Nutrient Management Newsletter for the Western U.S.

Nutrient Digest

VOLUME 7, ISSUE 3 | *A publication of the WERA-103 Committee** | FALL, 2015

EFFECTS OF COVER CROP TERMINATION TIMING, SPECIES, AND MIXTURES ON YIELD, PROTEIN, ECONOMIC RETURN AND SOIL QUALITY

By Clain Jones and Perry Miller, Montana State University

There is increasing interest in the use of legume green manures (LGMs) and cover crop mixtures (CCMs) to replace fallow in the semi-arid western U.S., yet there is little documentation of clear benefits from their use, especially in no-till systems.

This article summarizes results from three Montana studies evaluating LGM and CCM residues in wheat production systems, with a focus on subsequent grain yield, protein, net revenue, and soil quality in both tilled and non-tilled cropping systems.

Short Term Trials (Studies 1&2)

Grain yields over three years were not different between LGM (pea or lentil) and fallow treatments in no-till in Study 1 (Burgess et al., 2014). Grain protein following a pea green manure crop (GM) was higher than after fallow at all N rates and in all tillage systems, yet grain protein following a lentil GM crop was not different than after fallow.

The different responses between pea and lentil can be attributed to higher N fixation by pea than lentil (McCauley et al., 2012).

In Study 2 (on CCMs), good moisture in 2013 yielded high cover crop biomass (~1 – 2 ton/acre) at both study sites (Dutton and Bozeman). Cover crop biomass was about the same regardless of the species mix.

Spring wheat grain yield was higher following fallow conditions than following any of the ten cover

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IN-SEASON APPLICATIONS OF N FERTILIZER IMPROVE THE YIELD AND PROTEIN CONTENT OF IRRIGATED HARD SPRING WHEATS

By Mark Lundy, Steve Orloff, Steven Wright and Robert Hutmacher, University of California-Cooperative Extension

Nitrogen (N) management is a key management practice impacting the productivity and profitability of hard spring wheat. Wheat growers are paid not only for a crop's yield, but also for its protein content--factors that are often inversely related and influenced by the rate and application timing of N fertilizer. High rates of pre-season N fertilization are normally attractive to growers due to the reduced cost of the pre-season forms of N and the ease of application.

However, applying high rates of N pre-plant can result in reduced grain protein content because average root-zone N levels and plant N uptake may have declined once the crop reaches the grain filling stage, which is a critical time in determining grain protein.

Additionally, very high early rates of N fertilization may cause excessive vegetative growth and lodging as well as increase N losses to the environment through pathways such as nitrate leaching.

For these reasons, over the past several seasons we have evaluated how the timing

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crops at Dutton **(Figure 1).** Grain yield was higher after the pea and N-fixing treatments than after the full eight species mix when averaged across the three N treatments.

Protein was higher (more than 1 percentage point) after pea and N-fixing treatments than any of the other CCMs when no N was applied. Soil quality parameters (e.g., soil penetration resistance, potentially mineralizable N (PMN), temperature, soil enzyme activity, Olsen P, etc.) were not different between pea and the full mix after one cycle, but will be measured again after two cycles. In the companion field study, grain yields following CCMs were up to ~15 bu/acre lower than following fallow, likely because of high water and N use by late terminated cover crops (often approaching seed set).

