identifying grain lots suitable for specific markets based on protein content level. This study will provide insights into the potential for providing customers with hard white wheat that suits their specific quality needs by creating grain lots with the ideal combination of starch type, protein content, and protein quality for their targeted end product.

Converting Barley from a Low to a High Energy Feed

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Indeed supplementation with enzymes is now the rule, if barley is used as animal feed. Enzyme solutions are produced in fermenters, transferred to mixers with starch carrier material in the form of barley or wheat flour in order to stabilize the enzyme. After mixing, the material is dried in warm air and the pellets milled, homogenised and packaged for shipping. But barley acreage continues to decline because low-priced GMO corn with higher nutritional quality remains a strong competitor of barley even in areas where grain corn cannot mature.

Low nutritional value of barley is due to the absence in birds of an intestinal enzyme for efficient depolymerization of (1,3-1,4)-β-glucan, the major carbohydrate of the endosperm cell walls. It leads to high viscosity in the intestine, limited nutrient uptake, decreased growth rate, and unhygienic sticky droppings adhering to chickens and floors of the production cages. We have performed broiler chicken trials to investigate, if transgenic grain containing a protein-engineered thermostable (1,3-1,4)-β-glucanase in the endosperm can increase the nutritive value of barley-based diets to that of maize. Equal weight gain, feed consumption and feed efficiency was obtained. The frequency of chicks with sticky droppings was reduced to the level observed with maize diet. A barley-soybean diet containing 620g non-transgenic barley/kg needs only 0.2g (0.02%) transgenic grain/kg to achieve the high nutritive value, while commercial Avizyme 1100@ is added at a concentration of 1g/kg diet. The addition of transgenic grain compares to the amount of trace minerals added to standard diets. The transgene has been bred into modern barley varieties, providing a yield that compares favorably with that of Baronesse. The lines produce constant amounts of enzyme.

Small amounts of transgenic grain containing (1,3-1,4)-β-glucanase as feed additive can boost the production of non-transgenic barley in areas where grain maize cannot mature. Feeding 40 million broiler chicks in Washington with barley instead of imported maize will require 280 000 ton of **non-transgenic** barley but only 56 ton of transgenic barley, which could be produced on 25 acres of farmland. The barley feed with added transgenic grain provides an environmentally friendly alternative to enzyme additives, as it uses the sun for its production and thus avoids use of non-renewable energy for fermentations.

Part 4. Agronomics, Alternate Crops and Systems

Evaluating Chemical Fallow Systems for Weed Control Efficacy

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Research was conducted near Lind and Pullman, WA in the low and high rainfall production zones, respectively, to determine the efficacy of various herbicides in a chemical fallow system. Predominant species at Lind and Pullman were Russian thistle and mayweed chamomile, respectively. Weed density and biomass were measure on July 15 and August 4 at the same respective locations. At Lind, broadleaf weed populations and biomass tended to be greatest with glyphosate regardless of number or timing of applications. The lowest weed density and biomass were with 0.064 lbs. isoxaflutole plus 0.141 lbs. sulfentrazone/acre applied March 10 followed by 0.375 lbs glyphosate/acre applied April 12. Isoxaflutole plus sulfentrazone reduced broadleaf density and biomass 97 and 91%, respectively, greater than glyphosate applications. Treatments with weed density or biomass that not greater than isoxaflutole plus sulfentrazone included 0.188 and 0.141 lbs sulfentrazone/acre, 0.064 lbs flumioxazin/acre, 0.080 lbs isoxaflutole/acre, and 0.064 lbs flumioxazin plus 0.141 lbs sulfentrazone/acre. None of the treatments containing dicamba, metribuzin, or paraquat plus diuron differed from glyphosate treatments for weed density or biomass. At Pullman, greatest weed density and biomass tended to be with glyphosate only treatments applied April 28 or earlier. However, an additional glyphosate application made June 22 reduced plant density and biomass 97 and 100%, respectively, than earlier glyphosate applications. Tankmix combination of 0.064 lbs flumioxazin plus 0.141 lbs sulfentrazone/acre and 0.064 lbs isoxaflutole plus 0.141 lbs sulfentrazone/acre and sequential applications of 0.5 lbs paraquat plus 0.25 lbs diuron/acre also reduced weed density and biomass 90% or better compared to early applied glyphosate. The efficacy of treatments varied between locations due to different weed species. While glyphosate remains a critical component of chemical fallow systems, it is possible to achieve good weed control with fewer glyphosate applications when combined with residual herbicides.

Mechanical Weed Management in Conservation Tillage Systems

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Soils in much of the Pacific Northwest are highly prone to wind and water erosion under conventional farming practices. Conservation tillage systems help mitigate these effects but tend to favor the development of certain soil-borne fungal pathogens (i.e. *Rhizoctonia* spp., *Pythium* spp., and *Fusarium*) and depend on herbicides for weed control, leading to the development of herbicide resistant weed populations. This project is evaluating a Phoenix® rotary harrow prototype and a high-residue rotary hoe for mechanical weed control in conservation tillage wheat and pea production systems. We hypothesize that a pre-plant rotary harrow operation coupled with multiple rotary hoe operations will provide non-selective control of weeds, reduce soil-borne diseases, and help deplete soil weed seed bank populations. In addition, the rotary harrow and hoe provide minimal soil disturbance within the top 2 inches of soil while leaving a majority of the crop residues on the soil surface to protect against erosion. Preliminary data suggest that problem weeds, such as prickly lettuce and wild oat, can be controlled in wheat by this integrated mechanical approach without causing reductions in crop stands. Mechanical management of these weeds in spring peas appears to be more problematic.

Determining Best Crop Rotation for Effective Jointed Goatgrass Control Using Imidazolinone Resistant Wheat

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Researchers collected data during the fourth year of a long term study in eastern Washington to determine the frequency and time to use a herbicide-resistant winter wheat crop to manage jointed goatgrass (*Aegilops cylindrica*). Research activities continued at two locations: a) 18-22 inch (high) rainfall zone with a winter wheat/spring cereal/grain legume rotation, located near Pullman, WA, and b) 9-11 inch (low) rainfall zone with a winter wheat/summer fallow rotation, located near Pasco, WA. At Pullman, imidazolinone-resistant winter wheat (ClearFirst®) planted in the fall of 2003 was treated in April 2004 with imazamox herbicide at the rate of 6 oz/A imidazolinone + 2.5% UAN (v/v) + 0.25% surfactant (v/v). Control of jointed goatgrass in imidazolinone-resistant winter wheat plots was nearly 100%. The conventional winter wheat at Pullman averaged 420 spikelets yd^{-2} of jointed goatgrass and was treated with a tank mix of herbicides for broad-spectrum weed control. Average yields (clean grain) at Pullman were 106 bu/A for the imidazolinone-resistant winter wheat and 113 bu/A for the conventional winter wheat. At the Pasco north site, imidazolinone-resistant winter wheat (ORCF101) planted in the fall of 2003 was treated in March 2004 with imazamox herbicide at a rate of 5 oz/A + 2.5% Sol 32 (v/v) + 0.25% surfactant (v/v). Control of jointed goatgrass was good, with imidazolinone-resistant winter wheat plots averaging 68 spikelets yd^{-2}, compared to 1286 spikelets yd^{-2} in conventional winter wheat plots. Average crop yields (clean grain) were 50 bu/A for the imidazolinone-resistant winter wheat and 67 bu/A for the conventional winter wheat. The Pasco south site was fallow in the 2004 growing season and was seeded with Clearfield® (ID587) and Stephens winter wheat in September 2004.