Wheat Yield and Quality as Influenced by Coated Nitrogen (ESN) Timings, Rates and Mixtures with Urea

Final Report: Project Number R2012-19

Principle Investigator: Nancy Jo Ehlke

Contract #43438

Importance: Spring wheat is a crop of major importance to the farmers in northwest Minnesota with approximately 120,000 acres planted in Roseau and Lake of the Woods counties. Spring wheat does well in the climate of northern Minnesota, however, farmers are always looking for new technologies that will produce higher wheat yields and/or improve wheat quality. Perennial ryegrass is a grass seed crop raised in northwest Minnesota. Production estimates indicate over 18,000 acres of perennial ryegrass will be harvested in 2012. The majority of the perennial ryegrass acres are established with spring wheat. The practice of seeding perennial ryegrass under wheat protects ryegrass plants during the winter by catching snow with the wheat stubble, but may limit seed production in the subsequent year due to excessive plant growth and crop residue from the previous wheat crop on the seed field.

A proven management practice in wheat production is an application of a starter fertilizer at planting. This starter fertilizer usually contains phosphorus, potassium and nitrogen. One of the concerns with a starter fertilizer is high salt content which can injure emerging wheat and perennial ryegrass seedlings. Elevated levels of nitrogen and potassium are the most likely cause for this high salt content. For this reason, recommendations limit the amount of potassium and nitrogen placed with the seed to 30 lbs/acre. However, Environmentally Smart Nitrogen (ESN) which is a coated urea product, may allow elevated rates of nitrogen to be applied "down the tube" at planting without injury to wheat or ryegrass seedlings.

Goals and Objectives:

1. To compare various rates of ESN applied at planting to determine wheat and perennial ryegrass injury conducted as a small plot research trial.

2. To evaluate wheat yield and quality comparing the growers standard top dress urea treatment to a 50/50 blend of urea and ESN. These trials will be large plot, on-farm research to effectively evaluate the two fertilizer treatments using farm scale equipment.

3. To conduct a small plot research trial to determine the influence of ponded water and waterlogged soils on urea and ESN forms of nitrogen and their availability or loss to the wheat crop.

Materials and Methods:

Objective 1: To compare various rates of ESN applied at planting to determine wheat and perennial ryegrass injury. Phosphorus and potassium fertilizer rates were determined by soil test which indicate residual fertility levels were 4 lbs/A P_2O_5, 138 lbs/A K_2O, and soil pH = 8.0. Total nitrogen rate applied was based on wheat yield goal and was 110 lbs/A for all treatments. The standard treatment was the grower standard of applying P & K at planting and N applied broadcast and incorporated. The other treatments were various rates of ESN. ESN rates will be 15, 30, 45 and 60 pounds applied "down the tube" at planting with P and K. The balance of nitrogen requirements for each treatment were urea applied broadcast and incorporated prior to wheat seeding. This trial was a small plot trial in a RCB design with four replications. Samson wheat was seeded at 1.5 bu/A (90 lbs/A) and was underseeded with Arctic Green perennial ryegrass at 7 lbs/A on April 24, 2012. Wheat flag leaves were collected on

July 7, 2012 at anthesis for tissue analysis. Wheat yields were quantified by harvesting with a small plot combine with sub-samples taken for measuring yield and wheat quality parameters. Perennial ryegrass stands were evaluated after wheat harvest and seed production was measured in 2013 on a subset of the treatments (Tables 1, 2 and 3).

The in furrow applications of P and K were more effective in improving wheat yields than the broadcast treatments. If soil tests indicate that P and K are significantly lower than recommended, higher application rates of P and K may increase wheat yields. The application of foliar nitrogen at anthesis may have the potential to increase the protein level of wheat (17.1%). Putting ESN "down the tube" at planting showed a positive response up to the 30 lbs/A rate, higher rates appeared to be detrimental to stands of both wheat and ryegrass, especially under dry conditions. Stands of wheat and the underseeded perennial ryegrass were significantly reduced at the higher rates of ESN (78% versus 54% stand rating). Perennial ryegrass seed yields were also enhanced by the addition of P and K fertilizer. However, utilizing higher rates of P and K in the furrow or broadcast when seeding a wheat crop underseeded to perennial ryegrass is not sufficient to maximize ryegrass seed production in the following year. Additional broadcast applications in the Fall of P and K to establishment year stands of perennial ryegrass may enhance seed yields in the following year.

