Nitrogen Fertilizer Placement
An Important Component in the 4R Nutrient Stewardship

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Introduction

The 4R Nutrient Stewardship (Right Source applied at the Right Rate, Time and Place) should be the guiding principle in fertilizing crops. The fertilizer industry's nutrient stewardship concept links management of plant nutrition to sustainability. The fertilizer 4R's are connected to the goals of sustainable development (Fig. 1). For stakeholders, the 4Rs support an accurate understanding of the big picture, even for those who may not understand all the details of managing crop nutrients.

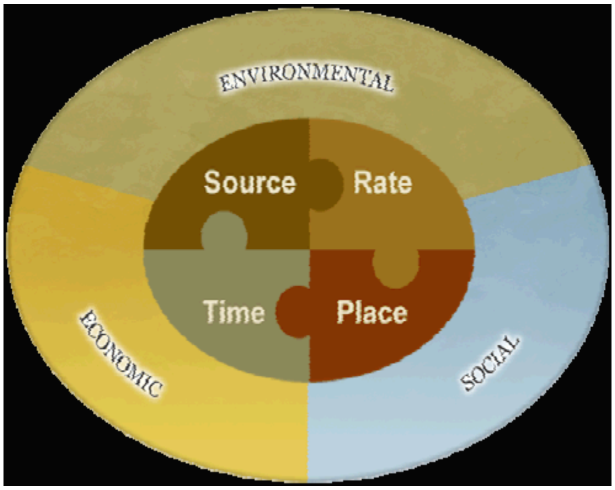

Figure 1. The 4R nutrient stewardship concept defines the right source, rate, time, and place for fertilizer application as those producing the economic, social, and environmental outcomes desired by all stakeholders to the plant ecosystem (Bruulsema, 2009)

Placement is an important component of the 4R nutrient stewardship, especially since fertilizer management practices need to adapt to the ever increasing trend in conservation farming that includes zero till and direct seeding as common practices. Generally, there are four methods of precision placement of fertilizer at seeding time, namely, placement of fertilizer directly with the seed, side-banding, midrow banding and paired row placement (Fig. 2).

Application of (N) directly with the seed can result in very efficient crop uptake of the applied nutrients. Some of the main factors that affect the decision for placing fertilizer N with the seed are listed in Table 1 along with some generalized conditions that render seed-placement a favourable or unfavourable practice. However, in most cases, the amount of N that can be applied in this manner is insufficient to obtain optimum/maximum yields. Further, excessive amounts of seedrow-applied N cause seed and seedling damage that can result in a delay in crop maturity and reduced yields. Karamanos et al. (2008a) suggested a modification of the existing

(Saskatchewan Agriculture and Food 2006) guidelines for safe seedrow N placement under "favourable" conditions based on spring moisture conditions and soil organic matter and attempted to quantify "favourable". This research resulted in the development of a safe rate seedrow N placement calculator (available from the author) and modified guidelines (Fig. 3; Table 2).

Table 1. General factors that can influence decisions to place N in the seedrow

Factor	Favourable	Unfavourable
Crop Grown	Cereals	Oilseeds, Pulses
Seedbed Moisture	Good, Moist	Poor or Dry
Soil Texture	High Clay Content	Sandy Soils
Type of Opener	Wide Spread	Confined Rows
Row Spacing	Narrow (6")	Wide (9-12")
Uniformity of Field	Uniform Landscape	Rolling, Eroded Hilltops
N source	Ammonium Nitrate	Urea
Free Lime in Soil	Absent or Low	Moderate to High
Soil Organic Matter	High OM Level	Llow OM Level
Seeding Depth	Shallow (to moisture)	Deep

