ANHYDROUS AMMONIA; COLD LIQUID vs HOT GAS SYSTEMS OF APPLICATION

by

W.D. Campbell and G.L. Hnatowich
Agricultural Research & Development Branch
Saskatchewan Wheat Pool

INTRODUCTION

According to Western Canadian Fertilizer Association figures shipments of anhydrous ammonia into Saskatchewan from 1981/82 - 1990/91 accounted for approximately 31% of the nitrogen received. It's prominent usage and producer acceptance can be attributed to its high nitrogen analysis and its comparative low cost. Despite the large usage of anhydrous ammonia, most research has been restricted to the granular forms of nitrogen, understandably, as appropriate small scale ammonia applicators are not available. Field research trials of anhydrous ammonia in western Canada have generally utilized field scale equipment and therefore inherent difficulties associated with experimental size, design and replication occur.

The retention of anhydrous ammonia in soil has been well reviewed (Henry et al.,1979; Broadbent and Stevenson, 1966; Parr and Papendick, 1966). In general, retention can be chemically and physically influenced by such factors as soil moisture, texture, organic matter, buffering capacity, CEC, nitrification capacity and pH. Hogg and Henry (1982) found that in excess of 90% of ammonia applied under field conditions was retained in a 5 cm zone from the point of injection. Therefore the volume of the retention zone will also vary upon the rate, depth and row spacing of application.

Traditionally, anhydrous ammonia application occurs in the hot 'conventional' form whereby the product is handled as a liquid under pressure but reverts to a gas at atmospheric pressure. With this system there is concern of gaseous losses to the above ground atmosphere during and after application. Recently, converter kits have been made available which act to maintain the ammonia in liquid form. The convertors serve as depressurization chambers for hot compressed anhydrous ammonia gas stored in the applicator or nurse tank. Anhydrous ammonia expands in the convertors and in doing so freezes, changing about 85% of the product to liquid. The low pressure liquid is then injected through the applicator by gravity. Proponents of the cold 'liquid' system suggest that with this method ammonia can be applied at shallower depths and atmospheric losses can be reduced. However, the authors have been unable to document research trials conducted in western Canada wherein the two systems have been compared. Consequently, a 3 year research project to evaluate the two systems was established in 1989. Experimental scale application equipment was designed and fabricated to facilitate appropriate testing methodology. Aspects evaluated within the system comparisons include time of application, depth and speed of application and influence of the type of injection opener.

MATERIALS AND METHODS

Field experiments on stubble were initiated in 1989 and concluded in 1991. A total of 14 sites were established within this period. Three sites were located in the dark brown soil zone, all others on black or grey soils. Results of analysis of composite samples of soil collected at each site are given in the appendix. Experimental design or trials was a split split block with six replicates (excepting the 1990 Watson location which contained four replicates).

At each location several individual trials were conducted. In experiments evaluating tillage (preworked vs no preworking) the pretillage operation was performed prior to the application of anhydrous fertilizer using a cultivator equipped with shovels to a depth of 5 cm. In depth trials, anhydrous ammonia was applied in both the cold liquid and hot conventional forms at depths of 5.0 cm and 12.5 cm using both injection knives and shovels. Similarly, with speed of application tests, anhydrous ammonia was applied with both systems at speeds of 4 and 8 km/hr, respectively, at a constant depth of 5.0 cm with shovel openers. In all trials fall and spring applications were established. All trials contained appropriate unfertilized treatments.

Anhydrous ammonia was applied at a rate of 57 kg/ha N in all tests. Phosphate fertilizer, as triple superphosphate, was seed placed at the recommended rate established by soil test analysis at each site. Experiments were seeded to barley with a small plot Hoe drill.

SYSTEMS APPLICATOR

A three meter deep tillage cultivator was used as the applicator.

A small anhydrous ammonia tank was mounted on load cells then the entire unit mounted to the cultivator. A ground driven positive displacement Dempster pump was used as the metering system.

