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Nitrogen Alternatives for Winter Wheat Production in Western Canada

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INTRODUCTION

Winter wheat has been fertilized by spring broadcasting of ammonium nitrate (AN) to limit losses of nitrogen due to leaching, denitrification or volatilization. In the colder and more moist areas of Western Canada a large number of studies have demonstrated that spring applied N is superior to fall applied N in terms of grain yield and recovery of nitrogen fertilizer in plant material (Fowler and Brydon 1989; Vaughan et al. 1990). These losses occur since application of fertilizer products in the early fall increases the potential for nitrification prior to soil freezing due to a longer period of suitable temperatures (Malhi et al. 1984).

Surface application of nitrogen in the spring can also result in significant nitrogen losses by volatilization. Harrison and Webb (2001) in a review of the effect of nitrogen fertilizer type indicated nitrogen losses from surface applied urea to be between 10 and 20% of the nitrogen applied but losses of over 40% have been recorded. Nitrogen from AN was negligible in many cases while urea ammonium nitrate (UAN) losses were intermediate.

We evaluated side banding of urea at the time of winter wheat plant, late fall application of UAN and the use of coulters to apply nitrogen below the soil surface in the fall or spring as potential methods of reducing nitrogen losses due to denitrification in the fall and volatilization in the spring.

MATERIALS AND METHODS

The design was a three replicate complete factorial with factor one being seeding dates of August 31, Sept 7, Sept 14 and Sept 21. Factor two was products and application method as indicated in the following list:

- Check plot (no N)
- Spring broadcast ammonium nitrate (AN)
- Urea at seeding (side-band or mid-row band)
- Urea ammonium nitrate solution (UAN) late fall surface band
- UAN late fall coulter band
- Urea spring broadcast
- UAN spring surface band
- UAN spring coulter band
- Fall coulter band no N followed by spring broadcast of AN
- Spring coulter band with no N followed by spring broadcast of AN

This trial was conducted at three sites over a period of three seasons. Statistical analysis was conducted using SAS GLM for the individual site years data is only presented where at least one treatment differed from the check (0 N).

Nitrogen application rate varied between site years but the goal was to apply nitrogen at approximately 70% of maximum yield potential for that site and soil moisture conditions so that differences in application method would be expressed. The four seeding dates were used to determine if delayed seeding of winter wheat interacted with the method and time of nitrogen application. Delayed seeding can reduce the conversion of urea to nitrate due to cooler soils but delayed seeding results in smaller plants which may be less able to survive the winter.

RESULTS AND DISCUSSION

The target of 40 kg ha^{-1} or less of soil nitrate nitrogen was not attained at Indian Head in 2003 or 2004 or at Brandon in 2004 (Table 1).

In no case was there a significant interaction between seeding date and nitrogen (Table 2). This is an indication that urea applied at seeding reacted the same, likely as a result of most of the urea being converted to nitrate prior to freezeup regardless of the seeding date. There was no impact of application method/product at the Melfort site in either season where there was a nitrogen response.

Urea applied at seeding was slightly less effective than spring applied ammonium nitrate (Table 3). Late fall urea ammonium nitrate (UAN) surface or coulter banding gave the lowest overall nitrogen response. The use of the coulter in the fall or spring followed by broadcasting of ammonium nitrate was slightly inferior to spring broadcast of ammonium nitrate alone. We speculate that the physical damage to the crop stand from the coulter might be overcome by the use of a guidance system to apply nitrogen

Table 1. Soil nutrient levels prior to planting

	mel03	mel04	mel05	indhd03	indhd04	indhd05	bran03	bran04	bran06
Soil test N kg ha^{-1}	29	34	34	**122**	**88**	20	44	**80**	34
Soil test P kg ha^{-1}	53	38	48	22	22	33	85	28	15
Fertilizer N kg ha^{-1}	75	75	75	70	93	117	70	70	70
Fertilizer P kg ha^{-1}	26	26	26	25	26	33	21	21	21
Soil texture	clay loam			clay			clay loam		
ph	6.2	6.3	6.2	7.8	8.0	8.0	7.8	8.2	8.0