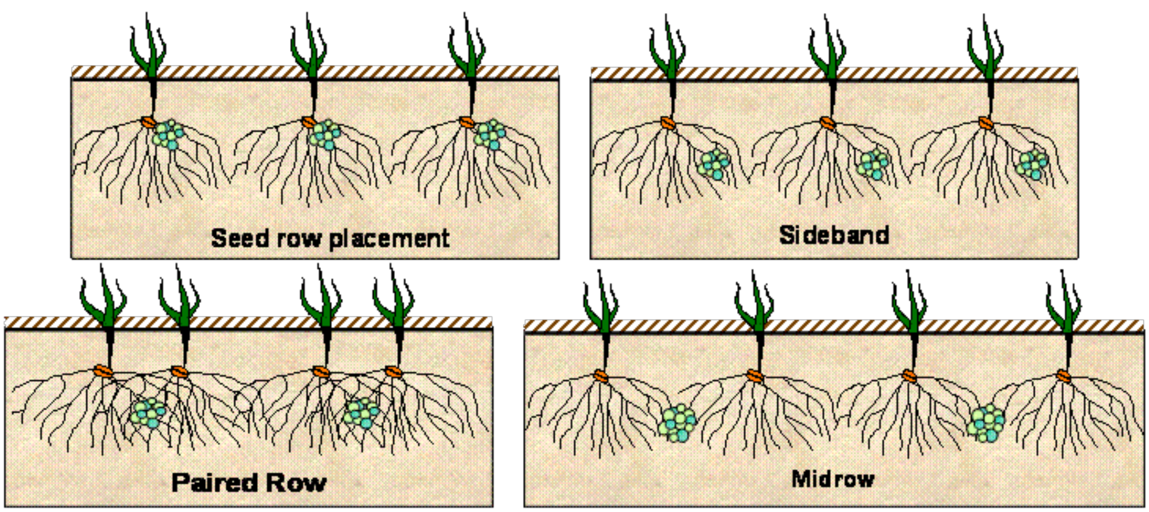

Figure 2. Common precision N placement techniques.

Placement of Liquid vs. Dry N Fertilizer

Often it is received that the fertilizer use efficiency of liquid is greater than that of dry fertilizers and that with liquid fertilizer it is possible to put more nutrition closer to the seed than with dry. Although this would be true when liquid fertilizer is applied with the seed in wide spread (2-inch) seedrow (Fig. 4), placement of liquid N fertilizer in narrow seedrow (11% SBU) is just as damaging as that of UREA (Fig. 5).