The cold liquid convertors were supplied by Triple "J" Custom 83 Ltd. of Melita, Manitoba. One convertor serves four shanks with both the liquid and gas forms. The conversion in the convertors is rated at 85% liquid and 15% gas. The liquid lines were 1.25 cm in diameter and the gas lines were 0.94 cm diameter. One single line ran from the pump manifold to the convertor.

The hot gas system consisted of four 0.94 cm lines that ran directly from the manifold on the pump down to the openers.

The manifold was installed with four quick connecting couplers. This allowed for a quick disconnect of one system or the other.

The shanks where spaced on 30 cm centres. Four shanks where used to give an effective fertilized plot size of 1.2 meters. A Dutch dual liquid gas banding knife and a 32 cm Co-op shovel where used as openers.

Calibration was performed by weighing the tank and the anhydrous ammonia, running the system for 1 km then reweighing the tank and remaining product. This was performed at tank pressures of 45 psi to 100 psi and an outside temperature range of 5 to 25 degrees celsius, replicated numerous times to ensure the output was consistent with weight.

Each system was operated independent of the other.

RESULTS AND DISCUSSION

COLD LIQUID vs HOT GAS

In all trials conducted during the 3 year period grain yields were increased significantly with anhydrous ammonia application, irregardless of the form of anhydrous used.

Individual site analysis and associated statistical analysis are outlined in the appendix. Table 1 summarizes the number of statistically significant differences obtained between the application systems. Table 1 is comprised from a total of 66 individual trials where direct system comparisons were made.

TABLE 1
COLD LIQUID vs HOT GAS APPLICATION
NUMBER OF SIGNIFICANTLY DIFFERENT YIELD RESPONSES

Test	No Yield Difference	Cold > Hot	Hot > Cold
Shovel	19	1	2
Knife	21	0	1
Speed	20	1	1
Total	60	2	4

On the basis of Table 1 it is apparent that, in general, no system favoured the other with respect to grain yield response of barley. Table 2 summarizes the yield of the cold liquid and the hot gas system of application over the three tests.

TABLE 2
COLD LIQUID vs HOT GAS APPLICATION
AVERAGE YIELD KG/HA

Test	Cold Liquid	Hot Gas	Difference
Shovel	2867	2877	10
Knife	2898	2938	40
Speed	2761	2760	1

DEPTH OF PLACEMENT

A total of 44 experiments were conducted evaluating the effect of the injection openers. Table 3 outlines a summary of the individual statistical responses obtained.

In the majority of trials no difference in yield was obtained due to the depth of anhydrous ammonia injection. This suggest's that adequate sealing of the soil was achieved at most sites. However significant yield differences were obtained in 10 trials in which deeper placement of ammonia achieved higher yields than shallow placement when shovel openers were used. This was not as frequently observed when knife openers were utilized. Results suggest that potential losses may be higher when shovels are used at shallow depths for ammonia application, or that the shallow depth resulted in higher seedbed moisture loss. As ammonia is lost during air drying (Blue and Eno, 1954), tillage effects on seed bed moisture loss could be a factor with shallow shovel injection.

TABLE 3
INJECTION OPENER vs DEPTH OF PLACEMENT
NUMBER OF SIGNIFICANT SITE DIFFERENCES IN YIELD

Injection Opener	No Difference	5.0 cm > 12.5 cm	12.5 cm> 5.0 cm
Shovel	12	0	10
Knife	20	1	1
Total # Tirals	32	1	11

Table 4 outlines the effect depth had on mean yield obtained with each opener.

TABLE 4
DEPTH OF PLACEMENT OF ANHYDROUS AMMONIA
YIELD KG/HA

Injection Opener	5.0 cm Depth	12.5 cm Depth	Yield Difference
Shovel	3113	3403	290
Knife	3370	3309	(61)

The effect of the anhydrous ammonia system used with respect to depth and injection opener is shown in Table 5.

