Nitrogen and Phosphorus recommendations for Manitoba for today's production costs

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Abstract

Nitrogen (N) and phosphorus (P) (as well as other nutrient) general guidelines are reviewed by a panel of government, industry and university experts on an annual basis and revisions as well as additions and corrections are reflected in the Soil Fertility Guide that is published (as well as posted on the web-site) by Manitoba Agriculture, Food and Rural Initiatives. However, a comprehensive review of the N and P databases for barley, wheat and canola has not been undertaken since September 1990. Post 1988 database of experiments conducted by Western Cooperative Fertilizers Limited was utilized to revise target yields and recommendations derived thereof in the last revision of the Manitoba provincial recommendations. Two hundred and sixty seven experiments with N as the primary focus and 152 experiments with P as the primary focus were analyzed individually and in groups as follows: for N, 97 experiments with barley, 145 with wheat were organized based on the classification used in the 1990 revision in those conducted in moist, dry and arid regions of the province, whereas 25 experiment with canola were analyzed as one group. Target yields and recommendations derived are compared to those of the 1977 and 1990 provincial databases; for P, 54 experiments with barley, 78 with wheat and 20 with canola were analyzed as one group per crop and yield increases based on the bicarbonate soil P test and a range of P application rates were derived. The results will form the basis for revised tables in the Soil Fertility Guide and allow development of a web-based tool to derive N and/or P net economic return using soil test values.

Introduction

Fertilizer nutrient recommendation guidelines for the province of Manitoba prior to the privatization of the provincial soil testing laboratory in 1992 were developed by the Manitoba Soil Fertility Sub-Council and were approved by the Manitoba Soil Fertility Advisory Committee. The Department of Soil Science at the University of Manitoba served as the repository of the "approved" recommendations of the time. Provincial fertilizer recommendations have not been updated or revised for wheat, barley, canola or flax since 1992 with last documented revisions in September 1990. Since the original studies were conducted to develop the current recommendations, Manitoba has moved away from summer fallow to continuous cropping, have reduced tillage intensity, include more crops, including pulses in the rotation, and have higher yield expectations due to technological and varietal improvements.

Recently, guidelines are developed by an ad hoc committee of government, university and industry research scientists, who act as advisors to the provincial Crop Nutrition Specialist, Crops Branch, Manitoba Agriculture, Food and Rural Initiatives, who subsequently compiles them into a publication known as the Soil Fertility Guide (Manitoba Agriculture, Food and Rural Initiatives 2008). Guidelines are offered in tabular form for three target yields and those for wheat, barley and canola are reproduced here for the benefit of the reader (Tables 1-5). It is entirely possible that the current recommendations, many of which were based on trials carried out on soils that were summerfallowed in the previous year, are no longer providing an accurate basis for N recommendations. Revising the traditional recommendations will aid in re-establishing confidence in the soil test and increase its use as a decision-making tool. This should lead to enhanced production through more appropriate fertilizer rates or enhanced profitability where additional nutrients are not required or required in higher rates to produce maximum economic yield.

Table 1. Nitrogen recommendations for hard red spring wheat (based on spring broadcast application) (Manitoba Agriculture, Food and Rural Initiatives, 2008).

NITROGEN RECOMMENDATIONS									
SOIL MOISTURE CATEGORY		DRY			MOIST			IDEAL		
TARGET YIELD, bu/ac		30	35	40	35	40	45	40	45	50
Fall NO_3 –N lb/ac in 0-24 in	Rating									
20	VL	30	55	100	45	70	110	65	90	120
30	L	10	30	80	25	45	85	45	70	100
40	M	0	10	60	5	30	65	25	50	80
50	M	0	0	40	0	10	50	5	30	60
60	H	0	0	20	0	0	25	0	10	40
70	H	0	0	0	0	0	0	0	0	20
80	VH	0	0	0	0	0	0	0	0	0
90	VH	0	0	0	0	0	0	0	0	0
100	VH+	0	0	0	0	0	0	0	0	0

Table 2. Nitrogen recommendations for winter wheat (based on spring broadcast application) (Manitoba Agriculture, Food and Rural Initiatives, 2008).

Fall NO_3 –N		NITROGEN RECOMMENDATIONS	Fall NO_3 –N		NITROGEN RECOMMENDATIONS
lb/ac in 0-24 in	Rating	(lb/ac)	lb/ac in 0-24 in	Rating	(lb/ac)
20	VL	150	80	VH	65
30	L	135	90	VH	50
40	M	120	100	VH+	35
50	M	110	110	VH+	20
60	H	95	120	VH+	10
70	H	80			

Table 3. Nitrogen recommendations for feed barley (based on spring broadcast application) (Manitoba Agriculture, Food and Rural Initiatives, 2008).

NITROGEN RECOMMENDATIONS									
SOIL MOISTURE CATEGORY		DRY			MOIST			IDEAL		
TARGET YIELD, bu/ac		60	65	70	80	85	90	40	95	105
Fall NO_3 –N lb/ac in 0-24 in	Rating									
20	VL	45	70	100	75	95	120	95	130	180
30	L	25	50	80	55	75	100	75	110	160
40	M	5	30	60	35	55	80	55	90	140
50	M	0	10	40	0	35	60	35	70	120
60	H	0	0	20	15	15	40	15	50	100
70	H	0	0	0	0	0	20	0	30	80
80	VH	0	0	0	0	0	0	0	10	60
90	VH	0	0	0	0	0	0	0	0	40
100	VH+	0	0	0	0	0	0	0	0	20

Table 4. Nitrogen recommendations for canola (based on spring broadcast application) (Manitoba Agriculture, Food and Rural Initiatives, 2008).

		NITROGEN RECOMMENDATIONS (lb/ac)			
TARGET YIELD, bu/ac		30	35	40	45
Fall NO_3 –N					
lb/ac in 0-24 in	Rating				
20	VL	75	105	135	165
30	L	55	85	115	145
40	M	40	70	95	125
50	M	25	55	80	110
60	H	15	40	70	100
70	H	5	35	60	90
80	VH	0	30	55	85
90	VH	0	25	55	85
100	VH+	0	25	55	85

Table 5. Excerpt from the P recommendations for cereal and canola from the Soil Fertility Guide (Manitoba Agriculture, Food and Rural Initiatives, 2008).

