Appendix 12: Background Information

Appendix 12 includes background information for the minority reports included in the document as well as additional proposed policies from members that were not considered by the majority. This section also includes documents provided by a member of CPAG in support of the majority opinion on genetically engineered crops. None of these documents have been edited or changed by Boulder County Parks and Open Space.

Appendix Index

Submitted by Richard Andrews and Ewell Culbertson, Cropland Policy Advisory Group members

27 October 2011.

<u>Recommended Cropland Policy – Definition of Sustainable Agriculture</u>

Sustainable agriculture is defined by a long term view and by farming practices that ensure that croplands can be farmed and crops produced in perpetuity without diminishing yield, quality of the crop, or health and resource of the soils, by continually regenerating soil quality in balance with what is removed in food and fiber.

Sustainable agriculture respects the natural environment, soil microbiological life, complex ecosystem services, and biodiversity. It must create neither on-site nor off-site negative impacts on the general and natural environment. Sustainable agriculture practitioners must be partners in the ecosystem, and must recognize with awe the complexity of life, and not seek to dominate but rather cooperate with nature and all the services it provides.

Sustainable agriculture, within the above noted fundamental characteristics and conditions, must also be conducted to provide a livable financial base for the farmer, and both serve and receive support from the local economy in which it operates.

Sustainable agriculture is characterized by a social culture that values the producers of foods, feeds and fibers, recognizing and rewarding agriculture as the most essential of all human activity.

Sustainable agriculture is defined by the production of safe and healthy foods, feeds for domestic animals and fibers, products free of toxins, maximized in nutritional quality.

<u>Rationale</u>-

In order to have a sound policy on sustainable agriculture, one must have a sound definition to know how to measure whether the goal is being achieved. The most important element of true sustainability is a very long term view, essentially perpetual. The opening sentence in the above proposed definition is the most important.

The methods and practices of sustainable agriculture simply cannot look only to the next crop profits if land quality and productivity is damaged in the process. There is simply too much at stake with respect to future food productivity to look only to a short time horizon.

Current economic theory if applied to agriculture will prove to be disastrous. It unfortunately discredits the long term value of all businesses and investments, including agriculture. Discounted cash flow analysis heavily discounts the value of the future. Such analyses do not include either the present value/cost or the future value/cost of impacts on our environment or the health costs to our population from toxin containing foods, from toxins released to our air and water, the reduced productivity of coastal waters contaminated by ag chemicals, the greenhouse gases released by reliance on fossil fuels and releases from ag wastes, the induced climate change, etc, etc.   These economic views distort reality and such economic models are simply not suitable to evaluate agricultural sustainablity.

Unfortunately many individuals and businesses use the word sustainability to mean perpetuating the status quo, doing what has been going on in recent and personally familiar time frames.

Soils and the water and climate are resources that are fundamental to agriculture.   Farming practices must build, not degrade or deplete soils to be sustainable. Farming practices must not put toxins into our soils, water and foods to be sustainable.   Sustainable agriculture must minimize its waste of resources that push the future to climate warming, with possible major consequences far beyond the borders of Boulder county, rising sea levels and permanent flooding of major croplands, disruption of crop productivity, enhanced pest and disease pressures, etc.

The production of foods is hands down the most important social activity of the human specie. Yet it is mostly an afterthought by most of the human population in the developed world.   To be sustainable, agriculture must recover a greater connection with the consumers of its essential products. The farmer must be properly rewarded for providing the life sustaining foods to the non-farming population.   Sustainable agriculture is dependent upon a better appreciation for and appropriate economic rewards to the farmer.

Overall sustainable agriculture is defined by the products it gives to society. Quality of those products is paramount, the true measure of and purpose of good agriculture. A key measure of sustainability is healthy and safe foods.

Submitted by Richard Andrews, Cropland Policy Advisory Group member, 26 October 2011

Recommended Cropland Policy on RD&D for Innovations in Sustainable Agriculture:

BCPOS shall make available appropriate lands from the croplands owned by the county for the purpose of conducting research, development and demonstration (RD&D) of innovative sustainable agricultural practices, including such things as evaluating new high value crops which can support and create local consumption or processing inputs to other local industries, perennial crops such as grains, fruits, vegetables, herbs and fibers, methods for reducing greenhouse gas emissions, methods to rejuvenate and build soil health and productivity, plant selection and animal husbandry by traditional non-GE methods, practices and methods to minimize nonrenewable energy in agriculture, long term comparative field trials of comparing different modes of crop production such as organic and mainstream methods, local non-GMO seed production, methods to better capture and utilize valuable plant nutrients, and other innovative concepts which can potentially benefit local economy, the local food supplies, and simultaneously protect and improve the environment, and the health and well being of Boulder County citizens.

All such RD&D shall be fully open for free access and application by everyone, no secrecy or licensing shall be allowed. Technologies may be freely used by the developers but without exclusivity. BCPOS will routinely disseminate the full results of all such RD&D conducted on its lands, shall hold annual reviews workshops or conferences, and use other appropriate means to release the knowledge gained. BCPOS shall be a repository of all such RD&D reports and shall make the reports readily available to all parties. Tenant farmers on BCPOS lands shall also be encouraged to host such RD&D on existing leased lands with the proviso that all such research shall be free and open and be submitted to BCPOS for dissemination.

BCPOS shall solicit proposals for such sustainable agriculture RD&D on an annual basis, or appropriate schedule based upon the available stock of land, with a goal of providing up to 5% of croplands for this purpose. Such lands shall be administered as a special lease for the purpose of RD&D and may include crop sharing or flat rentals as with other leases, or incentive leases to stimulate RD&D, or other methods found to be appropriate.

Rationale:

This proposed policy recommendation is designed to move Boulder County into the future as a leader in sustainable agricultural practices. It is designed to always be open to the innovation and entrepreneurial character that is so prevalent in Boulder County, but applied to the totally essential field of agriculture which must always remain vital for our very existence. It is designed to encourage experimentation, conducted with the objective of true sustainability for the very long term, not tied to practices that may be currently employed simply because they are familiar or historical.

There are institutions around the USA and world that are engaged in very innovative agriculture and it is proposed that Boulder County offer some of its croplands under this program to such innovators to broaden and test the applicability of their research in the climate and environment of our region. Such institutions may include (as examples):

- The Land Institute which is working diligently on selecting/developing perennial crops instead of annuals (notably grains) with the obvious benefits of reducing soil disruption and erosion, eliminating regular plantings, sequestering carbon, reducing annual inputs of external energy, and simultaneously building the soil health and resiliency.

- The Rodale Institute which has worked very successfully for years on enhancing the productivity of organic agriculture, demonstrating lower energy inputs, lower greenhouse gas emissions, higher farmer profits, and equivalent yields to “conventional” agriculture.

- And many others that may be cooperators such as: Leopold Institute, The Organic Center, local schools at secondary, vocational and community college educational levels, local industries with demands for unique or specialty crops, our local Colorado universities, etc.

This recommendation fits well with another proposal also offered, namely making BCPOS lands available for local crop seed production, specifically non-GMO and organic seed to support a transitioning away from corporate dominated seed and agricultural input monopolies. This can defuse the arguments often heard from mainstream farmers that non-GMO seed is simply not available.

This proposal can be an attractive model that other progressive counties around the country could emulate. It could attract significant R&D funding from the USDA and the Colorado Department of Agriculture through a multitude of programs, such as the CSU Specialty Crops Grower Research and Education Grants (GREG), or the USDA Sustainable Agriculture Research and Education grants (SARE).

Recommended Cropland Policy regarding Genetically Modified Organisms:

Submitted by Richard Andrews, Ewell Culbertson, Emily Prisco,

Cropland Policy Advisory Group members, 15 October 2011

<u>Policy Statement</u>:

1. ***No crops {or animals} grown on Boulder County Parks and Open Space (BCPOS) lands can be genetically modified as defined by the USDA. This requirement shall go into effect for the calendar year 2012. Prior approvals for genetically modified corn crops shall be rescinded, effective for crop year 2012.***

2. ***Boulder county shall establish goals and implementation programs for 10% of its croplands to be operated using organic production methods by 2015, 20% of its croplands to be operated using organic methods by 2020, and 50% of its croplands to be operated using organic production methods by the year 2025. Goals to transition to organic production shall be re-evaluated by BCPOS every five years to consider potential acceleration of transitioning to sustainable organic production.***

3. ***Boulder County Parks and Open Space shall declare all open space agriculture lands as non-GMO refuge areas. In order to provide tenant farmers with non-GMO options in their seed supplies, the BCPOS shall make available croplands for and encourage farming operations for the production of non-GMO seed, including such crops as sugar beets, corn, alfalfa, barley, wheat and other crops that are supply threatened by monopoly seed company practices. BCPOS shall establish and enforce genetic isolation measures to ensure the integrity of such non-GMO seed production activities, organic farming activities and its non-GMO refuge. GMO producers within insect pollinator, wind, water or other vector isolation buffers of open space lands shall be required to give prior notice to BCPOS and its tenant farmers, and shall take all necessary measure to prevent contamination of any non-GMO seed production and organic farming operations on BCPOS lands.***

<u>Rationale</u>:

<u>GMO Prohibition on Open Space</u>

The science behind the promotion and implementation of genetically modified organisms is deemed to be grossly inadequate despite the approvals granted by federal agencies. The complex ecosystem interactions, the soil health and plant nutritional implications, the food allergy and human health effects of GMO crops are insufficiently understood to warrant introduction into commercial agricultural operations. Given these inadequacies, the prudent course of action is precaution until the science can prove the safety of GMO crops to health and the environment. The direct and indirect effects of GMOs and associated introduced toxins are simply largely unknown. And what is being revealed by recent independent science has raised numerous warning flags. Unfortunately much of the evidence used to justify the USDA, FDA and EPA approvals of GMO crops and animals has been developed by the same companies promoting their sale. Even more disturbing, much of that evidence is never made public to allow third party independent review. Only in recent years has truly independent scientific research begun to be conducted and published in peer reviewed science journals. Much of that work has been conducted by academics and medical science professionals from countries other than the USA. It is a concern that corporate control of science in our otherwise respected academic institutions has limited and distorted open investigation. Even in the peer reviewed journals one must use great caution to seek out unbiased science.

In light of the more independent research which has reached scientific journals within the last several months, previously published reports and agency approvals of GMO crops and associated ag chemicals are often out of date. For example GMO technology overview documents from otherwise highly respected institutions such as the National Academy of Science/ National Research Council which was prepared between 2008 and 2009 and published as recently as 2010, are already dated and potentially inadequate, in light of very recent science (1). Similarly outdated is the FDA ruling of substantial equivalency between GMO foods and feeds and traditional ones. EPA rulings on approvals of pesticides, whether built into the tissues of a crop as with Bt or applied in concert with an HR crop like glyphosate, are simply not up to date with the science that has recently documented severe environmental and health concerns.

In this environment of rapidly evolving science, and given the contradictions or difference in conclusions about the science and public/environmental safety between earlier and more recent research, precaution in endorsing of GMOs is warranted. Should Boulder County decide to endorse GMO crops without sufficient knowledge of the consequences, it would be taking the path of risk and great uncertainty. Such a path is paved with potential legal liabilities of the County from future damages, not to mention potential for non-monetary liabilities in the form of damage to our environment, the very foundation for long term sustainability. The safe path is the path of proven organic production, proven over millennia, and rejection of GMOs, at least until high level of confidence in their safety can be proven.

Presently there are two predominant types of GMO food, feed and fiber crops that have been approved by federal agencies; those genetically engineered to be resistant to specific herbicides which are called herbicide resistant (HR) such as glyphosate tolerant crops, aka RoundUp Ready or RR; and those genetically engineered with bacterial genes to create toxins that translocate throughout the crop tissue to kill insects, e.g. bacillus thuringiensus (Bt) for insects, bacillus subtilis (Bs) for fungi, and other bacteria strains used for pest control.

There is a growing body of evidence that the benefits claimed by the developers and promoters of these GE crops are false, or misleading, or that the claims have become invalid over the years in which they have been used in agriculture. In some GMO cases a latency effect is being observed before negative impacts or even reversals of claimed benefits is being revealed. This has not been uncommon in the history of chemical based agriculture. It illustrates the inadequate knowledge, perhaps even the arrogance, of believing we understand the complexity of natural systems.

With respect to crops engineered to be resistant or tolerant to glyphosate or a similar herbicide, glufosinate, there is scientific evidence that these herbicides are not benign and either the applied chemicals or their metabolic breakdown products are persistent in the environment. This illustrates the issue that if science does not look for the right substances such as metabolic decay products or toxic adjuvants then conclusions about safety can be faulty. Similarly if the daisy chain of complex biochemical effects are not traced, one will not observe those distant sometimes very obscure relationships and connections. Refer to the policy recommendation document regarding glyphosate for a more complete discussion about chemicals that are intimately linked and used in association with the GMO seeds for these crops. One example is the recent discovery of glyphosate and its degradate, aminomethyl phosphonic acid (AMPA) in air (particulate and rain) samples throughout Mississippi and Iowa, a previously unsuspected and widespread general environmental dispersal of these toxins (2). Other research has shown that glyphosate, while generally described as having short persistence in soils due to binding with clays and due to metabolic degradation to AMPA, can in fact revert to unbound glyphosate when phosphorus fertilizers are applied to soils. This can potentially account for subsequent year negative effects on non-HR rotational crops and accumulation in soils. This is suspected to be a cause of the increasing prevalence of crop sudden death syndrome that has been recently occurring in Midwest soybean crops, and with Goss's wilt disease in corn. It must be understood that even HR GMO corn is not totally immune to damage from glyphosate, hence it is described as tolerant or resistant, not immune.

Claims are made that the overall use of pesticides will be reduced by the growing of GMO crops. However these claims are seriously disputed by statistics gathered by the USDA and other organizations (6). Arguments are made that if GMO crops are not allowed the alternative production methods will have to employ more toxic pesticides. Those arguments fail to acknowledge that non-pesticide methods of crop production, organic methods using up to date green manuring cover crops and rotations, or animal waste based fertilizers, are being proven in multi-decade comparative trials to simultaneously achieve equivalent or higher crops yields, greater organic yields in drought years, greater profitability to farmers, lower environmental impacts as measured by energy consumption and greenhouse gas releases, and safer more nutritious crops for animal feed and human foods. This is documented in just released thirty year side by side comparative trials with corn and soy crops grown with four different production methods: organic manure, organic legume, conventional synthetic fertilizers and pesticides, and each system divided into traditional tillage and no-till. GMO corn and soy was introduced into the system trials in 2008. (4)

Some of GMO crops that were introduced earlier have after more than a decade of use been found to exhibit declining yields or yield drag, some even experiencing total crop failures. Some GMO crops have resulted in the rapid evolution of super weeds that are tolerant of the companion pesticides, whether applied in concert with or engineered into the crop. These new weeds have forced abandonment of the GMO crops, for example GMO cotton. Health effects related to GMO and GMO related food and feed toxins are just now beginning to be observed, following a latency and in some cases simply not looking in the right place for effects in earlier science. (3)

A more detailed scientific white paper reviewing up to date peer reviewed published science about the health, ecosystem, and agricultural cropping aspects of GMOs is under preparation and will be provided as soon as possible as a supplement to this policy recommendation and summary rationale statement.

Sustainable Organic Transition Goals -

GMO crops are simply incompatible with county goals to transition to the more sustainable agricultural practices of organic and biodynamic cropping. Continuing to use GMO crops and the associated toxic pesticides will cause delays in transitioning to organic production. USDA National Organic Program rules require a three year minimum transition period for properties before certification can occur. In some views even this period is likely inadequate if very persistent chemicals have been used and applied to the land. USDA rules expressly prohibit the use of GMO crops and organisms in certified "organic" agriculture. Contaminated crops from either pesticide drift trespass or gene trespass from pollen transport simply cannot be used and labeled as "organic". Such trespass can is suspected to have occurred right here in Boulder County. The threat of genetic modified organism trespass is real and threatens the organic foods and feed industry, the fastest growing sector of agriculture.

The recommendation for creating GMO free refuge areas on all BCPOS lands is a step toward to accelerating the transition to organic production and protection of existing organic operations whether on or off open space lands.

The use of fossil fuel based agricultural chemicals is not a sustainable path in the long term. Organic agriculture is the preferred option for our future. It is inherently safer than agriculture that depends on applying toxins to our soils, leading to residues in our foods and feeds. Organic production methods are becoming more science based with each passing year. We are re-learning the benefits of feeding the soil with natural soil building materials, through cover crops and green manures, rather than simply repeatedly dosing with artificial chemicals. Conscientious animal husbandry, nutrient cycling, and integrated plant/crop agriculture creates and maintains balanced soil health and productive sustainable yields.

Establishing Open Space goals for organic transitioning is important to measure progress toward sustainability. The recommended goal of reaching 50% organic production on BCPOS lands by 2025 is entirely achievable. It could actually be achieved much quicker with appropriate establishment of relationships with organic markets in the immediate area, some already offered to current tenants. The county presently has approximately 640 acres of BCPOS croplands in organic production out of some 16,000 to 18,000 acres of cropland. This is a good start and well above the national percentage of less than 1%.   But it is understood that Boulder County and its citizenry want to be and should be leaders in sustainable agriculture.   A 50% goal is only an initial step and should be routinely reviewed for the possibility of achieving a higher level.   Others have suggested merely keeping pace with each annual organic acreage growth measure for the whole nation.   Boulder County should set its sights higher to be a real leader in sustainability.

__Open Space Croplands as non-GMO Refuge -- - Options for Sustainable Seed Sourcing and Security__

The concept of declaring all open space lands as GMO free refuge lands will make possible a more rapid transition to organic production goals.   It will provide greater assurance to organic producers that are near open space lands that their crops will not experience chemical or genetic trespass.

Another benefit of a GMO free refuge on open space lands is the potential to establish production of organic and non-GMO seed supplies. One of the frequent arguments given by mainstream tenant farmers in wanting to use GMO crops on open space is a concern or fear that they will not be able to obtain non-GMO seed for their crops such as corn, sugar beets and alfalfa.   This fear results from the growing centralization/monopolization of the seed companies in the USA, now consisting of only a handful of giant agrichem-biotech companies. They rule the markets. This situation is simply unhealthy for biodiversity and crop and food production security, and it is in violation of anti-trust laws which should protect farmers from unfair and uncompetitive business practices.

Boulder County can be a leader locally to begin to break these monopolistic practices while simultaneously promoting greater sustainability in local agriculture.   Boulder County Open space croplands can be used with appropriate isolation buffers for the production of locally grown non-GMO and organic seed.   It is recommended that BCPOS provide opportunities and encouragement for the establishment of local seed companies, perhaps even cooperatives set up by many of the local farmers and POS tenants.   This can be another great example of Boulder county leadership providing workable solution to the unhealthy situation in which today's agricultural community finds itself.   It is another path to sustainable agricultural practices.

__Recap__ -

Taking precautionary action now regarding GMOs rather than regretting future damages to health and the environment, is the prudent path for Boulder County.   Specifically Boulder County needs to protect its citizenry and the ecosystem inhabitants under its stewardship, such as our pollinators, birds, terrestrial invertebrates, and aquatic life, even we humans.   All are being exposed to genetically engineered organisms at a time when we human stewards lack a thorough and deep understanding of what the heath effects may be.   Until science can prove with high certainty that a particular GMO is absolutely safe, it must be banned from use. The alternative to business as usual agricultural cropping using unproven GMOs and associated toxins is a prompt transition to greater and greater use of organic farming methods. Finally, setting up mechanisms to confront aggressive corporate controlled agriculture systems to protect the genetic heritage of seeds and seed diversity is paramount to demonstrate progressive leadership for long term sustainability of Boulder County croplands.

References:

(1) National Research Council, The Impact of genetically engineered crops on farm sustainability in the United States, 2010, The National Academies Press, Washington, DC.

(2) Chang, Feng Chih, Simcik, M.F., Capel, P.D., 2011, Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere, Environ. Toxicol and Chem. , 30(3), 548-555.

(3) Michael McNeil, PhD, Ag Advisory Ltd, Algona, IA, August 2011, Presentation and panel-CPAG dialogue at Cropland Policy Advisory Group forum held in Longmont, Colorado, and in personal discussions at that event.

(4) The Farming System Trial (30 Years), August 2011, Rodale Institute, Kutztown, PA. (summary report available on line at www.rodaleinstitute.org and numerous detailed journal articles over the trial years)

(5) Antoniou, M.et al, June 2011, Roundup and birth defects: Is the public being kept in the dark?, Earth Open Source. (contains massive bibliographic citation listing on the subject)

(6) Benbrook, Charles, Nov 2009, Impacts of Genetically Engineered Crops on Pesticide Use: the first thirteen Years, The Organic Center (available online at www.organic-center.org)

Note: A much more in depth literature review on the subject of GMOs is under preparation, covering hundreds of peer reviewed journal articles, most dated within the last decade, many form 2010-2011. Subject areas will include human health effects, soil microbiological effects, plant/crop nutrition, non-target organism impacts, crop productivity/yields, etc.

TO: Jesse Rounds
Ron Stewart
David Bell
Will Toor
Ben Pearlman
Cindy Domenico

From: Famuer Rasmussen Jr. FAPC member
George Borcher FAPC member
Matt Pierce FAPC member
Richard P Miller FAPC member

Reference: Minority Report from BCFAPC members

We strongly support the Cropland Policy as written by CPAG and BCPOS as presented to us on 11/15/2011. We appreciate the work and expertise that produced this policy which succeeds in meeting the goals of BCPOS in protecting the vast resource of farm ground they own and manage while providing a reasonable operating framework for the farmers who partner with them to actively farm and manage BCPOS farms. This balanced environmentally friendly policy gives special consideration and assistance to organic farmers while benefitting from the economies of scale and management expertise offered by third and fourth generation farmers in Boulder County who produce more conventional crops. As a result, the land is farmed according to the highest standards of modern agriculture, and the results benefit farmers and BCPOS alike.

The BCPOS recommendations were months in the making and were considered by three advisory groups appointed by the commissioners: CPAG, BCFAPC and POSAC. These committees comprise a total of 27 members. **Of those 27 people, a majority (fourteen) of us stand unified in our support of the Cropland Policy as put forth by BCPOS on 11/15/2011.** The majority of CPAG members support it (6), which spent nine months researching, evaluating and crafting a policy in cooperation with BCPOS. We four members of FAPC support it and Jesse Rounds has email confirmation of such support from POSAC members Russell Hayes, Eric Hozempa, Paul Jurasin and Janice Moore.

We are dismayed by the ill-considered alternatives and last minute, cobbled together modifications to the BCPOS recommendations as expressed by some committee members and by the Citizens' Cropland Policy group. These modifications do not begin to rise to the level of the BCPOS document in terms of substance, balance, fairness and common sense. **The fourteen of us urge you to reject their alternatives and modifications and to support the 11/15/2011 Cropland Policy staff recommendation – by far the best way forward for all agriculture to co-exist and flourish on BCPOS croplands.**

In sum, we support the majority findings and opinion of the CPAG advisory group and the resulting BCPOS staff recommendation in its entirety. We voice the strongest opposition possible to the minority opinions of that committee, the Citizens' Cropland policy, and to the changes and modifications made by BCFAPC and POSAC.

We join together with the six members of CPAG and the four members of POSAC and with a unified majority voice (14 approve vs. 13 disapprove) we ask the Boulder County Commissioners to adopt the Staff recommended Cropland Policy as presented on 11/15/2011 resulting from the finding of the majority of the CPAG advisory group.

Sincerely,

Matt Pierce — Famuer Rasmussen Jr. — George Borcher — Richard Miller

Rounds, Jesse

From:	POSAC - Janice Moore
Sent:	Friday, November 25, 2011 6:48 PM
To:	Dick Miller
Cc:	Russell E. Hayes; Rounds, Jesse; Stewart, Ron
Subject:	Fwd: CPAG support

Dick,
This is the third of three emails from POSAC "minority" members, contacted individually; all of these folks (and I) support the original CPAG proposal.
Janice

Begin forwarded message:

From: "Russell E. Hayes" <russell.hayes@ionsky.com>
Subject: CPAG support
Date: November 20, 2011 7:27:05 PM MST
To: "'Janice Moore'" <janicemoore@comcast.net>

Janice,

Yes, I will add my name to the support of the unmodified (majority opinion) CPAG document. That means that I do not support the minority reports included in CPAG:
Mod of 4.9 on research lands
Mod after 6.1.6 saying no GM crops
Mod on pesticides after 6.2.3

I think that statements, such as your proposed letter and comments on 12/8 will have much more impact than "minority reports" – people's eyes are starting to glaze over. I would like to comment on 12/8 along the lines of agricultural practices are dynamic, and maintaining the successful agricultural characteristics of Boulder County means that we have to consider new practices and adopt those that fit. Closing out all present and future GMOs does not work – they should be examined on a case-by-case basis. Organic practices will never be 100% of agriculture in Boulder County.

I leave town in the morning of 11/23, but will be in email or cell phone contact.

Russell

Russell E. Hayes
Russell.Hayes@Colorado.edu
720-890-8632 (H)

From: POSAC - Janice Moore
Sent: Friday, November 25, 2011 6:43 PM
To: Dick Miller
Cc: POSAC - Eric Hozempa; Rounds, Jesse; Stewart, Ron
Subject: Fwd: dick miller's idea...

Hi, Dick,
this is the 2nd of the three emails. Eric Hozempa supports the CPAG proposal. He has a conflict the night of the public input to BOCC, but will try to get by there. He may also write them a letter.
Janice

Begin forwarded message:

From: Eric Hozempa <eric@longmontfoundation.org>
Subject: Re: dick miller's idea...
Date: November 20, 2011 8:38:55 PM MST
To: Janice Moore <janicemoore@comcast.net>

Janice,

I support that decision. I agree the CPAG document is well done

On Sun, Nov 20, 2011 at 6:41 PM, Janice Moore <janicemoore@comcast.net> wrote:
Hi,
Dick Miller of FAPC, who first had the idea about the joint minority report, wonders if minority members of POSAC would support the entire CPAG/county staff proposal? If such a thing could happen across the three committees, here's the scenario: -of the 27 members of all three councils, 14 would support, 13 would not. He is happy to offer rationale if anyone has trouble with that, and the farmers are even willing to give up their enhanced prairie dog control piece to achieve that, he says. What do you think? I'd certainly do that--I think that the CPAG document is carefully thought out and coherent…do let me know….
thanks!
Janice

--
Eric Hozempa
Executive Director
The Longmont Community Foundation
an affiliate of The Denver Foundation
401 Main Street, #102
Longmont CO 80501
303-678-6555 - office
303-358-4327 - mobile
www.longmontfoundation.org

Rounds, Jesse

From: POSAC - Janice Moore
Sent: Friday, November 25, 2011 6:39 PM
To: Dick Miller
Cc: Rounds, Jesse; Stewart, Ron; POSAC - Paul Jurasin
Subject: Fwd: dick miller's thoughts...

Hi, Dick,
This is the first of three emails that I received from POSAC members who fully support the CPAG proposal. All communication was 1:1 (me: the other POSAC member). I am copying these to Jesse and Ron for the record.

By the way, I fully support CPAG proposal as well--it is fair to farmers,in line with the best science, and in the best economic interest of Open Space.
Janice

Begin forwarded message:

From: "Paul Jurasin" <pjurasin@prodigy.net>
Subject: Re: dick miller's thoughts...
Date: November 20, 2011 7:56:50 PM MST
To: "Janice Moore" <janicemoore@comcast.net>

Hello,

As I said the other night, I think the CPAG proposal is well thought out and fair. The group had balanced membership and spent significant time working through all the issues. I would support the "un-tweaked" proposal.

Thanks,
Paul

Sent from my HTC on the Now Network from Sprint!

Submitted by Richard Andrews and Ewell Culbertson, Cropland Policy Advisory Group members

27 October 2011

***<u>Recommended Cropland Policy on GMO decisions</u>*:**

All decisions regarding the use in Boulder County of genetically modified organisms (GMOs), including crops, animals and other life-forms, and for each specific GMO, shall be made by the Boulder County Board of Commissioners using full and open due process and opportunities for public hearing. All submissions of technical information in support of or in opposition of a GMO shall be totally open for public review. No secret information shall be allowed to be used or considered in the review process. All suppliers of information during review shall be required to reveal any and all conflicts of interest or material gain from obtaining approval of a GMO.

Any properly conducted approval by the Board of Commissioners for the use of GMOs on county lands must be reviewed and concluded at least every five (5) years, or sooner if new scientific information is presented to the Commissioners which may invalidate the basis of prior approvals, consequently warranting reopening, modifying, or revoking of a prior approval. All such reviews or reopening shall be conducted promptly. Failure to conclude a review before the end of a five year period or within six months following a petition for review shall be deemed a denial or suspension of approval for continued use.

***<u>Rationale</u>*:**

Proposals by others on the Cropland Policy Advisory Group (CPAG) have recommended placing the decision making authority regarding genetically engineered or modified organisms with staff of Boulder County Parks and Open Space (BCPOS). This is an inadequate public process and inappropriate delegation of authority for such a complex and controversial issue. Instead the full Board of Commissioners is the appropriate place for such decisions since the Commissioners, unlike civil service staff, are fully accountable to the public through elections and recall processes. These decisions are also of such importance to the very long term agricultural sustainability of essential food producing croplands that they should not be delegated.

Due to the uniqueness of each GMO and the both intended effects and unintended consequences, individual review actions are necessitated. No blanket approvals by classes of GMOs are appropriate.

It is also noted that decisions regarding genetically modified organisms (GMOs) must extend to not only cropland plants but all GMOs, including plants, animals, bacteria, algae, and all lifeforms for which genetic engineering may be applied.

Much of the information used in regulatory reviews and approvals for GMOs and associated chemicals or biological agents at the federal level is developed, paid for, or otherwise sponsored by the corporations promoting the GMOs and associated chemical or biological agents. These potential conflicts of interest must be totally revealed during a publicly transparent review process, and given due critical analysis.

A mandatory review cycle of a minimum of five years is necessary for any approval of a GMO that may be granted by the Board of Commissioners. History teaches us that the impacts and consequences of many agricultural inputs, such as pesticides and chemicals has not been understood upon their introduction and often not until years later. The rapid evolution of science also occurs and decisions made without benefit of full understanding of the consequences to health and the environment need a periodic review, or in some cases an emergency review. The occurrence of new scientific findings which may invalidate prior approvals can happen at any time and should always be considered as legitimate cause for reopening any earlier decision. Timeliness of reviews shall be mandated to ensure that revealed or claimed negative consequences do not exacerbate potential damages from ongoing use. Similarly if claims of negative consequences are not validated upon proper public and Commissioners review the process needs to be expeditious. If doubt continues as to the safety to health and the environment of a GMO or its associated chemicals or biological agents, precaution is warranted and suspension of approval is the appropriate step.

Submitted by Richard Andrews and Ewell Culbertson, Cropland Policy Advisory Group members,

15 October 2011; updated 27 October 2011

<u>Recommended Cropland Policy on Glyphosate herbicide</u>:

Boulder County Parks and Open Space lands should ban the use of all pesticides containing glyphosate herbicides on its lands, including croplands, rangelands and other locations. A prompt phase out program of no more than one year duration should be implemented.

<u>Rationale</u>:

The herbicide glyphosate (N-phosphonomethyl glycine) is widely used around the world, including on Boulder County open space crop and rangelands, as well as in many other situations. It has been claimed to be safe by its manufacturers for decades, but a growing body of independent scientifically peer reviewed literature has shown otherwise, both with respect to negative environmental and human health effects. Claims that glyphosate has short persistence in the environment , largely based on its binding with clay in soils, have been proven false. The primary metabolic degradation product of glyphosate is AMPA (aminomethyl phosphonic acid) which also toxic to plants, is persistent and extremely mobile in the environment. Furthermore the toxic effects are glyphosate can reoccur in subsequent years due to the reversible release of adsorbed glyphosate from soil particles triggered by phosphorus fertilization, making it available for plant uptake and negative/toxic effects, even subsequently planted crops.

Glyphosate has been claimed to be beneficial as a companion to genetically modified crops that are designed to be resistant to glyphosate toxicity while the pesticide is deadly to weeds. But recent research increasingly documented in peer reviewed science journals is revealing the negative effects of glyphosate on plant/crop nutrition (particularly disrupting trace element uptake), soil microbiological diversity and health, stimulation of food crop and animal feed pathogens and mycotoxins, and over the longer term a drag on crop yields, plus the enhancement of super weed evolution. Of extreme importance is the growing body of evidence of the toxic effects of glyphosate on humans and other animals. There is very recent research published indicating that glyphosate and its many formulations is a causative agent for birth defects, notably brain and facial/cranial abnormalities, developmental disruptions/delays, endocrine disruption disorders and reproductive defects, carcinogenicity expressed such as non-Hodgkin lymphoma and leukemia, plus genotoxic DNA effects. Recently published research from Canada has found glyphosate and AMPA in women, and also found glufosinate and its degradate, closely related herbicides to glyphosate, in both pregnant women and their fetuses. Research from France has found that glyphosate is toxic to human placental cells. Numerous clinical studies with laboratory animals have found similar adverse health effects.

Glyphosate use in agriculture is heavily based upon convenience to the farmer but the near and long term risks simply are not judged to be worth the short term and diminishing benefits, plus the major concerns about impact to health and the environment. All of these negative effects warrant elimination of the use of glyphosate on the public lands of Boulder County. To do otherwise is incompatible with environmental stewardship and sustainable agricultural practices.

<u>Summary Background</u>: ***Glyphosate Herbicide (aka "Round Up" and other tradenames)*** -

The agricultural chemical glyphosate, also known as Round Up and other tradenames, is the most widely used herbicide ever (1). It is advertised as generally benign to non-target species and with short environmental half life. But it has recently been shown in scientific evidence, some published by long silent corporate insider research scientists, that its use has undesirable consequences. An overview of the interactions of glyphosate with physiology, nutrition and diseases of plants, and ramifications to agricultural sustainability has been published by Yamada, Kremer, Camargo e Castro, and Wood (2009)(2). Some of the papers reviewed by Yamada et al, as well as other peer reviewed articles are summarized below. Overall, the literature is massive that documents the negative consequences of glyphosate from a range of aspects from soil health, to food and animal feed quality, to environmental effects, and lately human health consequences. Another recent finding has been the discovery that the toxicity of glyphosate is significantly affected, often toward negative consequences, by the chemicals used in association with it, such as surfactants employed to increase the absorption into plant tissue. Some of these adjuvant chemicals are also inherently toxic by themselves and in combination with glyphosate doubly so. The following scientific review focuses on the most recent research and only includes peer reviewed and published science. It also relies mostly on science from sources that have no apparent or discernable ties to the chemical manufacturers of glyphosate that could potentially bias the results and interpretations.

<u>Crop Nutrition and Crop Health</u> -

One such negative consequence reported by Zobiole et al (3) of glyphosate is a decrease in soybean crop chlorophyll and photosynthetic activity, and related transpiration and stomatal conductance. They also observed significant decrease in macro and micro nutrients in leaf tissue with glyphosate treated plants, lower in the herbicide resistant (HR) plants than non-HR plants. Reduced biomass is observed in both above and below ground plant tissues in all glyphosate treated plants. Similarly, Bott et al (4) observed negative effects on zinc and manganese status in glyphosate treated soybeans. Glyphosate also inhibited root biomass production and elongation and lateral root development.