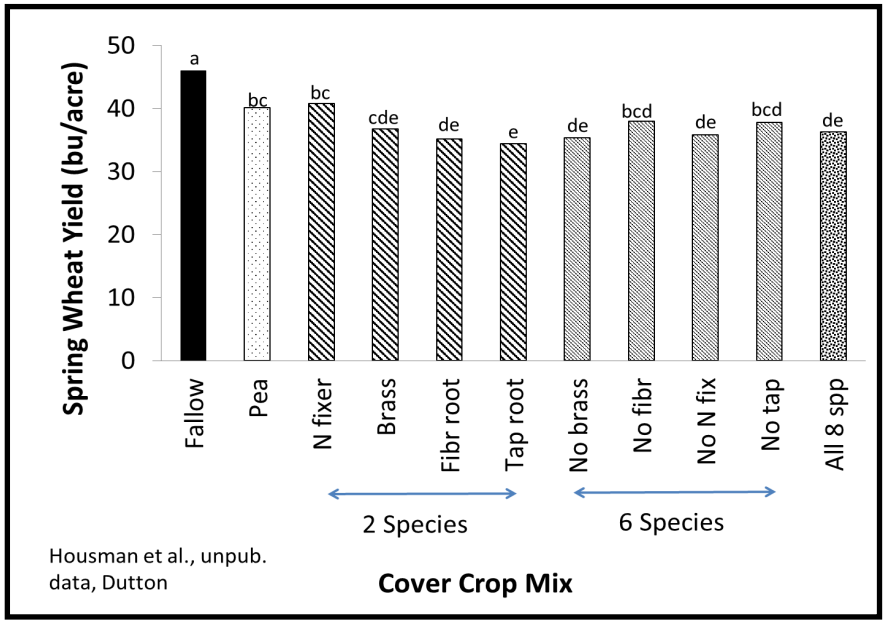

Figure 1. Spring wheat grain yield at Dutton, MT in 2014, averaged across three N rates (0, 60, and 120 lb N/acre) following ten cover crop treatments and a fallow control. Brass-brassica; Fibr- Fibrous rooted. All 8 spp = full mix. If no letters are the same above two bars, then there is more than a 95% chance that the yields are different between those two means.

Long-term trial (Study 3)

In the first three cycles of no-till LGM-wheat at Bozeman (annual precipitation ~16"), wheat yield was the same between wheat grown after LGM or fallow. However, after four LGM cycles, grain yield at the full N rate was 5 bu/acre higher following LGM than following fallow, and was 16 bu/acre higher following LGM than fallow at the ½ N rate **(Figure 2)**.

Most notably, grain yield was the same following LGM with the ½ N rate (only 5 lb N/ac applied) as following fallow that received 129 lb N/acre. Moist conditions in 2010 were apparently ideal for substantial N release from decomposition of accumulated legume residue. In fact, PMN in April 2010 was 50% higher in the LGM system than the fallow system (O'Dea et al., 2015). From 2009 to 2012, average economic return was similar between fallow-wheat and LGM-wheat at both N rates for both flat and steep protein

