pressure with herbicides or timely clipping.

Table 1. Effect of preplant manure or fertilizer applications on seeding-year alfalfa yields.

	Alfalfa Yield					
	Minnesota†			Wisconsin‡		
Treatment	Rosemount 1989	Rosemount 1990	Waseca 1989	1988	1989	1990
	tons dry matter / acre					
Control	1.62	1.01	1.36	0.88	1.61	2.68
Manure						
3000 GPA	1.79	1.58	1.45	- -	- -	- -
6000 GPA	1.96	1.89	1.24	- -	- -	- -
12000 GPA	1.62	2.05	1.30	1.16	2.07	3.26
18000 GPA	- -	- -	- -	1.07	1.91	3.31
24000 GPA	- -	- -	- -	1.20	2.30	3.45
Fertilizer						
Low	1.60	1.22	1.48	0.98	1.79	2.46
Medium	1.70	1.36	1.51	1.25	2.10	2.86
High	1.76	1.59	1.58	- -	- -	- -
Pr > F	0.01	0.00	0.00	0.05	0.00	0.02

† Adapted from Schmitt et al. (1993). Fertilizer treatments were equivalent amounts of P and K only. Manure at Rosemount contained 77+5+32 lb N, P, and K per 1000 gallons in 1989 and 33+7+25 in 1990; Waseca manure contained 36+6+19. ‡ Adapted from Peters (1991). Fertilizer treatments at Marshfield were equivalent to the low rate of manure without and with N, respectively. Manure contained 24+5+20, 27+6+30, and 26+4+21 lb / gallons of N, P, and K in 1988, 1989, and 1990, respectively.

Tissue Nutrient Accumulations

The accumulation of potassium (K) in the forage from repeated manure applications and subsequent luxury consumption of potassium might be a factor that limits the rate at which manure can be applied to alfalfa fields. In the Wisconsin study, alfalfa tissue levels exceeded 4.5 percent potassium for the first cutting in the establishment year where 540 lb K_2O / acre was applied with the high manure rate. In the production years, concentrations generally remained above 3.5 percent potassium. Feeding forages containing more than about 2.75 percent potassium may cause ration balance problems with respect to divalent cations such as magnesium and calcium, especially in dry cows and springing heifers. Since manure applications at typical rates may supply several hundred pounds of K_2O, this nutrient is often oversupplied. For example, the 12,000-gal / acre rate used in both the Minnesota and Wisconsin studies added about 360 and 270 lbs. K_2O / acre, respectively. The problem may be even more evident when manure is applied repeatedly to meet the nitrogen needs of crops.

Ability to Recycle Nitrogen

When plant-available nitrogen is present in the soil, alfalfa will mostly use the available nitrogen rather than expend energy to fix atmospheric nitrogen. Researchers have directly measured a decrease in alfalfa nitrogen fixation following topdressing with manure. Several studies have concluded that alfalfa has significant value as a nitrate "recycler" where excess soil nitrate has accumulated.

Alfalfa has the ability to extract and remove significant amounts of nitrogen from the soil. Research has shown that where manure had been previously applied at very high rates, alfalfa can remove accumulated nitrate to a depth of 12 feet by its second year of growth and the amount of nitrogen taken up is directly proportional to yield. The Minnesota studies demonstrate this recycling ability: seeding-year nitrogen removals ranged from 109 to 269 lb N / acre and production-year removals were from 254 to 357 lb. N / acre.

Although the Minnesota studies were not able to account for all of the manure-applied nitrogen, the authors do not believe significant nitrate leaching occurred in this system because soil samples taken periodically throughout the experiment showed no differences between the control and the manure treatments at the 3-foot depth. Appreciable amounts of nitrogen from the manure may have been immobilized, denitrified or volatilized after application. These data suggest that significant amounts of manure nitrogen may be applied to alfalfa without risk to the environment.

Management Suggestions

Producers who opt to apply manure prior to establishing a new alfalfa stand are likely to have better success if they follow these suggestions:

1. Avoid direct manure / seed contact. Make sure that broadcast manure is completely mixed into the soil and that injected manure is then secondarily tilled.
2. Do not apply more than 75 tons / acre of solid dairy manure or 20,000 gallons / acre of liquid dairy manure. Other types of manure containing higher salt and ammonia levels should be restricted more severely. Research has shown that both agronomic and environmental problems can be avoided at these levels.
3. Consider removing any companion crop as chopped forage as the manure-applied nitrogen may create a lodging problem.
4. On soils with a relatively high leaching potential (sands and loamy sands) apply manure within 3 to 4 weeks of seeding. On less leachable soils, manure may be applied in the fall before a spring alfalfa seeding. At high rates of application (above 40 tons / acre dairy manure equivalent) apply at least 6 weeks before seeding to minimize salt-induced germination problems.