FERTILIZER PHOSPHATE (P_2O_5) RECOMMENDED (lb/acre)					
Soil Phosphorus (Sodium bicarbonate test)			Cereals	Canola	
ppm	lb P/acre	Rating	S[1]	B[2]	S
0	0	VL	40	40	20
	5	VL	40	40	20
5	10	L	40	40	20
	15	L	35	35	20
10	20	M	30	30	20
	25	M	20	20	20
15	30	H	15	15	0
	35	H	10	10	0
20	40	VH	10	10	0
20+	40+	VH+	10	10	0

S[1] = seed-placed rates

B[2] = banded away from the seed

Database

Westco has a database of soil fertility trials conducted over the past decades including more recent trials than those utilized in constructing the current N recommendations. To enhance the database, it was decided that experiments conducted in South Eastern Saskatchewan, especially those on the highway 16 corridor from Yorkton, Saskatchewan to the Saskatchewan-Manitoba border are also included. Seven hundred and eleven experiments with nitrogen (N) as the primary focus were thus identified; however, it was deemed that experiment prior to 1987-88 growing season (370) were carried out with parameters already identified as outdated in the current database, hence, they were excluded from further analysis. Of the remaining 341 experiments, a further 74 were omitted as soil test data for the experimental sites were not available. The make-up of the 267 experiments utilized in this study is shown in Fig. 1.

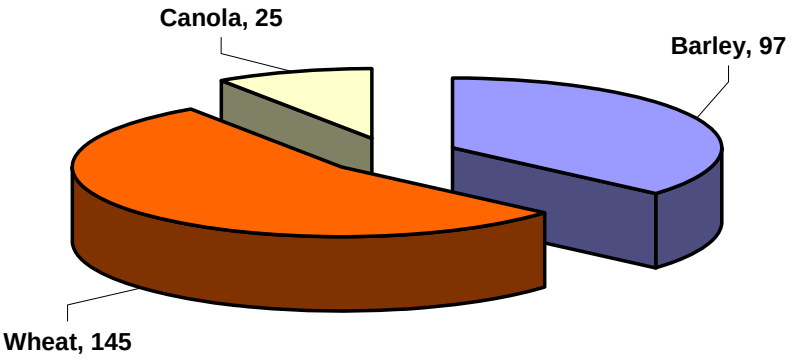

Figure 1. Make-up of the database of post 1987 experiments utilized to revise current N recommendations.

The nomenclature utilized in the September 1990 revision of the N guidelines was followed to maintain consistency and direct comparison of the current to the previous database. Hence, based on the experimental location, experiments for barley and wheat were classified into the categories, namely, those that were carried out under Arid, Dry and Moist conditions (not irrigated experiments were included in the database). The nomenclature utilized in the Soil Fertility Guide is different, as the conditions identified are Dry, Moist and Ideal. It is conceivable that there is a close relationship and correspondence between the three categories in the two sets of guidelines. However, the original one was retained to facilitate direct comparison to the previous provincial soil testing database. The distribution of experiments for each crop is provided in Fig. 2.

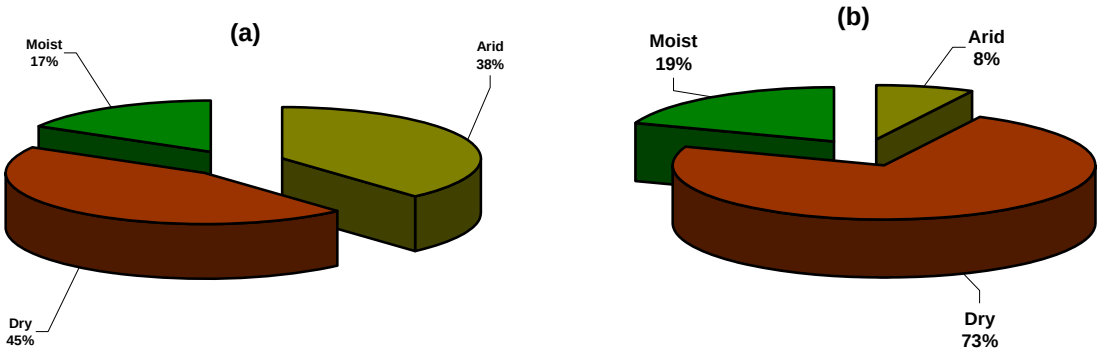

Figure 2. Proportion of the barley and wheat experiments carried out in the Moist, Dry and Arid regions of Manitoba.

Canola experiments were kept in one group as was the case in the previous database. The proportion of experiments in each of the major Soil Climatic Zones (SCZ) (Meyers and Karamanos 1997) is shown in Fig. 3.

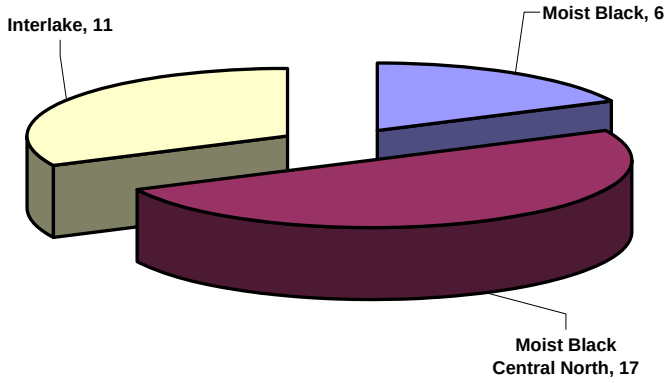

Figure 3. Number of canola experiments included in the database on a per SCZ basis.

One hundred and fifty two experiments with phosphorus (P) were compiled for the P recommendation guideline revision (Figure 4).

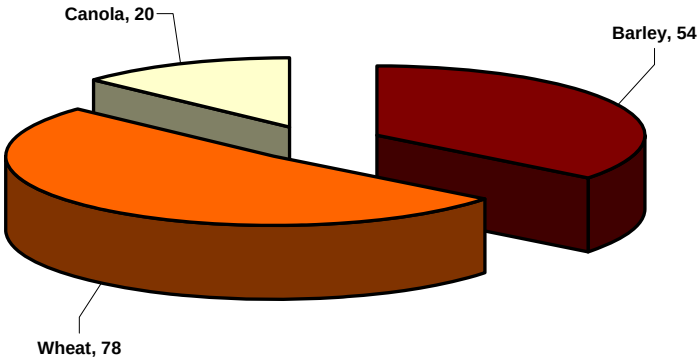

Figure 4. Number of P experiments for each of the main crops included in the database.

Nitrogen Recommendations

Barley

Overall barley grain yield increases with N fertilizer application ranged from -10.9 to 62.9 bu/acre (Fig. 5) and were a function of soil test N and agroecological conditions.

