



PRODUCTION

CLEARFIELD* Wheat

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Quick Facts...

CLEARFIELD* is a production system comprised of an herbicide-tolerant wheat variety (Above or AP502 CL) and Beyond™ herbicide to manage problematic weed species.

The CLEARFIELD* wheat varieties are not genetically modified organisms or GMOs because no foreign DNA was inserted into CLEARFIELD* wheat varieties during their development.

The biggest threat to prolonging the life of CLEARFIELD* technology is development of herbicide-resistant weed biotypes.

Winter wheat is a winter annual grass which ranks in the top three Colorado crops contributing to the state's economy. It is planted and emerges in the fall; overwinters as a small plant; grows fast and develops tillers in the spring; and is harvested in July. Winter annual grass weeds (jointed goatgrass, feral rye, and brome grass) with the same growth cycle as winter wheat have been difficult to control in conventional wheat-fallow rotations. These weeds annually account for millions of dollars of lost wheat production and reduced quality – dockage. There has been moderate success in controlling winter annual grasses in wheat by utilizing three-year crop rotations (wheat-spring crop-fallow) with chemical control of weeds before and after the wheat crop. However, before CLEARFIELD* wheat, there was no herbicide that could effectively control jointed goatgrass or feral rye in winter wheat.

CLEARFIELD* is a unique production system comprised of herbicide-tolerant wheat varieties; Beyond™ herbicide to manage problematic weed species; and a stewardship agreement with growers that ensures the use of best management practices for system sustainability. The first publicly-developed CLEARFIELD* winter wheat varieties to be released in the United States, 'Above' (from Colorado State University) and 'AP502 CL' (marketed by AgriPro Seeds) are tolerant to Beyond™ herbicide for use in the CLEARFIELD* wheat production system.

How was the CLEARFIELD* wheat system developed?

BASF Corporation developed CLEARFIELD* crop systems for corn, rice, canola, and sunflower. In the late 1980s, BASF scientists used a chemical mutagen for wheat to induce a mutation using the French wheat cultivar, 'Fidel', and found an herbicide-tolerant plant. Herbicide-tolerant Fidel was not commercially acceptable in the U.S. so BASF (then American Cyanamid) cooperated with breeders from the Texas Agricultural Experiment Station to incorporate the herbicide tolerance into a commercially acceptable line. Crosses to transfer the herbicide tolerance to adapted wheat varieties were completed at Texas A&M University in 1996. Populations segregating for herbicide tolerance and other traits were obtained by Colorado State University from BASF under a research agreement in 1997. After rigorous testing, two experimental breeding lines were selected for release to seed producers in 2001: Above and AP502 CL. At the same time these varieties were being selected and released, weed scientists at Colorado State were studying how to best use Beyond™ under Colorado conditions.

The CLEARFIELD* wheat varieties Above and AP502 CL

Above is an awned, white-chaffed, early maturing, semidwarf hard red winter wheat originating from the cross 'TAM 110'*4/FS2 made in 1996 at Amarillo, TX. In 2000 and 2001 trials, Above yielded more than Akron, TAM

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CLEARFIELD* Wheat Resources on the World Wide Web:

- <http://www.clearfieldssystem.com>, BASF Corporation Web site developed solely for CLEARFIELD* crop production systems.
- <http://jgg.unl.edu/index.htm>, Web site for the National Jointed Goatgrass Initiative covering JGG biology, distribution, control, and genetics.
- <http://wheat.colostate.edu/variety.html>, Colorado State's Wheat Breeding Program Web site that describes new varieties, including the full description of Above.

107, and TAM 110. Average test weight for Above in these trials was less than TAM 107, but more than TAM 110. Above matures 3.5 days earlier than Akron and about 1.5 days later than TAM 107. Above is short, similar to TAM 107, and has similarly good straw strength. Above is resistant to stem rust, susceptible to leaf rust, and moderately susceptible to both wheat streak mosaic virus and barley yellow dwarf virus. Above is resistant to greenbug, and susceptible to the Great Plains biotype of Hessian fly and Russian wheat aphid.

AP502 CL is an awned, red-chaffed, early maturing, semidwarf hard red winter wheat originating from the cross TXGH12588-26*4/FS2 made in 1996 at Amarillo, TX. TXGH12588-26 was an unreleased experimental line that was a sister selection to TAM 110. AP502 CL is very similar to Above in many respects, yet has shown lower average grain yield and test weight in Colorado variety trials. AgriPro Wheat intends to market AP502 CL in areas of the Great Plains where their distribution and marketing system is strongest.

Are the CLEARFIELD* wheat varieties genetically modified organisms (GMOs)?

