

Double-Cropped Winter Forages

BUL 869

By Bradford Brown and Thomas Griggs



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SUMMARY

- Double cropping winter forages with corn silage increases total forage available to dairy and other livestock operations while increasing total crop phosphorus (P) removal.
- To maximize forage production and/or P removal, plant early; use higher seeding rates than are necessary for grain production; and use a preplant nitrogen (N) fertilizer.
- Triticale produces more dry forage and removes more P than wheat or barley.
- The maximum rate of P uptake by winter forages occurs during late vegetative growth.
- Triticale boot-stage forage P concentrations varied widely depending on soil P enrichment, so accurate estimates of P removal require measuring both dry forage production and its P concentration.
- Since Idaho growing seasons tend to be short, direct seeding may facilitate timely replanting and maximum heat unit utilization.
- Boot-stage triticale forage protein can provide a reasonable indication of the adequacy of N for forage production.

INTRODUCTION

Due to water quality concerns, Idaho confined animal feeding operations (CAFOs) such as dairies are required 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 rules have established a soil test phosphorus (STP) threshold of 40 ppm (bicarbonate extraction) in the first foot in fields where there is potential for runoff. Above this threshold additional manure applications to the soil are limited to the amount of P removed by crops.

Some dairies have limited land resources and more manure P than can possibly be removed with annual cropping. Once the P 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 is helpful in mitigating the effects of P applied in manures and composts. Greater crop P removal slows the rate at which STP increases or helps reduce STP over time; reduces the need for capital improvements required for extending manure delivery systems; enables dairy herd expansion; or increases soil P loading capacity.

Double-crop (winter cereal and corn) forage systems appreciably increase the P removed over that removed with a single corn silage crop, and increase total forage for the dairy enterprise. Ideally, winter cereals harvested at the late vegetative or boot stage before heading (rather than soft dough near the end of grain fill) provide additional quality forage and increase P removal without sacrificing silage corn production.

A later dough-stage winter cereal forage harvest in southern Idaho precludes growing corn because the remaining growing season is too short. Furthermore, winter cereals do not take up much more P after heading (although they do produce more total biomass). Thus, a boot-stage harvest does not sacrifice P removal nearly as much as it does biomass.

Winter cereal forages in Idaho historically were removed at the dough stage. Dough stage forages are still produced, but the more predominant use of winter cereal forages currently is a late vegetative, boot-stage forage harvest to accommodate a more timely planting of corn, the summer crop of the double-cropping system. Since pertinent information on boot-stage winter cereal production and P removal as a component of the double-crop system in southern Idaho has not been summarized, that information is the focus of this bulletin.

Double cropping would not involve additional equipment for most enterprises already producing swathed and chopped forages. Double cropping would entail additional labor and operating costs.

Irrigation requirements would increase somewhat: for winter forage establishment possibly, but primarily to support spring vegetative growth. Winter forages in most dairies in the region are irrigated with storage lagoon water so they provide additional opportunity for emptying lagoons. Annual N requirements would increase for this double crop system.

While double cropping is an excellent way to maximize forage and P removal, winter forages may not fit into all dairy or beef enterprises. Furthermore, winter forage feed quality, which declines as winter forage approaches heading and flowering growth stages, can be an issue if the harvest is delayed by weather.

DRY MATTER PRODUCTION AND P REMOVAL

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 was conducted at the Parma Research and Extension Center (elevation 2300 ft) in southwestern Idaho involving three winter cereals (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. Boot-stage harvests were May 20, 1999, April 27, 2000, and May 11, 2001. Two non-planted fall treatments were also included: one used for the production of a single crop of 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.

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

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 (figure 2). Phosphorus removal basically mirrored forage production. However, minor differences in winter forage P concentrations tended to magnify the differences between some forages. For example, spring wheat averaged 75% of the forage production of winter triticale, but only 62% of the P removal. Consequently, forages differed more in P removal than they did in dry matter production.

Forage dry matter production, and especially P removal, appeared to decline with each season in winter forages unaffected by winterkill (figures 1 and 2). This was likely due to declining available soil P. Winter forage average P concentrations declined from 0.39% in the first season to 0.25% in the third season (data not shown). Soil test P also declined over the three years of double cropping to about 12 ppm.

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

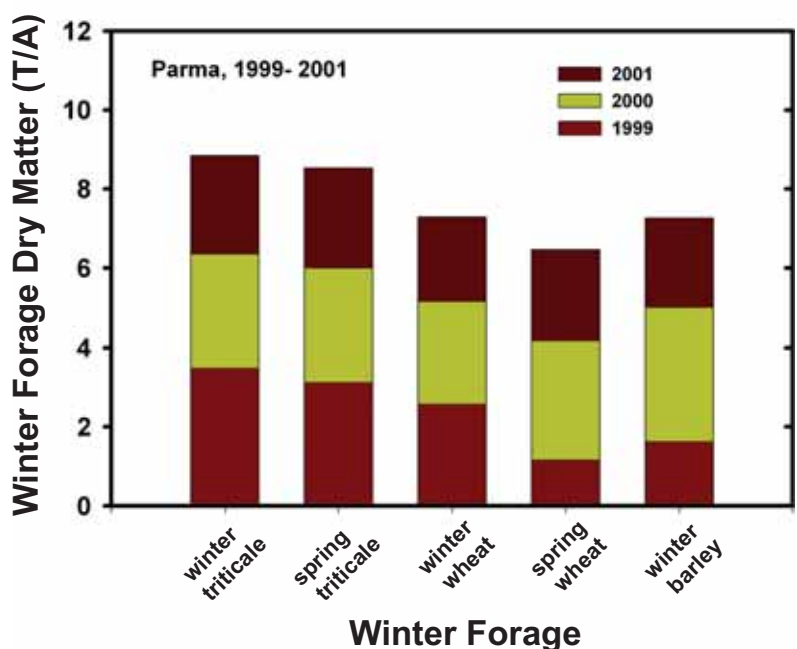


Figure 2. Annual and cumulative winter forage P removal when harvested at the boot stage

