Considerations When Applying Manure to Alfalfa

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

Manure application to alfalfa is a management option that is increasingly being considered by livestock producers. Increased regulatory pressure due to nutrient management planning, and concerns with ground and surface water pollution are prompting producers to look at alternative crops for manure applications. While corn may be the most efficient crop to use all manure's nutrients, many producers do not have enough corn acres to properly apply agronomic rates of manure.

Applying manure to alfalfa has several potential environmental, agronomic and management advantages. Alfalfa provides a significant amount of available cropland for spreading manure throughout the summer months. Agronomically, alfalfa removes/requires relatively high rates of nutrients and can benefit from the secondary and micronutrients as well as the macronutrients in manure. Environmentally, alfalfa will preferentially use available N, up to 300 lbs. N/acre/year, rather than symbiotically-fixing N, and because of its deep root system, can extract mobile nutrients (N, S, and B) at greater depths than corn.

To take advantage of these potential benefits of manure for alfalfa, producers will need to consider several factors in evaluating manure application practices in relation to the time when it is applied. Manure application strategies can generally be categorized by the time in the rotation when it is applied: 1) immediately prior to alfalfa seeding; 2) top-dressed to established alfalfa that will be harvested; and 3) following the last alfalfa harvest in preparation for the grain crop. Any of these choices result in some unique potential benefits and associated risks.

Strategy A: Apply Manure Before Alfalfa Establishment

Pre-plant manure application onto land to be seeded to alfalfa is a relatively new approach for fertilizing alfalfa. Past recommendations generally did not consider this option because of potential inefficiencies in use of the manure-N.

Effect on Alfalfa Yields

Several recently completed studies have examined the usefulness of pre-establishment manure applications to 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 prior to the establishment of alfalfa. Commercial fertilizer treatments applied at rates equivalent to the P and K contained in the manure also provided a basis for comparison. In both site-years at Rosemount the addition of manure resulted in significant increases in harvested forage yields over the controls, and 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 S and micronutrients applied with the manure; (3) the soil conditioning benefits associated with manure applications, or (4) the slightly higher amounts nutrients applied with manure compared to fertilizer. Similar results were seen in the Marshfield, Wisconsin experiments.

At Waseca, although increasing fertilizer rates increased yield on this low testing site (Bray P_1 = 8 ppm; K = 94 ppm), the manure did not increase yields. The combination of manure additions and the large application equipment created a severe compaction problem. This resulted in almost no alfalfa in the wheel tracks.

At all locations, there was also a tendency for higher yields in the first full hay year where the pre-plant 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, Minnesota experiments, weediness was increased by addition of either manure or fertilizer, but was most severe at the high rates of manure. Other researchers have reported increased weed competitiveness from N applications, although sometimes the enhanced weed growth was partly offset by additional alfalfa growth. The Wisconsin experiments also showed that weed growth was enhanced by addition of manure or N-containing fertilizer; however, this effect did not persist past the seeding year. Agronomically, the additional weed seeds and/or manure caused stimulation of weeds is the major problem associated with pre-seeding applications. Growers must be prepared to handle the extra weed pressure with herbicides or timely clipping.

Tissue Nutrient Accumulations

The accumulation of K in the forage from repeated manure applications and subsequent luxury consumption of K may be a factor that limits manure rates to alfalfa fields. Alfalfa tissue levels in the Wisconsin study exceeded 4.5% K for the first cutting in the establishment year where 540 lbs. K_2O/acre was applied with the high manure rate. In the production years, concentrations generally remained above 3.5% K. Forages containing more than about 2.75% K may cause ration balance problems with respect to divalent cations such as magnesium and, to a lesser extent, 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 over-supplied. For example, the 12,000 gal/acre rate used in both the Minnesota and Wisconsin studies added about 360 and 270 K_2O/acre, respectively. The problem may be even more evident when manure is applied repeatedly to meet the N needs of crops.