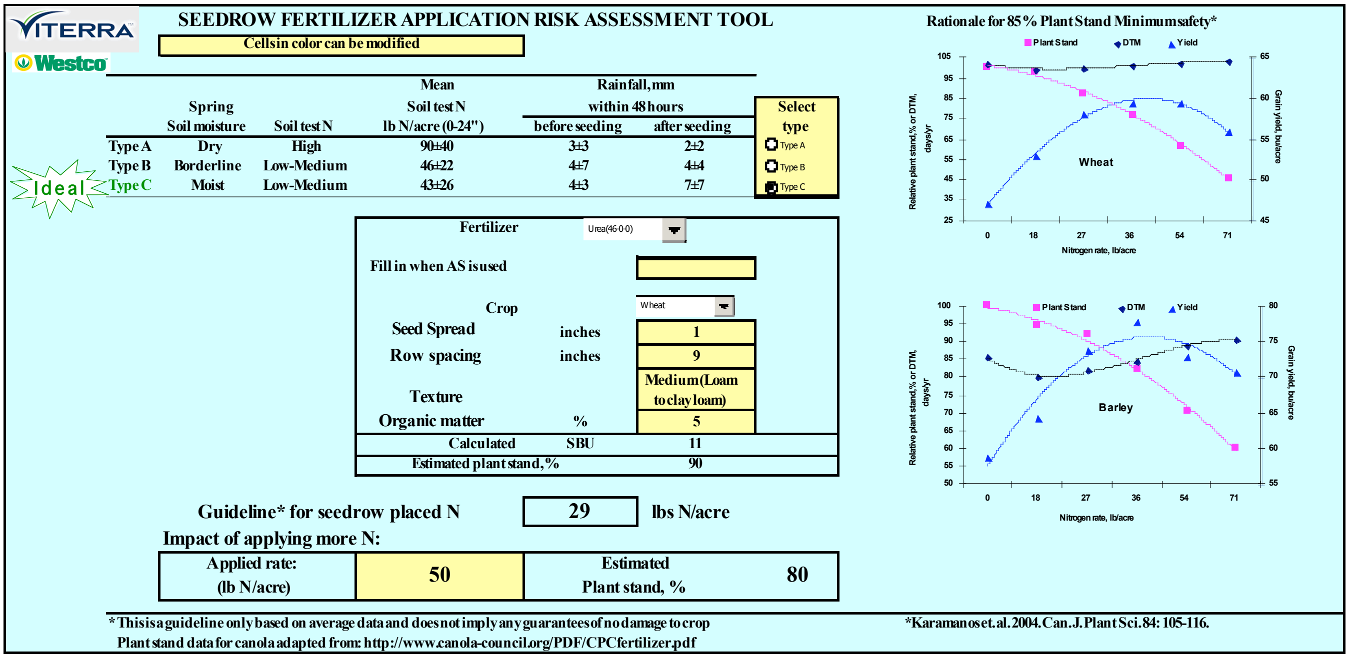

Figure 3. View of a tool developed to derive safe seedrow placed N rates with common crops in western Canada (Karamanos et al. 2008b).

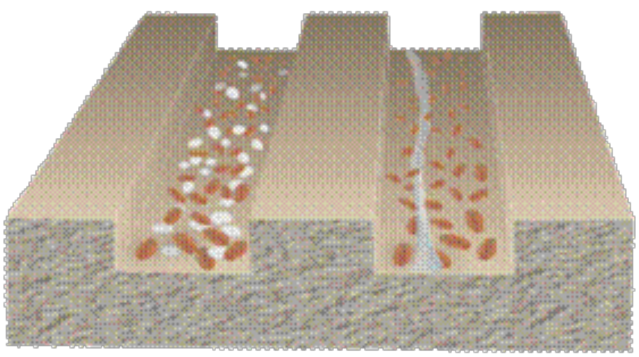

Figure 4. Liquid fertilizer applied in wider bands, e.g., 2” width is less injurious to seeds, as a seed has a greater probability to be adjacent to a 46-0-0 granule(left) than to the “stream” of 28-0-0 (right).

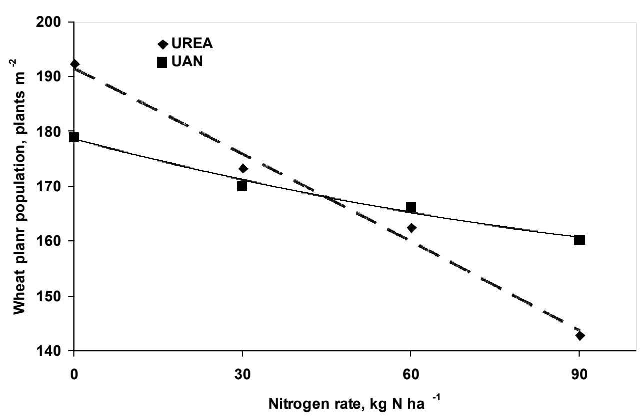

Figure 5. Effect of UREA (46-0-0) and urea ammonium nitrate (UAN, 28-0-0) placed directly with the seed in a narrow (11% SBU) seedrow on the plant population of wheat (Karamanos, unpublished data).

Table 2. Comparison of the generally accepted guidelines for safe rates of fertilizer placed with the seed in Saskatchewan (Saskatchewan Agriculture and Food 2006) and those derived from Karamanos et al. (2008a).

	1 inch spread[1]			2 inch spread[1]			3 inch spread[1]		
	(disc or knife)[2]			(spoon or hoe)			(sweep)		
	Row spacing			Row spacing			Row spacing		
	6”	9”	12”	6”	9”	12”	6”	9”	12”
	SBU[3]			SBU[3]			SBU[3]		
Soil texture	17%	11%	8%	33%	22%	17%	50%	33%	25%
Light (sandy loam)	20[4]	15	15	30	25	20	40	30	25
Type A	0	0	0	15	10	0	20	15	10
Type B	25	15	15	40	30	25	45	40	35
Type C	40	30	25	65	50	40	70	65	55
Medium (loam to clay loam)	30	25	20	40	35	30	50	40	35
Type A	10	5	5	25	15	10	30	25	20
Type B	35	25	25	50	40	35	55	50	45
Type C	50	40	35	75	60	50	80	75	65
Heavy (clay to heavy clay)	35	30	30	50	40	35	60	50	40
Type A	15	10	10	20	20	15	35	30	25
Type B	40	30	30	55	45	40	60	55	50
Type C	55	45	40	80	65	55	85	80	70

[1]Width of spread varies with air flow, soil type, moisture level, amount of residue and other soil conditions, so it must be checked under field conditions.

[2]Some openers give less than 1” spread.