No foreign, non-wheat, DNA was introduced or inserted into CLEARFIELD* wheat varieties at any time during the development. CLEARFIELD* wheat varieties are thus classified as "non-GMO" and are not subject to restrictions in either domestic or overseas markets. The induced mutagenesis process described above is a traditional plant breeding technique and has been used for several decades to create crop varieties (including wheat) that are grown on large acreages in the U.S. and around the world.

How does the herbicide system work in susceptible and tolerant plants?

By inhibiting the activity of the enzyme, acetolactate synthase (ALS), the first steps in the biosynthesis of the branched chain amino acids valine, leucine, and isoleucine are disrupted. In response to Beyond™ herbicide application, susceptible plants are deprived of these essential amino acids and eventually die. The ALS enzyme is unique to bacterial and plant species and is not found in the animal kingdom. Mutation gave rise to an altered form of the ALS enzyme that is not affected by the herbicide at normal application rates. Beyond™ herbicide received EPA Federal Registration for use in CLEARFIELD* wheat in December 2001.

What weed species does Beyond™ control?

Beyond™ is a broad-spectrum herbicide (grass and broadleaf weeds) that provides post-emergence and in-season residual weed control.

Grasses: jointed goatgrass (JGG), feral rye, *Bromus* species (downy brome, Japanese brome, cheat), Italian ryegrass, wild oats, and volunteer cereals. In field studies with Beyond™, feral rye is more difficult to control than JGG, indicating that a properly timed fall application at full rate is necessary to optimize feral rye control.

Winter annual broadleaf weeds: flix weed, henbit, chickweed, shepherdspurse, field pennycress, and other mustard species. Spring applications of Beyond™ will control or suppress summer annual broadleaf weeds such as common lambsquarters, pigweed, and wild buckwheat.

Who owns the CLEARFIELD* wheat varieties?

Under a three-party agreement among Colorado State University (CSU), the Colorado Seed Growers Association (CSGA), and the Colorado Wheat Research Foundation (CWRF), the ownership of Above was transferred by CSU to the CWRF. This release mechanism has been used for all Colorado State winter wheat varieties since 'Halt' was released in 1994. As with other CSU releases, an application for Plant Variety Protection under the Plant Variety

Protection Act (PVPA) was filed for Above to prevent unauthorized production and distribution of seed. The CWRF is responsible for PVPA enforcement and collecting royalties on the sale of certified seed. Royalties collected by the CWRF are transferred back to Colorado State to fund wheat breeding and other wheat-related research efforts. Ownership of AP502 CL was transferred to AgriPro Wheat by the CWRF. AP502 CL is protected under the PVPA in the same manner as Above is protected by the CWRF. The herbicide-tolerance gene in Above and AP502 CL is owned by BASF Corporation and protected by U.S. patents. BASF Corporation is charged with the responsibility of enforcing the patent and has launched a CLEARFIELD* stewardship program.

Public sector access to CLEARFIELD technology and future technologies from the private sector (BASF or others) that could have an equally important impact on Colorado wheat marketing or production depends on successful stewardship.*

CLEARFIELD* Stewardship

Stewardship of CLEARFIELD* technology is important to prolong its longevity for future generations of Colorado wheat producers. Sustaining the life of this technology is also in the public interest. The Colorado wheat crop is worth an estimated \$300 million annually. Loss of production due to winter annual grasses and dockage could account for 10 percent, or \$30 million dollars, in a single year.

The biggest threat to prolonging the life of CLEARFIELD* technology is developing herbicide-resistant weed biotypes. This could happen by either selecting for resistance among field weed populations or, in the case of jointed goatgrass (JGG), direct transfer of the resistance through natural outcrossing. Because wheat and JGG are genetically related, and the herbicide tolerance gene is found on a set of chromosomes common to both wheat and JGG, outcrossing from wheat to JGG can occur. While natural outcrossing of wheat and JGG has been observed at very low frequencies in the Pacific Northwest, it is not known to what extent it will occur in the Great Plains wheat varieties and environments. Unsuccessful stewardship might lead to the emergence of a wheat-JGG hybrid that (when backcrossed naturally to JGG) would give rise to a JGG population tolerant to Beyond™ and related herbicides.

Stewardship Requirements

- Growers **must purchase certified seed every year from a CLEARFIELD* seed retailer.** This means that saving seed to plant next year's crop will **not** be allowed (NO "brown-bagging" or "bin-running"). Seed increase fields (Foundation, Registered, and Certified) are grown following strict guidelines that ensure the fields are free of noxious weeds and "off-type" wheat. The use of registered or certified seed ensures proper herbicide tolerance to Beyond™ and prevents contamination from a non-CLEARFIELD* variety. The penalty for planting saved seed could be \$100/acre or more. Proof-of-purchase records for CLEARFIELD* wheat seed and Beyond™ herbicide must be provided to BASF prior to servicing of any claim.
- Growers who use Beyond™ herbicide agree to use it in accordance with the product label, including stated label rates and timing.

