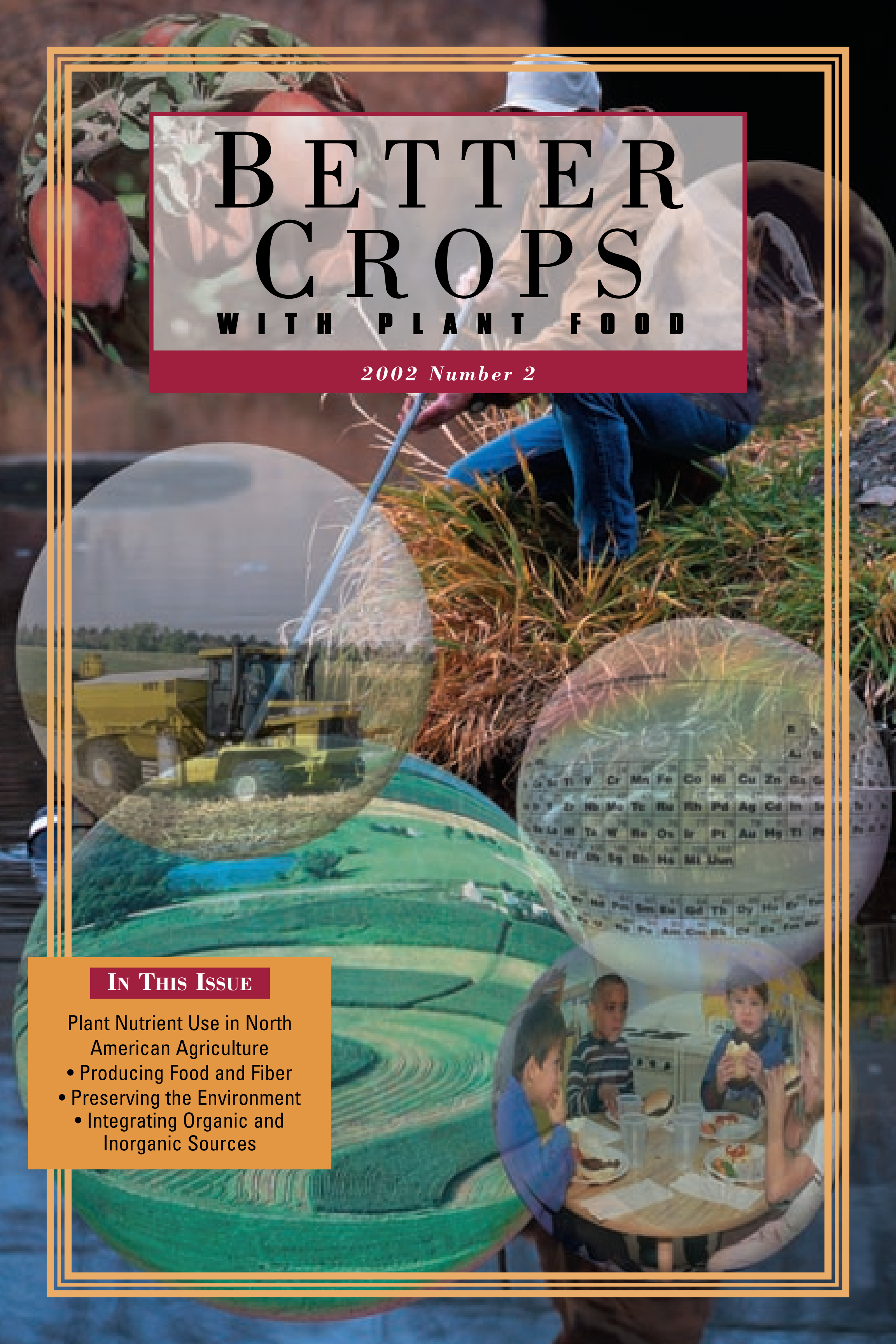

BETTER CROPS

WITH PLANT FOOD

2002 Number 2

IN THIS ISSUE

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- Producing Food and Fiber
- Preserving the Environment
- Integrating Organic and Inorganic Sources

BETTER CROPS WITH PLANT FOOD

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Our Cover: There is a need for better understanding of inorganic and organic nutrient sources for crops.
Photo Credit: USDA-ARS, USDA-NRCS, and PPI staff.

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Note: The articles in this issue of *Better Crops with Plant Food* are condensed from *Plant Nutrient Use in North American Agriculture*, PPI/PPIC/FAR Technical Bulletin 2002-1. The bulletin contains 10 chapters of information plus an executive summary and appendix tables.
See page 23 for more details.

Introduction to Inorganic and Organic Nutrients

By David W. Dibb

The word nutrient is a derivation of the word nutrition, which implies food. The term essential nutrient, then, is redundant in the sense that essentiality is defined as necessary to sustain life and food sustains life. In the plant world, an element is considered essential if it is necessary for the plant to complete its life cycle. No other element can substitute for it completely. Of the elements that have been identified by scientists, only a relatively small proportion is known to be essential to plants and animals.

There are differences in inorganic and organic nutrients, but there are also similarities. It is important to understand the advantages and disadvantages as well as the limitations of both nutrient sources.

Plant nutrients include gases, metals, and non-metals. All exist naturally, in both inorganic and organic forms. Three of the nutrients, nitrogen (N), phosphorus (P), and sulfur (S), are present in both inorganic and organic forms. Crops grow in a very thin layer of the Earth's crust, so it is important that nutrient levels be maintained by the addition of both organic (plant and animal residues) and inorganic (manufactured mineral fertilizers) sources.

Sometimes the word organic is used in connection with food. Often it is used to suggest that organic foods contain only good or natural elements that somehow enhance plant and animal health when compared to those foods grown with synthetic chemicals. Actually, whether organic or inorganic, all elements are chemical. The term organic relates to living (or the remains of once living) substances which contain carbon (C). Organic substances (dead plant or animal material in some stage of decomposition) are found in all agricultural soils and are constantly in transition back to their inorganic form. As they decompose, they contribute to the total soil inorganic nutrient pool necessary to grow the world's food requirement.

Attempting to separate organic and inorganic nutrients is difficult and of limited value because nature's processes are continually cycling them from one form to another. All nutrients go through natural cycles, following various pathways to their final destination of being absorbed and utilized by plants that grow all the food for humans and animals. In the process, some, such as N, P, and S, cycle back and forth between the inorganic and organic pools.

It is important to note that when supplied to plants in the organic form, nutrients still must cycle through the inorganic form before becoming available to plants. In fact, organic nutrient sources can be differentiated from inorganic (mineral) fertilizers in that they must be decomposed before the nutrients they contain are released, hopefully at a time when crop plants can use them. On the other hand, inorganic nutrients are supplied in soluble or slowly soluble forms, so the plant will have them available and take them up when they are needed. BC

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Inorganic Nutrient Use

By W.M. Stewart and T.L. Roberts

Commercial fertilizers were introduced to North American agriculture in the form of Peruvian guano (seabird droppings) in the 1840s. Production of inorganic superphosphate and mixed fertilizers began in the U.S. soon after the process for acidulating phosphate rock with sulfuric acid was patented in England in 1842. The development of the K industry was accelerated following the outbreak of World War I. Major K deposits were discovered in New Mexico in 1925, and high grade reserves were discovered in Saskatchewan in 1943.

The development of the N fertilizer industry lagged behind P and K until after World War II. The first successful synthetic ammonia (NH_3) plant was built in the U.S. in 1921. Within the next 10 years, several plants were operational. The first NH_3 plants in Canada came into production during the 1940s.

Use of commercial nitrogen (N), phosphorus (P), and potassium (K) fertilizers tripled from 1961 to 2000 in North America. However, since the late 1970s, crop removal to fertilizer use ratios have been climbing.

