Phosphorus Removal in a Double Cropped Forage System

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Abstract

Maximizing phosphorus (P) removal with cropping can increase statutory animal waste loading rates. The potential for increased P removal with a winter cereal/corn silage double crop forage system was evaluated in a three year study conducted at the Parma Research and Extension Center in a Greenleaf-Owyhee silt loam. The study involving three winter (barley, wheat, and triticale) and two spring cereals (wheat and triticale) all fall planted at three seeding rates (100, 150, or 200 lb/A) and then followed with a crop of silage corn. Winter forages were harvested at the boot stage and the corn was harvested as silage. Seeding rates of 150 lb per acre were often necessary for maximizing winter forage dry matter production and P removal. Winter triticale was the most productive winter forage producing 8.8 tons per acre of dry mass and removing 59 lb P per acre over the three years. Total P removal after three years with double cropping winter triticale and corn exceeded P removal with single crop corn by 42% or 50 lb P per acre over the three year period (169 vs 119 lb P per acre). Soil test P after three years was reduced 5.7 ppm more with double cropping than with a single corn crop. Double cropping winter forages and corn can increase the animal waste loading capacity of soils or hasten the decline in soil test P resulting from excessive P applied in the past.

Introduction

Public concern for water quality has led to adoption of Idaho regulations that require livestock producers to manage animal wastes as never before. Phosphorus (P) is the nutrient of greatest concern since it is the nutrient most responsible for nuisance aquatic growth such as algae. Currently adopted dairy rules have established upper limits of soil test phosphorus (STP) of 40 ppm in the first foot provided there is no runoff. Above this threshold additional waste applications to the soil are limited to the amount of P taken up by subsequent crops.

Whereas solid wastes are more easily separated and exported from a dairy enterprise, liquid effluent from lagoons is transported a limited distance due to the costs of pumping and piping. Furthermore, land resources with some dairies are limited and more waste P is applied than can possibly be removed with annual cropping. The STP under these conditions will sooner or later reach the P threshold, at which time dairies will either have to extend their delivery system to additional lands or reduce
the liquid wastes generated. Dairies could conceivably have to limit their milk production or herd size. Greater P removal by cropping would increase the time for STP thresholds to be reached, postpone the need for capital improvements required for extending delivery systems, hasten the reduction of excessive soil test P, enable dairy herd expansion, and increase soil P loading capacity.

Double crop (winter cereal-corn) forage systems have potential for appreciably increasing the P removed by cropping over that removed with a single corn crop, as well as increasing forages otherwise used in the dairy enterprise. Ideally, winter cereals harvested at the boot stage (rather than soft dough) provide additional forage without sacrificing corn production. Furthermore, winter cereal P accumulation, unlike total biomass, is largely completed by heading. Thus, a boot stage harvest does not sacrifice P removal nearly as much as it does biomass.

Methods

A three year study was conducted at the Parma Research and Extension Center in a Greenleaf-Owyhee silt loam involving three winter (barley, wheat, and triticale) and two spring cereals (wheat and triticale) all fall planted at three seeding rates (100, 150, or 200 lb/A). Planting dates for winter forages were October 21, 1998, September 27, 1999, and October 3, 2000. Two non-planted fall treatments were also included, one used for the production of a single forage crop of corn and the other kept fallow for the duration of the study. Treatments were repeated every year in the same plot so that cumulative effects of treatments on soil test P after three years could be determined. Treatments were arranged in a randomized complete block design with four replications.

Winter forage biomass was measured when most cereals were at the boot stage. Harvest dates were May 20, 1999, April 27, 2000, and May 11, 2001. Subsamples of the harvested biomass were collected and the dry matter content and total P concentrations subsequently determined.

A corn hybrid (minimum 105 day maturity) was planted as soon after the winter cereal harvest as possible, generally within 24 hrs. The corn was harvested for silage by late September to give sufficient time for an early October planting of the fall planted forages. Dry matter and P content of harvest subsamples were determined.

The field used for the study received a uniform application of 366 lb P₂O₅/A as fertilizer (0-45-0) on October 21 to raise the initial soil test level to above 30 ppm. Soil samples were collected preplant to characterize the site's fertility. Soil test P was measured after each winter cereal and corn harvest to document changes affected by double and single crop forage systems.

Results

Winterkill reduced winter barley and spring wheat stands in 1999 resulting in significantly less production and P uptake than with triticale or winter wheat. There was no winterkill in 2000 and 2001.
and forage production among fall planted forages did not differ as much as in 1999.

Seeding rates of 150 lb/A were required for maximum production in all years although effects of seeding rates on P uptake were not consistent for all winter forages (data not shown). Seeding rates of 200 lb/A provided no advantage over the 150 lb rate.

Winter forage production was lower in 2001 than in 2000. The three-year forage dry matter production was highest for the winter and spring triticale and lowest for spring wheat due to winterkill in 1999 (Fig. 1). Winter barley and spring wheat can remove P comparable to triticale in the absence of winter kill.

![Bar graph showing winter forage dry matter production](image)

**Figure 1.** Annual and cumulative winter forage dry matter production when harvested at the boot stage. Parma 1999-2001.

Three year P removal with double cropping ranged from 154 (spring wheat) to 169 lb/A (winter triticale) and exceeded single crop corn P removal by 36 to 50 lb P/A. Double cropping fall planted
forages and spring planted corn was appreciably more effective in P removal compared to single cropping corn.

Soil test P was reduced from over 30 ppm in the spring of 1999 to 11.8 ppm in fall 2001 after three years of double cropping. Annual corn reduced soil test P to 17.0 ppm. Soil test P after three years of fallowing declined to 22 ppm P. Residual P becomes increasingly less available with time due to precipitation reactions. This precipitation of residual P with time was responsible for as much of the decline in soil test P after three years as was due to crop removal.

![Figure 2](image.png)

**Figure 2.** Total P removal over three years with annual double crop and single crop corn (winter fallow, far right column).

In summary, double cropping winter forages and silage corn appreciably increased P removal over that accomplished with an annual corn crop. Winter triticale was the most productive winter forage. Seeding rates of 150 lb/A, higher than those required for maximum grain yield, were necessary for maximum boot stage forage production.