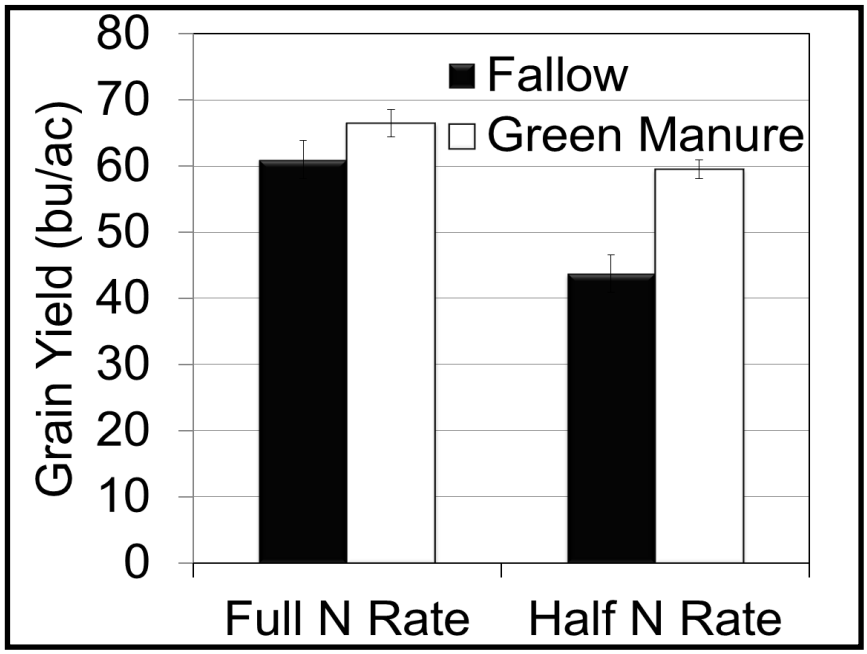

Figure 2. No-till spring wheat grain yield in 2010 following fallow or pea green manure after four cycles for full and ½ available N rates, Bozeman, MT, Study 3.

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FALL-PLANTED COVER CROPS: POTENTIAL AS LIVESTOCK FEED AND SOIL NUTRIENT SOURCE

By Lauren Hunter and Steve Hines, University of Idaho Extension

Cover crops are traditionally used as a soil-amending tool, but can also be viewed as a temporary pasture with a source of high-quality feed. Dual-purpose cover crops are utilized by producers wanting to achieve an economic advantage by grazing cover crops before using plant residue for soil improvement. Integrating cover crops into a crop and livestock system can be economically advantageous and biologically efficient. Properly managed livestock in a cropping system provides a good source of organic nutrients and an efficient nutrient cycling system. A grazed cover crop field provides soil nutrients from both the cover crops and livestock manure, keeping photosynthetic energy in the field. The grazing activity helps to break down and mix plant matter through ruminant and hoof action, speeding up decomposition.

Planting winter-hardy cover crops as a forage crop is advantageous for extending the grazing season in the fall and leaving residual re-growth for additional spring grazing or for soil residue. The advantage of selecting winter-hardy cover crops over winter-kill annuals, is additional forage potential in the spring and in some cases, more soil building material through higher yields. Winter-kill crops, like canola, can provide biomass over the fall months while the winter hardy crops are establishing. The most economical way to utilize a blend of winter hardy and winter kill cover crops is to plant following an early summer harvest, and graze in the

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Effects of cover crop termination, Continued from pg 2

discounts (Miller et al., 2015). Perhaps more importantly, the range in 4-yr net returns were much narrower for the LGM-wheat system ($378 - $441/acre) than for the fallow-wheat system ($303 – $477/acre), suggesting LGMs can reduce uncertainty about economic returns without reducing the expected value of those returns.

Management implications

In dry regions of the western U.S., cover crops need to be terminated early (e.g., by first pea bloom) to avoid large yield losses of the following crop, and the cover crop should contain at least 50% legume to enhance subsequent wheat grain protein. At least three cycles of cover crops are needed before they provide economic benefits. Finally, although diverse cover crop mixtures may have some benefits to pollinators or reduced risk of crop failure, they do not appear to increase yield, protein, or soil quality compared to pea in the short term.

Acknowledgments

Study 1 was funded by USDA-NIFA-AFRI and the Montana Fertilizer Advisory Committee. Study 2 was funded by a USDA-WSARE research and education grant. Study 3 was supported by the Montana Wheat and Barley Committee and Montana Fertilizer Advisory Committee. This work would not have been possible without the hard work of Anton Bekkerman, Macdonald Burgess, Jeff Holmes, Meg Housman, Justin O'Dea, Susan Tallman, and Cathy Zabinski.

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of N applications affect the yield and protein content of hard red and white spring wheats grown in diverse California environments. In experiments in the Intermountain Region and the Sacramento Valley we applied N fertilizer in different proportions at four stages of the crop cycle: pre-plant; tillering; late boot/early heading; and at flowering. For a given rate of N application, some treatments received all the N fertilizer pre-plant, whereas others received none until tillering, and still others received a portion at each of 2 or 3 crop growth stages. Urea was the fertilizer used and, for in-season applications, it was broadcast just before rain or irrigation events both to ensure that the N was available in the crop root zone and that volatilization losses were minimized. We compared the grain yield and protein content of the various N rate and timing treatments. We found that crops receiving pre-plant fertilizer application used N less efficiently than crops that received N applications at tillering and later. The reason is that, prior to tillering, the crop has relatively little demand for N. Then, between mid-tillering and the boot stage, the daily demand for N by the crop nearly triples, and this high rate of N demand continues through the flowering stage. Crop biomass is increasing rapidly during this period and grain formation is also occurring.

