REJUVENATING OLD FORAGE STANDS WITH LIQUID FERTILIZER.

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ABSTRACT

We initiated trials on old unproductive forage stands at 2 Saskatchewan locations to determine if their productivity could be restored with fertilizers. Fertilizing with N and P in general agreement with soil test recommendations provided yield responses that more than offset fertilizer costs. Dribble banding liquid urea-ammonium nitrate and ammonium poly-phosphate was an effective way of applying N and P, as was surface broadcasting granular ammonium nitrate plus mono-ammonium phosphate. No advantage was recorded to coulter application of the fluid fertilizer bands in this study. Dribble band application is a lower cost method than use of coulters, and this research would not support the investment, upkeep and operational cost of using coulters on forage lands. Adding ammonium thio-sulfate to liquid UAN provided a slight and inconsistent benefit over UAN alone. If this treatment adds little to fertilizer cost, it may be useful to insure against N losses under adverse conditions. Applying a 3 year supply of P at the beginning of the project was as effective as applying equal increments of P annually. In fact at Indian Head, the application of the 3 year P rate in year 1 was always the highest yielding treatment. Only when N and P were applied together was there a yield response at Indian Head, indicating that P was the major limiting nutrient. Applying N only at Scott did increase yield, but was ineffective compared to N plus P treatment. The residual effect of repeat fertilizer applications to these plots was dramatic. Check yields remained somewhat static, but fertilized yields tended to increase over time, typically increasing by about 50% in the first year of application. In the second year of application, the most effective fertilizer treatments more than doubled yields, and in the third year yields were tripled. These responses support previous research in the region which showed a progressive improvement in forage response to P additions over a series of years. We concluded that where the productivity of established forages has declined over time due to nutrient deficiencies, fertilizer additions can be an effective means of improving yields. Soil testing to evaluate the level of available nutrients is critical to ensure that all deficient nutrients are applied. Correcting deficiencies in P can be critical to achieving a profitable N response in forage crops.

INTRODUCTION

Forage crop fertilization is considered an optional feature for many farmers in the northern Great Plains, especially where dryland conditions limit forage yield. However, there is a large data base to support fertilization of forages as a means of maintaining yield, quality and stand purity fertilizers (Simons and Gross 1985; McCaughy and Simons 1995).

Most forage fields are highly productive during the first several years after seeding, but thereafter productivity typically declines. Breaking and re-seeding is one of the most common means of rejuvenating unproductive seeded forage, but is quite costly. If poor productivity is due to low fertility, it may be more economic to rejuvenate the forage by adding fertilizer nutrients. Repeat annual applications are more effective than single large applications intended to meet 3-5 year needs (Ukrainetz and Campbell 1988). Efficiency of N is enhanced by using granular ammonium nitrate as opposed to granular urea when surface broadcast (Ukrainetz et al 1988; Malhi et al 1995) mainly because urea is more readily lost to volatilization from the soil surface. Recovery of fertilizer N is higher for late spring application than for early spring, which is greater than late or early fall application (Malhi et al, 1995). Where both N and P are deficient, application of both nutrients is essential to ensure optimum responses (Ukrainetz et al 1988). For example, yield response was more than doubled, and the proportion of bromegrass (a desirable species) in the stand increased at the expense of bluegrass (a less desirable species) where N and P were applied compared to N alone (Bittman et al 1997). Applying N alone had the opposite effect on stand composition.

Granular ammonium nitrate is becoming difficult to access, and is costly. Banding improves effectiveness of urea, but application costs are higher and the forage stand may be damaged (Malhi et al, 1995). Surface broadcast applications of P fertilizers are relatively inefficient as P is quite immobile. Liquid fertilizer is becoming more readily available and is usually only slightly more expensive than granular forms and has been shown to be an effective way to meet forage nutrient requirements (Lardner et al 2000). However there is only limited information available on the relative effectiveness of liquid forms of N and P or on the most effective methods of application. We initiated a series of studies to evaluate the effect of solution fertilizer as surface dribble and in-soil bands on the productivity of forage grasses and compared that with surface broadcasting similar amounts of nutrients in granular forms.

MATERIALS AND METHODS

In 2003 and again in 2004 we initiated studies on forage fields that were seeded prior to 1970 on a Dark Brown Chernozemic loam soil at Scott and a Black Chernozemic clay at Indian Head Saskatchewan. At Scott the stand was a mixture of crested wheatgrass, bromegrass and alfalfa (10%), and at Indian Head it was bromegrass and alfalfa (30%). Both stands were were weed free other than for some invasion by less productive grass species. Both sites had a long history of hay removal with little or no fertilizer applied resulting in low (25 kg ha^{-1} or less) residual soil N and very low (less than 6 kg ha^{-1}) P at both sites when the studies were initiated. Supplies of available soil K and S were considered more than adequate to meet crop requirements.