Ability to Recycle Nitrogen

Alfalfa has the ability to extract and remove significant amounts of N 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 N taken up is directly proportional to yield. The Minnesota studies provide an example of this recycling ability where seeding-year N removals ranged from 109 to 269 lbs. N/acre and production-year removals were from 254 to 357 lbs. N/acre.

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

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

Management Considerations

Some management issues must be addressed if pre-seeding manure applications are to be successful. Following the suggestions listed below will improve your experience with making applications at this point in the rotation.

1. Avoid direct manure/seed contact by making sure that broadcast manure is completely mixed into the soil, or that injected manure is secondarily tilled.
2. Limit rates to not more than about 75 tons/acre of solid dairy manure or 20,000 gallons/acre of liquid dairy manure. Other types of manure containing higher salt 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 a chopped forage as the manure-applied N may create a lodging problem.
4. Apply manure within 3 to 4 weeks of seeding the forage on soils that have a relatively high leaching potential (sands, loamy sands), whereas manure may be applied in the fall before a spring alfalfa seeding on less leachable soils. At high rates of application (> 40 tons/acre dairy manure equivalent) application at least 6 weeks prior to seeding will minimize salt-induced germination problems.

Strategy B: Top-dress Manure onto Established Alfalfa

Top-dress applications of manure onto established alfalfa are sometimes made because these are the only fields available during the growing season. Although several studies have shown that top-dressed manure can be successfully applied to established alfalfa, this practice is considered risky due to possible plant injury, stand reduction, or nutrient runoff. The potential for alfalfa injury arises from the salts contained in the manure, including free ammonia, soil compaction, and from the physical damage to the crowns during application.

Crop Responses

A Wisconsin study with liquid dairy manure (Table 2) shows that although pre-plant manure application improved yields, subsequent top-dressed manure application decreased yields. The apparent recovery of yields for the top-dressed 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 top-dressed plots.

In other situations, topdressing manure has provided some yield benefits. For example, data from Minnesota showed yield increases up to 30% over the control from top-dress applications, but bare spots were apparent in the high rate top-dressed plots. Timing of the top-dress applications may influence the subsequent crop performance. In two separate studies where manure was top-dressed in the winter on frozen soil, there was a tendency for yield improvements where manure was added compared to the untreated control.

Nutrient Runoff

The effect of alfalfa's vegetative cover on runoff losses from fields that receive manure can be significant. As shown by a west central Minnesota study, topdressing manure on alfalfa fields may constitute more of a pollution hazard than spreading manure on plowed corn ground (Table 3). Some variation existed between years, but total N, total P and soluble P 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 N and P losses from winter-applied fertilizer and manure in runoff water from fallow soils or alfalfa sod. The concentration of nutrients in the runoff water was lower for fallow areas compared to vegetated areas. This suggested that although runoff volume is usually much less for vegetated soil compared to bare soil, vegetation prevents waste components from encountering the soil, thereby increasing the likelihood of then being lost in the spring runoff.

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

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

Management Considerations

Because of possible alfalfa injury or environmental problems from top-dress manure applications, the management suggestions provided below should be followed to minimize potential problems.

1. Apply to older stands. With a younger stand of alfalfa, any injury caused by manure applications will more severely affect subsequent cuttings. Since the production level and the quality of younger stands are also generally higher than for older stands, application to older stands reduces the risk.
2. Apply to poorer stands. Less dense stands generally have more grasses and/or weeds contributing to yields. Grasses/weeds are more tolerant to top-dressed manure applications than alfalfa. Grasses/weeds will also directly benefit from the N in manure. Thus, with thin alfalfa stands, manure applications may increase forage production, but it may be at further loss of the alfalfa stand.
3. Apply where nutrients are needed. On low testing soils, although top-dressed manure applications may cause some alfalfa injury, the overall effect is for better production because the response to the nutrients more than offsets the injury caused.
4. Limit rates to not more than 3000-5000 gallons of liquid or about 10 tons of solid dairy manure per acre in a single application. Higher salt manures, i.e., 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. The specific characteristics of the manure in question needs to be considered since the burn potential of the manure is a function of ammonium N and salt content.
5. Apply manure as soon as possible after harvest because as top-dressed manure applications are delayed, more alfalfa regrowth will be present and the burn potential increases. 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.

