THE BENEFITS OF MANAGING MANURES WITH ALFALFA

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Abstract: Alfalfa is a major crop in California, accounting for approximately ten percent of the irrigated acreage, contributing significantly to grower income and providing a major source of feed for the animal industry. The production of animals and animal products also generates large quantities of manures which can in turn be used in growing alfalfa. Wise use of manures can result in several benefits when growing alfalfa. Perhaps the most important is that manures supply nutrients -- particularly phosphorus and potassium. In addition, soil organic matter content is improved and water infiltration rates are usually increased. Although nitrogen is also supplied, alfalfa is very capable of supplying it's own nitrogen through the symbiotic relationship with rhizobium bacteria located in the root nodules. Perhaps even a greater benefit that alfalfa offers is that it is among the best crops to utilize the nitrogen supplied by manure before the nitrates are potentially leached into groundwater. Manures may however contain weed seeds, be picked up by hay harvesting equipment, contain high levels of salts such as sodium and chloride, and in some cases promote disease and insect problems.

Keywords: Alfalfa, manures as fertilizers, plant nutrients-phosphorus, potassium and sulfur, nitrate uptake by alfalfa-groundwater protection.

INTRODUCTION

Alfalfa is a major crop in California and contributes significantly to the feed supply of a diverse and large animal industry. This large animal population produces huge quantities of manures which, if utilized properly can benefit the growth of alfalfa. This presentation seeks to enumerate and discuss the ways in which manures can be of benefit in the growth and production of alfalfa.

UTILIZING MANURES IN ALFALFA PRODUCTION

Manures have been recognized for many years for supplying essential plant nutrients and other contributions to crop growth and yields (2, 3, 7, 11, 12). Changes in soil characteristics such as increased organic matter content, nutrient content and water intake rate are known to occur as a result of applications of manure (5, 6). Alfalfa production is most likely to be increased as the result of added phosphorus. This is principally because alfalfa yields throughout the state are most limited by inadequate supplies of the nutrient phosphorus. Even though phosphorus concentrations in manure are generally low (often less than 2% P_2O_5), rates of approximately 10 tons per acre may result in the application of up to 400 lbs P_2O_5 per acre. If frequent applications of manure are made such as every other year, a 10 ton per acre rate containing 2% P_2O_5 content will supply a 12 ton alfalfa crop having a 0.30% P or 0.68% P_2O_5 with sufficient phosphorus. In addition, small amounts will be going to build soil phosphorus levels. Even though alfalfa is provided with adequate levels of potassium from most California soils, the added potassium from manure assures an abundant supply to meet the need of approximately 400 to 600 lbs K_2O per year.

Sulfur, boron and molybdenum are several more essential plant nutrients that are known to be deficient in California alfalfa producing areas. Manures supply these nutrients as well as calcium, magnesium, other micronutrients and even large amounts of nitrogen.

This brings up a very important issue, does alfalfa use the nitrogen contained in the manure or use that provided by the rhizobium bacteria in the nodules on the roots. Since more energy is expended by alfalfa to fix nitrogen than to take up available supplies in the soil, it uses the nitrate or ammonium in the soil and that which results from the decomposition of manures. When the supplies of nitrogen from the soil and manure are

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depleted, then the symbiotic nitrogen fixation system provides needed amounts for the alfalfa. Not all of the nutrients added in manures become available to plants the first growing season after application. The nutrients from manures become part of the natural "cycling" in the soil. In other words they are used by various groups of microorganisms to decompose the organic residues added and after the decomposition is more or less complete the nutrients become available to plants. Researchers have found that in some cases, most (about 90%) of the nitrogen from poultry manure becomes available the first year, whereas dry corral manure from beef feed lots may only release 30 to 50% of its nitrogen the first year followed by 10 to 20% the second year and 5% or less the third and later years (8, 9).

Phosphorus and potassium availability have been shown to increase following applications of manures (1, 6, 10). Large applications or repeated smaller rates can increase significantly the soil test levels for both phosphorus and potassium (Table 1 and 2). This is particularly true for the surface foot of soil and even to deeper depths in the soil profile. Long-term rotation studies have indicated that crop responses to nutrient additions from manures are equal to or slightly greater than from inorganic fertilizers. In some situations the micronutrients added in manures have been credited for this increased yield response and in other cases the effect on soil physical characteristics such as increased organic matter content and water infiltration as well as improved structural aggregation to allow for better aeration is suggested.

