

# TRITICALE FOR PHOSPHORUS REMOVAL

**B. Brown**

University of Idaho, Parma Research and Extension Center

## ABSTRACT

Triticale is an important winter forage for double crop systems designed to maximize forage and phosphorus (P) removal for mitigating P enriched manured soils. Both forage and P removal require higher seeding rates than are required for grain production. Triticale P concentrations range widely depending on how enriched soils are with manure P, and up to two-thirds of the triticale could have concentrations differing by more than 10% from the default values assumed during nutrient management plan development. Nitrogen management for boot stage triticale differs from that needed for small grain production, as preplant fall-applied N promotes both forage yield and P uptake compared to spring top-dressing. The daily P uptake rate in triticale ranges from 0.5 to 1.0 lb P per acre.

## INTRODUCTION

Idaho regulations 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. Current Idaho dairy rules have established a soil test phosphorus (STP) threshold of 40 ppm (bicarbonate extraction) in the first foot when there is potential for runoff. Above this threshold additional waste applications are limited to the amount of P removed by crops. Some dairies have limited land resources and more waste P than can possibly be removed with annual cropping. Once the threshold is reached, compliance requires dairies to (1) reduce the P loading by reducing the manure generated, possibly limiting their milk production or herd size for the limited acreage, (2) increase land resources available for manure application through purchase or arrangement with other land owners, or extending delivery systems to previously non-manured fields, or (3) increase crop P removal.

Increasing the amount of P removed in harvested crops could be helpful in mitigating the affects of manure and compost P. Greater crop P removal would slow the rate at which STP increases or help reduce STP over time, postponing the need for capital improvements required for extending delivery systems, enable dairy herd expansion, or increase soil P loading capacity.

Double crop (winter cereal-corn) forage systems have the potential for appreciably increasing the amount of P removed by cropping over that removed with a single corn silage crop, as well as increasing forages otherwise used in the dairy enterprise, and possibly provide an extended window for manure applications. Ideally, winter cereals harvested at the late vegetative or boot stage (rather than soft dough) provide additional forage and increase P removal without sacrificing silage 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.

## DISCUSSION

### *Double cropped winter forages*

Several winter cereals have been evaluated for their capacity to accumulate P by the boot stage in a double crop forage system. A three year study conducted at the Parma R & E Center (elevation 2300 ft) in southwestern Idaho 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). Planting dates for winter forages were October 21, 1998, September 27, 1999, and October 3, 2000.

Total winter forage production over three years ranged from 6.5 to 8.8 tons of dry matter per acre (Fig. 1). Winter triticale averaged the highest in total forage production over the three years, but did not differ significantly from spring triticale. Winter wheat was less productive than triticale over three years. Winterkill reduced winter barley and fall planted spring wheat stands in the first year, reducing production in that year and the cumulative total production over the three years (Fig. 1). With no winterkill, annual forage production among fall planted forages did not differ appreciably.

Total winter forage P removal over three years ranged from 36 lb per acre for fall planted spring wheat to 58 lb per acre for winter triticale (Fig. 2). Phosphorus removal basically mirrored forage production. However, minor differences in winter forage P concentrations tended to magnify the differences between some forages. Consequently, forages differed more in P removal than they did in dry matter production.

These estimates of winter forage and P removal are probably conservative. Winter forage average P concentrations declined from 0.39% in the first season to 0.25% in the third season. Soil test P also declined over the three years of double cropping to about 12 ppm. Fields with higher soil test P than the 31 ppm measured in this study would likely result in higher forage P concentrations if not greater forage yield and P removal.

