Criteria for Seedrow Nitrogen Placement with Barley and Wheat

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Introduction

Introduction of no-till and direct seeding practices in the western Canadian prairies has resulted in expansion of the practice of placing N fertilizer with the seed. Almost fifty percent (49.5%) of the total seeded acres in western Canada were in no-till according to the 2006 census (Statistics Canada 2006). Greatest percentages were in Saskatchewan and Alberta, where no-till systems accounted for 60 and 48 % of the seeded area, respectively.

Application of nitrogen directly in the seedrow can result in very efficient crop uptake of the applied nutrients. However, in most cases, the amount of nitrogen that can be applied in this manner is insufficient to obtain high yields. Excessive amounts of seedrow-applied nitrogen cause seed and seedling damage that can result in a delay in crop maturity and reduced yields. Current guidelines for seed-row placement of nitrogen in general and urea in particular to avert seedling damage (Bremner 1995) are based on seedbed utilization, soil texture (Saskatchewan Agriculture and Food 2006) and seedbed moisture (Western Cooperative Fertilizers Limited 2002).

It has now become apparent that the suggested guidelines are considered to be excessively restrictive by many farmers. In fact, these guidelines are frequently exceeded by some cereal growers who apply their total N requirement (40 - 70 lbs. N/acre) in this manner with excellent results. However, the farmers who are presently applying higher rates of seedrow N fertilizer have gained a great deal of experience and expertise with this practice.

Current guidelines (Fig. 1, Table 1) are offered based on "favorable conditions", i.e., excellent seedbed moisture, free of lime and salts, uniform soil, good organic matter, seeding depth not excessive, good seed quality. These guidelines are maximum rates of N seedrow placed N as urea and it is commonly accepted that they should be significantly reduced on soils that are low in organic matter or in soils that contain free lime and/or salts in the surface layer; furthermore, that if the seedbed is relatively dry, the maximum amount of seedrow urea-N must be drastically reduced to avoid serious germination damage. However, none of the above recommendations have been quantified for the farmers and often farmers apply N rates far greater that soil and weather conditions warrant. Hence, the objective of this study was to attempt to further refine existing N seedrow guidelines, expand them to non-favorable conditions and develop a simple tool for the farmer to assess the risk of applying N with the seed. Only the spring CWRS wheat and barley data are presented here.

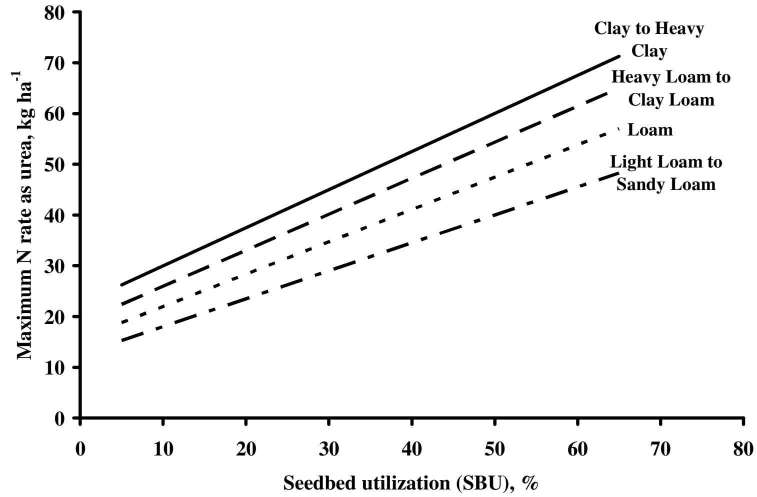

Figure 1. Maximum allowable seedrow placed urea N for cereal crops under favorable conditions (Western Cooperative Fertilizers Limited 2002).

Table 1. Saskatchewan Agriculture and Food (2006) guidelines for safe rates of fertilizer placed with the seed.

Soil texture	1 inch spread[1] (disc or knife)[2]			2 inch spread[1] (spoon or hoe)			3 inch spread[1] (sweep)		
	Row spacing			Row spacing			Row spacing		
	6”	9”	12”	6”	9”	12”	6”	9”	12”
	SBU[3]			SBU[3]			SBU[3]		
	17%	11%	8%	33%	22%	17%	50%	33%	25%
Light (sandy loam)	20	15	15	30	25	20	40	30	25
Medium (loam to clay loam)	30	25	20	40	35	30	50	40	35
Heavy (clay to heavy clay)	35	30	30	50	40	35	60	50	40

[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.

Materials and Methods

Twenty-seven site-years of experiments with CWRS wheat and ten with barley were conducted at 20 different locations in the Canadian Prairie Provinces over four years from 1992 to 1995. The experimental design was a randomized complete block with six replicates that included three seedbed utilization rates, 10, 20 and 40% and five N rates (0, 20, 40, 60 and 80 kg N ha^{-1}). In 1992 and 1994 CWRS wheat was seeded at all sites with a five-row Bander at 20.3-cm (8 inch) spacing, whereas in 1995 a six-row airseeder with 22.5-cm spacing was used. In all cases, phosphate was applied in the seedrow at a rate of 30 kg P_2O_5 ha^{-1}. Each plot was 1.02 m (5 rows) wide and 5.8 m long in 1992-94 and 1.37 m (6 rows) and 6.1 m long in 1995. At maturity, the plots were combined using a Wintersteiger Nurserymaster Elite experimental combine and the grain samples were dried at 60 ^oC by forced air and weighed to determine grain yield.