Water intake and organic matter content of soils have been increased following manure applications (5, 6). Table 3 indicates the increase in organic matter content the year after manure treatments were made and also up to 5 years (1979) after applications were completed. Water intake rates measured in irrigations following harvest show only small differences between manure treatments (Table 4), whereas total infiltration times during the growing season in sorghum are much less (Table 5). Since alfalfa fields often become compacted during harvest operations, the increased organic matter hopefully will simulate microbial activities such that increased aggregation of soil particles will occur. Partial alleviation of the soil compaction and improved aeration as well as greater water infiltration can benefit alfalfa growth.

Turning our discussion to a different perspective entirely let's consider how alfalfa can play an important environmental role. Several research studies indicate that alfalfa is capable of taking up a significant amount of nitrate-nitrogen before it reaches the groundwater. In part this is due to the deep rooting characteristic of alfalfa but it is also true that large amounts (>600 lbs/A) of nitrogen are needed to produce good yields of high quality. Figure 1 indicates the amount of nitrate-nitrogen present in the soil at the time of seeding alfalfa and after the final cutting each year (4). Three years prior to the seeding of alfalfa, annual manure applications of 0, 10, 20, 50 and 100 tons per acre were made to different experimental plots which had been planted to annual crops. In addition, another treatment consisting of 200 lbs N per acre as ammonium nitrate was included. The three year totals of manure were 0, 30, 60, 150 and 300 tons/A along with the 600 lbs N/A ammonium nitrate treatment. Note that the bars for 1971 at the time of alfalfa seeding, all show approximately 400 kg N/ha (357 lbs N/A) or more for the ammonium nitrate (N) and the manure treatments 22 (10 tons/A) or 45 metric tons/ha (20 tons/A) in the surface 1.8 m (6 ft) of soil. The 112 metric tons/ha (50 tons/A) has about 1200 kg N/ha (1071 lbs N/A) and the highest manure treatment has slightly more than 1600 kg N/ha (1429 lbs N/A) as nitrate in the top 1.8 m or 6 foot of soil. After the first and second years of alfalfa production, the solid black bars for 1972 and shaded for 1973 indicate much lower nitrate-nitrogen levels in the surface 0 to 1.8 m (6 foot) of soil. Slightly lower levels of nitrate-N were observed in the 1.8 to 3.6 m (6 to 12 ft) depth the end of 1973 for the 0, N, 22 (10) and 45 (20) treatments but not for the 112 (50) and 224 (100) treatments. The increase in nitrate-N concentrations at this depth over the years 1971 to 1973, for the 112 and 224 treatments can be explained by the mineralization or production of nitrate-nitrogen from the water soluble organic matter that has been leached downward from the two highest manure application rates. Also, the two years of alfalfa cropping had removed only slightly more than one-third of the total nitrate-N in the soil for the two highest manure treatments. In summary this study indicates alfalfa removed significant amounts of nitrate-nitrogen from the top 6 foot of soil and even some from the 6 to 12 foot soil depth.

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Table 1. Sodium bicarbonate extractable phosphorus in soil samples taken after harvest from manure treated plots. (After Meek, B. D., et al.).

Manure Applied 1971-74	Phosphorus Applied in Manure	$NaHCO_3$ - Extractable P				
		0 to 1 ft depth				1-2 ft depth
		1974	1977	1978	1979	1979
tons/A	lbs P_2O_5/A	---------- ppm				
0- 0- 0- 0	0	9a*	14a	19a	17a	8a
80- 0- 0- 0	3000	69 bc	53 b	51 b	41 b	10ab
20-20-20-20	3000	98 cd	58 b	61 b	50 bc	10ab
40-40-40- 0	4500	122 d	71 b	68 b	65 cd	14 b
160- 0- 0- 0	6000	120 d	94 c	87 c	69 d	12ab

* Column values followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

Table 2. Exchangeable potassium in soil samples taken after harvest from manure treated plots. (After Meek, B. D., et al.).

Manure Applied 1971-74	Potassium Applied in Manure	Exchangeable Potassium			
		1974		1979	
		0-1 ft	1-2 ft	0-1 ft	1-2 ft
tons/A	lbs K_2O/A	---------- ppm --			
0- 0- 0- 0	0	609a*	479a	491a	302a
80- 0- 0- 0	5700	942 b	600a	660 b	317a
20-20-20-20	5700	1258 c	458a	762 b	362a
40-40-40- 0	8550	1482 d	609a	911 c	551 b
160- 0- 0- 0	11400	983 b	486a	692 b	407ab

* Column values followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

Table 3. Organic matter content in soil samples (0-1 ft depth) taken after harvest from manure treated plots. (After Meek, B. D., et al.).