TABLE 5
AMMONIA SYSTEM, DEPTH AND OPENER
YIELD KG/HA

	Shovel		Knife		
System	5.0 cm	12.5 cm	5.0 cm	12.5 cm	Avg.
Cold Liquid	3080	3459	3328	3317	3296
Hot Gaseous	3147	3346	3413	3302	3302
Difference	(67)	113	(85)	15	(6)

Analysis of variance indicated there was no interaction between the system, depth or type of opener. Highest yields were, however, obtained when the cold liquid system was used at deeper depths using a shovel. Yield differences obtained with this difference would however be insufficient in terms of the additional fuel, horsepower and wear on equipment necessary to obtain this depth of placement with shovel openers.

PREWORKED VS NON WORKED

Pretillage operations prior to fertilization and seeding did not influence grain yield. Preworked treatments produced an average yield of 2919 kg /ha (mean of time and system of application, and opener). Comparative non tillage treatments produced a mean yield of 2881 kg/ha. Analysis of variance procedures indicated than in all trials, save one, pretillage operations had no significant effect on grain yield. At the Watrous location in 1990 pretillage prior to fertilization significantly reduced grain yield. At this location only 40% of normal precipitation occurred during May, pretillage exasperated the early season moisture deficit.

TIME OF APPLICATION; FALL VS SPRING

Table 6 outlines the average yields of the openers with fall and spring applications.

TABLE 6
EFFECT OF OPENERS AND TIME
YIELD KG/HA

Opener	Fall	Spring	Avg.
Shovel	2917	2828	2873
Knife	2899	2937	2918
Average	2908	2883	

Generally very little difference in grain yield was obtained due to the time of application or type of injection opener used. Spring applications utilizing a shovel or sweep type opener resulted in slightly lower yields, due to the increased soil disturbance associated with this type of opener seedbed moisture loss may have been influenced. Although average yields for time of application were comparable it should be noted that time of application did tend to vary depending upon year and location. In general spring applications in 1991 were superior to fall due to the optimal growing conditions throughout the season. During this season fall applied ammonia may have been subject to denitrification or leaching losses or both. During 1989 when less than favourable environmental conditions prevailed fall applications of anhydrous achieved greater yields than comparative spring applications. These results concur with ammonia trials conducted in the northern U.S., and are similar to granular fertilizer responses obtained to fall and spring application in Saskatchewan (Walsh, 1970; Chalk et al.,1975; Hnatowich et al.,1988).

SPEED OF APPLICATION

Table 7 outlines the average yield of barley as affected by two speeds of application and form of ammonia.

TABLE 7
EFFECT OF SYSTEM AND SPEED OF APPLICATION
YIELD KG/HA

Type of System	Speed of Application 4 km/hr	8 km/hr
Liquid	3140	3124
Gas	3133	3122

Neither ammonia system appeared to be adversely affected by doubling the speed of application. At higher speeds soil is thrown farther from the opener and losses of ammonia might be expected to be greater. In these trials either proper sealing of the soil occurred, speed did not greatly disturb the soil or the amount of ammonia retained was sufficient to achieve optimal yields.

ACKNOWLEDGEMENTS

The authors would like to gratefully acknowledge financial funding from the Westco/Pool Agronomy Fund.

LITERATURE CITED

Blue, W.G., and C.F. Eno. 1954. Distribution and retention of anhydrous ammonia in sandy soils. Soil Sci. Soc. Am. Proc. 12: 157-164.

Broadbent, F.E., and F.J. Stevenson. 1966. Organic matter interactions. p. 169-187. In M.H. McVicker et al. (ed.) Agriculture anhydrous ammonia technology and use. Agric. Ammonia Inst., Memphis, Tenn.

Chalk, P.M., D.R. Keeney, and L.M. Walsh. 1975. Crop recovery and nitrification of fall and spring applied anhydrous ammonia. Agron. J. 67: 33-37.

Henry, J.L., T.J. Hogg, and E.A. Paul. 1979. The effect of anhydrous ammonia on soil. p. 34-57. In Proceedings of the 1979 Soils and Crops Workshop. Saskatoon Sask.

Hnatowich, G.L., J.T. Harapiak, and N.A. Flore. 1988. Soil conservation through extended crop rotations - effective fertilizer applications. p. 308-330. In Proceedings of the 1988 Soils and Crops Workshop. Saskatoon, Sask.