[3]SBU (Seedbed Utilization) is the amount of the seedbed over which the fertilizer has been spread. Thus, it is a reflection of the relative concentration of fertilizer. SBU (%) is the width of spread divided by the row spacing multiplied by 100. For example, if the seeding implement has a six-inch spacing and spreads the seed and fertilizer over two inches, the SBU would be 2 ÷ 6 x 100 = 33 per cent. The higher the SBU, the more fertilizer that can safely be applied with the seed. Although some openers will also spread seed and fertilizer vertically, SBU does not take this into account, since it is generally recommended that all seed be placed at an even depth for even germination and emergence.

[4] Underlined values represent Saskatchewan Agriculture and Food (2006) guidelines.

The impact of Urea (46-0-0) or Urea Ammonium Nitrated (28-0-0) placed in a variety of ways was assessed in a two-year (1999-2000) program in Saskatchewan (Karamanos, unpublished data). Specifically, 46-0-0 was placed with the seed and side banded one inch to the side and one inch below the seed, whereas 28-0-0 placed with the seed, dribbled banded on the surface or placed off the seed row by ¼ of and inch (Fig. 6). Adhering to the 4R stewardship principle, seed placement of excessive rates of N would result in reduction in seed emergence and plant counts and eventually yield loss and, therefore, should be avoided. Under best management practices (BMP), UREA (46-0-0) may be placed with the seed according with the guidelines described in Table 1 and UAN (28-0-0) can be directly placed with the seed in wider seedrows. The results from the above experiments (Fig. 7) corroborate with these observations and, furthermore, suggest that given the right placement, both UREA and UAN performed equally.

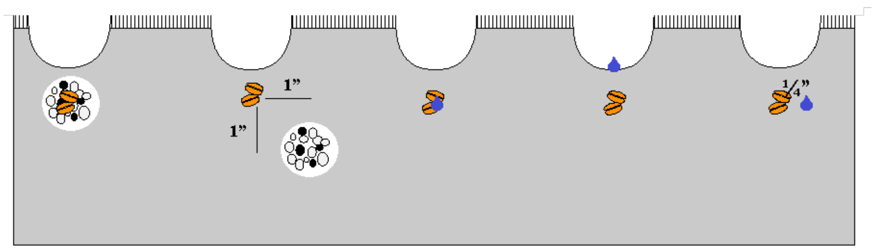

Figure 6. Schematic representation of methods of UREA and UAN placement in the placement experiments.

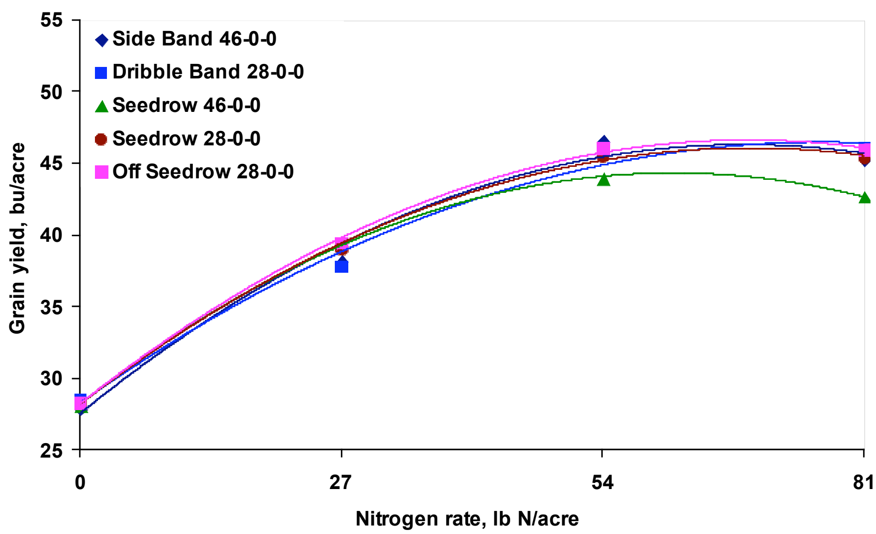

Figure 7. Effect of UREA and UAN placement on the yield of wheat at various fertilizer N rates.

Placement of Enhancement Products

The use of a number of enhanced efficiency products has been advocated in order to overcome the restraint of the rates of N that can be safely placed with the seed. Recent research has focused on two such products in particular, NBPT (commonly Agrotain) and polymer coated urea (ESN).