As a result, N fertilizer applied at tillering and beyond, accompanied by enough water to move it into the root zone and stimulate crop growth and N uptake, results in higher yields and higher grain protein content.

Figure 1 depicts the percentage of the applied N converted into grain as a function of N application timing. This was determined by calculating the difference between the grain N content in the unfertilized versus fertilized plots, expressed as a percentage of the total fertilizer N applied. The highest percentages of N fertilizer recovery by the crop occurred for applications at tillering and at flowering. Although N applied at the late boot/early heading stage was less efficiently used by the crop than N applied at tillering and flowering, applications at this stage were still more effectively recovered by the crop than pre-plant applications of N.

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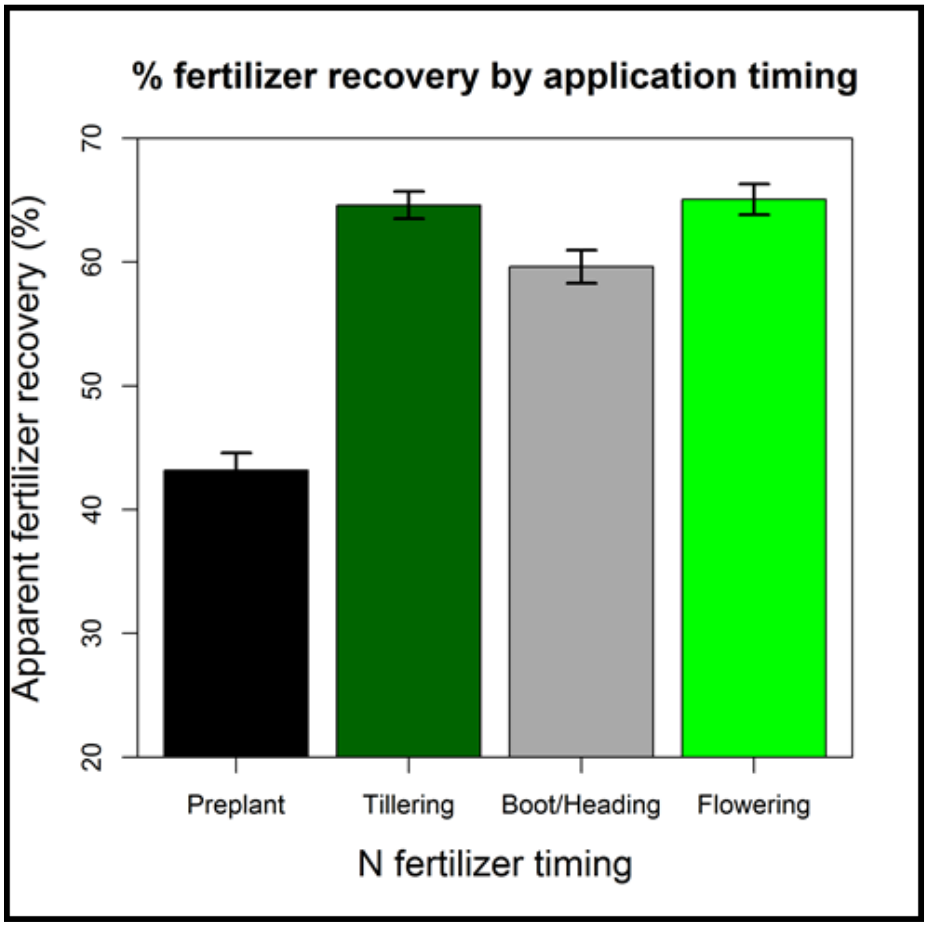