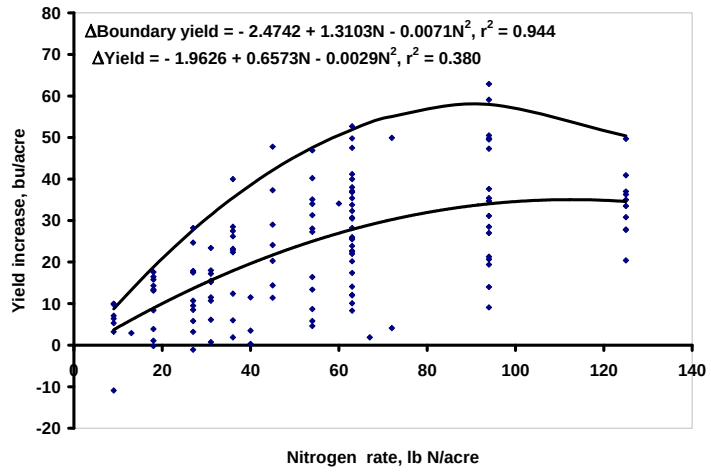

Figure. 5. Yield response of barley to N application under non-restricted (boundary) and average overall conditions.

Grain yields derived with experiments in the current database, when experiments were grouped into those carried out in each of the three soil moisture categories, are compared to those of the 1990 revision in Fig. 6. Although the concept of N supply has been abandoned since 1990, yield increases are plotted versus N supply to provide a direct comparison of the current to the 1990 database.

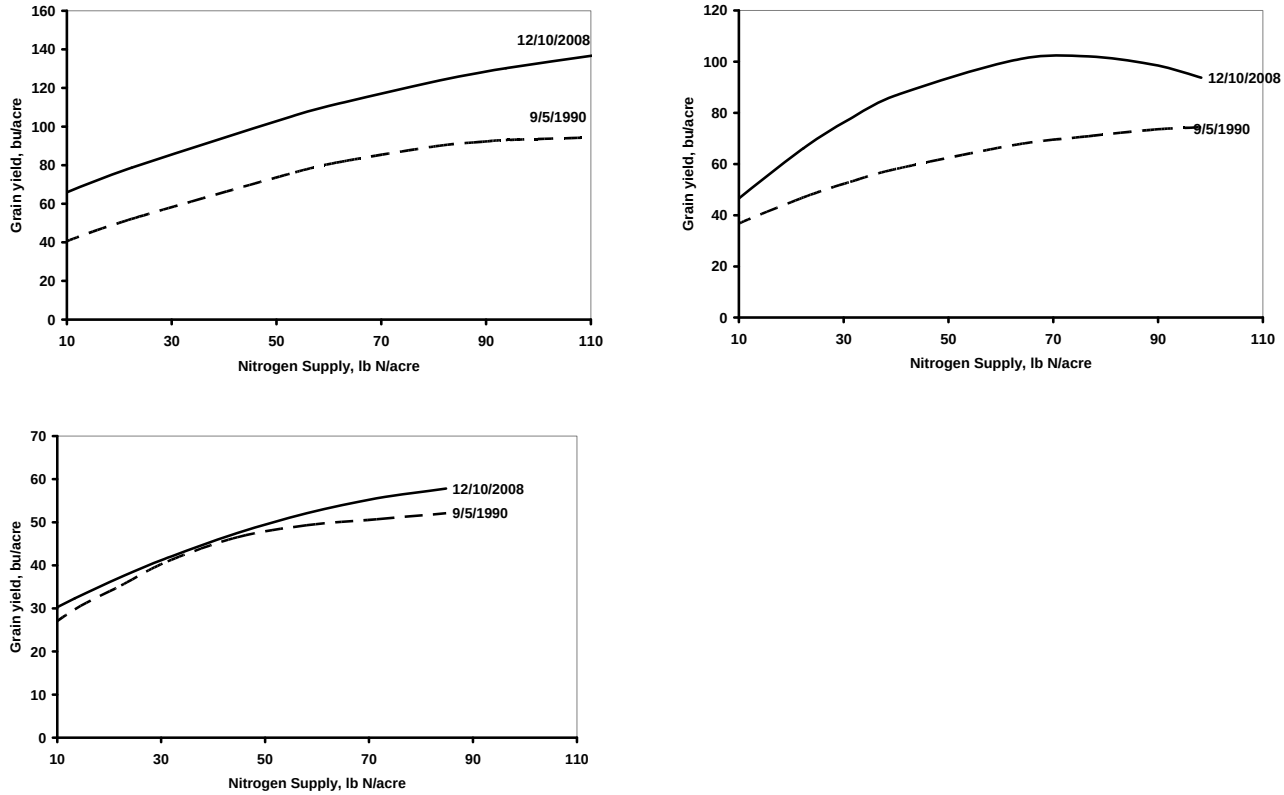

Figure 6. Comparison of average barley yield responses as a function of N supply (soil test N + ½ of fertilizer N) under moist, dry and arid conditions.

Average grain yields in the current database were significantly greater under moist conditions, which reflects the greater yield potential of newer cultivars and improvement in cultivation practices. Cultivation practices may be the reason why grain yields under dry conditions were slightly greater in the current compared to the 1990 database, especially at higher N application rates. Essentially grain yields under arid conditions were similar, since moisture use was the main limiting factor in both cases. A comparison of grain yields under the three soil moisture regimes as a function of soil + fertilizer N is afforded in Fig. 7

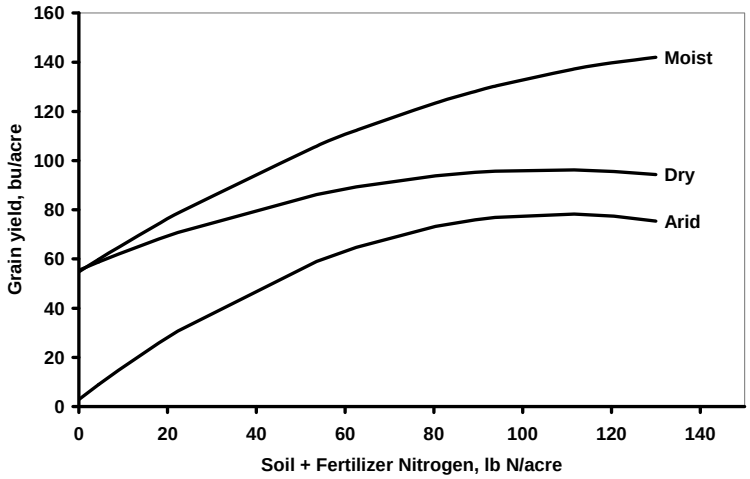

Figure 6. Comparison of average barley grain yields under the three soil moisture regimes as a function of soil + fertilizer N.

CWRS Wheat

Overall CWRS wheat grain yield increases with N fertilizer application ranged from -0.9 to 41.8 bu/acre (Fig. 7) and were a function of soil test N and agroecological conditions.