Reduction in seedling damage when of urea treated with Agrotain® is seed-placed has been attributed to an increase in the duration of urea diffusion away from the seedrow, as a result of the reduction in urea hydrolysis with application of Agrotain® (Malhi et al 2003); it has been shown to occur with a number of crops, such as barley (Grant and Bailey 1999; Pauly et al. 1996), wheat (Xiaobin et al. 1995; Pauly et al. 1996; Malhi et al. 2003), canola (Pauly et al. 1996; Malhi et al. 2003) and corn (Schlegel 1991). Grant and Bailey (1999) observed that improvement in seed-placed urea safety with Agrotain® was dependent on the environmental conditions occurring after seeding. This was verified in a study by Karamanos et al. (2004); however, increase in stand density as a result of less seedling damage was greater in barley (Fig. 8) than wheat (Fig. 9) or canola (Fig. 10). Further, reduction in emergence counts by 15% compared to the control had no impact on either yield or days to maturity. Treating urea with Agrotain® at rates as low as one third of the recommended rate overall produced similar results to those of the recommended rate.

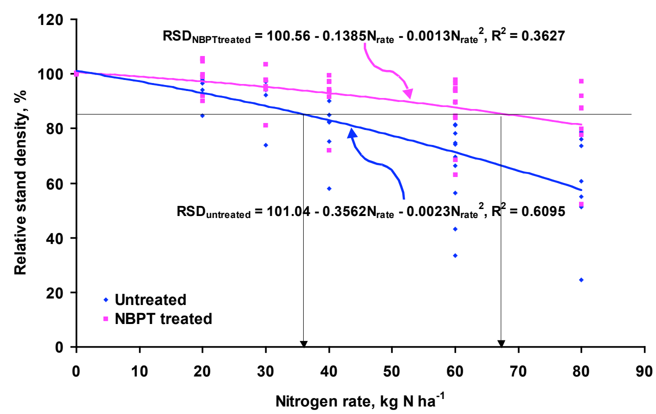

Figure 8. Effect of Agrotain® treatment of urea on the stand density of barley.

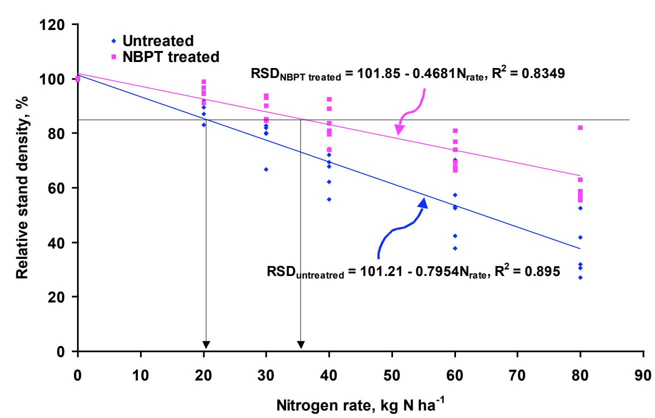

Figure 9. Effect of Agrotain® treatment of urea on the stand density of wheat.

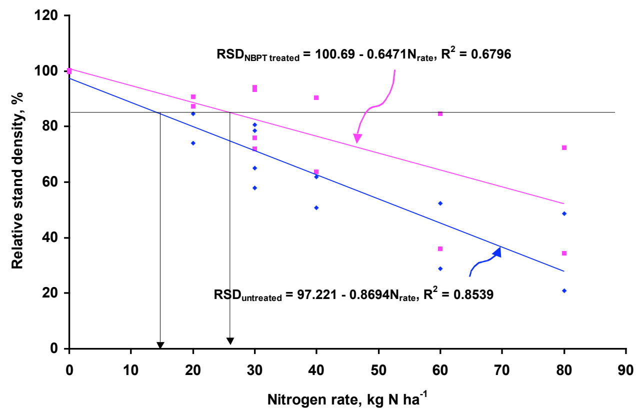

Figure 10. Effect of Agrotain® treatment of urea on the stand density of canola.

General guidelines (Tables 3 and 4) for applying seedrow Agrotain® treated urea N were developed from the above work that based on the following conditions: (a) an application rate of 5.2 litres of Agrotain® per tonne of urea, (b) optimum seedbed preparation, (c) less than 15% seedling damage and (d) no impact on days to maturity. Proper application of Agrotain™ on urea is predicated on following these guidelines.