Objective 2: To evaluate wheat yield and quality from the grower standard top dress urea compared to a 50/50 blend of urea and ESN. These trials were on-farm demonstrations that evaluated the two fertilizer treatments. Nitrogen top dress rate will vary with the farmer cooperators wheat yield goal. Field layout for these trials will be alternate treatments (Terragator boom width) across the entire width of the field. Harvest data was collected with the farmers combine (yield maps preferred) or weights from a weigh wagon or grain cart. Wheat quality was determined by sub-samples taken from each treatment. ESN may offer the potential to improve wheat yield and quality (protein), especially if the product is not released until later in the plant developmental stages of spring wheat. A top dress application of ESN and urea may offer the potential to improve both wheat yields and quality. All planting, harvesting and treatments were applied by the farmer collabortors. The University of Minnesota research personnel assisted with plot layout, note taking, harvest information, and sample processing.

Location 1: Amundson Brothers Farm north of Wannaska, MN in Roseau county. The field was fertilized with 120 lbs/A nitrogen preplant incorporated to spring wheat underseeded with perennial ryegrass.

Location 2: Helmstetter Farm north or Roosevelt, MN in Lake of the Woods county. The field was fertilized with 140 lbs/A nitrogen applied with an Amity drill at the time of planting of spring wheat underseeded with perennial ryegrass.

The data is in Table 4 and shows few differences between the two fertility treatments. The only significant difference was the protein percentage was significantly higher with the 50% ESN/50% urea treatment at Location 1. No other differences were detected. With environmental conditions such as moisture and temperature playing critical roles in the release of nitrogen from both ESN and urea, repeating this trial over growing seasons may help determine if there is an advantage to using both forms of nitrogen in wheat production.

Objective 3: A small plot research trial was designed to determine the influence of ponded water and waterlogged soils on urea and ESN forms of nitrogen. Urea, ESN and various ratios of urea and ESN were applied prior to wheat planting and incorporated. Treatments applied were 100% urea, 100% ESN

and urea + ESN at a ratio of 25/75, 50/50 and 75/25. The experiment was seeded on May 24, 2012 using a randomized complete block experimental design with four replications. Samson wheat was seeded at 1.5 bu/A and Arctic Green perennial ryegrass was underseeded at 7 lbs/A. The previous crop was soybean in 2010 and 2011. Fertility was applied prior to the final tillage operation before planting and all plots received MES10 and MOP at 9-30-30-7S. Irrigation was applied at 0.75 inches twice weekly after emergence if there was insufficient rainfall. Flag leaf samples were harvested on July 7, 2012 for tissue analysis off of selected treatments. Wheat yields were quantified by harvesting the experiment with a small plot combine, seed samples were taken for wheat quality parameters (Table 5).

Significant differences for wheat yield was detected with the 100% urea treatment producing lower seed yields than any of the other treatments with ESN. This indicates that under wet conditions which are common in this area of northern Minnesota, there may be a benefit to including ESN as at least a portion of your total nitrogen application. There was no consistent trend for increased protein, test weight, lodging or plant height. Flag leaf tissue analysis also showed few differences and no consistent trends.

In the second year (2013), perennial ryegrass seed yields were taken. Fertility treatments equivalent to 120 lbs/A total nitrogen were surface applied to the plots. The Fall treatments were 100% urea or 100% ESN applied on October 18, 2012; the Spring treatments were 100% urea and 75% urea and 25% ESN applied May 22, 2013; and a split application of 50% ESN in the Fall and 50 % urea in the spring. Data collected included seed yield, vigor, relative chlorophyll index (RCI) as a measure of nitrogen use efficiency, harvest height, and harvest date (Table 6).

Differences in seed yield were detected with the 75% urea/25% ESN and the 50% urea/50% ESN fertility treatments. It appears that having a portion of the nitrogen in a protected form such as ESN has the potential to increase seed yield most likely from releasing nitrogen to the crop more slowly and at a later growth stage. Spring applications of nitrogen fertilizer produced higher seed yields than applications made the previous fall. Few differences were observed in other traits evaluated. The use of protected forms of nitrogen fertilizer as part of the fertility regime warrants further evaluation.