Manure Applied 1971-74	Organic Matter Content					
	1970	1971	1973	1975	1977	1979
tons/A	---------------------------------- %					
0- 0- 0- 0	0.8a*	1.0a	1.1a	1.2a	0.9a	1.0a
80- 0- 0- 0	0.9a	1.9 bc	1.6ab	1.9 b	1.3 b	1.3 b
20-20-20-20	0.8a	1.3a	1.9 bc	2.2 bc	1.4 b	1.5 b
40-40-40- 0	0.9a	1.4ab	2.3 cd	2.6 cd	1.5 b	1.5 b
160- 0- 0- 0	0.9a	2.2 c	2.0 bc	2.0 b	1.6 b	1.4 b

* Column values followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

Table 4. Infiltration rates at two times during irrigation taken after harvest from manure treated plots. (After Meek, B. D., et al.).

Manure Applied 1971-74	Infiltration Rates					
	1971		1973		1977	
	0.75[xx]	12.0	1.25	9.0	0.75	9.0
tons/A	------------------------------ cm/hour					
0- 0- 0- 0	0.4a*	0.1a	0.9a	0.2a	2.9a	0.3ab
80- 0- 0- 0	2.0a	0.5a	1.6 b	0.4a	2.5a	0.5 bcd
20-20-20-20	1.0a	0.3a	1.6 b	0.3a	2.9a	0.6 d
40-40-40- 0	2.0a	0.4a	1.4 b	0.5a	2.8a	0.2a
160- 0- 0- 0	2.8a	0.8a	1.6 b	0.5a	3.1a	0.6 d

* Column values followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

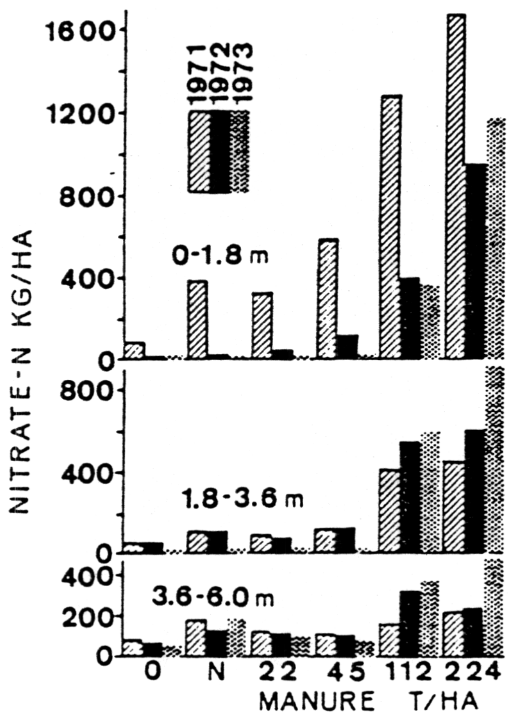
[xx] Time in hours after irrigation was started.

Table 5. Total infiltration times measured for each irrigation during the growing period of sorghum in 1971-1973. (After Meek, B. D., et al.).

Manure Applied 1971-74	Infiltration Times				
	1971	1972		1973	
	6 (4.0)[xx]	6 (4.5)	7 (4.5)	4 (4.6)	6 (3.8)
tons/A	hr				
0- 0- 0- 0	19a*	24a	25a	42a	20a
80- 0- 0- 0	6 c	11 bc	12 bcd	27 b	14 b
20-20-20-20	11 b	17 b	15 b	18 cd	8
40-40-40- 0	7 bc	6 c	11 cd	10 de	4 de
160- 0- 0- 0	5 c	10 bc	14 bc	28 b	16 b

* Column values followed by the same letter are not significantly different at the 5% level, according to Duncan's Multiple Range Test.

xx Irrigation number during the season followed by inches of water applied in parenthesis.



Soil Depth
1.8 m = 6 ft
3.6 m = 12 ft
6.0 m = 20 ft

Nitrate-N
200 kg/ha = 178 lbs/A
400 kg/ha = 357 lbs/A
800 kg/ha = 714 lbs/A
1600 kg/ha = 1429 lbs/A

Manure Applied
22 T/HA = 10 tons/A
45 T/HA = 20 tons/A
112 T/HA = 50 tons/A
224 T/HA = 100 tons/A

N fertilizer applied at 200 lbs/A

Figure 1. Nitrate-nitrogen in soil initially and after 1 and 2 years of alfalfa (After Mathers, A. C. et al. 1975).