Organic Crop Management and Soil Phosphorus

By C. Welsh, M. Tenuta, D. Flaten, C. Grant, and M. Entz

Long-term organic production systems show a deficiency of plant-available phosphorus (P), but not total P. High crop removal of P with alfalfa had the greatest impact on soil P.

The inability to add fertilizer P to an organic farming system, as currently defined, limits the ability of soils to balance other nutrients, such as nitrogen (N) and sulfur (S), and to achieve yield goals. While soils are well known to be able to supply some P to crops even after many years of production and no P additions, the amount supplied is often insufficient to optimize crop yields. Also, many organic growers are hard pressed to find an adequate supply of organic manure to supply P to their production fields.

Soil testing for P estimates the soil P supply available for plant uptake. However, these analytical methods do not take into account those less available forms of soil P which are known to be quite significant in many soils, especially clay soils. As a result, these questions are often asked:

Is the depletion of soil P in organic cropping systems a general depletion, or just a reduction in plant-available P?

What impact does annual crop removal of a nutrient like P have on the stable, recalcitrant fractions of soil P?

A cropping systems study initiated at the University of Manitoba in 1992 evaluated the impact of crop rotation and production inputs (herbicides and fertilizers) on crop yield, weed dynamics, energy use, and soil fertility. The project is located on a Rego Black Chernozem (Udic Boroll), with a textural analysis of 12% sand, 32% silt, and 55% clay. Soil organic matter content is 5.5%. The three cropping systems included wheat/dry pea/wheat/flax, wheat/alfalfa/alfalfa/flax (no manure), and wheat/alfalfa/alfalfa/flax (composted manure). A previously cropped area was also restored to native tall grass prairie with no crop removal.

The conventional production systems received fertilizer and herbicide treatments, while the organic production systems received no herbicide or fertilizer additions. The amount of P applied annually in conventional systems ranged from 0 to 27 lb P_2O_5/A. After 12 years (1993-2004), soil samples were collected and soil P (0 to 6 in.) was evaluated. Soils were evaluated using a modified Hedley fractionation procedure, including P removed with water, sodium bicarbonate, sodium hydroxide, and hydrochloric acid. Total P was also determined using inductively coupled plasma. The P balance was estimated using average P content of crops harvested (*Soil Fertility Guide for Manitoba*), measured crop yields, and annual fertilizer and manure additions.

The P balance calculated for the crop rotations showed a P deficit when no fertilizer P was added to the organic systems, and a surplus when fertilizer P was added to the conventional systems (**Figure 1**). The large P deficit for the organic forage-grain production systems reflects the high level of nutrient removal with alfalfa production and harvest. This P deficit was much larger than the organic grain production system, where only grain was removed

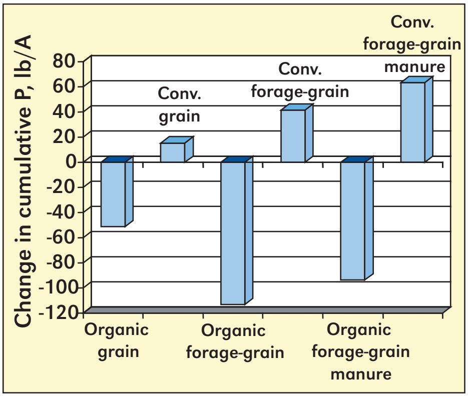

Figure 1. Expected P balance for 1993-2004.

from the cropping system and all straw returned. The P surplus recorded for the conventional forage-grain systems reflects P fertilizer additions in excess of estimated crop removal at this location.

The soil P analysis revealed that the management system used in the study had a much greater impact on soil P levels than the cropping system (**Figure 2**). The levels of plant-available P in the soil sample fractions (water, sodium bicarbonate and sodium hydroxide) were significantly ($p<0.05$) lower for the organic management. The more plant-unavailable (recalcitrant) hydrochloric acid fraction was not different between cropping systems or management. This indicates that during the 12-year period of this study, it was the plant-available forms of soil P which were selectively altered most by management.

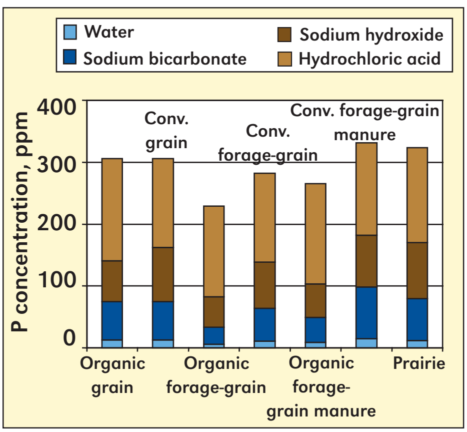

Figure 2. Total P concentrations in organic and conventional systems under different crop rotations.

It is important to note that while the calculated P balance (**Figure 1**) showed a P deficit for the organic grain rotation, soil fractionation of P indicated that it had similar soil P levels as the conventional production system (**Figure 2**). This similarity in soil P levels after 12 years of grain crop removal and no P addition reflects the large buffering capacity of these clay soils. Only the organic forage-grain cropping systems show a difference in the plant-available forms of soil P as determined by the detailed Hedley fractionation procedure (**Figure 2**), and the soil test results (**Table 1**).

Table 1. Soil test P after 12 years.

Rotation[1]	Management: Organic	Management: Conv.
	-------- P, ppm[2] --------	
WPWF	30a	38a
WAAF	9b	21a
WAAF-M	14b	35a
Prairie	35a	

[1]Wheat (W), pea (P), flax (F), alfalfa (A), manure (M).
[2] ppm = parts per million; Levels followed by the same letter are not different at p=0.05.

We speculate that the difference in both plant-available and unavailable forms of P in the soils of the organic and conventional systems may be showing some shift in P forms with time. Without replenishment of plant-available P in the organic forage-grain system, P will be the most limiting nutrient in the future. BC

Ms. Welsh (e-mail: umwelsh@cc.umanitoba.ca) is a graduate student, Dr. Tenuta a soil microbiologist, and Dr. Flaten a soil scientist in the Department of Soil Science; Dr. Entz is an agronomist in the Department of Plant Science, all at the University of Manitoba. Dr. Grant is a Soil Scientist with Agriculture and Agri-Food Canada in Brandon, Manitoba.