The experimental results were analyzed statistically with ANOVA procedures using SYSTAT 8.0 (SPSS 1998).

Results and Discussion

Wheat

Analysis of the population of the twenty-seven experiments with CWRS wheat revealed that the results fell into three categories (Types), as follows:

Type A (Fig. 2, Table 2): Essentially there was no impact of fertilizer N rate on the yield of CWRS wheat at wide (40%) SBU, however, application of N at narrow SBU (10 and 20%) resulted in grain yield decreases. Relative plan stand was reduced with application of N in all cases, however, at 40% SBU the reduction was within the limits that no grain yield penalty is anticipated (Karamanos et al. 2004). The experiments that exhibited Type A behavior are included in Table 1.

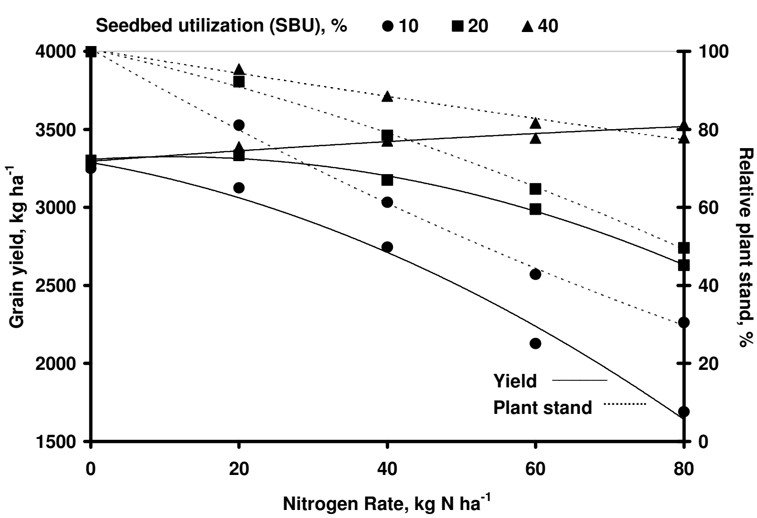

Figure 2. Yield and relative plant stand in Type A experiments.

Table 2. Main characteristics, mean yields and statistical effects for CWRS wheat experiments exhibiting Type A behavior.

Location:		Irricana, AB	Gladstone, MB	Neepawa, MB	Minnedosa, MB	Crossfield, AB	Gladstone, MB	Coaldale, AB	Strathmore, AB
Organic matter, %:		3.6	4	4.3	6.4	8	3.9	2.9	3.8
Texture:		Loam	Sandy Loam	Sandy Loam	Loam	Loam	SL	Loam	Loam
Cultivar:		Conway	Katepwa	Katepwa	Katepwa	Roblin	Roblin	Katepwa	Roblin
Previous crop:		Fallow	Wheat	Wheat	Wheat	Canola	Wheat	Canola	Wheat
Seeding date:		May 3	May 25	May 26	May 23	Apr 30	May 24	Apr 30	May 4
Harvest date:		Sep 19	Sep 24	Sep 24	Oct 5	Oct 1	Sep 30	Aug 29	Aug 24
SBU	10	2075	3065	3120	2398	4452	1960	2223	1416
	20	3245	3436	3477	2529	4632	2410	3175	1787
	40	3649	4054	3829	2690	4682	2656	3630	1924
N rate, kg ha^{-1}	0	3717	4165	3504	2456	4584	2516	3384	1905
	20	3433	4022	3685	2558	4692	2519	3496	1855
	40	2910	3607	3637	2729	4781	2473	3020	1775
	60	2525	3108	3487	2530	4603	2226	2775	1581
	80	2364	2691	3064	2423	4282	1973	2373	1429
Main effects									
Seeding rates		**[1]	**	**	NS	**	**	**	**
SBU		**	**	**	**	**	**	**	**
Seeding X SBU		**	**	**	**	**	**	**	**
Contrasts									
Seeding rate[2]	Linear	**	**	**	NS	**	**	**	**
	Quadratic	NS	NS	**	*	**	**	NS	*
SBU	Linear	**	**	**	**	**	**	**	**
	Residual	**	NS	**	NS	NS	**	**	**
Interactions[3]									
SL X SBUL		**	**	**	**	**	**	**	**
SL X SBUR		*	NS	NS	NS	**	**	**	**

**, *, NS = significant at P<0.1, <.05 and not significant, respectively; [2] cubic and residual were NS; [3] remaining were NS.

Type B (Fig. 3, Table 2): Essentially there was no impact of fertilizer N rate on the yield of CWRS wheat at narrow (10%) SBU, however, application of N at wide SBU (20 and 40%) resulted in grain yield increases up to a point. Relative plan stand essentially remained unaffected at 40% SBU and low N rates, whereas at higher N rates the relative stands of both wider and narrow SBU were gradually reduced. The experiments that exhibited Type B behavior are included in Table 2.