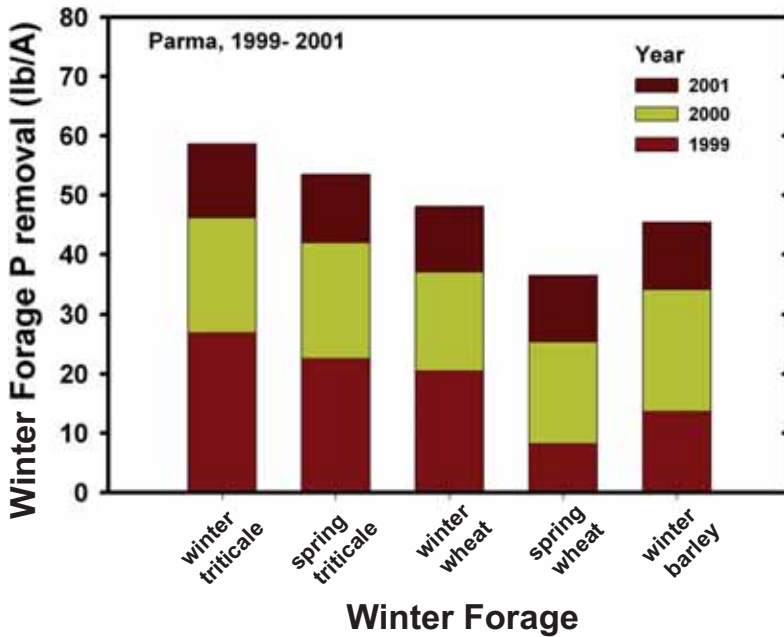
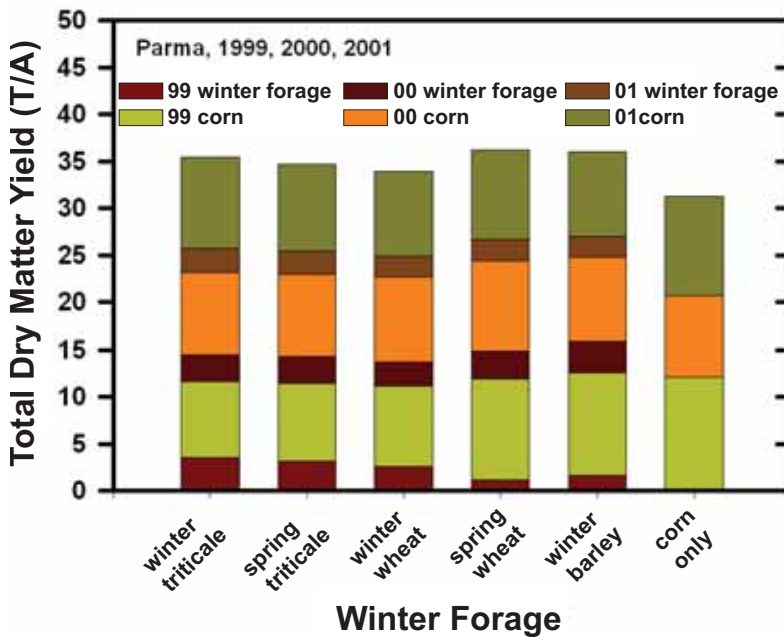


Figure 3. Annual and cumulative winter forage and silage corn dry matter (DM) yield



Fields with soil test P considerably above the values in this trial would likely result in higher forage P concentrations, and possibly greater forage yield and P removal. While the highest soil test P measured in the first year of our study was 31 ppm, soil test P can range up to several hundred ppm in manured fields.

Following winter forages, cumulative corn silage yield over the three years ranged from 5 to 16% less than corn alone. Lower corn yields following winter forage were primarily due to poorer stands from no-till plantings and regrowth of triticale in the first year. Total forage yield (winter forage and corn silage) ranged from 31 dry tons per acre with corn alone, to 36 dry tons per acre with double-cropped spring wheat and corn (figure 3).

Corn silage P removal ranged from 105 to 119 lb per acre over the three years, considerably more than removed with the winter forage (figure 4). Average silage corn P removal was not affected over the three years by previous winter forages, as silage corn yield may have been. Interestingly, winter forage/silage corn combinations that resulted in the highest P removal did not always result in the greatest total double-crop 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 and corn, to a low of 154 lb P per acre with spring wheat and corn. Corn grown alone (not as part of a double-cropping system) removed only 120 lb P per acre. Silage corn grown in areas with longer growing seasons likely has greater potential for yield and P removal than indicated here.