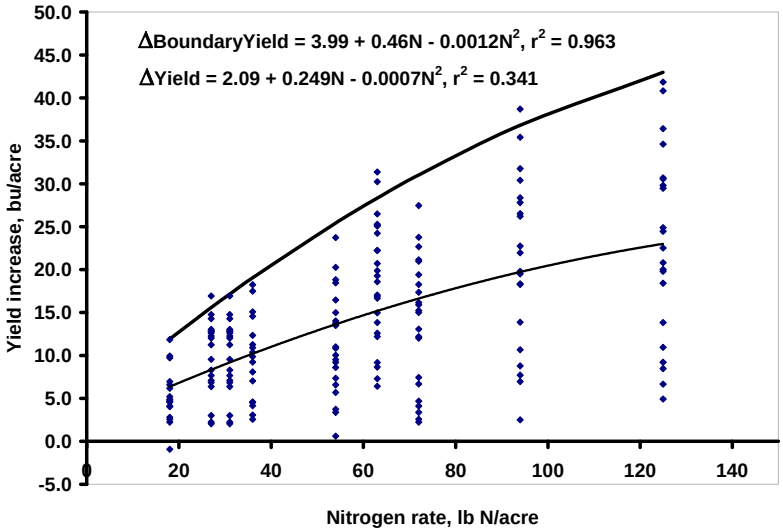

Figure. 7. Yield response of wheat to N application under non-restricted (boundary) and average overall conditions.

Similarly to barley, grain yields derived with experiments in the current database when experiments were grouped into those carried out in each of the three soil moisture categories are compared to those of the 1990 revision in Fig. 8. Average CWRS wheat grain yields in the current database were significantly greater under moist, slightly greater under dry and similar under arid conditions, reflecting the same conditions as those described for barley.

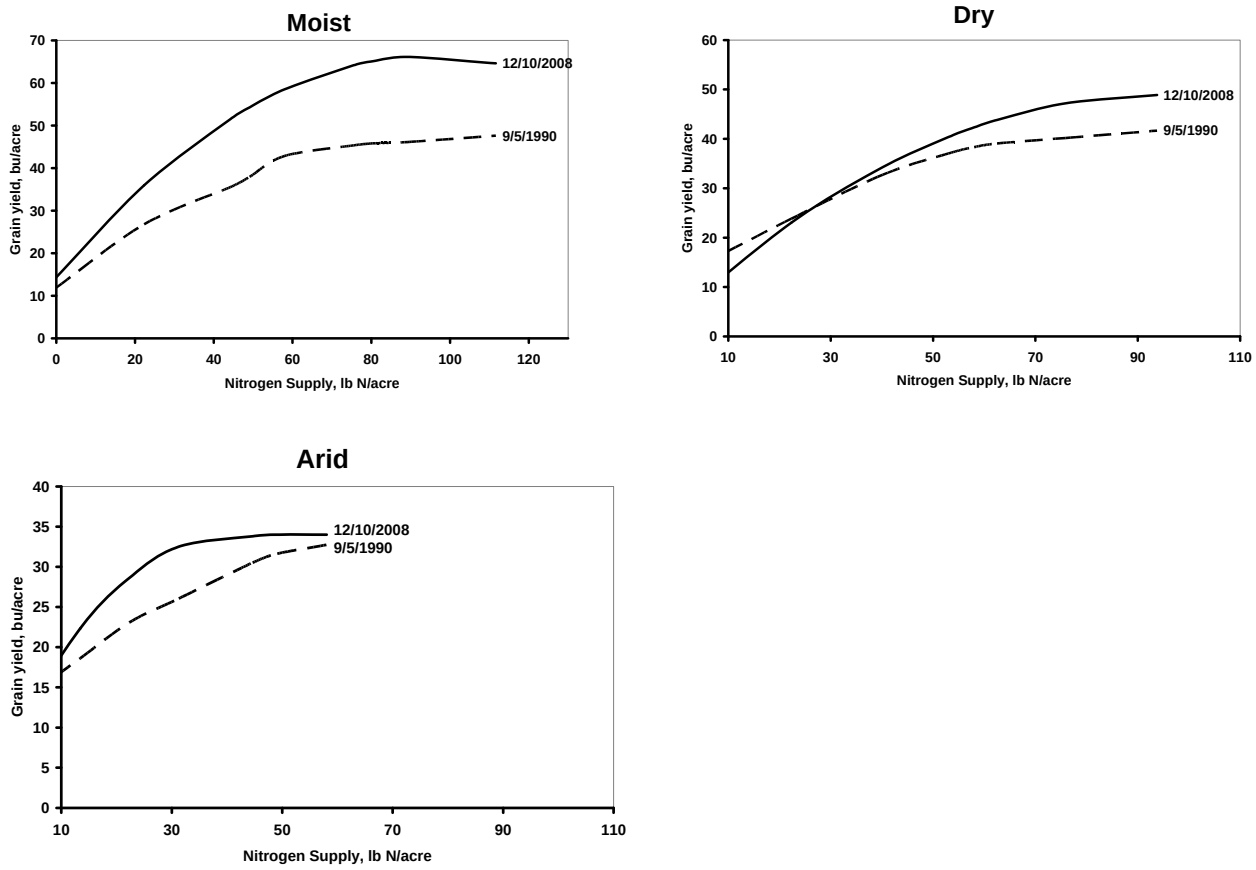

Figure 8. Comparison of average yield responses as a function of N supply (soil test N + ½ of fertilizer N) under moist, dry and arid conditions.

A comparison of grain yields under the three soil moisture regimes as a function of soil + fertilizer N is afforded in Fig. 9.

Canola

Target yields in the 1990 edition of the Manitoba Agriculture provincial soil testing laboratory tables ranged from 475 to 2700 kg ha $^{-1}$ (7.1 to 40.2 bu/acre) (Table 6).

Although the average maximum yield of conventional canola cultivars in the current database was essentially identical to the one in the 1990 revision, that of the unfertilized control was 2.5-fold higher reflecting the increased N fertility in the last two decades. On average, the maximum yield for hybrid canola cultivars was 11.5 bu/acre (or 28%) higher, which is close agreement with the research data published by Karamanos et al. (2005) for the western Canadian prairie soils, who found that maximum hybrid canola cultivar yield was 34% greater than that of conventional canola cultivars.