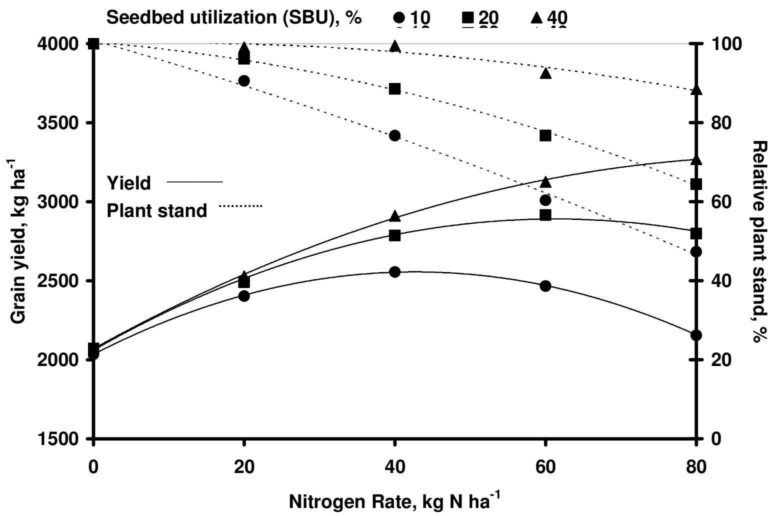

Figure 3. Yield and relative plant stand in Type B experiments.

Type C (Fig. 4): In this Type, application of N resulted in grain yield increases independently of SBU. Relative plan stand remained unaffected at 40% SBU and declined at narrower SBU with high N rates, however, again they remained within the limits that no grain yield penalty is anticipated (Karamanos et al. 2004). The experiments that exhibited Type C behavior are included in Table 3.

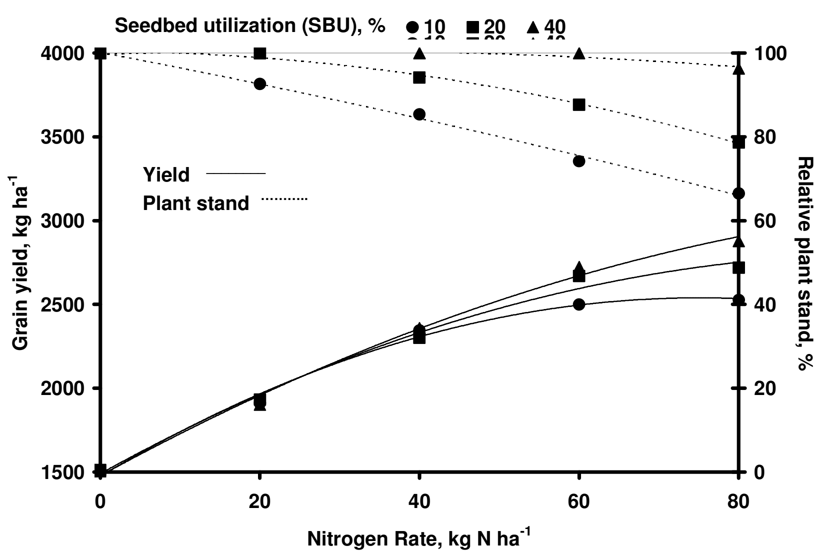

Figure 4. Yield and relative plant stand in Type C experiment.

Table 2. Main characteristics, mean yields and statistical effects for CWRS wheat experiments exhibiting Type B behavior.

		Irricana, AB	Shoal Lake, MB	Yorkton, SK	Yorkton, SK	Irrricana, AB	Minnedosa, MB	Binscarth, MB	Yorkton, SK	Red Deer, AB	Kamsack, SK	Yorkton, SK
Location:		Irricana, AB	Shoal Lake, MB	Yorkton, SK	Yorkton, SK	Irrricana, AB	Minnedosa, MB	Binscarth, MB	Yorkton, SK	Red Deer, AB	Kamsack, SK	Yorkton, SK
Organic matter, %:		3.6	5.8	5.1	4.8	4.1	6.4	5.5	7	8	5.2	5.3
Texture:		L	CL	CL	CL	L	L	L	CL	CL	CL	CL
Cultivar:		Conway	Katepwa	Katepwa	Katepwa	Roblin	Roblin	Roblin	Katepwa	Roblin	Roblin	Roblin
Previous crop:		Wheat	Wheat	Wheat	Wheat	Barley	Wheat	Wheat	Canola	Canola	Peas	Canola
Seeding date:		May 3	May 23	May 27	May 27	May 1	May 24	May 25	May 20	May 11	May 26	May 27
Harvest date:		Sep 19	Oct 7	Oct 8	Oct 8	Sep 11	Sep 30	Sep 26	Sep 24	Sep 9	Sep 14	Sep 13
SBU	10	1533	1840	2032	1967	2888	1383	2057	1849	3555	3706	3574
	20	2200	1758	2471	2188	3055	1530	2188	2152	3889	4411	3741
	40	2441	2012	2566	2320	2938	1814	2347	2333	3990	4748	3930
N rate, kg ha^{-1}	0	1606	1621	1775	1867	1848	1080	1789	1494	3351	4026	2745
	20	2036	1907	2244	2133	2663	1592	2097	1958	3653	4452	3358
	40	2390	2036	2434	2261	3127	1790	2358	2357	3908	4543	3978
	60	2276	1980	2644	2319	3555	1774	2436	2418	4090	4409	4289
	80	1982	1805	2687	2211	3608	1643	2307	2330	4056	4012	4373
							Main effects					
Seeding rates		**[1]	**	**	*	**	**	**	**	**	**	**
SBU		**	**	**	**	**	**	**	**	**	**	**
Seeding X SBU		**	**	**	**	NS	**	**	**	**	**	**
							Contrasts					
Seeding rate[2]	Linear	**	*	**	**	**	**	**	**	**	NS	**
	Quadratic	**	**	**	*	**	**	**	**	*	**	**
SBU	Linear	**	**	**	**	NS	**	**	**	**	**	**
	Residual	**	**	**	**	**	NS	NS	**	**	**	NS
							Interactions[3]					
SL X SBUL		**	**	**	**	NS	**	**	**	**	**	**
SL X SBUR		**	NS	NS	NS	NS	NS	NS	**	**	**	NS
SQ X SBUL		**	*	NS	NS	*	**	**	**	NS	**	NS