Relevance: The MN State Climatological Working Group weather records indicate the probability that Roseau County will receive over 70% of average rainfall in April and May is 55 and 40%, respectively. The rainfall patterns in northern Minnesota are variable and can range from extremes on the low side (drought) to the high side (flood). Long term weather records in Roseau County indicate June is the wettest month of the year. Rainfall events in the 2 to 3 inch range are a common event early growing season. Rainfall events in the 2 to 3 inch range can have a negative effect on the amount of nitrogen available for crop growth and development. Waterlogged soils in the late-spring and early summer are one of the primary reasons given for loss of applied nitrogen. ESN is a coated form of urea. This coated form of urea may reduce the quantity of nitrogen loss due to waterlogged soils early in the growing season which in turn may increase wheat yields and protein. This project will add to the knowledge base of nitrogen use efficiency, and may increase wheat yield and protein by the comparisons of two nitrogen forms, various applications methods, rates and timings.

Table 1. Wheat yield, quality, stand, height, lodging and RCI and perennial ryegrass stands after wheat harvest.

Treatment	Surface[1] Applied Fertilizer	In Furrow[2] Applied Fertilizer	Bu./Ac.[3]	Protein	Test Wt.	Stand[4] counts 8/13	Height inches 7/11	Lodging[5] score 7/29	RCI[6] 7/2	RCI[6] 7/20	% Stand[7] Ryegrass 9/21
Standard treatment	110-0-0	0	**44.3**	16.8	61.1	41	27.8	1.5	287	127	83
MES10	100-0-0	9-30-30-7S	**69.4**	14.9	61.0	56	31.5	3.8	481	134	85
MES10 (2x) + K_20 (2x)	90-0-0	18-60-60-14S	**75.8**	14.9	60.8	51	32.0	4.8	543	149	88
MAP	100-0-0	9-30-30	**69.6**	15.5	61.2	50	30.8	3.0	386	117	85
MES10 Surface apply	110-30-30-7s	0	**65.5**	15.6	61.2	55	30.5	2.5	445	123	88
MES10 + 15# ESN	85-0-0	25-30-30-7S	**71.6**	15.2	61.0	49	31.7	2.8	440	136	83
MES10 + 30# ESN	70-0-0	40-30-30-7S	**63.8**	15.8	60.6	47	30.5	3.3	443	159	73
MES10 + 45# ESN	55-0-0	55-30-30-7S	**62.8**	15.8	60.8	52	31.0	3.5	437	157	58
MES10 + 60# ESN	40-0-0	70-30-30-7S	**57.5**	16.1	60.0	45	30.5	2.8	394	178	50
30# ESN only- no P or K	80-0-0	30-0-0	**49.1**	16.8	61.2	39	28.3	1.0	285	127	68
MES10 + 30# foliar N at anthesis[8]	70-0-0	9-30-30-7S	**67.5**	17.1	60.5	52	30.3	2.8	338	128	88
LSD @10% Level			**4.0**	0.4	0.3	3.5	1.1	0.8	50	24	0.9
CV(%)			**5.3**	2.2	0.4	11.9	2.9	24.1	10.3	14.4	9.6

[1]Fertilizer surface applied and tilled in prior to planting.

[2]Fertilizer applied with wheat and ryegrass in furrow at planting.

[3]Yield= Bushels/acre corrected to 12% moisture. Hail damage documented based on seed shatter per plot prior to harvest and added to yield (averaged 0.9 bu/acre)

[4]Wheat stand = culms(stems) counted per square foot after harvest.

[5]Lodging score: 1=Erect to 9=Flat

[6]RCI=Relative Chlorophyll Index -larger number equals more chlorophyll.

[7]Ryegrass stand is a visual % estimate of stand of the under seeded ryegrass after wheat harvest.

[8] 10 gal./acre 28% N sprayed on as foliar at anthesis

Table 2. Tissue analysis of wheat flag leaves harvested at anthesis on July 7, 2012.