The use of commercial NPK fertilizers in North America increased rapidly after the middle of the last century, tripling between 1961 and 2000, with much of the increase occurring before 1980 (**Figure 1**). Higher fertilizer consumption during the 40-year period corresponded to increases in average crop yields. This relationship should not be surprising since it has been estimated that nutrient inputs are responsible for up to 50 percent of total crop yield. While there are some challenges to documenting such estimates, they are generally supported by research. Data from long-term studies representing 157 years of crop production…with significant variability in crop response to nutrient applications because of crop

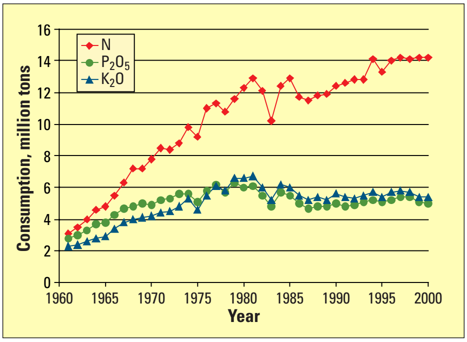

Figure 1. Consumption of N, P_2O_5, and K_2O in North America (U.S. and Canada) from 1961 to 2000.

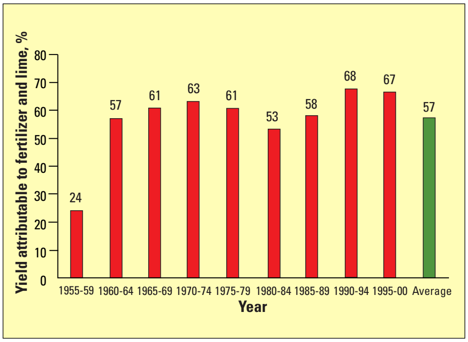

Figure 2. Continuous corn yield from Morrow Plots attributable to N, P, and K fertilizer and lime over 46 years (Reetz, 2001, personal communication).

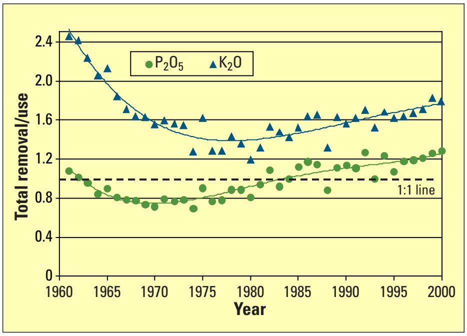

Figure 3. Estimated total nutrient removal relative to inorganic nutrient use in the U.S. from 1961 to 2000.

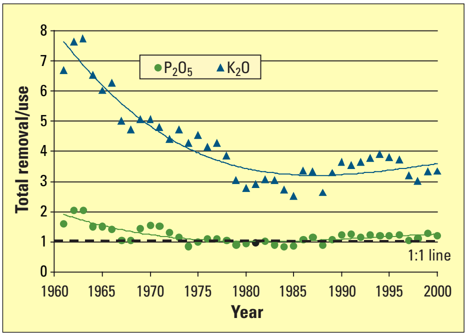

Figure 4. Estimated total nutrient removal relative to inorganic nutrient use in Canada from 1961 to 2000.

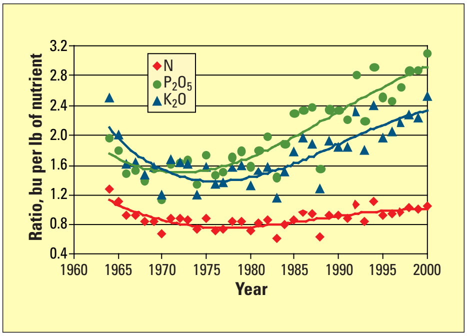

Figure 5. Ratio of corn production to estimated N, P, and K fertilizer use on corn in the U.S.

Commercial fertilizer use in North America is responsible for 30 to 50 percent of crop yield.

species, climate, and other factors…indicate that fertilizer's contribution to total crop yield is in the 30 to 50 percent range. An example of such research is the study established by the University of Illinois in 1876, known as the Morrow Plots. In this study, 57 percent of the yield of continuous corn is attributable to N, P, and K fertilizer and lime (**Figure 2**).

Since the late 1970s, P and K removal/use ratios in the U.S. have been steadily increasing (**Figure 3**). They have also been increasing in Canada, but at a much slower rate (**Figure 4**). In fact, both the U.S. and Canada have been depleting soil P and K for several years if organic nutrient use is not taken into account. However, only a small percentage of cropland in the U.S. actually receives nutrients from manure...17 percent of the corn acres and 6 percent of the soybean acres.

Even though inorganic fertilizer N use has leveled off and P and K use has dropped in recent years, crop yields continue to climb. As a result, apparent fertilizer use efficiency has increased, as illustrated by corn in the U.S. (**Figure 5**).

While we should continue to strive to improve nutrient use efficiency, we should also keep in mind that at least a part of the apparent improvement in efficiency is the result of mining (depletion) of soil nutrients. BC

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Inorganic Phosphorus and Potassium Production and Reserves

By T.L. Roberts and W.M. Stewart

The U.S. is the world's largest producer of phosphate rock, accounting for nearly 30 percent of the total world production, averaged over the past five years (**Table 1**). It is also the world's largest consumer and exporter of phosphate rock. More than 90 percent of phosphate ore mined in the U.S. is used to make chemical fertilizers and animal feed; the remainder goes to production of elemental P and industrial phosphates.

Domestic production of marketable phosphate rock steadily increased from 1970 until the early 1980s, where it peaked at about 60 million tons. Since then annual production has varied from 41 to 55 million tons with an average of about 45 million tons in the last five years. Trends in consumption have closely followed production.

Forecasting extent and life of exploitable deposits is not easy and estimates of world phosphate reserves vary greatly. The U.S. Bureau of Mines and U.S. Geological Survey define reserves as those deposits that can be economically extracted or produced at the time of determination. Resources are defined as reserves plus all other mineral deposits that may potentially be feasible at some time in the future. Reserve base is that part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices.

The U.S. has about 8 percent of world reserves and 8 percent of the global reserve base (**Table 1**). If future consumption equaled the mine production averaged over the last five years, American phosphate reserves would last 25 years and the remainder of the reserve base another 73 years. This compares to a world reserve life of 88 years and reserve base life of 343 years.

The world's phosphorus (P) and potassium (K)-containing ore bodies are finite, and non-renewable resources. Estimates of reserve life are difficult to predict. However, at current production levels and costs, North America has sufficient P ore reserves to last about 25 years and almost 100 years if higher cost ore is included. There is sufficient K available for hundreds of years.

While exploitable P deposits have a finite life, it does not mean that the U.S. or other countries will run out of phosphate rock at some specific time in the future. Reserves and reserve base do not include resources, which are not presently economically recoverable. U.S. phosphate resources are immense. Onshore phosphate resources for the Atlantic Coastal Plain have been estimated at about 24 billion tons. Southeastern offshore deposits are believed to extend from peninsular Florida to possibly as far north as the Grand Banks. As much as 200 billion tons of phosphate resources may occur in the Miocene sediments of the Continental Shelf offshore Georgia. In the western U.S., resources less than 325 yards below ground and that could be surface mined are estimated at 28 billion tons, with more than 500 billion tons at depths too deep for present mining technology.

The world mined 30.2 million short tons of potash in 2001. Canada was the largest producer at 10.1 million tons, or 35 percent of the world's total production. The U.S. was the sixth largest producer with 5 percent of the world's total.

Canada continues to be the world's

largest exporter of potash (43 percent of the world trade in 2000), and the U.S. remained the largest user with about 20 percent of the world's consumption. More than 90 percent of the potash used in the U.S. comes from Canada.

North American and world reserves and resources of potash are extensive. Canada and the U.S have 5 billion tons of reserves, which represents 54 percent of world reserves, enough to last almost 600 years, at current consumption rates (**Table 2**). With just over 11 billion tons of potash in the North American reserve base, there is sufficient K to meet domestic and export needs for centuries.