Strategy B: Topdressing Manure on Established Alfalfa

Producers sometimes topdress manure onto established alfalfa because these are the only fields available during the growing season. Although several studies have shown that manure can be successfully topdressed on established alfalfa, this practice increases the risk of injuring plants, reducing stands and causing nutrient runoff. The potential for alfalfa injury arises from the salts in the manure (including free ammonia), soil compaction and physical damage to the crowns during application.

Crop Responses

A Wisconsin study with liquid dairy manure (Table 2) shows that although preplant manure application improved yields, subsequent manure topdressings decreased yields. The apparent recovery of yields for the topdressed plots in 1983 was due to increased weed growth. The wheel track areas from repeated applications were particularly affected. Crown counts confirmed that there was less alfalfa in the topdressed plots.

Topdressing manure has provided some yield benefits in other situations. Data from Minnesota showed yields were up to 30 percent higher where manure was topdressed than in control plots; however, bare spots were apparent in plots where manure was topdressed at high rates. Timing of the topdress applications may influence crop performance. In two separate studies where manure was topdressed in the winter on frozen soil, the topdressed plots tended to show better yields than did the untreated control plots.

Nutrient Runoff

When manure is applied in the late fall or winter, alfalfa's vegetative cover can significantly increase nutrient losses from fields that receive manure. A west-central Minnesota study showed that topdressing manure on alfalfa fields may constitute more of a pollution hazard than spreading manure on plowed corn ground (Table 3). Results varied somewhat between years, but it is clear that total nitrogen, total phosphorus and soluble phosphorus losses averaged about 10 times higher from the manured alfalfa than from the manured corn.

A southwest Wisconsin study used small runoff plots to examine the nitrogen and phosphorus losses from winter-applied fertilizer and manure in runoff water from fallow soils or alfalfa sod. The runoff water from fallow areas contained a lower concentration of nutrients compared to that from vegetated areas. These findings suggest that vegetation prevents waste components from coming in contact with the soil, thereby increasing the likelihood of being lost in the spring runoff.

Clearly, the major risk is associated with surface-applied manure to frozen soils. On unfrozen soil, simulated rainfall studies show that surface-applied manure does not appear to greatly increase the pollution potential of runoff from alfalfa fields. Several studies have observed that runoff carried much larger nutrient loads where

Table 2. Effect of preplant or topdressed liquid dairy manure on alfalfa yields.†

	Alfalfa Yield			
	Without topdress		With topdress ‡	
Preplant manure rate	1982	1983	1982	1983
gallons / acre	tons dry matter / acre			
0	3.32	5.19	- -	- -
5000	3.84	5.07	3.01	5.30
10000	3.86	5.40	3.09	5.35
20000	3.96	5.65	3.15	4.96

† Manitowoc County; data from S.R. Hendrickson (personal communication).
‡ Topdressed after each cutting at 1200 gallons / acre.

Table 3. Effect of manure on soil, and water and nutrient loss from spring snowmelt (3-year average). †

Treatment	Soil loss	Runoff	*Nutrient losses* Total N	Total N	Soluble P
	lb / acre	inch	---------- lb / acre ----------		
		Corn			
Check	38	2.6	1.0	0.1	0.09
Fall manure, plowed under	36	0.6	0.6	0.3	0.12
Fall manure on frozen soil	0	0.5	1.5	0.5	0.30
Spring manure on snow	0	0.5	1.8	0.2	0.09
		Alfalfa			
Check	0	3.4	2.4	0.1	0.09
Fall manure on frozen soil	0	2.8	18.5	5.4	3.32
Spring manure on snow	0	1.4	13.2	2.4	0.95

† Adapted from Young and Mutchler (1976).

manure was applied to alfalfa during winter than when it was applied during fall.

These experiments emphasize that under some conditions, especially where manure is topdressed on steeply sloping, frozen soil, runoff losses of manure nutrients may be unacceptably large. The magnitude of this environmental risk must be determined on a site-by-site basis.

Management Considerations

To minimize possible alfalfa injury or environmental problems from topdress manure applications, producers should follow these suggestions.

1. Apply to older stands. With a younger stand of alfalfa, any injury caused by manure applications will more severely affect subsequent cuttings. Because the yield and quality of younger stands also tends to be higher, application to older stands reduces the risk.