Hogg, T.J., and J.L. Henry. 1982. The ammonia content in soils following field application of anhydrous ammonia. Can. J. Soil Sci. 62: 213-216.

Parr, J.F., Jr., and R.I. Papendick. 1966a. Retention of ammonia in soils. p. 213-236. In M.C. McVicker et al. (ed.) Agriculture anhydrous ammonia technology and use. Agric. Ammonia Inst., Memphis, Tenn.

Walsh, L.M. 1970. Lets take another look at fall fertilization. Crops and Soils Magazine 22(9): 8-9.

Appendices 1:

SOIL TEST ANALYSIS

Location	Year	Depth cm	Texture	pH	Cond. mS/m	NO_3-N	P	K_2O	SO_4-S
Denholm	89	0-15	Loam	7.2	0.3	14	19	415	27
		15-30	Loam	7.3	0.3	10			21
		30-60	Clay L	7.8	0.3	11			29
Nipawin	89	0-15	Loam	8.2	9.0	16	15	123	27+
		15-30	Loam	8.2	1.5	9			27+
		30-60	Loam	8.4	0.9	5			54+
Prince Albert	89	0-15	Sandy L	7.7	2.3	135+	33	168	24
		15-30	Sandy L	7.9	2.4	84			24
		30-60	Sandy L	8.0	1.4	56			24
Denholm	90	0-15	Loam	6.7	0.4	9	25	617	17
		15-30	Loam	6.7	0.2		6		12
		30-60	Loam	6.9	0.4		3		42
Paddockwood	90	0-15	Loamy S	6.8	0.2	3	20	247	14
		15-30	Sandy L	7.3	0.2	3			12
		30-60	Sandy L	7.7	0.3	6			18
Watrous	90	0-15	Clay L	7.8	0.4	17	24	695	27+
		15-30	Clay L	6.3	0.6	19			27+
		30-60	Clay L	7.6	3.1	7			54+
Watson	90	0-15	Loamy S	7.4	0.3	11	22	280	14
		15-30	Loamy S	7.5	0.2	7			11
		30-60	Loamy S	7.9	0.3	15			27
Beatty	91	0-15	Clay L	6.8	0.6	5	19	570	8
		15-30	Clay	7.0	0.1	3			7
		30-60	Clay	7.3	0.5	5			28
Denholm	91	0-15	Loam	6.7	0.2	3	24	520	9
		15-30	Loam	7.4	0.2	2			9
		30-60	Loam	7.9	0.7	4			48
Paddockwood	91	0-15	Loamy S	7.5	0.2	14	24	110	11
		15-30	Loamy S	7.8	0.2	7			5
		30-60	Loamy S	7.9	0.3	20			25
Watrous	91	0-15	Loam	6.2	0.2	6	28	820	7
		15-30	Clay L	6.8	0.6	6			24
		30-60	Clay L	7.5	2.8	31			48

Appendices 2:

The following outlines the individual site analysis using Duncans Multiple Range analysis. Means with the same letter are not significant at the 5% level. Each site is run independent of the other. No comparison between sites can be made. All are read horizontally.

YIELD RESPONSE DUE TO APPLICATION METHOD KNIFE OPENER

Location	Year	Cold Liq	Conventional
		Yield kg/ha	
		Fall	
Denholm	89	3306 A	3269 A
Nipawin	89	3826 A	3863 A
Prince Albert	89	3196 A	3167 A
Denholm	90	2251 A	2247 A
Paddockwood	90	3068 B	3197 A
Watrous	90	2825 A	2770 A
Watson	90	3059 A	3091 A
Beatty	91	2703 A	2777 A
Denholm	91	2343 A	2312 A
Paddockwood	91	1756 A	1780 A
Watrous	91	3626 A	3721 A
		Spring	
Denholm	89	3133 A	3219 A
Nipawin	89	3716 A	3809 A
Prince Albert	89	3458 A	3628 A
Denholm	90	2129 A	1915 B
Paddockwood	90	2369 A	2541 A
Watrous	90	2715 A	2833 A
Watson	90	2711 A	2714 A
Beatty	91	2612 A	2550 A
Denholm	91	2566 A	2626 A
Paddockwood	91	2593 A	2667 A
Watrous	91	3969 A	3955 A