Table 3. Guidelines for applying seedrow Agrotain® treated urea N with cereals (except hulless barley).

	Maximum Seed-placed rate (lb N/acre as urea)					
	Light Texture S to SL		Medium Texture L to SL		Heavy Texture C to HvC	
SBU	No Agrotain	+Agrotain	No Agrotain	+Agrotain	No Agrotain	+Agrotain
10%	15	25	25	40	30	50
20%	20	30	35	50	40	60
30%	30	40	45	60	50	70

Table 4. Guidelines for applying seedrow Agrotain® treated urea N with canola, flax and hulless barley.

	Maximum Seed-placed rate (lb N/acre as urea)					
	Light Texture S to SL		Medium Texture L to CL		Heavy Texture C to HvC	
SBU	No Agrotain	+Agrotain	No Agrotain	+Agrotain	No Agrotain	+Agrotain
10%	5	15	10	20	15	25
20%	15	25	15	25	25	35
30%	20	35	25	35	35	55

Polymer coated urea (such as ESN) can afford an excellent means to increase safety of N fertilizer placed with the seed. The average effect of blending polymer coated urea with uncoated urea at a rate of 67 lb/acre on the grain yield of barley and wheat are illustrated in Fig. 11 and 12.

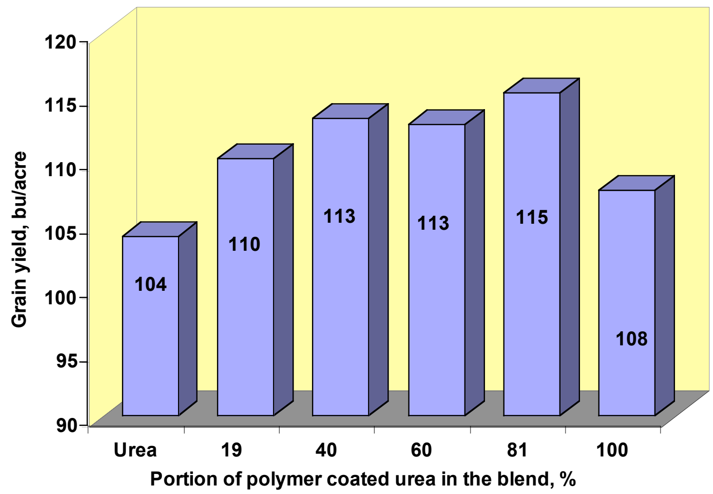

Figure 11. Effect of blending uncoated and polymer coated urea in seedrow placement with SBU of 11% on the yield of barley (Karamanos, unpublished data – nine site years).

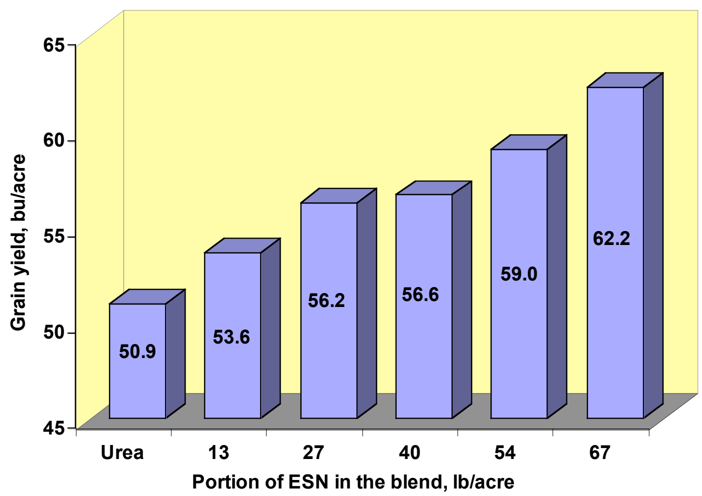

Figure 12. Effect of blending uncoated and polymer coated urea in seedrow placement with SBU of 11% on the yield of wheat (Karamanos, unpublished data – eighteen site years).

