Phosphorus Removal in a Double Crop 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 on a Greenleaf-Owyhee silt loam. The study involved 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. 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 of double cropping winter triticale and corn exceeded P removal with single crop corn by 42% or 50 lb P per acre (169 vs 119lb 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 P removal, the animal waste loading capacity of soils, or hasten soil test P decline.

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 algal growth. Current dairy rules have established upper limits of soil test phosphorus (STP) of 40 ppm in the first foot. Above this threshold additional waste applications to the soil are limited to the amount of P removed by 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, or 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. The objective of this study was to evaluate the winter cereal – silage corn double crop system for its potential to increase both forage production and P removal over that with a single corn crop.

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 crop silage 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 cereals were planted in seven rows spaced at seven inches. Nitrogen fertilizer as urea was top-dressed April 16, 1999, April 24, 2000, and March 23, 2001 at rates of 100 lb N/A in 1999 and 2000 and 200 lb N/A in 2001. 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. Total biomass fresh weight was measured from 50 ft^2, and subsamples of the harvested biomass were collected, weighed 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 first year corn was planted May 20 into the winter cereal stubble without tillage using a conventional John Deere Flex planter with double disk openers. But due to poor stands the first year, the soil was rototilled to about 3 inches before planting corn in subsequent years. Roundup Ready corn was planted in the last two years to control the winter cereal re-growth. The corn was harvested for silage by late September to give sufficient time for an early October planting of the fall planted forages. Corn harvest dates were September 21, 21, and 5 in 1999, 2000, and 2001, respectively. Total biomass fresh weight was measured from 125 ft^2 from the two 30 inch beds comprising the plot. Fresh weight, dry matter and P content of harvest subsamples were determined.

The field used for the study received a uniform application of 366 lb P_2O_5/A as fertilizer (0-45-0) on October 21, 1998 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 after the first and last corn harvest to document changes affected by double and single crop forage systems. Nitrogen fertilizer as urea was side-dressed at the rate of 120 lb N/A on May 30, 2000 and urea was broadcast and incorporated May 14, 2001 at the rate of 200 lb N/A.

Results and Discussion

Winterkill reduced winter barley and spring wheat stands in 1999 resulting in significantly less production and P uptake than with spring and winter 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. The triticale and winter wheat forage production appeared to decline each year. Production in 2001 averaged about 70% as much as in 1999. Forage dry matter production ranged from a low of 1.37 T/A in spring wheat that partially winter killed to 3.49 T/A for winter triticale the first year. The three-year forage dry matter production was highest for the winter (8.8 dry tons/A) and spring triticale (8.5 dry tons/A) and lowest for spring wheat (6.5 dry tons/A) due to winterkill in 1999 (Fig. 1).

Mean winter forage P concentrations declined from the first year high of 0.391% in 1999, to 0.315 % in 2000, to 0.249% in 2001. Concentrations declined likely due to declining available P. Winter forage P concentrations did not consistently differ in each year. Mean winter forage P removal declined from 18.4 lb/A the first year to only 10.7 lb/A in the last. The P removal was the result of both declining biomass production and reduced forage P concentrations. Winter barley and spring wheat can remove P comparable to triticale in the absence of winter kill.

Corn stands were poorest and corn silage yield lowest when no-till planted the first year in winter forage stubble unaffected by winterkill. First year corn also was adversely affected by winter cereal re-growth. Consequently, corn stands the first year were highest and yields greater following fall planted cereals that had lost part of the stand from winterkill. Corn yields were unaffected by previous winter forage in subsequent years.

Mean corn dry matter production averaged 9.49, 8.89, and 9.41 dry tons/A following the winter cereals in 1999, 2000, and 2001 respectively. Corn production did not decline each year as did the winter forages. Corn forage P concentrations also did not decline as they did in winter forages and averaged 0.187% for 1999, 0.192% for 2000, and 0.226% for 2001. Corn P removal

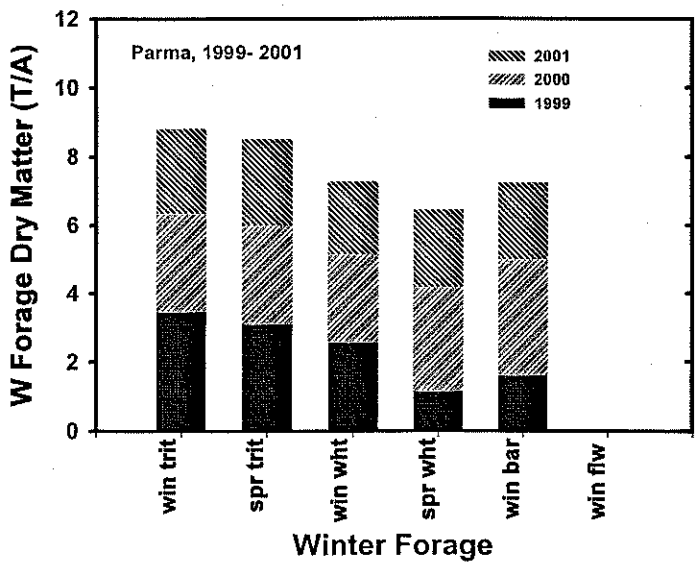

Figure 1. Annual and cumulative winter forage dry matter production when harvested at the boot stage. Parma 1999-2001.

averaged 35, 34, and 42 lb P/A for 1999, 2000, and 2001 respectively.

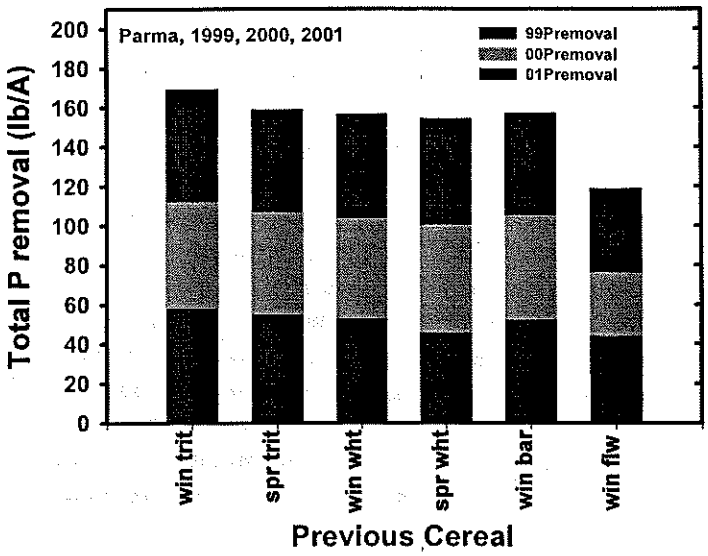

Figure 2. Total P removal over three years with annual double crop and single crop corn (winter fallow, far right column).

Three year total 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. These P removal estimates are probably conservative relative to forage production from fields with previous excessive animal waste P. Winter forage production, P concentrations, and P removal were more sensitive to declining soil test P than was corn. This may be related to cooler soil temperatures during winter forage growth that reduce P availability. Where soil test P is several fold higher than the initial values for our site, winter forage P removal would be less limiting and greater for the three year period.

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.

In summary, double cropping winter forages and silage corn appreciably increased P removal over that accomplished with single cropping corn. 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.

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