ACCOUNTING OF NITROGEN LEVELS IN SASKATCHEWAN SOILS

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INTRODUCTION

Soil nitrogen levels in the fall of 1991 bear the mark of two big harvests. Collectively in the last two years crops grown in Saskatchewan have removed nearly 1.1 million metric tonnes of nitrogen in the grain alone. This amount of nitrogen has essentially been exported from the soil.

Crops are grown with nitrogen from three sources. Nitrogen which is present in the soil in the spring, nitrogen released from the soil over the growing season via mineralization of organic nitrogen, and nitrogen applied through fertilizers. The often quoted contribution of rain can only amount to 3-5 lb N per acre per year and is not considered a source of nitrogen that would sustain crop growth in the prairies. At the same time "available" nitrogen is converted back to organic "non-available" forms through the process of immobilization.

The objective of this presentation was to conceptually assess the impact of the two big harvests in 1990 and 1991 on the overall nitrogen status of Saskatchewan soils and the need for supplemental nitrogen in the upcoming (1992) crop year.

PARAMETERS USED IN CALCULATIONS

The major nitrogen inputs and outputs from the soil were estimated for the 1987 through to 1991 crop years for each Crop District in Saskatchewan using the following parameters and assumptions:

Soil Climatic Zone (SCZ). Each Crop District was assigned one SCZ (Henry, 1990) only as shown in Table 1 to simplify calculations.

Crop Yields. The average crop yields for each Crop District were taken directly from the FINAL report for each year. The yield for each crop expressed in bu/ac was multiplied by the total area seeded to the crop.

Rotation. The rotations described in Table 2 were assumed for each year.

Crop Nitrogen Removal. The nitrogen removal by each crop accounted for is presented in Table 3. Total removal was calculated by multiplying the yield in each Crop District by the values shown in Table 3 for each crop and the total area in each District seeded to each crop. However, only the portion removed by grain/seed was considered as an nitrogen output from the soil system.

Soil Nitrogen. The mean soil test nitrogen values for each Crop District were summarized for each year from fall soil testing values of the previous year. The fall soil testing values were considered statistically representative, since on average 85% of soil testing is performed in the fall of any given year.

Table 1. Soil Climatic Zone assigned to each Crop District

Soil Crop District	Soil Climatic Zone
1A	Moist Dark Brown
1B	Brown
2A	Dark Brown
2B	Dark Brown
3AS	Brown
3AN	Brown
3BS	Brown
3BN	Brown
4A	Brown
4B	Dark Brown
5A	Black
5B	Moist Black
6A	Dark Brown
6B	Moist Dark Brown
7A	Black
7B	Moist Dark Brown
8A	Grey
8B	Moist Black
9A	Moist Black
9B	Moist Black

Table 2. Assumed rotations for each SCZ.

Soil Climatic Zone	Stubble-Fallow (%-%)	Stubble yearly (%)
Brown & Dry Brown	50-50	0
Dark Brown	60-40	33
Moist Dark Brown	65-35	46
Black	75-25	66
Moist Black	85-15	71
Grey	85-15	71

To arrive at "total" soil test nitrogen in a given year, the soil test levels for fallow and stubble fields were multiplied by the total (cropped plus fallow) area in each Crop District according to the percentages for each crop rotation shown in Table 2. On average the following distribution was calculated:

Total area	25 million acres
Crops seeded on stubble	6.5 million acres
Crops seeded on fallow	9.5 million acres
Fallow	7 million acres

Table 3. Aboveground N uptake by crops

Crop		Aboveground lbs N/bu of grain
Wheat	- HRS	1.8
	- Durum	1.8
Canola		2.5
Flax		2.3
Barley		1.2
Oats		1.0

Nitrogen Mineralization and Immobilization. Typical organic soil nitrogen levels and typical straw yield values were used for the purposes of calculating the mineralization and immobilization components. Typical straw yields are based on a 20 bu/ac wheat producing 2,000 lb/ac straw and a linear function between grain and straw yield. The assumptions for calculation of the mineralization and immobilization components of the model are listed in Table 4 (Henry, 1991).

Table 4. Typical straw yields and total soil N values.

SCZ	Typical straw* yields (lb/ac)	Organic soil N (lb/ac)
Dry Brown	2000	2000
Brown	2500	2500
Dark Brown	3000	3000
Moist Dark Brown	3200	3500
Black	3500	5000
Moist Black	3500	6000
Grey	3500	2000

* To calculate N immobilization from straw use 1% of the weight of straw. This is based on the fact that straw is 0.5% N and the N requirement for no immobilization is 1.5%.

The straw values were adjusted each year on the basis of grain/seed yield. Rates of mineralization also varied according to the amount of average precipitation in each Crop District on a yearly basis and ranged between 0.8% to 1.2% of the organic nitrogen for dry to wet years.

Nitrogen Use Efficiency. The nitrogen use efficiency factors were 50% for soil and fertilizer and 80% for mineralizable nitrogen (Henry, 1991).

Total Nitrogen Fertilizer Consumption. It was assumed that nitrogen fertilizer consumption in a given year was equal to the liftings of the fertilizer for that year.