Figure 1. Percentage of N fertilizer recovered in the grain as a function of timing of N application. Data represent averages across experimental sites in the Sacramento Valley and Intermountain Region of California during the 2013-14 season. Patwin, a hard white wheat, was grown at the Sacramento Valley site, which was flood irrigated twice during the growing season. Yecora Rojo, a hard red wheat, was grown at the Intermountain Region site, which was sprinkler irrigated throughout the season.

In-season N and spring wheat, Continued from page 4

Figure 2 shows plants at mid-tillering in two of the experimental treatments at the Intermountain Region site in 2014. Treatment A received all of the N fertilizer as pre-plant application. Treatment B received no N until the day this photo was taken, when it received 80% of its seasonal N; the remaining 20% was applied at flowering. Treatment B yielded 16% more grain than Treatment A and had more than 1 percentage point higher protein, despite its relative N deficiency at the tillering stage of growth.

In the end, because so much more of the N uptake occurred after this stage of growth, the tillering-flowering applications better matched the overall timing of N demand by the crop and allowed it to stage a "come from behind" victory relative to the crop that received all of its N pre-plant.

We should note that the seeding rate used in our experiment was relatively high (120 lb acre^{-1}). In a situation where seeding rates or plant populations were low and tillering was limited by N deficiency, these results might have been different. In addition, although waiting until tillering to apply N resulted in higher yield and protein content, it may not be wise for growers to completely forgo a pre-plant application.

A small pre-plant application may be beneficial to prolong the window when N can be applied and provide a "cushion" in case weather conditions do not permit an application right at tillering.

The key point is that producers should consider applying more N in-season and less pre-plant to improve yield and protein content. For more information, contact Mark Lundy at melundy@ucanr.edu.