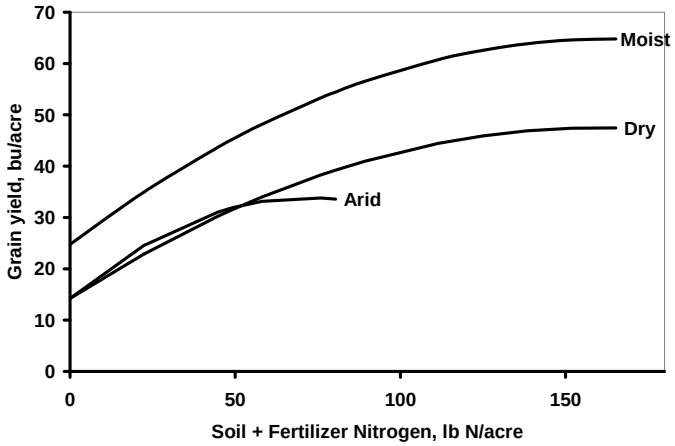

Figure 9. Comparison of average CWRS wheat grain yields under the three soil moisture regimes as a function of soil + fertilizer N.

Table 6. Average canola seed target yields in the September 5, 1990 revision of the Manitoba Agriculture database (converted to bu/acre).

Fert. N	Soil NO_3-N															
lb/acre	0	4	9	13	18	22	27	31	36	40	45	49	54	67	71	80
0	7.1	8.9	10.6	12.1	13.5	14.9	16.2	17.5	18.6	19.6	20.5	21.4	22.2	23.4	24.4	25.0
18	9.6	11.5	12.8	14.7	16.0	17.3	18.5	19.8	21.1	22.3	23.0	23.6	24.9	26.1	26.8	27.5
36	12.1	14.1	15.3	17.2	18.5	19.8	21.1	22.3	23.6	24.9	25.5	26.1	27.5	28.7	29.3	30.0
54	14.7	16.6	17.9	19.8	21.1	22.3	23.6	24.9	26.1	27.5	28.1	28.7	30.0	31.3	31.9	32.5
72	17.2	19.1	20.4	22.3	23.6	24.9	26.1	27.5	28.7	30.0	30.6	31.3	32.5	33.8	34.5	35.0
90	18.3	21.7	23.0	24.9	26.1	27.5	28.7	30.0	31.3	32.5	33.2	34.2	35.0	36.4	37.0	37.7
110	22.3	24.3	25.5	27.5	28.7	30.0	31.3	32.7	34.2	35.0	35.7	37.0	37.7	38.9	39.5	40.2
125	24.9	26.8	28.3	30.0	31.3	32.7	34.2	35.7	37.0	37.7	38.2	39.5	40.2			
145	27.5	29.3	31.3	32.5	34.2	35.7	37.0	38.2	39.5	40.2						
160	30.0	31.9	33.8	35.0	37.0	38.2	39.5									
180	32.5	34.5	36.4	37.7	39.5											

Target yields derived in this study for conventional and hybrid canola cultivars are shown in Tables 7 and 8.

Table 7. Average conventional canola cultivar seed target yields in the current database.

Fert. N	Soil NO_3-N															
lb/acre	0	4	9	13	18	22	27	31	36	40	45	49	54	67	71	80
0	18.3	19.5	20.7	21.9	23.1	24.2	25.2	26.3	27.3	28.3	29.2	30.1	30.9	33.3	34.0	35.4
0	18.3	19.5	20.7	21.9	23.1	24.2	25.2	26.3	27.3	28.3	29.2	30.1	30.9	33.3	34.0	35.4
18	23.1	24.2	25.2	26.3	27.3	28.3	29.2	30.1	30.9	31.8	32.6	33.3	34.0	36.0	36.5	37.6
36	27.3	28.3	29.2	30.1	30.9	31.8	32.6	33.3	34.0	34.7	35.4	36.0	36.5	38.0	38.5	39.2
72	34.1	34.8	35.4	36.0	36.6	37.1	37.6	38.1	38.5	38.9	39.3	39.6	39.9	40.5	40.6	40.8
90	36.6	37.2	37.7	38.1	38.5	38.9	39.3	39.6	39.9	40.1	40.3	40.5	40.6	40.8	40.8	40.7
110	38.7	39.1	39.4	39.7	40.0	40.2	40.4	40.6	40.7	40.8	40.8	40.8	40.8	41.0	41.0	41.0
107	38.5	38.9	39.2	39.5	39.8	40.1	40.3	40.5	40.6	40.7	41.0	41.0	41.0			
145	40.7	40.8	40.8	40.8	40.8	40.8	40.7	41.0	41.0	41.0						
160	40.8	40.8	40.7	40.6	41.0	41.0	41.0									
180	41.0	41.0	41.0	41.0	41.0											

Table 8. Average hybrid canola cultivar seed target yields in the current database.

Fert. N	Soil NO_3-N															
lb/acre	0	4	9	13	18	22	27	31	36	40	45	49	54	67	71	80
0	25.9	26.9	27.9	28.9	29.9	30.8	31.7	32.7	33.5	34.4	35.3	36.1	36.9	39.2	39.9	41.3
18	29.9	30.8	31.7	32.7	33.5	34.4	35.3	36.1	36.9	37.7	38.4	39.2	39.9	42.0	42.6	43.9
36	33.5	34.4	35.3	36.1	36.9	37.7	38.4	39.2	39.9	40.6	41.3	42.0	42.6	44.4	45.0	46.1
54	36.9	37.7	38.4	39.2	39.9	40.6	41.3	42.0	42.6	43.2	43.9	44.4	45.0	46.6	47.1	48.0
72	40.0	40.7	41.4	42.1	42.7	43.3	43.9	44.5	45.1	45.6	46.1	46.7	47.1	48.5	48.9	49.6
90	42.7	43.3	43.9	44.5	45.1	45.6	46.2	46.7	47.2	47.6	48.1	48.5	48.9	50.0	50.3	50.9
110	45.4	45.9	46.4	46.9	47.4	47.8	48.3	48.7	49.1	49.5	49.8	50.1	50.5	51.3	51.5	51.9
125	47.1	47.5	48.0	48.4	48.8	49.2	49.6	49.9	50.3	50.6	50.9	51.1	51.4			
145	49.0	49.4	49.8	50.1	50.4	50.7	51.0	51.2	51.5	51.7						
160	50.2	50.5	50.8	51.1	51.3	51.6	51.8									
180	51.5	51.7	51.9	52.1	52.2											

Phosphorus Recommendations

Guidelines for P fertilizer rates shown in Table 5 evolved from those developed in 1977 and revisited in 1982 (Table 9) and 1990 (Table 10).

Table 9. Phosphorus recommendations for cereal and canola effective July 1977 and revised in September 1982.

Soil Phosphorus (Sodium bicarbonate test) lb P/acre	Rating	Fertilizer , lb P_2O_5/acre	
		Cereals	Canola
0 - 11	VL	45	20
12 - 19	VL	44-36	20
20 - 28	M	35-25	20
29 - 40	H	24-11	0
40 - 100	VH	10	0
101+	VH+	10	0

Table 10. Phosphorus recommendations for cereal and canola as revised in September 1990.