New experiments were started in 2002 and 2003 at both locations. All studies included the following treatments applied each of three years:

1. Check with no fertilizer or coulter treatments in any year.
2. Coulter treatment in year one with liquid urea ammonium nitrate (UAN) and ammonium poly-phosphate (APP) coulter banded in years 2 and 3.
3. Broadcast ammonium nitrate and mono-ammonium phosphate (MAP) granular each year.
4. Dribble band liquid UAN and APP each year.
5. Dribble band liquid UAN (with1% ammonium thiosulfate) and APP each year.
6. Coulter band liquid UAN and APP each year.
7. Coulter band UAN ONLY each year.
8. Broadcast 3X rate of MAP year one and coulter band liquid UAN each year.

At Scott, N rates were 30 kg ha^{-1} in 2003, and 60 kg ha^{-1} in 2002, 2004 and 2005; and at Indian Head were 85 kg ha^{-1} every year. Rates of P_2O_5 were 33 and 100 kg ha^{-1} for the 1X and 3X rates at both locations. Forage yield was determined by cutting a 1m wide strip from each plot, weighing the forage and drying a sub sample to convert fresh weight to dry matter yield. Sub samples were retained for quality analyses [data not reported].

Statistical analyses were performed on data from each location year. We also grouped data over location years and analyzed data from the sites where fertilizer treatments were applied the first, second and third time. This was done to provide some insight into the consistency of responses over location years, and into residual effects of fertilizer application.

Moisture conditions were highly unfavorable at Scott in 2002, resulting in a forage crop failure. Moisture supply improved each year after 2002 at both locations, and by 2005 moisture was above normal. At Indian Head, the timing of rain during the 2004 growing season was very favorable, and yield was higher than for 2005 when total moisture was highest. At Scott however, yields were highest in 2005.

RESULTS AND DISCUSSION

Most treatment responses were consistent within a location, but there was a significant location by treatment interaction. Most if not all the interaction effect could be attributed to different responses to the N without P treatments at the 2 locations. At Scott, we noted a small positive yield response to N without P after 2 and 3 years, while at Indian Head, N alone yielded the same as the unfertilized check [Table 2].

Table 1. Moisture conditions at Scott and Indian Head during 2002 to 2004.

	2002	2003	2004	2005	Long Term
Scott - potential recharge overwinter*	80	147	159	167	165
- April 1 to July 31 precipitation	93	136	158	246	194
- total potentially available moisture	173	283	317	409	359
I. Head - potential recharge overwinter*	104	226	142	241	220
- April 1 to July 31 precipitation	202	127	282	223	227
- total potentially available moisture	306	353	424	464	447

* Potential overwinter recharge = total precipitation from previous Aug 1 to March 31 of current year.
** LTN = Long term normal [1971-2000 mean precipitation].

Dribble banding liquid UAN and APP was an effective and efficient way to apply fertilizers to old forages. Yield was similar to surface broadcasting UAN plus MAP granular at similar rates. Adding ATS to liquid UAN provided a slight benefit over UAN alone at Indian Head in 2005. If this treatment adds little to fertilizer cost, it may be useful as insurance against N losses under adverse conditions. Applying a 3 year supply of P as MAP at the outset was as effective as applying equal increments of P as MAP or APP annually.

Table 2. Forage yield responses [kg ha^{-1}] to fertilizer treatments at Scott and Indian Head SK [Each value is a mean of 2 years of data except at Scott for year 1 where only one year of data was available].

Scott	Year 1	Year 2	Year 3	Mean
1.Check, no fertilizer	1720cd*	1850c	1670c	1750
2.Coulters only year 1 then coulter N and P	1450d	2550bc	3520ab	2510
3.Broadcast granular N and P	2320ab	3020ab	3510ab	2950
4.Dribble liquid N and P	2460ab	3130a	3590ab	3060
5.Dribble liquid N and P with ATS	2630a	3080a	3600a	3100
6.Coulter liquid N and P	2380ab	3030ab	3670a	3030
7.Coulter N only	2080bc	2770b	3370b	2740
8.Broadcast 3X granular P year 1, and coulter liquid N each year	2490ab	2950ab	3770a	3070
Indian Head				
1.Check, no fertilizer	1110b	1070d	1120c	1100
2.Coulters only year 1 then coulter N and P	1030b	1680c	3110b	1800
3.Broadcast granular N and P	1820a	3560ab	4080a	3150
4.Dribble liquid N and P	1920a	3240b	3350b	2840
5.Dribble liquid N and P with ATS	1870a	3060b	3820a	2920
6.Coulter liquid N and P	1680a	2930b	3860a	2820
7.Coulter N only	1290b	1210d	1050c	1180
8.Broadcast granular P at 3X year 1, and granular N each year	2050a	3740a	3780a	3200