Application of Anhydrous Ammonia at Seeding

Successfully applying ammonia at seeding requires good ammonia retention in the soil, seed and fertilizer separation, which are directly associated with the type of opener and soil conditions, and, accurate metering and uniform distribution of ammonia. Factors that can influence good serration between ammonia (Fig. 13) and the seed include opener design (Fig. 14) and condition (Fig. 15), speed of application, spread of ammonia in the zone of application and soil type (texture, CEC and organic matter in particular).

Avoiding "Hot Bands"

A "hot band" is generated as a result of dual banding N and phosphorus (P), or placement of N and P in the same band, when N rates are very high, especially at wider row spacing, which leads to higher N concentrations in the band (Fig. 16). They are a result of the high solubility of N, which tends to dissolve faster than P and create a "hallow" around the P fertilizer granules, thus preventing plant root from reaching P that is trapped in the centre of the hallow.

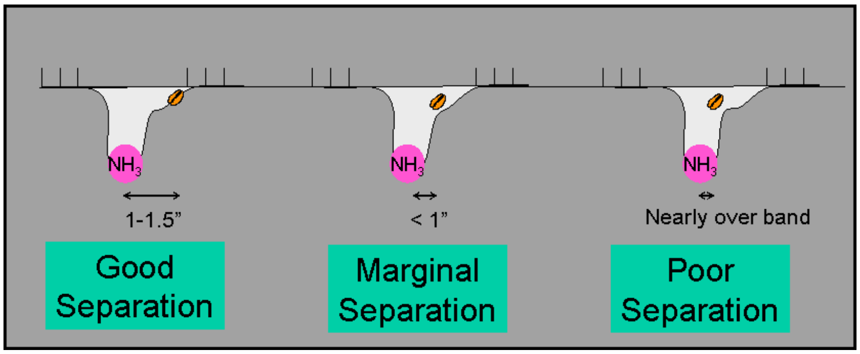

Figure 13. Lateral key separation of ammonia from the seed is key to successful application at seeding.

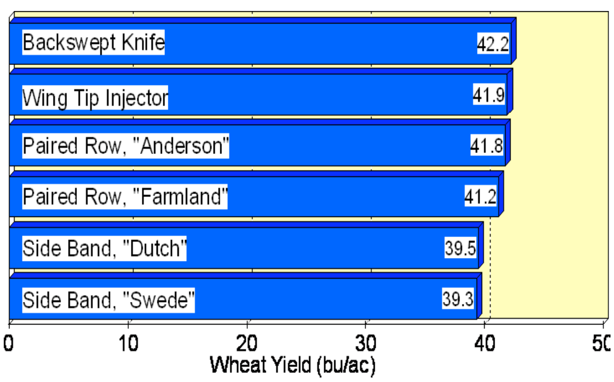

Figure 14. Unpublished data from early 1990's work on impact of openers on application of ammonia with the seed by Westco agronomy.

Figure 15. Worn off openers can lead to reduced separation between fertilizer and seed.

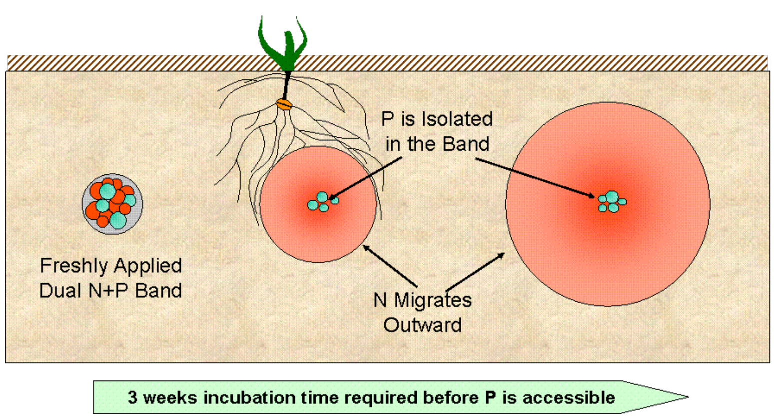

Figure 16. Schematic representation of a "hot band" that leads P being trapped due to the high solubility of N that migrates around the P fertilizer granules in a dual band.

Some general guidelines based on some earlier Westco research are summarized in Table 3.

Table 3. General guidelines of maximum limits over which the probability of creation of a "hot band" increases (Westco, unpublished data)

Row Spacing	Maximum rate (lb/acre)
12	80-90
16	60-70
24	40-45

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