Zobriole, Kremer et al (16) have reported on the comparison of first generation (RR1) and second generation (RR2) genetically modified soybean cultivars, effects of growth stage and rates of glyphosate application, plus no glyphosate controls with these cultivars. They measure chlorophyll content, nodulation, biomass and nutrient accumulation. Overall conclusions were that RR2 did not improve yield indicating measures compared to RR1. Glyphosate significantly decreased chlorophyll content vs. control and reduction was more pronounced as rate increased and application was delayed during plant growth; observed chlorotic symptoms may relate to decreased photosynthetic rates due to glyphosate damage, potentially exacerbated by immobilization of Mg and Mn being chelated by glyphosate. These observations are consistent with Cakmak et al (18), Zablowtowicz and Reddy (17), and Zobriole et al (3). So the conclusion one draws is that even with genetically modified crops designed to be resistant to glyphosate, its use creates negative consequences to key indicator parameters of plant health and nutrition. In other words glyphosate actually injures the GMO crops it is designed to be used with.

Numerous researchers have in recent years discovered that glyphosate and its metabolites can interact with trace elements such as manganese, magnesium, zinc, iron, and nickel in the soil and inhibit their availability for plant uptake. Some of the elements are key to plant health, notably photosynthetic activity, root development, etc. Bailey et al (37) reported on this in 2002, Bernards et al (38) in 2005, and many others.

<u>Environmental Dispersal and Contamination</u> –

Glyphosate and metabolites such as AMPA are increasingly being found in the general environment, including natural waterways, the littoral plant communities, benthic organisms and mucks, and even in the atmosphere. This is a disturbing but not unexpected finding since glyphosate has been used for more than 3 decades and in the recent two decades it has become the number one herbicide throughout the world. It was once considered and represented as a non-persistent pesticide and relatively benign. That is now clearly challenged by mounting evidence not only about its presence in the general environment but by new research into the toxicity to many organisms other than the target weeds.

Kolpin et al (20) reports on glyposate and AMPA occurrences in surface water streams, including one Colorado location, the South Platte near Denver. This study focused on sampling of municipal wastewater treatment plant effluents, and upstream-downstream of the receiving streams. Overall, there was a two fold increase in detection of glyphosate and AMPA, comparing upstream from downstream; and AMPA was detected 67.5% compared to glyphosate (17.5%). While this indicates urban uses of this herbicide are significant contributor to dispersal, it does show that the degradate AMPA is very important to track in environmental evaluations, not just the parent compound glyphosate.

In another study Kolpin et al (19) reported on herbicides and degradates in municipal wells in Iowa. They found a 53% frequency of occurrence of herbicides and associated degrades in these drinking water supplies during a 2001 sampling. In this work, glyphosate and AMPA was not detected.

Very little is known about atmospheric occurrence or transport and depositional fate of glyphosate and AMPA. However very recent work by the USGS and University of Minnesota has been published by Chang et al (21). They sampled air particulates in Mississippi and Iowa and rain in Indiana during growing seasons. Glyphosate was detected 60 to 100% of the time in both air and rain.

Glyphosate concentrations were higher in rain than other high use herbicides. For the Iowa case, they estimate that approximately 0.2% to 0.7% of glyphosate that is applied was measured in air samples and ultimately washed out of the atmosphere in wet deposition. Given the huge amounts applied this is quite significantly large drift or volatiles that release to the general environment. This can have profound impact on non-target plants, and on organic production. For example, in Mississippi alone, during 2008 and estimated 2,750 kg of glyphosate was applied to crops with a combination of aircraft and ground rigs. AMPA was detected at approximately 5 to 10% of the concentrations of glyphosate, lower during the major application seasons and increasing with time after last application. Rain is believed to be an efficient removal mechanism for these toxins, since they exist as particulates, removing on average 97% of the atmospheric load by a weekly rainfall of ≥30 mm (about 1.1”). The question remains of course about the toxic effects on non-target plants where this deposition ends up. The two mechanisms for suspension of glyphosate and AMPA in air are immediate drift from sprayer application and post application wind erosion of particulate glyphosate and AMPA from the surface of soils.

In a dryer climate such as Boulder county, deposition mechanisms of these glyphosate and AMPA herbicide particulates will be different than the Mississippi valley. Nevertheless application drift and consequent chemical trespass is always a significant concern with any spray applied agricultural chemical. But subsequent wind erosion and offsite deposition of the soil particles containing such herbicides as glyphosate and its degradates is also quite important and likely an important local contamination mechanism to neighboring farms and general environment, given the windy character of cropland in Boulder county.

Littoral and periphyton freshwater community ecological effects of glyphosate have been observed. Vera et al (22) studied the effects of glyphosate on macrophyte colonization in outdoor experimental aquatic mesocosms. They simulated glyphosate runoff and aerial drift contamination of constructed shallow pond environments. They observed an algal eutrophication stimulation by Roundup, likely due to excess available phosphorus, which in turn produced a delay in the periphytic colonization of vascular wetland plants. Cyanobacter species were also favored by mesocosms receiving input of glyphosate.

A comprehensive literature survey has not been conducted in this area of glyphosate and AMPA ecological and non-target species effects. The above discussion is considered very incomplete at this time.

Soil Microbiological Effects -

Glyphosate is a non-selective, broad spectrum herbicide. It kills plants by disruption/inhibition the EPSPS enzyme (the shikimic pathway) which is plant essential for synthesis of aromatic amino acids. It also stimulates infection of roots of susceptible plants by certain soil micro-organisms, allowed by a decrease in normal plant biochemical defense compounds called phytoalexins. Kremer et al (5) observed that glyphosate treated soybeans, both HR and non-HR cultivars, exuded to soils higher levels of carbohydrates and amino acids, which in turn stimulated soil fungal populations. Kremer and Means (6) also report that glyphosate interactions with rhizosphere microorganisms occurred with maize (corn) crops, stimulating pathogenic *Fusarium*, and altering other soil bacteria colonization. They note that root colonization by the pathogenic *Fusarium* increased significantly after glyphosate applications during the growing seasons, with heavier infestation on HR resistant cultivars of both soybeans and corn, compared to non-HR cultivars and crops not treated with glyphosate. Other observed negative effects were reduced manganese plant translocation and availability, antagonistic bacterial effects, and reduced soy nodulation, and consequent reduced nitrogen fixation. This nodulation nitrogen fixation effect is counterproductive to a key objective to crop rotations with legumes (such as soybean) which can help build the nitrogen content in soils, and consequently reduce the demand for nitrogen fertilizer additions. Similar concerns may also apply to the recently approved HR GE alfalfa, the leading forage and legume crop.

Recently published related research by Johal and Huber (7) has documented an increased incidence of damaging fungal infections in croplands treated with glyphosate. They state, " this relatively simple, broad spectrum, systemic herbicide can have extensive unintended effects on nutrient efficiency and disease severity, thereby threatening its agricultural sustainability." They note that glyphosate can induce weakening of plant defenses and resulted in increased pathogen populations with greater virulence of diseases. The micronutrient connection is due to glyphosate induced immobilization of key nutrients necessary for disease resistance in plants. In a related study by Fernandez et al (8) prior applications of glyphosate (within previous 18 months) have been statistically associated with wheat and barley cereal crop diseases in the following crop caused by Fusarium spp., in particular, head blight due to *F. avenaceum* and *F. graminearum*. Counter to the understood benefits of reduced tillage, no or minimum till methods also positively influenced enhanced disease intensity when in combination with prior glyphosate use. A concern with these serious fungal diseases is crop losses and downgrading or disqualification of grain quality due to the presence of mycotoxin compounds exuded by Fusarium which are toxic to cattle and people and for uses of barley such as malting. The economic consequences can be severe. It is thought that the soil health effect of glyphosate is disruption of the fungal communities and competitive natural balances, favoring the pathogenic fungi over beneficials. This study indirectly speaks to the longevity of activity of glyphosate and possibly its metabolic decay products in soils, negatively affecting crops in subsequent years.

Another mechanism of unintended harm from glyphosate is killing or functionally degrading beneficial non-target soil organisms, such as the important symbiotic nitrogen fixing bacteria, *Rhizobium japonicum*, in both HR and non HR soybean. Moorman et al (9) investigated the accumulation of hydrobenzoic acid in glyphosate treated cultures of Bradyrhizobium japonicum and found it to be increased by glyphosate cases, a negative indicator. Potential effects of glyphosate may be alteration of the symbiotic interactions between this bacterium and the herbicide.

Similar inhibitory negative effects may occur with nitrogen fixing symbiotic bacteria in glyphosate treated alfalfa and other host symbioses plants of these beneficial bacteria, and potentially non-symbiotic soil algae nitrogen fixers; more research is needed to evaluate these concerns.

While glyphosate is designed specifically to function with GMO crops, it has been found that a glyphosate metabolic and toxic decay product, aminomethylphosponic acid (AMPA) can negatively affect HR GMO plants. Reddy et al (10) determined that AMPA resulted in injury to HR soybean and reduced chlorophyll content, diminished shoot fresh weight, suggesting this is the damaging chemical agent.

Tesfamariam et al (11) investigated the effect of waiting time between glyphosate applications directly to soils versus foliar weed applications. They measured the phytotoxic effects on the non-target plant, sunflower at various time intervals after glyphosate applications. Detrimental effects were more pronounced in the case of foliar weed applications, indicating greater toxicity when glyphosate (or its metabolic decay products) translocated via weed root tissue residues compared to direct soil application.

Recent research by Bott and others (15) has discovered that glyphosate can be remobilized in the soil by subsequent applications of phosphorus fertilizers. This counters the claims that glyphosate has a short toxic persistence in soils. It has long been known that glyphosate competes with other forms of applied phosphorus for binding sites, notably on soil clay particles. The Bott et al study examined soybean as a test crop, with numerous different soil types, and multiple glyphosate and phosphorus application rates. It revealed that the remobilization of the herbicide glyphosate by P-fertilization does occur and can damage subsequent plantings. On glyphosate treated soils, significant soy plant damage was observed, including shikimate accumulation in root tissue (an indicator of glyphosate toxicity), declines in germination, biomass, and plant nutritional status, etc. Soil type did have an effect on the nature and extent of plant effects, likely related to P fixation potential, CEC, plant available iron, textural properties and soil organic matter.

Human Health Effects -

Perhaps even more alarming is a growing body of evidence that glyphosate and its metabolic breakdown products are more toxic and longer lasting in the environment than previously reported or claimed by manufacturers, and toxic to non-target species, including humans. Glyphosate has been preliminarily implicated in epidemiological studies as a causative agent of neural defects and cranial-facial birth defects in populations in Chaco Province of Argentina (12). Those studies are considered by many as insufficiently controlled studies or peer reviewed. However they should be considered seriously and should justify additional research. More thorough and controlled medical science from University of Buenos Aires, Argentina, by Paganelli et al (13) investigated health effects of glyphosate herbicides with embryonic tadpoles and found teratogenic effects, related to impairment of retinoic acid signaling. Retinoic acid biochemistry is associated with the observed human birth defects and cranial-facial malformations noted in the above mentioned Chaco Province epidemiological reports.

Gasnier et al (16) examined the effects of glyphosate and various formulations on human liver HepC2 cells, a well known model for xenobiotic toxicity. They measured cytotoxicity, genotoxicity, anti-estrogenic and anti-androgenic effects, as well as androgen-estrogen conversion and mRNA. All measured parameters were disrupted within 24 hours at sub-agricultural doses with all of the glyphosate formulations. The nature of formulations had significant effect, indicating possible synergistic effects from multiple ingredients. They conclude, "Glyphosate-based herbicides present DNA damages and CMR [*carcinogenic-mutagenic-reprotyoxic*] effects on human cells and in vivo." And further, "These herbicides mixtures also present ED [*endocrine disruption*] effects on human cells, at doses far below agricultural dilutions and toxic levels on mitochrondrial activities and membrane integrity." They also note that the nature of the glyphosate formulation, that is the various other chemicals used in combination with glyphosate, have a significant effect on observed toxic effects. Also of note is that the effects were observed at levels near the residual authorized levels in transgenic feed stuff. Clearly they raise human and animal health warnings that have not previously been noted.

A major treatise on the human and animal health effects of glyphosate has been recently completed by Michael Antoniou et al (23), just published in June 2011. Antoniou is head of Gene Expression and Therapy Group, Dept of Medical and Molecular Genetics, King's College London School of Medicine UK. The major thrust of this report is the link of glyphosate to birth defects. The report also reviews independent scientific literature linking glyphosate to endocrine disruption, damage to DNA, reproductive and developmental toxicity, neurotoxicity and cancers.

Dallegrave et al (24) published in Reproductive Toxicology research on assessing reproductive effects of glyphosate exposures of pregnant female Wistar rats on the offspring. The results showed, "glyphosate-Roundup did not induce maternal toxicity but induced adverse reproductive effects on male offspring rats: a decrease in sperm number…and daily sperm production during adulthood, an increase in the percentage of abnormal sperms and dose-related decrease in the serum testosterone level at puberty, and signs of individual spermatid degeneration during both periods…..and vaginal canal-opening delay in exposed female offspring."

Romano et al (25) also studied Wistar rats, and found related effects. They state, "results showed that the herbicide [glyphosate] significantly changed the progression of puberty in dose-dependent manner; reduce d the testosterone production in semineferous tubules morphology, decreased significantly the epithelium height." They conclude, "commercial formulation of glyphosate is a potent endocrine disruptor in vivo, causing disturbances in the reproductive development of rats when the exposure was performed during the puberty period."

Manas et al (26)(27) conducted research using Comet assay and cytogenetic tests to investigate genotoxic effects of both glyphosate and AMPA. Glyphosate was found to be genotoxic in the comet assay with Hep-2 cells of mice. With AMPA there was a significant level of DNA damage or genotoxicity in Hep-2 cells; in human lymphocytes there was statistically significant clastogenic effect; and in vivo micronucleus tests showed significant increases in toxicity as well. AMPA was found to be genotoxic in three different tests performed.

Bolognesi and colleagues (28) tested genotoxicity of glyphosate and Roundup formulation with mice, treated intraperitoneally, using a battery of tests; and also using human lymphocyte cells, in vitro.

Both pesticide forms.   DNA damaging activity was observed as DNA strand breaks, chromosomal alterations, indicating genotoxicity.

Benachour and Seralini (29) evaluated toxicity of four different formulations of glyphosate and adjuvants (POEA) on three different human cell types (placental, umbilical cord vein, embryonic kidney) using low dilutions, well below agricultural levels, to simulate possible low residue levels found foods or feed.   All Roundup formulations caused cell death within 24 hours, inhibiting mitochrondrial activity, necrosis, and induction of apoptosis.   Effects were confirmed by observed DNA fragmentation, and nuclear fragmentation and shrinkage. It was found that AMPA and POEA separately and synergistically damage cell membranes. The mixtures of these formulation ingredients are generally more harmful when combined with glyphosate, confirming the labeled "inerts" are not inert.   Benachour et al (30) provide additional research defining the time and dose dependent effects of Roundup on human embryonic and placental cells.

Epidemiological studies conducted in Sweden by Ericksson et al (31) has confirmed an association between known exposure to phenoxyacetic acids and non-Hodgkins lymphoma (NHL), and have further strengthened an association between exposure to glyphosate and NHL.   The latency period typical for glyphosate and onset of NHL is often greater than 10 years.   Work by Anneclaire De Roos and colleagues (32) examined the cancer incidence among 57, 311 licensed glyphosate exposed pesticide applicators in Iowa and North Carolina.   There was a suggested association between exposure and multiple myeloma incidence, but not other cancer subtypes; further analysis for longer term assessment is planned.

The effects of glyphosate on human placental cells, and aromatase, the enzyme responsible for estrogen synthesis was researched by Richard and colleagues (33).   Glyphosate and Roundup were found to be toxic to human placental JEG3 cells within 18 hours at concentrations lower with agricultural use.   Roundup with adjuvants was more toxic than glyphosate alone. At lower concentrations both forms were disruptive to aromatase activity and mRNA.   Endocrine disruption was observed, and is suggested similar effects may be found in other mammals.

Aris and Leblanc (35) tested for blood levels of glyphosate, AMPA, glufosinate and its metabolite MPPA, plus the Cry1Ab protein (a Bt toxin) in the blood of non-pregnant, pregnant and their fetuses, performed in Quebec, Canada .   Glyphosate and glufosinate were detected in non-pregnant women. MPPA and CryAb1 toxin was detected in both non-pregnant and pregnant women as well as their fetuses.   This opens questions about the effects and exposures of these pesticides on human embryos, and raises questions about transfer of these toxins across placenta.   In an epidemiological study in Ontario of farm populations, an association between preconception exposure to glyphosate and elevated risk of late term abortions was observed (36).

Anadon et al (34) reports in rat brain tissue glyphosate induced 5-hydroxytryptamine (5_HT), serotonin and dopamine depletion, in dose-dependent effects in frontal cortex, midbrain and striatum, with accompanying increases in the metabolites of serotonin and dopamine.

Effects of Adjuvant Chemicals -

The city manager of Boulder, Colorado just released in 2011 a memo directing parks and maintenance staff to cease using Roundup, a commercial version of glyphosate. The ban was triggered by recent research about the elevated health risks and toxicity of glyphosate in combination with an adjuvant surfactant chemical polyethoxylatedtalloamine (POEA)(14). Surfactants are commonly used with active agent pesticides to decrease the surface tension of applied liquids and cause greater contact and penetration of the active poison with plant tissues. This ban is in concert with an overall policy trend by the City of Boulder and in draft versions of the latest update to the Boulder Valley Comprehensive Plan to minimize the use of all pesticides except those identified as "minimum risk" under EPA definitions.

Crop Yield Drag –

Crop yield drag, i.e. comparative reduction in yield, and other negative crop effects have been observed over time with glyphosate resistant crops such as soybean and corn. Many of these observed effects have been related to crop nutrition and crop health discussed above. While in initial years some of the glyphosate resistant crops exhibited yield gains, on the longer term yields have sometimes gone into decline. This has been postulated to be due to increasing binding of key trace elements as glyphosate and its metabolites have accumulated in soils which in turn have caused a decrease in trace element plant availability through chelation processes (metals binding).

Crop Production Economics: Costs vs. Benefits -

Local farmers say that their economic profitability is improved by the use of glyphosate as an effective herbicide. They spray early upon weed emergence and say they can make fewer or no additional cultivation passes per crop cycle. This clearly makes their farming more convenient, and may arguably reduce tractor fuel consumption and labor. However, for truly sustainable farming, this does not account for many external costs such as long term soil health, human health, stimulation of the evolution of glyphosate resistant weeds, and other negative consequences that must also be considered. But these factors are not considered in the farming accounting systems, but are only assessed indirectly and often with great lag times, appearing as long term productivity declines, loss of non-target species, health care bills, etc. Spraying of glyphosate does cause chemical trespass, even when done with care and observance of atmospheric conditions, sometimes damaging, destroying or threatening the crops and livelihood of downwind and downstream organic farms. These costs are often left for neighbors or subsequent generations to deal with. On balance, the risks of applying glyphosate and adjuvant toxins for the sake of current season profitability or the simplicity gains in farming are insufficient justification for the real costs.

So the weed control benefits sought by farmers from this broad spectrum herbicide may in fact be counterproductive with negative effects on beneficial soil organisms, to longer term impacts on soil health, increased crop disease prevalence, and even reductions in crop yields or losses by mycotoxins, and with growing human health concerns to those applying it and coming into contact with this poison by its widespread use. A more in depth evaluation of glyphosate and related herbicides such as glufosinate is needed to assist in cropland policy development by BCPOS.

Recap - Summary –

The primary regulatory agency for herbicides such as glyphosate is the U.S. Environmental Protection Agency which must approve the use of such toxic agricultural chemicals that are designed to control or kill weeds. Glyphosate was approved decades ago, in the mid 1970s. However, based upon recent research findings it deserves a serious re-examination and much more unbiased scientific research across numerous disciplines, from soil chemistry and soil microbiology, to crop diseases, to animal feed effects, to food safety and human health effects, and comparative studies between more benign methods of agricultural production and chemical pesticide methods, etc.

Until such additional research can prove the safety and necessity of glyphosate over the near and long term, its use should be discontinued. The role of Boulder County should be to disallow its use as a precautionary step until legitimate and independent scientific verification of safety can be assured.

It should be noted that this review only deals with the environmental and health effects of the herbicide glyphosate and does not cover the issues of companion herbicide resistant genetically modified crops designed to tolerant to it. That is the subject of other policy recommendations, rationale statements, and literature reviews.

It should also be noted that this literature review is not to be considered comprehensive and the sheer volume of published literature on these subjects is enormous and rapidly growing.

References:

(1) Anon., Sustainable Agriculture Literature Review, March 2011, report to Boulder County parks and Open Space, by Natural Capitalism Solutions, Hygiene, Colorado.

(2) Yamada, T., R.J. Kremer, P. R. de Camargo e Castro, B.W. Wood, preface: Glyphosate interactions with physiology, nutrition, and diseases of plants: Threat to agricultural sustainability?, Euro. J. of Agronomy, 31, 1110113, 2009.

(3) Zobiole, L.H.S., et al, Glyphosate reduces shoot concentrations of mineral nutrients in glyphosate-resistant soybeans, Plant Soil 328, 57-69, 2010.

(4) Bott, S., et al, Glyphosate-induced impairment of plant growth and micronutrient status in glyphosate-resistant soybean (glycine max L.), Plant Soil 312, 183-194, 2008.

(5) Kremer, R.J., N.E. Means, S. Kim, Glyphosate affects soybean root exudation and rhizosphere micro-organisms, Intern. J. Environ. Anal. Chem. 55(15) 1165-1174, 2005.

(6) Kremer, R.J. and N.E. Means, Glyphosate and glyphosate-resistant crop interactions with rhizosphere microorganisms, Euro. J. Agronomy 31 153-161, 2009.

(7) Johal, G.S. and D.M. Huber, Glyphosate effects on diseases of plants, Euro. J. Agronomy 31, 144-152, 2009.

(8) Fernandez, M.R. et al, Glyphosate associations with cereal diseases caused by Fusarium spp. In the Canadian Prairies, Euro. J. Agronomy 31, 133-141, 2009.

(9) Moorman, T.B., et al, Production of Hydroxybenzoic Acids by Bradyrhizobium japonicum Strains after Treatment with glyphosate, J. Agric. Food Chem., 40, 289-293, 1992.

(10) Reddy, K.N., A.M.Rimando, S.O. Duke, Aminomethylphosphonic Acid, a Metabolite of Glyphosate, Causes Injury in Glyphosate-Treated, Glyphosate-Resistant Soybean, J. Agric. Food Chem., 52, 5139-5143, 2004.

(11) Tesfamariam, T. et al, Glyphosate in the rhizosphere – Role of waiting times and different glyphosate binding forms in soils for phytotoxicity to non-target plants, Euro. J. Agronomy, 31, 126-132, 2009.

(12) Dr. Fancisco Baquero, Ministry of Public Health, Memoranda to Governor of Chaco Province from Water Pollutants Investigation Committee, Chaco Province, Argentina, Feb, 2010 and forwarded April 8, 2010; and other related reports on cancer and birth defects in children and newborns.

(13) Paganelli, A. et al, Glyphosate-Based herbicides Produce Teratogenic Effects on Vertebrates by Impairing Retinoic Acid Signaling, Chem. Res. Toxicol. 23, 1586-1595, 2010.

(14) Heath Urie (Camera Staff writer), City Manager pulls Roundup Weed Killer, Boulder Daily Camera, May 2, 2011.

(15) Bott, S., et al, May 2011, Phytoxicity of glyphosate soil residues re-mobilized by phosphate fertilization, Plant & Soil, 342 (1/2), pp. 249-263.

(16) Zobriole, L.H.S., R.J. Kremer, R.S. Oliveira, J. Constantin, 2011, Glyphosate affects chlorophyll, nodulation, and nutrient accumulation of second generation glyphosate-resistant soybean (Glycine max L.), Pesticide Biochemistry and Physiology, 99, pp 53-60.

(17) Zablotowicz, R.M., K.N. Reddy, 2007, Nitrogenase activity, nitrogen content, and yield responses to glyphosate in glyphosate-resistant soybean, Crop Protection, 26, 370-376.

(18) Cakmak, I., A. Yazici, Y. Tutus, L. Oztuk, 2009, Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium, and iron in non-glyphosate resistant soybean, Eur. J. Agron., 31, pp. 114-119.

(19) Kolpin, D.W. et al, 2004, Degradates provide insight to spatial and temporal trends of herbicides in ground water, Ground Water, 42(4), pp. 601-608.

(20) Kolpin, D.W., et al, 2006, Urban contributions of glyphosate and its degradate AMPA to streams in the United States, Science of the Total Environment, 354, pp. 191-197.

(21) Chang, Feng-Chih, Simcik, M.F. and Capel, P.D., 2011, Occurrence and fate of the pesticide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere, Environ. Toxicol. And Chem., 30 (3) 548-555.

(22) Vera, M.S., et al 2010, New evidences of Roundup (glyphosate formulation) impact on the periphyton community and the water quality of freshwater ecosystems, Ecotoxicology 19, 710-721.

(23) Antiniou, M. et al, June 2011, Roundup and birth Defects: Is the public being kept in the dark?, Earth Open Source.

(24) Dallegrave, E. et al, 2007, Pre- and postnatal toxicity of the commercial glyphosate formulation in Wistar rats, Achives of Toxicology, 81, 665-673.

(25) Romano, R.M. et al 2010, Prepubertal exposure to commercial formulation of the herbicide glyphosate alters testosterone levels and testicular morphology, Archives of Toxicology, 84, 309-317.

(26) Manas, F. et al, 2009, Gentoxicity of glyphosate assessed by the comet assay and cytogenic tests, Environ. Toxicol. And Pharmacol., 28, 37-41.

(27) Manas, F. et al, 2009, Genotoxicity of AMPA, the environmental metabolite of glyphosate, assessed by the Comet assay and cytogenic tests, Ecotoxicol. And Environ. Safety, 72, 834-837.

(28) Bolognesi, C. et al, 1997, Genotoxic activity of glyphosate and its technical formulation Roundup, J. Agric. Food Chem. 45, 1957-1962.

(29) Benachour, N. and Gilles-Eric Seralini, 2009, Glyphosate Formulations Induce apoptosis and necrosis in human umbilical, embryonic and placental cells, Chem. Res. Toxicol. 22,97-105.

(30) Benachour, N. et al 2007, Time- and Dose-Dependent effects of Roundup on Human Embryonic and Placental Cells, Arch. Environ. Contam. Toxicol. 53, 126-133.

(31) Ericksson, M. et al 2008, Pesticide exposure as risk factor for non-Hodgkin lymphoma including histopathological subgroup analysis, Jour. Of Cancer, 123, 1657-1663.

(32) DeRoos, A.J. et al, 2005, Cancer incidence amoung glyphosate-exposed pesticide applicators in the Agricultural health study, Environ. Health Perspectives, 113(1), 49-54.

(33) Richard, S. et al, 2005, Differential effects of glyphosate and Roundup on human placental cells and aromatase, Environ. Health Perspectives 113(6) 716-720.

(34) Anadon, A. et al, 2008, Neurotoxicological effects o fht herbicide glyphosate, Tox. Ltrs. Abstracts, 180S, S01.

(35) Aris, A. and S. LeBlanc, 2011, Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern townships of Quebec, Canada, Reprod. Toxicol. 31(4) 528-533.

(36) Arbuckle, T.E., Z. Lin, L.S. Mary, 2001, An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario Farm Population, Environ Health Perspect, 109 (8), 851-857.

(37) Bailey, W.A. et al, 2002, Glyphosate interactions with manganese, Weed Tech, 16(4) 792-799.

(38) Bernards, M.L., Thelen, K.D. et al, 2005, Glyphosate interaction with managanese in tank mixtures and its effect on glyphosate absorption and translocation, Weed Science 53, 787-794.

Recommended Cropland Policy on Neonicitinoid Pesticides and Pollinators:

Submitted by Richard Andrews and Ewell Culbertson, Cropland Policy Advisory Group members

15 October 2011; updated 27 October 2011

Policy Statement:

Boulder County Parks and Open Space lands should ban the use of all neonicitinoid pesticides on its lands, both croplands, rangelands and other locations.

Rationale:

The systemic pesticides called neonicitinoids have been connected as a causative and/or contributing agent in honey bee colony collapse disorder (CCD). CCD is directly affecting bee populations in Boulder County and many beekeepers have experienced major colony losses and honey production declines in the last year alone. Bees and other pollinators are beneficial insects that serve to pollinate many important local food crops, and some species serve as predator controls of other insects that are harmful to food crops. These pesticides are also known to cause declines in avian life and to be toxic to aquatic life, terrestrial invertebrates, mammals and other species in the general environment. They have very long half lives with cumulative buildup potential in the soils and plant tissue. Very little research has been uncovered on the toxic effects to humans via foods and other contamination pathways, suggesting much more research is needed. To limit these harmful effects to our environment, particularly our important pollinators, and the potential effects on our foods and human health, these chemicals and their use should be banned on public lands owned and controlled by the county, most notably Parks and Open Space croplands. These chemicals are detrimental to and incompatible with sustainable agricultural practices.

Summary Background:* *Neonicitinoids (Clothianidin, Imidacloprid, and other neonicitionoids, sold under various tradenames such as Poncho, Votiva, Propser, etc.) -

One example of an unintended consequence and unsustainable agricultural practice is the use of family of systemic pesticide chemicals known as the neonicitinoids. This class of pesticides is commonly used for seed treatments as a systemic insecticide, notably on canola, mustard, rapeseed, corn (including field, sweet and popcorn) and sorghum. Other uses are also now involving direct application to soil surface and foliage at much higher rates than in seed coatings, for turfgrass, tobacco, apples, pears and ornamentals, in other words many that situations that may even be used in homeowner applications.

For a long time, it has been known that nicotine and its related compounds and derivatives are toxic, not just to tobacco smokers but to other life-forms, some of which are agricultural pests. One of the most common currently used neonicitinoids is clothianidin, a product of Bayer Crop Sciences, a major European agricultural chemical company. This chemical is used as a seed coating, and in direct soil and foliar applications, and in other delivery methods. This chemical is a persistent chemical in aerobic soil conditions with a half life of 148 days up to 1155 days (3). For eventual activity or chemical-physical-metabolic decay it would therefore take up to about 32 years to reach low or near zero levels. In other words it is a very persistent chemical pesticide with long term consequences to soil health and the environment. Furthermore it is quite stable to hydrolysis degradation at most common environmental pH and temperature conditions. With repeated use, it can therefore build up in soils and create unhealthy soil concentrations. Being water soluble systemic pesticides, neonicitinoids move into the plant tissue by vascular pathways, even to flower parts, and can consequently expose pollinators to repeated intakes of contaminated nectar and pollen. This also means that the pesticide is taken into the food and animal feed parts of crops. Little if any research has been found regarding these pathways and possible health effects to animals or humans eating these crops. These pesticides are classified as mobile to highly mobile in soils and can also readily move into ground and surface water. Methods of application involving soil or foliar applications, since they are typically at higher rates than with seed coatings, represent a definite risk to the potential for leaching into ground water or contaminating surface water by runoff from fields. EPA risk assessment documents for use with corn and canola refer to clothianidin as "having "extreme mobility and persistence …in the environment." (5)

Negative effects on aquatic invertebrate animals and aquatic vascular plants have been documented in the field due to contamination of water. Acute and chronic risks to avian and mammalian species have also been identified from exposures, particularly related to use, spills, and storage of clothianidin for treated seeds (3). Studies also indicate toxic effects on terrestrial invertebrates such as earthworms, and non-vascular plants such as algae. Indicator test aquatic species such as daphnids also have been shown to be sensitive at chronic levels as low as 0.12 ppm, resulting in reproductive effects. Clothianidin was found to be highly toxic to sediment dwelling aquatic invertebrates (Chironimus riparius, midge) were found to express toxicity at levels LC50 of 11 ppb, and NOACE of 1.1 ppb, and Leptocheirus plumolosus with LC50 at 20.4 ppb, NOACE of 11.6 ppb.

Colony collapse disorder (CCD) with honey bees is a complex issue, with the probability that it is caused or contributed to by many interconnected factors. Increasingly, certain pesticides are being found to contribute to this problem which otherwise may appear to be caused by mites, fungi and other causes. The neonicitinoid pesticides are now linked to these disease and pest causes through stresses to the health of honey bees, and subsequent lowered resistance to other contributing agents of CCD.

Acute high toxicity effects to honey bees are noted in internal EPA risk assessments. And storage of gathered clothianidin in bee hive food pollen and nectar stocks become repeat dosages of the chemical toxins, causing chronic buildup and exposures of the bees, particularly to the larvae and long life queen. While the lower levels of the chemicals are not always detectable in the bee, in controlled studies with known exposures have shown correlations to bee health effects and toxicity. One study showed mortality, and negative effects on pollen gathering, plus reduced honey yields. Linkages are now being discovered between bee stress, increased presence of fungal pathogens such as Nosema ceranae, and reduced disease resistance by bees.

The EPA approved the use of clothianidin in 2003 on the condition that Bayer Crop Science conduct chronic toxicity effects. EPA refused to release the Bayer studies, still only saying their determinations are "scientifically sound". To open the records of EPA, the Natural Resources Defense Council (NRDC) sued EPA in 2008 for access to the documents held in secret. Eventually they were published and upon independent review found to be "woefully inadequate". Since the introduction in the U.S. and wide scale use with crops, U.S. bee colonies have declined by 30 to 90 percent. (7)

While many wish to rely on the federal regulatory agencies to protect our environment and health, Tom Theobold, a respected Boulder county beekeeper, late in 2010, uncovered and released new 2010 EPA scientific risk assessment documents which refute the prior official EPA approval record of determination for pesticide registration of clothianidin (1)(2). Unfortunately, secrecy is still the rule because even EPA pesticide review reports do not provide scientific references or access to the actual toxicological reports submitted by the chemical company applicants. In addition, there are no open literature citations listed in the EPA report that can be reviewed independently. As a result, no independent scientific evaluation is reasonably possible.