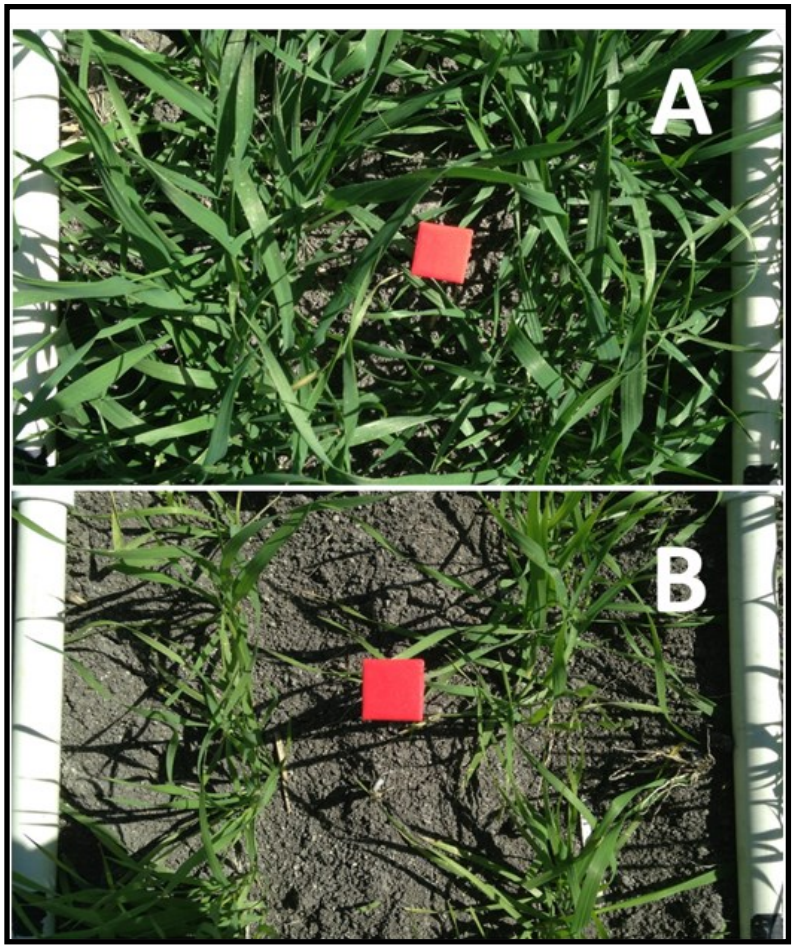

Figure 2. Comparison of Yecora Rojo growth at mid-tillering (5/22/14; 36 DAP) at the Intermountain Region site; 100% of seasonal N application pre-plant (A), and no N application until tillering

Fall-planted cover crops, Continued from pg 3

fall and spring. Winter hardy cover crops can also be planted as a full-season forage crop. A full-season temporary pasture of winter-hardy cover crops is most economically used to graze multiple times in the summer and fall, leaving residual regrowth for spring.

The cover crop mix selected by producers plays a role in livestock average daily gain or preference as well as soil nutrient benefits. Producers in the west commonly select cover crop mixes comprised of grasses/grains, legumes, and canola. The obvious dual-purpose cover crops are legumes, which fix atmospheric nitrogen, and accumulate nitrogen as protein in the above ground forage. Canola and other brassica species have long taproots and/or horizontal roots that scavenge nutrients deep in the soil profile, primarily nitrogen and phosphorus, preventing nutrients from leaching below the plant root zone. In order to accommodate higher average daily gains, timing of grazing and plant selection is an important component for managing dual-purpose cover crops.

University of Idaho Extension Research: Using a Western Sustainable Agriculture Research & Education and an NRCS Critical Issues grant, University of Idaho (UI) Extension tested the suitability of fall planted cover crop species for high-desert farming systems. Researchers evaluated yield and forage quality during the fall. A demonstration-grazing period on cover crop plots provided qualitative data on livestock preference.

Dual-Purpose Cover Crop Yield and Forage Quality Results: Forage production in the fall with seven weeks of growth following grain harvest was the highest for hairy vetch/triticale followed by triticale, Austrian win-

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A canola, triticale, and legume fall mix. The canola and triticale will grow rapidly in the fall, often out competing any perennial legumes in the mix. If more legume growth is desired, reduce the seeding rate of brassicas and cereals.

ter pea/triticale, and a canola/triticale mix (**Figure 1**). Relative feed value (RFV) is a comparison of forage quality to that of full bloom alfalfa (rated as a value of 100); a RFV above 100 is higher quality than a RVF below 100. For comparisons, good quality Idaho alfalfa hay has a RFV of 170 or higher. After seven weeks of fall growth the highest cover crop RFVs were Austrian winter pea (197), hairy vetch (195), and canola/triticale (183; **Figure 2**).

The RVF is slightly lower for the legume/cereal blends compared to the 100% legumes, but the advantages of the blends are reduced seed cost and increased forage biomass. Overall, the source of feed with 68 days of fall growth provided an economical source of high quality feed during a time, typically associated with fallow fields. Contact Lauren Hunter at lhunter@uidaho.edu for more information.