[1] **, *, NS = significant at P<0.1, <.05 and not significant, respectively; [2] cubic and residual were NS; [3] remaining were NS.

Table 3. Main characteristics, mean yields and statistical effects for CWRS wheat experiments exhibiting Type C behavior.

		Weteaskiwin, AB	Neepawa, MB	Minnedosa, MB	Irrricana, AB	Yorkton, SK	Carbon, AB	Moose Jaw, SK	Moose Jaw, SK
Organic matter, %:		1.7	4.3	6.4	4.1	7	5.9	4.4	4.4
Texture:		L	SL	L	L	CL	L	C	C
Cultivar:		Roblin	Katepwa	Katepwa	Roblin	Katepwa	Roblin	Roblin	Roblin
Previous crop:		Barley	Wheat	Wheat	Barley	Wheat	Canola	Chem Fallow	Durum wheat
Seeding date:		May 16	May 26	May 23	May 5	May 19	May 4	May 27	May 27
Harvest date:		Sep 17	Sep 24	Oct 6	Sep 11	Sep 24	Aug 23	Sep 18	Sep 12
SBU	10	4109	3940	1253	2888	2399	1478	1969	1956
	20	4207	4106	1217	3055	2446	1580	1965	2132
	40	4213	4464	1291	2938	2518	1639	2111	2181
Nitrogen rate, kg ha^{-1}	0	3676	4146	712	1848	1937	785	1018	1162
	20	4001	4477	972	2663	2175	1211	1654	1616
	40	4321	4394	1382	3127	2622	1621	2133	2178
	60	4477	4069	1518	3555	2755	2049	2643	2602
	80	4407	3764	1685	3608	2782	2163	2627	2889
Main effects									
Seeding rates		**[1]	**	**	**	**	**	**	**
SBU		NS	**	NS	**	NS	*	**	**
Seeding X SBU		NS	**	*	NS	NS	NS	**	**
Contrasts									
Seeding rate[2]	Linear	**	**	**	**	**	**	**	**
	Quadratic	**	**	*	**	NS	**	**	**
SBU	Linear	NS	**	NS	NS	*	**	**	**
	Residual	NS	0.0	NS	**	NS	NS	NS	**
Interactions[3]									
SL X SBUL		**	**	NS	NS	NS	**	**	**
SL X SBUR		NS	*	NS	NS	NS	NS	*	**

[1] **, *, NS = significant at P<0.1, <.05 and not significant, respectively; [2] cubic and residual were NS; [3] remaining were NS.

Barley

The number of experiments with barley was quite limited in relation to those with wheat. The experiments essentially fell into two types that corresponded to Type A and Type C of wheat (Fig. 5 and 6) and are included in Table 4.

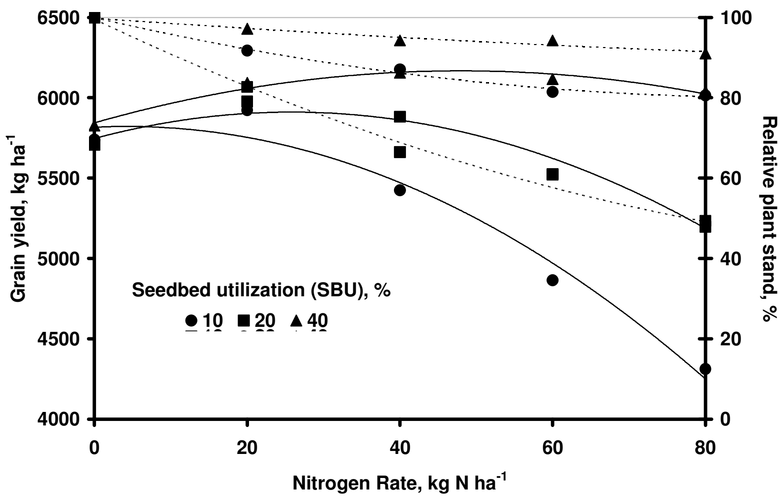

Figure 5. Yield and relative plant stand in Type A experiment.