2. Apply to poorer stands. Thinner stands generally have more grasses or weeds contributing to yields. Grasses and weeds tolerate topdressed manure better than alfalfa does. Grasses and weeds will also directly benefit from the nitrogen in manure. Applying manure to thin alfalfa stands may increase forage production, but it may cause further loss of the alfalfa stand.

3. Apply where nutrients are needed. Although topdressed manure applications may cause some alfalfa injury on nutrient-poor soils, the overall effect is for better production because the response to the nutrients more than offsets the injury caused.

4. Don't apply more than 3000-5000 gallons of liquid or about 10 tons of solid dairy manure per acre in a single application. Higher salt manures (specifically swine manure from finishing houses) should be reduced proportionally. The primary issue for most producers is the maximum application rate that does not cause stand injury or environmental problems. Specific manure characteristics need to be considered because the burn potential of the manure is a function of ammonium nitrogen and salt content.

5. Apply manure as soon as possible after harvest. The longer the manure application is delayed after cutting, the more the alfalfa regrowth and the greater the burn potential, as new leaves are most sensitive.

6. Adjust manure equipment to provide a uniform application. The distribution from the

outlet port must be uniform for liquid manure, and clumps of solid manure must be eliminated from solid manure equipment.

7. Pay attention to the condition of the soil. Driving over fields with moist or wet soil increases the risk of compaction injury on crowns. Where possible, apply manure when cooler temperatures and post-application rainfall will reduce burn potential.

Strategy C: Applying Manure Immediately Before Plowdown

Historically, the most common way to apply manure on alfalfa was to spread it immediately before rotating the field to a grain crop. This approach has several advantages. Alfalfa injury is no longer a concern. It's easy to apply manure on untilled, smooth fields. The labor is available in late summer before corn harvest, and there is a wide time window to get the manure applied.

There is also a downside: this approach carries a high probability of loading the field with more nitrogen than is needed for the following crop. When you add up the nitrogen contributed by the alfalfa and the manure, and then add in the nitrogen from any fertilizer applied, the total amount of available nitrogen may exceed recommendations. Research in several states has found little, if any, response to additional nitrogen following alfalfa (Table 4). It may turn out that the environmental costs of this management strategy are simply too high.

Management Considerations

1. Limit manure rate to the amount of nitrogen required by the following crop after accounting for the nitrogen contributed by the alfalfa (the legume credit).

2. Apply only to the very poorest hay fields where alfalfa top growth has been removed. Both the stand density and amount of top growth present when the stand is killed affect the legume credit. This credit is smallest in poor stands with little regrowth.

3. Apply to fields immediately before tillage or topdress prior to secondary tillage to reduce the risk of direct manure runoff losses.

4. Use the pre-sidedress nitrogen test before applying any nitrogen fertilizer. This test has been particularly useful in confirming the amount of available nitrogen from manure and legumes.

Table 4. Summary of corn grain responses to fertilizer N following alfalfa.

	Sites		
State	Total	Responsive	Optimum N rate
			lb / acre
Iowa (Morris et al., 1993)	29	6	25
Wisconsin (Bundy and Andraski, 1993)	24	0	0
Minnesota (Schmitt and Randall, 1994)	5	1	42
Pennsylvania (Fox and Piekielek, 1988)	3	0	0

Summary

Preplant manure applications generally can have a positive effect on seedling-year alfalfa dry matter production where weeds are adequately controlled. This response may also be carried over into the full production years. The exact cause for these responses is not completely clear, but may include seedling-year nitrogen responses, secondary or micronutrient benefits and/or improvements in soil physical and biological condition. Although manure may increase certain seedling-year weed problems these usually do not persist past the first cutting. Repeated manure applications at high rates may increase forage potassium to unacceptably high levels.

Topdressing manure to established alfalfa is somewhat more risky. While benefits can be obtained, especially on low-testing soils or on legume-grass mixtures, problems from compaction, salt burn and stand suffocation can occur. Alfalfa can be a major sink for recycling nitrogen and other nutrients; however, topdress applications, especially to frozen soils, may result in large nutrient runoff losses. Various management practices including using low rates on the poorest stands immediately after cutting will help reduce the agronomic and environmental risks associated with following this strategy.

Applying at the end of the alfalfa rotation may leave more nitrogen than the following crop can use. This can lead to large, unacceptable environmental risks from nitrate leaching. A producer who takes this approach must consider the nitrogen contributed from both the legume and the manure. Removing all of the alfalfa top growth before application and limiting manure rates by taking into account the alfalfa nitrogen credit is essential.

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