

Nitrogen Recovery from Broadcast Urea is Affected by Application Timing and Agrotain®

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INTRODUCTION

Urea is currently the most common fertilizer N source used by Montana growers, comprising approximately 80% of total N consumption. In winter wheat systems, urea is often broadcast to the soils during the late fall, winter, or early spring following crop emergence. The practice of fertilizing fields in a separate operation is done primarily to expedite seeding operations. Although an excellent N fertilizer source, the N in urea is susceptible to volatility as ammonia (NH₃) gas which can ultimately affect the fraction or portion of N recovered by the crop, and hence productivity. Previous trials in Montana have shown that N volatility will vary greatly with application timing. Nitrogen loss as NH₃ can be quite large (>20% of applied N rate) following urea applications in the late-fall and winter (i.e., Nov to March). These losses can be decreased by 60-65% with the addition of Agrotain® (active ingredient N-(n-butyl) thiophosphoric triamide, NBPT). Similarly, NH₃ loss can be mitigated by applying urea to dry soil surfaces in advance of large precipitation events that are more likely to occur in early spring than late fall or winter (Montana Fertilizer eFacts. No. 70, June 2015).

The goal of fertilizer management strategies should be to minimize N loss (to atmosphere and ground water) and to provide for the highest recovery of applied N by the crop. Given the importance of application timing and Agrotain® on NH₃ loss from urea, this study was conducted to determine the impact of these two parameters on fertilizer N recovery, and grain yield and protein of winter wheat. Urea applications were made during three periods (late-fall, winter, early spring) to simulate production practices in Montana, and fertilizer N recovery was defined as the percentage of applied N recovered in wheat grain at harvest.

METHODS

Experiments were conducted over three seasons (2011-2012, 2012-2013, and 2013-2014) on dryland farms in Fergus County, Montana. All fields were under no-till wheat-fallow management. Experiments were conducted in fields expected to be responsive to N fertilizer. Soil analysis revealed only 17, 39, and 23 lb N/acre in the soil (0-24" depth) based on samples collected in September of each respective season. Surface-applied urea and urea+Agrotain Ultra® (3.4 quart/ton urea) at 90 lb N/acre were applied at three timings to determine volatilization losses (Table 1) using a micrometeorological approach (<http://landresources.montana.edu/ureavolatilization/>). Fertilizer N recovery was determined by utilizing ¹⁵N-enriched fertilizer (at 45 and 90 lb N/acre) in microplots.

Table 1. Urea fertilizer application date and cumulative ammonia (NH₃) loss for three timings (90 lb N/acre).

Season	Timing	Date of application	Urea	Urea+ Agrotain®
			----- % -----	
2011-2012	late-fall	29-Nov-11	13.4	5.9
	winter	28-Feb-12	13.0	4.1
	spring	24-Apr-12	1.2	0.0
2012-2013	late-fall	12-Dec-12	19.3	5.9
	winter	08-Feb-13	10.6	3.6
	spring	12-Apr-13	4.3	1.4
2013-2014	late-fall	01-Dec-13	16.3	6.2
	winter	02-Feb-14	10.6	4.9
	spring	12-Apr-14	1.5	0.0

RESULTS

Urea application timing and Agrotain® both affected fertilizer N recovery in grain (Figure 1). Spring urea applications resulted in greater recovery of N fertilizer (average = 37.4%) than late-fall (26.3%) and winter (28.0%) applications. This response was likely because N applied in April was more closely synchronized with crop demand for N. In addition, N loss from NH₃ volatilization was lower from spring applications than late-fall and winter applications (Table 1). Ammonia loss was lower in the spring because large precipitation events followed the application of urea, allowing for urea to infiltrate into the soil where it was protected from volatilization.

Agrotain® enhanced fertilizer N recovery from urea, in particular from the late-fall and winter applications that were most affected by volatility. Addition of Agrotain® to urea increased fertilizer N recovery by an average (3 year mean) of 8.4 and 5.4% (Agrotain® recovery - urea recovery) for the late-fall and winter applications, respectively. In all trials, fertilizer N recovery was below 50%. In any given year a considerable fraction of applied N will be consumed by soil microbes and enter the organic N pool, or remain in the soil as nitrate after harvest.

The impact of urea application timing was also evident in wheat grain protein (Table 2). Grain protein was generally higher for spring (12.3%) applications than late fall (10.7%) and winter (10.8%) applications, which reflects the greater fertilizer N recovery for the spring applications. Also, late-fall and winter applications of urea were affected more by volatilization than the spring applications. Addition of Agrotain® improved grain protein by an average of 0.8% units reflecting the reduced N loss by volatilization.

Grain yield was generally less sensitive than grain protein to application timing and Agrotain®. Grain yield was only affected by application timing in 2013-2014, where yields from spring-applied N exceeded late-fall and winter N by 4 and 5 bu/acre respectively. Similar, there was only one instance where grain yield was improved by Agrotain®, i.e., late-fall 2011-2012 (6.7 bu/acre).

