

Research Report

Phosphorus Removal in a Double Crop Forage System

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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 rules for dairy have established upper limits of soil test phosphorus (STP) of 40 ppm in the first foot provided there is no runoff. Exceeding this threshold requires that additional waste applications are limited to the amount of P taken up by the subsequent cropping rotation.

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 liquid waste P is applied to these lands 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, reduce the liquid wastes generated, or increase the loading rate for their fields. Dairies could conceivably have to limit their milk production or herd size. If the solid waste fraction of the effluent is not exported to more distant fields the limitation is exacerbated.

Greater P removal by cropping would in turn increase soil P loading capacity, increase the time for STP thresholds to be reached, postpone the need for capital improvements required for extending delivery systems, and possibly enable dairy herd expansion. Double crop forage systems (winter cereal-corn) 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 the boot stage. Thus, a boot stage harvest does not sacrifice P removal. An additional advantage is that winter cereals grow well into the fall and earlier in the spring than warm season forages. This may justify waste applications during late fall or early spring when waste applications are normally disallowed. If so, less effluent would need to be stored.

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Winter cereals are occasionally evaluated for their forage potential but seldom for the potential for P uptake and removal. Furthermore, optimum seeding rates for winter cereal grain production may differ from those required for maximum forage or P removal. Excessive seeding rates for grain frequently result in tillers that do not produce grain but may otherwise increase forage or P uptake. The seeding requirements for maximizing cereal forage and P removal have not been determined.

The primary objective of this research was to evaluate the potential for increased P removal with a winter cereal - corn silage double crop forage system. Secondary objectives were to evaluate winter cereal forages and the seeding rates necessary to maximize forage and P removal.

Methods

A three year field study was conducted at the Parma Research and Extension Center involving three winter (Hoody barley, Stephens wheat, and Trical 815 triticale) and two spring cereals (Penawawa wheat and Trical 2700 triticale) all early fall planted at seeding rates of 100, 150, or 200 lb/A. A non-planted fall treatment was also included. Plots measured 5 feet wide and 30 feet long. Treatments were arranged in a randomized complete block design with four replications. Biomass was measured when winter cereals were at the boot stage and their total P content determined. A corn hybrid (minimum 105 day maturity) was planted as soon after the winter cereal harvest as possible. The corn was harvested for silage by late September to give sufficient time for an early October planting of the fall planted forages.

There was no tillage prior to planting corn in 1999 but soils were rototilled and culti-packed after winter forage harvests in subsequent years. Corn was planted May 14 on 30" beds using double disk openers. Corn emergence and final stands in both 2000 and 2001 were affected primarily by pheasant feeding.

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

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Results

The three year field study was completed in 2001 at the Parma Research and Extension Center. Winterkill reduced winter barley and spring wheat stands in 1999 resulting in significantly less forage 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 appreciably. Winter forage production was lower in 2001 than in 1999 and 2000. The winter forage dry matter produced over three-years was highest for the winter and spring triticale and lowest for spring wheat (**Fig. 1**).

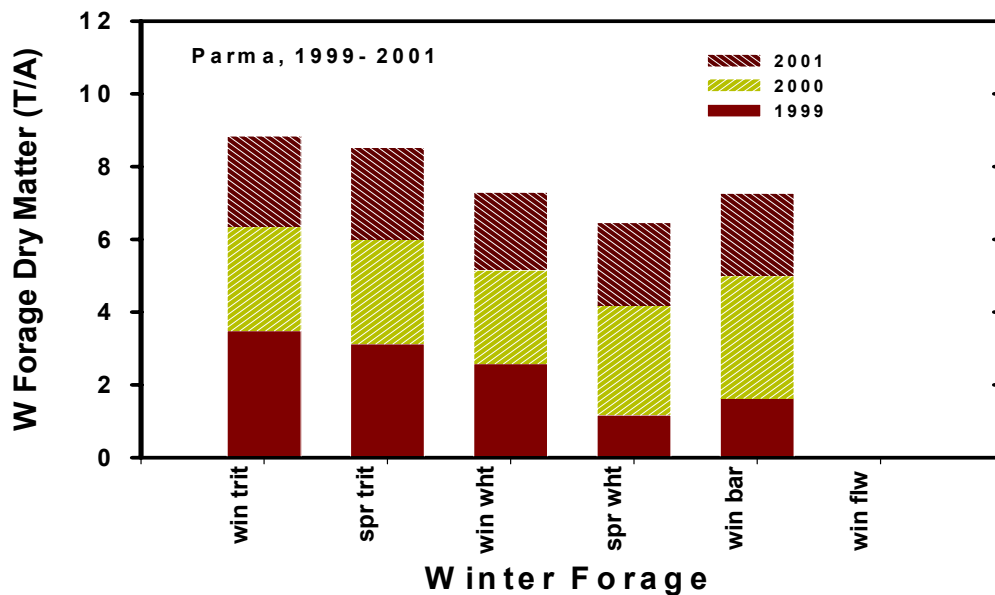


Figure 1. Annual and cumulative winter forage dry matter production when harvested at the boot stage. Parma 1999-2001.