Figure 4. Annual and cumulative winter forage and silage corn P removal

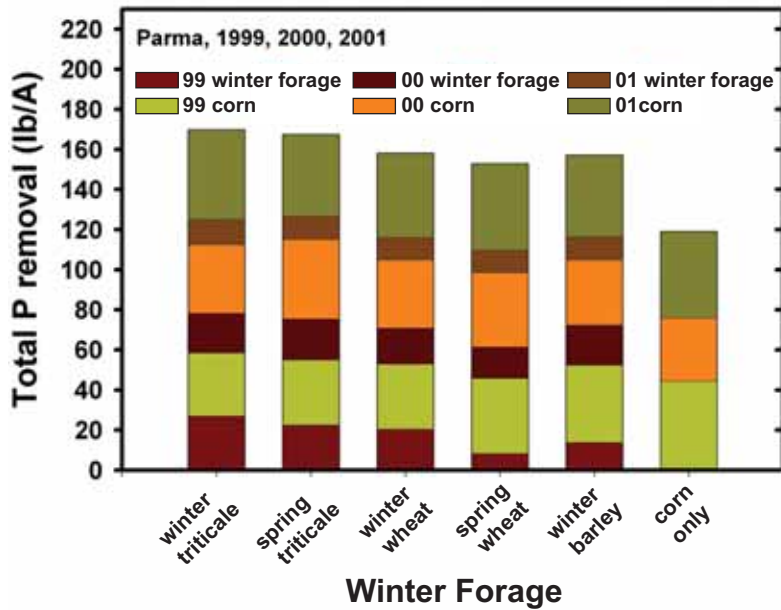
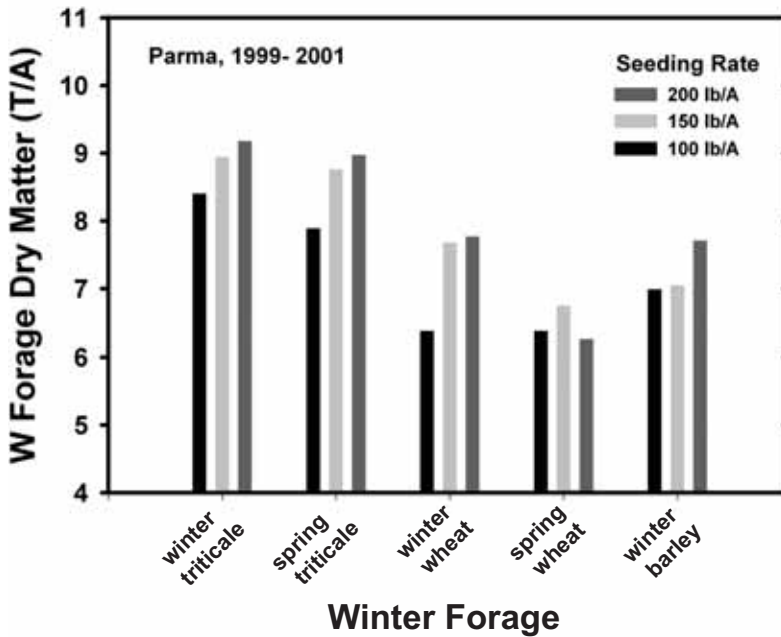


Figure 5. Winter forage boot stage dry matter as affected by winter forages and seeding rates



WINTER FORAGE SEEDING RATES

Seeding rates exceeding 100 lb/A seldom increase grain yield of early planted winter cereals, in part because many tillers are produced that never produce a grain-bearing head. While non-bearing tillers may not contribute significantly to grain yield, they can contribute to boot-stage forage production and P removal. Since seeding rates appropriate for boot-stage harvested forage were not well established, the winter forages at Parma were evaluated at three seeding rates (100, 150, and 200 lb seed per acre).

Seeding rates of 150 lb/A were required for maximum production in all years for winter triticale, spring triticale, and winter wheat forages (figure 5). Spring wheat and winter barley dry matter production were less sensitive to seeding rates. Phosphorus removal was not as sensitive to seeding rate as was dry matter production. Only in winter triticale and winter wheat were seeding rates of 150 lb per acre necessary for maximum P removal (figure 6). Spring triticale and spring wheat P removal were less sensitive than the winter types to seeding rates over the three-year period. 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 AND REMOVAL

It is important to test the P in crops used to remove P from the soil, in order to more accurately document the P removed, and how much P is fed in the animal's ration. An estimated average value of P removal may not at all reflect how much P is in your particular crop.

Figure 6. Winter forage boot stage P uptake as affected by winter forages and seeding rates