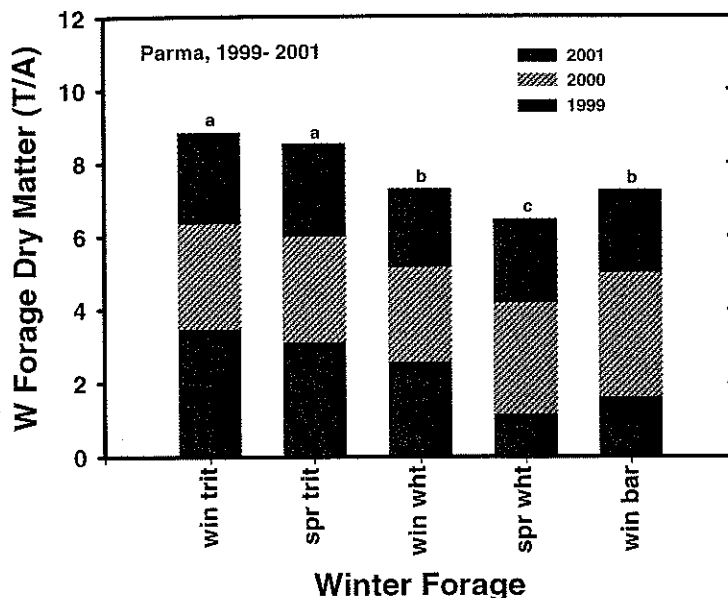


Figure 1. Annual and cumulative winter forage dry matter production when harvested at the boot stage. Parma 1999-2001.

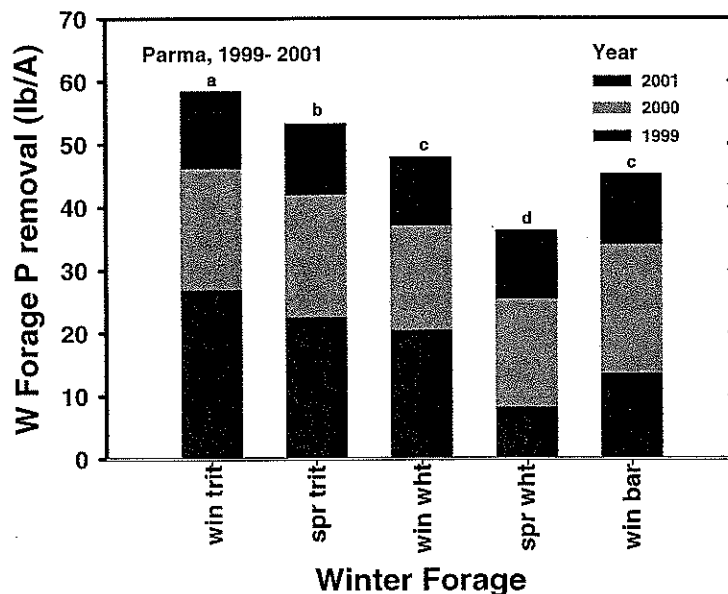


Figure 2. Annual and cumulative winter forage P removal when harvested at the boot stage. Parma 1999-2001.

Following winter forages, corn silage yield over the three years following winter forages ranged from about 5 to 16% less than corn alone. Total double crop forage yield ranged from 31 dry tons per acre with corn alone to 36 dry tons per acre with spring wheat and corn.

Corn silage P removal ranged from 105 to 119 lb per acre over the three years, considerably more than removed with the winter forage. The combined P removal with winter forage/corn silage double cropping ranged from a high of 168 lb P per acre with winter triticale-corn to the low of 154 lb P per acre with spring wheat-corn. Silage corn grown in areas with longer or shorter growing seasons likely has greater or less potential for yield and P removal than indicated here.

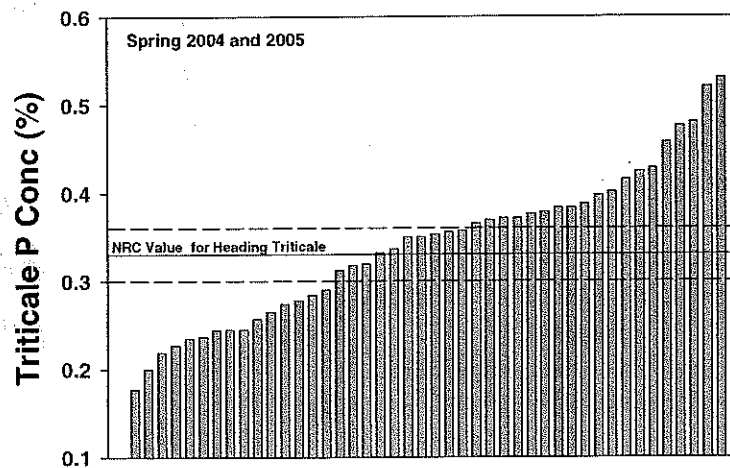
Seeding rates of 150 lb/A were required for maximum production in all years for winter triticale, spring triticale, and winter wheat forages (Fig. 5). Phosphorus removal was not as sensitive to seeding rate as was dry matter production. Only winter triticale and winter wheat required seeding rates of 150 lb per acre for maximizing P removal. Seeding rates of 200 lb/A for winter wheat and triticale provided little if any advantage in productivity or P removal over the 150 lb/A rate.