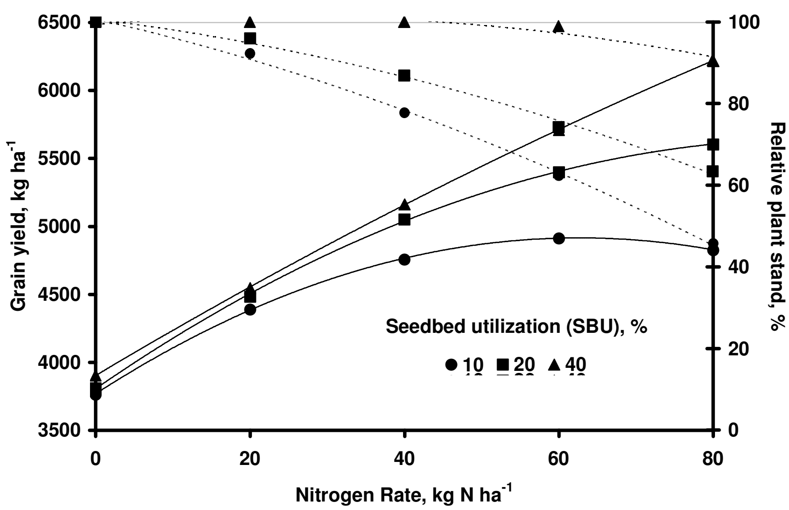

Figure 6. Yield and relative plant stand in Type C experiment.

Parameters Affecting Seedrow Placed Nitrogen rates

An attempt was made to identify common characteristics in the experiments of each group. There was a range of both soil texture and soil organic matter (SOM) within each group; however, each group was characterized by a distinct range in soil test N levels as well as amounts of precipitation within 48 hours both prior to and after seeding (Table 5).

Table 4. Main characteristics, mean yields and statistical effects for all barley experiments.

		Type A				Type C					
Location:		Irricana	Crossfield	Bentley	Red Deer	Calgary	Airdrie	Turin	Red Deer	Red Deer	Wetaskiwin
Organic matter, %:		3.6	6.5	8.5	6.9	5.1	5.1	3.1	7.6	7.6	1.2
Texture:		Loam	Loam	L	CL	CL	L	L	CL	CL	SL
Cultivar:		Harrington	Harrington	Brier	Harrington	Manley	B1602	Harrington	Harrington	Harrington	B1602
Previous crop:		Fallow	Canola	Barley	Wheat	Barley	Barley	Wheat	Canola	Oats	Canola
Seeding date:		Jun 2	May 1	May 16	May 6	May 1	May 2	Apr 29	May 12	May 11	May 14
Harvest date:		Sep 28	Sep 18	Sep 11	Sep 21	Sep 2	Aug 24	Aug 19	Sep 7	Sep 7	Sep 8
SBU	10	56.4	60.4	167.9	106.1	39.4	65.6	128.6	98.2	88.4	85.3
	20	58.7	83.8	168.1	110.8	55.9	72.4	129.4	103.9	93.9	87.8
	40	62.3	95.4	177.3	114.9	64.4	74.2	137.7	107.1	98.8	87.6
N rate, kg ha^{-1}	0	51.6	93.7	170.8	112.3	37.6	51.1	116.5	82.1	72.4	67.2
	20	65.6	91.8	174.3	114.6	52.8	58.7	129.2	92.8	88.0	77.5
	40	64.2	82.7	173.8	112.4	60.2	74.3	137.2	103.6	94.6	86.7
	60	60.1	70.9	170.2	108.1	60.9	82.4	135.6	115.2	102.7	98.9
	80	54.3	60.2	166.6	105.5	54.7	86.9	140.8	121.6	110.8	104.1
						Main effects					
Seeding rates		**[1]	**	NS	**	**	**	**	**	**	**
SBU		**	**	**	**	**	**	**	**	**	*
Seeding X SBU		**	**	**	**	**	**	NS	**	NS	**
		Contrasts									
Seeding rate[2]	Linear	NS	**	NS	**	**	**	**	**	**	**
	Quadratic	**	**	*	**	**	*	NS	NS	NS	NS
SBU	Linear	**	**	**	**	**	**	**	**	**	*
	Residual	NS	**	*	*	**	**	NS	**	NS	*
						Interactions[3]					
SL X SBUL		**	**	**	**	**	**	NS	**	**	**
SL X SBUR		NS	**	NS	**	**	**	NS	NS	NS	NS

[1] **, *, NS = significant at P<0.1, <.05 and not significant, respectively; [2] cubic and residual were NS; [3] remaining were NS.

Stepwise multiple regression revealed that within group SOM level, SUB and N rate could explain 63 to 83% of the yield changes as a result of seedrow placed N within each of the three types of response for CWRS wheat (Table 6). Nitrogen rate was of least consequence under drier conditions, where SOM appeared to play the most important role (Fig. 7); the reverse was the case under moist to wet conditions (Fig. 8 and 9).