Statements by the EPA scientists in the 2010 EPA report are nevertheless revealing. They state, regarding a previous field study (MRID 46907801/46907802) which supported prior clothianidin registration, "deficiencies were identified that render the study supplemental" and "it does not satisfy the [EPA] guideline 850.3040 and another field study is needed to evaluate the effects of clothianidin on bees through contaminated pollen and nectar. Exposure through contaminated pollen and nectar and potential toxic effects therefore remain an uncertainty for pollinators." (3) The EPA report further states, "it appears that clothianidin exposure to honeybees has the potential for high toxicity on both an acute contact and oral basis" and it quotes, "one honeybee study showed that mortality, pollen foraging activity, and honey yield were negatively affected by residues of clothianidin." (3)

An unpublished report from a top USDA bee researcher, Jeffrey Pettis, of the Beltsville Agricultural Research Service (ARS) Bee Research Laboratory , has reportedly also found the Bayer Crop Sciences manufactured clothianidin pesticide harmful to honeybees, with potential links to CCD and co-pathogen fungal proteins, the effects observed even at below detection limits for the neonicitinoid (3). This study is a collaborative work with entomologist of Dennis van Englesdorp of Penn State University. We still await the public release of this important report, and may ultimately need to use Freedom of Information Act methods for its disclosure since it was completed two years ago. While waiting for release, both Pettis of ARS and van Engelsdorp of Penn State have spoken publicly on the documentary film, *The Strange Disappearance of the Honeybees*. Pettis describes their study in which two sets of honeybees were exposed to a known fungal pathogen (Nosema ceranae), one set also exposed to a neonicitinoid, the other a control and not exposed. In the film Pettis states, "…we saw an increase, even if we fed the pesticide at very low levels--an increase in Nosema levels--in direct response to the low level of feeding of neonicitionoids, as compared to the ones which were fed normal protein." Van Englesdorp noted that the neonicitionoid exposures of the bees were below detection limits in the bees. He notes, "the only reason we knew the bees were exposed is because we exposed them." These findings reveal how incredibly complex are the issues of introduced environmental toxins, even at exceedingly low levels, in our environment; and that they can go unnoticed by science, but still have profound implications to ecosystems.(2)

This bee colony disorder is a serious problem with our important pollinators and many important food crops depend upon bees. Many ornamental and wild flowering plants are also served by bee pollinators. The issue is too important both locally and nationally to be left to the slow and sometimes politically influenced processes of the federal agencies. The National Honey Bee Advisory Board, American Beekeeping Federation, American Honey Producers Association, Beyond Pesticides, Pesticide Action Network North America and the Center for Biological Diversity have all petitioned EPA to review its decision to allow use of clothianidin (4). This wake up call is heavily based upon the uncovered internal documents from EPA's own scientific staff, as well as emerging scientific studies by the US. Department of Agriculture, Bee Research Laboratory in Beltsville, Maryland.

Several European Union nations have already banned these chemicals, including Germany where many of them continue to be manufactured and sold to the rest of the world. Bans are in place in Italy, Slovenia and France (7) with others under petition for review and disapproval, including the UK. At least on retailer in the UK, the Co-operative Group, announced with its "Plan Bee" that it would prohibit the use of eight different insecticides for use with its brand of fresh produce to help reverse the decline in British honeybees. (8) The UK has reportedly banned the direct spraying of clothianidin, only allowing it with seed treatment. The ban in Germany of clothianidin and seven other insecticides immediately followed a dramatic die off in 2008 of 50-60% of bees, the incident linked to aerial drift releases of neonicitinoids from treated maize (corn) sowing, and according to the German Professional Beekeepers' Association, some beekeepers lost all of the hives. (8)

Precautionary action now rather than belated regret is called for by local governments since the federal agencies are not acting on this strong evidence. Specifically Boulder County needs to protect its citizenry and the ecosystem inhabitants under its stewardship, such as our essential honeybee pollinators, and other non-target affected beneficial insects, birds, terrestrial invertebrates, and aquatic life, even we humans who are also being exposed without an understanding as to the health effects on us. Until science can prove pesticides such as the neonicitinoid group of insecticides are absolutely safe, they must be banned from use. Such materials are simply incompatible with the practice of ecological and agricultural sustainability.

References:

(1) Theobold, Tom, Do We Have a Pesticide Blowout?, Bee Culture, July 2010, pp. 66-69; and personal communications with Tom Theobold by R. Andrews

(2) Philpott, T., Top USDA bee researcher also found Bayer pesticide harmful to honey bees, http://www.grist.org/2011-01-21-top-USDA......

(3) DeCant, J. and M. Barrett, U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, executive memorandum and report of Environmental Risk Assessment on subject: Clothianidin Registration of Prosper T400 Seed Treatment on Mustard Seed (Oilseed and Condiment) and Poncho/Votivo Seed Treatment on cotton, PC Code 044369, Nov 2, 2010. (This document also internally references other EPA documents which were the basis of prior registrations for clothianidin. It is notable in that it defines many uncertainties and inadequacies in the previous approvals of this pesticide.)

(4) Letter to U.S. EPA Administrator and office of Pesticide programs, Dec 8, 2010 from and multiple signers representing six honey bee and pesticide groups: National Honey Bee Advisory Board, American Beekeeping Federation, American Honey Producers Association, Beyond Pesticides, Pesticide Action Network – North America, Center for Biological Diversity.

(5) EFED Risk Assessment for the Seed Treatment of Clothianidin 600FS on Corn and Canola, U.S. Environmental Protection Agency, 20 February 2003, pg.3. (EFED means "environmental fate and effects division" a branch in EPA, Office of Pesticide Programs).

(6) Theobold, Tom, letter and position statement of Boulder County Beekeepers Association to Boulder County Commissioners, October 2011.

(7) Darlington, D., None of your beeswax, Sierra, Vol. 96, No.4, Jul/Aug 2011, p. 18.

(8) Abram, M., 28 March 2009, Seed treatment error bring pesticides into bee debate, Crops, pp 22-25.

<u>Other reference materials</u>:

(1) Schaker, Michael, A Spring Without Bees, 2008. (Discusses temporal and geographic links between colony collapse in the US and neonicitinoids.)
(2) Tennekes, Henk A., A Disaster in the Making, 2010. (discusses how bird populations are declining precipitously on European farmland treated with clothianidin.)
(3) Benjamin, A., B. McCallum, 2009, A World Without Bees, Pegasus Books, NY, pp. 133-162. (extensive review of the incidents of bee poisonings, ongoing research, and the connections with neonicitinoid insecticides)
(4) Anon., Nov 2008, Ecologist, Pesticide Penalty, Vol 38 (9), p 11.
(5) Amer. Vegetable Grower, May 2010, Vol 58(5), p. 7.

Submitted by Richard Andrews, Cropland Policy Advisory Group member, 27 October 2011

Recommended Cropland Policy regarding Inventorying and Optimizing Cropland Use –

Boulder County Parks and Open Space (BCPOS) shall conduct and maintain a multi-characteristic mapping and an inventory of all open space lands to identify and rank the highest and most productive uses of all lands suitable for production of crops, with a priority given to crops that support local markets and needs for food, specialty crops, fiber and feed for food producing livestock. Characteristics to be mapped and ranked include soil quality and land capability classifications, water resources and existing and potential water infrastructure for crop production, slope, topography, and aspects, microclimate and exposure, surrounding and nearby land uses, natural resources such as wildlife corridors and habitat characteristics, and multi-purpose uses such as recreational, educational, transportation corridors, and other relevant factors. Ranking criteria shall be employed to balance economic, social and environmental qualities for croplands for the collective benefit and maximizing productivity of such lands, for the benefit of both farmers and owners of the commonwealth.

The mapping and inventory data base shall be utilized to assist in the cropland leasing program to achieve the highest and best use of the cropland suitable open space lands, and to guide the solicitation of offered lands for cropping by tenant farmers, the selection of proposed uses by candidate tenants, or for other special set aside uses such as research, development and demonstration (RD&D) of sustainable agriculture, agricultural educational activities, genetic isolation for seed production or organic production zones, etc . Adjustments to historical cropland lease parcel boundaries shall be made as appropriate to either combine or subdivide parcels to achieve the highest and best use of croplands in the inventory.

Rationale –

In order to achieve the greatest possible services to the local economy and to be compatible with essential ecological services of our natural world, and to honor the collective ownership of Boulder County open space lands for the benefit of its residents and businesses, the highest and best utilization of the publicly owned agricultural lands should be a primary goal of the open space cropland program. Objectives of optimization of the use of BCPOS croplands are to best serve and support the local economy, to provide for a maximized employment opportunity for primary and secondary agriculturally related occupations, to maximize the production of high quality foods and other agricultural products that are locally consumed or processed, to build a more secure and sustaining food system serving all sectors of the commuity, to minimize the food miles and the energy impacts of food distribution, and to do all this with respect for the environmental systems that support the perpetual productivity and health of the croplands.

Historical crop uses, while sometimes being the optimal uses, are not necessarily so now or into the future, despite generations of practice. The determination of highest and best uses must be a dynamic process, capable of changing and evolving as social, economic, and environmental characteristics dictate. As an example, much of the arable and irrigated land of Boulder County at the founding of our state was dedicated to production of feedstuff for draft animals for the mining of metals, and transportation. That changed with technological and local industrial shifts. Even now Boulder County land is heavily used by a very large population of horses, and consequently those lands are not used for providing local food production. In evaluating highest and best use, particularly if priority ranking is given to creating locally secure foodshed systems, such allocations of uses should be re-evaluated and policies adjusted accordingly. As another example, major commodity crops grown locally are not often used locally or converted locally into processed foods, as they once were. Even the historical sugar beet agriculture is not as it once was with a local processing mill in every town in the South Platte valley. The driving forces for choice of crops are often due to artificial market stimulation of crop subsidies, but these program incentives do not necessarily represent highest and best uses of the lands on which those crops are grown. Changes are happening in these artificial crop selection drivers. An inventory system to assist in the transitioning to a non-subsidized agriculture will be most useful as we move into a different future.

Different lands are capable of growing different types of crops, and mapping is a useful means to identify the most suitable crops for a given area. A dominating and the most notable distinctions in crop suitability in our arid environment is irrigable lands versus drylands. Due to sometimes antiquated and illogical but exacting legal constraints of water law, adjustments of the areal irrigation patterns are very difficult to adjust. So what is dryland farming will no doubt largely remain so well into the future. Nevertheless, higher efficiency irrigation systems are happening and changing the cropping methods, sometimes the crops grown. The historical secondary ditching for water delivery can be changed to redefine the irrigated field boundaries, or to grow different crops. Such changes can occur, even when allocations of total water use may not. Making such changes to historical patterns should not be ruled out merely based on history and secondary delivery system locations if a higher crop use and productivity can be achieved.

Much of the data base for such mapping already exists from the soils mapping of the USDA and the capability classifications they have also overlaid on those soils maps. Decades ago, lands throughout the state and county were classified into areas of highly productive agricultural potential. Virtually all of Boulder county has been mapped for its natural resources such as wildlife habitat, T&E and species of concern, minerals, viewscapes, etc. The network of existing irrigation ditches, lakes and other distribution of crop water is well known, as well as the legal constraints that dictate where and how the water can be used. But tradition in water use practices does not necessarily equate to the highest and best use of that critical resource. Experts in land characteristics regarding needs for specialty crops are readily available from the USDA, extension service, universities, and other local advisors. All of these existing classifications and personnel resources can be used to assist in the open space inventory and ranking process.

The optimization of cropland use should be an evolving program, not instituted overnight, but phased in and tied to the overall objectives of moving to ever greater sustainable agriculture in the county, that phrase used in its broadest context. The mapping process can provide a broad holistic view of croplands and their relationships across artificial parcel boundaries.

As a possible example, designation of agricultural zones for different types of crops and crop production methods can assist with assembling uses that are compatible with neighboring uses. To facilitate good neighbor policies in a diverse agriculture environment, negative effects across parcel boundaries could be minimized by aggregating compatible use parcels. This could include zones to create buffers or clustering of operations to avoid chemical and genetic trespass through the air, irrigation water or pollinators, or genetic dispersal between organic farming or non-GMO seed production farms which need isolation, separating them from farming operations that use chemicals or GMOs. Ultimately these buffer and isolation zones can disappear as agriculture moves inevitably to more sustainable methods that are not utilizing toxic chemicals or genetically engineered organisms that can do harm beyond the farm borders.

Submitted by Richard Andrews and Ewell Culbertson, Cropland Policy Advisory Group members,

28 October 2011

Recommended Cropland Policy on Jointly Owned Open Space:

For open space lands that are owned by more than one party, the management of such lands shall be conducted using the most restrictive policies of any of the joint owners regarding environmental and public health aspects of property management, irrespective of ownership percentage or which party is the designated managing party. All future acquisitions of open space that are purchased in partnership with other parties shall include specific provisions in the acquisition agreements and/or management plans to implement the most restrictive environmental and public health policies of the joint owners. Any deviation from this management policy involving public entities shall require public hearings and due process by each public party.

Rationale:

There are open space properties that were or may be in the future jointly acquired or are otherwise jointly owned, particularly properties that have combined the assets for purchase by county, municipalities, public improvement or special taxing districts or other governmental entities. Particularly with respect of environmental protection, human health, and land use, the most restrictive policies of the involved public entity owners in such partnerships shall apply to the ongoing management of the particular property.

In such jointly owned properties, current practice has been to divide up for management of individual properties by agreements between the entities to designate a managing party, but such agreements have not necessarily dealt with the question of differences in management style and policy, or differences in legal substance arising from one or more of the entities. The typical procedure to date has been that whichever party is designated to be the managing or operating partner, that entity's policies were applied. As an example, in a recent case, the BCPOS has allowed GMO corn to be grown on a jointly owned agricultural open space parcel which is jointly owned with the City of Boulder. Growing GMOs on city lands is in conflict with the long standing city open space policies of and directives from City council of the City of Boulder. The reasonable resolution in such cases is to establish a joint operating policy that the most restrictive environmental or public health or land use policy by any of the ownership entities would apply. In the above cited example, GMO crops would not be allowed. Such policies as prairie dog management, pesticide use, natural resources, and water use are examples of where this use of the most restrictive policy would apply.

In some cases non-public entities such as land conservation non-profits, trusts, foundations or establishment/purchase of conservation easements may also effectively be partner owners of open space lands. In such cases where public review may not be a part of the policy setting procedures of one of the entities, BCPOS shall endeavor to negotiate such arrangements and legal contracts to institute county cropland management sustainable agriculture policy into such agreements.

Summary

With the advent of genetic-engineering technology in agriculture, the science of crop improvement has evolved into a new realm. Advances in molecular and cellular biology now allow scientists to introduce desirable traits from other species into crop plants. The ability to transfer genes between species is a leap beyond crop improvement through previous plant-breeding techniques, whereby desired traits could be transferred only between related types of plants. The most commonly introduced genetically engineered (GE) traits allow plants either to produce their own insecticide, so that the yield lost to insect feeding is reduced, or to resist herbicides, so that herbicides can be used to kill a broad spectrum of weeds without harming crops. Those traits have been incorporated into most varieties of soybean, corn, and cotton grown in the United States.

Since their introduction in 1996, the use of GE crops in the United States has grown rapidly and accounted for over 80 percent of soybean, corn, and cotton acreage in the United States in 2009. Several National Research Council reports have addressed the effects of GE crops on the environment and on human health.[1] However, the effects of agricultural biotechnology at the farm level—that is, from the point of view of

[1]*Genetically Engineered Organisms, Wildlife, and Habitat: A Workshop Summary* (2008); *Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects* (2004); *Environmental Effects of Transgenic Plants: The Scope and Adequacy of Regulation* (2002); *Ecological Monitoring of Genetically Modified Crops: A Workshop Summary* (2001); *Genetically Modified Pest-Protected Plants: Science and Regulation* (2000).

the farmer—have received much less attention. To fill that information gap, the National Research Council initiated a study, supported by its own funds, of how GE crops have affected U.S. farmers—their incomes, agronomic practices, production decisions, environmental resources, and personal well-being. This report of the study's findings expands the perspectives from which genetic-engineering technology has been examined previously. It provides the first comprehensive assessment of the effects of GE-crop adoption on farm sustainability in the United States (Box S-1).

In interpreting its task, the committee chose to analyze the effects of GE crops on farm-level sustainability in terms of environmental, economic, and social effects. To capture the broad array of potential effects, the committee interpreted "farm level" as applying both to farmers who do not produce GE crops and those who do because genetic engineering is a technology of extensive scope, and its influences on farming practices have affected both types of farmers. Therefore, to the extent that peer-reviewed literature is available, the report draws conclusions about the environmental, economic, and social effects, both favorable and unfavorable, associated with the use of GE crops for all farmers in the United States over the last 14 years. The report encapsulates what is known about the effects of GE crops on farm sustainability and identifies where more

BOX S-1
Statement of Task

An NRC committee will study the farm-level impacts of biotechnology, including the economics of adopting genetically engineered crops, changes in producer decision making and agronomic practices, and farm sustainability.

The study will:

- review and analyze the published literature on the impact of GE crops on the productivity and economics of farms in the United States;
- examine evidence for changes in agronomic practices and inputs, such as pesticide and herbicide use and soil and water management regimes;
- evaluate producer decision making with regard to the adoption of GE crops.

In a consensus report, the committee will present the findings of its study and identify future applications of plant and animal biotechnology that are likely to affect agricultural producers' decision making in the future.

research is needed. A full sustainability assessment of GE crops remains an ongoing task because of information gaps on certain environmental, economic, and social impacts.

Genetic-engineering technology continues to stir controversy around scientific issues and ideological viewpoints. This report addresses just the scientific questions and adopts an "evidentiary" standard of using peer-reviewed literature to form conclusions and recommendations. GE-trait developments may or may not turn out to be a cost-effective approach to addressing challenges confronting agriculture, but a review of their impact and an exploration of what is possible are necessary to evaluate their relative efficacy. Therefore, the report details the challenges and opportunities for future GE crops and offers recommendations on how crop-management practices and future research and development efforts can help to realize the full potential offered by genetic engineering.

KEY FINDINGS

The order of findings in this summary reflects the structure of the report and does not connote any conclusions on the part of the committee regarding the relative strength or importance of the findings. In general, the committee finds that genetic-engineering technology has produced substantial net environmental and economic benefits to U.S. farmers compared with non-GE crops in conventional agriculture. However, the benefits have not been universal; some may decline over time; and the potential benefits and risks associated with the future development of the technology are likely to become more numerous as it is applied to a greater variety of crops. The social effects of agricultural biotechnology have largely been unexplored, in part because of an absence of support for research on them.

Environmental Effects

Generally, GE crops have had fewer adverse effects on the environment than non-GE crops produced conventionally. The use of pesticides with toxicity to nontarget organisms or with greater persistence in soil and waterways has typically been lower in GE fields than in non-GE, nonorganic fields. However, farmer practices may be reducing the utility of some GE traits as pest-management tools and increasing the likelihood of a return to more environmentally damaging practices.

Finding 1. When adopting GE herbicide-resistant (HR) crops, farmers mainly substituted the herbicide glyphosate for more toxic herbicides.

However, the predominant reliance on glyphosate is now reducing the effectiveness of this weed-management tool.

Glyphosate kills most plants without substantial adverse effects on animals or on soil and water quality, unlike other classes of herbicides. It is also the herbicide to which most HR crops are resistant. After the commercialization of HR crops, farmers replaced many other herbicides with glyphosate applications after crops emerged from the soil (Figures S-1, S-2, and S-3). However, the increased reliance on glyphosate after the widespread adoption of HR crops is reducing its effectiveness in some situations. Glyphosate-resistant weeds have evolved where repeated applications of glyphosate have constituted the only weed-management tactic. Ten weed species in the United States have evolved resistance to glyphosate since the introduction of HR crops in 1996 compared with seven that have evolved resistance to glyphosate worldwide in areas not growing GE crops since the herbicide was commercialized in 1974. Furthermore, communities of weeds less susceptible to glyphosate are

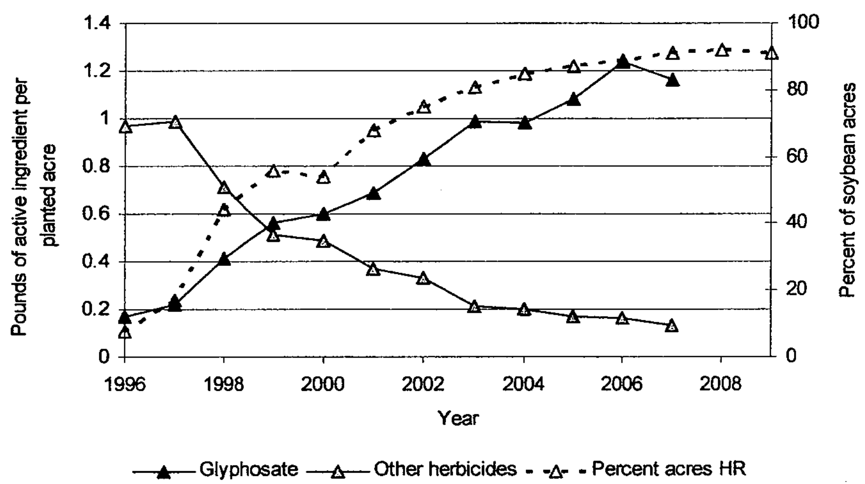

FIGURE S-1 Application of herbicide to soybean and percentage of acres of herbicide-resistant soybean.
NOTE: The strong correlation between the rising percentage of HR soybean acres planted over time, the increased applications of glyphosate, and the decreased use of other herbicides suggests but does not confirm causation between these variables.
SOURCE: USDA-NASS, 2001, 2003, 2005, 2007, 2009a, 2009b; Fernandez-Cornejo et al., 2009.

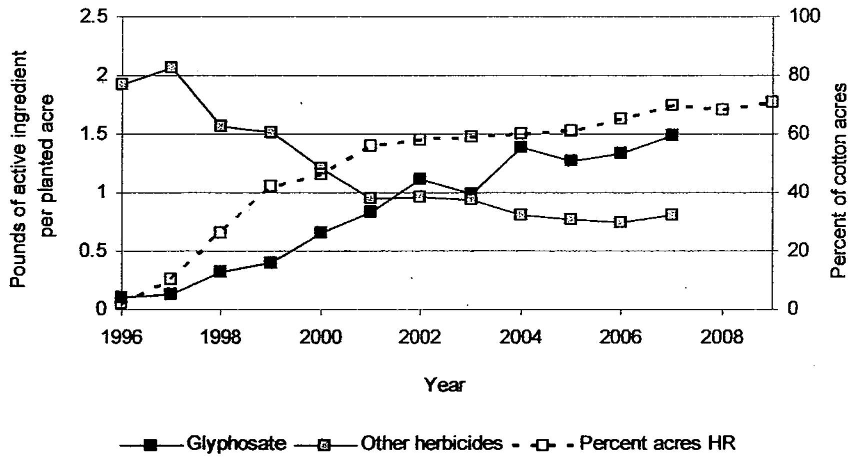

FIGURE S-2 Application of herbicide to cotton and percentage of acres of herbicide-resistant cotton.

NOTE: The strong correlation between the rising percentage of HR cotton acres planted over time, the increased applications of glyphosate, and the decreased use of other herbicides suggests but does not confirm causation between these variables.

SOURCE: USDA-NASS, 2001, 2003, 2005, 2007, 2009a, 2009b; Fernandez-Cornejo et al., 2009.

becoming established in fields planted with HR crops, particularly fields that are treated only with glyphosate.

Finding 2. The adoption of HR crops complements conservation tillage practices, which reduce the adverse effects of tillage on soil and water quality.

Farmers have traditionally used tillage to control weeds in their fields, interrupting weed life cycles before they can produce seeds for the following year. However, using tillage to help manage weeds reduces soil quality and increases soil loss from erosion. Tilled soil forms a crust, which reduces the ability of water to infiltrate the surface and leads to runoff that can pollute surface water with sediments and chemicals. Conservation tillage, which leaves at least 30 percent of the previous crop's residue on the field, improves soil quality and water infiltration and reduces erosion because more organic matter is left on the soil surface, thereby decreasing disruption of the soil. The adoption of HR crops

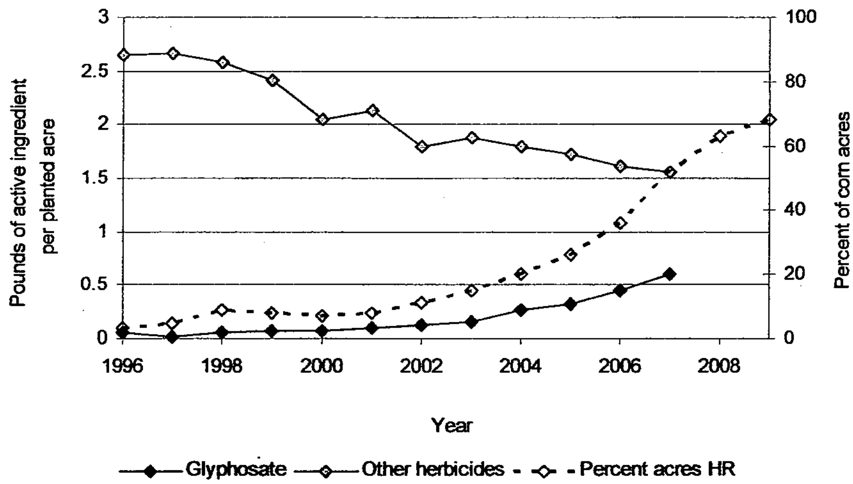

FIGURE S-3 Application of herbicide to corn and percentage of herbicide-resistant corn.
NOTE: The strong correlation between the rising percentage of HR corn acres planted over time, the increased applications of glyphosate, and the decreased use of other herbicides suggests but does not confirm causation between these variables.
SOURCE: USDA-NASS, 2001, 2003, 2005, 2007, 2009a, 2009b; Fernandez-Cornejo et al., 2009.

allows some farmers to substitute glyphosate application for some tillage operations as a weed-management tactic and thereby benefits soil quality and probably improves water quality, although definitive research on the latter is lacking. However, empirical evidence points to a two-way causal relationship between the adoption of HR crops and conservation tillage. Farmers who use conservation tillage are more likely to adopt HR crop varieties than those who use conventional tillage, and those who adopt HR crop varieties are more likely to practice conservation tillage than those who use non-GE seeds.

Finding 3. Targeting specific plant insect pests with Bt corn and cotton has been successful, and the ability to target specific plant pests in corn and cotton continues to expand. Insecticide use has decreased with the adoption of insect-resistant (IR) crops. The emergence of insect resistance to Bt crops has been low so far and of little economic or agronomic consequence; two pest species have evolved resistance to Bt crops in the United States.

Bt toxins, which are produced by the soil-dwelling bacterium *Bacillus thuringiensis*, are lethal to the larvae of particular species of moths, butterflies, flies, and beetles and are effective only when an insect ingests the toxin. Therefore, crops engineered to produce Bt toxins that target specific pest taxa have had favorable environmental effects when replacing broad-spectrum insecticides that kill most insects (including beneficial insects, such as honey bees or natural enemies that prey on other insects), regardless of their status as plant pests. The amounts of insecticides applied per planted acre of Bt corn and cotton have inverse relationships with the adoption of these crops over time (Figures S-4 and S-5), though a causative relationship has not been established or refuted because other factors influence pesticide-use patterns.

Since their introduction in 1996, the use of IR crops has increased rapidly, and they continue to be effective. Data indicate that the abundance of refuges of non-Bt host plants and recessive inheritance of resistance are two key factors influencing the evolution of resistance. The refuge strategies mandated by the Environmental Protection Agency, and the promotion of such strategies by industry, likely contributed to increasing the use of refuges and to delaying the evolution of resistance to Bt in key pests.

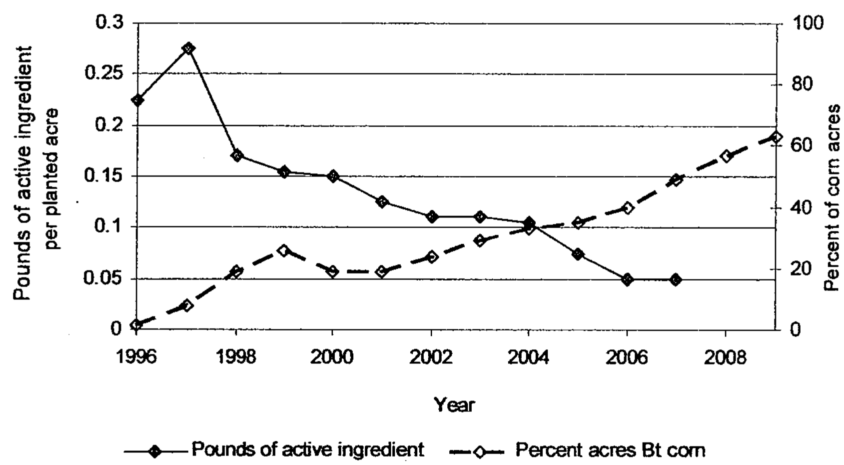

FIGURE S-4 Pounds of active ingredient of insecticide applied per planted acre and percent acres of Bt corn, respectively.
NOTE: The strong correlation between the rising percentage of Bt corn acres planted over time and the decrease in pounds of active ingredient per planted acre suggests but does not confirm causation between these variables.
SOURCE: USDA-NASS, 2001, 2003, 2005, 2007, 2009a, 2009b; Fernandez-Cornejo et al., 2009.

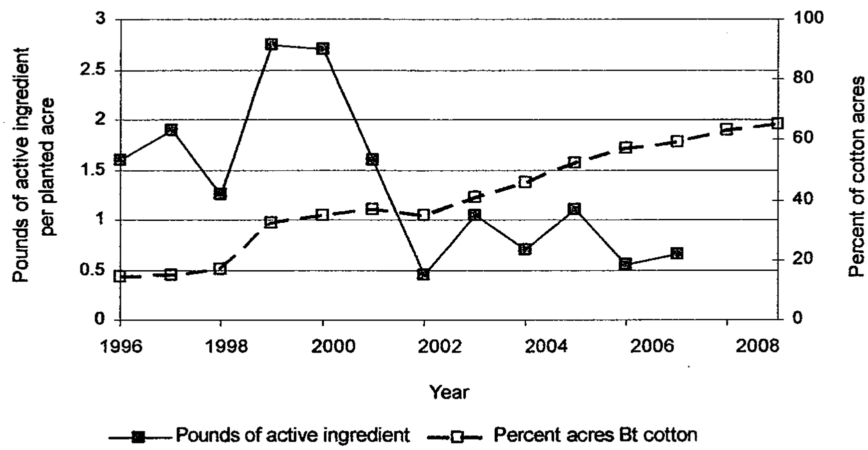

FIGURE S-5 Pounds of active ingredient of insecticide applied per planted acre and percent acres of Bt cotton, respectively.
NOTE: The strong correlation between the rising percentage of Bt cotton acres planted over time and the decrease in pounds of active ingredient per planted acre suggests but does not confirm causation between these variables.
SOURCE: USDA-NASS, 2001, 2003, 2005, 2007, 2009a, 2009b; Fernandez-Cornejo et al., 2009.

Nevertheless, some populations of two generalist pests have evolved resistance to Bt crops in the United States, although the agronomic and economic consequences appear to be minor. With the introduction of multiple Bt toxins in new hybrids or varieties, the probability of resistance to Bt crops is further reduced.

Finding 4. For the three major GE crops, gene flow to wild or weedy relatives has not been a concern to date because compatible relatives of corn and soybean do not exist in the United States and are only local for cotton. For other GE crops, the situation varies according to species. However, gene flow to non-GE crops has been a concern for farmers whose markets depend on an absence of GE traits in their products. The potential risks presented by gene flow may increase as GE traits are introduced into more crops.

Gene flow between many GE crops and wild or weedy relatives is low because GE crops do not have wild or weedy relatives in the United States or because the spatial overlap between a crop and its relatives is not extensive. How that relationship changes will depend on what GE crops are commercialized, whether related species with which they are capable of interbreeding are present, and the consequences of such interbreeding on weed management. Gene flow of approved GE traits into non-GE varieties of the same crops (known as adventitious presence) remains a serious concern for farmers whose market access depends on adhering to strict non-GE presence standards. Resolving this issue will require the establishment of thresholds for the presence of GE material in non-GE crops, including organic crops, that do not impose excessive costs on growers and the marketing system.

Economic Effects

The rapid adoption of GE crops since their commercialization indicates that the benefits to adopting farmers are substantial and generally outweigh additional technology fees for these seeds and other associated costs. The economic benefits and costs associated with GE crops extend beyond farmers who use the technology and will change with continuing adoption in the United States and abroad as new products emerge.

Finding 5. Farmers who have adopted GE crops have experienced lower costs of production and obtained higher yields in many cases because of more cost-effective weed control and reduced losses from insect pests. Many farmers have benefited economically from the adoption of Bt crops by using lower amounts of or less expensive insecticide applications, particularly where insect pest populations were high and difficult to treat before the advent of Bt crops.

The incomes of those who have adopted genetic-engineering technology have benefited from some combination of yield protection and lower costs of production. HR crops have not substantially increased yields, but their use has facilitated more cost-effective weed control, especially on farms where weeds resistant to glyphosate have not yet been identified. Lower yields were sometimes observed when HR crops were introduced, but the herbicide-resistant trait has since been incorporated into higher-yielding cultivars, and technological improvement in inserting the trait has also helped to eliminate the yield difference. In areas that suffer substantial damage from insects that are susceptible to the Bt toxins, IR crops have increased adopters' net incomes because of higher yields and reduced insecticide expenditures. Before the introduction of Bt crops, most farmers accepted yield losses to European corn borer rather than incur the expense and uncertainty of chemical control. Bt traits to address corn rootworm problems have lowered the use of soil-applied and seed-applied insecticides. In areas of high susceptible insect populations, Bt cotton has been found to protect yields with fewer applications of topical insecticides. More effective management of weeds and insects also means that farmers may not have to apply insecticides or till for weeds as often, and this translates into cost savings—lower expenditures for pesticides and less labor and fuel for equipment operations.

Finding 6. Adopters of GE crops experience increased worker safety and greater simplicity and flexibility in farm management, benefitting farmers even though the cost of GE seed is higher than non-GE seed. Newer varieties of GE crops with multiple GE traits appear to reduce production risk for adopters.

Farmers who purchase GE seed pay a technology fee—a means by which seed developers recover research and development costs and earn profits. GE seed is typically more expensive than conventional seed, and the net return in terms of higher yields and lower costs of production for a farmer considering adoption does not always offset the technology fee. However, studies have found that high rates of adoption of GE crops can be attributed in part to the value that farmers place on increased worker safety, perceived greater simplicity and flexibility in farm management (including more off-farm work opportunities), and lower production risk. Farmers and their employees not only face reduced exposure to the harsh chemicals found in some herbicides and insecticides used before the introduction of GE crops but have to spend less time in the field applying the pesticides. Because glyphosate can be applied over a fairly wide timeframe, farmers who use HR crops have greater flexibility regarding when they treat weeds in their fields. Those benefits must be balanced with the risk that such flexibility in application timing may reduce crop-yield potential attributable to weed interference. Newer GE varieties that have multiple pest-control traits may result in more consistent pest management and thus less yield variability, a characteristic that has substantial value for risk-averse producers. The value of those benefits may provide additional incentives for adoption that counteract the extra cost of GE seed.

Finding 7. The effect GE crops have had on prices received by farmers for soybean, corn, and cotton is not completely understood.

Studies suggest that the adoption of GE crops that confer productivity increases ultimately puts downward pressure on the market prices of the crops. However, early adopters benefit from higher yields or lower production costs more than nonadopters even with lower prices. The gains tend to dissipate as the number of adopters increases, holding technological progress constant. Thus, as the first adopters, U.S. farmers have generally benefited economically from the fact that GE crops were developed and commercialized in the United States before they were planted by farmers in other countries. The extent to which GE-crop adoption in developing countries will influence productivity and prices, and therefore U.S. farm incomes, is not completely understood. There is a paucity of studies of the economic effects of genetic-engineering technology in recent years even though adoption has increased globally.