YIELD OF BARLEY
AT VARIOUS DEPTH OF
PLACEMENT OF ANHYDROUS AMMONIA
KNIFE OPENER

		Yield kg/ha			
		Fall			
		NH_3 at		Check at	
Location	**Year**	**4 cm**	**12.5 cm**	**4 cm**	**12.5 cm**
Denholm	89	3907 A	3993 A	2640 B	2588 B
Nipawin	89	4145 B	4354 A	3328 D	3548 C
Prince Albert	89	3334 A	3141 AB	2995 B	3240 AB
Denholm	90	2672 A	2861 A	1738 B	1726 B
Paddockwood	90	3813 A	3915 A	2454 B	2385 B
Watrous	90	2963 A	2717 A	2775 A	2732 A
Watson	90	3147 AB	3268 A	3088 AB	2870 B
Beatty	91	3254 A	3095 A	2436 B	2175 C
Denholm	91	3090 A	3188 A	1621 B	1412 C
Paddockwood	91	2308 A	2056 B	1327 C	1425 C
Watrous	91	4138 A	3985 A	3217 B	3365 B
		Spring			
Denholm	89	3796 A	3710 A	2572 B	2598 B
Nipawin	89	4083 A	3994 AB	3328 C	3627 BC
Prince Albert	89	3627 A	3447 A	3531 A	3568 A
Denholm	90	2788 A	2532 A	1318 B	1449 B
Paddockwood	90	3029 A	3308 A	1713 B	1722 B
Watrous	90	3002 A	2662 A	2629 A	2812 A
Watson	90	3157 A	3306 A	2593 B	2675 B
Beatty	91	3079 A	3126 A	2008 B	2112 B
Denholm	91	3483 A	3504 A	1713 B	1686 B
Paddockwood	91	3000 A	2980 A	2083 C	2479 B
Watrous	91	4174 A	4047 AB	3829 BC	3799 C

PREWORKED VERSUS NON-PREWORKED
PRIOR TO NH_3 APPLICATION
KNIFE OPENER

Location	Year	Yield kg/ha Fall Preworked	Not
Denholm	89	3303 A	3272 A
Nipawin	89	3783 A	3909 A
Prince Albert	89	3336 A	3025 B
Denholm	90	2252 A	2246 A
Paddockwood	90	3247 A	3036 A
Watrous	90	2577 B	3014 A
Watson	90	3159 A	2988 A
Beatty	91	2783 A	2698 A
Denholm	91	2354 A	2301 A
Paddockwood	91	1869 A	1666 A
Watrous	91	3782 A	3562 A
		Spring	
Denholm	89	3202 A	3145 A
Nipawin	89	3890 A	3638 A
Prince Albert	89	3601 A	3485 A
Denholm	90	2054 A	1990 A
Paddockwood	90	2589 A	2326 A
Watrous	90	2527 B	3024 A
Watson	90	2743 A	2682 A
Beatty	91	2700 A	2462 A
Denholm	91	2575 A	2619 A
Paddockwood	91	2669 A	2589 A
Watrous	91	3939 A	3985 A

YIELD RESPONSE DUE TO APPLICATION METHOD SHOVEL OPENER

		Yield kg/ha	
		Fall	
Location	Year	Cold Liq	Conventional
Denholm	89	3244 A	3072 A
Nipawin	89	4020 A	3784 B
Prince Albert	89	3199 A	3213 A
Denholm	90	2106 A	2160 A
Paddockwood	90	2893 A	2982 A
Watrous	90	2855 A	2650 B
Watson	90	3095 A	3091 A
Beatty	91	2747 A	2799 A
Denholm	91	2165 A	2231 A
Paddockwood	91	2019 A	1998 A
Watrous	91	4025 A	4035 A
		Spring	
Denholm	89	3062 A	3004 A
Nipawin	89	3221 A	3378 A
Prince Albert	89	3211 A	3265 A
Denholm	90	1839 B	2011 A
Paddockwood	90	2627 B	2909 A
Watrous	90	2825 A	2770 A
Watson	90	2889 A	2984 A
Beatty	91	2569 A	2556 A
Denholm	91	2619 A	2488 A
Paddockwood	91	2105 A	2143 A
Watrous	91	3925 A	3849 A