The stewardship requirements (to be enforced) and recommendations (common sense good stewardship practices) were developed to prolong the life of CLEARFIELD technology in the field. Colorado wheat producers need to study these carefully before signing CLEARFIELD* stewardship grower agreements with BASF prior to or at the time of seed purchase.*

Stewardship Recommendations

- 1) **Don't plant CLEARFIELD* wheat more than two out of four years.** Avoiding continuous use of CLEARFIELD* wheat on the same land greatly reduces the probability of selection of herbicide-tolerant weed biotypes. Spring crop rotations with corn, sorghum, sunflowers, or millet break the cycle of winter annual weeds and promote the use of alternate mode-of-action herbicides.
- 2) **Limit the reliance on ALS-inhibiting herbicides** and where applicable, use sequential or tankmix partner herbicides with multiple modes-of-action on target weed species.

*The UNIQUE CLEARFIELD SYMBOL and CLEARFIELD® are trademarks of BASF. ©2001 All Rights Reserved. Always read and follow label directions.

3) Properly manage weeds in wheat-fallow-wheat rotations. In the fallow year, control weeds (especially winter annuals) with burndown (non-ALS) herbicides or tillage before they set seed.

4) Specific Recommendations for Jointed Goatgrass: Treat the entire CLEARFIELD* wheat field with a labeled rate of Beyond™ herbicide. The labeled rate of Beyond™ will provide a high level of JGG control and reduce the chance of outcrossing. Control JGG in fencerows, road ditches, and pastures around CLEARFIELD* wheat fields before JGG seed set to further reduce the chance of outcrossing.

BASF's CLEARFIELD* Stewardship Grower Agreement

Wheat producers who desire planting CLEARFIELD* wheat varieties are required to sign an agreement with BASF stating they will adhere to the stewardship requirements. Signing this agreement is coordinated by the seed dealer at the point of sale. The wheat producer acknowledges that CLEARFIELD* wheat technologies are protected under U.S. patent law, CLEARFIELD* wheat varieties are PVPA protected, and crops grown from protected CLEARFIELD* varieties may only be sold in normal commercial channels for wheat and not saved or sold for use as seed. Seed producers will obtain the signed agreements and forward the seed purchase information to BASF who maintains a CLEARFIELD* wheat technology database. The database matches grower seed and herbicide purchases.

CLEARFIELD* Wheat Development

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What will be the label rate and cost of Beyond™?

The label rate will be 4 to 6 oz/acre and 4 oz will cost approximately \$15 to \$16/acre. Growers should check with their local ag chemical retailer for specific Beyond™ pricing. In the Central Plains, growers who purchase CLEARFIELD* certified seed and Beyond™ herbicide will be eligible for a certified seed bonus consisting of 200 Harvest Points (equivalent to \$2/acre).

Will spraying Beyond™ be mandatory?

No, but it will be highly recommended and a condition for qualifying for BASF's certified seed bonus.

What will Above seed cost?

Seed cost is not fixed for any varieties of certified seed so the cost of Above will depend on the demand for the seed plus a 1 cent/lb royalty as there is with all other CWRF varieties. A technology fee will not be levied on the price of Above seed by BASF.

Colorado seed growers who purchased foundation Above seed in fall 2001 for sale of registered or certified seed in fall 2002.

Grower	County	Phone Number
Gayle Anderson	Sedgwick	970-463-5735
Andrews Bros. Seed	Yuma	970-848-0709
Bill Brooks	Baca	719-523-4473
Edsel Collette	Yuma	970-362-4302
Cooksey Farms	Weld	303-849-5214
CSF Farms	Kit Carson	970-664-2281
Danny Dickinson	Logan	970-253-5005
Dry Creek Seed	Lincoln	719-763-2367
E & H Farms	Weskan, KS	785-943-5386
Kochis Farms	Elbert	719-775-2596
Allen Letterly	Weld	970-454-0989
Curtis Lewton	Adams	303-644-4327
Doug Melcher	Prowers	719-537-6214
Midcap Farms	Morgan	970-483-5566
Gerry Ohr	Washington	970-383-2326
Pachner Farms	Washington	970-345-2852
Plainsman Agri Search	Baca	719-324-5643
Kenneth Pottorff	Kit Carson	719-348-5213
Gary Rafert	Phillips	970-854-2607
Terry Ring	Logan	970-253-5009
Scherler Farms	Kiowa	719-729-3367
Leslie Smith	Logan	970-265-3991
Thunderbird L & L	Kiowa	800-289-1415
Randy Trupp	Adams	303-644-3416
Wagers Seeds	Washington	970-842-2022

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