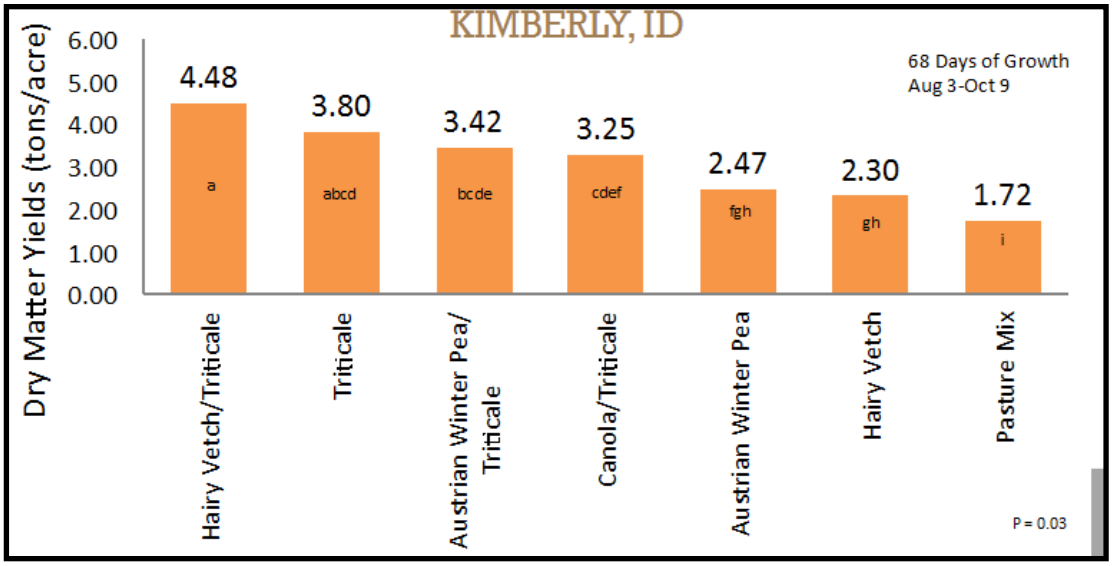

Figure 1. Biomass dry matter yield for replicated cover crop species trial in Kimberly, Idaho. Biomass yields were collected on Oct. 9th, 2012. Planting date- Aug. 3rd, 2012.

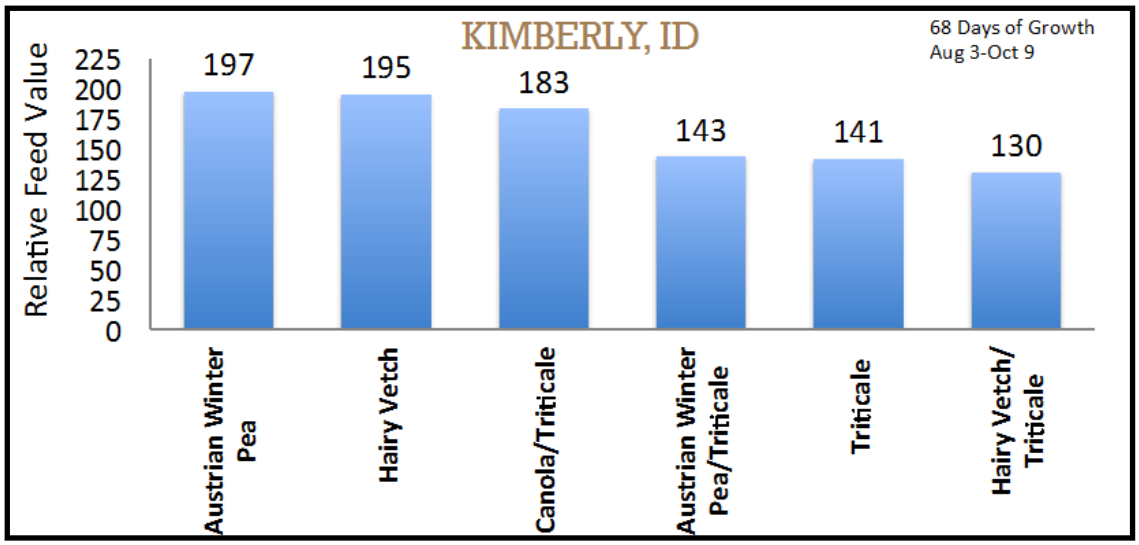

Figure 2. Relative Feed Value (RFV) for replicated cover crop species trial in Kimberly, Idaho. RFV information was collected on October 9th, 2012. Planting date - August 3rd, 2012.