Table 2. Impact of alternative nitrogen management strategies on winter wheat seed yields Prob > F for main effects and contrasts

	df	mel04	mel05	Indhd03	indhd04	indhd05	bran03	bran06
Rep	2	**0.000**	0.108	**0.031**	**0.013**	0.613	0.754	0.101
Seeddate	2	**0.000**	**0.000**	**0.000**	0.547	0.264	0.961	**0.000**
Seeddate*Trt	27	0.365	0.070	0.725	0.367	0.352	0.945	0.561
Trt	9	**0.000**	**0.000**	**0.041**	**0.000**	**0.000**	**0.004**	**0.000**
UAN fall coulter VS AN	1	0.847	0.919	0.602	**0.000**	**0.000**	0.578	0.895
UAN fall surface band VS AN	1	0.447	0.182	0.086	**0.000**	**0.000**	0.717	0.179
UAN spring VS urea broadcast	1	0.525	0.204	0.381	0.552	**0.000**	0.124	**0.002**
UAN spring coulter VS AN	1	0.759	0.807	0.392	0.364	**0.001**	0.942	**0.027**
UAN surface band VS UAN coulter	1	0.225	0.369	0.211	0.450	0.336	**0.019**	0.075
UAN surface band SPR VS AN	1	0.284	0.781	0.157	0.074	**0.000**	**0.019**	0.388
Urea at seeding VS AN spring	1	0.361	0.145	**0.040**	0.762	0.980	**0.015**	0.230
Urea spring broadcast VS UAN spring	1	0.351	0.278	0.298	0.337	**0.000**	**0.012**	**0.046**
Urea spring broadcast VS AN spring	1	0.847	0.919	0.602	**0.000**	**0.000**	0.578	0.895

AN = ammonium nitrate
UAN = urea ammonium nitrate solution
Coulter = coulter application 5 cm below the soil surface

Table 3. Impact of alternative nitrogen application strategies on winter wheat yields kg ha^{-1}

Treatment	mel04	mel05	Indhd03	indhd04	indhd05	bran03	bran06	mean	%AN
Urea at seeding	3816	4571	3553	4915	2645	2915	3731	3735	**96**
UAN late fall surface band	3792	5087	3616	3886	1885	3619	3475	3623	**93**
UAN late fall coulter band	3637	4849	3834	3916	2004	3415	3705	3623	**93**
Urea spring broadcast	3691	5092	3859	4823	2616	3496	3504	3869	**99**
UAN spring surface band	3842	4883	3671	4658	2121	4069	3897	3877	**99**
UAN spring coulter band	3718	4876	3773	4812	2173	3522	4154	3861	**99**
Fall coulter band - spring broadcast AN	2710	4902	3492	4921	2657	3376	3988	3721	**95**
Spring coulter band - spring broadcast AN	3532	4845	3607	4890	2530	3224	___	3771	**96**
Check plot (no N)	2848	3239	3339	3663	1648	3437	2238	2916	**75**
Spring broadcast AN	3668	4830	3928	4967	2642	3538	3730	3900	**100**

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between the rows. In this data set the mean performance of spring broadcast urea, dribble band UAN and coulter band UAN were similar. This differs from Fowler and Brydon (1989) who found that in one third of their trials broadcast urea was up to 50% less effective than broadcast ammonium nitrate. Losses from urea are greater when soil pH is greater than 7.0 which is common in many soils. The lack of response to application method at Melfort may be due in part to the fact these soils had a pH of 7.0 which would tend to reduce the conversion of ammonium to ammonia. The use of controlled release urea and urea treated with urease and nitrification inhibitors have been shown to be of significant value in some locations but were not commercially available when this test was conceived.

CONCLUSIONS

The use of a coulter in the spring or fall, followed by early spring application of ammonium nitrate (AN) reduced grain yield relative to broadcasting of AN. Damage from coulters might be minimized by the use of guidance systems to operate between crop rows. Urea banded at the time of seeding and spring broadcast urea had 4-5% lower yields than broadcast AN. Spring dribble banded urea ammonium nitrate (UAN) yielded 99% of spring broadcast AN. The most effective nitrogen application system will vary since weather conditions can favour immobilization and volatilization in some sites and denitrification in others. The use of non contact injection technologies should be thoroughly investigated in situations where there are high surface residues.

REFERENCES

Fowler, D.B. and Brydon.J. 1989. No-till winter wheat production on the Canadian Prairies: Placement of urea and ammonium nitrate fertilizers. Agron. J. 81:518-524.

Harrison, R. and Webb, J. 2001. A review of the effect of N fertilizer type on gaseous emissions. Advances in Argonomy 73:65-108

Lafond, G. P., Gan, Y. T., Johnston, A. M., Domitruk, D., Stevenson, F. C. and Head, K. W. 2001. Feasibility of applying all nitrogen and phosphorus requirements at planting of no-till winter wheat. Can. J. Plant Sci. 81: 373–383.

Mahli, S. S. and Nyborg, M. 1983. Field study of the fate of fall-applied 15N-labelled fertilizer in three Alberta soils. Agron. J. 75:71–74.

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