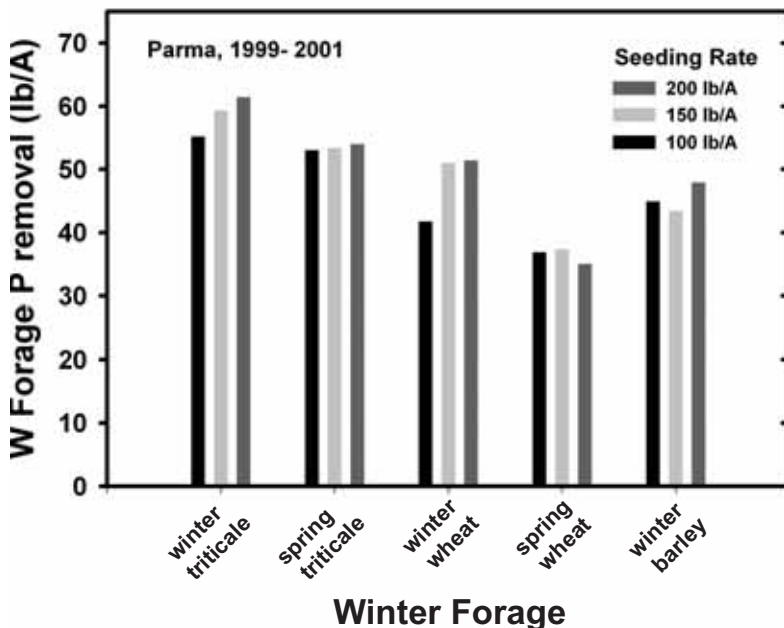
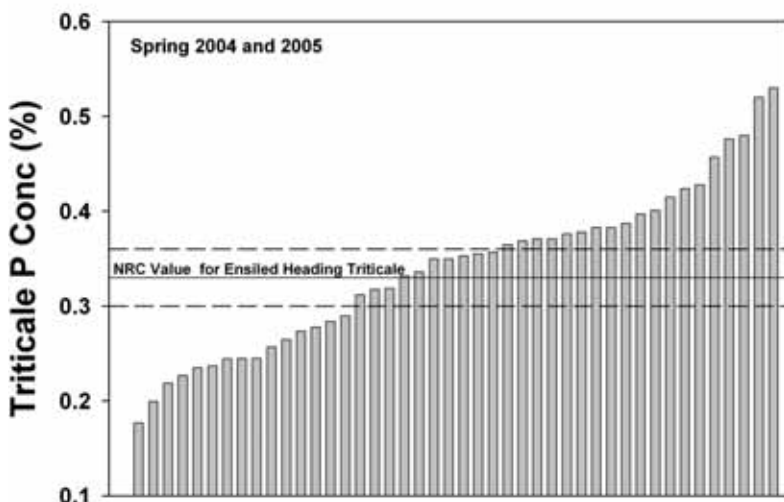


Figure 7. Winter triticale boot stage forage P concentrations for southern Idaho manured fields



For example, the Idaho OnePlan software uses an estimate of triticale P concentration based on the National Research Council (NRC) value of 0.34% P for heading triticale ensiled. Since triticale P concentrations from southern Idaho manured fields were poorly documented, a survey was conducted of 44 manured fields in the Magic and Treasure Valleys during spring 2004 and 2005 to establish an Idaho baseline. We found considerable variation in P concentrations of the triticale grown.

Triticale total P concentration ranged widely from 0.18 to 0.53% P, with a mean of 0.33% for boot-stage samples (figure 7). This mean value is practically the same as the NRC mean value of 0.34% for triticale at heading (after ensiling). However, there was a wide variation in P concentrations. In figure 7 the mean is bracketed by lines representing P concentrations differing by 10% from the mean. Forage P in most samples falls outside the range of 0.30-0.36% P. Over three-quarters of the fields were either above (43%) or below (34%) the 10% bracket on each side of the mean. Using a mean value for triticale P concentration for calculating P removal with triticale would grossly underestimate P removal in some fields and overestimate P removal in others. The range nevertheless suggests considerable potential for accumulating P quantities above those required for growth.

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. In other words, when growth is abundant, individual plants may have a lower P concentration than when growth is more limited.

Western Idaho triticale dry biomass ranged from 1.58 to 5.95 tons/A in 2004, and 2.95 to 3.81 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 that documented in research trials to date involving non-manured soils. Biomass and P removal ranged every bit 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 estimates of P removal has significant implications. Overestimating P removal can lead to higher manuring rates that steadily increase soil test P values. The opposite occurs when NRC values underestimate P removal and manuring rates or estimates are lower than those allowed by the statute. In the latter case, soil test P would decline more rapidly as more P is actually removed than is applied with manure. Underestimating P removal could cause you to overestimate the lands required to accommodate your CAFO. Higher estimated land requirements unnecessarily increase the costs for development or expansion of an operation, or the estimated amount of manure that should be exported, leading to unnecessary hauling and application costs.

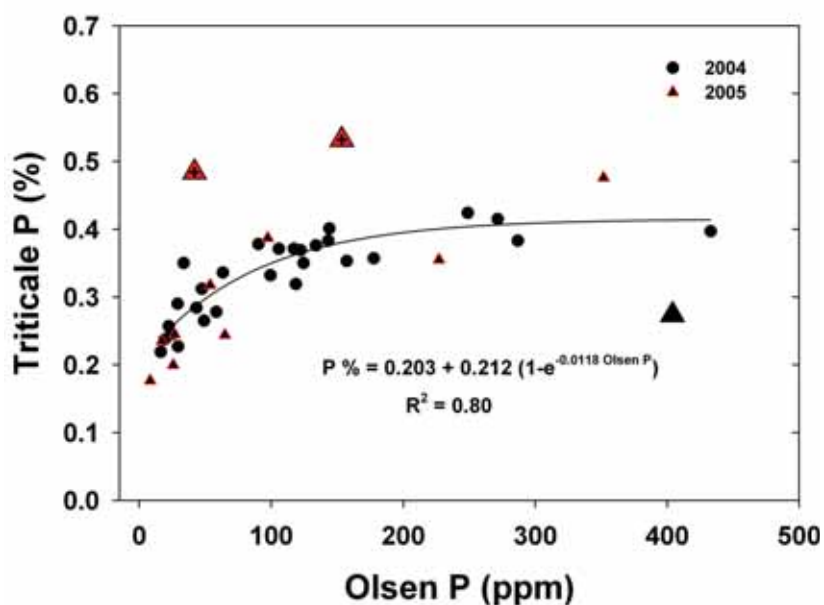
Using more accurate (measured yield and forage analysis based) P removal estimates also has significant implications for forage N fertilization. If your crops are removing more P than the book value, then you will be able to apply more manure to the land, and thus will need to buy less N fertilizer. Conversely, if less P removal occurs than the book value, manuring rates may be reduced and more fertilizer N may be needed.