Seeding rates above 100 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. Winter wheat, barley, and triticale dry matter generally increased with higher seeding rates but spring wheat did not. There was generally no advantage to increasing the seeding rate to the highest rate of 200 lb/A from the 150 lb/A rate.

Corn following the 1999 winter forages was less vigorous and stunted, with roots that appeared to be affected by winter forage hosted stubby root nematode. Corn production and P uptake in 1999 was directly related to corn stands and vigor. Corn production and P uptake after winter forages was less affected by winter forages in 2000 and 2001. P

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uptake was lower in 2000 than 1999 in the corn only planting for reasons that are not clear.

Total P removal after three complete years of the double crop system are shown in **Figure 2**. Three year P removal with double cropping ranged from 154 to 169 lb/A, and exceeded single crop corn P removal by 35.5 to 50.3 lb P/A depending on the winter forage.

With no cropping in winter or summer, STP declined over the three years from a high of 31.5 ppm in spring 1999 to 21.3 ppm after the final corn harvest in summer 2001. This decline in STP represents the loss in available P over time from incorporation into microbial tissue as well as slow reactions involving the precipitation/adsorption of soluble P with soil Ca and possibly Fe and Mn. This natural decline in STP in the absence of cropping is fortuitous as it will serve to reduce P available for runoff or leaching. It also serves to lengthen the time required for STP, with continued waste applications, to reach the 40 ppm threshold. In the event that the STP is above the threshold, the slow P reaction will hasten the drop in STP to the threshold with periodic P removal in harvested forages.

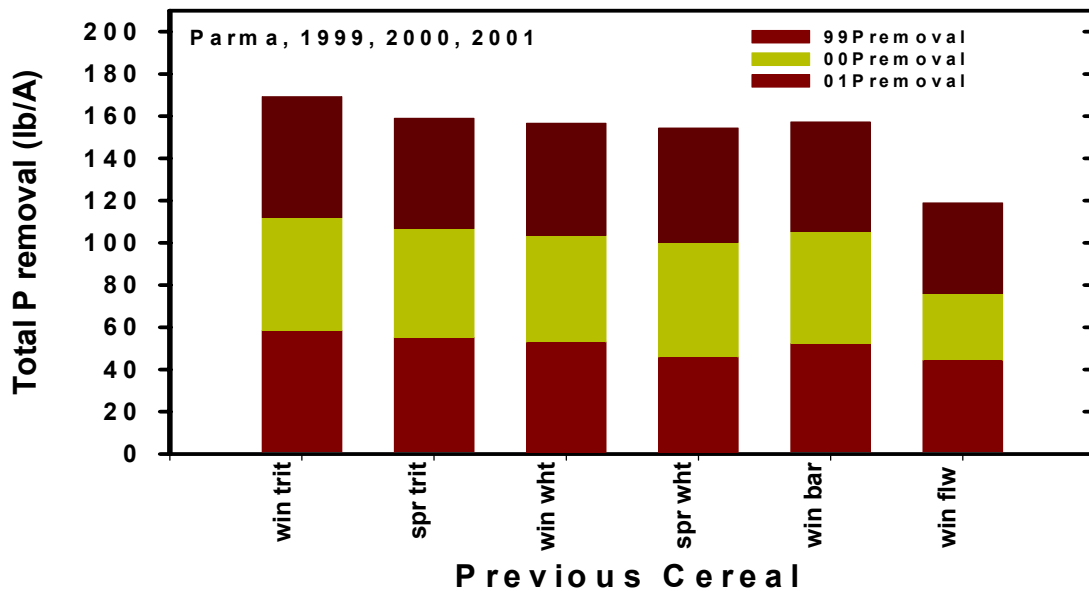


Figure 2. Double crop forage P removal in 1999, 2000, and 2001 as affected by previous winter cereal forage. Single crop corn P removal is indicated on the far right column above the winter fallow (winflw)

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With annual cropping to a single corn crop, STP declined over three seasons to 17.5 ppm P, only 3.8 ppm P lower than the fallow treatment. Double cropping with winter cereals (triticale) and corn reduced STP to 11.8 ppm P after three years. Double cropping reduced STP 5.7 ppm more than annual cropping to a single corn crop. There were no differences over three years in soil test P due to the type of winter forage. Seeding rates did not affect STP after three years.

Summary

Double cropping fall planted forages and spring planted corn was shown to be appreciably more effective in P removal and reducing STP compared to single cropping corn. The superior yield and P removal with winter or spring triticale vs either spring or winter wheat at boot stage harvests was clearly demonstrated over the three year study. Seeding rate effects were less clear but higher rates than are normally required for grain yield will be necessary for maximum boot stage forage production. Higher seeding rates did not consistently increase P removal in forages. Double cropping appears to be a viable option for ameliorating excessive waste P applied to soil.