Finding 8. To the extent that economic effects of GE-crop plantings on non-GE producers are understood, the results are mixed. By and large, these effects have not received adequate research.

Decisions made by adopters of GE crops can affect the input prices and options for both farmers who use feed and food products made with GE ingredients and farmers who have chosen not to grow GE seed or do not have the option available. The effects on those not using genetic-engineering technology have not been studied extensively. Livestock producers constitute a large percentage of corn and soybean buyers and therefore are major beneficiaries of any downward pressure on crop price due to the adoption of GE crops. Feed costs are nearly half the variable costs for livestock producers, so even moderate price fluctuations can affect their net incomes substantially. Livestock producers also benefit from increased feed safety due to reduced levels of mycotoxins in the grain. However, no quantitative estimation of savings to livestock operators due to the adoption of GE crops and the resulting effect on the profitability of livestock operations has been conducted. Similarly, a number of other economic effects predicted by economic theory have not been documented.

Favorable and unfavorable externalities are not limited to the cost and availability of inputs. To the extent that genetic-engineering technology successfully reduces pest pressure on a field and regionally, farmers of fields in the agricultural landscape planted with non-GE crops may benefit via lower pest-control costs associated with reductions in pest populations. However, nonadopters of genetic-engineering technology also could suffer from the development of weeds and insects that have acquired pesticide resistance in fields within the region planted to GE crops. When that happens, farmers might have to resort to managing the resistant pests with additional, potentially more toxic or more expensive forms of control, even though their practices may not have led to the evolution of resistance.

Inadvertent gene flow from GE to non-GE varieties of crops can increase production costs. Gene flow occurs through cross-pollination between GE and non-GE plants from different fields, co-mingling of GE seed with non-GE seed, and germination of seeds left behind (volunteers) after the production year. Similarly, if GE traits cross into weedy relatives, weed-control expenses will be higher for all fields on to which the weeds spread, whether a farmer grows GE crops or not. In addition, gene flow of GE traits into organic crops could jeopardize crop value by rendering outputs unsuitable for high-value foreign or other markets that limit or do not permit GE material in food products; the extent of that effect has not been documented during the last 5 years. On the other hand, the segregation of GE traits from organic production may have benefited organic producers by creating a market in which they can receive a premium for non-GE products.

Social Effects

The use of GE crops, like the adoption of other technologies at the farm level, is a dynamic process that both affects and is affected by the social networks that farmers have with each other, with other actors in the commodity chain, and with the broader community in which farm households reside. However, the social effects of GE-crop adoption have been largely overlooked.

Finding 9. Research on the dissemination of earlier technological development in agriculture suggests that favorable and unfavorable social impacts exist from the dissemination of genetic-engineering technology. However, these impacts have not been identified or analyzed.

Because GE crops have been widely adopted rapidly, it is reasonable to hypothesize that there have been social effects on adopters, nonadopters, and farmers who use GE products, such as livestock producers. For example, based on earlier research on the introduction of new technologies in agriculture, it is possible that certain categories of farmers (such as those with less access to credit, those with fewer social connections to university and private-sector researchers, or those who grow crops for smaller markets) might be less able to access or benefit from GE crops. The introduction of genetic-engineering technology in agriculture could also affect labor dynamics, farm structure, community viability, and farmers' relationships with each other and with information and input suppliers. However, the extent of the social effects of the dissemination of GE crops is unknown because little research has been conducted.

Finding 10. The proprietary terms under which private-sector firms supply GE seeds to the market has not adversely affected the economic welfare of farmers who adopt GE crops. Nevertheless, ongoing research

is needed to investigate how market structure may evolve and affect access to non-GE or single-trait seed. Furthermore, there has been little research on how increasing market concentration of seed suppliers affects overall yield benefits, crop genetic diversity, seed prices, and farmers' planting decisions and options.

During the 20th century, the U.S. seed industry evolved from small, family-owned businesses that multiplied seeds developed by university scientists to a market dominated by a handful of large, diversified companies. Universities still contribute to seed development, but seed companies have invested considerably in the research, development, and commercialization of patent-protected GE traits for large seed markets. Thus, corn, soybean, and cotton have received the bulk of private research attention in the last few decades. Large seed companies have not commercialized GE traits in many other crops because their market size has been insufficient to cover necessary research and development costs or because of concerns related to consumer acceptance and gene flow. Public research institutions continue to enhance the genetics of other crops, but full access to state-of-the-art technology (like genetic engineering) that may be beneficial to crops in smaller markets is often not available to public researchers because of patent protections.

Studies conducted in the first few years after the introduction of GE crops found no adverse effects on farmers' economic welfare from the consolidation of market power in the seed industry. However, the current developmental trajectory of GE-seed technology is causing some farmers to express concern that access to seeds without GE traits or to seeds that have only the specific GE traits that are of particular interest to farmers will become increasingly limited. Additional concerns are being raised about the lack of farmer input into and knowledge about which seed traits are being developed. Although the committee was not able to find published peer-reviewed material that documented the degree of U.S. farmers' access to non-GE seed and the quality of the seed, testimony provided to the committee suggests that access to non-GE or nonstacked seed may be restricted for some farmers or that available non-GE or nonstacked seed may be available in older cultivars that do not have the same yield characteristics as newer GE cultivars.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion 1. Weed problems in fields of HR crops will become more common as weeds evolve resistance to glyphosate or weed communities less susceptible to glyphosate become established in areas treated exclusively with that herbicide. Though problems of evolved resistance

and weed shifts are not unique to HR crops, their occurrence, which is documented, diminishes the effectiveness of a weed-control practice that has minimal environmental impacts. Weed resistance to glyphosate may cause farmers to return to tillage as a weed-management tool and to the use of potentially more toxic herbicides.

A number of new genetically engineered HR cultivars are currently under development and may provide growers with other weed-management options when fully commercialized. However, the sustainability of those new GE cultivars will also be a function of how the traits are managed. If they are managed in the same fashion as the current genetically engineered HR cultivars, the same problems of evolved herbicide resistance and weed shifts may occur. Therefore, farmers of HR crops should incorporate more diverse management practices, such as herbicide rotation, herbicide application sequences, and tank-mixes of more than one herbicide; herbicides with different modes of action, methods of application, and persistence; cultural and mechanical control practices; and equipment-cleaning and harvesting practices that minimize the dispersal of HR weeds.

Recommendation 1. Federal and state government agencies, private-sector technology developers, universities, farmer organizations, and other relevant stakeholders should collaborate to document emerging weed-resistance problems and to develop cost-effective resistance-management programs and practices that preserve effective weed control in HR crops.

Conclusion 2. Given that agriculture is the largest source of surface water pollution, improvements in water quality resulting from the complementary nature of herbicide-resistance technology and conservation tillage may represent the largest single environmental benefit of GE crops. However, the infrastructure to track and analyze these effects is not in place.

Recommendation 2. The U.S. Geological Survey and companion federal and state environmental agencies should receive the financial resources necessary to document the water quality effects related to the adoption of GE crops.

Conclusion 3. The environmental, economic, and social effects on adopters and nonadopters of GE crops has changed over time, particularly because of changes in pest responses to GE crops, the consolidation of the seed industry, and the incorporation of GE traits into most varieties of corn, soybean, and cotton. However, empirical research into the environmental and economic effects of changing market conditions and farmer practices have not kept pace. Furthermore, little work has

been conducted regarding the effects on livestock producers and non-adopters and on the social impacts of GE crops. Issues in need of further investigation include the costs and benefits of shifts in pest management for non-GE producers due to the adoption of GE crops, the value of market opportunities afforded to organic farmers by defining their products as non-GE, the economic impacts of GE-crop adoption on livestock producers, and the costs to farmers, marketers, and processors of the presence of approved or unapproved GE traits and crops in products intended for restricted markets. As more GE traits are developed and inserted into existing GE crops or into other crops, understanding the impacts on all farmers will become even more important to ensuring that genetic-engineering technology is used in a way that facilitates environment, economic, and social sustainability in U.S. agriculture.

Recommendation 3. Public and private research institutions should allocate sufficient resources to monitor and assess the substantial environmental, economic, and social effects of current and emerging agricultural biotechnology on U.S. farms so that technology developers, policy makers, and farmers can make decisions that ensure genetic engineering is a technology that contributes to sustainable agriculture.

Conclusion 4. Commercialized GE traits are targeted at pest control, and when used properly, they have been effective at reducing pest problems with economic and environmental benefits to farmers. However, genetic engineering could be used in more crops, in novel ways beyond herbicide and insect resistance, and for a greater diversity of purposes. With proper management, genetic-engineering technology could help address food insecurity by reducing yield losses through its introduction into other crops and with the development of other yield protection traits like drought tolerance. Crop biotechnology could also address "public goods" issues that will be undersupplied by the market acting alone. Some firms are working on GE traits that address public goods issues. However, industry has insufficient incentive to invest enough in research and development for those purposes when firms cannot collect revenue from innovations that generate net benefits beyond the farm. Therefore, the development of these traits will require greater collaboration between the public and private sectors because the benefits extend beyond farmers to the society in general. The implementation of a targeted and tailored regulatory approach to GE-trait development and commercialization that meets human and environmental safety standards while minimizing unnecessary expenses will aid this agenda (Ervin and Welsh, 2006).

Recommendation 4. Public and private research institutions should be eligible for government support to develop GE crops that can deliver valuable public goods but have insufficient market potential to justify private investment. Intellectual property patented in the course of developing major crops should continue to be made available for such public goods purposes to the extent possible. Furthermore, support should be focused on expanding the purview of genetic-engineering technology in both the private and public sectors to address public goods issues. Examples of GE-crop developments that could deliver such public goods include but are not limited to

- *plants that reduce pollution of off-farm waterways through improved use of nitrogen and phosphorus fertilizers,*
- *plants that fix their own nitrogen and reduce pollution caused by fertilizer application,*
- *plants that improve feedstocks for renewable energy,*
- *plants with reduced water requirements that slow the depletion of regional water resources,*
- *plants with improved nutritional quality that deliver health benefits, and*
- *plants resilient to changing climate conditions.*

REFERENCES

Ervin, D., and R. Welsh. 2006. Environmental effects of genetically modified crops: Differentiated risk assessment and management. In *Regulating agricultural biotechnology: Economics and policy*. eds. R.E. Just, J.M. Alston, and D. Zilberman, pp. 301–326. New York: Springer.

Fernandez-Cornejo, J., R. Nehring, E.N. Sinha, A. Grube, and A. Vialou. 2009. Assessing recent trends in pesticide use in U.S. agriculture. Paper presented at the 2009 Annual Meeting of the Agricultural and Applied Economics Association (Milwaukee, WI, July 26–28, 2009). Available online at http://aeconsearch.umn.edu/handle/49271. Accessed June 16, 2009.

USDA-NASS (U.S. Department of Agriculture–National Agricultural Statistics Service). 2001. Acreage. June 29. Cr Pr 2-5 (6-01). Washington, DC. Available online at http://usda.mannlib.cornell.edu/usda/nass/Acre//2000s/2001/Acre-06-29-2001.pdf. Accessed April 14, 2009.

———. 2003. Acreage. June 30. Cr Pr 2-5 (6-03). Washington, DC. Available online at http://usda.mannlib.cornell.edu/usda/nass/Acre//2000s/2003/Acre-06-30-2003.pdf. Accessed April 14, 2009.

———. 2005. Acreage. June 30. Cr Pr 2-5 (6-05). Washington, DC. Available online at http://usda.mannlib.cornell.edu/usda/nass/Acre//2000s/2005/Acre-06-30-2005.pdf. Accessed April 14, 2009.

———. 2007. Acreage. June 29. Cr Pr 2-5 (6-07). Washington, DC. Available online at http://usda.mannlib.cornell.edu/usda/nass/Acre//2000s/2007/Acre-06-29-2007.pdf. Accessed April 14, 2009.

———. 2009a. Data and statistics: Quick stats. Washington, DC. Available online at http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp. Accessed June 22, 2009.

———. 2009b. Acreage. June 30. Cr Pr 2-5 (6-09). Washington, DC. Available online at http://usda.mannlib.cornell.edu/usda/current/Acre/Acre-06-30-2009.pdf. Accessed November 24, 2009.

THE IMPACT OF **GENETICALLY ENGINEERED CROPS** ON **FARM SUSTAINABILITY** IN THE UNITED STATES

Committee on the Impact of Biotechnology on
Farm-Level Economics and Sustainability

Board on Agriculture and Natural Resources

Division on Earth and Life Studies

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[1]The views expressed here are those of the authors and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Preface

Not since the introduction of hybrid corn seed have we witnessed such a sweeping technological change in U.S. agriculture. Hundreds of thousands of farmers have adopted the first generation of genetically engineered (GE) crops since their commercialization in 1996. Although not all GE varieties that have been commercialized have succeeded, those targeted at improved pest control now cover over 80 percent of the acres planted to soybean, cotton, and corn—that is, almost half of U.S. cropland. Forecasts suggest an expansion in GE-crop plantings in many other countries.

GE crops originate in advances in molecular and cellular biology that enable scientists to introduce desirable traits from other species into crop plants or to alter crop plants' genomes internally. Those powerful scientific techniques have dramatically expanded the boundaries that have constrained traditional plant breeding. A new technology adopted so widely and rapidly has substantial economic, social, and environmental impacts on farms and their operators. Inevitably, both advantages and risks or losses emerge from such massive changes. The National Research Council has conducted multiple studies of specific aspects of GE crops, such as regulatory-system adequacy and food safety. However, the assigned tasks restricted the scope of their reports. As pressure mounts to expand the use of GE crops for energy, food security, environmental improvement, and other purposes, the scope and intensity of impacts will grow. Now is an opportune time to take a comprehensive look at the track record of GE crops and to identify the opportunities and challenges looming on the horizon. The National Research Council therefore supported the Committee on the Impact of Biotechnology on Farm-Level Economics and Sustainability to investigate this topic.

Despite the rapid spread of GE crops in U.S. agriculture, the technology continues to stir controversy around scientific issues and ideological viewpoints. The committee focused on the scientific questions associated with the farm-level impacts of the adoption of genetic-engineering technology and refrained from analyzing ideological positions, either pro or con. The committee adopted an "evidentiary" standard of using peer-reviewed literature on which to form our conclusions and recommendations. It is my hope that the report will give readers a firm grasp of the state of evidence or lack thereof on the scientific issues.

True to its charge, the committee adopted a sustainability framework that required an evaluation of environmental, economic, and social impacts of GE crops. Those three dimensions constitute the essential pillars of sustainability science. The summary and opening and closing chapters bring together the three perspectives for a fuller view of the technology's impact.

Given the controversies, readers will want to know the committee's composition and how it conducted its work in arriving at conclusions and recommendations. The biographies in Appendix C show a group of highly accomplished natural and social scientists who possess a broad array of research experience and perspectives on GE crops. That diversity of disciplines and expertise proved beneficial in introducing checks and balances in evaluating information from many angles. The committee members divided into teams to work on the various sections of the report on the basis of the members' expertise. The drafts by each team were reviewed by the full committee to ensure that everyone had a chance to comment on and improve and approve each section. I was continually impressed with the members' dedication to a hard-nosed and impartial evaluation of the best science on GE crops. Equally important, they kept open minds in considering new evidence presented by their colleagues and external experts. The result was a model multidisciplinary research process in which each of us learned from the others and improved the report quality.

In closing, I want to express my deep appreciation to the committee members for their tireless work and good humor in completing such a challenging task while working full time at their regular jobs. Their commitment and professionalism exemplify the best of public science. Each member made significant contributions to the final report. The committee also benefited from the testimony of several experts in the field and from the numerous comments of many conscientious external reviewers.

Finally, the quality of the report would not have been attained without excellent support and substantive input by study director Kara Laney, the valuable assistance of Kamweti Mutu, the insightful counsel of Robin Schoen, and the editorial work of the National Research Council.

David E. Ervin, *Chair*
Committee on the Impact of Biotechnology
on Farm-Level Economics and Sustainability

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This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council Report Review Committee. The purpose of the independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of the report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of the report was overseen by Drs. Alan G. McHughen, University of California, Riverside, and May R. Berenbaum, University of Illinois, Urbana-Champaign. Appointed by the National Research Council, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests with the authoring committee and the institution.

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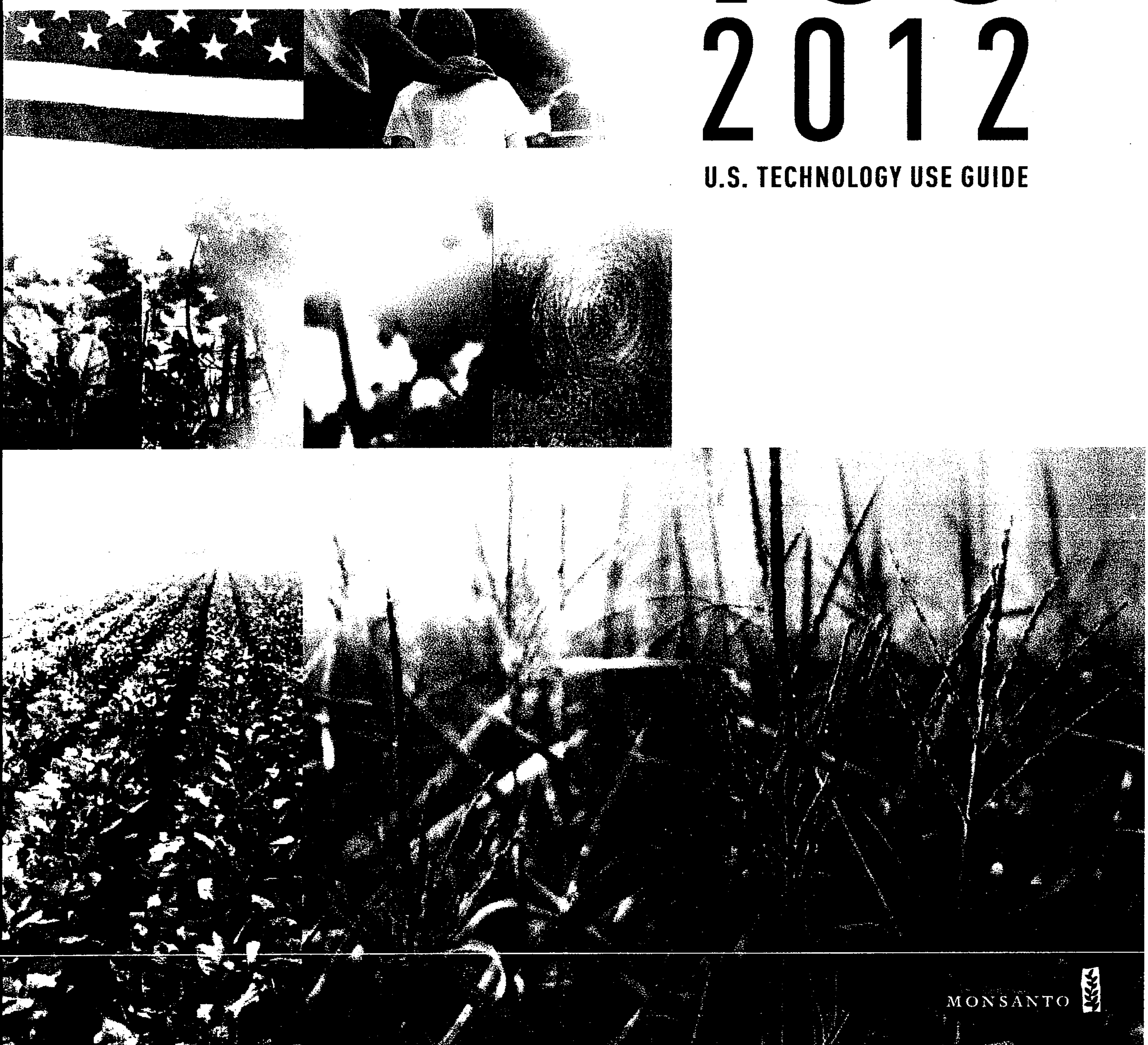
Abbreviations and Acronyms

ACCase	acetyl-CoA carboxylase
ALS	acetolactate synthase
AMPA	aminomethylphosphonic acid
APHIS	Animal and Plant Health Inspection Service (U.S. Department of Agriculture)
BST	bovine somatotropin
Bt	*Bacillus thuringiensis*
Cry	crystal-like (protein)
DNA	deoxyribonucleic acid
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPSPS	enzyme 5-enolpyruvyl-shikimate-3-phosphate synthase
GE	genetically engineered
GMO	genetically modified organism
HPPD	hydroxyphenylpyruvate dioxygenase
HR	herbicide-resistant
IPR	intellectual-property rights

IR	insect-resistant
ISHRW	International Survey of Herbicide Resistant Weeds
MCL	maximum contaminant level
NOP	National Organic Program
NOSB	National Organic Standards Board
OFPA	Organic Foods Production Act
PTO	U.S. Patent and Trademark Office
R&D	research and development
USDA	U.S. Department of Agriculture
USDA-ERS	U.S. Department of Agriculture, Economic Research Service
USDA-NASS	U.S. Department of Agriculture, National Agricultural Statistics Service
VR	virus-resistant

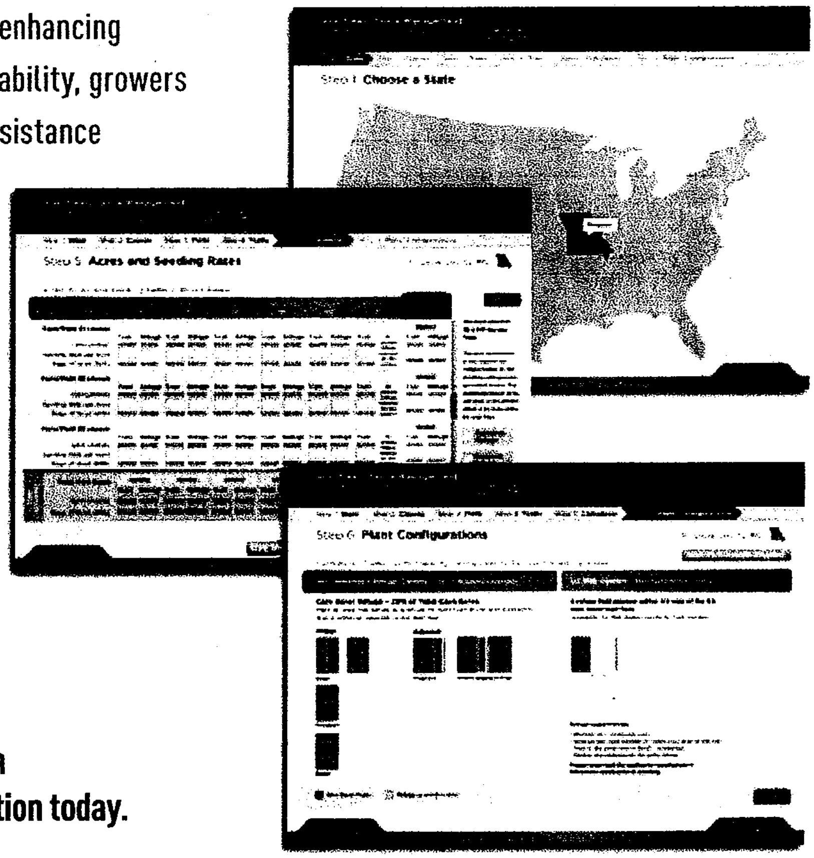
TUG 2012

U.S. TECHNOLOGY USE GUIDE



Calculating Your Corn Refuge—Made Easy!

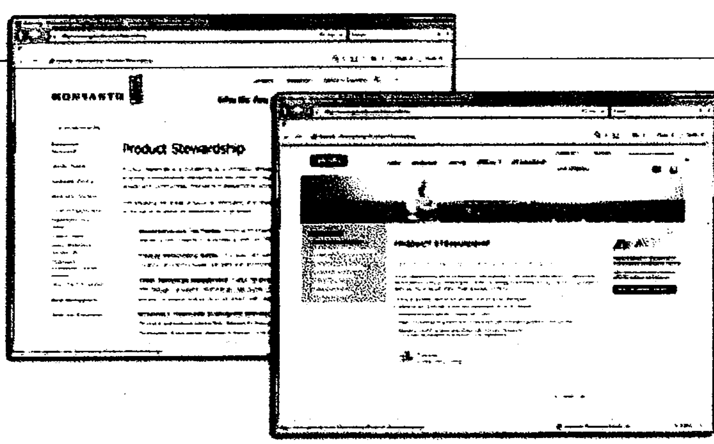
As part of our commitment to enhancing grower productivity and profitability, growers can download a free Insect Resistance Management (IRM) corn refuge calculator.



This tool will help you:

- Determine appropriate refuge calculation based upon your growing area and the trait(s) you're planting
- Calculate quantity of standard seed bags to purchase
- View possible planting options for your selected trait categories

Visit www.irmcalculator.com to download the free application today.



Now You Can Access **TRAIT STEWARDSHIP** on Genuity.com as well as Monsanto.com

INTRODUCTION

This 2012 Technology Use Guide (TUG) provides a concise source of technical information about Monsanto's current portfolio of technology products and sets forth requirements and guidelines for the use of these products. As a user of Monsanto Technology, it is important that you are familiar with and follow certain management guidelines. Please read all of the information pertaining to the technology you will be using, including stewardship and related information. Growers must read the 2012 IRM Grower Guide prior to planting for important information on planting and Insect Resistance Management.

This technical guide is not a pesticide product label. It is intended to provide additional information and to highlight approved uses from certain product labels. Read and follow all precautions and directions in the label booklet and separately published supplemental labeling for the Roundup® agricultural herbicide product you are using, as well as any other pesticide products.

Included in this guide is information on the following:

If you have any questions, contact your Authorized Retailer or Monsanto at 1-800-768-6387.

STEWARDSHIP OVERVIEW

A MESSAGE ABOUT STEWARDSHIP

Monsanto Company is committed to enhancing grower productivity and profitability through the introduction of new agricultural biotechnology traits. These new technologies bring enhanced value and benefits to growers, and growers assume new responsibilities for proper management of these traits. Growers planting seed with biotech traits agree to implement the following stewardship requirements, including, but not limited to:

- Reading, signing and complying with the Monsanto Technology/ Stewardship Agreement (MTSA) and reading all annual license terms updates before purchase or use of any seed containing a Monsanto trait.
- Reading and following the directions for use on all product labels.
- Following applicable stewardship guidelines as outlined in this TUG.
- Reading and following the IRM Grower Guide prior to planting; complying with the applicable IRM requirements for specific biotech traits as mandated by the Environmental Protection Agency (EPA).
- Observing regional planting restrictions mandated by the U.S. EPA.
- Following the Weed Resistance Management Guidelines to help minimize the risk of resistance development.
- Using seed containing Monsanto Technologies solely for planting a single commercial crop.
- Complying with any additional stewardship requirements, such as grain or feed use agreements or geographical planting restrictions, that Monsanto deems appropriate or necessary to implement for proper stewardship or regulatory compliance.
- Selling crops or material containing biotech traits only to grain handlers that confirm their acceptance, or using those products on-farm.
- Not moving material containing biotech traits across boundaries into nations where import is not permitted.
- Not selling, promoting and/or distributing within a state where the product is not yet registered.

WHY IS STEWARDSHIP IMPORTANT?

Each component of stewardship offers these benefits to growers:

- Signing the MTSA provides growers access to Monsanto's germplasm and the biotech trait technologies therein.
- Following IRM requirements guards against insect resistance to *Bacillus thuringiensis (B.t.)* and other technologies, enabling the long-term durability of these technologies and meeting EPA requirements.
- Utilizing biotech seed only for planting a single commercial crop helps preserve the effectiveness of biotech traits, and encourages investment for future biotech innovations, which further improves farming technology and productivity.

SEED PATENT INFRINGEMENT

If Monsanto reasonably believes that a grower has planted saved seed containing a Monsanto biotech trait, Monsanto will request invoices and records to confirm that fields in question have been planted with newly purchased seed. This information is to be provided within 7 days after written request. Monsanto may inspect and test all of the grower's fields to determine if saved seed has been planted. Any inspections will be coordinated with the grower and performed at a reasonable time to best accommodate the grower's schedule.

CROP OR MATERIAL HANDLING STEWARDSHIP STATEMENT

Monsanto Company is a member of Excellence Through Stewardship® (ETS). Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto's Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. Any crop or material produced from commodity crop products can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for commodity crop products. Excellence Through Stewardship® is a registered trademark of Biotechnology Industry Organization.

Do not export Genuity® Roundup Ready® alfalfa seed or crop, including hay or hay products, to China pending import approval. In addition, due to the unique cropping practices do not plant Genuity® Roundup Ready® Alfalfa in Imperial County, California, pending import approvals in China and until Monsanto grants express permission for such planting.

Do not export Genuity® Roundup Ready® Flex Pima cottonseed, meal, linters, or gin trash to Korea pending import approval.

If you have questions about seed stewardship or become aware of individuals utilizing biotech traits in a manner other than as noted above, please call 1-800-768-6387. Letters reporting unauthorized or improper use of biotech traits may be sent to:

Monsanto Trait Stewardship
800 N. Lindbergh Boulevard NC3C
St. Louis, MO 63167

For more information on Monsanto's practices related to seed patent infringement, please visit: **www.monsanto.com/ourcommitments/Pages/seed-patent-protection.aspx**

Anyone may provide Anonymous or Confidential reports as follows:

"Anonymous" reporting results when a person reports information to Monsanto in such a way that the identity of the person reporting the information cannot be identified. This kind of reporting includes telephone calls requesting anonymity and unsigned letters.

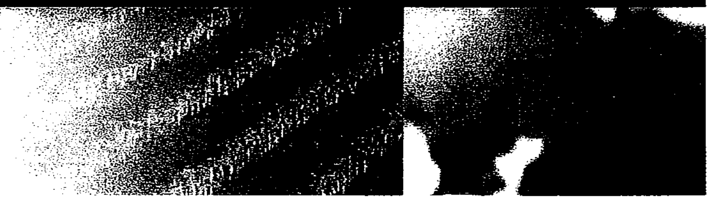
"Confidential" reporting results when a person reports information to Monsanto in such a way that the reporting person's identity is known to Monsanto. Every effort will be made to protect a person's identity, but it is important to understand that a court may order Monsanto to reveal the identity of people who are "known" to have supplied relevant information.

beyond the seed

You're buying more than just seed. You're getting value today and innovation for tomorrow.

COMMITMENT. INNOVATION. PERFORMANCE.

The Beyond the Seed Program was launched by the American Seed Trade Association (ASTA) to raise awareness and understanding of the value that goes beyond the seed. The future success of U.S. agriculture depends upon quality seed delivered by an industry commitment to bring innovation and performance through continued investment. For more information about seed technology, visit ASTA's Beyond the Seed Program at www.beyondtheseed.org.



Insect Resistance Management (IRM)

An effective IRM program is a vital part of responsible product stewardship for insect-protected biotech products. Monsanto is committed to implementing an effective IRM program for all of its insect-protected *B.t.* technologies in all countries where they are commercialized. Such programs strike a balance among available knowledge, practicality, and grower acceptance and implementation of the plan.

The U.S. EPA requires that Monsanto implement, and that growers who purchase insect-protected products follow, an IRM plan. IRM programs for *B.t.* traits are based upon an assessment of the biology of the major target pests, grower needs and practices, and appropriate pest management practices. These mandatory regulatory programs have been developed and updated in cooperation with grower and consultant organizations, including the National Corn Growers Association and the National Cotton Council, extension specialists, academic scientists, and regulatory agencies.

These programs contain several important elements. One key component is a refuge. A refuge is simply a portion of the relevant crop (corn or cotton) that does not contain a *B.t.* technology for the insect pests targeted by the planted biotechnologies. The lack of exposure to the *B.t.* proteins in refuges means that there will be susceptible insects nearby to mate with any rare resistant insects that may emerge from the biotech crop. Susceptibility to *B.t.* products is then passed to offspring, preserving the long-term effectiveness of the technology.

Growers who purchase seeds containing *B.t.* traits must plant a structured refuge.* Refuge size, configuration, and management are described in detail in the current IRM Grower Guide.

Monsanto is committed to the preservation of *B.t.* technologies. Please do your part to preserve *B.t.* technologies by implementing the correct IRM plan on your farm. Failure to follow IRM requirements and to plant a proper refuge may result in the loss of a grower's access to Monsanto technologies.

COMPLIANCE MONITORING PROGRAM

The U.S. EPA requires Monsanto to take corrective measures in response to a finding of grower IRM non-compliance. As mandated by the EPA, Monsanto or an approved agent of Monsanto must monitor refuge management requirements. The MTSA signed by the grower requires that upon request by Monsanto or its approved agent, a grower must provide the location of all fields planted with Monsanto technologies and the locations of all associated refuge required areas. The grower must cooperate fully with any field inspections, and allow Monsanto or an agent of Monsanto to inspect all fields and refuge areas to ensure an approved insect resistance management program has been followed. All inspections will be performed at a reasonable time and arranged in advance with the grower so that the grower can be present.

IRM REQUIREMENT

Growers must read the current IRM Grower Guide prior to planting for information on required IRM. You may download a copy of the current IRM Grower Guide at **www.monsanto.com** or **www.genuity.com**, or you may call 1-800-768-6387 to request a copy by mail.

Before opening a bag of seed, be sure to read, understand and accept the stewardship requirements, **including applicable refuge requirements for insect resistance management**, for the biotechnology traits expressed in the seed as set forth in the Monsanto Technology/Stewardship Agreement that you sign. By opening and using a bag of seed, you are reaffirming your obligation to comply with the most recent stewardship requirements.

*In some areas, a natural refuge option is available for Genuity® Bollgard II®. There are no requirements for a separate structured refuge for Genuity® SmartStax® RIB Complete™ corn when planted in the U.S. Corn-Growing Area. However, Genuity SmartStax RIB Complete requires a 20% planted, structured refuge in the Cotton-Growing Area. See the current IRM Grower Guide for details.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) describes an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information is used to manage pests in a manner that is least harmful to people, property and the environment.

PREVENTION

Use the best agronomic management practices, in conjunction with the appropriate seed product, to obtain the greatest yield benefits.

Use seed products, seeding rates and planting technologies appropriate for each specific crop and geographical area. As much as possible, manage the crop to avoid plant stress.

- Employ appropriate scouting techniques and treatment decisions to preserve beneficial insects that can provide additional insect pest control.
- Manage for appropriate maturity and harvest schedules. Destroy crop residue immediately after harvest to avoid regrowth and minimize selection for resistance in late-season infestations.
- Use soil management practices that encourage destruction of over-wintering pests.
- Use proper crop rotation practices and target pests with multiple modes of action to make it more difficult for pests to adapt. In areas where crop rotation is not practiced, or where rotation occurs but high pest populations are observed, the use of products with multiple modes of action, such as Genuity® SmartStax® RIB Complete™, is strongly recommended.

MONITORING PESTS

Carefully monitor fields for all pests to determine the need for remedial insecticide treatments. For target pests, scouting techniques and supplemental treatment decisions should take into account the fact that larvae must hatch and feed before they can be affected by the *B.t.* protein(s). Fields should be scouted regularly, following periods of heavy or sustained egg lay, especially during bloom, to determine if significant larval survival has occurred.