Table 5. Soil test N values and precipitation within 48 hours of seeding for each Type of response to seedrow placed N with CWRS wheat.

	Soil NO_3-N, kg ha^{-1} (0-60 cm)				Precipitation, mm							
					Before				After			
	Min	Max	Mean	Std. dev.	Min	Max	Mean	Std. dev	Min	Max	Mean	Std. dev.
Type A	38	144	91	39	0.0	8.4	2.7	3	0.0	6.0	1.7	3
Type B	20	88	46	22	0.0	22.0	3.7	7	0.0	16.6	4.3	5
Type C	16	86	43	26	0.0	8.4	3.5	3	0.6	31.0	6.7	11

Table 6. Results of stepwise multiple regression within each Type of response to seedrow placed N with wheat.

Type A		Type B		Type C	
Parameter	R^2	Parameter	R^2	Parameter	R^2
SOM	0.552	N rate	0.350	N rate	0.531
SBU	0.670	SBU	0.478	SOM	0.764
N rate	0.826	SOM	0.629	SBU	0.775

The two types of responses for barley led to almost identical results both in terms of soil test N and precipitation with 48 hours of seeding (Table 7) and SUB and SOM (not shown here).

Table 7. Soil test N values and precipitation within 48 hours of seeding for each Type of response to seedrow placed N with barley.

	Soil NO_3-N, kg ha^{-1} (0-60 cm)				Precipitation, mm							
					Before				After			
	Min	Max	Mean	Std. dev.	Min	Max	Mean	Std. dev	Min	Max	Mean	Std. dev.
Type A	86	130	119	24	0.0	1.2	0.3	0.5	0.0	1.8	0.6	0.9
Type C	30	142	55	43	4.4	0.0	4.4	8.2	0.0	5.4	2.7	3.1

The results from this detailed analysis of twenty seven experiments with CWRS wheat and ten with barley allowed the development of a tool that a producer can use to minimize the risk from seedrow placed N with wheat and barley (as well as canola, flax, oats and peas). The tool is in the form of an excel spreadsheet (Fig. 10) and requires the input of Type of responses anticipated based on soil moisture conditions, soil test N, SUB and SOM. The tool has been enhanced with data from other work by Karamanos et al. (2004) as well as data derived by the Canola Council of Canada (http://www.canola-council.org/PDF/CPCfertilizer.pdf) to provide an estimate of population stand under seedrow N rates in excess of those derived by this tool.