* means followed by the same letter do not differ at P=0.05. Columns with no letters have not been statistically analyzed to date.

Where coulter banding without fertilizer was done the first year, yield was reduced at Scott, but the loss was not statistically significant. When this treatment was fertilized in subsequent years, yields continued to be lower than where fertilizer N and P were coulter banded every year, except at Scott in year 3. This suggests that repeat applications of fertilizer over a period of years alter [or rejuvenate] old unproductive forage stands such that subsequent fertilizer additions become even more effective.

The economic value of yield responses were calculated based on 10 year average [1991-2002] farm gate forage values of $82 per tonne and N and P costs of $0.84 and $0.57 per kg, as reported by Saskatchewan Agriculture and Food [Table 3]. Economic returns were generally good for all treatments that involved application of N and P. In year 1, returns were generally lowest, and highest in year 3. This likely reflects generally improving moisture conditions over the years the studies were in place, but likely also reflects improved responses where fertilizer was applied in previous years. Where coulter treatment was applied without fertilizer in year 1, and N and P coulter banded in years 2 and 3, economic returns always lagged behind similar treatments where N and P were coulter banded every year. Over the 3 year period, there was a tendency for the treatment that received a three year supply of P in year 1 and none in subsequent years, with N applied each year, to provide higher returns than any other treatments at Indian Head, but not at Scott. Differences from this treatment compared to other that received other N plus P treatments were small compared to treatments that did not get either or both nutrients. At Indian Head, the yield response to N alone was not sufficient to offset the cost of the fertilizer.

Table 3. Value [\$ ha^{-1}] of increased forage yield over unfertilized check minus fertilizer N and P costs at Scott and Indian Head SK with N valued at \$0.84 kg^{-1} and P_2O_5 at \$0.57 kg^{-1} and forage at \$82 t^{-1} during 2002 to 2005. [Each value is a mean of 2 years of data including Scott for year 1 where the forage failed to provide harvestable yield in 2002].

Scott	Year 1	Year 2	Year 3	Mean
1.Check, no fertilizer	0	0	0	0
2.Coulters only year 1 then coulter N and P	**-22**	**-12**	82	16
3.Broadcast granular N and P	5	26	82	38
4.Dribble liquid N and P	17	35	88	47
5.Dribble liquid N and P with ATS	31	31	89	50
6.Coulter liquid N and P	10	27	95	44
7.Coulter N only	4	6	70	27
8.Broadcast 3X granular P year 1, and coulter liquid N each year	**-62**	40	122	33
Indian Head				
1.Check, no fertilizer	0	0	0	0
2.Coulters only year 1 then coulter N and P	**-7**	**-40**	73	9
3.Broadcast granular N and P	**-32**	114	73	85
4.Dribble liquid N and P	**-24**	87	114	59
5.Dribble liquid N and P with ATS	**-28**	73	131	59
6.Coulter liquid N and P	**-43**	62	134	51
7.Coulter N only	**-46**	**-60**	**-96**	**-67**
8.Broadcast granular P at 3X year 1, and granular N each year	**-13**	147	147	94

SUMMARY

- Applying N and P in general agreement with soil test recommendations provided yield responses that more than offset the application costs.
- Dribble or coulter banding of N and P is an effective way to apply fertilizer [particularly if granular ammonium nitrate is unavailable in future].
- Dribble banding is likely to be preferred as it does not damage the forage, and is less costly to apply than with coulters.
- Adding ATS to liquid UAN may be useful to insure against N losses under adverse conditions as it provided a slight benefit over UAN alone in one case.
- Failure to balance N and P where both are deficient could be costly as yield responses may not offset costs.
- The full benefit of fertilizer is likely only realized where forages are fertilized repeatedly over time.
- Applying a multi year supply of P may be more efficient that similar amounts applied annually on some soils.
- Fertilizing with N and P is an effective way to rejuvenate old forage stands.

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