In cotton, scouting should include a modified whole-plant inspection, including terminals and all stages of fruit. Larvae larger than 1/4 inch (3- to 4-days old) are generally recognized as survivors that may not be controlled by Genuity® Bollgard II® cotton.

CONTROLLING COTTON PESTS

Monsanto recommends the use of appropriate remedial insecticide treatments to ensure desired levels of control if any cotton insect pest reaches locally established thresholds in Genuity Bollgard II cotton.

Although Genuity Bollgard II cotton will sustain less damage from some of the most troublesome lepidopteran pests, it will not provide protection against all pests and may require insecticide treatments of target pests under conditions of high pest pressure. Insect pests should be monitored and treated with insecticides when necessary, using recommended thresholds and following label directions. Whenever possible, select insecticides that are least harmful to beneficial insects.

Weed Management

Monsanto believes product stewardship is a fundamental component of customer service and responsible business practices. Monsanto is committed to the proper use and long-term effectiveness of its proprietary herbicide brands through a four-part stewardship program: developing appropriate weed control recommendations, continuing research to refine and update recommendations, education on the importance of effective weed management and responding to repeated weed control inquiries through a product performance evaluation program.

As leaders in the development and stewardship of Roundup® agricultural herbicides and other products, Monsanto invests significantly in research done in conjunction with academic scientists, extension specialists and crop consultants, that includes an evaluation of the factors that can contribute to the development of weed resistance and how to properly manage weeds to delay the selection for weed resistance. Visit **www.weedtool.com** for practical, best practices-based information on reducing the risk for development of glyphosate-resistant weeds and for managing the risk on a field-by-field basis. In addition, visit **www.wssa.net** to access weed resistance training lessons that provide in-depth educational materials.

GROUP NUMBER

Glyphosate, the active ingredient in Roundup agricultural herbicides, is a Group 9 herbicide based on the mode of action classification system of the Weed Science Society of America. Any weed population may contain plants naturally resistant to Group 9 herbicides. Such resistant weed plants may not be effectively managed using Group 9 herbicides, but may be effectively managed utilizing another herbicide alone or in mixtures from a different Group and/or by using cultural or mechanical practices. However, a herbicide mechanism of action classification by itself may not adequately address specific weeds that are resistant to specific herbicides. Consult your local company representative, state cooperative extension service, professional consultants or other qualified authorities to determine appropriate actions for treating specific resistant weeds.

WEED MANAGEMENT GUIDELINES

Proactively implementing diversified weed control strategies to help minimize selection for weed populations resistant to one or more herbicides is recommended. A diversified weed management program may include the use of multiple herbicides with different mechanisms of action and overlapping weed spectrum with or without tillage operations and/or other cultural practices. Research has demonstrated that using the labeled rate and following label use directions is important to delay the selection for resistance. Scouting after a herbicide application is important because it can facilitate the early identification of weed shifts and/or weed resistance and thus provide direction on future weed management practices. One of the best ways to contain resistant populations is to implement measures to avoid allowing weeds to reproduce by seed or to proliferate vegetatively. Cleaning equipment between sites and avoiding movement of plant material between sites will greatly aid in retarding the spread of resistant weed seed.

In Roundup Ready® cropping systems it is also important to start with a clean field, using either a burndown herbicide application or tillage, and to optimize glyphosate performance by controlling weeds early when they are small and actively growing.

In summary,

- Start with a clean field, free of weeds
- Use a diverse set of weed control tools, including residual herbicides that use a different mechanism of action
- Add other products, at the right rate and timing for the weed, to Roundup agricultural herbicides when needed
- Control weed escapes and remove weeds before they set seed

The Roundup Ready PLUS™ program sponsored by Monsanto is based upon the principle of growers implementing diversified weed management programs in Roundup Ready crops as described above. It is composed of recommendations and programs. Roundup Ready PLUS represents Monsanto's commitment to stewarding weed resistance to glyphosate and other herbicides in Roundup Ready crops. For more information visit **www.roundupreadyplus.com.**

GLYPHOSATE-RESISTANT WEEDS

Monsanto actively investigates and studies weed control complaints and claims of weed resistance. When glyphosate-resistant weed biotypes are confirmed, Monsanto provides recommended control measures, which may include additional herbicides, tank-mixes or cultural practices. Monsanto actively communicates all of this information to growers through multiple channels, including the herbicide label, **www.weedscience.org,** supplemental labeling, this TUG, media and written communications, Monsanto's website, **www.weedmanagement.com,** and grower meetings.

Growers must be aware of, and proactively manage for, glyphosate-resistant weeds in planning their weed control program. If a weed is known to be resistant to glyphosate, then a resistant population of that weed is by definition no longer controlled with labeled rates of glyphosate. Roundup® agricultural herbicides are not warranted to cover the failure to control glyphosate-resistant weed populations.

Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

Read and follow all product labeling before making in-crop or other applications of Roundup® agricultural herbicides or using any other pesticide. For supplemental labels or fact sheets for Monsanto products, call 1-800-768-6387. Monsanto does not restrict your ability to use approved glyphosate-herbicides, other than Roundup agricultural herbicides, so long as the product is specifically approved for in-crop use on the applicable crop. Read the product label or contact the product manufacturer if you have questions about EPA or state approvals for in-crop use. MONSANTO DOES NOT MAKE ANY REPRESENTATIONS, WARRANTIES OR RECOMMENDATIONS CONCERNING THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES WHICH ARE LABELED FOR USE ON CROPS CONTAINING ROUNDUP READY® TECHNOLOGIES. MONSANTO SPECIFICALLY DISCLAIMS ALL RESPONSIBILITY FOR THE USE OF THESE PRODUCTS IN CROPS CONTAINING ROUNDUP READY TECHNOLOGIES. ALL QUESTIONS AND COMPLAINTS ARISING FROM THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES SHOULD BE DIRECTED TO THOSE COMPANIES.

RECOMMENDATIONS FOR MANAGING GLYPHOSATE-RESISTANT WEEDS IN ROUNDUP READY CROPS

Various weed biotypes are known to be resistant to glyphosate. For the most current weed control recommendations for glyphosate-resistant biotypes, refer to **www.weedmanagement.com** or call 1-800-768-6387.

Approved supplemental labeling for Roundup agricultural herbicides can be obtained by calling 1-800-768-6387.

GLYPHOSATE ENDANGERED SPECIES INITIATIVE

Before making an application of any glyphosate-based herbicide product, licensed growers of crops containing Roundup Ready Technology must access the website **www.pre-serve.org** to determine whether any mitigation requirements apply to the planned application to those crops, and must follow all applicable requirements. The mitigation measures described on the website are appropriate for all applications of any glyphosate-based herbicide to all crop lands.

Growers making only ground applications to crop land with a use rate of less than 3.5 lbs. of glyphosate a.e./A are not required to access the website. If a grower does not have web access, the seed dealer can access the website on behalf of the grower to determine the applicable requirements, or the grower can call 1-800-332-3111 for assistance.

ROUNDUP BRAND AGRICULTURAL HERBICIDES FOR USE WITH ROUNDUP READY CROPS

Herbicide products sold by Monsanto for in-crop use with Roundup Ready crops for the 2012 crop season are as follows:

Roundup WeatherMAX®

Roundup PowerMAX®

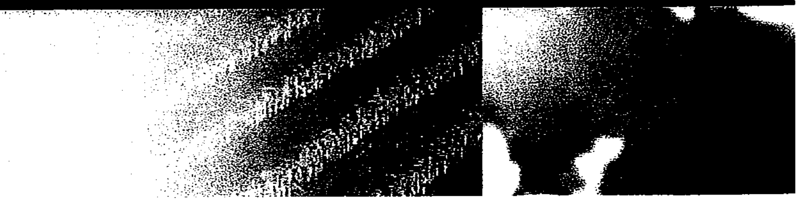
Tank-mixtures of Roundup agricultural herbicides with insecticides, fungicides, micronutrients or foliar fertilizers are not recommended as they may result in reduced weed control, crop injury, reduced pest control or antagonism. Refer to the product label, supplemental labeling or fact sheets published separately by Monsanto for the Roundup agricultural herbicides tank-mix recommendations.

SURFACTANT USE WITH ROUNDUP BRAND AGRICULTURAL HERBICIDES AND OTHER GLYPHOSATE PRODUCTS IN ROUNDUP READY CROPS

The addition of surfactants or additives containing surfactants to glyphosate spray solutions may increase the potential for crop injury.

When using Roundup WeatherMAX® or Roundup PowerMAX® herbicides, NO additional surfactant is needed for optimal performance for applications in Roundup Ready crops. Other glyphosate products labeled for use in Roundup Ready technologies may require the addition of surfactant or other additives to optimize performance.

Note: As the labels for Roundup WeatherMAX and Roundup PowerMAX state for use on Roundup Ready Cotton and Roundup Ready Flex Cotton, DO NOT add surfactant or additives containing surfactant to spray solutions of these products for postemergence (in-crop) or preharvest applications on these crops. All other glyphosate-containing agricultural products labeled for use on Roundup Ready Cotton and Roundup Ready Flex Cotton should have this same restriction; nonetheless, Monsanto does not recommend the addition of surfactant or additives containing surfactant to spray solutions of any glyphosate agricultural products used for postemergence (in-crop) or preharvest applications on these crops.



Coexistence

Coexistence in agricultural production systems and supply chains is well established and well understood. Different agricultural systems have coexisted successfully for many years around the world. Standards and best practices were established decades ago and have continually evolved to deliver high purity seed and grain to support production, distribution and trade of products from different agricultural systems. For example, production of similar commodities such as field corn, sweet corn and popcorn has occurred successfully and in close proximity for many years. Another example is the successful coexistence of oilseed rape varieties with low erucic acid content for food use and high erucic acid content for industrial uses.

The introduction of biotech crops generated renewed discussion focused on coexistence of biotech cropping systems with conventional cropping systems and organic production. These discussions have primarily focused on the potential marketing impact of the introduction of biotech products on other systems. The health and safety of biotech products are not an issue because their food, feed and environmental safety are demonstrated before they enter the agricultural production system and supply chain.

The coexistence of conventional, organic and biotech crops has been the subject of several studies and reports. These reports conclude that coexistence among biotech and non-biotech crops is not only possible but is occurring. They recommend that coexistence strategies be developed on a case-by-case basis considering the diversity of products currently in the market and under development, the agronomic and biological differences in the crops themselves and variations in regional farming practices and infrastructure. Furthermore, coexistence strategies are driven by market needs and should be developed using current science-based industry standards and management practices. The strategies must be flexible, facilitating options and choice for the grower and the food/feed supply chain, and must be capable of being modified as changes in markets and products warrant.

Successful coexistence of all agricultural systems is achievable and depends on communication, cooperation, flexibility and mutual respect for each system among growers. Agriculture has a history of innovation and change, and growers have always adapted to new approaches or challenges by utilizing appropriate strategies, farm management practices and new technologies.

The responsibility for implementing practices to satisfy specific marketing standards or certification lies with that grower who is growing a crop to satisfy a particular market. Only that grower is instructed to employ the practices appropriate to ensure the integrity of his/her crop. This is true whether the goal is high-oil corn, white/sweet corn or organically produced yellow corn for animal feed. In each case, the grower is seeking to produce a crop that is supported by a market price and consequently that grower assumes responsibility for satisfying reasonable market specifications. That said, the grower needs to be aware of the planting intentions of his/her neighbor in order to gauge the need for appropriate management practices.

Identity Preserved Production

Some growers may choose to preserve the identity of their crops to meet specific markets. Examples of Identity Preserved (I.P.) corn crops include production of seed, white, waxy or sweet corn, specialty oil or protein crops, food grade crops and any other crop that meets specialty needs, including organic and non-genetically enhanced specifications. Growers of these crops assume the responsibility and receive the benefit for ensuring that their crop meets mutually agreed-upon contract specifications.

Based on historical experience with a broad range of I.P. crops, the industry has developed generally accepted I.P. agricultural practices. These practices are intended to manage I.P. production to meet quality specifications, and are established for a broad range of I.P. needs. The accepted practice with I.P. crops is that each I.P. grower has the responsibility to implement any necessary processes. These processes may include sourcing seed appropriate for I.P. specifications, field management practices such as adequate isolation distances, buffers between crops, border rows, planned differences in maturity between adjacent fields that might cross-pollinate and harvest and handling practices designed to prevent mixing and to maintain product integrity and quality. These extra steps associated with I.P. crop production are generally accompanied by incremental increases in cost of production and consequently of the goods sold.

GENERAL INSTRUCTIONS FOR MANAGEMENT OF MECHANICAL MIXING AND POLLEN FLOW

For all crop hybrids or varieties that they wish to identity preserve, or otherwise keep separated, growers should take steps to prevent mechanical mixing. Growers should make sure all seed storage areas, transportation vehicles and planter boxes are cleaned thoroughly both prior to and subsequent to the storage, transportation or planting of the crop. Growers should also make sure all combines, harvesters and transportation vehicles used at harvest are cleaned thoroughly both prior to and subsequent to their use in connection with the harvest of the grain produced from the crop. Growers should also make sure all harvested grain is stored in clean storage areas where the identity of the grain can be preserved.

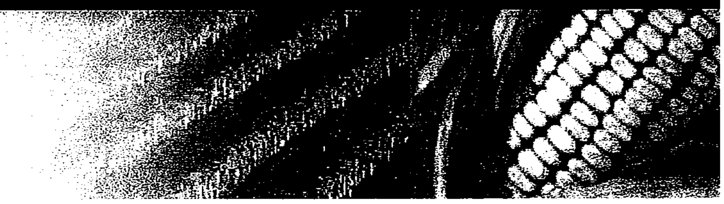
Self-pollinated crops, such as soybeans, do not present a risk of mixing by cross-pollination. If the intent is to use or market the product of a self-pollinated crop separately from general commodity use, growers should plant fields a sufficient distance away from other crops to prevent mechanical mixture during harvest.

Growers planting cross-pollinated crops, such as corn or alfalfa, who desire to preserve the identity of these crops, or to help minimize the potential for these crops to outcross with adjacent fields of the same crop kind, should use the same generally accepted practices to manage mixing that are used in any of the currently grown I.P. crops of similar crop kind.

It is generally recognized in the industry that a certain amount of incidental, trace level pollen movement occurs, and it is not possible to achieve 100% purity of seed or grain in any crop production system. A number of factors can influence the occurrence and extent of pollen movement. As stewards of technology, growers are expected to consider these factors and talk with their neighbors about their cropping intentions.

Growers should take into account the following factors that can affect the occurrence and extent of cross-pollination to or from other fields. Information that is more specific to the crop and area may be available from state extension offices.

- **Cross-pollination is limited.** Some plants, such as potatoes, are incapable of cross-pollinating, while others, like alfalfa, require cross-pollination to produce seed. Importantly, cross-pollination only occurs within the same crop kind, like corn to corn.
- **The amount of pollen produced within the field can vary.** The pollen produced by the crop within a given field, known as pollen load, is typically high enough to pollinate all of the plants in the field. Therefore, most of the pollen that may enter from other fields falls on plants that have already been pollinated with pollen that originated from plants within the field. In crops such as alfalfa, the hay cutting management schedule significantly limits or eliminates bloom, and thereby restricts the potential for pollen and/or viable seed formation.
- **The existence and degree of overlap in the pollination period of crops in adjacent fields varies.** This will vary depending on the maturity of crops, planting dates and the weather. For corn, the typical pollen shed period lasts from 5 to 10 days for a particular field. Therefore, viable pollen from neighboring fields must be present when silks are receptive in the recipient field during this brief period to produce any grain with traits introduced by the out-of-field pollen.
- **Distance between fields of different varieties or hybrids of the same crop:** The greater the distance between fields the less likely their pollen will remain viable and have an opportunity to mix and produce an outcross. For wind-pollinated crops, most cross-pollination occurs within the outermost few rows of the field. In fact, many white and waxy corn production contracts ask the grower to remove the outer 12 rows (30 ft.) of the field in order to remove most of the impurities that could result from cross-pollination with nearby yellow dent corn. Furthermore, research has also shown that as fields become further separated, the incidence of wind-modulated cross-pollination drops rapidly. Essentially, in-field pollen has an advantage over the pollen coming from other fields for receptive silks because of its volume and proximity to silks.
- **The distance pollen moves.** How far pollen can travel depends on many environmental factors, including weather during pollination, especially wind direction and velocity, temperature and humidity. For bee-pollinated crops, the grower's choice of pollinator species and apiary management practice may reduce field-to-field pollination potential. All these factors will vary from season to season, and some factors from day to day and from location to location.
- **For wind-pollinated crops, the orientation and width of the adjacent field in relation to the dominant wind direction.** Fields oriented upwind during pollination will show dramatically lower cross-pollination for wind-pollinated crops, like corn, compared to fields located downwind.



CORN TECHNOLOGIES

GENUITY® SMARTSTAX® RIB COMPLETE™ This hybrid contains Cry1A.105, Cry2Ab2, Cry1F, Cry3Bb1, Cry34Ab1 and Cry35Ab1 from *Bacillus thuringiensis (B.t.)* that together control European corn borer, southwestern corn borer, southern cornstalk borer, corn earworm, fall armyworm, stalk borer, lesser corn stalk borer, sugarcane borer, western bean cutworm, black cutworm, western corn rootworm, northern corn rootworm, and Mexican corn rootworm. Routine applications of insecticides to control these insects are usually unnecessary when corn containing Genuity SmartStax RIB Complete is planted. This hybrid also contains Roundup Ready® 2 Technology and LibertyLink® technology that provide tolerance to in-crop applications of labeled Roundup® agricultural herbicides and Ignite® herbicides, respectively, when applied according to label directions. **The refuge seed of Genuity SmartStax RIB Complete is contained in the bag, resulting in a refuge configuration that is interspersed within the field.**

GENUITY® SMARTSTAX® This hybrid contains Cry1A.105, Cry2Ab2, Cry1F, Cry3Bb1, Cry34Ab1 and Cry35Ab1 from *B.t.* that together control European corn borer, southwestern corn borer, southern cornstalk borer, corn earworm, fall armyworm, stalk borer, lesser corn stalk borer, sugarcane borer, western bean cutworm, black cutworm, western corn rootworm, northern corn rootworm, and Mexican corn rootworm. Routine applications of insecticides to control these insects are usually unnecessary when corn containing Genuity SmartStax is planted. This hybrid also contains Roundup Ready 2 Technology and LibertyLink® technology that provide tolerance to in-crop applications of labeled Roundup agricultural herbicides and Ignite® herbicides, respectively, when applied according to label directions.

GENUITY® VT TRIPLE PRO™ This hybrid contains Cry1A.105, Cry2Ab2 and Cry3Bb1 from *B.t.* that together control European corn borer, southwestern corn borer, sugarcane borer, southern cornstalk borer, corn earworm, fall armyworm, corn stalk borer, western corn rootworm, northern corn rootworm, and Mexican corn rootworm. This hybrid also contains Roundup Ready 2 Technology that provides tolerance to in-crop applications of labeled Roundup agricultural herbicides when applied according to label directions.

GENUITY® VT DOUBLE PRO™ This hybrid contains Cry1A.105 and Cry2Ab2 from *B.t.* that together control European corn borer, southwestern corn borer, sugarcane borer, southern cornstalk borer, corn earworm, corn stalk borer, and fall armyworm. This hybrid also contains Roundup Ready 2 Technology that provides tolerance to in-crop applications of labeled Roundup agricultural herbicides when applied according to label directions.

YIELDGARD VT TRIPLE® This hybrid contains Cry1Ab and Cry3Bb1 from *B.t.* that together control European corn borer, southwestern corn borer and sugarcane borer as well as excellent protection against western corn rootworm, northern corn rootworm, and Mexican corn rootworm. This hybrid also contains Roundup Ready 2 Technology that provides tolerance to in-crop applications of labeled Roundup agricultural herbicides when applied according to label directions.

YIELDGARD VT ROOTWORM/RR2® This hybrid contains the Cry3Bb1 protein from *B.t.* which controls western corn rootworm, northern corn rootworm, and Mexican corn rootworm. This hybrid contains Roundup Ready 2 Technology that provides tolerance to in-crop applications of labeled Roundup agricultural herbicides when applied according to label directions.

YIELDGARD® CORN BORER This hybrid contains Cry1Ab from *B.t.* which controls European corn borer, southwestern corn borer and sugarcane borer. YieldGard Corn Borer with Roundup Ready Corn 2 contains the Roundup Ready Corn 2 trait (NK603) that provides tolerance to in-crop applications of labeled Roundup agricultural herbicides when applied according to label directions.

ROUNDUP READY® 2 TECHNOLOGY Corn hybrids with Roundup Ready 2 Technology include Roundup Ready Corn 2 and seed products displaying the Roundup Ready 2 Technology logo. Products with Roundup Ready 2 Technology contain in-plant tolerance to the active ingredient in Roundup agricultural herbicides.

Growers must read the IRM Grower Guide prior to planting for information on required IRM. You may download a copy of the current IRM Grower Guide at **www.monsanto.com** or **www.genuity.com**, or you may **call 1-800-768-6387** to request a copy by mail.

Genuity VT Double PRO is not approved for sale or planting in Maine.

Genuity SmartStax is not approved for sale or planting in Maine, Puerto Rico (except for breeding, testing, propagation), and the U.S. Virgin Islands.

Genuity SmartStax RIB Complete is not approved for sale or planting in Maine and at the time of printing approval is pending in New York. Genuity SmartStax RIB Complete requires a 20% planted, structured refuge in the Cotton-Growing Area.

Attention: The U.S. EPA has prohibited the sale, distribution, and planting of seed containing the MON 863 Event, which includes the following Monsanto products: YieldGard® Rootworm, YieldGard Rootworm with Roundup Ready® Corn 2, YieldGard Plus® and YieldGard Plus with Roundup Ready Corn 2. Any remaining inventory of seed containing the MON 863 Event must be handled in accordance with legal and regulatory requirements (non-treated seed can be sold as grain, and treated seed must be disposed of properly).
It is a violation of federal law to sell or distribute an unregistered pesticide.

CORN WITH ROUNDUP READY® 2 TECHNOLOGY

These products include Roundup Ready 2 Technology

Weed Management

The Roundup Ready® 2 Technology system enables flexibility, broad-spectrum weed control and proven crop safety. Growers can select the weed control program that best fits the way they farm and provides them the greatest benefit. Options include the use of a residual herbicide with Roundup® agricultural herbicides, tank-mixing other herbicides with Roundup agricultural herbicides where appropriate and a total postemergence program.

Corn yield is very sensitive to early-season weed competition. Weed control systems must provide growers the opportunity to control weeds before they become competitive. The Roundup Ready 2 Technology system provides a mechanism to control weeds at planting and once they emerge. Failure to control weeds with the right rate, at the right time and with the right product, can lead to increased weed competition, weed escapes, the potential for selecting for weed resistance and possible decreased yields. Use a diversity of weed management tools, including multiple herbicide modes of action if appropriate, alone or in tank mixes, with Roundup agricultural herbicides, based on the weed spectrum in the field and according to label directions.

GUIDELINES

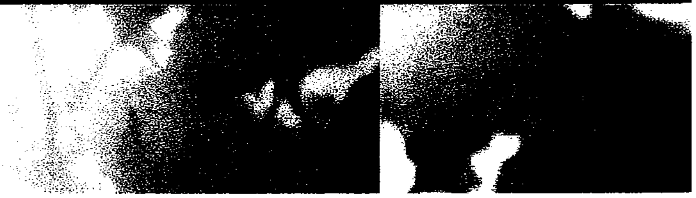
Follow all pesticide label requirements. Follow the guidelines below to help minimize the risk of developing glyphosate-resistant weed populations in a Roundup Ready 2 Technology system.

- Start clean with a burndown herbicide or tillage. Early-season weed control is critical to yield.
- Apply preemergence residual herbicides such as Harness® Xtra, Degree Xtra®, TripleFLEX® Herbicide or other residual herbicides at the application rate specified on the product label.
- Or apply a preemergence residual herbicide at the appropriate application rate tank-mixed with a minimum of 22 oz/A Roundup WeatherMAX® in-crop before weeds exceed 4" in height.
- Follow with a postemergence in-crop application of Roundup WeatherMAX at a minimum of 22 oz/A for additional weed flushes before they exceed 4" in height.
- Roundup WeatherMAX may be tank-mixed with other herbicides for postemergence weed control.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

ADDITIONAL INFORMATION

- Use full labeled rate of residual when application is 14 days or more prior to planting, when tough grasses such as barnyardgrass, shattercane, seedling johnsongrass, or sandbur are present, or when known glyphosate-resistant biotypes are present.
- Use a minimum of 2.5 pt/A of Harness on woolly cupgrass and wild proso millet. Products containing atrazine will provide improved control of cocklebur, giant ragweed, morningglory, and Palmer amaranth. For control of glyphosate-resistant marestail (horseweed), Palmer amaranth and other difficult-to-control weeds, apply Roundup WeatherMAX as a tank-mix with 2,4-D, dicamba or Status® herbicide.
- Use 22 to 32 oz/A of Roundup WeatherMAX when morningglory or perennial weeds are present or when broadleaf weeds are 4" or taller.
- Growers are provided excellent crop safety and full yield potential with applications made from planting through 48" of corn height. Drop nozzles must be used between 30" and 48" of corn height.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Roundup Ready Corn 2 to determine use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- If using another residual herbicide, follow the labeled use rate instructions applicable to Roundup Ready Corn 2. You may apply up to the full residual herbicide labeled rate for corn.
- Atrazine may also be used as a residual herbicide in the Roundup Ready Corn 2 System.
- Maximum use rates apply to the total application of all glyphosate-containing products. See the Roundup WeatherMAX label for more information on maximum use rates.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.



COTTON TECHNOLOGIES

GENUITY® BOLLGARD II® WITH ROUNDUP READY® FLEX COTTON varieties offer growers the benefits of both insect protection and glyphosate tolerance combined in one crop. These varieties exhibit the same insect protection qualities as Genuity® Bollgard II® and are tolerant to in-crop applications of Roundup WeatherMAX® and Roundup PowerMAX® herbicides.*

GENUITY® ROUNDUP READY® FLEX COTTON varieties possess improved tolerance to the active ingredient in Roundup agricultural herbicides. This technology gives growers the opportunity to make in-crop broadcast applications of Roundup WeatherMAX or Roundup PowerMAX from crop emergence up to seven (7) days prior to harvest.

GENUITY® BOLLGARD II® WITH ROUNDUP READY® COTTON varieties offer growers the benefits of both insect control and glyphosate tolerance combined in one crop. This variety exhibits the same insect protection qualities as Genuity Bollgard II, and enables growers to make in-crop applications of Roundup WeatherMAX or Roundup PowerMAX according to label directions.*

GENUITY BOLLGARD II COTTON varieties contain two distinct insecticidal proteins, Cry1Ac and Cry2Ab2, from *Bacillus thuringiensis (B.t.)* that increase the efficacy and spectrum of control and reduce the chance that resistance will develop to the *B.t.* insecticidal proteins. Genuity Bollgard II cotton controls tobacco budworm, pink bollworm and cotton bollworm. Genuity Bollgard II cotton also provides control against fall armyworm, beet armyworm, cabbage and soybean loopers and other secondary leaf- or fruit-feeding caterpillar pests of cotton. Applications of insecticides to control these pests are substantially reduced with Genuity Bollgard II.*

ROUNDUP READY COTTON varieties contain in-plant tolerance to the active ingredient in Roundup® agricultural herbicides, enabling growers to make in-crop applications of Roundup WeatherMAX or Roundup PowerMAX according to label directions.

Growers must read the IRM Grower Guide prior to planting for information on required IRM. You may download a copy of the current IRM Grower Guide at **www.monsanto.com** or **www.genuity.com,** or you may **call 1-800-768-6387** to request a copy by mail.

*Sale or commercial planting of products containing Genuity Bollgard II is prohibited in Hawaii, Puerto Rico, the U.S. Virgin Islands, and in Florida south of Route 60 (near Tampa). Genuity Bollgard II cotton is not registered in the following states: Alaska, Colorado, Connecticut, Delaware, Idaho, Illinois, Indiana, Iowa, Maine, Massachusetts, Michigan, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Washington, Washington D.C., West Virginia, Wisconsin, and Wyoming. Therefore, sale or commercial planting of Genuity Bollgard II cotton is not allowed.

GENUITY® BOLLGARD II® WITH ROUNDUP READY® FLEX COTTON

GENUITY® ROUNDUP READY® FLEX COTTON

genuity
BOLLGARD II WITH ROUNDUP READY FLEX COTTON

genuity
ROUNDUP READY FLEX COTTON

Managing Genuity Bollgard II with Roundup Ready Flex cotton and Genuity Roundup Ready Flex cotton requires a grower to follow the recommended weed management guidelines associated with cotton containing each individual trait. Growers of Genuity Bollgard II with Roundup Ready Flex cotton must follow the required refuge options, practicing IRM and managing target and non-target pests as described for Genuity Bollgard II cotton in the IRM Grower Guide.

MARKET OPTIONS

Upland Cotton *(Gossypium Hirsutum)*

Genuity Bollgard II with Roundup Ready Flex cotton and Genuity Roundup Ready Flex cotton have regulatory clearance in the United States, but do not have import approval in all export markets. Processed fractions from these products, including linters, oil, meal, cottonseed and gin trash, must not be exported without all necessary approvals in the importing country. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted.

Pima Cotton *(Gossypium Barbadense)*

Do not export Genuity Roundup Ready Flex Pima cottonseed, meal, linters, or gin trash to Korea pending import approval. Grower must deliver cotton to an Arizona, California, New Mexico, or Texas gin that is on Monsanto's approved list (available at **www.genuity.com** under the Commodity Marketing section of the Stewardship tab) or to a third party who agrees to use products for domestic feed use. Do not market cottonseed, meal, linters or gin trash from Genuity Roundup Ready Flex Pima to a third party who may send such products or processed fractions outside of the approved countries.

Weed Management

Weed control in cotton is essential to help maximize both fiber yield and quality potential. Cotton is very sensitive to early-season weed competition, which can result in unacceptable stands and/or reduced yield potential. The Genuity Roundup Ready Flex cotton system, with improved tolerance to the active ingredient in Roundup® agricultural herbicides, provides growers with the right tools to control weeds.

Select timing of application based on the most difficult-to-control weed species in your field.

Post-direct or hooded sprayers can be used to achieve more thorough spray coverage on weeds, and can allow the use of other approved herbicides to control tough weeds.

Residual herbicide(s) may be applied as either a preemergence (including preplant incorporated), postemergence, and/or layby application as allowed on the label of the specific product being used. Weeds growing at the time of the residual herbicide application will need to be controlled using a postemergence herbicide.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedresistance.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.

GUIDELINES

Follow all label directions. Follow the guidelines below to minimize the risk of developing weed resistance in a Genuity Roundup Ready Flex cotton system:

- Scout fields before and after each burndown and in-crop application.
- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- Add soil residual herbicide(s) and cultural practices as part of a Genuity Roundup Ready Flex cotton weed control program.
  - Soil residual herbicides are critical to control emerging glyphosate-resistant weeds, such as Palmer amaranth.
  - Residual herbicides should be used multiple times during the growing season if glyphosate-resistant weeds are expected.
- In-crop, apply Roundup WeatherMAX® herbicide at a minimum of 22 oz/A when weeds are less than 3" in height and tank-mix with another approved herbicide, if necessary.
- Late-season control of emerged weeds with a diversity of control tools will reduce the potential of adding more seeds to the seedbank.
- Clean equipment before moving from field to field to minimize the spread of weed seed (as well as nematodes, insects and other cotton pests).
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

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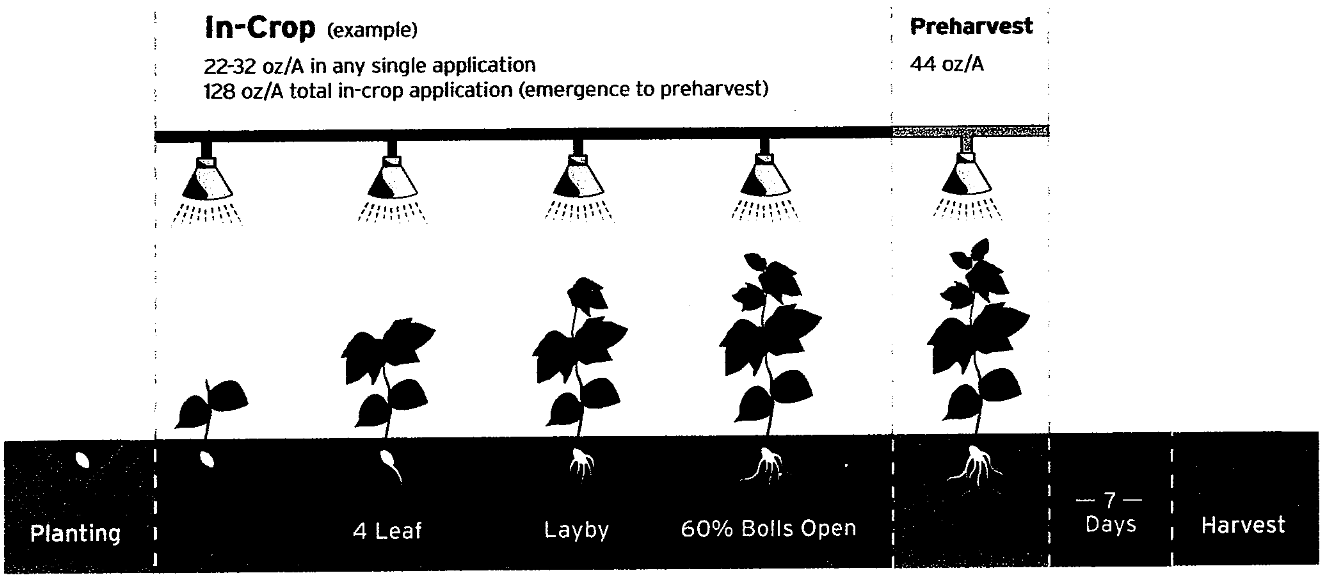
GENUITY® BOLLGARD II® WITH ROUNDUP READY® FLEX COTTON and GENUITY® ROUNDUP READY® FLEX COTTON

APPLICATION OF ROUNDUP WEATHERMAX® AND ROUNDUP POWERMAX® HERBICIDES

- May be applied in-crop, from crop emergence up to 7 days prior to harvest.
- A maximum rate of 32 oz/A per application may be applied using ground application equipment while the maximum is 22 oz/A per application by air.
- There are no growth or timing restrictions for sequential applications.
- Four (4) quarts/A is the total in-crop volume allowed from emergence to 60% open bolls.
- A maximum total volume of 44 oz/A may be applied between layby and 60% open bolls.
- Post-directed application of Roundup WeatherMAX or Roundup PowerMAX, either alone or in a tank-mix with another herbicide labeled for post-directed application in cotton, may be used to achieve more thorough spray coverage of weeds.