Knowing actual triticale forage P concentrations may also be useful for adjusting P in the ration. Feeding forages with a higher P concentration can reduce the need for P supplementation. Reducing ration P concentrations will reduce P content of manures. This in turn enables higher manuring rates and reduced dependence on purchased fertilizer N.

When there are no forage P analyses to use for estimating P removal, as when a nutrient management plan is first developed for an old or new dairy or feedlot, there may be a better estimate of triticale P concentration than using the NRC book value of 0.34% P. There may be soil test P information available even if there is no history of triticale production and the related forage P analysis. In this survey, triticale P concentrations increased and then stabilized as soil test P increased (figure 8).

For older animal enterprises with fields that show high soil P (above 150 ppm), a more appropriate default value would be 0.40% P. Conversely, in fields with low to moderate soil test P (below 40 ppm P), as perhaps with new CAFOs, a more appropriate initial default value for boot stage triticale P concentration might be 0.30%. While the soil-test-based estimates of triticale P concentration may be useful for initial planning, they should not substitute for P analyses of actual triticale harvested.

Figure 8. Triticale boot stage forage P concentrations in southern Idaho. (Large symbols are outliers that are not included in the regression.)



Other chemical elements in the forage also range widely. For example, potassium (K) in forage triticale ranged from 1.97 to 6.17%, and averaged 3.71%. Forage triticale K was high enough in some locations to be of concern, since excessive forage K can suppress magnesium uptake, leading to milk fever. Copper (Cu) in triticale differed by as much as tenfold. Elevated forage Cu may reflect contributions from foot baths. Likewise, forage zinc (Zn) concentrations ranged from 12.7 to 102 ppm. Zinc levels of less than 20 ppm could limit boot-stage forage production. Sodium (Na) concentrations in triticale 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.

NITROGEN MANAGEMENT FOR WINTER FORAGE

A phosphorus-based manuring standard reduces manuring rates compared to a nitrogen-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.

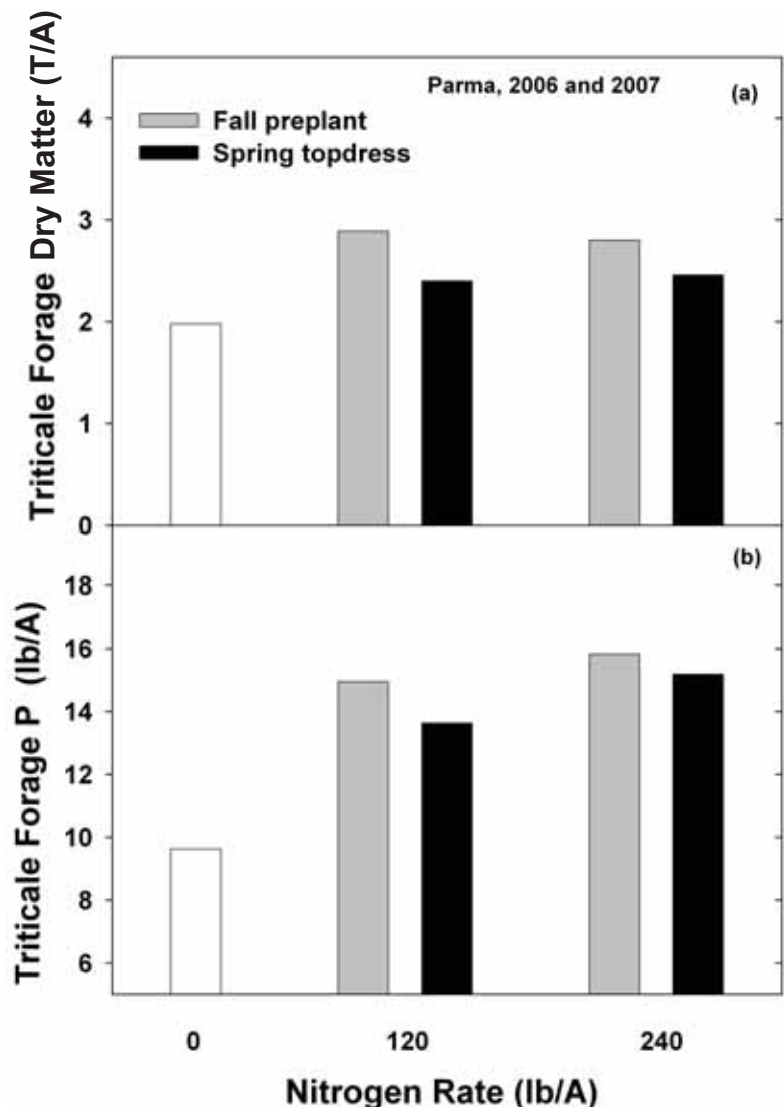
Whereas the N and P requirements for maximizing the grain yield of irrigated small grains or corn silage are reasonably well established, the N requirements for boot-stage triticale forage are not. For grain production, late winter/early spring topdressed N is frequently more effective than fall preplant fertilizer N. Fall preplant 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 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.