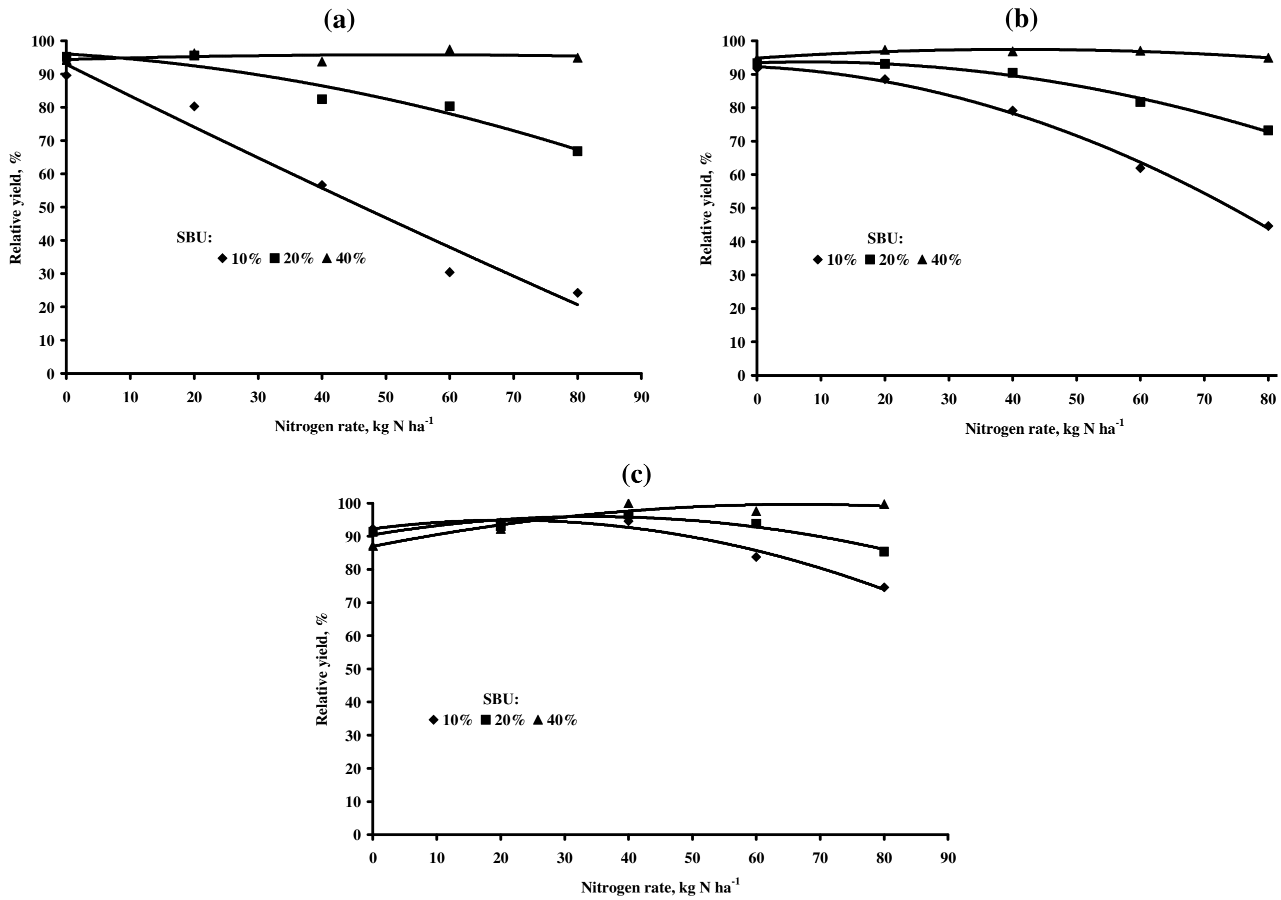

Figure 7. Impact of N rate and SBU on the yield of wheat at different SOM levels of Type A experiments; (a) SOM<3.5%, (b) SOM 3.5-6%, (c) SOM>6%.

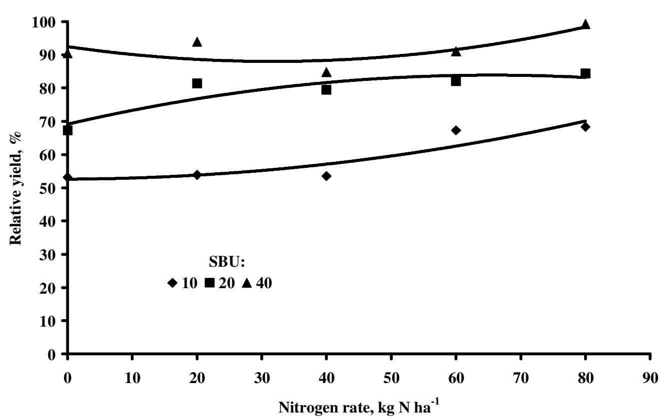

Figure 8. Impact of N rate and SBU on the yield of wheat at all SOM levels of Type C experiments.