6. Apply to fit soils. It is important to pay attention to the condition of the soil when applying manure. Due to the compaction injury on crowns, driving over fields with moist or wet soil increases the injury risk. Where possible make applications when cooler temperatures and post-application rainfall will reduce burn potential.

Strategy C: Apply Manure Immediately Before Plowdown

Historically, the most common place to spread manure is on an alfalfa field immediately before it is to be rotated to the next crop. This situation eliminates the concern for alfalfa injury, the applications are easy to make on the smooth fields, the labor is available in late summer before corn harvest, and there is a wide window for application.

While this time of application is widely used by producers, there is a high probability that such applications result in an excess of N in the soil for the following crops. With the N contribution from the alfalfa, the N contribution from the manure, and in some cases, the additional fertilizer N applied, the total amount of available N will be greater than is recommended. Research in several states has indicated little, if any, response to additional N following alfalfa (Table 4). This choice of application time may have reduced applicability as the environmental costs may be too high.

Management Considerations

1. Limit manure rate to the amount of N required by the following crop after accounting for the legume credit.
2. Apply only to the very poorest hay fields where alfalfa top growth has been removed. Both stand density and amount of top growth present when the stand is killed affect the legume credit. Where stands are poor and little regrowth is present this credit is smallest.
3. Apply to fields immediately before tillage or top-dress prior to secondary tillage to reduce the risk of direct manure runoff losses.
4. Use the presidedress nitrogen test before applying any fertilizer N to these fields. This test has been particularly useful in confirming the amount of available N from manure and legumes.

Summary

Pre-plant 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 N responses, secondary or micronutrient benefits and/or improvements in soil physical 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 K to unacceptably high levels.

Topdressing manure to established alfalfa is somewhat riskier. 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 N and other nutrients; however, top-dress 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.

Applications made as alfalfa is being rotated into another crop may result in excess N available to the following crop. This can lead to unacceptable large environmental risks from nitrate leaching. Applications need to consider the N availability from both the legume and the manure. Removing all the alfalfa top growth before application and limiting manure rates by considering the alfalfa N credit is essential.

Selected References

Bundy, L.G., and T.W. Andraski. 1993. Soil and plant nitrogen availability tests for corn following alfalfa. J. Prod. Agric. 6:200-206.

Converse, J.C., G.D. Bubenzer, and W.H. Paulson. 1976. Nutrient losses in surface runoff from winter spread manure. Trans. ASAE 19:517-519.

Daliparthy, J., S.J. Herbert, and P.L.M. Veneman. 1994. Dairy manure applications to alfalfa: Crop response, soil nitrate, and nitrate in soil water. Agron. J. 86:927-933.

Fox, R.H., and W.P. Piekielek. 1988. Fertilizer N equivalence of alfalfa, birdsfoot trefoil and red clover for succeeding corn crops. J. Prod. Agric. 1:313-317.

Hensler, R.F., R.J. Olsen, S.A. Witzel, O.J. Attoe, W.H. Paulson, and R.F. Johannes. 1970. Effect of method of manure handling on crop yields, nutrient recovery and runoff losses. Trans. ASAE 13:726-731.

Kunelius, H.T. 1974. Effects of weed control and N fertilization at establishment on the growth and nodulation of alfalfa. Agron. J. 66:806-809.

Mathers, A.C., B.A. Stewart, and B. Blair. 1975. Nitrate-nitrogen removal from soil profiles by alfalfa. J. Environ. Qual. 4:403-405.

Morris, T.F., A.M. Blackmer, and N.M. El-Hout. 1991. Optimal rates of nitrogen fertilization for first-year corn after alfalfa. J. Prod. Agric. 6:344350.

Peters, J.B. 1991. Comparison of manure as an organic fertilizer source and commercial fertilizer for establishment and production of alfalfa. Sustainable Ag Program Final Report. Wis. Dept. of Agric., Trade, and Consumer Protection, Madison, WI. 25 p.

