Maximizing Phosphorus Removal with Winter Cereal/Corn Double-Crop Forage Production

By Bradford D. Brown

Maximizing P removal from soil with intensive cropping can sometimes be advantageous for manure management. Double-cropping with winter forages and silage corn increased total forage production, increased P removal, and reduced soil P concentrations more than with corn alone.

Surface water quality concerns have sometimes led to P-based limits on manuring rates, where higher manuring rates are limited by P removed in harvested crops. Since harvested forages remove large amounts of P, increasing their production will improve the P balance in manured fields, which can: 1) slow or avoid soil P enrichment, 2) enable herd size to be maintained or expanded to an economic scale, 3) avoid the need for increased land resources, or 4) hasten the soil test P decline in P-enriched soil.

Fall-planted small grain cereals produce forage during the cooler part of the year without sacrificing corn production. Harvesting winter cereals at the boot stage, rather than soft dough, produces less biomass but allows corn to be planted at normal planting dates. Since P accumulation precedes biomass production, a boot stage harvest does not sacrifice P uptake and removal nearly as much as it does biomass. The objective of this study was to evaluate the winter cereal/silage corn double-crop system for its potential in southern Idaho to increase both forage production and P removal over that with corn alone.

A 3-year irrigated double-crop (small grain harvested at boot stage followed by silage corn grown in a single year) forage study was conducted on a Greenleaf-Owyhee silt loam (Xeric Calciargid) at the University of Idaho Parma R & E Center. The double-cropping involved three winter (barley, wheat, and triticale) and two spring cereals (wheat and triticale), fall planted at three seeding rates (100, 150, or 200 lb/A) and followed with silage corn. Two non-planted fall treatments were also included: silage corn alone and one kept bare for the duration of the study.

The site had an initial P concentration of 20 ppm bicarbonate-extractable P and then received 366 lb P_2O_5 /A (as 0-45-0). Winter-grown cereals were fertilized on the soil surface with 100 lb urea-N/A in the spring of 1999 and 2000, and with 200 lb N/A in 2001. Fertilizer N for corn was sidedressed as urea in multiple applications totaling 200 lb N/A in 1999, 270 lb N/A in 2000, and 200 lb N/A in 2001. Corn and winter cereals were furrow irrigated as needed. Soil samples were routinely taken from each plot during the experiment. Forage and corn yields and tissue composition were measured using standard methods.

Dry matter yield differed for the small grain cereals depending on the year (**Figure 1**). Dry matter production over the 3 years was higher for winter triticale (9 tons/A) than for winter or spring wheat and winter barley (average 7 tons/A). Winterkill reduced winter barley stands by 23% and spring wheat stands by 45% in 1999, resulting in considerably less forage than with spring and winter triticale or winter wheat. Spring wheat yield rebounded the second year and did not differ significantly from winter triticale, and exceeded the yield for winter wheat. Winter wheat was consistently lower yielding than either winter or spring triticale. Spring genotypes, in the absence of winterkill, were as productive as the winter genotypes. Seeding rates higher than 100 lb/A were required to maximize winter forage yield.

Triticale plots are shown at the research site.

Mean winter forage P uptake over the 3 years was greatest for winter triticale, but P uptake differed among forages depending on the year (**Figure 2**). Accu-

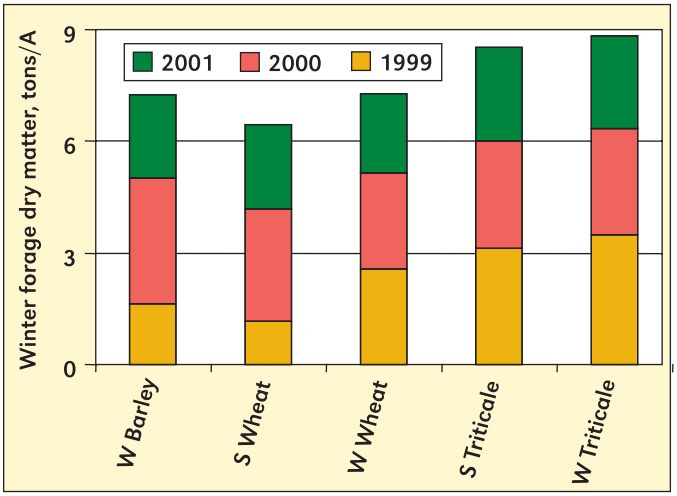

Figure 1. Cumulative winter forage production when harvested at the boot stage for 3 years.

Abbreviations and notes for this article: P = phosphorus; ppm = parts per million; N = nitrogen.

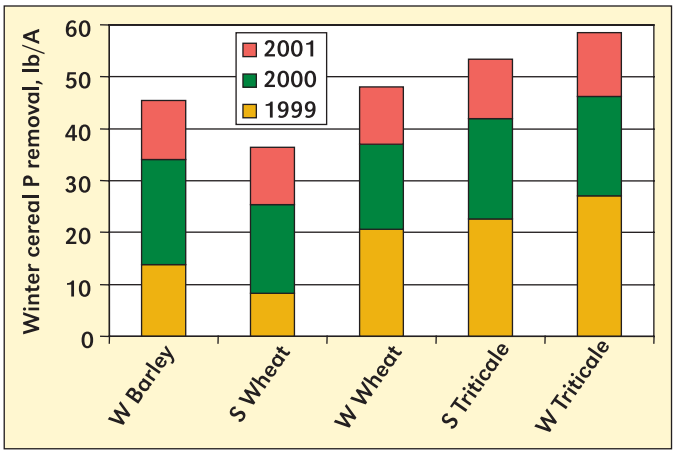

Figure 2. Cumulative P removal in winter cereals harvested at the boot stage for 3 years.

mulation of P by winter barley and spring wheat was reduced in 1999 due to winterkill. With no winterkill, winter forages differed little in P uptake. Mean winter forage P concentrations declined from the first year high of 0.39% P in 1999, to 0.32% in 2000, and to 0.25% in 2001. This decline is assumed to be due to reduced available P. Winter forage P uptake also declined with successive harvests, the decline ranging up to 46% for winter wheat and 54% for winter triticale. Average P uptake across all winter forages declined 38% from 2000 (23 lb P/A) to 2001 (14 lb P/A). Declining P uptake resulted from both lower biomass and declining forage P concentrations.