Estimates of the world's potash resources vary widely, but by all accounts resources are huge, ranging from about 160 to 250 billion tons K_2O. Canada's potash resources are conservatively projected at 60 billion tons, while U.S. resources are estimated at 6 billion tons... enough to produce at current levels for several thousand years. BC

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TABLE 1. World phosphate rock production, reserves, and reserve base.

Country	Average production, 1997-2001, thousand tons	Reserves[1], million tons	Reserve life[2], years	Reserve base, million tons	Reserve base life[2], years
United States	44,851	1,102	25	4,408	98
Brazil	4,875	364	75	408	84
China	24,134	1,102	46	11,020	457
Israel	4,487	198	44	882	196
Jordan	6,350	992	156	1,873	295
Morocco/ Western Sahara	25,346	6,281	248	23,142	913
Russia	11,020	220	20	1,102	100
Senegal	1,860	55	30	176	95
South Africa	3,152	1,653	524	2,755	874
Syria	1,955	110	56	882	451
Togo	1,917	33	17	66	34
Tunisia	8,697	110	13	661	76
Other countries	12,364	1,322	110	4,408	357
Total (rounded)	**151,000**	**13,224**	**88**	**51,794**	**343**

[1]Reserve and reserve base cost less than $36/ton and $90/ton, respectively. Cost includes capital, operating taxes, royalties (if applicable), miscellaneous costs, and a 15 percent rate of return on investment, FOB mine (1992 costs).
[2]Life based on 1997-2001 five-year average mine production.
Source: U.S. Geological Survey.

TABLE 2. World potash production, reserves, and reserve life.

Country	Average production, 1997-2001, thousand tons	Reserves, million tons	Reserve life[1], years	Reserve base, million tons	Reserve base life[1], years
Belarus	3,780	827	219	1,102	292
Brazil	332	331	996	661	1,992
Canada	9,704	4,849	500	10,689	1,102
Chile	73	11	152	55	758
China	205	154	753	507	2,473
France	488	0.6	1		
Germany	3,741	782	209	937	250
Israel	1,827	44	24	639	350
Jordan	1,130	44	39	639	565
Russia	4,232	1,984	469	2,424	573
Spain	645	22	34	39	60
Ukraine	57	28	481	33	576
United Kingdom	608	24	40	33	54
United States	1,411	99	70	331	234
Other countries		55		154	
Total (rounded)	**28,500**	**9,257**	**325**	**18,734**	**658**

[1]Life based on 1997-2001 five-year average mine production.
Source: U.S. Geological Survey.

Organic Nutrients

By A.E. Ludwick and A.M. Johnston

Organic nutrient sources are economic and agronomic resources that can supplement inorganic fertilizer use. They contain varying concentrations of essential nutrients and provide organic carbon (C) that enhances physical properties of soils. When applied in excess of crop removal, organic nutrients can be potentially damaging to the environment because of excessive nitrate (NO_3^-) leaching to groundwater, phosphorus (P) moving to surface waters through runoff and erosion, and ammonia (NH_3) loss to the atmosphere. Indiscriminate use of animal manure and sewage sludge can also create human health hazards because of the accumulation of heavy metals and pathogens. A further challenge of managing manure as a nutrient source is that of variable composition, as shown in **Table 1**.

Livestock production operations are declining in number and growing in size. This concentration of animal units (AU) has led to problems in utilizing manure for maximum agronomic and environmental benefit. The issue facing North America is how to economically transport or otherwise utilize a product of large volume and low nutrient content.

TABLE 1. Average composition of various manures.

	Total N, % by wt.	NH_4-N, % of total N	Ratio $N:P_2O_5$	Ratio $N:K_2O$
Liquid				
Hog	0.37	62	1.5:1	1.9:1
Dairy	0.29	48	1.8:1	0.9:1
Beef	0.25	64	1.4:1	1.2:1
Poultry	0.75	75	1.2:1	2.0:1
Solid				
Hog	1.00	27	0.7:1	1.2:1
Dairy	1.10	12	3.4:1	2.0:1
Beef	0.59	12	1.8:1	0.8:1
Poultry	2.00	27	1:1	1.5:1

Calculated from OMAFRA, 1998; (based on total composition).

The dominant source of livestock manure potentially recoverable in North America is from confined animal operations, including beef and dairy cattle, swine, and poultry...about 38 million animals in the U.S. The total number of such operations is declining, but average size is increasing.

Nutrients from manure that are available for land application in North America were recently estimated at about 2,865 million pounds of nitrogen (N), 3,691 million pounds of P_2O_5, and 4,318 million pounds of K_2O (**Table 2**). Much of this manure is already being used in crop production, so it represents a part of the nutrient pool rather than a potential addition. It is uncertain, however, what proportion of the nutrients from manure is being efficiently utilized as opposed to that being disposed of as a waste.

Poultry contributes the largest amount of recoverable N and P of all livestock types in the U.S., while milk cows contribute the most potassium (K), **Table 3**. The contributions of poultry and swine have been increasing while other livestock types have been on the decline.

For example, the poultry contribution of recoverable N grew from

TABLE 2. Recoverable nutrients from manure produced by livestock in the U.S. in 1997 and Canada in 1996.

	Million pounds of recoverable nutrients (available for soil application)		
	N	P_2O_5	K_2O
U.S.			
Fattened cattle	390	582	755
Milk cows	636	559	1,072
Other beef and dairy	131	248	364
Swine	274	634	811
Poultry	1,153	1,268	812
All livestock types	2,583	3,290	3,814
Canada			
Fattened cattle	102	153	185
Milk cows	89	78	140
Other beef and dairy	12	26	33
Swine	45	104	125
Poultry	33	39	21
All livestock types	282	400	505
Total, North America	**2,865**	**3,691**	**4,318**

U.S. N and P data: Kellogg et al., 2000.
U.S. K data: Dr. C.H. Lander, NRCS (personal communication).
Canadian data: Anonymous, 1997.

TABLE 3. Percent of total recoverable manure nutrients accounted for by each livestock type in the U.S. in 1997.

	Recoverable nutrients, %		
Livestock type	**N**	**P_2O_5**	**K_2O**
Fattened cattle	15.1	17.7	19.8
Milk cows	24.6	17.0	28.1
Other beef and dairy	5.1	7.5	9.5
Swine	10.6	19.3	21.3
Poultry	44.6	38.5	21.3
All types	100.0	100.0	100.0

N and P data: Kellogg et al., 2000.
K data: Dr. C.H. Lander, NRCS (personal communication).

The amount of livestock manure available for land application in North America continues to increase.

34 percent in 1982 to 45 percent in 1997, while the swine contribution grew from 9 percent in 1982 to 11 percent in 1997. The greatest percent decline in recoverable manure nutrient contribution during this period occurred for milk cows.

The amount of farm-level manure will continue to increase as confined livestock numbers rise. Also, the percentage of recoverable nutrients will likely increase as handling and processing facilities improve. Estimates for the U.S. show that currently only 20 percent of excreted manure N and about 37 percent of P and K are recoverable.

Historically, manure has been applied based on its N content, but repeated applications on the same areas have resulted in a buildup of soil P. Guidelines are now being developed to evaluate the environmental hazards associated with this excess P and how they can be minimized through controlled application rates. BC

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Economics of Nutrient Systems and Sources

By H.F. Reetz, Jr. and G.D. Schnitkey

The long-term economic viability of a crop production system depends on sound management decisions such as the selection of nutrient sources. Commercial fertilizers are the most common, but they can be supplemented, or sometimes replaced, by nutrients generated by the crop rotation [primarily nitrogen (N) from legumes], livestock manure, or other organic sources. Economic analysis of the nutrient management plan becomes more complex when organic nutrient sources are used.