Triticale boot-stage forage was generally more productive with fall preplant N than spring topdressed N (figure 9a). Phosphorus uptake also tended to be higher with the preplant N timing (figure 9b).

Figure 9. Triticale boot stage forage dry matter (a) and P uptake (b)



Uptake of P was higher with previous compost applied (figure 10) and the increase with N was greatest in compost-treated, higher P soil. Uptake of P appears to be more sensitive than forage yield to available N in soils enriched with P.

The optimum rate of N fertilization may be difficult to predict. In our study, the optimum preplant N turned out to be 120 lb per acre in 2006, but only 60 lb per acre in 2007 despite lower residual N at

Figure 10. Boot stage triticale P uptake. (Uptake of P is averaged across both years and N timing.)

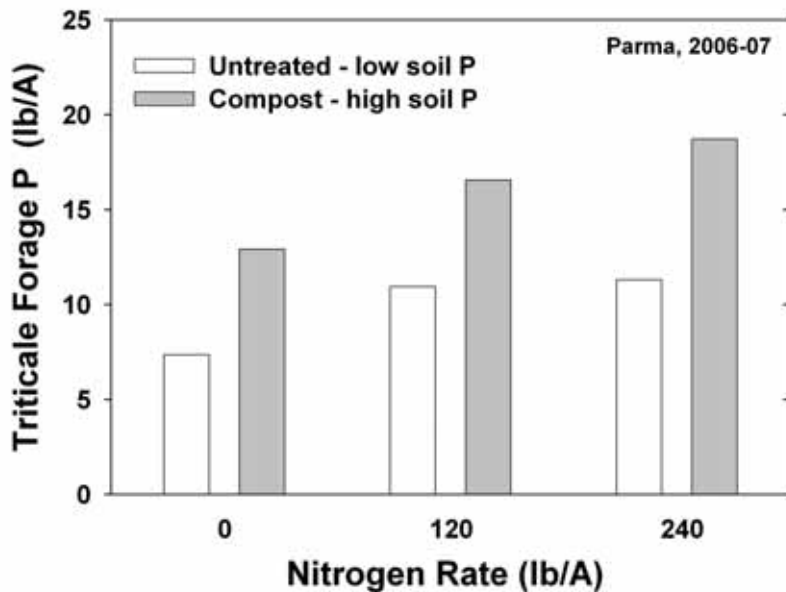
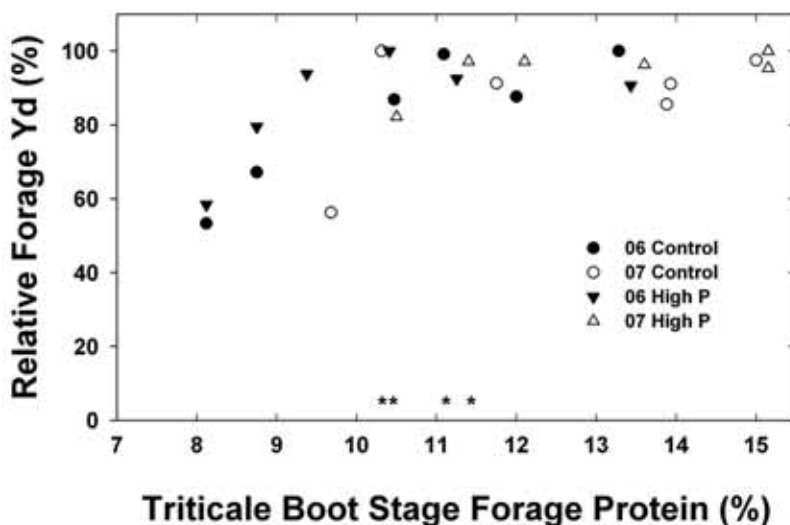


Figure 11. Boot stage triticale relative forage yield (percent of maximum) as related to forage protein concentration.



planting (118 lb N/A in 2005 and 76 in 2006). One reason may be that the lower production in 2007 did not require as much N. Climatic conditions affecting productivity likely will affect the total N required.

High forage nitrate-N concentrations (over 1000 ppm) can be toxic to livestock when available N appreciably exceeds the optimum. High nitrate-N concentrations are not generally an issue if the forage is not drought-stressed at harvest. In our irrigated study with no stress, we exceeded the optimum rate by four times, and the nitrates in the forage still did not reach toxic levels. For example, nitrates in the forage were higher in 2007 than 2006, yet reached only 890 ppm with the highest preplant N rate of 300 lb N/A. Nevertheless, a nitrate analysis should be included with other tests performed to determine feed quality. Nitrates tended to be higher with spring topdress than preplant N, especially at N rates above the optimum.

While it is difficult to recommend an optimum level of fertilizer N, you can get a sense after the harvest as to whether your N fertilization was adequate, by measuring the protein content of the forage. Protein is routinely measured in harvested forages to better balance livestock rations. Maximum forage production coincided with boot-stage forage protein ranging from 10.5 to 11.0% (figure 11). Therefore, if forage protein is within this range or higher, the N fertilization provided was likely adequate.

PLANTING DATES FOR WINTER FORAGE

Early planting dates for winter forages (mid September to early October in the Treasure Valley, early to mid September in the Magic Valley) are critical for maximizing boot-stage forage production. The longer it takes winter forages to reach the boot stage, the more delayed the boot-stage harvest, and the more the growing season for corn is reduced. Shortened growing seasons for corn necessitate using shorter season and less productive hybrids. Alternatively, harvesting earlier than boot stage sacrifices winter forage dry matter production and P removal.