Soil Phosphorus (Sodium bicarbonate test) lb P/acre	Rating	Fertilizer , lb P_2O_5/acre	
		Cereals	Canola
0- 9	VL	45	20
10 - 19	VL	44-36	20
20 - 29	M	35-25	20
30 - 39	H	24-11	0
40 - 49	VH	10	0
50+	VH+	10	0

Overall yield increases for barley, wheat and canola under non-restricted (boundary) and average conditions are shown in Fig. 10.

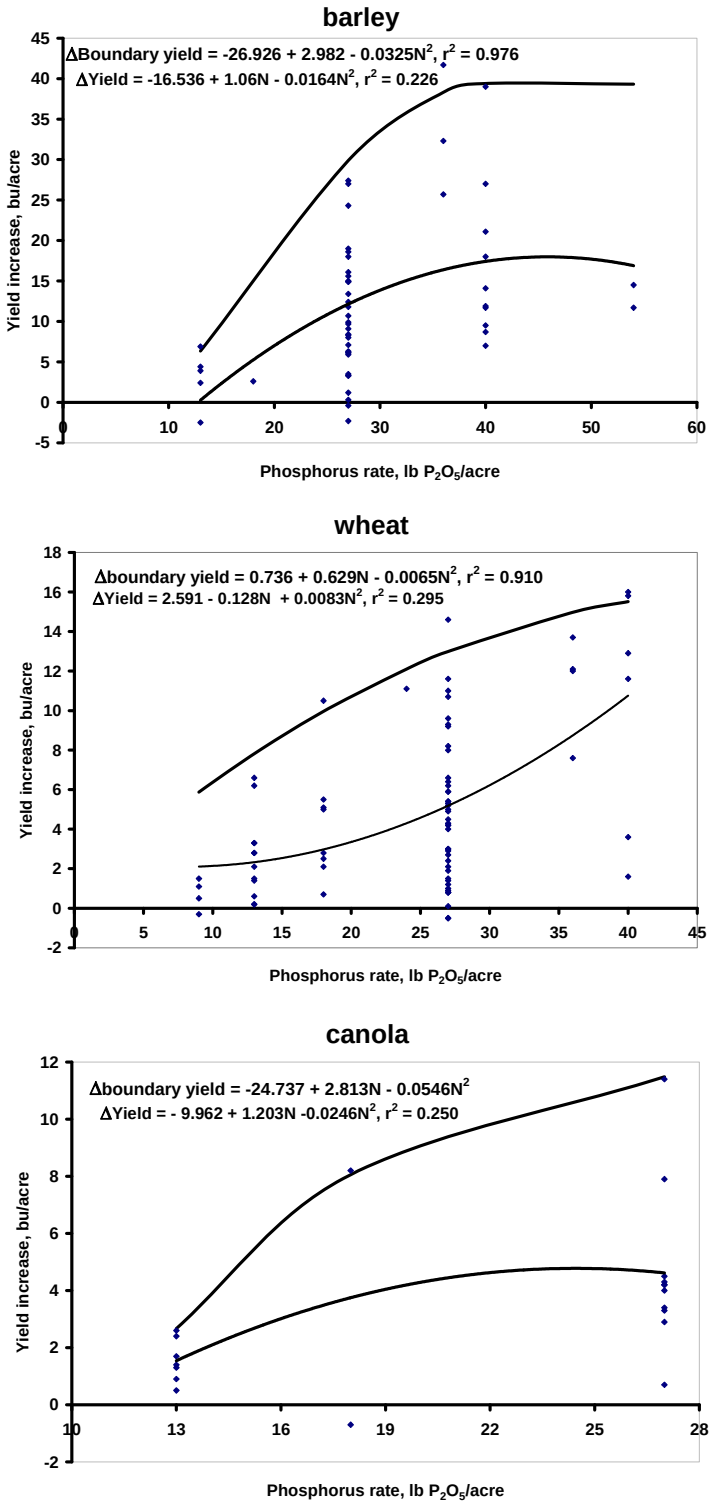

Figure. 10. Yield responses to P application under non-restricted (boundary) and average overall conditions.

Average grain yield increases as a function of soil test (Olsen et al. 1954) and rate of P_2O_5 application are summarized for each crop in Tables 11 through 13.

Table 11. Matrix showing maximum average barley grain yield increases for a given soil test P level and the P fertilization rate with which the maximum yield was achieved (hatched portion as recommended at the December 8, 2008 expert committee meeting).

Fertilizer		Soil Phosphorus (Sodium bicarbonate test), lb P/acre							
lb P_2O_5/acre	ΔY	5	10	15	20	25	30	35	40+
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0	0.0	4.3	4.2	3.4	3.0	3.0	3.0	3.0
15	2.2	2.2	5.8	5.2	3.9	3.0	3.0	3.0	3.0
20	6.4	6.4	9.9	6.2	4.4	3.0	3.0	3.0	3.0
25	9.7	9.7	13.3	9.6	4.9	3.0	3.0	3.0	3.0
30	12.3	12.3	15.9	12.2	7.6	3.0	3.0	3.0	3.0
35	14.2	14.2	17.7	14.1	9.4	3.0	3.0	3.0	3.0
40	15.3	15.3	18.9	15.2	10.5	3.0	3.0	3.0	0.0
45	15.7	15.7	19.2	15.5	10.9	3.0	3.0	3.0	0.0
50	15.3	15.3	18.8	15.1	10.5	3.0	3.0	3.0	0.0
55	14.1	14.1	17.7	14.0	9.4	3.0	3.0	3.0	0.0
60	12.2	12.2	15.8	12.1	7.5	3.0	3.0	3.0	0.0

Table 12. Matrix showing maximum average CWRS wheat grain yield increases for a given soil test P level and the P fertilization rate with which the maximum yield was achieved (hatched portion as recommended at the December 8, 2008 expert committee meeting).

Fertilizer		Soil Phosphorus (Sodium bicarbonate test), lb P/acre							
lb P_2O_5/acre	ΔY	5	10	15	20	25	30	35	40+
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	4.0	3.2	3.9	2.0	2.0	2.0	2.0	2.0	2.0
15	6.2	5.4	2.2	2.0	2.0	2.0	2.0	2.0	2.0
20	8.2	7.3	4.1	2.5	2.0	2.0	2.0	2.0	2.0
25	9.8	8.9	5.7	4.1	2.5	2.0	2.0	2.0	2.0
30	11.1	10.3	7.1	5.5	3.8	2.0	2.0	2.0	2.0
35	12.1	11.3	8.1	6.5	4.9	2.0	2.0	2.0	0.0
40	12.9	12.0	8.8	7.2	5.6	2.0	2.0	2.0	0.0
45	13.3	12.5	9.3	7.7	6.1	2.0	2.0	2.0	0.0
50	13.5	12.7	9.5	7.9	6.3	2.0	2.0	2.0	0.0
55	13.4	12.6	9.4	7.8	6.1	2.0	2.0	2.0	0.0
60	13.0	12.1	8.9	7.3	5.7	2.0	2.0	2.0	0.0

Table 13. Matrix showing maximum average canola grain yield increases for a given soil test P level and the P fertilization rate with which the maximum yield was achieved (hatched portion as recommended at the December 8, 2008 expert committee meeting).