### *Triticale phosphorus concentrations*

The estimates of P removal with winter forages depend on both the dry matter production and the dry matter P concentrations. For nutrient management planning using the Idaho OnePlan, estimates of triticale P concentration are based on the National Research Council (NRC) values of 0.34% P for heading triticale. Where winter triticale P contents were measured in the study above in non-manured fields, those P contents may differ from the P contents of forages from heavily manured fields where soil test P can measure several-fold higher.

Triticale P concentrations from southern Idaho manured fields were poorly documented. Therefore a survey was conducted of 44 manured fields in the Magic and Treasure Valleys during spring 2004 and 2005 to establish an Idaho baseline for the range in P concentrations in boot stage triticale forage.

Triticale total P concentration ranged widely from 0.18 to 0.53% P, with a mean of 0.33% for boot stage samples (Fig. 3). This mean is practically the same as the NRC value of 0.34% for triticale at heading. In Figure 3 the mean is bracketed by lines representing P concentrations differing by 10%. Forage P in two thirds of the fields was outside the range of 3.0-3.6% P; either above (43%) or below (23%) the 10% bracketed mean. Using a mean value for triticale P concentration for calculating P removal with triticale would grossly underestimate P removal in heavily manured fields and over estimate P removal in others.



**Figure 3. Winter triticale boot stage forage P concentrations for southern Idaho manured fields.**

Tissue P concentrations can be diluted with greater dry matter production, and higher concentrations may occur when dry matter production is limited by factors other than available P. Total dry matter was estimated in fields where samples were collected from discreet areas. Western Idaho triticale dry biomass ranged from 1.6 to almost 6 tons/A in 2004, and 3 to 3.8 tons/A in 2005. The P removed ranged from 7 to over 36 lb/A in 2004 and from 13 to 34 lb/A in 2005. Triticale forage P removal exceeding 30 lb/A is considerably more than we documented in the research trial reported above in non-manured soils. Biomass and P removal ranged as much as P concentrations. Total P concentrations and dry matter production both should be measured for the most accurate estimates of P removal.

Using NRC based estimates of P removal has significant implications. Overestimating P removal (using a NRC triticale P value for the calculation that exceeds the actual forage P concentration) can lead to higher manuring rates that steadily increase soil test P values. This may be desirable in cases where soil test P is initially low and limiting forage production, as might occur when new land is acquired with a history of less sustainable P applied, or if producers were overly cautious and manuring rates were not sufficient to sustain productivity. Conversely, when NRC values underestimate P removal, manuring rates or estimates are lower than those allowed by the statute, and soil test P could be expected to decline more rapidly as more P is actually removed than is applied.

Theoretically, reduced manuring on high soil P fields and higher manuring in low soil P fields will cause all soil test P values to ultimately converge to some central value. In this survey, triticale P concentrations were exponentially related to soil test P. From this relation, using the current threshold of 40 ppm P from the NRCS 590 standard, the predicted value for triticale forage P is only about 0.28% P, well below the NRC default value of 0.34% P used in the Idaho OnePlan or the mean for the surveyed fields. Using the same relation, the NRC triticale forage % P value of 0.34% would be associated with over 60 ppm soil test P.

Forage triticale potassium (K) ranged from 2.0 to 6.2% and averaged 3.71%. Forage triticale K was high enough in some locations to be of concern, as milk fever incidence can be related to excessive forage K. Other forage mineral element concentrations ranged widely. Triticale copper (Cu) differed by as much as tenfold. Elevated forage Cu may reflect contributions from foot baths. Forage zinc (Zn) concentrations ranged from 12.7 to 102 ppm. Forage Zn < 20 ppm is marginal for many crop tissues and could be limiting boot storage forage production. Triticale sodium (Na) concentrations varied the most of all minerals ranging from 146 to 7552 ppm. Forage Na likely reflects both the history of manuring as well as the amount of sodium salts used in the ration.