PREHARVEST APPLICATION

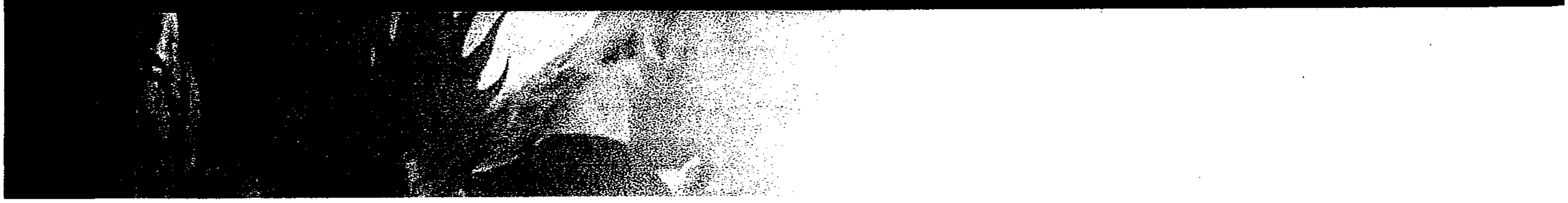
- Up to 44 oz/A may be applied after cotton reaches 60% open bolls and before harvest, if needed.
- Application must be made at least 7 days prior to harvest.
- The maximum volume of Roundup WeatherMAX and Roundup PowerMAX® that may be used in a single season is 5.3 quarts/A.



CROP SAFETY OF IN-CROP GLYPHOSATE APPLICATIONS

Monsanto has determined that a combination of components in glyphosate formulations have the potential to cause leaf injury when applied during later stages of crop growth. Roundup WeatherMAX and Roundup PowerMAX are the only Roundup® agricultural herbicides labeled and approved for use in Genuity® Roundup Ready® Flex cotton.

Leaf injury may occur if the products are not used according to the product label, used at rates higher than directed or if overlap of spray occurs in the field. Growers must confirm that any glyphosate formulation to be used on Genuity Roundup Ready Flex cotton is labeled for use on Genuity Roundup Ready Flex cotton and has been tested to demonstrate crop safety.



GENUITY® BOLLGARD II® WITH ROUNDUP READY® COTTON

ROUNDUP READY® COTTON

Managing Genuity® Bollgard II® with Roundup Ready® cotton and Roundup Ready® cotton requires that a grower follow the recommended weed management guidelines associated with cotton containing each individual trait. Growers of Genuity Bollgard II with Roundup Ready cotton varieties must follow the required refuge options, practicing IRM and managing target and non-target pests as described for Genuity Bollgard II cotton in the IRM Grower Guide.

MARKET OPTIONS

Gin by-products of cotton containing Genuity Bollgard II and Genuity Bollgard II with Roundup Ready Cotton traits, including cottonseed for feed uses, are fully approved for export to Canada, Japan, Mexico and South Korea. Cottonseed containing Monsanto traits may not be exported for the purpose of planting without a license from Monsanto.

It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted.

APPLICATION OF ROUNDUP WEATHERMAX® AND ROUNDUP POWERMAX®

Roundup Ready cotton is genetically improved to provide tolerance to the active ingredient in Roundup® agricultural herbicides. Roundup Ready cotton can receive in-crop applications of Roundup agricultural herbicides only through the four-leaf stage. With the introduction of Genuity Roundup Ready Flex cotton, there is the potential for both Roundup Ready cotton and Genuity Roundup Ready Flex cotton to be used on a grower's farm. This creates concern for the crop safety of Roundup Ready cotton. Monsanto recommends that growers:

- Maintain accurate records of which technologies have been planted and where they have been planted.
- Communicate the field plan with other members of their work force to ensure proper applications for each technology.
- Clearly mark fields to indicate which technology has been planted.

Weed Management

Weed control in cotton is essential to help maximize both fiber yield and quality potential. Cotton is very sensitive to early-season weed competition, which can result in unacceptable stands and/or reduced yield potential. The Roundup Ready cotton system provides growers with the right tools to control weeds before they become competitive.

GUIDELINES

Follow all pesticide label directions. Follow these guidelines to help minimize the risk of developing glyphosate-resistant weed populations in a Roundup Ready cotton system:

- Scout fields before and after each burndown and in-crop application.
- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- Add soil residual herbicide(s) and cultural practices as part of a Roundup Ready weed control program.
  - Soil residual herbicides are critical to control emerging glyphosate-resistant weeds, such as Palmer pigweed.
  - Residual herbicides should be used multiple times during the growing season if glyphosate-resistant weeds are expected.
- In-crop, apply Roundup WeatherMAX® herbicide at a minimum of 22 oz/A when weeds are less than 3" in height and tank-mix with other herbicides with a different mode-of-action and approved for in-crop application to cotton, if necessary.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Roundup Ready cotton to determine appropriate use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- Late-season control of emerged weeds with a diversity of cultural practices and herbicides will reduce the potential of adding more seeds to the seedbank.
- Clean equipment before moving from field to field to minimize the spread of weed seed (as well as nematodes, insects and other cotton pests).
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

ADDITIONAL INFORMATION

Roundup Ready cotton has excellent tolerance to the active ingredient in Roundup WeatherMAX during the vegetative stage of growth, allowing early-season in-crop applications. Incomplete tolerance during the reproductive stage requires that applications after the 4-leaf (node) stage be properly post-directed, avoiding direct application to the cotton plant.

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GENUITY® BOLLGARD II® WITH ROUNDUP READY® COTTON and ROUNDUP READY COTTON

ATTENTION: Use of Roundup® agricultural herbicides in accordance with label directions is expected to result in normal growth of Roundup Ready® cotton, however, various environmental conditions, agronomic practices, and other factors make it impossible to eliminate all risks associated with the product, even when applications are made in conformance with the label specifications. In some cases, these factors can result in boll loss, delayed maturity, and/or yield loss.

In-crop applications must be at least 10 days apart and the cotton must have at least two nodes of incremental growth between glyphosate herbicide applications. Record the growth stage at first application.

In situations where the potential for weed infestations is high (including perennial weeds), make the first application early enough to allow a second application before cotton exceeds the fourth true-leaf stage. In-crop applications after the fourth true-leaf stage can result in boll loss, delayed maturity, and/or yield loss.

After the fourth true-leaf stage through layby, Roundup WeatherMAX® herbicide may be applied using precision post-directed or hooded sprayers that direct the spray to the base of the cotton plant. Avoid contact of spray solution with cotton leaves to the maximum extent possible. Excessive foliar contact can result in boll loss, delayed maturity, and/or yield loss.

Residual herbicide(s) may be applied as either a preemergence (including preplant incorporated), postemergence, and/or layby application as allowed on the label of the specific product being used. Weeds growing at the time of the residual herbicide application will need to be controlled with a postemergence herbicide.

Apply Roundup WeatherMAX in-crop from crop emergence through the fourth true-leaf (node) stage (until the fifth true leaf reaches the size of a quarter).

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.

GENUITY® ROUNDUP READY 2 YIELD® SOYBEANS

ROUNDUP READY® SOYBEANS

Genuity® Roundup Ready 2 Yield® and Roundup Ready® Soybean varieties contain in-plant tolerance to the active ingredient in Roundup® agricultural herbicides, so you can spray Genuity Roundup Ready 2 Yield or Roundup Ready Soybeans with Roundup agricultural herbicides in-crop from emergence through flowering.

Weed Management

Starting clean with a weed-free field and controlling subsequent weeds when they are small are critical to obtaining excellent weed control and maximum yield potential. The Roundup Ready Soybean System provides the flexibility to use the diversity of herbicide tools necessary to control weeds before planting, at planting and in-crop. Failure to control weeds with the right rate, at the right time and with the right product, can lead to increased weed competition, the potential for selecting for weed resistance and possible decreased yield.

Spray labeled Roundup agricultural herbicides in-crop from emergence (cracking) through flowering (R2 stage soybeans) for unsurpassed weed control, proven crop safety and maximum yield potential. R2 stage soybeans end when a pod 5 millimeters (3/16") long at one of the four uppermost nodes appears on the main stem along with a fully developed leaf (R3 stage).

GUIDELINES

Follow all pesticide label directions. Follow the guidelines below to help minimize the risk of developing glyphosate-resistant weed populations in a Roundup Ready Soybean System:

- Scout fields before and after each burndown and in-crop application.
- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- Include a soil-applied residual herbicide such as Valor®, Valor® XLT, Gangster® or Authority® brand of products, applied at an appropriate rate as listed on the label.
- In-crop, apply Roundup WeatherMAX® herbicide at a minimum of 22 oz/A before weeds exceed 4" in height. Warrant® Herbicide may be applied postemergence to soybeans, but prior to weed emergence for residual control of small grasses and small-seeded broadleaf weeds.
- If an additional flush of weeds occurs, a sequential application of Roundup WeatherMAX at 22 oz/A before weeds exceed 4" in height may be needed.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Genuity Roundup Ready 2 Yield Soybeans or Roundup Ready Soybeans to determine appropriate use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- Refer to individual product labels for approved tank-mix partners.
- Clean equipment before moving from field to field to help minimize the spread of weed seed.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

ADDITIONAL INFORMATION

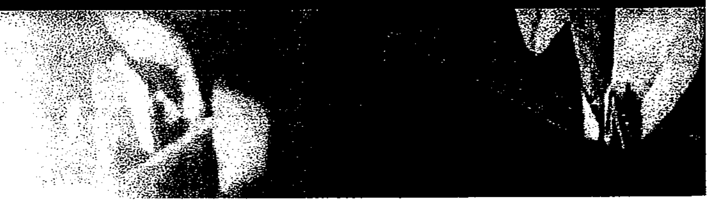
Crop rotation following Genuity Roundup Ready 2 Yield and Roundup Ready Soybeans is encouraged. Use of a residual herbicide is encouraged especially if the cropping system is a continuous Roundup Ready system.

If initial application is delayed and weeds are larger, increase the application rate of Roundup WeatherMAX within the limits specified on the label.

Weeds such as lambsquarters, waterhemp, pigweed, and giant ragweed tend to emerge throughout the season. Sequential Roundup WeatherMAX applications or the addition of a soil residual herbicide may be required for control of subsequent weed flushes.

Use of a residual herbicide or other postemergence herbicides in a tank-mix with Roundup agricultural herbicides could enhance control.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for specific herbicide products can be obtained by calling 1-800-768-6387.



GENUITY® ROUNDUP READY® ALFALFA

Genuity® Roundup Ready® Alfalfa varieties have in-plant tolerance to the active ingredient in Roundup® agricultural herbicides, enabling growers to apply Roundup agricultural herbicides up to 5 days before cutting for unsurpassed weed control with excellent crop safety and preservation of forage quality potential.

HAY AND FORAGE MANAGEMENT

Genuity Roundup Ready Alfalfa must be managed for high quality hay/forage production, including timely cutting to promote high forage quality (i.e., before 10% bloom) and to prevent seed development. Where conventional alfalfa seed production is intermingled with forage production, Genuity Roundup Ready Alfalfa must be harvested at or before 10% bloom to help minimize potential pollen flow from Genuity Roundup Ready Alfalfa to conventional alfalfa. In all other areas Genuity Roundup Ready Alfalfa must be harvested prior to green pod stage. Growers who are unwilling to or who cannot make this commitment to stewardship should not continue to grow Genuity Roundup Ready Alfalfa.

An in-crop weed control program using Roundup WeatherMAX® or Roundup PowerMAX® herbicide can provide excellent weed control in most situations. A residual herbicide labeled for use in alfalfa may also be applied postemergence in alfalfa. Contact a Monsanto Representative, local crop advisor or extension specialist to determine the best option for your situation.

ALFALFA IN-CROP ROTATION

Avoid planting alfalfa in a field from which an alfalfa crop has recently been removed. Recommended rotational crop sequences fall into two categories—grass crops (e.g., corn and cereal crops) and broadleaf crops.

GENUITY ROUNDUP READY ALFALFA STAND TAKEOUT

Use appropriate, commercially available herbicide treatments in reduced tillage systems, or in combination with tillage, to terminate a Genuity Roundup Ready Alfalfa stand. Refer to your regional Technical Bulletin for specific stand removal recommendations.

If necessary, use tillage and/or additional herbicide application(s) after stand takeout, and prior to planting of the subsequent rotational crop to manage any newly-emerged or surviving alfalfa.

Note: Roundup agricultural herbicides are **not** effective for terminating Genuity Roundup Ready Alfalfa stands.

MANAGEMENT OF GENUITY ROUNDUP READY ALFALFA VOLUNTEERS IN ROTATIONAL CROP FIELDS

In a timely manner, use recommended and commercially available mechanical and/or herbicidal methods for managing volunteer Genuity Roundup Ready Alfalfa in rotational crop fields.

- Implement treatments before volunteers become too large to control or begin to compete with the rotational crop.
- Herbicide alternatives are available for management of volunteer alfalfa in grass crops.
- Rotation with certain broadleaf crops is not advisable if the grower is not willing to implement recommended stand termination practices.
- In the event that no known mechanical or herbicidal options are available to manage volunteer Genuity Roundup Ready Alfalfa in the desired rotational crop, you should change to a crop with established volunteer management practices for that rotation.

Note: Roundup agricultural herbicides are **not** effective for terminating Genuity Roundup Ready Alfalfa volunteers.

PLANTING LIMITATION

Genuity Roundup Ready Alfalfa is not permitted to be planted in any wildlife feed plots.

STEWARDSHIP

All Genuity Roundup Ready Alfalfa growers are required to sign the Monsanto Technology/Stewardship Agreement (MTSA) limited-use license which provides the terms and conditions for the authorized use of the product. The MTSA must be signed and approved before purchase or use of seed.

The MTSA explicitly prohibits all forms of commercial seed harvest on the stand. Every grower of Genuity Roundup Ready Alfalfa agrees to only lawfully plant Genuity Roundup Ready Alfalfa, and not to plant Genuity Roundup Ready Alfalfa for the production of seed, unless under specific contract to produce seed. For additional information visit the USDA website: **http://www.aphis.usda.gov/biotechnology/alfalfa_history.shtml**

MARKET OPTIONS

Grower must lawfully plant Genuity Roundup Ready Alfalfa, direct any product produced from a Genuity Roundup Ready Alfalfa seed or crops (including hay and hay products) only to those countries where regulatory approvals have been granted, and grow and manage Genuity Roundup Ready Alfalfa in accordance with the information found in this TUG. Pending import approvals in China, do not export Genuity Roundup Ready Alfalfa seed or crops (including hay or hay product) to China. In addition, due to the unique cropping practices do not plant Genuity Roundup Ready Alfalfa in Imperial County, California, pending import approval in China and until Monsanto grants expressed permission for such planting. It is a violation of national and international laws to move material containing biotech traits across boundaries into nations where import is not permitted.

To meet sales reporting requirements, the seed supplier is required to identify and list all Genuity Roundup Ready Alfalfa field locations. Therefore, all growers must provide their seed supplier with the GPS coordinates of all their Genuity Roundup Ready Alfalfa fields.

For more information and the latest updates on Genuity Roundup Ready Alfalfa, go to the specialty tab at **www.genuity.com**

Weed Management

GUIDELINES

Follow all pesticide label requirements. Follow the guidelines below to help minimize the risk of developing glyphosate-resistant weed populations in Genuity Roundup Ready Alfalfa:

- Scout fields before and after each herbicide application.
- To control flushes of weeds in established alfalfa, make applications of Roundup WeatherMAX® or Roundup PowerMAX® herbicide at 22 to 44 oz/A before weeds exceed 6" in height, up to 5 days before cutting.
- Use other approved herbicide products tank-mixed or in sequence with Roundup® agricultural herbicides as part of a Genuity Roundup Ready Alfalfa weed control program, if appropriate for the weed spectrum present.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

To preserve the quality potential of forage and hay in established stands, apply Roundup WeatherMAX after weeds have emerged but before alfalfa re-growth interferes with application spray coverage of the target weeds.

ADDITIONAL INFORMATION

- Always start with a weed-free field. In no-till and reduced-till systems, apply a Roundup WeatherMAX burndown application to control existing weeds at least 1 to 2 weeks before planting.
- An initial application of 22 to 44 oz/A of Roundup WeatherMAX should be applied at or before the 3 to 4 trifoliate growth stage.

Note: Due to the genetic diversity of alfalfa, up to 10% of the seedlings are susceptible and will not survive the first application of Roundup agricultural herbicides. The initial application is necessary to eliminate the effects of stand gaps created by loss of non-Roundup Ready plants and to ensure adequate spray coverage of emerging weeds before crop canopy interference.

- Applications between cuttings may be applied as a single application or in multiple applications (e.g., two applications of 22 oz/A). Sequential applications should be at least 7 days apart.
- If using another Roundup agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Genuity Roundup Ready Alfalfa to determine appropriate use rates.
- Maximum use rates apply to the total application of all glyphosate-containing products. See the Roundup WeatherMAX label for more information on maximum use rates.
- If using Roundup PowerMAX, application rates are the same as for Roundup WeatherMAX.
- In addition to those weeds listed in the Roundup WeatherMAX label booklets, this product will suppress or control the parasitic weed, dodder *(Cuscuta spp.)* in Genuity Roundup Ready Alfalfa. Repeat applications might be necessary for complete control.
- For tough-to-control weeds or weeds not controlled by Roundup agricultural herbicides, use labeled rates of other approved herbicides, alone or in tank-mixtures, with Roundup agricultural herbicides.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.

GENUITY® ROUNDUP READY® SPRING CANOLA

Genuity® Roundup Ready® Spring Canola hybrids contain in-plant tolerance to the active ingredient in Roundup® agricultural herbicides, so you can spray Genuity Roundup Ready Spring Canola with Roundup agricultural herbicides in-crop from emergence through the 6-leaf stage of development.

The introduction of the Roundup Ready trait into leading spring canola hybrids and varieties gives growers the opportunity for unsurpassed weed control, proven crop safety and maximum yield potential. With Genuity Roundup Ready Spring Canola, growers have the weed management tool necessary to help improve spring canola profitability, while providing a viable rotational crop to help break pest and disease cycles in cereal-growing areas.

PLANTING LIMITATION

Genuity Roundup Ready Spring Canola is not permitted to be planted in any wildlife feed plots.

Weed Management

GUIDELINES

Follow all pesticide label directions. Follow the guidelines below to minimize the risk of developing glyphosate-resistant weed populations in a Genuity Roundup Ready Spring Canola System:

- Scout fields before and after each burndown and in-crop application.
- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- In-crop, apply Roundup WeatherMAX® herbicide before weeds exceed 3" in height.
- A sequential application of Roundup WeatherMAX herbicide may be needed.
- Use mechanical weed control, cultivation and/or residual herbicides where appropriate in your Genuity Roundup Ready Spring Canola.
- Use additional herbicide modes of action, residual herbicides and/or mechanical weed control in other Roundup Ready crops you rotate with Genuity Roundup Ready Spring Canola.
- Clean equipment before moving from field to field to minimize the spread of weed seed.
- There are several options for control of volunteer Genuity Roundup Ready Spring Canola in rotational crops including Roundup Ready Soybeans and Roundup Ready Sugarbeets. Talk to your local seed representative or dealer for suggestions that fit your area.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

ADDITIONAL INFORMATION

- Spray when canola is at the 0- to 6-leaf stage of growth. To maximize yield potential, spray Genuity Roundup Ready Spring Canola at the 1- to 3-leaf stage to eliminate competing weeds. Short-term yellowing may occur with later applications, with little effect on crop growth, maturity, or yield.
- Wait a minimum of 10 days between applications. Two applications of Roundup WeatherMAX will:
  - Control late flushes of annual weeds such as foxtail, pigweed, and wild mustard.
  - Provide season-long suppression of Canada thistle, quackgrass, and perennial sow thistle.
  - Provide better yield potential by eliminating competition from both annuals and hard-to-control perennials.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Genuity Roundup Ready Spring Canola for appropriate use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- Maximum use rates apply to the total application of all glyphosate-containing products. See the Roundup WeatherMAX label for more information on maximum use rates.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.

GENUITY® ROUNDUP READY® WINTER CANOLA

Genuity® Roundup Ready® Winter Canola varieties have been developed for seeding in the fall and harvesting the following spring/summer. Genuity Roundup Ready Winter Canola varieties contain in-plant tolerance to the active ingredient in Roundup agricultural herbicides, so you can spray Genuity Roundup Ready Winter Canola with Roundup agricultural herbicides in-crop from emergence to the pre-bolting stage.

The introduction of the Roundup Ready trait into winter canola varieties gives growers the opportunity of unsurpassed weed control, crop safety and maximum yield potential. Genuity Roundup Ready Winter Canola offers growers an important option as a rotational crop in traditional monoculture winter wheat production areas. Introducing crop rotation is an important factor in reducing pest cycles, including weed and disease problems.

GRAZING

Monsanto recommends that Genuity Roundup Ready Winter Canola not be grazed. While Genuity Roundup Ready Winter Canola may in the future provide growers additional opportunity as a forage for grazing livestock, at the present time insufficient information exists to allow safe and proper grazing recommendations. Preliminary data suggest that excessive grazing can significantly reduce yield, *and that careful nitrate management is critical in managing Genuity Roundup Ready Winter Canola as a forage to limit the risk of livestock nitrate poisoning.* State universities are assessing that potential and the appropriate instructions for grazing Genuity Roundup Ready Winter Canola. They will provide grazing management guidelines when their research is completed.

PLANTING LIMITATION

Genuity Roundup Ready Winter Canola is not permitted to be planted in any wildlife feed plots.

Weed Management

GUIDELINES

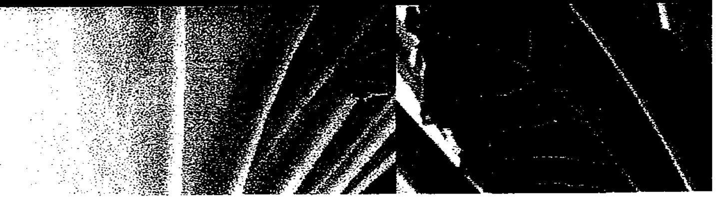
Follow all pesticide label directions. Follow the guidelines below to minimize the risk of developing glyphosate-resistant weed populations in a Genuity Roundup Ready Winter Canola System:

- Scout fields before and after each burndown and in-crop application.
- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- In-crop, apply Roundup WeatherMAX herbicide before weeds exceed 3" in height.
- A sequential application of Roundup WeatherMAX herbicide may be needed.
- Use mechanical weed control, cultivation and/or residual herbicides where appropriate in your Genuity Roundup Ready Winter Canola.
- Use additional herbicide modes of action, residual herbicides and/or mechanical weed control in other Roundup Ready crops you rotate with Genuity Roundup Ready Winter Canola.
- Clean equipment before moving from field to field to minimize the spread of weed seed.
- There are several options for control of volunteer Genuity Roundup Ready Winter Canola in rotational crops. Talk to your local seed representative or dealer for suggestions that fit your area.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.

ADDITIONAL INFORMATION

- Spray when Genuity Roundup Ready Winter Canola is at the 2–3 leaf stage of growth. Early applications can eliminate competing weeds and improve yield potential.
- Two applications of Roundup WeatherMAX will provide control of early emerging annual weeds and winter emerging weeds such as downy brome, cheat and jointed goatgrass.
- For sequential applications, spray Genuity Roundup Ready Winter Canola at the 2–3 leaf stage and when weeds are small and actively growing. Applications must be made prior to bolting. Use the higher rate in the range when weed densities are high, when weeds have over wintered or when weeds become large and well established.
- Application of greater than 16 oz/A prior to the 6-leaf stage could result in temporary yellowing and/or growth reduction.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Genuity Roundup Ready Winter Canola for appropriate use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- Maximum use rates apply to the total application of all glyphosate-containing products. See the Roundup WeatherMAX label for more information on maximum use rates.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.



GENUITY® ROUNDUP READY® SUGARBEETS

For Genuity® Roundup Ready® Sugarbeets in the U.S.: On February 8, 2011, the U.S. Department of Agriculture (USDA) published its decision to implement interim measures of deregulation with conditions for the planting of Genuity Roundup Ready Sugarbeets root crops, and of planting under USDA permit for Genuity Roundup Ready Sugarbeets seed crops. Genuity Roundup Ready Sugarbeets can only be sold, transported and planted in compliance with the conditions imposed by USDA and as set forth in mandatory compliance agreements with USDA, which must be in place prior to transport or planting.

Genuity Roundup Ready Sugarbeet varieties have in-plant tolerance to the active ingredient in Roundup® agricultural herbicides, enabling growers to apply labeled Roundup agricultural herbicides from planting through 30 days prior to harvest for unsurpassed weed control, with excellent crop safety and preservation of yield potential.

AGRONOMIC PRINCIPLES IN SUGARBEETS

Genuity Roundup Ready Sugarbeets provide a mechanism to control weeds at planting, and once Genuity Roundup Ready Sugarbeets emerge. Bolting sugarbeets must be rogued or topped in Genuity Roundup Ready Sugarbeet fields.

PLANTING LIMITATION

Genuity Roundup Ready Sugarbeets are not permitted to be planted in any wildlife feed plots.

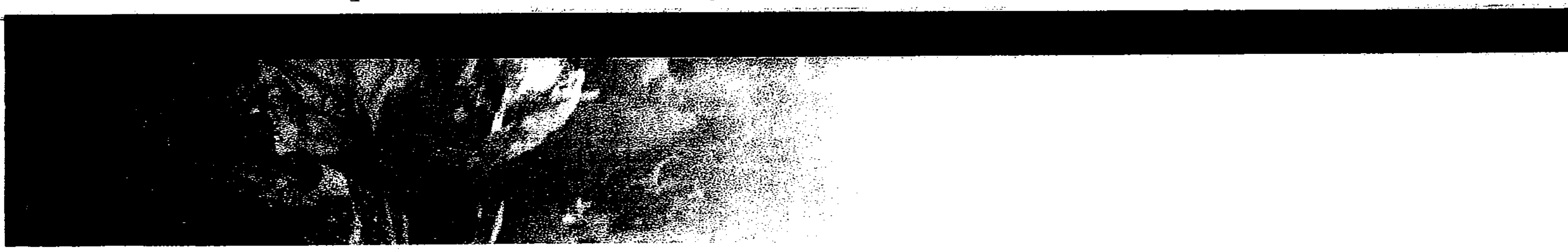
MARKET OPTIONS

Any product produced from a Genuity Roundup Ready Sugarbeet crop or seed may only be used, exported to, processed or sold in countries where regulatory approvals have been granted. It is a violation of national and international laws to move material containing biotech traits across boundaries into nations where import is not permitted.

STEWARDSHIP

All Genuity Roundup Ready Sugarbeet growers must sign the Monsanto Technology/Stewardship Agreement (MTSA) limited-use license which provides the terms and conditions for the authorized use of the product. The MTSA must be signed and approved prior to purchase or use of seed.

The grower agrees to transport and plant Genuity Roundup Ready Sugarbeets only for the production of a root crop, and not for seed production, and only in compliance with the conditions imposed by the USDA under the deregulation with conditions and as set forth in mandatory compliance agreements with USDA, which grower agrees will be in place prior to transport or planting. For the most current information, visit the specialty tab at **www.genuity.com** or contact your local authorized seed dealer.



Weed Management

Sugarbeets are extremely sensitive to weed competition for light, nutrients and soil moisture, and can lose yield potential rapidly if weeds are not controlled early. Research on sugarbeet weed control suggests that sugarbeets need to be kept weed-free for the first eight weeks of growth to protect yield potential. Therefore, weeds must be controlled when they are small and before they compete with Genuity® Roundup Ready® Sugarbeets (before weeds exceed crop height). **More than one in-crop herbicide application will be required** to help control weed infestations to protect yield potential as Roundup agricultural herbicides have no soil residual activity.

A postemergence weed control program using Roundup WeatherMAX® or Roundup PowerMAX® herbicide can provide excellent weed control in most situations. A residual herbicide labeled for use in sugarbeets may also be applied preplant, preemergence or postemergence in Genuity Roundup Ready Sugarbeets. Contact a Monsanto representative, local crop advisor or extension specialist to determine the best option for your situation.

GUIDELINES

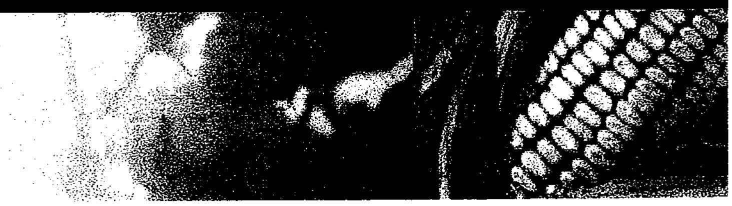
Follow all pesticide label directions. Follow the guidelines below to help minimize the risk of developing glyphosate-resistant weed populations in Genuity Roundup Ready Sugarbeets:

- Start with a clean field, using either a burndown herbicide application, residual herbicide or tillage, making sure weeds are controlled at planting.
- Early-season weed control is critical to protect sugarbeet yield potential. Apply the first in-crop application of Roundup WeatherMAX at a minimum of 22 oz/A while weeds are less than 2" in height.
- Follow with additional postemergence in-crop application of Roundup WeatherMAX at a minimum of 22 oz/A for additional weed flushes before weeds exceed 4" in height.
- Use mechanical weed control, cultivation and/or residual herbicides where appropriate.
- Use additional herbicide modes of action, residual herbicides and/or mechanical weed control in other Roundup Ready crops you rotate with Genuity Roundup Ready Sugarbeets.

ADDITIONAL INFORMATION

- Add ammonium sulfate at a rate of 17 lbs/100 gallons of spray solution with Roundup® agricultural herbicides to maximize product performance. Tank-mixtures of Roundup agricultural herbicides with fungicides, insecticides, micronutrients or foliar fertilizers are not recommended. Sequential applications should be at least 10 days apart.
- For tough-to-control weeds or weeds not controlled by Roundup agricultural herbicides, use labeled rates of other approved herbicides, alone or in tank-mixtures, with Roundup agricultural herbicides.
- Report any incidence of repeated non-performance of Roundup agricultural herbicides or other glyphosate products on a particular weed to the appropriate company representative, local retailer, or county extension agent.
- If using another approved glyphosate agricultural herbicide, you must refer to the label booklet or supplemental labeling for the use of that brand on Genuity Roundup Ready Sugarbeets for appropriate use rates.
- If using Roundup PowerMAX®, application rates are the same as for Roundup WeatherMAX.
- Maximum use rates apply to the total application of all glyphosate-containing products. See the Roundup WeatherMAX label for more information on maximum use rates.

Various weed biotypes are known to be resistant to glyphosate. For the current weed control recommendations for glyphosate-resistant weed biotypes, **refer to www.weedmanagement.com or call 1-800-768-6387.** Approved supplemental labeling for Monsanto herbicide products can be obtained by calling 1-800-768-6387.



NOTES

ReNEW NOW!

All of our valued customers wishing to continue planting Monsanto technologies must renew their Monsanto Technology/ Stewardship Agreement (MTSA) to avoid license expiration. Growers need to have a signed MTSA dated 2010 or later. Every year, Monsanto is required to communicate stewardship information to all licensed growers.

Renew on-line at **www.renewmtsa.com.** It's fast, simple and secure, and the renewal will be processed within days.

Or call 1-800-768-6387 between 7:00 AM and 6:00 PM CST, Monday through Friday, and select Option 3.

To avoid license expiration, license renewal applications must be received by December 1, 2011.

This guide was printed using Utopia II XG Cover and Text which contains 30% post-consumer waste. Savings derived from using 30% post-consumer fiber in lieu of 100% virgin fibers:

- Saves the equivalent of 567 mature trees
- Reduces solid waste by 15,751 pounds
- Reduces waste water by 259,425 gallons
- Reduces greenhouse gas emissions by 53,865 pounds

Before opening a bag of seed, be sure to read, understand and accept the stewardship requirements, **including applicable refuge requirements for insect resistance management**, for the biotechnology traits expressed in the seed as set forth in the Monsanto Technology/Stewardship Agreement that you sign. By opening and using a bag of seed, you are reaffirming your obligation to comply with the most recent stewardship requirements.

Based on the decision of the U.S. Department of Agriculture (USDA) on January 27, 2011, **Genuity® Roundup Ready® Alfalfa** seed is available for sale and distribution by authorized Seed Companies or their dealers for use in the United States only. This seed may not be planted outside of the United States, or for the production of seed, or sprouts.

Monsanto Company is a member of Excellence Through Stewardship® (ETS). Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto's Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. Commodity crop products have been approved for import into key export markets with functioning regulatory systems. Any crop or material produced from commodity crop products can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for commodity crop products. Excellence Through Stewardship® is a registered trademark of Biotechnology Industry Organization.

***B.t.* products** may not yet be registered in all states. Check with your Monsanto representative for the registration status in your state.

IMPORTANT IRM INFORMATION: RIB Complete™ corn does not require the planting of a structured refuge **except** in the Cotton-Growing Area where corn earworm is a significant pest. See the IRM Grower Guide for additional information. Always read and follow IRM requirements.

2011 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT
(Limited Use License)

Form Number

PLEASE MAIL THE SIGNED 2011 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT TO: Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141

GROWER INFORMATION (please print)

Please complete this section with your business information. To sign this Monsanto Technology/Stewardship Agreement ("Agreement") you must be the **operator/grower** for all fields that will grow plants from Seed (as defined below). You represent that you have full authority to and do hereby bind to this Agreement yourself, all entities for which you obtain Seed, all individuals and entities having an ownership interest in any entities for which you obtain Seed, and that Monsanto Company has not barred any of those individuals or entities from obtaining this limited-use license. Your name must be filled in and must match the signature below. This Agreement becomes effective if and when Monsanto issues the Grower a license number from Monsanto's headquarters in St. Louis, Missouri. Monsanto does not authorize seed dealers or seed retailers to issue a license of any kind for Monsanto Technologies.

NEW LICENSE ☐ **RENEWAL** ☐

Grower's Full Legal Name (First/Middle/Last) Dr. Mr. Mrs. Ms. Suffix (Sr, Jr, II, III)

Farm Business Name

Grower's Mailing Address (no P.O. Boxes)

Farm Physical Address (as listed with the FSA)

Grower's City **State** **Zip**

Farm City **State** **Zip**

Area Code **Home Phone** **Fax**

Last Four of Social Security # **Role** Operator Owner/Operator Farm Manager Other

Area Code **Cell Phone** **Email**

SEED SUPPLIER

Business Name **Area Code** **Phone**

City **State** **Zip**

THIS SPACE FOR MONSANTO OFFICE USE ONLY, PLEASE LEAVE THIS SECTION BLANK:

Lic. #: Batch #: Date:

This Monsanto Technology/Stewardship Agreement is entered into between you ("Grower") and Monsanto Company ("Monsanto") and consists of the terms on this page and on the reverse side of this page.

This Monsanto Technology/Stewardship Agreement grants Grower a limited license to use Roundup Ready® soybeans, Genuity® Roundup Ready 2 Yield® soybeans, YieldGard® Corn Borer corn, Roundup Ready® Corn 2 corn, YieldGard® Corn Borer with Roundup Ready® Corn 2 corn, YieldGard VT Triple® corn, YieldGard VT Rootworm/RR2® corn, Genuity® VT Triple PRO™ corn, Genuity® SmartStax™ corn, Roundup Ready® cotton, Genuity® Bollgard II® cotton, Bollgard II® with Roundup Ready® cotton, Genuity® Roundup Ready® Flex cotton, Genuity® Bollgard II® with Roundup Ready® Flex cotton, Vistive® low linolenic soybeans, Genuity® Roundup Ready® sugarbeets, Genuity® Roundup Ready® Canola, Genuity® Roundup Ready® alfalfa, Monsanto patented germplasm and Monsanto Plant Variety Protection rights ("Monsanto Technologies"). Seed containing Monsanto Technologies are referred to herein as ("Seed"). This Agreement also contains Grower's stewardship responsibilities and requirements associated with the use of Seed and Monsanto Technologies.