YIELD OF BARLEY
AT VARIOUS DEPTH OF
PLACEMENT OF ANHYDROUS AMMONIA
SHOVEL OPENER

		Yield kg/ha			
		Fall			
		NH_3 at		Check at	
Location	Year	4 cm	12.5 cm	4 cm	12.5 cm
Denholm	89	3530 B	3908 A	2716 C	2547 C
Nipawin	89	3961 AB	4200 A	3641 C	3775 BC
Prince Albert	89	3506 A	3395 A	2980 B	2918 B
Denholm	90	2872 A	2777 A	1357 B	1468 B
Paddockwood	90	3276 B	3895 A	2301 C	2242 C
Watrous	90	2540 B	3266 A	2656 B	2612 B
Watson	90	3147 AB	3268 A	3088 AB	2870 B
Beatty	91	3044 A	3113 A	2584 B	2552 B
Denholm	91	2565 B	3131 A	1529 C	1567 C
Paddockwood	91	1959 B	2592 A	1720 B	1761 B
Watrous	91	4162 AB	4321 A	3878 BC	3760 C
		Spring			
Denholm	89	3303 B	3812 A	2500 C	2473 C
Nipawin	89	3280 B	4080 A	3097 BC	2757 C
Prince Albert	89	3137 B	3400 A	3253 AB	3172 B
Denholm	90	2244 A	2497 A	1594 B	1336 B
Paddockwood	90	3052 B	3674 A	2156 C	2191 C
Watrous	90	2963 A	2717 A	2775 A	2733 A
Watson	90	3157 A	3306 A	2593 B	2675 B
Beatty	91	2909 A	3088 A	2168 B	2085 B
Denholm	91	3299 B	3627 A	1643 C	1644 C
Paddockwood	91	2770 A	2663 A	1615 B	1448 B
Watrous	91	3982 AB	4031 A	3658 B	3878 AB

PREWORKED VERSUS NON-PREWORKED PRIOR TO NH_3 APPLICATION SHOVEL OPENER

Location	Year	Yield kg/ha Fall Preworked	Not
Denholm	89	3198 A	3105 A
Nipawin	89	3898 A	3892 A
Prince Albert	89	3218 A	3195 A
Denholm	90	2057 A	2208 A
Paddockwood	90	2987 A	2888 A
Watrous	90	2718 A	2787 A
Watson	90	2999 A	3187 A
Beatty	91	2846 A	2800 A
Denholm	91	2238 A	2158 A
Paddockwood	91	2124 A	1892 A
Watrous	91	4127 A	3934 A
		Spring	
Denholm	89	3056 A	3011 A
Nipawin	89	3375 A	3221 A
Prince Albert	89	3145 A	3332 A
Denholm	90	2039 A	1811 B
Paddockwood	90	2855 A	2682 A
Watrous	90	2577 B	3014 A
Watson	90	2953 A	2913 A
Beatty	91	2597 A	2528 A
Denholm	91	2517 A	2589 A
Paddockwood	91	2188 A	2060 A
Watrous	91	3860 A	3915 A