Fertilizer		Soil Phosphorus (Sodium bicarbonate test), lb P/acre							
lb P_2O_5/acre	ΔY	5	10	15	20	25	30	35	40+
0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.0	1.5	1.3	1.7	2.0	2.0	2.0	2.0	2.0
15	2.1	2.7	2.5	2.9	2.0	2.0	2.0	2.0	2.0
20	3.3	3.8	3.6	4.0	2.0	2.0	2.0	2.0	2.0
25	4.3	4.9	4.7	5.1	2.0	2.0	2.0	2.0	2.0
30	5.4	5.9	5.7	6.1	2.0	2.0	2.0	2.0	2.0
35	6.3	6.9	6.7	7.1	2.0	2.0	2.0	2.0	2.0
40	7.3	7.8	7.6	2.0	2.0	2.0	2.0	2.0	0.0
45	8.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0
50	9.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0
55	9.7	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0
60	10.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0

Net Return to N and P Fertilization

Nitrogen

To derive economic return comparisons to N fertilization the principle of net return as described by Rankin (2005):

Net Return = (wheat price x yield increase) - (N price x N rate) [Eq. 1]

and using Equation 2 and the parameters in Table 14.

$$\{a + b \times (N_{rate}+N_{residual}-N_{ideal})^2 + c \times (N_{rate}+N_{residual}-N_{ideal})\} - \{b \times (N_{residual}-N_{ideal})^2 + c \times (N_{residual}-N_{ideal})\}$$

[Eq. 2]

Table 14. Parameters used in Equation 2 to derive grain yield increases.

Crop	Soil type – moisture supply conditions	a	b	c
CWRS wheat	Moist	0	-0.0015	0.4902
	Dry	0	-0.0013	0.4159
	Arid	0	-0.0038	0.5464
Barley	Moist	-1.6996	-0.0026	0.8195
	Dry	2.2188	-0.0032	0.63997
	Arid	1.601	-0.0011	0.343
Canola	All	0	-0.0009	0.2311
Hybrid canola	All	0	-0.0005	0.202

Three examples with CWRS wheat under Moist, Dry and Arid conditions for a range of wheat prices ($3.50 to $6.50/bushel) and two prices of N - 50¢ and $1.00 per lb of N, represented by (a) and (b) in all three examples – are provided in Fig. 11, 12 and 13. An average soil test of 40 lb N/acre (0-24" depth) was used in all three examples. The CWRS Wheat:N Price Ratio in the graphs represent the average "grain buying power" of CWRS wheat or, in other words, the lb N that one would purchase with one bushel of CWRS wheat at the given price for wheat and fertilizer N. It is apparent that as the crop price increases, the spread in N fertilizer rate at which the average maximum net return from N fertilization with two greatly different fertilizer N prices narrows. The actually spread, of course, will vary depending on the N soil test and could be further refined by narrowing the crop and fertilizer N price increments. Similar trends are observed with barley and canola, when the principle of net return is utilized for these crops.

(a)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	7.0	8.0	9.0	10.0	11.0	12.0	13.0
70	27.0	$59.37	$72.86	$86.34	$99.82	$113.30	$126.78	$140.27
80	29.6	$63.66	$78.46	$93.27	$108.08	$122.89	$137.70	$152.50
90	32.0	$66.89	$82.87	$98.86	$114.84	$130.82	$146.81	$162.79
100	34.0	$69.07	$86.08	$103.09	$120.10	$137.11	$154.12	$171.13
110	35.8	$70.20	$88.09	$105.97	$123.86	$141.75	$159.63	$177.52
120	37.2	$70.28	$88.90	$107.51	$126.12	$144.73	$163.34	$181.96
130	38.4	$69.32	$88.50	$107.69	$126.88	$146.07	$165.26	$184.44
140	39.2	$67.30	$86.91	$106.53	$126.14	$145.75	$165.37	$184.98
150	39.8	$64.23	$84.12	$104.01	$123.90	$143.79	$163.68	$183.57

*Yield responses are averages from 25-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

(b)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	3.5	4.0	4.5	5.0	5.5	6.0	6.5
70	27.0	$24.37	$37.86	$51.34	$64.82	$78.30	$91.78	$105.27
80	29.6	$23.66	$38.46	$53.27	$68.08	$82.89	$97.70	$112.50
90	32.0	$21.89	$37.87	$53.86	$69.84	$85.82	$101.81	$117.79
100	34.0	$19.07	$36.08	$53.09	$70.10	$87.11	$104.12	$121.13
110	35.8	$15.20	$33.09	$50.97	$68.86	$86.75	$104.63	$122.52
120	37.2	$10.28	$28.90	$47.51	$66.12	$84.73	$103.34	$121.96
130	38.4	$4.32	$23.50	$42.69	$61.88	$81.07	$100.26	$119.44
140	39.2	($2.70)	$16.91	$36.53	$56.14	$75.75	$95.37	$114.98
150	39.8	($10.77)	$9.12	$29.01	$48.90	$68.79	$88.68	$108.57

*Yield responses are averages from 25-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

Figure 11. Net return to N fertilizer application at two N prices 50¢ (a) and $1.00 (b) per lb of N for a soil with 40 lb N/acre in the 0-24” depth under Moist soil type – moisture supply category.