It is not clear if declining soil P limited dry matter production. Forage P concentrations in 2001 were above those previously cited as necessary for the production of grain (0.15 to 0.2% P), but this critical range may not be appropriate for boot stage forage production.

The presence of winter forages in 1999 significantly affected the stand and vigor of the corn. Corn stands were poorest (reduced 25 to 32%) and vigor lowest when it was no-till planted into greater stubble of the winter

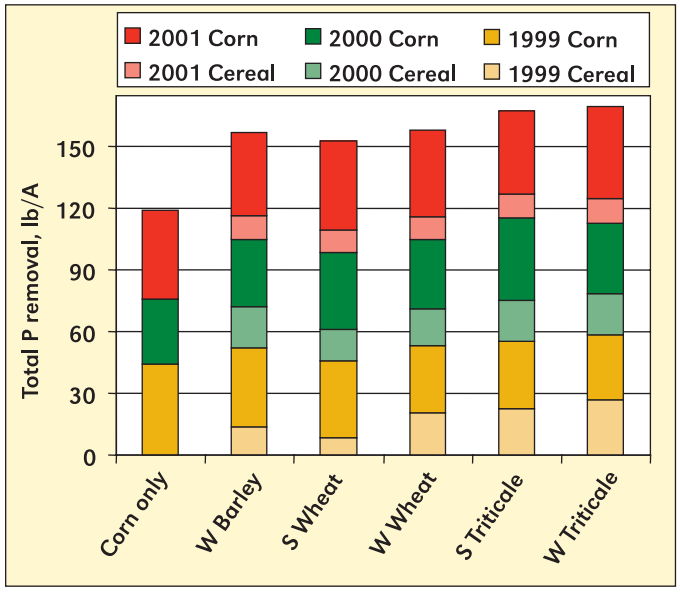

Figure 3. Total P removal in corn and winter cereals over 3 years.

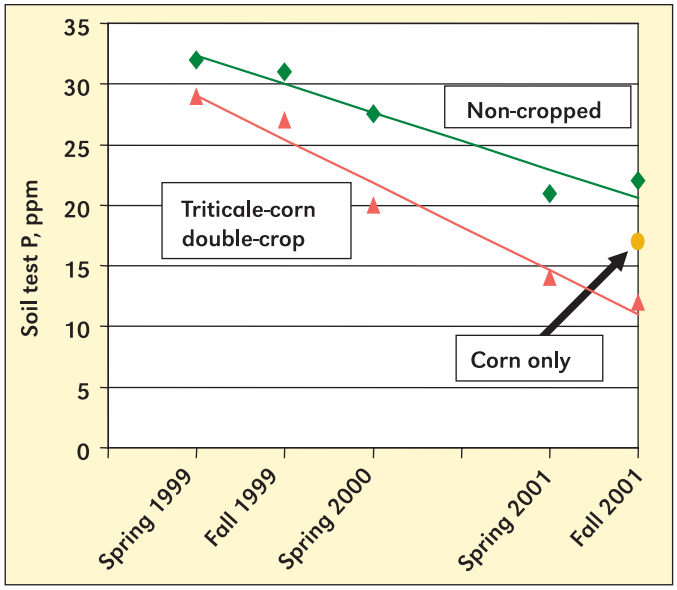

Figure 4. Decline in soil P concentrations in triticale/corn double-cropped or non-cropped plots during a 3-year experiment.

cereals unaffected by winterkill. Corn vigor was also reduced by triticale regrowth. Corn stands and corn yields were not affected by previous winter forages in subsequent years with rototilling. In contrast to winter cereals, corn forage P concentrations and uptake did not decline with successive harvests. Total biomass yield after 3 years of the double-crop (with the exception of the winter wheat/corn combination) was 10 to 16% and P removal was 40% greater than corn alone (**Figure 3**). For the double-cropped treatments, as much P was harvested during the 3 years as was initially applied. To put this in perspective for manuring, an additional 3-year uptake of 50 lb P/A by the winter cereals would allow application of 5 tons/A more broiler litter or 23 tons/A more fresh dairy manure.

Crop P removal measurements in this study may be conservative compared with highly P enriched soils. For highly enriched soils, winter forage P concentrations likely would not decline as rapidly nor winter forage yields be as limited by reduced P as they were in this study. Winter forage P concentrations and P uptake were more sensitive to declining soil test P than corn, which may be related to cooler soil temperatures during the period of winter forage growth.

Soil P concentrations declined during the study in both cropped and non-cropped treatments, but the decline was greater with double-cropping than with corn alone (**Figure 4**). As expected, the applied P became gradually less soluble over time due to factors such as P sorption, precipitation, and incorporation into organic matter. BC

Additional details on this study can be found in: Brown, B. 2006. SSSA Journ. 70:1951-1956.

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