Nutrient use should be evaluated on the basis of all crops in a rotation as well as the entire farm enterprise. When manure is used, it should be sold or charged as an expense to the crop on which it is applied and treated as an income for the farm livestock enterprise where it was produced. If the farm has no livestock, there still may be opportunity to obtain manure from local concentrated livestock operations. It is important to analyze the value of manure compared to commercial fertilizer as a nutrient source.

Economic comparisons of different cropping systems for central Illinois provide examples of how crop rotation influences profitability. Nutrient management is an important part of that analysis. Evaluation of various manure sources and storage systems is included to show the economic value of the nutrients supplied.

Rotation Impacts on Fertilizer Sources: Corn/Soybean Example

Crop rotation is an important factor in decisions about nutrient sources. Nitrogen is usually the nutrient of economic concern in rotation systems. In a corn/soybean rotation, for example, the value of the N in manure applied for the soybean year is relatively low, because it will likely replace only N that would normally be fixed by nodulating bacteria living on the soybean roots. Planning manure application to best match the crop's need for N will help capture more of the value of the manure. If the N is lost or not needed by the growing crop, that value is forfeited, and the potential for groundwater pollution increases.

A comparison of several cropping system scenarios will help illustrate an approach to evaluating the value of various nutrient sources in different crop management systems. The effect of crop residues and nutrient removals from the crops in the rotation form the basis for agronomic and economic comparison.

Table 1 lists budgets giving annual revenues and costs for corn and soybeans when the preceding crop is either corn or soybeans. For example, the corn following soybeans column gives a budget for corn, given that the previous year's crop was soybeans. While multi-crop rotations are sometimes suggested as an alternative that could provide organic nutrient sources, these budget comparisons help illustrate why Illinois farmers have shifted toward the corn-soybean system. Where there is a special market or need for wheat or alfalfa, such a system still has its place among viable options. The budgets in **Table 1** do not include government payments. This is appropriate for looking at rotations because payments are

TABLE 1. Crop budgets for central Illinois, 2001.

	Corn following soybeans,	Corn following corn,	Soybeans following corn,	Soybeans following soybeans,	Wheat,	Alfalfa estab.,	Alfalfa,
	....	.... bu	....	....	....	.... tons	....
Average yield per acre	158	148	49	44	75	2.5	4
Price received, $/bu or $/ton	2.00	2.00	5.45	5.45	2.30	100	100
Revenue, $/A	316	296	267	240	173	250	400
Variable costs, $/A							
Fertilizer and lime	58	63	20	20	42	41	46
Pesticides	32	39	33	33	0	48	32
Seed	33	33	19	19	15	48	0
Drying and storage	17	16	6	6	8	0	0
Machinery repair, fuel, and hire	34	34	28	28	19	35	42
Total variable costs, $/A	174	185	106	106	84	172	120
Fixed costs, $/A							
Labor	25	25	20	20	20	30	30
Building repair and depreciation	8	8	8	8	8	8	8
Machinery depreciation	19	19	17	17	15	15	15
Interest on investment	23	23	23	23	16	16	15
Overhead	15	15	15	15	15	20	15
Land (cash rent equivalent)	145	145	145	145	145	145	145
Total fixed costs, $/A	235	235	228	228	219	234	228
Total costs, $/A	409	420	334	334	303	406	348
Revenue less variable costs, $/A	142	111	161	134	89	78	280
Revenue less total costs, $/A	-93	-124	-67	-94	-131	-156	52

Source: Based on calculations and other publications by authors.

not tied to production practices. Prices received reflect the higher of market prices or loan rates.

In the above comparison, corn following soybeans yielded 10 bu/A higher than corn following corn. Research shows that yields decline by up to 10 percent when a rotation is not used. Fertilizer and lime costs are higher for corn following corn because of higher amounts of N recommended than for corn following soybeans. Pesticide costs are also higher because of higher insecticide applications on corn following corn. As a result, the corn following soybeans rotation is more profitable than the corn following corn. Phosphorus (P) and potassium (K) are applied at replacement levels.

The budgets shown in **Table 1** are used in **Table 2** to evaluate rotations. These examples show the annual average expenses and revenues for each of the rotations, providing an average cash flow picture for comparison. Revenues and costs for a rotation represent a blend of revenue and costs for a blend of the crops in the rotation. For example, the corn/soybean rotation has a $39 fertilizer and lime cost. This equals half of the $58 fertilizer and lime cost from corn

Both economic and agronomic benefits have been identified with crop rotation.

TABLE 2. Returns and costs of alternative rotations in central Illinois, 2001.

	Corn/ soybeans	Conti- nuous corn	Corn/ soybeans/ wheat	Corn/ soybeans/ alfalfa (estab.)	Corn/ soybeans/ alfalfa (4 yrs.)
Revenue, $/A	292	296	252	278	339
Variable costs, $/A					
Fertilizer and lime	39	63	40	40	43
Pesticides	33	39	22	38	35
Seed	26	33	22	33	17
Drying and storage	12	16	10	8	4
Machinery repair, fuel, and hire	31	34	27	32	37
Total variable costs, $/A	141	185	121	151	135
Fixed costs, $/A					
Labor	23	25	22	25	28
Building repair and depreciation	8	8	8	8	8
Machinery depreciation	18	19	17	17	16
Interest on investment	23	23	21	21	18
Overhead	15	15	15	17	16
Land (cash rent equivalent)	145	145	145	145	145
Total fixed costs, $/A	232	235	228	233	230
Total costs, $/A	373	420	349	384	365
Revenue less variable costs, $/A	151	111	131	127	204
Revenue less total costs, $/A	-81	-124	-97	-106	-26

Sources: Calculations based on costs from Table 1.

following soybeans and half of the $20 per acre costs from soybeans following corn. The most profitable rotation is corn/soybeans/ alfalfa (4 years). Most farmers do not include alfalfa in their rotations because marketing alfalfa can be difficult, particularly if an outlet cannot be identified. Compared to corn and soybeans, alfalfa requires more intensive management and a completely different set of equipment. The second most profitable rotation is corn/soybeans. The revenue less variable cost for corn/soybeans is $151. The revenue less total cost is -$81 per acre. A 50 percent corn and 50 percent soybeans rotation is the most popular rotation in central Illinois. Much of the reason for this is that it is the most profitable grain crop combination. Moving to alfalfa or other higher end crops would add costs. Wheat in the rotation decreases profitability. Similarly, adding alfalfa for only the establishment year to a corn/soybeans rotation decreases profitability.

Considering Livestock Manure as a Nutrient Resource

Livestock manure is an important resource for some farms. Where it is available, it is a good nutrient source. However, there is not enough manure produced to meet a large percentage of the nutrient needs of intensive crop production. Perhaps even more important, the manure production tends to be in areas not geographically located near the cropland that can utilize it.

Table 3 shows daily nutrient production from livestock. Nutrient production can vary tremendously depending on many factors, including the animal's diet. Large operations can produce significant amounts of manure. Even with a relatively low value per animal per day, the cumulative value of manure from a large livestock enterprise is a significant economic value to the overall farm operation. However, livestock manure does have some limitations. One of the most serious is the variability in nutrient content

TABLE 3. Daily nutrient production from different species of livestock.

	Animal weight, lb	Manure produced	N	P_2O_5	K_2O	Value[1], $/day
		....	.... lb/day	....	....	
Dairy	1,000	82.00	0.410	0.168	0.324	0.164
Beef	1,000	60.00	0.339	0.252	0.285	0.163
Veal	200	12.40	0.054	0.013	0.056	0.022
Swine-nursery	35	2.30	0.016	0.012	0.012	0.008
Swine-grower	65	4.20	0.029	0.023	0.023	0.014
Gestating sow	275	8.90	0.062	0.048	0.088	0.035
Poultry-layer	4	0.21	0.003	0.003	0.001	0.001
Poultry-broiler	2	0.14	0.002	0.001	0.001	0.001

[1]Valued based on $0.22, $0.22, and $0.14 price per pound for N, P_2O_5, and K_2O, respectively.
Sources: Midwest Plan Service 18, 1991.

because of different feed rations. Storage system and duration, application method, and timing relative to crop growth will impact the amount of nutrient actually available for crop production. For example, N loss from denitrification during storage in a lagoon or volatilization during surface application will reduce the value associated with manure N.