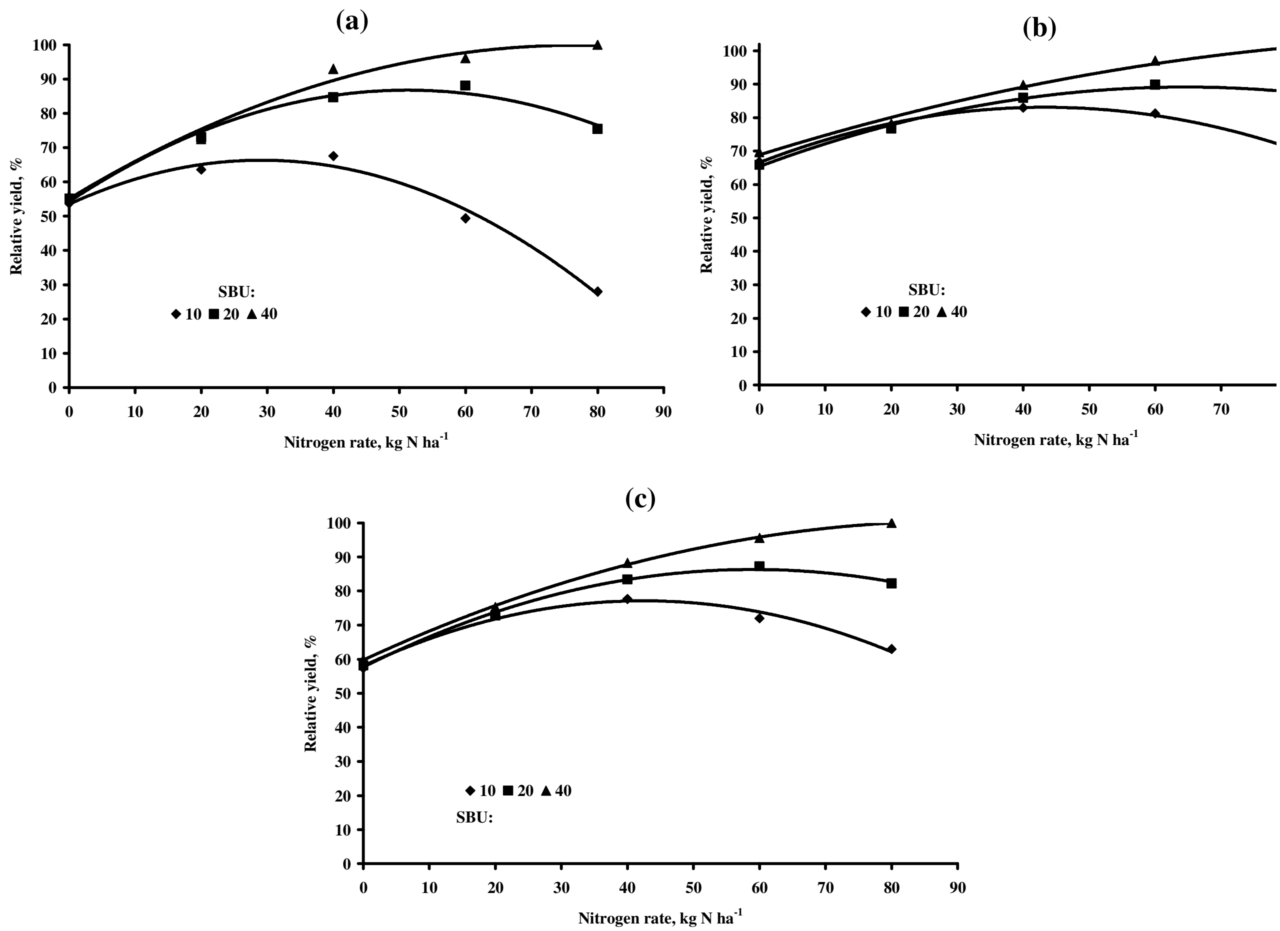

Figure 9. Impact of N rate and SBU on the yield of wheat at different SOM levels of Type B experiments; (a) SOM<3.5%, (b) SOM 3.5-6%, (c) SOM>6%.

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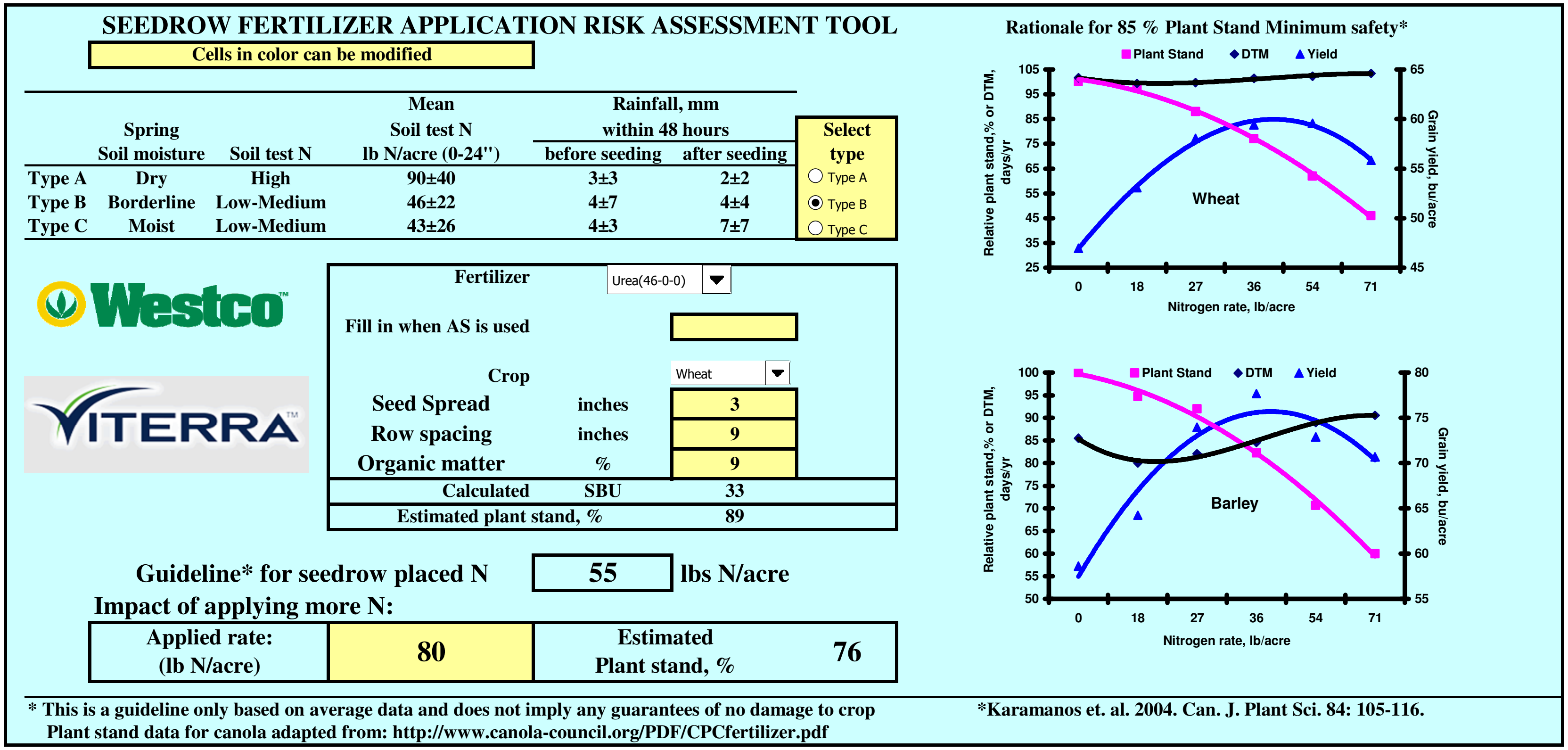

Figure 10. View of a tool developed to derive safe seedrow placed N rates with common crops in western Canada.