YIELD OF BARLEY AS AFFECTED BY SPEED OF ANHYDROUS AMMONIA APPLICATOR

Location	Year	Applict Date Fall vs Spring	Yield kg/ha NH_3 at 4 km/hr	Yield kg/ha NH_3 at 8 km/hr	Yield kg/ha Check at 4 km/hr	Yield kg/ha Check at 8 km/hr
Denholm	89	spring	4131 A	4048 AB	3811 B	3923 AB
Nipawin	89	spring	3480 A	3357 A	2587 B	2589 B
Prince Albert	89	spring	3640 A	3673 A	3311 C	3387 BC
Denholm	90	spring	2706 A	2978 A	1324 B	1389 B
Paddockwood	90	spring	3079 A	2132 A	2021 B	1828 B
Watrous	90	spring	2057 A	1965 A	1935 A	1887 A
Watson	90	spring	3042 A	3281 A	2569 B	2395 B
Beatty	91	spring	2985 A	3015 A	2110 B	2188 B
Denholm	91	spring	3004 A	3118 A	1628 B	1655 B
Paddockwood	91	spring	3142 A	3048 A	2142 B	2069 B
Watrous	91	spring	3775 A	3733 A	3372 B	3388 B
Denholm	89	fall	3410 A	3380 A	2770 B	2765 A
Nipawin	89	fall	3732 A	3582 A	3138 A	3157 A
Prince Albert	89	fall	3736 A	3681 A	3150 B	2987 B
Denholm	90	fall	2665 A	2710 A	1352 B	1348 B
Watson	90	fall	2664 A	2687 A	2339 B	2122 B
Watrous	90	fall	2207 A	1967 AB	1904 B	1851 B
Beatty	91	fall	3223 A	3208 A	2371 B	2360 B
Denholm	91	fall	2676 A	2761 A	1546 B	1593 B
Paddockwood	91	fall	2747 A	2678 AB	2361 BC	2324 C
Watrous	91	fall	3445 A	3446 A	3409 A	3332 A

BARLEY YIELDS AS AFFECTED BY DIFFERENT ANHYDROUS AMMONIA APPLICATION SYSTEMS SPEED TEST

		Yield kg/ha	
		Fall	
Location	**Year**	**Cold Liq**	**Conventional**
Denholm	89	3051 A	3105 A
Nipawin	89	3397 A	3416 A
Prince Albert	89	3332 A	3445 A
Denholm	90	2007 A	2030 A
Paddockwood	90	2534 A	2413 A
Watrous	90	2011 A	1956 A
Watson	90	2483 A	2423 A
Beatty	91	2840 A	2777 A
Denholm	91	2163 A	2140 A
Paddockwood	91	2534 A	2519 A
Watrous	91	3433 A	3435 A
		Spring	
Denholm	89	2965 A	3042 A
Nipawin	89	4091 A	3863 B
Prince Albert	89	3514 A	3548 A
Denholm	90	2106 A	2068 A
Paddockwood	90	2450 A	2567 A
Watrous	90	1960 A	1956 A
Watson	90	2854 A	2790 A
Beatty	91	2525 A	2625 A
Denholm	91	2404 A	2312 A
Paddockwood	91	2485 A	2715 A
Watrous	91	3528 B	3596 A

PREWORKED VERSUS NON-PREWORKED
YIELD OF BARLEY KG/HA
SPEED TEST

		Yield kg/ha	
		Fall	
Location	Year	Preworked	Not
Denholm	89	3473 A	3309 A
Nipawin	89	3398 A	3415 A
Prince Albert	89	3064 A	3092 A
Denholm	90	2086 A	1952 A
Paddockwood	90	2502 A	2445 A
Watrous	90	1822 A	2148 A
Watson	90	2457 A	2449 A
Beatty	91	2904 A	2677 A
Denholm	91	2257 A	2053 A
Paddockwood	91	2689 A	2365 A
Watrous	91	3574 A	3287 A
		Spring	
Denholm	89	3042 A	2964 A
Nipawin	89	4055 A	3900 A
Prince Albert	89	3582 A	3483 A
Denholm	90	2129 A	2047 A
Paddockwood	90	2658 A	2357 A
Watrous	90	1705 B	2216 A
Watson	90	2827 A	2817 A
Beatty	91	2665 A	2489 A
Denholm	91	2339 A	2378 A
Paddockwood	91	2715 A	2485 A
Watrous	91	3639 A	3486 A