Testing the manure is an important, but mostly overlooked, part of the planning process. Transportation costs must be considered in determining manure value. The high volume, low nutrient analysis of manure makes transportation costly, so it rarely can be economically transported more than a short distance from the livestock operation. Manure is an important nutrient source if properly handled and if care is taken to balance nutrients in the manure with other fertilizer materials in a complete nutrient management plan.

USDA photo by Ken Hammond.

Livestock manure can be an important nutrient source if managed properly.

Economics of Organic Production Systems

Crop production systems that use no commercial fertilizers, but depend entirely on manure and other organic sources, face certain limitations...including economic considerations. They tend to be centered around specific markets. Favorable economics depend, to a large extent on the availability of organic nutrient sources, the ability to produce profitable yields, and the dependability of the markets. To use the "USDA Organic" label in marketing, restrictive practices are required. Organic production systems can be an economically sound alternative for those who are willing and able to participate in the limited opportunities to market products. BC

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Crop Nutritional Needs

By A.M. Johnston and N.R. Usherwood

Agriculture's greatest challenge is to continue to increase crop yields per unit of land farmed to meet the food requirements of a growing world population. It is no secret that proper nutrient management has been and continues to be critical to advances in crop production. Understanding site-specific nutrient requirements and optimum rate, time, and method of nutrient application is essential for improving crop yield, quality, and profitability while protecting the environment.

> With improved yields, removal of nutrients has increased. Effective and efficient resupply of nutrients requires access to reliable information about crop yield levels, nutrient requirements, and nutrient removal.

Yields have increased significantly in North America during the past 40 years. For example, from 1961 to 2000, average corn yields increased 1.9 bu/A per year in the U.S. and 1.1 bu/A per year in Canada. Wheat yields increased 0.4 bu/A per year in both the U.S. and Canada. As crop yields increase, so do nutrient requirements. Soils must be fertile to meet the growing-season demands of a high yielding crop. Research has shown that in a particular season under optimum growing and response conditions, recovery of applied nutrients can be as high as 70 percent for nitrogen (N), 20 percent for phosphorus (P), and 30 percent for potassium (K). Much of the unused nutrients will be available for subsequent crops, but the fact remains that soils must be high in soil fertility to keep nutrient supply from being a yield-limiting factor.

By utilizing uptake values and crop yields, it is possible to estimate nutrients removed from the field by harvested crops. Nutrient removal estimates for North American crop classes are presented in **Table 1**. Crops remove approximately 19, 7, and 11 million tons of N, P_2O_5, and K_2O, respectively, each year from the fields of North America. Forages are responsible for over one-fifth of the P removal and half the K removal by all crops. The high level of nutrient removal by forage crops underscores the importance of nutrient replacement to maintain high yields and extend longevity and quality of the forage stand. BC

TABLE 1. Nutrient removal by major crops in the U.S. and Canada.

Crop type	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	.... Million tons			.... % of total		
U.S. (1998-2000 avg)						
Field crops	11.9	4.4	4.4	74	76	46
Forage crops	3.7	1.2	4.7	23	22	49
Specialty crops	0.4	0.1	0.5	3	2	5
Total	**16.0**	**5.7**	**9.6**	**100**	**100**	**100**
Canada (2000)						
Field crops	1.9	0.7	0.6	77	81	46
Forage crops	0.6	0.2	0.7	23	19	54
Total	**2.5**	**0.9**	**1.3**	**100**	**100**	**100**

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Nutrients and Environmental Quality

By C.S. Snyder and T.W. Bruulsema

Scientists have long stated that there is no scientific basis for claims that organic nutrients are superior to inorganic nutrients. Still, there is widespread public perception that organic agricultural systems are more environmentally friendly and more sustainable than high-yielding conventional farming systems. In fact, long-term studies from around the world indicate that sustained yields and soil productivity can be achieved with balanced nutrition, using either or both organic and mineral fertilizer nutrient sources.

When properly managed, mineral fertilizers and animal manure can increase soil productivity, enhance sustainability, and increase carbon (C) sequestration. There are, however, management challenges and risks associated with both nutrient sources relative to 1) nitrogen (N) and phosphorus (P) losses to surface and groundwater; 2) heavy metal accumulation; 3) pathogen accumulation; and 4) greenhouse gas production.

Regardless of the source, plant nutrients are absorbed primarily as inorganic ions. For example, N is taken up as either ammonium (NH_4^+) or nitrate (NO_3^-), phosphorus as HPO_4^{2-} or $H_2PO_4^-$, and potassium (K) as K^+. Thus, even if the nutrient source is organic, it must undergo transformation so the nutrients it contains can be released in the inorganic form before crop plants can use them.

Organic matter (OM) has long been known to have positive influences on soil structure, tilth, bulk density, and moisture-holding characteristics. Among its other benefits are increases in the soil's cation exchange capacity (CEC) and reduced soil runoff and erosion losses. The humus fraction of OM, along with certain cations, is able to retain significant amounts of P, and OM can reduce P fixation under some acid soil conditions. However, continued heavy applications of animal manure can result in P movement into groundwater as the manure is mineralized. It should be noted that groundwater NO_3^--N levels are likely to be elevated long before P because NO_3^- is far more mobile in the soil than is P.

Micronutrients and heavy metals occur naturally in varying amounts in rocks, soils, and water. Several heavy metals are essential or beneficial to both plants and animals, but can become toxic if accumulated in excessive amounts (**Table 1**). Proper management can reduce or eliminate the buildup of toxic levels in agricultural soils.

More than 97 percent of mineral fertilizers manufactured in North America are made from natural sources such as atmospheric gases or mineral deposits rather than industrial by-products. Cadmium (Cd) is the heavy metal of most concern because of the levels found naturally in phosphate rock, the principal ore from which phosphate fertilizers are made. While the long-term use of phosphate fertilizers can result in a gradual buildup of Cd in the soil, it would take hundreds or even thousands of years at normal application rates to reach critical levels. Micronutrient and heavy metal concentrations in animal manure and sewage sludge are highly variable. At typical use rates, loadings are generally higher from biosolids than from fertilizers.

As with successful crop production,

nutrient input is essential for sustained aquatic productivity, but an excess of nutrients such as N and P can over-stimulate aquatic growth, creating algal blooms. As the plants die, bacteria begin to decompose them, using dissolved oxygen (O_2) in the water. When the O_2 levels become too low, some aquatic plants and animal life can suffer, and less mobile organisms may die. Concern over this situation has been well publicized for the U.S Chesapeake Bay area and the Gulf of Mexico. Nitrogen and P from commercial fertilizers have been blamed as a primary cause of increased nutrient flux in such surface water bodies.

TABLE 1. Reaction of plants and animals to trace elements.

Element	Essential or beneficial to: Plants	Animals	Potentially toxic to: Plants	Animals
Arsenic	No	Yes		Yes
Cadmium	No	No	Yes	Yes
Chromium	No	Yes	Yes	DU
Cobalt	Yes[3]	Yes	Yes	Yes
Copper	Yes	Yes	Yes	Yes[2]
Lead	No	No	Yes	Yes
Mercury	No	No	DU[1]	Yes
Molybdenum	Yes	Yes	DU	Yes[2]
Nickel	No[3]	Yes	Yes	Yes
Selenium	Yes	Yes	Yes	Yes (4 ppm)
Zinc	Yes	Yes	DU	DU

Source: Webber and Singh, 1995.

[1]DU = Data on critical limits unavailable.

[2]Toxic to ruminants (cattle and sheep) at 5 to 20 parts per million (ppm).

[3]Other sources consider Cobalt to be nonessential and Nickel to be essential (PPI Soil Fertility Manual).