Treatment	Surface[1] Applied Fertilizer	In Furrow[2] Applied Fertilizer	Flag leaf samples taken 7/7/2012 (anthesis) Nitrogen	Phosphorus	Potassium	Sulfur	Calcium	Magnesium	Choride	Zinc	Iron	Manganese	Copper	Boron
			%							ppm				
Standard treatment	110-0-0	0	3.4	0.12	1.70	0.38	0.55	0.47	0.62	22.0	117.0	14.0	12.0	12.0
MES10	100-0-0	9-30-30-7S	3.6	0.16	1.50	0.34	0.49	0.50	0.73	17.5	102.5	30.5	10.0	14.0
MES10 (2x) + K_20 (2x)	90-0-0	18-60-60-14S	3.8	0.18	1.37	0.36	0.61	0.64	0.58	16.0	128.5	49.5	10.0	13.5
MAP	100-0-0	9-30-30	3.5	0.16	1.40	0.33	0.49	0.58	0.59	19.0	105.0	24.0	10.0	11.0
MES10 Surface apply	110-30-30-7s	0												
MES10 + 15# ESN	85-0-0	25-30-30-7S	3.7	0.17	1.35	0.37	0.53	0.59	0.57	16.5	106.0	31.0	10.5	14.5
MES10 + 30# ESN	70-0-0	40-30-30-7S												
MES10 + 45# ESN	55-0-0	55-30-30-7S												
MES10 + 60# ESN	40-0-0	70-30-30-7S												
30# ESN only- no P or K	80-0-0	30-0-0	3.9	0.14	1.73	0.37	0.52	0.45	0.51	20.0	99.0	16.5	10.5	13.0
MES10 + 30# foliar N at anthesis[8]	70-0-0	9-30-30-7S	4.2	0.13	0.90	0.36	0.44	0.48	0.39	18.0	117.0	26.0	11.0	12.0
LSD @10% Level			0.6	0.02	0.35	0.05	0.01	0.12	0.08	3.8	9.2	12.8	2.2	2.6
CV(%)			6.5	4.20	10.20	5.70	8.10	9.30	5.80	8.5	3.4	19.1	8.4	8.4

[1]Fertilizer surface applied and tilled in prior to planting.

[2]Fertilizer applied with wheat and ryegrass in furrow at planting.

[3]Yield= Bushels/acre corrected to 12% moisture. Hail damage documented based on seed shatter per plot prior to harvest and added to yield (averaged 0.9 bu/acre)

[4]Wheat stand = culms(stems) counted per square foot after harvest.

[5]Lodging score: 1=Erect to 9=Flat

[6]RCI=Relative Chlorophyll Index -larger number equals more chlorophyll.

[7]Ryegrass stand is a visual % estimate of stand of the under seeded ryegrass after wheat harvest.

[8] 10 gal./acre 28% N sprayed on as foliar at anthesis

Table 3. 2013 Perennial ryegrass seed yields on a subset of 2012 fertilty treatments applied to wheat.

2012 In Furrow[1] Treatment	20121 In furrow Rate	Fertilizer[2] Broadcast 10/17/2012	2013 Ryegrass Yield % of mean	2013 Ryegrass Yield #/ac.	Vigor[3] 7/1/13	RCI[4] 7/1	RCI[4] 7/15	Harvest Ht.(in.)	Harvest Date
No P or K added	0	**0**	**43.1**	412	3.3	327	253	16	24-Jul
MES10 (2x) + K_20 (2x)	18-60-60-14s	**0**	**96.3**	920	6.5	414	272	21	27-Jul
MES10	9-30-30-7s	**9-30-30-7s**	**110.8**	1058	7.5	490	293	22	27-Jul
MAP	9-30-30	**9-30-30**	**110.4**	1054	6.8	491	298	21	26-Jul
MES10 (Surface apply)	9-30-30-7s	**9-30-30-7s**	**109.4**	1045	7.3	465	265	22	24-Jul
MES10 + 15# ESN	25-30-30-7s	**9-30-30-7s**	**108.9**	1040	6.8	460	297	21	29-Jul
MES10 + 30# N applied foliar at anthesis	9-30-30-7s	**9-30-30-7s**	**121.3**	1158	8.5	545	302	22	27-Jul
	LSD @5% Level		**14.1**	135	1	62	33	2	4

Mean Yield of all plots was 955 lbs/A.

120-0-0 broadcast applied to all plots on May 22, 2013.

[1]All fertility applied in furrow'down the tube' with wheat/ryegrass at planting in 2012 except for treatment #5 which was surface applied.

[2]Rate surface applied for ryegrass crop in 2013.

[3]Vigor rating: 1 = least vigorous to 9 = most vigorous.

[4]RCI=Relative Chlorophyll Index - larger number indicates more chlorophyll and potentially higher nutrient status.

Table 4. On-farm research compairng a 50/50 blend of ESN/urea to 100% urea applied preplant to spring wheat underseeded with perennial ryegrass.