To illustrate planting date influence, Stephens winter wheat was planted September 30, October 16, and November 2, 1983 at Parma, ID. Forage dry matter at two harvest dates are shown for each of the planting dates in figure 12. On the May 11 harvest, wheat planted October 16 was only 52% as productive as the September 30 planting, and the November 2 planting only 28% as productive. Whereas the September 30 planting had reached the boot stage with flag leaves fully emerged, the later plantings were at earlier stages of development.

Forage dry tonnage increased by the next harvest on May 24, and increases were greatest in the later plantings. By the May 24 harvest, later plantings had partially caught up with the first planting in dry tons produced. Even so, the November 2 planting was only 52% as productive as the September 30 planting. Corn planted subsequent to a May 24 winter forage harvest would be a relatively late planting of corn for western Idaho, and typically less productive if a shorter season hybrid were required.

Concentrations of P were not measured in these wheat forages. Assuming P concentrations are similar to those measured in other wheat forage studies with comparable available P, we assume forage P of 0.25%. Using this P concentration, the total winter forage P uptake for the September 30, October 16 and November 2 plantings would be 15.5, 8.2, and 5.7 lb P per acre respectively. Earlier planting dates result in more P uptake.

Figure 12. Wheat winter forage dry matter as affected by fall planting date and spring sampling at Parma, ID, 1983

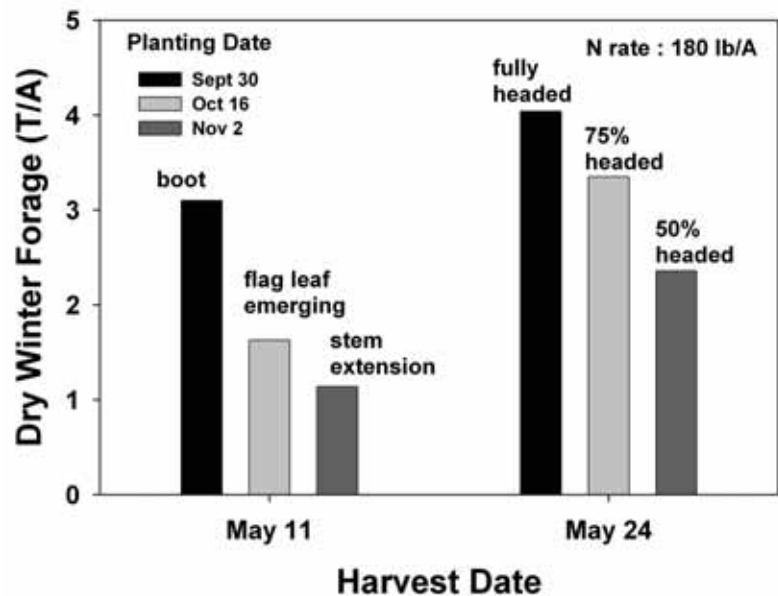
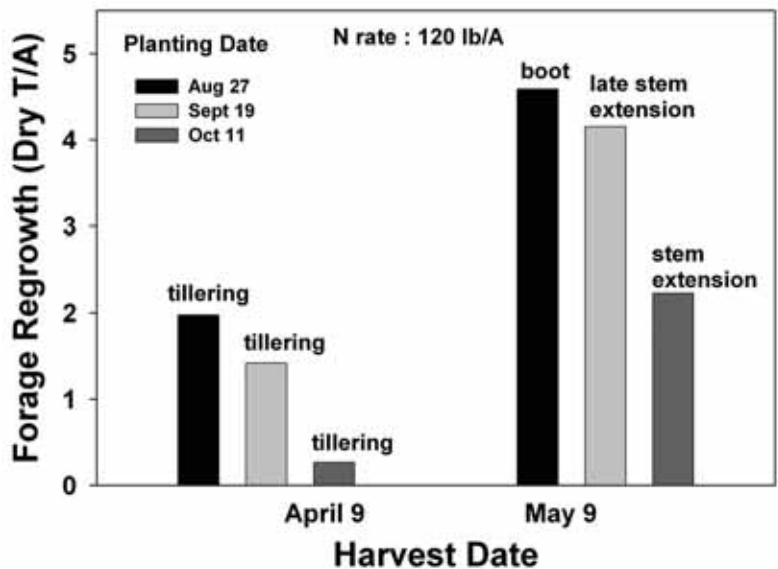


Figure 13. Mean winter forage re-growth after simulated late fall grazing at Logan, UT in 2003



Planting dates of winter forages at higher elevations were also shown to drastically affect both fall grazing potential and spring forage regrowth productivity. At Logan, UT (elevation 4598 ft), planting dates in 2001 and 2002 ranging from August 22 to October 11 were evaluated to determine fall and spring productivity of several cultivars of barley, triticale, and wheat. Forage dry matter production per acre by the mid-November harvest decreased 47 to 62 lb per day as planting dates were delayed from the first planting date (either August 22, 2001 or August 27, 2002). Forage mass of regrowth the following spring (April) decreased by 37 to 76 lb per day depending on the cultivar. The average forage regrowth at two spring cuttings of all winter forages at Logan are shown in figure 13.

Optimum winter forage planting dates, within the context of double-cropping with corn, will vary depending on elevation and the length of the frost-free growing season for corn. Winter forage planting dates will be later and the spring harvest earlier in milder climates, providing additional frost-free days for using longer-season and more productive corn hybrids. If corn silage production is paramount, planting dates for winter forages will frequently be later than optimal, as producers will be reluctant to sacrifice silage yield by using shorter-season corn hybrids.