Scientists recognize that under current crop rotations and management in the U.S. Midwest, there is no way to keep N and P out of drainage waters and, ultimately, rivers and streams that feed the Mississippi River. However, practices that improve N use efficiency, such as placement, timing, source, and application rate, can minimize the impact of nutrient enrichment in surface and groundwater. Also, P management, as well as other practices such as tillage systems, can reduce the impact of P (and N) on water quality. For example, research in Arkansas showed that vegetative filter strips can be quite effective in reducing runoff P losses. Other studies have shown that properly designed vegetative filter strips have decreased N and P losses by 40 to 90 percent.

Excess NO_3^- in groundwater poses a potential threat to humans. In agricultural soils, contamination is most likely in humid or irrigated areas where sandy soils overlay shallow aquifers. In clay or clay loam soils that drain slowly, denitrification can significantly reduce NO_3^- and prevent its leaching to groundwater. Large applications of animal manure can increase the soil's total N and inorganic N contents. Nitrate is the primary end product of manure decomposition and may pose environmental risks when manure is applied to provide N rates above crop use. On well drained or tile drained soils, the potential for NO_3^- leaching goes up as manure rates increase.

Risks from Pathogens

Animal wastes contain intestinal bacteria, many of which present substantial human health risks if ingested through drinking water. One of the bacteria of most concern is *E. coli* O157:H7. The U.S. Centers for Disease Control (CDC) has estimated that there are about 70,000 cases of infection and more than 60 deaths each year caused by this particular bacterial strain. While animal manure is not the only source for this pathogen, it is a contributor.

Viruses have also been reported in manure. Those found in poultry litter may present a bigger environmental problem than bacteria. A number of antibiotics, growth hormones, and disinfectants are used to protect animal health and to improve production. The consequences and fate of these substances have not been thoroughly assessed.

Air Quality

Odors from ammonia (NH_3) and other gases are released from animal production facilities, in waste storage lagoons, stockpiles, composted wastes, and in excreta by grazing animals. Odor-causing gases can arise from

TABLE 2. Total organic C, corn-derived C, and native C found in fertilized and unfertilized corn plots, using ^{13}C

Fertilization N-P_2O_5-K_2O, lb/A	Total C	Corn-derived C	Native C
	....	tons/A	....
0-0-0	36	5	31
115-70-30	40	9	31

Source: Gregorich and Drury, 1996.

the decay of organic substances in the absence of O_2. Besides the offensive odors from gases such as hydrogen sulfide (H_2S), some of the gases can cause health problems. High NH_3 concentrations can be detrimental to birds and to farm laborers as well. Atmospheric loss of NH_3 from N fertilizers is considerable. Such losses can be minimized by proper N management.

Increased emissions of greenhouse gases (GHGs) are thought to increase the potential for global warming. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the three most important GHGs associated with agriculture. Carbon dioxide emissions in agriculture come from the burning of fossil fuel and the decomposition of OM and crop residues. Methane comes primarily from ruminant animals, livestock manure, wetlands, and rice production. Any N source is subject to denitrification reactions in the soil, so all forms of N, organic and inorganic, contribute to N_2O emissions. Proper management minimizes the effect.

Agriculture has an opportunity to significantly reduce CO_2 emissions by sequestering more C in the soil. One 35-year study showed that fertilization increased the amount of corn-derived C while maintaining native soil C (**Table 2**). Fertilization and crop rotation increased both crop yields and soil organic matter levels.

Former U.S. Assistant Secretary of Agriculture, Dr. C.E. Hess, stated that agriculture has a great opportunity to help mitigate climate change by stashing CO_2 as C in soil and vegetation. Practices requiring good agricultural husbandry, which should be implemented anyway, can be quite effective for sequestering C. For cropland, these practices include building soil OM levels, improving soil fertility, and growing more food on less land.

Role of Nutrients in Stabilizing C in Soil OM

Sound nutrient management aids the capture of atmospheric CO_2, improves photosynthesis, enhances O_2 release to the atmosphere, and increases soil C. Several studies have shown the correlation between N fertilization and C sequestration. Long-term research has also shown that soil organic N and C levels are highest when conservation tillage is combined with rotations of high residue crops and adequate, balanced fertility to increase crop yields.

Summary

Mineral fertilizers and animal manure are valuable nutrient sources for crop production to meet the world's food and fiber demands. Fertilizers are more predictable and thus more manageable nutrient sources. Improperly managed, any source can potentially pollute the soil, water, and air.

The growing challenge for agriculture is to find ways to increase crop yields and improve nutrient use efficiency while stabilizing nutrients...not removed in harvested crops...in crop residues and, ultimately, OM in the soil. Nutrient management must be site-specific and cost effective to protect the viability of North American agriculture. At the same time it must also include considerations for the protection of our soil, water, and air resources. That means protection from surface runoff, leaching, and gaseous emissions.

There is no reason crop production systems based on sound nutrient management cannot sustain optimum yield production while also protecting the environment. BC

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Nutrients and Product Quality

By T.W. Bruulsema

The belief that organic nutrients promote food quality while mineral fertilizers promote quantity has been proven by research to be overly simplistic. Managing organic and inorganic nutrients clearly affects both quality and output of various cropping systems. Nutrient inputs should be chosen to efficiently provide balance for optimum results, specific to each soil and crop.

Crop quality factors such as protein, phytate (phytic acid), and trace mineral bioavailability can be manipulated by properly managing nitrogen (N) and phosphorus (P) fertilization. Nitrogen, P, and potassium (K) have been shown to increase sugar content in sweet corn, and increasing K levels boosted vitamin C levels in several vegetable crops.

Both organic and inorganic nutrient sources influence proteins, minerals, and vitamins in crop products, and affect their bioavailability. They also impact pests that reduce quality. With recent science on nutraceuticals, today's crop producers are becoming more effective in meeting human nutritional needs for promoting health and preventing disease.

Phytochemicals, Functional Foods, and Nutraceuticals

Functional foods are defined as foods that contain bio-active ingredients thought to enhance health and fitness. They are also called designer foods or pharma-foods. The active ingredients are phytochemicals, such as lycopene in tomatoes. These phytochemicals are not among the traditional nutrients (carbohydrates, proteins, fats, minerals, and vitamins) and are often called nutraceuticals, although that term is increasingly being used specifically for extracted concentrates.

Functional foods are associated with the prevention and treatment of at least four of the leading causes of death: cancer, diabetes, hypertension, and heart disease. A wide range of plants, including field crops like grains and soybeans, horticultural crops like broccoli and tomatoes, and specialty crops like ginseng and echinacea, contain nutraceutical ingredients.

Role of NPK in Phytochemical Synthesis

Only a few of the many phytochemicals with nutraceutical properties contain N, P, or K in their chemical structure. But since they are formed as a result of photosynthesis, they depend on the availability of essential nutrients. For example, research has shown that K has a positive influence on isoflavone levels in soybeans (**Table 1**) and lycopene in tomatoes.

USDA photo by Ken Hammond.

Safe, nutritious food can be produced with either inorganic or organic nutrients, or both in combination.

Diseases and Insects

Certain plant diseases can be suppressed by application of balanced nutrients. For example, P has been shown to reduce common root rot in barley and K has reduced rusts in cereals and stalk rot in corn. Potassium has also decreased leaf diseases in cotton and N and P have minimized wilt infection in potatoes and stain in soybeans. Recent research has shown that chloride (Cl^-) reduces the incidences of several diseases in small grains.

TABLE 1. Concentration of isoflavones in soybean seeds in response to applied K fertilizer (two sites, three years, 1998-2000).

K_2O application	Genistein	Daidzein	Glycitein	Total[1]
Spring banded	938	967	146	2,051
None	831	854	130	1,815
Increase due to K, %	13	13	12	13

[1]Total isoflavone concentration expressed as aglycone; sum of three components; parts per million (ppm).