(a)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	7.0	8.0	9.0	10.0	11.0	12.0	13.0
50	17.5	$36.41	$45.18	$53.95	$62.73	$71.50	$80.27	$89.04
60	20.3	$40.96	$51.10	$61.23	$71.37	$81.51	$91.64	$101.78
70	22.7	$44.60	$55.97	$67.34	$78.72	$90.09	$101.46	$112.83
80	25.0	$47.33	$59.81	$72.28	$84.76	$97.24	$109.71	$122.19
90	26.9	$49.15	$62.60	$76.05	$89.51	$102.96	$116.41	$129.86
100	28.6	$50.07	$64.36	$78.66	$92.95	$107.25	$121.54	$135.84
110	30.0	$50.07	$65.08	$80.09	$95.10	$110.10	$125.11	$140.12
120	31.2	$49.16	$64.75	$80.35	$95.94	$111.53	$127.13	$142.72
130	32.1	$47.34	$63.39	$79.44	$95.49	$111.53	$127.58	$143.63

*Yield responses are averages from 67-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

(b)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	3.5	4.0	4.5	5.0	5.5	6.0	6.5
50	17.5	$11.41	$20.18	$28.95	$37.73	$46.50	$55.27	$64.04
60	20.3	$10.96	$21.10	$31.23	$41.37	$51.51	$61.64	$71.78
70	22.7	$9.60	$20.97	$32.34	$43.72	$55.09	$66.46	$77.83
80	25.0	$7.33	$19.81	$32.28	$44.76	$57.24	$69.71	$82.19
90	26.9	$4.15	$17.60	$31.05	$44.51	$57.96	$71.41	$84.86
100	28.6	$0.06	$14.36	$28.66	$42.95	$57.25	$71.54	$85.84
110	30.0	($4.93)	$10.08	$25.09	$40.10	$55.10	$70.11	$85.12
120	31.2	($10.84)	$4.75	$20.35	$35.94	$51.53	$67.13	$82.72
130	32.1	($17.66)	($1.61)	$14.44	$30.49	$46.53	$62.58	$78.63

*Yield responses are averages from 67-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

Figure 12. Net return to N fertilizer application at two N prices 50¢ (a) and $1.00 (b) per lb of N for a soil with 40 lb N/acre in the 0-24" depth under Dry soil type – moisture supply category.

(a)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	7.0	8.0	9.0	10.0	11.0	12.0	13.0
20	9.4	$22.93	$27.63	$32.34	$37.04	$41.74	$46.45	$51.15
30	13.0	$30.40	$36.89	$43.37	$49.86	$56.35	$62.83	$69.32
40	15.8	$35.22	$43.10	$50.99	$58.88	$66.77	$74.66	$82.54
50	17.8	$37.37	$46.28	$55.19	$64.10	$73.01	$81.92	$90.83
60	19.1	$36.86	$46.42	$55.97	$65.52	$75.07	$84.62	$94.18
70	19.6	$33.70	$43.51	$53.33	$63.14	$72.95	$82.77	$92.58
80	19.4	$27.87	$37.57	$47.26	$56.96	$66.66	$76.35	$86.05
90	18.4	$19.39	$28.58	$37.78	$46.98	$56.18	$65.38	$74.57
100	16.6	$8.24	$16.56	$24.88	$33.20	$41.52	$49.84	$58.16

*Yield responses are averages from 55-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

(b)

		Expected CWRS Wheat Price						
		$3.50	$4.00	$4.50	$5.00	$5.50	$6.00	$6.50
N Rate	Yield Increase from 0 lb. N*	Net Return ($/ac.)** CWRS Wheat:N Price Ratio						
(lb./acre)	(bu./ac.)	3.5	4.0	4.5	5.0	5.5	6.0	6.5
20	9.4	$12.93	$17.63	$22.34	$27.04	$31.74	$36.45	$41.15
30	13.0	$15.40	$21.89	$28.37	$34.86	$41.35	$47.83	$54.32
40	15.8	$15.22	$23.10	$30.99	$38.88	$46.77	$54.66	$62.54
50	17.8	$12.37	$21.28	$30.19	$39.10	$48.01	$56.92	$65.83
60	19.1	$6.86	$16.42	$25.97	$35.52	$45.07	$54.62	$64.18
70	19.6	($1.30)	$8.51	$18.33	$28.14	$37.95	$47.77	$57.58
80	19.4	($12.13)	($2.43)	$7.26	$16.96	$26.66	$36.35	$46.05
90	18.4	($25.61)	($16.42)	($7.22)	$1.98	$11.18	$20.38	$29.57
100	16.6	($41.76)	($33.44)	($25.12)	($16.80)	($8.48)	($0.16)	$8.16

*Yield responses are averages from 55-site years
Calculations are based on the premise that an "ideal" fertilization program results in 30 lb N/acre residual N in 0-24" depth
Current N rate from your soil test report or common practice
**Net Return = (wheat price x yield increase) - (N price x N rate)
Net return in blue represents maximum for the CWRS Wheat:N Price Ratio range in this table and in Orange within $1.00 of maximum

Figure 13. Net return to N fertilizer application at two N prices 50¢ (a) and $1.00 (b) per lb of N for a soil with 40 lb N/acre in the 0-24" depth under Arid soil type – moisture supply category.

Phosphorus

The same principle of net return (Rankin, 2005) was used for P:

Net Return = (wheat price x yield increase) - (P_2O_5 price x P_2O_5 rate) [Eq. 3]

however, with one modification in the way that yield increase was calculated. This was necessitated as soil test P values and fertilizer P_2O_5 are not interchangeable, as is the case for N. Hence, instead of developing equations to describe the relationship between yield increases and soil test and fertilizer P, a matrix with specific yield increases for specific soil test values and specific P_2O_5 rates was developed for each crop (already shown in Tables 11 through 13) and were used after rounding off P soil test values to the nearest 10 lb/acre value. For example, the yield increase for a CWRS wheat crop grown on a soil with a soil test value of 11 lb bicarbonate extractable P (Olsen et al. 1954) that is rounded off to 20 will be 4.1 bu/acre with application of 20 lb P_2O_5/acre (Table 12) to satisfy sufficiency requirements. The net return for a soil with a bicarbonate soil test of 15-24 lb P/acre, when the price of P is 75 ¢ and $1.00/lb P_2O_5, respectively, is illustrated in Fig. 14.

(a)

P_2O_5 rate (lb./acre)	Yield Increase from 0 lb. P_2O_5* (bu./ac.)	Net Return ($/ac.)**						
Expected CWRS Wheat Price:		$3.80	$4.20	$4.60	$5.00	$5.40	$5.80	$6.20
		CWRS Wheat:P_2O_5 Price Ratio						
		5.1	5.6	6.1	6.7	7.2	7.7	8.3
20	4.1	$0.61	$2.25	$3.89	$5.54	$7.18	$8.82	$10.47

(b)

P_2O_5 rate (lb./acre)	Yield Increase from 0 lb. P_2O_5* (bu./ac.)	Net Return ($/ac.)**						
Expected CWRS Wheat Price:		$3.80	$4.20	$4.60	$5.00	$5.40	$5.80	$6.20
		CWRS Wheat:P_2O_5 Price Ratio						
		3.8	4.2	4.6	5.0	5.4	5.8	6.2
20	4.1	($4.36)	($2.72)	($1.08)	$0.57	$2.21	$3.85	$5.50

Figure 14. Net return to P fertilizer application at two P prices 0.75 (a) and $1.00 (b) per lb of P_2O_5 for a soil with 15-24 lb P/acre in the 0-6" depth.

The results fro this project will be incorporated in the Manitoba Agriculture, Food and Rural Initiatives web-site.

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