Crop Nutrient Removals vs. Fertilizer Additions in North Dakota

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North Dakota has an agricultural system in which large amounts of plant nutrients are exported from the state in marketed crops. The relation between the amount of nutrients exported from the state, soil test levels, and the amount of commercial fertilizer applied can give insight into potential soil fertility problems.

North Dakota Crop Production

Small grains are grown on about 70 percent of the cropped land in North Dakota (Table 1). The acreage of land used in the production of sunflower has increased from about 120,000 acres in 1971 to over a million acres at the present time. Most of these products and the nutrients they contain are exported from the state when they are marketed.

About 17 percent of the crop land in North Dakota is used for the production of hay. However, unlike small grains and sunflowers, most of the hay produced remains in the state and is used as cattle feed. Consequently, some of the nutrients contained in hay are returned to the land in the form of manure. Other crops such as flax, corn, potatoes, sugarbeets and beans are grown on approximately 9 percent of the crop land.

Table 1. Average harvested acres (000 acres) of the major crops grown in North Dakota between 1971-1980.*

Crop	Area
	000 acres
Wheat (all)	9,650
Sunflower	1,160
Oats	1,260
Barley	2,070
Sugarbeets	130
Potatoes	120
Flax	570
Corn (grain)	220
Corn (silage)	300
Edible beans	130
Hay (all)	3,330
Soybeans	180
TOTAL	19,110

*From: North Dakota Crop and Livestock Statistics, Dept. of Agric. Economics, NDSU and USDA Economics, Statistics and Cooperative Service.

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Nutrient Removal by Crops vs. Fertilizer Additions

Harvested crops remove tremendous amounts of nutrients from North Dakota soils each year. The nutrients removed in the greatest quantity are nitrogen (N), phosphorus (P) and potassium (K). The amount of these nutrients removed per harvested unit (bushel, ton, etc.) are given in Table 2. These data were multiplied by the average production of the major crops in North Dakota to determine the amount of N, P and K removed (Table 3). Approximately 400,000 tons of N, 60,000 tons of P (140,000 tons of P_2O_5) and 150,000 tons of K (180,000 tons of K_2O) are removed from the soils of North Dakota each year. About half of the N and P are from land planted to wheat.

Table 2. Nutrient removal per harvested unit of major crops grown in North Dakota.

Crop	Harvested Unit	Nutrient N	P	K
		---lb/harvested unit* ---		
Wheat (all)	bu	1.60	0.25	0.20
Sunflower (all)	cwt	2.90	0.50	0.60
Oats	bu	0.65	0.11	0.16
Barley	bu	1.10	0.18	0.30
Sugarbeets	ton	4.17	0.25	6.90
Potatoes	cwt	0.30	0.09	0.50
Flax	bu	2.00	0.37	0.62
Corn (grain)	bu	0.90	0.15	0.20
Corn (silage)	ton	6.67	1.16	5.40
Edible beans	cwt	6.66	0.58	1.94
Hay (all)	ton	28.00	4.40	32.00
Soybeans	bu	3.20	0.36	1.16

*Sunflower data from M.S. thesis of Allen A. Faulkner entitled, "Effect of Plant Density and Fertility Treatment on the Uptake of N, P & K by Sunflower" 1977. Other data from various publications of the American Potash Institute.

Table 3. Average production (1970-1980) and nutrient removal of the major crops grown in North Dakota.

Crop	Production*	Nutrient Removal N	P [P_2O_5]	K [K_2O]
	000	----------000 tons----------		
Wheat (all)	255,000 bu	204	32 [73]	26 [31]
Sunflower (all)	13,800 cwt	20	7 [7]	4 [5]
Oats	61,500 bu	20	3 [7]	5 [6]
Barley	85,500 bu	47	8 [18]	13 [16]
Sugarbeets	2,025 tons	4	0.3 [0.7]	7 [8]
Potatoes	19,200 cwt	3	1 [2]	5 [6]
Flax	6,000 bu	6	1 [2]	2 [2]
Corn (grain)	14,600 bu	7	1 [2]	1 [1]
Corn (silage)	1,690 tons	6	1 [2]	5 [6]
Edible beans	5,000 cwt	17	1 [2]	5 [6]
Hay (all)	4,500 tons	66	10 [23]	76 [91]
Soybeans	3,500 bu	6	1 [2]	2 [2]
TOTAL		406	62 [142]	151 [181]

*Data from North Dakota Crop and Livestock Statistics, Dept. of Agricultural Economics, NDSU and USDA Economics, Statistical and Cooperative Service.