	Bushels/ac[3]		% Protein		Test weight		RCI[4]
Treatment	Loc 1[1]	Loc 2[2]	Loc 1	Loc 2	Loc 1	Loc 2	Loc 2: 7/24/2012
50% ESN/50% Urea	67.3	70.7	14.1	13.6	61.5	61.9	118
100% Urea	67.5	70.2	13.7	13.6	61.7	62.1	102
LSD @10% level	NS	NS	0.2	NS	NS	NS	NS
CV	2.2	1.5	0.7	0.7	0.4	0.2	13.8

Experimental Design= RCB with 3 Replications

[1]Loc 1= Amundson Brothers Farm north of Wannaska, MN in Roseau county.
120 lbs/A N applied preplant incorporate to spring wheat underseeded with perennial ryegrass.

[2]Loc 2=Helmstetter farm north of Roosevelt, MN inLake of the Woods county.
14lbs/A N applied with Amity drill at planting on 4-24-2012

[3] Yields corrected to 12% Moisture

[4]RCI- Relative chlorophyll index- Higher number = more chlorophyll in measured plant material only at location 2 on July 24, 2012 at the hard dough stage.

Table 5. Water logged soil nitrogen utilization of spring wheat underseeded with perennial ryegrass
Magnusson Research Farm- Roseau,Mn.

Treatment	Yield	Protein	Test Weight	Lodging[2] 7/31/2012	Height 7/10/2012	RCI[3] 7/2/2012	RCI[3] 7/20/2012	Flag leaf samples taken 7/7/2012 (anthesis) N	P	K	S	Ca	Mg	Zn	Fe	Mn	Cu	B	Cl
	Bu./ac[1]	%		score	in.			%						ppm					
100% Urea	**66.8**	12.6	61.0	4.0	34.0	752	185	3.4	0.235	1.515	0.30	0.47	0.505	13.5	111.5	23.0	7.0	11.5	0.38
75% Urea+25% ESN	**69.0**	12.9	61.0	3.8	33.8	761	215												
50% Urea+50% ESN	**68.5**	12.2	60.8	4.0	34.8	748	139	3.5	0.245	1.780	0.30	0.46	0.465	15.0	109.5	31.5	7.0	10.0	0.53
25% Urea+75% ESN	**71.1**	12.7	60.9	4.5	35.0	802	173												
100% ESN	**71.9**	12.5	61.0	4.3	34.0	786	168	3.4	0.250	1.715	0.32	0.48	0.500	14.5	111.5	21.5	7.0	12.0	0.47
LSD at 5 % Level	**3.3**	0.6	NS	1.1	0.9	NS	51	NS	NS	0.26	NS	NS	NS	NS	NS	NS	NS	1.75	NS
CV(%)	**3.1**	3.2	0.5	18.2	1.8	8.4	18.9	6.3	2.9	3.6	9.4	16.6	11.8	2.8	6.7	15.5	11.7	3.7	12.4

Planting Date- 4/24/2012.
Plot Design= RCB with 4 Replications.

[1]Yields adjusted to 12% moisture. Hail damage measured on per plot basis by seed count on ground prior to harvest (averaged 0.9 bu/plot)

[2]Lodging-1= Erect; 9=Flat.

[3]RCI=Relative Chlorophyll Index -larger number=more chlorophyll.

Table 6. Urea versus ESN fertilizers applied at different dates and rates to Arctic Green perennial ryegrass. Magnusson Research farm

Trt#	Fertilizer Treatment	2013 Seed Yield		Vigor	RCI[4]		Harvest	
		% of mean	lbs/A	7/1/13	7/1	7/15	Ht.(in.)	Date
1	100% urea -Spring	**97.8**	1100	8.5	403	309	22	28-Jul
2	75% urea+25% ESN -Spring	**111.1**	1250	8.5	456	300	21	28-Jul
3	50% ESN-Fall + 50% urea-Spring	**106.8**	1201	8.5	416	280	21	24-Jul
4	100% ESN-Fall	**91.1**	1025	7.8	376	255	20	24-Jul
5	100% urea-Fall	**93.4**	1051	8.3	355	243	19	24-Jul
	LSD @5% Level	**10.4**	117	0.7	46	27	1	0
	CV(%)	6.8	6.8	5.7	7.4	6.3	3.9	0

Experimental Design= RCB with 4 Replications

Grand mean = 1125 lbs/A perennial ryegrass seed

Fertility: 9-30-30-7s applied to all plots 10/18/2012 and a total of 120 lbs/A nitrogen applied to alll plots.

Soil test (4/20/2012): 16 lbs/A P_2O_5, 158 lbs/A K_2O and pH: 7.9.