FERTILIZER FACTS

- Surface broadcast applications of urea to winter wheat should be applied in the spring to achieve the greatest fertilizer N recovery. Fertilizer N recovery (percentage of applied N recovered) in winter wheat averaged 26, 28 and 37% for late-fall, winter,

and spring applications, respectively.

- Late-fall and winter applications are more susceptible than spring applications to N loss as a result of NH₃ volatilization. The addition of Agrotain® can mitigate N loss by 60-65%.
- Grain protein was higher for spring urea applications than late-fall and winter applications.

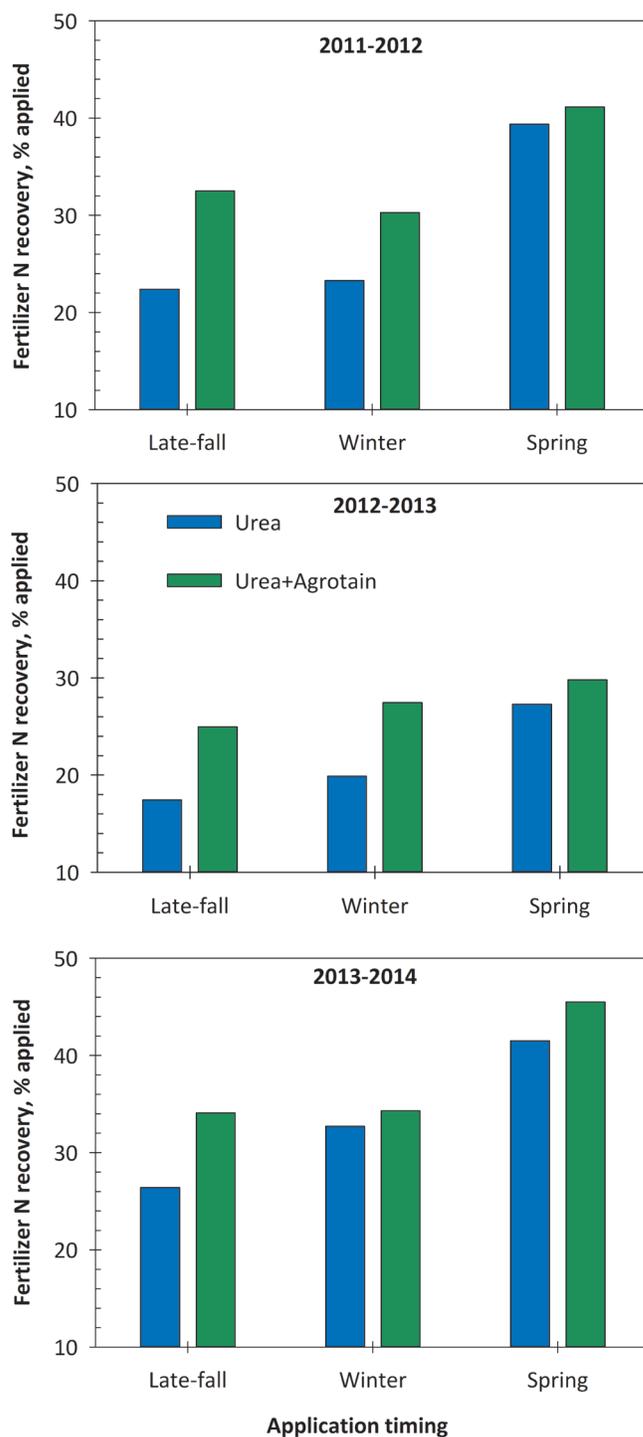


FIGURE 1. Fertilizer N recovery in the grain of winter wheat (c.v. Falcon) as affected by timing of applications and addition of Agrotain®. Mean of two N rates (45 and 90 lb N/acre).

Table 2. Effect of urea application timing (late-fall, winter, and spring) and Agrotain® on grain protein and yield of winter wheat (cv. Falcon). N rate = 90 lb N/acre.

Parameter	Season	Fertilizer	Application timing		
			Late-fall	Winter	Spring
----- % -----					
Grain protein	2011-2012	Urea	10.6a†	10.7a	13.0b
		Urea+Agrotain®	11.5a	11.6a	13.8b
	2012-2013	Urea	9.7a	9.7a	10.7b
		Urea+Agrotain®	10.5a	10.7ab	11.3b
	2013-2014	Urea	11.0a	11.2a	12.5b
		Urea+Agrotain®	12.6b	12.0a	12.9b
----- bu/acre -----					
Grain yield	2011-2012	Urea	49.3	52.7	49.6
		Urea+Agrotain®	56.0*	54.2	51.6
	2012-2013	Urea	59.5	62.0	60.4
		Urea+Agrotain®	60.9	60.7	58.2
	2013-2014	Urea	50.4	49.0	53.5
		Urea+Agrotain®	49.7	48.4	54.5

† Means in a row with at least one of the same letter are not significantly different with 95% confidence.

* Yield with Urea+Agrotain® is significantly different than with urea at P <0.05 level.

ACKNOWLEDGEMENTS

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