Potassium

Soil tests and experience have shown that the soils of North Dakota are well supplied with potassium, except for a few sandy soils. From the standpoint of balanced plant nutrition and economics, potassium fertilization should not be of great concern on many soils at the present time. Since only 4 percent of the soils in North Dakota have K soil test levels of medium or below (1) (Table 4), only about 6,000 tons of K fertilizer are needed each year to replace the potassium removed by crops. Presently about 22,000 tons of potassium fertilizers are being applied annually to our soils (2). This is more than enough to maintain potassium soil test levels, provided the fertilizer is being applied to the soils that need it.

Table 4. Summary of soil test phosphorus and potassium levels for North Dakota.

Soil test category	Phosphorus	Potassium
	----------% ----------	
Low	20	0
Medium	44	4
High	23	15
Very high	13	81

Phosphorus

North Dakota farmers are doing a very good job of maintaining the P levels in their fields. Approximately 62,000 tons of P are removed by crops each year and about 50,000 tons or 81 percent of the P removed is being replaced as fertilizer. On the average this is good. Hopefully most of the fertilizer is being applied to low testing fields and not to those already testing very high.

Nitrogen

While significant losses of P and K only occur through crop removal and erosion, N balances are more difficult to determine. Nitrogen can be gained or lost from a soil in various ways. Nitrogen gains occur through atmospheric fixation and when legumes are included in a crop rotation. Losses of N can be a result of denitrification, leaching or volatilization.

When a soil is in sod or some other type of no-tillage cropping system, organic matter levels tend to increase. Cultivation of these soils promotes the mineralization of this organic matter and a subsequent increase in available nitrogen to plant growth. Each year these soils are cultivated, the amount of organic matter mineralized becomes less. At some point in time, the amount of nitrogen released each year will become relatively constant assuming nitrogen has not been added as fertilizer. The length of time required for this to occur depends on the amount and type of organic matter which was present originally.

Most soils in North Dakota have been cultivated long enough so that the amount of nitrogen released from soil humus each year is rather constant. In the western quarter of the state about 30 pounds of N per acre are released each year and in the eastern quarter it is about 55 pounds per acre. At present the amount of mineralization is probably more related to the amount of crop residue and its nitrogen content.

The use of nitrogen fertilizer in North Dakota has greatly increased in recent years. In 1970 approximately 100,000 tons of N were applied. This level increased to 300,000 tons in 1982 (2). The amount of N which is removed by crops each year is 400,000 tons (Table 3). As a result, the reserve supply of N in our soils is decreasing. Nitrogen deficient crops are commonly observed.

Table 5. Crop nutrient removal versus nutrients applied in commercial fertilizer (1982)* in North Dakota.

	Nutrient N	P [P_2O_5]	K [K_2O]
	----------000 tons----------		
Removal	406	62 [142]	151 [181]
Addition	300	50 [114]	22 [28]
Percentage added	74	81	12

*Sunflower data from M.S. thesis of Allen A. Faulkner entitled, "Effect of Plant Density and Fertility Treatment on the Uptake of N, P & K by Sunflower" 1977. Other data from various publications of the American Potash Institute.

Summary

Soils inherently contain only a finite quantity of nutrients. When more nutrients are removed than are being replaced, soil eventually becomes depleted. Data from this study indicate that in North Dakota, plant nutrients are not being replaced in quantities large enough to replace all of the nutrients being removed by crops (Table 5).

The difference between removal and replacement is not serious with potassium, as the level in most of the state's soils is very high. On the average, North Dakota soils are medium in nitrogen and phosphorus. These nutrients are not being added in amounts large enough to replace the amount being removed by harvested crops. As a result, yields are below potential simply because of a lack of nutrients.

The systematic use of soil testing is a valuable tool for the management of soil fertility. Knowledge of the nutrient levels in each field will help avoid the application of fertilizer when it is not needed and will determine the amount of fertilizer to apply to different soils. Knowledgeable use of plant nutrients on wheat in North Dakota will often result in a return of five dollars for every dollar invested in fertilizer.

References

1. Dahnke, W.C., L.J. Swenson, Arlyce Johnson and Adeline Klein. 1982. Summary of soil fertility levels for North Dakota: 1972-1981. Bulletin No. 512, North Dakota Agric. Expt. Sta., Fargo, ND 58105.
2. Hargett, Norman L. and Janice T. Berry. 1983. 1982 fertilizer summary data. ISSN.0146.1850, National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, AL 35660.