Knowing actual triticale forage P concentrations may be useful for adjusting P in the ration. Feeding higher P concentration forages may reduce the need for P supplementation in the ration, reduce P content of manures, increase manuring rates, and reduce dependence on purchased fertilizer N.

#### ***Nitrogen management for boot stage triticale forage and phosphorus uptake***

A phosphorus based manuring standard reduces manuring rates as compared to an N based standard, and ultimately requires the purchase of fertilizer N to maintain or maximize forage production. This occurs because the N:P ratio of manure, especially if composted, is lower than the N:P ratio of harvested forage.

Whereas the N and P requirements for maximizing the grain yield of irrigated small grains or corn silage are reasonably well established, the N requirements for boot stage triticale forage are not. For grain production, late winter/early spring top-dressed N is frequently more effective than fall pre-plant fertilizer N. Fall pre-plant fertilizer N reportedly increases vegetative growth without increasing grain yield and is

discouraged by NRCS 590 standards governing waste applications.

Whereas excessive vegetative growth for the production of wheat grain is undesirable, it is beneficial for a boot stage forage harvest, P removal and P remediation. Phosphorus uptake and forage P concentrations are reported to be directly related to available N.

To evaluate N timing and rate for triticale boot stage forage production, quality, and P content, a study was conducted on plots previously treated with or without compost that resulted in marginally low to relatively high available P. Optimum preplant N was 120 lb per acre in 2006 and 60 lb per acre in 2007, despite residual N at planting that did not differ appreciably between the two years.

Triticale boot stage forage was generally more productive with fall preplant N than spring top-dressed N at the 120 N rate (Fig. 4). Phosphorus uptake also tended to be higher with the preplant N timing. Whereas in 2006 and 2007, forage dry matter production for the 120 and 240 lb N rates did not differ appreciably, P uptake

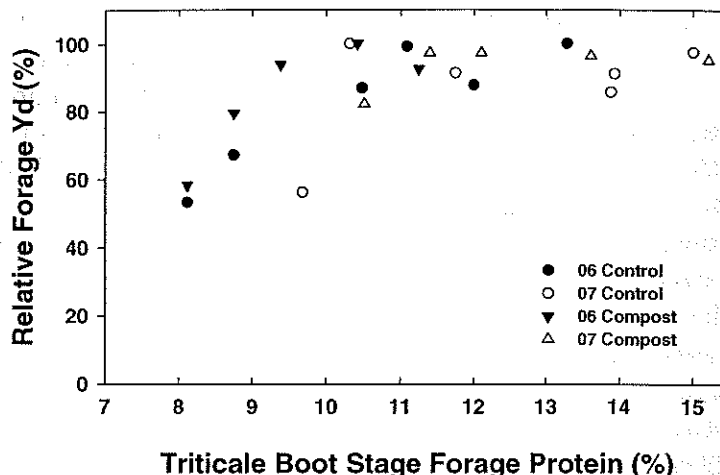


Figure 4. Triticale boot stage forage dry weight and phosphorus uptake in 2006 (a, c) and 2007 (b, d) as affected by available soil P, nitrogen rate (0, 120, 240 lb/A) and timing (fall preplant vs spring top-dress).