A number of plant diseases have been reduced following manure application, including *Fusarium* diseases of tomato and lettuce, *Rhizoctonia solani* diseases of radish and rice, and *Sclerotinia sclerotiorum* disease of lettuce.

Management of nutrients to enhance resistance to disease and insects should recognize that:

- No nutrient controls all diseases.
- Nutrient balance is as important as any single nutrient level.
- Nutrients help more by stimulating growth than by increasing resistance.
- Damage or predisposition imposed by early deficiencies and imbalances may not be offset by later applications.
- Local environmental conditions may enhance or nullify the effect of a particular nutrient.

Organic Versus Conventional Production Systems

Comparison of food produced from organic farming systems and conventional systems is quite different from comparison of nutrients supplied by organic and inorganic sources. Producers in conventional production systems commonly apply a combination of organic and inorganic nutrient sources and so do organic producers. The differences have more to do with solubility and manufacture.

Organic production systems are characterized by standards that minimize or eliminate use of synthetic or manufactured inputs and encourage maximum use of natural resources. They rely on green manures, crop rotation, and animal manures. They may also include mineral nutrients in their naturally occurring state; for example, rock phosphate as a source of P and, in some cases, potassium sulfate (K_2SO_4) or sylvinite as a source of K. Nutrient input levels in organic farming systems also tend to be lower than in conventional systems because the philosophy is aimed at growing crops under more natural conditions, and deficiencies of N, P, and K are natural conditions.

Organic systems may also vary more widely in nutrient availability because of reliance on indigenous soil fertility which exhibits strong spatial variability. Comparing the relative effectiveness of organic versus conventional farming in producing high quality food is difficult. Few producers or researchers have extensive knowledge of both systems, so bias is a factor that cannot be entirely removed. Scientists have concluded, however, that organic foods are neither healthier nor safer than conventionally produced or genetically modified crops.

Summary

Managing nutrients, whether organic or inorganic, clearly can affect the quality of the output from crop production systems, be they organic or conventional. Both systems are capable of producing quality food. Nutrient inputs should be chosen to efficiently supply an appropriate balance of fertility to optimize yield and quality, specific to each soil and crop.

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Nutrient Budgets in North America

By P.E. Fixen and A.M. Johnston

Nutrient budgets are valuable in that they provide insight into the balance between inputs and outputs in crop production. Unlike financial budgets, however, they are only partial budgets because of inaccuracies in determining inputs/outputs. There are many sources of error, including variations in crop removal, estimation of N fixation by legumes, nutrient compositions of various manure sources, etc.

Manufactured mineral fertilizers are the primary nutrient sources (inputs), although significant amounts are provided through N fixation by legumes and the application of manure. In North America, only N fertilizer use increased during the last 20 years of the 20th century, with minor declines in P and K use. The ratio of N to P_2O_5 and K_2O nearly doubled during that time. Also, there was a large increase in the numbers of livestock grown in confined feeding operations, significantly increasing the amounts of recoverable manure nutrients.

Crop nutrient removal (outputs) occurs in the forms of grains, oilseeds, fruits, vegetables, fiber, hay, and forage that are exported from production fields. Other outputs include erosion losses, leaching, dentrification, and volatilization.

Partial N budgets (**Table 1**) show that for North America, the amount of N removed in harvested crops is equivalent to about 77 percent of inputs (fixation, fertilizer, and recoverable manure). Nitrogen recovery in the leading U.S. corn states is about 82 percent, compared to 75 percent for the U.S. as a whole. Recovery in Canada is 94 percent.

> Partial nitrogen (N) budgets for North America show that the amount of N removed in harvested crops is equivalent to 77 percent of major inputs. The partial phosphorus (P) budget for North America shows that P removal exceeds P applied as fertilizer by 29 percent. When recoverable manure is included in the evaluation, removal represents 95 percent of inputs. The partial potassium (K) budget shows that crops currently remove 44 percent more than the amount of K being applied as fertilizer or recoverable in manure.

The partial P budget for North America shows that removal exceeds P applied as fertilizer by 29 percent (**Table 2**). When recoverable manure is included in the evaluation, removal represents 95 percent of inputs.

The partial K budget shows that crops in North America currently remove twice the amount of K being applied as fertilizer (**Table 2**). When all recoverable manure is considered, removal still exceeds input by 44 percent. In the leading U.S. corn states, removal of P and K exceeds fertilizer applied plus recoverable manure by approximately 30 percent.

Historical trends in partial P budgets for the U.S. and Canada are shown in **Figures 1** and **2** as the ratio of P removed by common crops to the sum of fertilizer P and recoverable manure P. Over the entire 40-year period in the U.S., P removal has been less than inputs. In fact, in the late 1960s and early 1970s, P removal was only 60 percent of P inputs. This resulted in build up of soil test P in many regions of the U.S., especially the Corn Belt. Since 1970, the removal to use ratio has consistently trended higher

TABLE 1. Partial N budgets for North America (average of 1998-2000).

Region	Crop removal[1]	Legume fixation	Applied fert.	Recoverable manure	Balance[2]	Removed by crop harvest, % without manure	Removed by crop harvest, % with manure
	....	....	billion lb	....	....		
Six leading corn states	14.5	8.4	8.8	0.5	3.3	84	82
U.S.	32.1	15.6	24.7	2.6	10.8	80	75
Canada	5.02	1.41	3.64	0.28	0.31	99	94
North America	37.1	12.0	28.3	2.9	11.1	82	77

[1]N removed in harvested portion of alfalfa, soybeans, peanuts, 49% of lentils, and 54% dry peas. It was assumed that any fixed N not recovered in the harvested crop was countered by soil N taken up during the growing season.
[2](Fixation + fertilizer + manure) - removal.
Source: Adapted from *Plant Nutrient Use in North American Agriculture*, PPI/PPIC/FAR Technical Bulletin 2002-1.

TABLE 2. Partial P and K budgets for North America (average of 1998-2000).

Nutrient	Region	Crop removal	Applied fert.	Recoverable manure	Balance[1]	Removal to use ratios without manure	Removal to use ratios with manure
		....	billion lb	....	....		
P_2O_5	Six leading corn states	5.1	3.0	0.9	-1.3	1.71	1.33
	U.S.	11.4	8.8	3.3	0.7	1.30	0.95
	Canada	1.87	1.51	0.40	0.04	1.24	0.98
	North America	13.3	10.3	3.7	0.7	1.29	0.95
K_2O	Six leading corn states	6.6	4.1	1.0	-1.5	1.62	1.30
	U.S.	19.3	10.1	3.8	-5.9	1.91	1.39
	Canada	2.64	0.78	0.5	-1.36	3.40	2.06
	North America	21.9	10.9	4.3	-6.7	2.02	1.44

[1](Fertilizer + manure) - removal.
Source: Adapted from *Plant Nutrient Use in North American Agriculture*, PPI/PPIC/FAR Technical Bulletin 2002-1.

and is now over 0.90 for the U.S. as a whole and greater than 1.0 for much of the Corn Belt, as discussed earlier.

The previous P budget analysis includes all recoverable manure P in the U.S. even though an unknown quantity of that manure is applied to pastures and disposed of in ways other than in accordance with the nutritional needs of crops. Thus, the analysis utilizes an inflated estimate of the P agronomically applied to the common crops included in the removal estimates. In an attempt to avoid the over estimation of manure P in the budget, **Figure 3** utilizes the estimates of manure P applied to corn, soybeans, wheat, and cotton derived from USDA-ERS surveys for 1990 to 1996. Using this estimate of manure P, the P removal to use trend line crosses 1.0 in the late 1980s and suggests that P removal exceeded use by approximately 20 percent in the year 2000.

In Canada, P removal was slightly less than inputs (utilizing all recoverable manure P) during much of the 40-year period (**Figure 2**). The low point in the trend line was 0.75 and occurred in about 1980. During the 1990s, P inputs and outputs were essentially equal. Considering that the problems associated with distribution and agronomic utilization of manure P in the U.S. are equally relevant in Canada, a good portion of Canadian crop production is dependent on soil P reserves.