1. **GOVERNING LAW:** This Agreement and the parties' relationship shall be governed by the laws of the State of Missouri and the United States (without regard to the choice of law rules).

2. **BINDING ARBITRATION FOR COTTON-RELATED CLAIMS MADE BY GROWER:** Any claim or action made or asserted by a cotton Grower (or any other person claiming an interest in the Grower's cotton crop) against Monsanto or any seller of cotton Seed containing Monsanto Technology arising out of and/or in connection with this Agreement or the sale or performance of the cotton Seed containing Monsanto Technology other than claims arising under the patent laws of the United States must be resolved by binding arbitration. The parties acknowledge that the transaction involves interstate commerce. The parties agree that arbitration shall be conducted pursuant to the provisions of the Federal Arbitration Act, 9 U.S.C. Sec 1 et seq. and administered under the Commercial Dispute Resolution Procedures established by the American Arbitration Association ("AAA"). The term "seller" as used throughout this Agreement refers to all parties involved in the production, development, distribution, and/or sale of the Seed containing Monsanto Technology. In the event that a claim is not amicably resolved within 30 days of Monsanto's receipt of the Grower's notice required pursuant to this Agreement any party may initiate arbitration. The arbitration shall be heard in the capital city of the state of Grower's residence or in any other place as the parties decide by mutual agreement. When a demand for arbitration is filed by a party, the Grower and Monsanto/sellers shall each immediately pay one half of the AAA filing fee. In addition, Grower and Monsanto/sellers shall each pay one half of AAA's administrative and arbitrator fees as those fees are incurred. The arbitrator(s) shall have the power to apportion the ultimate responsibility for all AAA fees in the final award. The arbitration proceedings and results are to remain confidential and are not to be disclosed without the written agreement of all parties, except to the extent necessary to effectuate the decision or award of the arbitrator(s) or as otherwise required by law.

3. **FORUM SELECTION FOR NON-COTTON-RELATED CLAIMS MADE BY GROWER AND ALL OTHER CLAIMS:** THE PARTIES CONSENT TO THE SOLE AND EXCLUSIVE JURISDICTION AND VENUE OF THE U.S. DISTRICT COURT FOR THE EASTERN DISTRICT OF MISSOURI, EASTERN DIVISION, AND THE CIRCUIT COURT OF THE COUNTY OF ST. LOUIS, MISSOURI, (ANY LAWSUIT MUST BE FILED IN ST. LOUIS, MO) FOR ALL CLAIMS AND DISPUTES ARISING OUT OF OR CONNECTED IN ANY WAY WITH THIS AGREEMENT AND/OR THE USE OF THE SEED OR THE MONSANTO TECHNOLOGIES, EXCEPT FOR COTTON-RELATED CLAIMS MADE BY GROWER. THE PARTIES WAIVE ANY OBJECTION TO VENUE IN THE EASTERN DIVISION OF THE U.S. DISTRICT COURT FOR THE EASTERN DISTRICT OF MISSOURI, INCLUDING THOSE BASED, IN WHOLE OR IN PART, ON THE DIVISIONAL VENUE LOCAL RULE(S) OF THE U.S. DISTRICT COURT FOR THE EASTERN DISTRICT OF MISSOURI.

   THIS AGREEMENT CONTAINS A BINDING ARBITRATION PROVISION FOR COTTON RELATED CLAIMS PURSUANT TO THE PROVISIONS OF THE FEDERAL ARBITRATION ACT, 9 U.S.C. §1 ET SEQ., WHICH MAY BE ENFORCED BY THE PARTIES.

4. **GROWER AGREES:**
   - To accept and continue the obligations of this Monsanto Technology/Stewardship Agreement on any new land purchased or leased by Grower that has Seed planted on it by a previous owner or possessor of the land; and to notify in writing purchasers or lessees of land owned by Grower that has Seed planted on it that the Monsanto Technology is subject to this Monsanto Technology/Stewardship Agreement and they must have or obtain their own Monsanto Technology/Stewardship Agreement.
   - To read and follow the applicable sections of the Technology Use Guide ("TUG") and the Insect Resistance Management/Grower Guide ("IRM/Grower Guide") which are incorporated into and are a part of this Agreement, for specific requirements relating to the terms of this Agreement, and to abide by and be bound by the terms of the TUG and the IRM/Grower Guide as they may be amended from time to time.
   - To implement an Insect Resistance Management ("IRM") program as specified in the applicable Genuity® Bollgard II® cotton and YieldGard® corn sections of the most recent IRM/Grower Guide and to cooperate and comply with these IRM programs.
   - To acquire Seed containing these Monsanto Technologies only from a seed company with technology license(s) from Monsanto for the applicable Monsanto Technology(ies) or from a licensed company's dealer authorized to sell such licensed Seed.
   - To acquire Seed from authorized seed companies (or their authorized dealers) with the applicable license(s).
   - To use Seed containing Monsanto Technologies solely for planting a single commercial crop.
   - Not to save or clean any crop produced from Seed for planting, not to supply Seed produced from Seed to anyone for planting, not to plant seed for production other than for Monsanto or a Monsanto licensed seed company under a seed production contract.
   - Not to transfer any Seed containing patented Monsanto Technologies to any other person or entity for planting.
   - To plant and/or clean Seed for Seed production, if and only if, Grower has entered into a valid, written Seed production agreement with a Seed company that is licensed by Monsanto to produce Seed. Grower must either physically deliver to that licensed Seed Company or must sell for non-seed purposes or use for non-seed purposes all of the Seed produced pursuant to a Seed production agreement.
   - Grower may not plant and may not transfer to others for planting any Seed that the Grower has produced containing patented Monsanto Technologies for crop breeding, research, or generation of herbicide registration data. Grower may not conduct research on Grower's crop produced from Seed other than to make agronomic comparisons and conduct yield testing for Grower's own use.
   - To direct crops produced from Seed to appropriate markets as necessary. Any grain or material produced from Seed can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted.
   - To lawfully plant Genuity® Roundup Ready® alfalfa; and if growing Genuity® Roundup Ready® alfalfa, to direct any product produced from a Genuity® Roundup Ready® alfalfa seed or crop, including hay and hay products, only to those countries where regulatory approvals have been granted, and to grow and manage Genuity® Roundup Ready® alfalfa in accordance with the TUG.
   - To use on Roundup Ready® or Genuity® Roundup Ready® crops only a labeled Roundup® agricultural herbicide or other authorized non-selective herbicide which could not be used in the absence of the Roundup Ready® gene (see TUG for details on authorized non-selective products). Use of any selective herbicide labeled for the same crop without the Roundup Ready® gene is not restricted by this Agreement. MONSANTO DOES NOT MAKE ANY REPRESENTATIONS, WARRANTIES OR RECOMMENDATIONS CONCERNING THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES WHICH ARE LABELED FOR USE IN ROUNDUP READY® CROP(S). MONSANTO SPECIFICALLY DISCLAIMS ALL RESPONSIBILITY FOR THE USE OF THESE PRODUCTS IN ROUNDUP READY® OR GENUITY® ROUNDUP READY® CROP(S). ALL QUESTIONS AND COMPLAINTS ARISING FROM THE USE OF PRODUCTS MANUFACTURED OR MARKETED BY OTHER COMPANIES SHOULD BE DIRECTED TO THOSE COMPANIES.
   - To pay all applicable fees due to Monsanto that are a part of, associated with or collected with the Seed purchase price or that are invoiced for the seed. If Grower fails to pay Monsanto for cotton related Monsanto Technologies, Grower agrees to pay Monsanto default charges at the rate of 14% per annum (or the maximum allowed by law whichever is less) plus Monsanto's reasonable attorneys' fees, court costs and all other costs of collection.
   - To provide Monsanto copies of any records, receipts, or other documents that could be relevant to Grower's performance of this Agreement, including but not limited to, Summary Acreage History Report, Form 578 (producer print), Farm and Tract Detail Listing and corresponding aerial photographs, Risk Management Agency claim documentation, and dealer/retailer invoices for seed and chemical transactions. Such records shall be produced following Monsanto's actual (or attempted) oral communication with Grower and not later than seven (7) days after the date of a written request from Monsanto.
   - To identify and allow Monsanto and its representatives access to land farmed by or at the direction of Grower (including refuge areas) and bins, wagons, or seed storage containers used or under the control or direction of Grower, for purposes of examining and taking samples of crops, crop residue or seeds located therein. Such inspection, examination or sampling shall be available to Monsanto and its representatives only after Monsanto's

[The Agreement continues on the reverse side of this page.]

GROWER SIGNATURE AND DATE REQUIRED ▶

Name Date

Distribution: White to Monsanto, Yellow to Dealer, Pink to Grower actual (or attempted) oral communication with Grower and after at least seven (7) days prior written request by Monsanto to Grower.

- To allow Monsanto to obtain Grower's internet service provider ("ISP") records to validate Grower's electronic signature, if applicable.

5. GROWER RECEIVES FROM MONSANTO COMPANY:

- A limited use license to purchase and to plant Seed in the United States except in any state or county where the products do not have all the necessary approvals and to apply Roundup® agricultural herbicides and other authorized non-selective herbicides over the top of Roundup Ready® or Genuity® Roundup Ready® crops. Check with your local Monsanto representative if you have questions about the approval status in your state. Monsanto retains ownership of the Monsanto Technologies including the genes (for example, the Roundup Ready® gene) and the gene technologies. Grower receives the right to use the Monsanto Technologies subject to the conditions specified in this Agreement.
- Monsanto Technologies are protected under U.S. patent law. Monsanto licenses the Grower under applicable U.S. patents listed below (other than the Dow AgroSciences Patent Rights), to use Monsanto Technologies subject to the conditions listed in this Agreement. Dow AgroSciences LLC and Agrigenetics, Inc. (collectively "Dow AgroSciences") licenses the Grower under its applicable U.S. patents listed below (the "Dow AgroScience Patent Rights") to use Dow AgroSciences' Event TC 1507 and Event DAS 59122-7 to the extent either is present in any SmartStax Seed being obtained by Grower pursuant to this Agreement. Monsanto being authorized to act on Dow AgroSciences' behalf for this Agreement, subject to the conditions listed in this Agreement. These licenses do not authorize Grower to plant Seed in the United States that has been purchased in another country or plant Seed in another country that has been purchased in the United States. Grower is not authorized to transfer Seed to anyone outside of the U.S.
- Enrollment for participation in Roundup Rewards® program.
- A limited use license to prepare and apply on glyphosate-tolerant soybean, cotton, alfalfa, or canola crops (or have others prepare and apply) tank mixes of, or sequentially apply (or have others sequentially apply), Roundup® agricultural herbicides or other glyphosate herbicides labeled for use on those crops with quizalofop, clethodim, sethoxydim, fluazifop, and/or fenoxaprop to control volunteer Roundup Ready® Corn 2 corn in Grower's crops for the 2011 growing season. However, neither Grower nor a third party may utilize any type of co-pack or premix of glyphosate plus one or more of the above-identified active ingredients in the preparation of a tank mix.

6. GROWER UNDERSTANDS:

- **Monsanto Company is a member of Excellence Through Stewardship® (ETS).** Monsanto products are commercialized in accordance with ETS Product Launch Stewardship Guidance, and in compliance with Monsanto's Policy for Commercialization of Biotechnology-Derived Plant Products in Commodity Crops. These products have been approved for import into key export markets with functioning regulatory systems. Any crop or material produced from these products can only be exported to, or used, processed or sold in countries where all necessary regulatory approvals have been granted. It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Growers should talk to their grain handler or product purchaser to confirm their buying position for these products. Excellence Through Stewardship® is a registered trademark of Biotechnology Industry Organization.
- Insect Resistance Management: When planting any YieldGard® brand corn products, Genuity® brand corn products or Genuity® Bollgard II® cotton products, Grower must implement an IRM program according to the size and distance guidelines specified in the IRM/Grower Guide, including any supplemental amendments. Grower may lose Grower's limited use license to use these products if Grower fails to follow the IRM program required by this Agreement.
- Crop Stewardship & Specialty Crops: Refer to the section on *Coexistence and Identity Preservation* in the TUG for applicable information on crop stewardship and considerations for production of identity preserved crops.
- Corn Trait Performance: All hybrids containing Monsanto corn traits (YieldGard® Corn Borer corn, YieldGard® Rootworm corn, YieldGard® Plus corn, and Roundup Ready® Corn 2 corn) have been screened for the presence of the appropriate protein and have passed that screening prior to commercial sale. YieldGard® Rootworm corn and YieldGard® Plus corn hybrids have achieved industry leading success rates in excess of 99%. A small number of these hybrids may infrequently demonstrate variable levels of performance in fields and not meet grower expectations.

7. SPECIAL LIMITATIONS ON PRODUCTS CONTAINING MON 863 (ie. YieldGard® Rootworm corn, YieldGard® Plus corn, YieldGard® Rootworm with Roundup Ready® Corn 2 corn, YieldGard® Plus with Roundup Ready® Corn 2 corn):
Monsanto's U.S. Environmental Protection Agency (EPA) registration for the MON 863 event expires on September 30, 2010. However, on 8/25/2010, EPA published a proposed order in the Federal Register that would permit limited sales, distribution, and planting of any existing stocks of seed containing the MON 863 event through July 1, 2011. The EPA Order, which has an effective date of 9/30/2010, specifies that existing stocks of seed containing the MON 863 event can only be planted by July 1, 2011, for production of a corn crop. Therefore, unless EPA otherwise limits, any sale, distribution, or planting of existing stocks of seed containing the MON 863 event is prohibited after July 1, 2011.

8. GENERAL TERMS:
Grower's rights may not be transferred to anyone else without the written consent of Monsanto. If Grower's rights are transferred with Monsanto's consent or by operation of law, this Agreement is binding on the person or entity receiving the transferred rights. If any provision of this Agreement is determined to be void or unenforceable, the remaining provisions shall remain in full force and effect.

Grower acknowledges that Grower has received a copy of Monsanto's TUG and the IRM/Grower Guide. To obtain additional copies of the TUG and/or the IRM/Grower Guide, contact Monsanto at 1-800-768-6387 or go to www.monsanto.com. Once effective, this Agreement will remain in effect until either the Grower or Monsanto choose to terminate the Agreement, as provided in Section 9 below. Information regarding new and existing Monsanto Technologies, including any additions or deletions to the U.S. patents licensed under this agreement, and any new terms will be mailed to you each year. Continuing use of Monsanto Technologies after receipt of any new terms constitutes Grower's agreement to be bound by the new terms.

9. TERMINATION:
Grower may choose to terminate this Agreement in its entirety effective immediately by delivering written notice to Monsanto. Monsanto may choose to terminate this Agreement in whole or in part by delivering written notice to Grower. Grower must deliver the notice of termination to Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141. If this Agreement is terminated pursuant to such a notice, Grower's responsibilities and the other terms herein shall survive (such as but not limited to Grower's obligation to use Seed for a single commercial crop) as to Seed previously purchased by the Grower.

In the event Grower violates the terms of this Agreement, then the Grower's rights under this Agreement shall automatically terminate. However, Grower's responsibilities and the other terms herein shall survive as to all Seed purchased or used by the Grower (such as but not limited to Grower's obligation to use Seed for a single commercial crop, Grower's obligation to pay Monsanto for its attorneys' fees, costs and other expenses incurred in enforcing its rights under this Agreement, and Grower's agreement to the choice of law and forum selection provisions contained herein). Further, Grower shall not be entitled to obtain a future limited-use license from Monsanto unless Monsanto provides Grower with specific written notice expressly recognizing the prior breach and prior termination of the limited-use license and expressly granting and/or reissuing the limited-use license previously obtained (and terminated) pursuant to this Agreement. Grower expressly acknowledges that Grower's submission of a new Monsanto Technology Stewardship Agreement and Monsanto's issuance of a new license number shall not satisfy the specific written notice reference above and that any such action shall have no legal effect. If Grower is found by any court to have breached any term of this Agreement and/or to have infringed one or more of the U.S. patents listed below, Grower agrees that, among other things, Monsanto and Dow Agrosciences, as appropriate, shall be entitled to preliminary and permanent injunctions enjoining Grower and any individual and/or entity acting on Grower's behalf or in concert therewith from making, using, selling, or offering Seed for sale. Additionally, Grower agrees that any such finding of infringement by Grower shall entitle Monsanto and Dow Agrosciences, as appropriate, to patent infringement damages to the full extent authorized by 35 U.S.C. § 271 et. seq. Grower will also be liable for all breach of contract damages. If Grower is found by any court to have infringed one or more of the U.S. patents listed below or otherwise to have breached this Agreement, Grower agrees to pay Monsanto and the licensed Monsanto Technology provider(s) and Dow AgroSciences, as appropriate, their attorneys' fees and costs and other expenses incurred in enforcing rights under this Agreement including, but not limited to, expenses incurred in the investigation of the breach of this Agreement and/or infringement of one or more of the U.S. patents listed herein.

Grower accepts the terms of the following NOTICE REQUIREMENT, LIMITED WARRANTY AND DISCLAIMER OF WARRANTY AND EXCLUSIVE LIMITED REMEDY by signing this Agreement and/or opening a bag of Seed. If Grower does not agree to be bound by the conditions of purchase or use, Grower agrees to return the unopened bags to Grower's seed dealer.

10. NOTICE REQUIREMENT:
As a condition precedent to Grower or any other person with an interest in Grower's crop asserting any claim, action, or dispute against Monsanto and/or any seller of Seed regarding performance or non-performance of Monsanto Technologies or Seed, Grower must provide Monsanto a written, prompt, and timely notice (regarding performance or non-performance of the Monsanto Technologies) and to the seller of any Seed (regarding performance or non-performance of the Seed) within sufficient time to allow an in-field inspection of the crop(s) about which any controversy, claim, action, or dispute is being asserted. The notice will be timely only if it is delivered 15 days or less after the Grower first observes the issue(s) regarding performance or non-performance of the Monsanto Technology and/or the Seed. The notice shall include a statement setting forth the nature of the claim, name of the Monsanto Technology, and Seed hybrid or variety. Grower must deliver the notice to Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141.

11. LIMITED WARRANTY AND DISCLAIMER OF WARRANTIES:
Monsanto warrants that the Monsanto Technologies licensed hereunder will perform as set forth in the TUG when used in accordance with directions. This warranty applies only to Monsanto Technologies contained in planting Seed that has been purchased from Monsanto and seed companies licensed by Monsanto or the seed company's authorized dealers or distributors. EXCEPT FOR THE EXPRESS WARRANTIES IN THE LIMITED WARRANTY SET FORTH ABOVE, MONSANTO MAKES NO OTHER WARRANTIES OF ANY KIND, AND DISCLAIMS ALL OTHER WARRANTIES, WHETHER ORAL OR WRITTEN, EXPRESS OR IMPLIED INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.

12. GROWER'S EXCLUSIVE LIMITED REMEDY:
THE EXCLUSIVE REMEDY OF THE GROWER AND THE LIMIT OF THE LIABILITY OF MONSANTO OR ANY SELLER FOR ANY AND ALL LOSSES, INJURY OR DAMAGES RESULTING FROM THE USE OR HANDLING OF SEED (INCLUDING CLAIMS BASED IN CONTRACT, NEGLIGENCE, PRODUCT LIABILITY, STRICT LIABILITY, TORT, OR OTHERWISE) SHALL BE THE PRICE PAID BY THE GROWER FOR THE QUANTITY OF THE SEED INVOLVED OR, AT THE ELECTION OF MONSANTO OR THE SEED SELLER, THE REPLACEMENT OF THE SEED. IN NO EVENT SHALL MONSANTO OR ANY SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, SPECIAL, OR PUNITIVE DAMAGES.

Thank you for choosing our advanced technologies. We look forward to working with you in the future. If you have any questions regarding the Monsanto Technologies or this license, please call the Monsanto Customer Relations Center at: 1-800-768-6387.

13. PLEASE MAIL THE SIGNED 2011 MONSANTO TECHNOLOGY/STEWARDSHIP AGREEMENT TO:
Grower Licensing, Monsanto, 622 Emerson Road, Suite 150, St. Louis, MO 63141.

14. UNITED STATES PATENTS:
The licensed U.S. patents include: for Bollgard® cotton – 5,322,938; 5,352,605; 5,530,196; 6,943,282; for Genuity™ Bollgard II® cotton – 5,322,938; 5,338,544; 5,352,605; 5,362,865; 5,530,196; 5,659,122; 5,717,084; 5,728,925; 6,489,542; 6,943,282; 7,064,249; 7,223,907; for Genuity® Bollgard II® with Roundup Ready® cotton – 5,322,938; 5,338,544; 5,352,605; 5,362,865; 5,378,619; 5,530,196; 5,659,122; 5,717,084; 5,728,925; 6,051,753; 6,083,878; 6,489,542; 6,943,282; 7,064,249; 7,223,907; RE39247; for Genuity® Bollgard II® with Roundup Ready® Flex Cotton – 5,322,938; 5,338,544; 5,352,605; 5,362,865; 5,530,196; 5,659,122; 5,717,084; 5,728,925; 6,051,753; 6,083,878; 6,489,542; 6,660,911; 6,943,282; 6,949,696; 7,064,249; 7,112,725; 7,141,722; 7,223,907; 7,381,861; RE39247; for Bollgard® with Roundup Ready® cotton – 5,322,938; 5,352,605; 5,378,619; 5,530,196; 5,717,084; 5,728,925; 6,051,753; 6,083,878; 6,943,282; RE39247; for Bollgard® with Roundup Ready® Flex Cotton – 5,322,938; 5,352,605; 5,530,196; 5,717,084; 5,728,925; 6,051,753; 6,083,878; 6,660,911; 6,943,282; 6,949,696; 7,112,725; 7,141,722; 7,381,861; RE39247; for Mavera® high value corn with lysine – 7,157,281; for Genuity® Roundup Ready 2 Yield® Soybeans – 5,717,084; 5,728,925; 6,051,753; 6,660,911; 6,949,696; 7,141,722; 7,608,761; 7,632,985; RE39247; for Roundup Ready® Alfalfa – 5,362,865; 5,378,619; 5,659,122; 5,717,084; 5,728,925; 6,051,753; 7,566,817; RE39247; for Genuity® Roundup Ready® Canola – 5,378,619; 5,463,175; 5,717,084; 5,728,925; 5,750,871; 6,051,753; 6,083,878; 7,306,909; 7,718,373; RE38825; RE39247; for Roundup Ready® Corn – 5,554,798; 5,641,876; 5,717,084; 5,728,925; 6,025,545; 6,040,497; 6,083,878; for Roundup Ready® Corn 2 – 5,322,938; 5,352,605; 5,424,412; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,083,878; 6,825,400; 7,582,434; RE39247; for Roundup Ready® Cotton – 5,352,605; 5,378,619; 5,530,196; 5,717,084; 5,728,925; 6,051,753; 6,083,878; RE39247; for Genuity® Roundup Ready® Flex Cotton – 5,717,084; 5,728,925; 6,051,753; 6,083,878; 6.660,911; 6,949,696; 7,112,725; 7,141,722; 7,381,861; RE39247; for Roundup Ready® Soybeans – 5,352,605; 5,530,196; 5,717,084; 5,728,925; RE39247; for Genuity® Roundup Ready® Sugarbeets – 5,378,619; 5,717,084; 5,728,925; 6,051,753; 6,083,878; 7,335,816; RE39247; for YieldGard® Corn Borer corn – 5,352,605; 5,424,412; 5,484,956; 5,593,874; 5,859,347; 6,180,774; for YieldGard® Corn Borer with Roundup Ready® Corn – 5,322,938; 5,352,605; 5,424,412; 5,484,956; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,083,878; 6,180,774; RE39247; for YieldGard® Corn Borer with Roundup Ready® Corn 2 – 5,322,938; 5,352,605; 5,424,412; 5,484,956; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,083,878; 6,180,774; 6,825,400; 7,582,434; RE39247; for YieldGard® Rootworm corn – 5,352,605; 5,484,956; 6,063,597; 6,501,009; 7,408,096; 7,544,862; 7,705,216; for YieldGard® Plus corn – 5,352,605; 5,424,412; 5,484,956; 5,593,874; 5,859,347; 6,063,597; 6,180,774; 6,501,009; 7,408, 096; 7,544,862; for YieldGard® Plus with Roundup Ready® Corn 2 – 5,322,938; 5,352,605; 5,424,412; 5,484,956; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,063,597; 6,083,878; 6,180,774; 6,501,009; 6,825,400; 7,408,096; 7,554,862; 7,582,434; RE39247; for YieldGard® Rootworm with Roundup Ready® Corn 2 – 5,322,938; 5,352,605; 5,424,412; 5,484,956; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,063,597; 6,083,878; 6,501,009; 6,825,400; 7,408,096; 7,544,862; 7,582,434; 7,705,216; RE39247; for YieldGard VT PRO™ – 5,322,938; 5,352,605; 5,378,619; 5,424,412; 6,051,753; 6,489,542; 6,645,497; 6,713,063; 6,962,705; 7,064,249; 7,070,982; 7,250,501; 7,304,206; 7,618,942; for Genuity® VT Double PRO™ – 5,322,938; 5,352,605; 5,378,619; 5,424,412; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,051,753; 6,083,878; 6,489,542; 6,645,497; 6,713,063; 6,825,400; 6,962,705; 7,064,249; 7,070,982; 7,250,501; 7,304,206; 7,582,434; 7,618,942; RE39247; for YieldGard VT Rootworm/RR2® – 5,322,938; 5,352,605; 5,424,412; 5,554,798; 5,641,876; 5,717,084; 5,728,925; 6,025,545; 6,063,597; 6,083,878; 7,544,862; RE39247; for YieldGard VT Triple® – 5,322,938; 5,352,605; 5,424,412; 5,484,956; 5,554,798; 5,593,874; 5,641,876; 5,717,084; 5,728,925; 5,859,347; 6,025,545; 6,063,597; 6,083,878; 6,180,774; 7,544,862; RE39247; for Genuity® VT Triple PRO™ – 5,322,938; 5,352,605; 5,378,619; 5,424,412; 5,554,798; 5,641,876; 5,717,084; 5,728,925; 6,025,545; 6,051,753; 6,063,597; 6,083,878; 6,489,542; 6,645,497; 6,713;063; 6,962,705; 7,064,249; 7,070,982; 7,250,501; 7,304,206; 7,544,862; 7,618,942; RE39247; for tank mix - 6,239,072 ; for Drought – 5,641,876; 7,786,353; for Genuity® SmartStax™– 5,322,938; 5,352,605; 5,378,619; 5,424,412; 5,550,318; 5,554,798; 5,641,876; 5,717,084; 5,728,925; 6,025,545; 6,051,753; 6,063,597; 6,083,878; 6,489,542; 6,645,497; 6,713,063; 6,962,705; 7,064,249; 7,070,982; 7,112,665; 7,250,501; 7,304,206; 7,544,862; 7,618,942; RE39247.

Dow AgroScience Patent Rights for Genuity® SmartStax™ – 5,510,474; 6,083,499; 6,127,180; 6,218,188; 6,340,593; 6,548,291; 6,624,145; 6,893,872; 6,900,371; 6,943,282.

Genuity® Roundup Ready® Alfalfa seed is currently not for sale or distribution. The movement and use of Genuity® Roundup Ready® Alfalfa forage is subject to a USDA Administrative Order available at http://www.aphis.usda.gov/brs/pdf/RRA_A8_final.pdf.

B.t. products may not yet be registered in all states. Check with your Monsanto representative for the registration status in your state.

Roundup Rewards® applies only to Roundup® branded and other agricultural herbicides specified by Monsanto. Program details referenced in this publication are subject to change and should be verified by visiting RoundupRewards.com or checking with your local Monsanto dealer.

Growers may utilize the natural refuge option for varieties containing the Bollgard II® trait in the following states: AL, AR, FL, GA, KS, KY, LA, MD, MS, MO, NC, OK, SC, TN, VA, and most of Texas (excluding the Texas counties of Brewster, Crane, Crockett, Culberson, El Paso, Hudspeth, Jeff Davis, Loving, Pecos, Presidio, Reeves, Terrell, Val Verde, Ward and Winkler). The natural refuge option does not apply to Bollgard II cotton grown in areas where pink bollworm is a pest, including CA, AZ, NM, and the above listed Texas counties. It also remains the case that Bollgard® and Bollgard II cotton cannot be planted south of Highway 60 in Florida, and that Bollgard cotton cannot be planted in certain other counties in the Texas panhandle. Refer to the Technology Use Guide and IRM/Grower Guide for additional information regarding Bollgard II, Bollgard, natural refuge and EPA-mandated geographical restrictions on the planting of *B.t.* cotton.

ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS. It is a violation of federal law to promote or sell an unregistered pesticide. For tank mixtures, the applicable labeling for each product must be in the possession of the user at the time of application. Follow applicable use instructions, including application rates, precautions and restrictions of each product used in the tank mixture. Monsanto has not tested all tank mix product formulations for compatibility or performance other than specifically listed by brand name. Always predetermine the compatibility of tank mixtures by mixing small proportional quantities in advance.

IMPORTANT: Grain Marketing and Seed Availability: It is a violation of national and international law to move material containing biotech traits across boundaries into nations where import is not permitted. Consult with your seed representative for current stewardship information.

Roundup Ready® crops contain genes that confer tolerance to glyphosate, the active ingredient in Roundup® brand agricultural herbicides. Roundup® brand agricultural herbicides will kill crops that are not tolerant to glyphosate. Bollgard®, Bollgard II®, Genuity®, Roundup®, Roundup Ready®, Roundup Ready 2 Yield®, Roundup Rewards®, SmartStax™, Vistive®, VT Double PRO™, VT Triple PRO™, YieldGard®, YieldGard VT®, YieldGard VT Rootworm/RR2®, and YieldGard VT Triple® are trademarks of Monsanto Technology LLC. All other trademarks are the property of their respective owners. ©2010 Monsanto Company. [22189Apgd] 5A-7K-10-4933

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Integrated Crop Management NEWS

Use Facts to Make Glyphosate and Glyphosate Resistant Crop Decisions

By Bob Hartzler and Mike Owen, Department of Agronomy

Information presented recently on the Web and in seminars across the Midwest has portrayed devastating consequences due to the widespread use of glyphosate and glyphosate resistant crops. It is important to recognize that there is little data published in refereed journals to support these claims. Data that are available have been taken greatly out of context to support the accusations.

The issues and claims have been brought forward by Dr. Don Huber, retired professor of Plant Pathology at Purdue University. Recently, Purdue University faculty members have responded to these claims and using peer-reviewed science, have refuted the statements made by Dr. Huber.

Their final statement summarizes the available evidence of the impact glyphosate and GMO crops have on plant health, **"We encourage crop producers, agribusiness personnel, and the general public to speak with University Extension personnel before making changes in crop production practices that are based on sensationalist claims instead of facts."**

The complete Purdue University statement, "Glyphosate's Impact on Field Crop Production and Disease Development," is available online.

An article providing an overview of the effects of glyphosate on mineral nutrition and plant diseases was prepared earlier by Iowa State University weed scientists. Read the article, Glyphosate Interactions with Micronutrients and Plant Diseases, for additional research-based information.

Bob Hartzler and Micheal Owen are professors of agronomy and weed science extension specialists with responsibilities in weed management and herbicide use.

This article was published originally on 2/25/2011 The information contained within the article may or may not be up to date depending on when you are accessing the information.

Bio
BIOTECHNOLOGY
INDUSTRY ORGANIZATION

Farmers Successfully Practice Coexistence

Biotech, conventional and organic crops all contribute to safe, reliable and diverse food supply

The practice of farmers successfully growing and marketing crops – whether biotech, conventional or organic – in close proximity is known as coexistence. Farmers have been successfully practicing coexistence for years.

Biotech crops (grown on 154 million acres of U.S. land) and organic crops (grown on 2.5 million acres of U.S. land) play an important role in providing healthful foods and in helping farmers provide for a growing population and meet the needs of diverse agricultural markets.

> ***Feeding a world population of 9.1 billion in 2050 will require raising overall food production by 70 percent (nearly 100 percent in developing countries).***
> *- United Nations Food and Agriculture Organization*

Maintaining Farmer Choice is Imperative

Farmers should have the choice to plant crops that best meet their needs, whatever the practice: organics, conventional, or biotech.

In support of coexistence practices, growers who produce high-value crops under identity-preserved systems have a long history of cooperating with their neighbors to isolate crops from adjacent fields.

BIO Supports Coexistence Efforts

BIO supports cooperative efforts among growers and agricultural practices that foster coexistence of different production methods. Coexistence enables farmers to choose what crops and what market-driven production systems they prefer to bring high-value products to U.S. and international markets.

Incidental Commingling Occurs

In any working agricultural production system, incidental commingling of trace amounts of seed, grain or food product with another occurs. This is a reality of plant biology, seed production and the distribution of commodity crops, and was occurring long before the development of biotech products.

Still, not one organically certified farm has lost its USDA certification due to the presence of commingled biotech plant material since the beginning of the federal National Organic Program.

It's important to remember that commingling is not a safety issue, as the biotech crop has already obtained full regulatory authorizations.

Coexistence Proves Successful in Practice

Research and experience with growing different crops using different production methods in close proximity with one another has proven that, by implementing sound agronomic practices in combination with good communication between growers, productive coexistence can be achieved successfully.

For example, long-standing coexistence practices have been effective in allowing canola to be grown in the same region as rapeseed, even though these two crops are destined for different markets and cannot be commingled. Similarly, field corn and popcorn are grown in the same regions but managed so that commingling does not occur.

The agricultural biotechnology industry has been involved in a variety of coexistence-related efforts across the country. Examples include:

- Legislation passed in Hawaii to promote farmer-to-farmer dialogues coordinated by the state farm bureau;

- Legislation in California to organize coexistence dialogues by the state's department of agriculture and markets;

- Federal grant-funded coexistence discussions coordinated by the North Dakota State University Extension Service, which resulted in numerous best management practices to minimize risk from the presence of biotech materials at low levels in non-biotech crop production systems.

With a focus on cooperation and the different production practices of individual farmers, these initiatives demonstrate the importance of local and regional approaches to coexistence.

Food and Environmental Safety is Assured

Biotech crops are among the most heavily regulated agricultural products. The expertise of three federal agencies, the U.S. Environmental Protection Agency (EPA), the U.S. Food and Drug Administration (FDA), and the U.S. Department of Agriculture (USDA), is brought to bear on these products.

Products derived from this technology do not enter the food supply until all appropriate federal agencies have determined that they are as safe as conventional crops. Biotech crops have been cultivated for more than 15 years, and foods derived from biotechnology have been eaten by billions of people without a single documented health problem.

Next-generation biotechnology products are poised to bring productivity benefits to the market, but they must work their way through a complex, rigorous regulatory system before their potential can be realized.