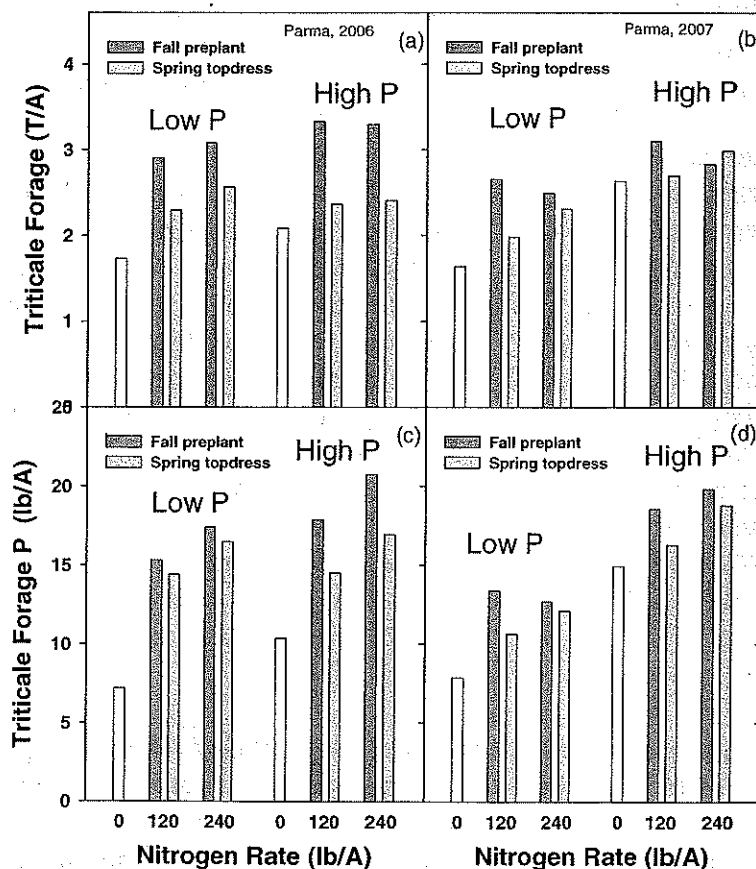


Figure 5. Triticale boot stage relative yield relationship to forage protein.

was greater for the higher N rate in both years where available P was highest (compost treatment). The increase in P uptake with higher N ranged from 6.8 to 16.5% in compost treated soil. Uptake of P appears to be more sensitive than forage yield to available N in soils enriched with animal waste P.

Forage nitrates can be toxic to livestock when available N appreciably exceeds the optimum. Boot stage forage nitrate concentrations increased when the N rates exceeded the optimum for yield and tended to be higher with spring top-dress than preplant N.

Protein is routinely measured in harvested forages to better balance livestock rations. Forage protein may also indicate whether triticale winter forage received adequate N. Boot stage forage protein resulting from the N applied to non-compost and compost treatments were related to the relative forage production (percent of maximum within each year). Maximum production coincided with boot stage forage protein ranging from 10.5 to 11.0% (Fig. 5).

### *Triticale phosphorus uptake rate*

Triticale P uptake is rapid from mid stem extension to flowering. Uptake from compost and non-compost treated soil at Parma was measured in 2005 and 2006 in fall planted triticale (Figure 6). Uptake of P was greatest each year from the compost treated soil due to much higher available soil P.

The daily uptake of P ranged from 0.5 lb /A for the non-compost treated soil to 1.0 lb P/A for the compost treated soil. For soils with soil test P well above the 40 ppm threshold, the higher P uptake rate can be expected. This study also revealed that boot stage forage was more limited by moderate-to-low soil P than was the yield of grain (data not shown).

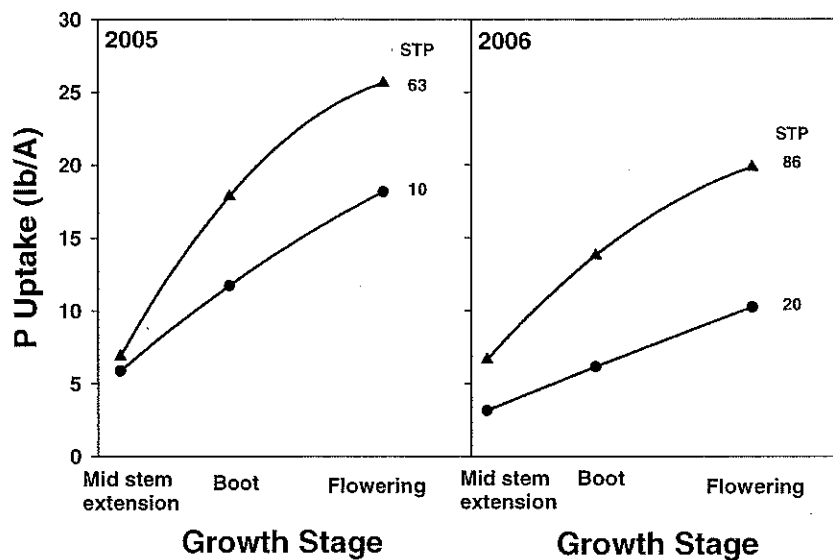


Figure 6. Cumulative P uptake from mid-stem extension to flowering as affected by compost applied two years before.