Russelle, M.P., and G.C. Buzicky. 1988. Legume response to fresh dairy cow excreta. p. 166-170. In Proc. Forage and Grassland Conf., Baton Rouge, LA 11-14 Nov 1988. AFGC, Belleville, KY.

Schertz, D.L., and D.A. Miller. 1972. Nitrate-N accumulation in the soil profile under alfalfa. Agron. J. 64:660-664.

Schmitt, M.A., and G.W. Randall. 1994. Developing a soil nitrogen test for improved recommendations for corn. J. Prod. Agric. 7:328-334.

Schmitt, M.A., C.C. Sheaffer, and G.W. Randall. 1993. Preplant manure and commercial P and K fertilizer effects on alfalfa production. J. Prod. Agric. 6:385-390.

Schmitt, M.A., C.C. Sheaffer, and G.W. Randall. 1994. Manure and fertilizer effects on alfalfa plant nitrogen and soil nitrogen. J. Prod. Agric. 7:104-109.

Wendt, R.C., and R.B. Corey. 1980. Phosphorus variations in surface runoff from agricultural lands as a function of land use. J. Environ. Qual. 9:130-136.

Young, R.A., and C.K. Mutchler. 1976. Pollution potential of manure spread on frozen ground.J. Environ. Qual. 5:174-179.

This publication was prepared as an activity of the North Central Regional Committee, NCR 183, Utilization of Animal Manure and other Organic Wastes in Agriculture. It summarizes existing information on use of manure on alfalfa and does not include original research results obtained by the NCR 183 committee. Members of the committee include:

State Agricultural Experiment Stations –

Illinois	Robert G. Hoeft
Indiana	Brad C. Joern
Iowa	Randy J. Killorn
Kansas	Raymond E. Lamond
Michigan	Lee W. Jacobs and Howard Peterson
Minnesota	Michael A. Schmitt
Missouri	John A. Loy
Nebraska	Charles A. Shapiro
Ohio	Jay Johnson
South Dakota	James R. Gerwing
Wisconsin	Kieth A. Kelling
USDA – ARS	Bahman Eghball and Michael Russelle
CSREES	Maurice Horton

Administrator Advisor – William Ravlin, Ohio

[1]Professor and Extension Soil Scientist, Dept. of Soil Science, Univ. of Wisconsin-Madison and Associate Professor and Extension Scientist, Dept. of Soil, Water and Climate, Univ. of Minnesota-St. Paul, respectively.

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

Treatment	Minnesota Alfalfa Yield (tons/acre) [1]			Wisconsin Alfalfa Yield (tons/acre) [2]		
	Rosemount **1989**	Rosemount **1990**	Waseca **1989**	**1988**	**1989**	**1990**
Control Manure	1.62	1.01	1.36	0.88	1.61	2.68
3000 GPA	1.79	1.58	1.45	--	--	--
6000 GPA	1.96	1.89	1.24	--	--	--
12000 GPA	1.62	2.15	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

[1]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, K per 1000 gallons in 1989 and 33+7+25 in 1990; Waseca manure contained 36+6+19

[2]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/gallon of N, P, and K in 1988, 1989, and 1990, respectively

Table 2. Effect of preplant or topdressed liquid dairy manure on alfalfa yields[1]

Preplant Manure Rate (gallons/acre)	Alfalfa Yield without Topdress (ton/acre dry matter)		Alfalfa Yield with Topdress[2] (ton/acre dry matter)	
	1982	**1983**	**1982**	**1983**
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

[1]Manitowoc County; data from S.R. Hendrickson (personal communication).

[2]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).[1]

Treatment	Soil Loss (lb/acre)	Runoff (inch)	Nutrient Losses (lb/acre)		
			Total N	Total N	Soluble P
	Corn				
Check	39	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	0.3
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

[1]Adapted from Young and Mutchler (1976).

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

State	Sites		Optimum N rate (lb/acre)
	Total	Responsive	
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