RESULTS AND DISCUSSION

There was a very good agreement between the predicted levels of soil nitrogen, which was available for the next crop (unused portion) and the overall averages of soil test levels in 1988 and 1989 (Table 5). However, in 1990 and 1991 the 7% and 15% discrepancy, between predicted and actually determined levels, respectively, most likely represent nitrogen losses for which no allowance was made in the calculations of the annual balance.

Even with the simplistic approach utilized here to arrive at a nitrogen balance for the 1987-91 period, the accumulation of residual nitrogen levels in 1988 and 1989 is clearly illustrated (Figure 1). Nitrogen available for crop production varied slightly from year to year, which illustrates the paramount effect of climatic conditions on achieved yields (Figure 2). However, the record yield obtained in 1990 and 1991 can be also attributed to the "residual" nitrogen levels accumulated over the preceding drought years.

The scenario presented in Table 5 for a "normal" year would suggest that prospective yields at fertilization levels similar to those of the last two years would most likely be below normal. Above average precipitation and ideal conditions for nitrogen mineralization will certainly improve prospects for an "average" crop yield in 1992 if fertilization levels similar to those of 1990 and 1991 were to be maintained.

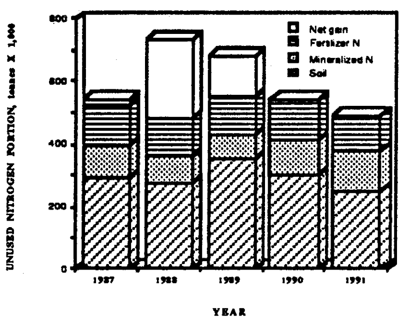

Figure 1. Unused portion of available nitrogen at the end of each of the last five crop years.

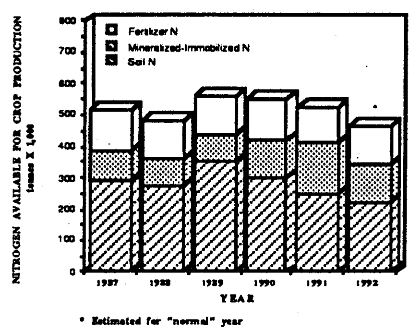

Figure 2. Nitrogen available from main sources for crop production in the last five years.

REFERENCES

Henry, J.L. 1990. Development of crop water production functions for wheat, barley and canola to revise nitrogen fertilizer recommendations in Saskatchewan. University of Saskatchewan, Saskatoon, Sask., Mimeo Report 16 pp.

Henry, J.L. 1991. Development of soil test based nitrogen fertilizer recommendations for wheat, barley, canola, flax oats. University of Saskatchewan, Saskatoon, Sask., Mimeo Report 10 pp.

Table 5. Nitrogen inputs and outputs from Saskatchewan soils for the period of 1987-1991.

YEAR	DESCRIPTION	DEBIT	CREDIT	BALANCE
Spring 1987*	Soil nitrogen levels = 580,000 tonnes	--	290000	290000
	Mineralized nitrogen = 505,000 tonnes	--	404000	694000
	Fertilizer nitrogen = 264,000 tonnes	--	132000	826000
	Immobilized nitrogen = 380,000 tonnes	304000	--	522000
	Available for crop production			522000
	Actually removed by grain export			503000
	net gain			19000
	Unused portion			542000
Spring 1988*	Soil nitrogen levels = 550,000 tonnes	--	275000	275000
	Mineralized nitrogen = 410,000 tonnes	--	328000	603000
	Fertilizer nitrogen = 246,000 tonnes	--	123000	726000
	Immobilized nitrogen = 300,000 tonnes	240000	--	486000
	Available for crop production			486000
	Actually removed by grain export			240000
	net gain			246000
	Unused portion			716000
Spring 1989*	Soil nitrogen levels = 700,000 tonnes	--	350000	350000
	Mineralized nitrogen = 410,000 tonnes	--	328000	678000
	Fertilizer nitrogen = 246,000 tonnes	--	123000	801000
	Immobilized nitrogen = 300,000 tonnes	240000	--	561000
	Available for crop production			561000
	Actually removed by grain export			430000
	net gain			131000
	Unused portion			676000
Spring 1990*	Soil nitrogen levels = 600,000 tonnes	--	300000	300000
	Mineralized nitrogen = 550,000 tonnes	--	440000	740000
	Fertilizer nitrogen = 260,000 tonnes	--	130000	870000
	Immobilized nitrogen = 400,000 tonnes	320000	--	550000
	Available for crop production			550000
	Actually removed by grain export			550000
	net gain			0
	Unused portion			540000
Spring 1991*	Soil nitrogen levels = 500,000 tonnes	--	250000	250000
	Mineralized nitrogen = 605,000 tonnes	--	484000	734000
	Fertilizer nitrogen = 230,000 tonnes	--	115000	849000
	Immobilized nitrogen = 400,000 tonnes	320000	--	529000
	Available for crop production			529000
	Actually removed by grain export			540000
	net gain			-11000
	Unused portion			475000
Fall 1991*	Soil nitrogen levels = 410,000			
	For "normal" year			
Spring 1992	Soil nitrogen levels = 450,000 tonnes	--	225000	225000
	Mineralized nitrogen = 480,000 tonnes	--	384000	609000
	Fertilizer nitrogen = 230,000 tonnes	--	115000	724000
	Immobilized nitrogen = 320,000 tonnes	256000	--	468000
	Available for crop production			468000