Similar to P, K in most agricultural soils is well-buffered by soil reserves, making it important to relate current nutrient budgets to past budgets and to soil test levels and trends. Unlike with P, the trend line for the K removal to use ratio has been greater than 1.0 for the entire 40-year period in both the U.S. and Canada (**Figures 1** and **2**). In Canada, it has

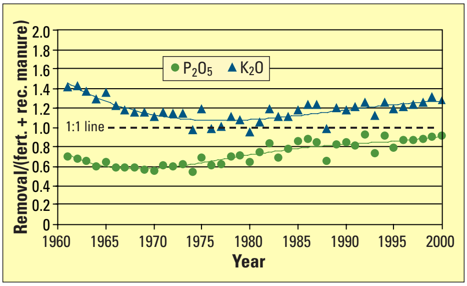

Figure 1. Ratio of P and K removal by common crops to fertilizer P and K use plus recoverable manure in the U.S.

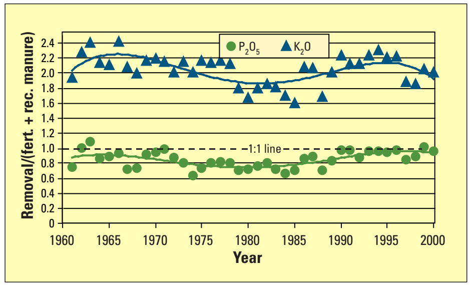

Figure 2. Ratio of P and K removal by common crops to fertilizer P and K use plus recoverable manure in Canada.

generally been near 2.0, while in the U.S. it was at 1.4 in the early 1960s, decreased to about 1.1 in the late 1970s, and has since been increasing to where it is today, near 1.3. Restricting manure K estimates to what is applied to corn, soybean, wheat, and cotton, increases the ratios and results in a current value near 1.6 (**Figure 3**).

Although the nutrient budgets presented and discussed in this article are fraught with limitations and assumptions, we believe this to be one of the most comprehensive attempts ever made at estimating and understanding the application and use of plant nutrients in North America. Overall, it paints a picture of fairly high and improving efficiency of nutrient use.

For the nutrient budget of North America as a whole, there is no evidence of P or K surpluses. All the fertilizer P and K currently being used and all the P or K recoverable from manure can be used in crop production. However, with increasing numbers of confined

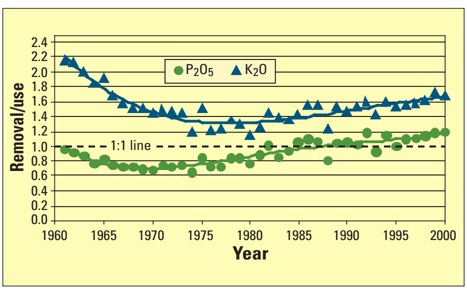

Figure 3. Ratio of P and K removal by common crops to fertilizer use plus manure nutrients applied to corn, soybeans, wheat, and cotton in the U.S.

livestock and, thus, more recoverable manure, nutrient management is becoming more of a challenge. Because of high costs of transporting manure, over-application on lands near confined animal areas is a potentially serious problem. The dilemma of manure distribution makes the development of realistic nutrient budgets a serious challenge for agriculture.

The nutrient budgets identify another reason for concern. Many of our historically most productive soils are at risk of being systematically depleted of nutrients necessary to maintain their productivity. This chronic under-replacement of essential nutrients will eventually reduce the productivity and competitiveness of agricultural systems in these regions. Care must be used to avoid mistaking management practices that cause soil fertility depletion with practices that appear to increase nutrient use efficiency. BC

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InfoAg 2003 Planned

The sixth Information Agriculture Conference, InfoAg 2003, is scheduled for July 29 through August 1, in 2003. The location again will be the Adam's Mark Hotel at the Indianapolis Airport, site of InfoAg 2001.

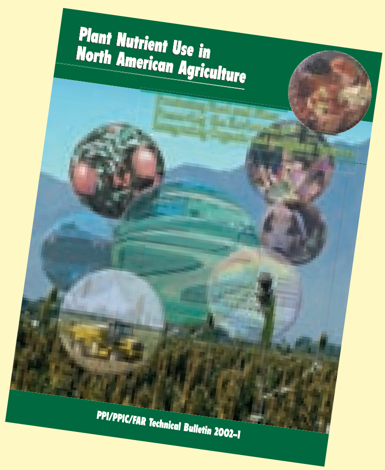
The event will begin with an all-day field trip by bus to visit a fertilizer dealer who is using site-specific systems with his customers, followed by a tour of the Davis-Purdue Agriculture Research Center in eastern Indiana where university staff and cooperators are conducting a wide variety of site-specific management and remote sensing projects. A cookout on the evening of July 29 will transition to the traditional conference that begins on the morning of July 30. Program features will include hands-on workshops on data management and interpretation, exhibits and demonstrations of the latest technology, and ample opportunity to attend seminars by farmers, dealers, technology developers, and researchers.

For more details, check the website at **www.ppi-far.org/infoag**.

Plant Nutrient Use in North American Agriculture Technical Bulletin and CD-ROM Available

A new publication available from PPI reviews current information on nutrient sources...both organic and inorganic. PPI/PPIC/FAR Technical Bulletin 2002-1 discusses the differences and similarities, advantages and disadvantages, relative abundance or scarcity, and amounts of plant nutrients required to produce today's food demands. Estimated availability of organic and inorganic fertilizers, management challenges of each source, potential effects on the environment, and how that concern can be managed are also addressed.

The publication contains 100+ pages in 10 chapters and appendices. It may be purchased for $25.00 per copy. A CD-ROM, also available for $25.00 each, includes a pdf file showing the pages of the report, a PowerPoint file of most figures (graphs) in the report, and Excel worksheets where applicable. **The printed publication and the CD-ROM may be purchased as a package for the price of $35.00, plus shipping and handling.**



To order *Plant Nutrient Use in North American Agriculture* or for more information, contact: Circulation Department, PPI, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837; phone (770) 825-8082 or 825-8084; fax (770) 448-0439. E-mail: circulation@ppi-far.org, or check the website at **www.ppi-ppic.org.**

CHECK OUT THE FACTS

Somebody recently sent me some 'facts' about how things were in the U.S. back in 1902, taken directly from the Internet. Among the 'facts' were statistics such as: average life expectancy was 47 years; there were 8,000 cars in the entire country; the population of Las Vegas was 30. Now, I don't know how accurate these numbers are. They could be right on target or totally false. I didn't take the time to check them out.

Earlier this year on a local TV station, the evening news anchor was doing a story on organically produced foods and touting their benefits over those produced with chemicals. It was pretty obvious the news person, just as I, hadn't bothered to check out the facts before reporting the story. The difference, though, is that I filed a disclaimer with my 'facts.' The newscaster didn't.

It's amazing how easily people are taken in when it comes to believing what they are told. I suppose it's because most folks are basically honest and expect others to be as well. Also, admit it or not, all of us have a little gossip in our systems, along with the urgency to be the first to report a breaking story. Maybe that's why we buy into the pitch of a good sales person or a smooth talking politican.

Thankfully, most of the time the product or service we buy is a good value, and we can rationalize that politicians have always been – well – politicans. However, when it comes to the food we eat, we are obligated to know the facts or seek them out. Our very health is at stake.

The Institute has just released a new publication, *Plant Nutrient Use in North American Agriculture*, which talks about the use of organic and inorganic plant nutrients in food production. The bulletin is a literature-cited review of the current status of nutrient use and impacts. Written primarily by PPI staff, it is balanced in its approach and is well documented with scientific facts. It should be a must-read for all those involved in the nutritional aspects of food production, particularly if they develop nutrient management plans.

Check out the facts about *Plant Nutrient Use in North American Agriculture* in this issue of *Better Crops*. Then you will know the truth.

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