While producers don't always have control over the timeliness of planting winter forages, planting dates have considerable influence on forage quantity and P removal.

NO-TILL PLANTING

The time required to plant corn after harvesting winter forage, or to plant winter forages after harvesting corn silage, can stretch to several days or weeks depending on available labor, equipment, and weather conditions. Preparing new seed beds for planting subsequent crops can make it even harder to plant at optimal times. As we have shown above, planting delays can significantly affect winter forage productivity.

No-till or strip-till seedings can facilitate more timely plantings. While no-till and strip-tillage are not commonly used by most irrigated producers, they are used by a few. There is typically little residue associated with planting winter forage into harvested silage corn, or corn into winter forage stubble. However, using conven-

tional double disk openers for planting corn into the short winter forage stubble can be problematic without some tillage to soften the ground and uproot the live crowns.

Even where corn is successfully established with no-till plantings following triticale removal, triticale regrowth in the corn row especially was problematic and appreciably reduced corn vigor. Regrowth of wheat and barley was not as much of a problem for corn as with triticale. Using herbicides to control triticale regrowth may be possible, but those applications depending on leaf interception can be problematic, since there is little leaf surface immediately after the winter forage harvest.

Strip tillage is therefore recommended over no-till, because it reduces the competition from triticale regrowth.

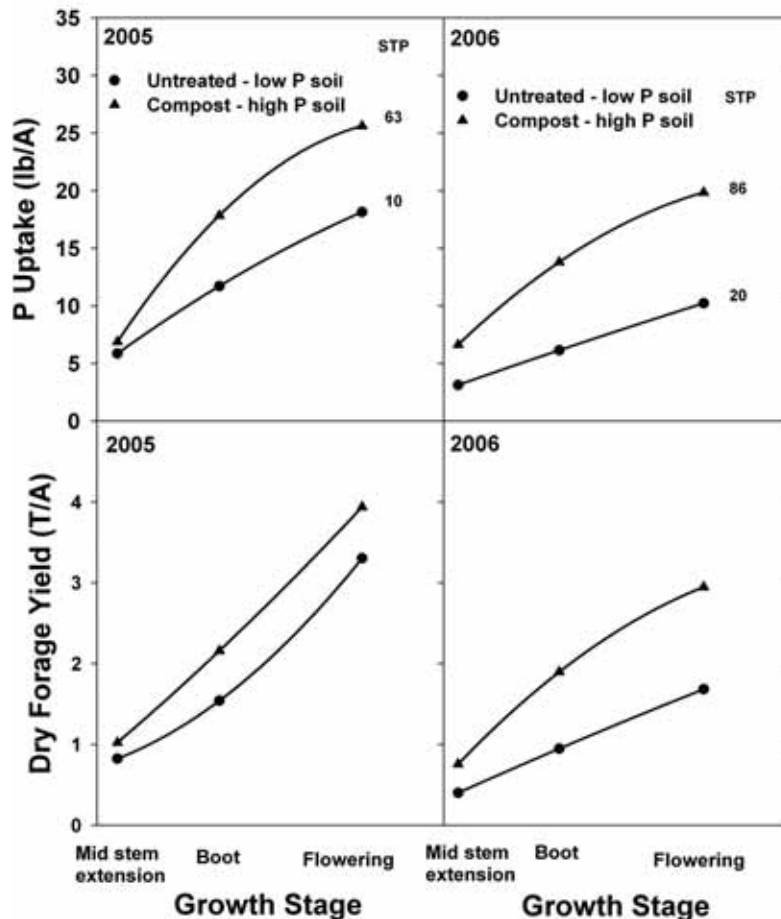
GROWTH STAGE AND P UPTAKE

Generally, deciding when to harvest the winter forage is dictated by the onset of the corn growing season. Regardless of the growth stage of the winter forage, producers are apt to sacrifice winter forage production and P removal in favor of a more timely and productive corn planting.

Triticale P uptake is most rapid from mid-stem extension to flowering. Uptake of P from compost and non-compost treated soil at Parma was measured in 2005 and 2006 in fall-planted triticale (figure 14). In compost treated soil, triticale P uptake increased 7 lb P/A over 7 days in 2006 and 11 lb P/A over 10 days in 2005 for an average daily P uptake of 1 lb P per day from mid-stem extension to the boot stage. From the boot stage to flowering, daily P uptake slowed to about 60% of the earlier rate. The daily uptake of P was about 50% less for the untreated low P soil. Uptake of P was greatest each year from the compost treated soil due to much higher available soil P. For soils with soil test P well above the 40 ppm threshold, the higher P uptake rate can be expected.

The dry forage increase from mid-stem extension to flowering in the compost treated soil was 2.92 tons/A over 24 days in 2005 and 2.19 tons/A over 17 days in 2006 for an average daily increase of 0.125 tons/day. 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 14. Cumulative P uptake and dry matter produced at different growth stages



ADDITIONAL RESOURCES FROM UNIVERSITY OF IDAHO EXTENSION:

Mitigating High-Phosphorus Soils:
<http://info.ag.uidaho.edu/pdf/BUL/BUL0851.pdf>

Dairy Manure Field Applications: How Much is Too Much?
<http://info.ag.uidaho.edu/pdf/CIS/CIS1156.pdf>

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