Biotech Adoption Continues to Grow

U.S. farmers overwhelmingly choose to plant biotech crops, especially corn, soybeans and cotton, but also sugar beets, squash, papaya, alfalfa and canola.
- U.S. adoption of biotech soybeans is **93 percent** in 2010.
- U.S. adoption of biotech corn is **86 percent** in 2010.
- U.S. adoption of biotech cotton is **93 percent** in 2010.

-*Adoption of Genetically Engineered Crops in the U.S.*, USDA's Economic Research Service, July 1, 2010.

ISAAA Brief 42-2010: Executive Summary

Global Status of Commercialized Biotech/GM Crops: 2010

Introduction

This Executive Summary focuses on the 2010 biotech crop highlights, which are presented and discussed in detail in ISAAA Brief 42, Global Status of Commercialized Biotech/GM Crops: 2010.

2010 is the 15th Anniversary of the commercialization of biotech crops.

2010 is the fifteenth anniversary of the commercialization of biotech crops, first planted in 1996. As a result of the consistent and substantial economic, environmental and welfare benefits offered by biotech crops, millions of large, small and resource-poor farmers around the world continued to plant significantly more hectares of biotech crops in 2010. **Progress was made on several major fronts: accumulated hectares from 1996 to 2010 reached an historic global milestone; a significant double-digit year-over-year increase in biotech crop hectarage was posted, as well as a record number of biotech crop countries; the number of farmers planting biotech crops globally increased substantially; across-the-globe growth, reflected increased stability of adoption and that biotech crops are here to stay.** These are very important developments given that biotech crops already contribute to some of the major challenges facing global society, including: **food security and self-sufficiency, sustainability, alleviation of poverty and hunger, help in mitigating some of the challenges associated with climate change and global warming; and the potential of biotech crops for the future is enormous.**

Accumulated hectarage from 1996 to 2010 exceeded an unprecedented 1 billion hectares for the first time, signifying that biotech crops are here to stay.

Remarkably, in 2010, the accumulated hectarage planted during the 15 years, 1996 to 2010, **exceeded for the first time, 1 billion hectares, which is** equivalent to more than 10% of the enormous total land area of the USA (937 million hectares) or China (956 million hectares). **It took 10 years to reach the first 500 million hectares in 2005, but only half that time, 5 years, to plant the second 500 million hectares to reach a total of 1 billion hectares in 2010.**

A record 87-fold increase in hectarage between 1996 and 2010, making biotech crops the fastest adopted crop technology in the history of modern agriculture

The growth from 1.7 million hectares of biotech crops in 1996 to 148 million hectares in 2010 is an unprecedented 87-fold increase, making biotech crops the fastest adopted crop technology in the history of modern agriculture. Importantly, this reflects the trust and confidence of millions of farmers worldwide, who have consistently benefited from the significant and multiple benefits that biotech crops offered over the last 15 years, and has provided farmers with the strong motivation and incentive to plant more hectares of biotech crops every single year since 1996, mostly with double-digit percentage annual growth. **Over the last fifteen years, farmers, who are the masters of risk aversion, have consciously made approximately 100 million individual decisions to plant an increasing hectarage of biotech crops year after year, because of the significant benefits they offer.** Surveys confirm that close to 100% of farmers decided to continue to plant, after their first experience with biotech crops because of the benefits they offer.

Strong double digit-growth of 10% in hectarage in the 15th year of commercialization – notably, the 14 million hectare increase was the second largest increase in 15 years.

Global hectarage of biotech crops continued its strong growth in 2010 for the fifteenth consecutive year – **a 10%, or 14 million hectare increase, notably the second largest increase in 15 years, reaching 148 million hectares,** – up significantly from a 7% growth or 9 million hectares increase and a total of 134 million hectares in 2009. Measured more precisely, in 2010 adoption of biotech crops increased to 205 million "trait hectares", equivalent to a 14% growth or 25 million "trait hectares", up from 180 million "trait hectares" in 2009. Measuring in "trait hectares" is similar to measuring air travel (where there is more than one passenger per plane) more accurately in "passenger miles" rather than "miles".

Number of countries planting biotech crops soared to a record 29, up from 25 in 2009 – for the first time, the top ten countries each grew more than 1 million hectares.

It is noteworthy that in 2010, the number of biotech countries planting biotech crops reached 29, up from 25 in 2009 (Table 1 and Figure 1). Thus, the number of countries electing to grow biotech crops has increased consistently from 6 in 1996, the first year of commercialization, to 18 in 2003, 25 in 2008 and 29 in 2010. **For the first time the top ten countries each grew more than 1 million hectares;** in decreasing order of hectarage they were; **USA (66.8 million hectares), Brazil (25.4), Argentina (22.9), India (9.4), Canada (8.8), China (3.5), Paraguay (2.6), Pakistan (2.4), South Africa (2.2) and Uruguay with 1.1 million hectares.** The remaining 19 countries which grew biotech crops in 2010 in decreasing order of hectarage were: **Bolivia, Australia, Philippines, Burkina Faso, Myanmar, Spain, Mexico, Colombia, Chile, Honduras, Portugal, Czech Republic, Poland, Egypt, Slovakia, Costa Rica, Romania, Sweden and Germany. The number of biotech crop mega-countries (countries growing 50,000 hectares, or more) increased to 17 in 2010 from 15 in 2009. The strong growth in 2010 provides a very broad and stable foundation for future global growth of biotech crops.**

Table 1. Global Area of Biotech Crops in 2010: by Country (Million Hectares)

Rank	Country	Area (million hectares)	Biotech Crops
1	USA*	66.8	Maize, soybean, cotton, canola, sugarbeet, alfalfa, papaya, squash
2	Brazil*	25.4	Soybean, maize, cotton
3	Argentina*	22.9	Soybean, maize, cotton
4	India*	9.4	Cotton
5	Canada*	8.8	Canola, maize, soybean, sugarbeet
6	China*	3.5	Cotton, papaya, poplar, tomato, sweet pepper
7	Paraguay*	2.6	Soybean
8	Pakistan *	2.4	Cotton
9	South Africa*	2.2	Maize, soybean, cotton
10	Uruguay*	1.1	Soybean, maize
11	Bolivia*	0.9	Soybean
12	Australia*	0.7	Cotton, canola
13	Philippines*	0.5	Maize
14	Myanmar*	0.3	Cotton
15	Burkina Faso*	0.3	Cotton
16	Spain*	0.1	Maize
17	Mexico*	0.1	Cotton, soybean
18	Colombia	<0.1	Cotton
19	Chile	<0.1	Maize, soybean, canola
20	Honduras	<0.1	Maize
21	Portugal	<0.1	Maize
22	Czech Republic	<0.1	Maize, potato
23	Poland	<0.1	Maize
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize
26	Costa Rica	<0.1	Cotton, soybean
27	Romania	<0.1	Maize
28	Sweden	<0.1	Potato
29	Germany	<0.1	Potato
	Total	**148.0**	

* 17 biotech mega-countries growing 50,000 hectares, or more, of biotech crops

Source: Clive James, 2010.

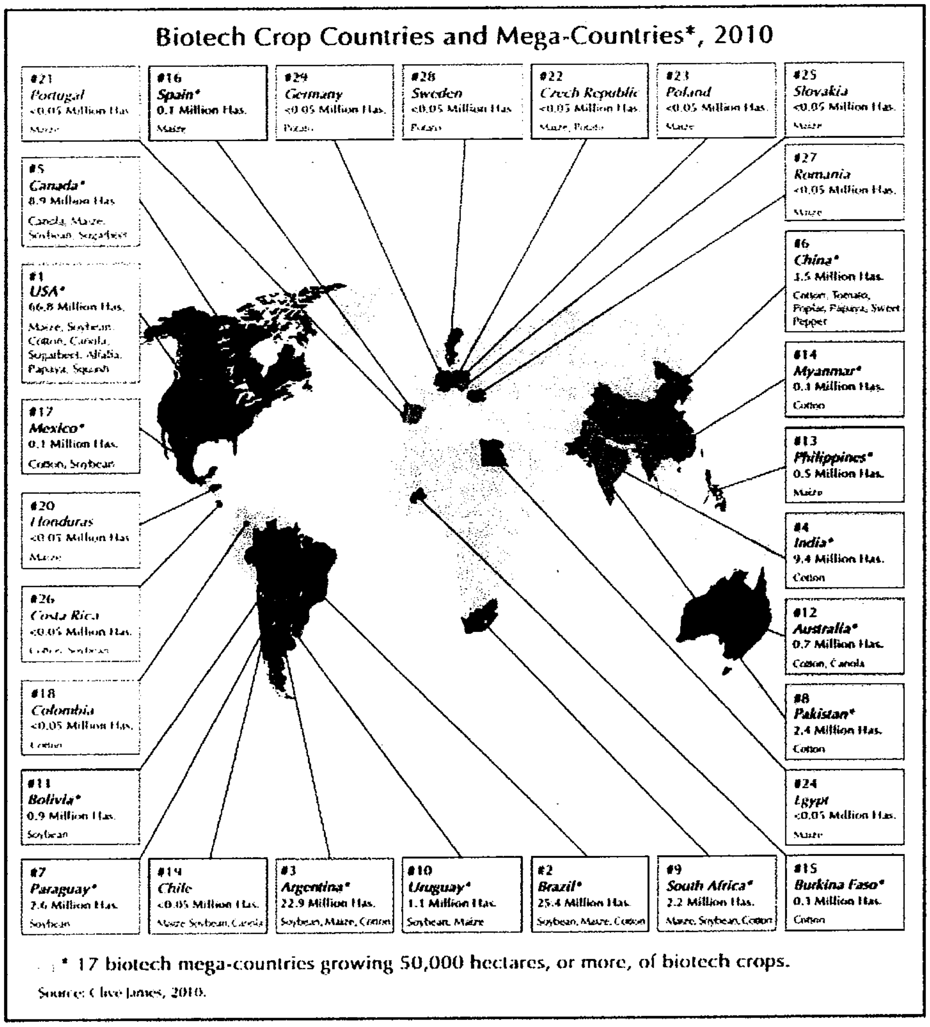


Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2010

Three new countries planted approved biotech crops for the first time in 2010 and Germany resumed planting.

Pakistan planted Bt cotton, as did **Myanmar**, and notably **Sweden**, the first Scandinavian country to plant a biotech crop, planted **"Amflora"**, a potato with high quality starch. Germany also resumed adoption of biotech crops by planting "Amflora" , for a net gain of four countries in 2010.

Of the 29 biotech crop countries in 2010, 19 were developing countries compared with only 10 industrial countries.

The strong trend for more developing countries than industrial countries to adopt biotech crops is expected to continue in the future with about **40 countries expected to adopt biotech crops by 2015,** the final year of the second decade of commercialization. By coincidence, 2015 also happens to be the Millennium Development Goals year, when global society has pledged to cut poverty and hunger in half – a noble humanitarian goal that biotech crops can contribute to, in an appropriate and significant way.

In 2010, the 15th year of commercialization, a record 15.4 million farmers grew biotech crops – notably, over 90% or 14.4 million were small resource-poor farmers in developing countries; estimates of number of beneficiary farmers are conservative due to a spill-over of indirect benefits to neighboring farmers cultivating conventional crops.

It is a historical coincidence that 2010, the 15th consecutive year of planting biotech crops, was also the year when a record 15.4 million small and large farmers from both developing and industrial countries planted biotech crops, up by 1.4 million from 2009. Notably, over 90%, or 14.4 million, were small and resource-poor farmers in developing countries. This is contrary to the predictions of some critics, who speculated, prior to the commercialization of biotech crops, that biotech crops were only for the rich and large farmers in industrial countries. However, experience has proven that to-date, by far, the largest number of beneficiary farmers, are small and resource-poor farmers in developing countries; this trend is likely to even strengthen in the future as most of the growth will be in developing countries. In 2010, the total number of small resource-poor farmers growing biotech crops were mainly in the following countries: **6.5 million in China cultivating an average of only 0.6 hectares of Bt cotton; 6.3 million in India; 0.6 million in Pakistan; 0.4 million in Myanmar; over a quarter million in the Philippines; almost 100,000 in Burkina Faso, and the balance of 0.2 million in the other 13 developing countries cultivating biotech crops.** Moreover, these estimates of the number of beneficiary farmers are conservative because studies in China indicate that an **additional 10 million farmers, planting crops other than Bt cotton but infested by the same cotton bollworm pest, are deriving indirect or spill-over benefits due to Bt cotton suppressing pest infestation levels of cotton bollworm (up to 90% lower)** on conventional crops such as maize and soybean. **Thus, up to 10 million more small and resource-poor farmers are secondary beneficiaries of Bt cotton in China. This spill-over effect in China is consistent with the results of a US study where farmers planting Bt maize for the period 1996 to 2009 derived benefits of US$2.6 billion but farmers planting conventional maize in the same region benefited 65% more, at US$4.3 billion in indirect benefits due to the suppression of pest infestations effected by Bt maize.**

Developing countries grew 48% of global biotech crops in 2010 – they will exceed industrial countries before 2015 – growth rates are also faster in developing countries than industrial countries.

The percentage of global biotech crops grown by developing countries has increased consistently every year over the last decade, from 14% in 1997, to 30% in 2003, 43% in 2007 and 48% in 2010. **Developing countries are almost certain to plant more biotech crops than industrial countries, well before the MDG year of 2015. Rate of hectarage growth in biotech crops between 2009 and 2010 was much higher in developing countries, 17% and 10.2 million hectares, compared with industrial countries at 5% and 3.8 million hectares.**

The lead developing countries are China, India, Brazil, Argentina and South Africa.

There are five principal developing countries growing biotech crops, China and India in Asia, Brazil and Argentina in Latin America, and South Africa in the continent of Africa, with a combined population of 2.7 billion (40% of global), which are exerting leadership with biotech crops. Collectively, the five countries planted 63 million hectares in 2010, equivalent to 43% of the global total and are driving adoption in the developing countries. Furthermore, benefits from biotech crops are spurring strong political will and substantial new R&D investments in biotech crops in both the public and private sectors, particularly in China, Brazil and India.

Brazil increased its hectarage of biotech crops, more than any other country in the world, an impressive 4 million hectare increase.

For the second year running Brazil, the engine of biotech crop growth in Latin America had the largest absolute year-over-year increase, **an impressive 4 million hectare increase over 2009.**

In Australia, biotech crops recovered after a multi-year drought with the largest proportional year-on-year increase of 184%.

Following a multi year drought which was the worst in the history of the country, the total hectarage of **biotech crops in 2010 increased significantly to over 650,000 hectares from approximately 250,000 hectares in 2009** (a 184% increase). Increases were recorded for both biotech cotton and canola.

Burkina Faso had the second largest proportional increase of biotech hectarage of any country in the world, an increase of 126%.

For the second consecutive year, Burkina Faso in West Africa had a very high proportional increase which was the second highest percentage increase in the world in 2010. **Bt cotton hectarage in 2010 increased by 126% to reach 260,000 hectares (65% adoption) farmed by 80,000 farmers, compared with 115,000 hectares in 2009.**

In India, stellar growth continued with 6.3 million farmers growing 9.4 million hectares of Bt cotton, equivalent to 86% adoption rate.

Mexico, the center of biodiversity for maize, successfully conducted the first field trials of Bt and herbicide tolerant maize.

After an eleven year moratorium, which precluded field trials of biotech maize in Mexico, the first experimental field trials were successfully conducted in 2010, which demonstrated the effectiveness of biotech crops for the control of insect pests and weeds. This is consistent with international experience with commercializing biotech maize in more than 10 countries around the world for about 15 years. Further trials planned for 2011 will evaluate biotech maize semi-commercially. These trials will generate valuable information regarding the use of adequate biosafety measures that will allow coexistence of biotech and conventional maize to be practiced on a realistic and pragmatic basis, as well as to provide accurate cost-benefit data regarding economic benefits for farmers. The first permits for biotech maize trials to be conducted semi-commercially in 2011 were requested in the last quarter of 2010.

EU biotech crop adoption grows to a record of eight countries following approval of "Amflora" potato – the first approval for planting in 13 years in the EU. Six countries grew Bt maize, three grew Amflora, and one country grew both.

A record number of eight EU countries planted biotech crops in 2010; six countries continued to plant 91,193 hectares of Bt maize (compared with 94,750 hectares in 2009), led by Spain; **three countries, the Czech Republic, Sweden (the first Scandinavian country to plant a biotech crop), and Germany planted small hectarages of "Amflora" potato totaling 450 hectares in the three countries for seed multiplication and initial commercial production. "Amflora",** approved in 2010, is the first biotech crop to be approved by the EU for planting in thirteen years. Other biotech potatoes, including one that is resistant to the important disease "late blight", the cause of the Irish famine of 1845, are under development in EU countries and expected to be released before 2015, subject to regulatory approval.

In 2010, more than half the world's population (59% or 4 billion people) lived in the 29 countries, which planted 148 million hectares of biotech crops.

More than half (59% or 4.0 billion people) of the global population of 6.7 billion live in the 29 countries where biotech crops were grown in 2010 and generated significant and multiple benefits worth over US$10 billion (10.7) globally in 2009. Notably, more than half (52% or 775 million hectares) of the ~ 1.5 billion hectares of cropland in the world is in the 29 countries where approved biotech crops were grown in 2010.

For the first time, biotech crops occupied a significant 10% of ~1.5 billion hectares of all cropland in the world, providing a stable base for future growth.

The 148 million hectares of biotech crops in 2010 occupied for the first time, a significant 10% of all 1.5 billion hectares of cropland in the world.

Adoption by crop – herbicide tolerant soybean remains the dominant crop.

Biotech soybean continued to be the principal biotech crop in 2010, occupying 73.3 million hectares or 50% of global biotech area, followed by biotech maize (46.8 million hectares at 31%), biotech cotton (21.0 million hectares at 14%) and biotech canola (7.0 million hectares at 5%) of the global biotech crop area. After entering the EU, Romania was denied the opportunity of continuing to benefit from successful production of RR®soybean. Romania's Minister of Agriculture estimates that the EU ban is costing Romania US$131 million annually – he is requesting urgent approval for resumption of planting RR®soybean in Romania.

Adoption by trait – herbicide tolerance remains the dominant trait.

From the genesis of commercialization in 1996 to 2010, herbicide tolerance has consistently been the dominant trait. **In 2010, herbicide tolerance deployed in soybean, maize, canola, cotton, sugarbeet and alfalfa, occupied 61% or 89.3 million hectares of the global biotech area of 148 million hectares.** In 2010, the stacked double and triple traits occupied a larger area (32.3 million hectares, or 22% of global biotech crop area) than insect resistant varieties (26.3 million hectares) at 17%. **The insect resistance trait products were the fastest growing trait group between 2009 and 2010 at 21% growth, compared with 13% for stacked traits and 7% for herbicide tolerance.**

Stacked traits are an increasingly important feature of biotech crops – 11 countries planted biotech crops with stacked traits in 2010, 8 were developing countries.

Stacked products are a very important feature and future trend, which meets the multiple needs of farmers and consumers and these are now increasingly deployed by eleven countries listed in descending order of hectarage – USA, Argentina, Canada, South Africa, Australia, the Philippines, Brazil, Mexico, Chile, Honduras, and Colombia, (8 of the 11 are developing countries), with more countries expected to adopt stacked traits in the future. A total of 32.3 million hectares of stacked biotech crops were planted in 2010 compared with 28.7 million hectares in 2009. In 2010, the USA led the way with 41% of its total 66.8 million hectares of biotech crops stacked, including 78% of maize, and 67% of cotton; the fastest growing component of stacked maize in the USA was the triple stacks conferring resistance to two insect pests plus herbicide tolerance. Double stacks with pest resistance and herbicide tolerance in maize were also the fastest growing component in 2010 in the Philippines, increasing from 338,000 in 2009 to 411,000 in 2010, up by a substantial 22%. Biotech maize with eight genes, named SmartstaxTM, was released in the USA and Canada in 2010 with eight different genes coding for several pest resistant and herbicide tolerant traits. Future stacked crop products will comprise both agronomic input traits for pest resistance, tolerance to herbicides and drought plus output traits such as high omega-3 oil in soybean or enhanced pro-Vitamin A in Golden Rice.

Contribution of biotech crops to Sustainability – the multiple contributions of biotech crops are already being realized in the following ways and have enormous potential for the future.

The World Commission on Environment and Development defined sustainable development as follows: ***"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations,***

1987). Biotech crops are already contributing to sustainability and can help mitigate the effects of climate change in the following five ways:

- ***Contributing to food, feed and fiber security and self sufficiency, including more affordable food, by increasing productivity and economic benefits sustainably at the farmer level;***

Biotech crops already play an important role by increasing productivity per hectare and coincidentally decreasing cost of production as a result of reduced need for inputs. Economic gains at the farm level of ~ US$65 billion were generated globally by biotech crops during the period 1996 to 2009, of which just less than half, 44%, were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and just over half, 56%, due to substantial yield gains of 229 million tons. The 229 million tons comprised 83.5 million tons of soybean, 130.5 million tons of maize, 10.5 million tons of cotton lint, and 4.8 million tons of canola over the period 1996 to 2009. For 2009 alone, economic gains at the farm level were ~ US$10.7 billion, of which approximately 25%, were due to reduced production costs (less ploughing, fewer pesticide sprays and less labor) and approximately 75%, due to substantial yield gains of 41.7 million tons. The 41.67 million tons comprised 9.7 million tons of soybean, 29.4 million tons of maize, 1.9 million tons of cotton lint, and 0.67 million tons of canola in 2009. Thus, biotech crops are already making a contribution to higher productivity and lower costs of production of current biotech crops, and have enormous potential for the future when the food staples of rice and wheat, as well as pro-poor food crops such as cassava, will benefit from biotechnology (Brookes and Barfoot, 2011, forthcoming).

- ***Conserving biodiversity, biotech crops are a land saving technology;***

Biotech crops are a land-saving technology, capable of higher productivity on the current 1.5 billion hectares of arable land, and thereby can help preclude deforestation and protect biodiversity in forests and in other in-situ biodiversity sanctuaries. Approximately 13 million hectares of biodiversity - rich tropical forests are lost in developing countries annually. If the 229 million tons of additional food, feed and fiber produced by biotech crops during the period 1996 to 2009 had not been produced by biotech crops, an additional 75 million hectares of conventional crops would have been required to produce the same tonnage. Some of the additional 75 million hectares would probably have required fragile marginal lands, not suitable for crop production, to be ploughed, and for tropical forest, rich in biodiversity, to be felled to make way for slash and burn agriculture in developing countries, thereby destroying biodiversity. Similarly, for 2009 alone, if the 42 million tons of additional food, feed and fiber produced by biotech crops during 2009 had not been produced by biotech crops, an additional 12 million hectares of conventional crops would have been required to produce the same tonnage for 2009 alone (Brookes and Barfoot, 2011, forthcoming).

- ***Contributing to the alleviation of poverty and hunger;***

Fifty percent of the world's poorest people are small and resource-poor farmers, and another 20% are the rural landless completely dependent on agriculture for their livelihoods. Thus, increasing income of small and resource-poor farmers contributes directly to the poverty alleviation of a large majority (70%) of the world's poorest people. **To-date, biotech cotton in countries such as China, India, Pakistan, Myanmar, Philippines, Burkina Faso and South Africa have already made a significant contribution to the income of 14.4 million poor farmers in 2010, and this can be enhanced significantly in the remaining 5 years of the second decade of commercialization, 2011 to 2015.** Of special significance is biotech rice which has the potential to benefit 250 million poor rice households in Asia, (equivalent to one billion beneficiaries based on 4 members per household) growing on average only half a hectare of rice with an income as low as US$1.25 per day - they are some of the poorest people in the world. It is evident that much progress has been made in the first fifteen years of commercialization of biotech crops, but progress to-date is just the "tip of the iceberg" compared with potential progress in the second decade of commercialization, 2006-2015. It is a fortunate coincidence that the last year of the second decade of commercialization of biotech crops, 2015, is also the year of the Millennium Development Goals (MDG). **This offers a unique opportunity for the global crop biotechnology community, from the North and the South, the public and the private sectors, to define in 2010 the contributions that biotech crops can make to the 2015 Millennium Development Goals and also a more sustainable agriculture in the future** - this gives the global biotech crop community five years to work towards implementing a global strategy and action plan for biotech crops that can deliver on the MDG goals of 2015.

- ***Reducing agriculture's environmental footprint;***

Conventional agriculture has impacted significantly on the environment and biotechnology can be used to reduce the environmental footprint of agriculture. Progress to-date includes: a significant reduction in pesticides; saving on fossil fuels; decreasing CO2 emissions through no/less ploughing; and conserving soil and moisture by optimizing the practice of no till through application of herbicide tolerance. The accumulative reduction in pesticides for the period 1996 to 2009 was estimated at 393 million kilograms (kgs) of active ingredient (a.i.), a saving of 8.8% in pesticides, which is equivalent to a 17.1% reduction in the associated environmental impact of pesticide use on these crops, as measured by the Environmental Impact Quotient (EIQ) - a composite measure based on the various factors contributing to the net environmental impact of an individual active ingredient. The corresponding data for 2009 alone was a reduction of 39.1 million kgs a.i. (equivalent to a saving of 10.2% in pesticides) and a reduction of 21.8% in EIQ (Brookes and Barfoot, 2011, forthcoming).

Increasing efficiency of water usage will have a major impact on conservation and availability of water globally. Seventy percent of fresh water is currently used by agriculture globally, and this is obviously not sustainable in the future as the population increases by almost 50% to 9.2 billion by 2050. The first biotech maize hybrids with a degree of drought tolerance are expected to be commercialized by 2012 in the USA, and the first tropical drought tolerant biotech maize is expected by 2017 for Sub Saharan Africa. The advent of drought tolerance in temperate tropical maize in the industrial countries will be a major milestone but will be of even much greater significance in tropical maize in Sub Saharan Africa, Latin America and Asia. Drought tolerance has also been incorporated in several other crops including wheat, which has performed well in initial field trials in Australia, with the best lines yielding 20% more than their conventional counterparts. **Drought tolerance is expected to have a major impact on more sustainable cropping systems worldwide, particularly in developing countries, where drought is more prevalent and severe than industrial countries.**

- ***Helping mitigate climate change and reducing greenhouse gases.***

The important and urgent concerns about the environment have implications for biotech crops, which contribute to a reduction of greenhouse gases and help mitigate climate change in two principal ways. First, permanent savings in carbon dioxide (CO_2) emissions through reduced use of fossil-based fuels, associated with fewer insecticide and herbicide sprays; in 2009, this was an estimated saving of 1.36 billion kg of CO_2, equivalent to reducing the number of cars on the roads by 0.6 million. Secondly, additional savings from conservation tillage (need for less or no ploughing facilitated by herbicide tolerant biotech crops) for biotech food, feed and fiber crops, led to an additional soil carbon sequestration equivalent in 2009 to16.3 billion kg of CO_2, or removing 7.2 million cars off the road. Thus in 2009, the combined permanent and additional savings through sequestration was equivalent to a saving of 17.6 billion kg of CO_2 (~18 billion kg) or removing 7.8 million cars (~8 million cars) from the road (Brookes and Barfoot, 2011, forthcoming).

Droughts, floods, and temperature changes are predicted to become more prevalent and more severe as we face the new challenges associated with climate change, and hence, there will be a **need for faster crop improvement programs to develop varieties and hybrids that are well adapted to more rapid changes in climatic conditions.** Several biotech crop tools, including tissue culture, diagnostics, genomics, molecular marker-assisted selection (MAS) and biotech crops can be used collectively for **'speeding the breeding'** and help mitigate the effects of climate change. Biotech crops are already contributing to reducing CO_2 emissions by precluding the need for ploughing a significant portion of cropped land, conserving soil, and particularly moisture, and reducing pesticide spraying as well as sequestering CO_2.

In summary, collectively the above five thrusts have already demonstrated the capacity of biotech crops to contribute to sustainability in a significant manner and for mitigating the formidable challenges associated with climate change and global warming; and the potential for the future is enormous. Biotech crops can increase productivity and income significantly, and hence, can serve as an engine of rural economic growth that can contribute to the alleviation of poverty for the world's small and resource-poor farmers.

There is an urgent need for appropriate cost/time-effective regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries

The most important constraint to the adoption of biotech crops in most developing countries, that deserves highlighting, is the lack of appropriate cost/time-effective and responsible regulatory systems that incorporate all the knowledge and experience of 15 years of regulation. **Current regulatory systems in most developing countries are usually unnecessarily cumbersome and in many cases it is impossible to implement the system to approve products which costs US$1 million or more to deregulate – this is beyond the means of most developing countries.** The current regulatory systems were designed more than 15years ago to meet the initial needs of industrial countries dealing with a new technology and with access to significant resources for regulation which developing countries simply do not have – t**he challenge for developing countries is "how to do a lot with little."** With the accumulated knowledge of the last fifteen years it is now possible to design appropriate regulatory systems that are responsible, rigorous and yet not onerous, requiring only modest resources that are within the means of most developing countries – **this should be assigned top priority. This is a moral dilemma, where the demands of regulatory systems have become "the end and not the means."**

Conclusions of the Study Week on Biotech Crops and Food Security hosted by the Pontifical Academy of Sciences

The Pontifical Academy of Sciences, (PAS) Study Week from 15-19 May 2009, organized by Dr. Ingo Potrykus addressed the important issue of **"Transgenic Plants for Food Security in the Context of Development."** The following were some of the principal conclusions endorsed by the participants, in which the Vatican was not involved:

- enhance the provision of reliable information to regulators, and producers to facilitate sound decision -making based on current knowledge;
- standardize and rationalize the principles involved in the evaluation and approval of new crop varieties, irrespective of the breeding process (Genetically Engineered [GE] or conventional) so that they are scientific, risk-based, predictable and transparent;
- re-evaluate the application of the precautionary principle to GE crops using scientific prediction as a

basis for action;

- evaluate the Cartagena Protocol, to ensure that it is consistent with current scientific understanding;
- free GE techniques from excessive, unscientific regulation, to facilitate the enhancement of crop productivity and nutrition;
- promote technology to assist small farmers to optimize crop productivity;
- encourage the wide adoption of sustainable productive practices to improve the lives of the poor and needy;
- ensure that appropriate GE and molecular marker-assisted breeding are used to improve crops grown in food-insecure, poor nations;
- encourage international aid agencies and charities to take urgent action to provide support and exercise moral responsibility to guarantee food security;
- facilitate private-public cooperative relationships to ensure the cost-free exploitation of GE technologies for the common good in the developing world where they will have the greatest impact.

These very important conclusions along with more information from 31 scientific contributions, including the conference statement have been published in all the major languages. For further information see (New Biotechnology, 2010, http://www.askforce.org/web/Vatican-PAS-Studyweek-Elsevier-publ-20101130/Press-Release-PAS-Studyweek-20101127.pdf; Participants:http://www.ask-force.org/web/Vatican-Studyweek-Elsevier/Participants-List-english-email.pdf).

Status of Approved Events for Biotech Crops

While **29** countries planted commercialized biotech crops in 2009, an additional **30** countries, totaling **59** have granted regulatory approvals for biotech crops for import for food and feed use and for release into the environment since 1996. It is noteworthy that 75% of the world's population live in the 59 countries that have approved biotech crops for planting or import. A total of 964 approvals have been granted for 184 events for 24 crops. Thus, biotech crops are accepted for import for food and feed use, and for release into the environment in 59 countries, including major food importing countries like **Japan, which do not plant biotech crops. Of the 59 countries that have granted approvals for biotech crops, USA tops the list followed by Japan, Canada, Mexico, Australia, South Korea, the Philippines, New Zealand, the European Union, and China.** Maize has the most events approved (60) followed by cotton (35), canola (15), potato and soybean (14 each). The event that has received regulatory approval in most countries is herbicide tolerant soybean event GTS-40-3-2 with 23 approvals (EU=27 counted as 1 approval only), followed by herbicide tolerant maize (NK603) and insect resistant maize (MON810) with 20 approvals each, and insect resistant cotton (MON531/757/1076) with 16 approvals worldwide.

Global value of the biotech seed market alone was valued at US$11.2 billion in 2010 with commercial biotech maize, soybean grain and cotton valued at ~US$150 billion for 2010.

In 2010, the global market value of biotech crops, estimated by Cropnosis, was US$11.2 billion, (up from US$10.6 billion in 2009); this represents 22% of the US$51.8 billion global crop protection market in 2010, and 33% of the US$34 billion commercial seed market. The estimated global farm-scale revenues of the harvested commercial "end product", (the biotech grain and other harvested products) is much greater than the value of the biotech seed alone (US$11.2 billion) - extrapolating from 2008 data, biotech crop harvested products would be valued at approximately US$150 billion globally in 2010, and projected to increase at up to 10 - 15% annually.

Future Prospects

Outlook for the remaining five years, 2011 to 2015, of the second decade of commercialization of biotech crops, 2006 to 2015

The adoption of biotech crops in the five year period 2011 to 2015 will be dependent mainly on three factors: first, the timely implementation of appropriate, responsible and cost/time-effective regulatory systems; second, strong political will and support; a continuing wave of improved biotech crops that will meet the priorities of industrial and developing countries in Asia, Latin America and Africa.

The outlook for biotech crops in the remaining 5 years of the second decade of commercialization, 2011 to 2015, looks encouraging. From 2011 to 2015, about 12 countries are projected to adopt biotech crops for the first time, bringing the total number of biotech crop countries globally to approximately 40 in 2015. These new countries are likely to include up to three to four in each of the regions of Asia, West Africa and East/Southern Africa with fewer in Latin/Central America and Western/Eastern Europe. Western Europe is by far the more difficult region to predict because the issues are not related to science and technology considerations but are of a political nature and influenced by ideological views of activist groups. The potato crop may offer new and appropriate opportunities for the EU.

There is considerable potential for increasing the biotech adoption rate of the four current large hectarage biotech crops (maize, soybean, cotton, and canola), which collectively represented almost 150 million hectares of biotech crops in 2010 from a total global potential of 315 million hectares; thus, there are approximately 150 million hectares for potential adoption. In the next five years the timing of the deployment of biotech rice, as a crop, and drought tolerance as a trait (first in maize and later in other crops) are seminal for catalyzing the further adoption of biotech crops globally. In contrast to the first generation biotech crops that realized a significant increase in yield and production by protecting crops from losses caused by pests, weeds, and diseases, the second generation biotech crops will offer farmers additional new incentives for further increasing yield. Quality traits, such as omega-3, will become more prevalent providing a much richer mix of traits for deployment in conjunction with a growing number of input traits.

Four years ago in North America, a decision was made to delay the introduction of biotech herbicide tolerant wheat, but this decision has recently been revisited as it becomes evident that wheat is failing to compete with the relative advantages conferred on biotech maize and soybean which are more profitable for farmers to grow as a result of higher yields and lower production costs. In the US, the three-year average yield of wheat over the previous eight years increased from 41.6 bushels in 1999-01 to 43.2 bushels in 2007-09, a 3.8 percent increase. Over that same time period, the US three-year average maize yields increased by 14.7 percent and soybeans by 9.7 percent. Many countries and companies are now fast-tracking the development of a range of biotech traits in wheat including drought tolerance, disease resistance and grain quality. The first biotech wheat is expected to be ready for commercialization by about 2017.

Between now and 2015, there will also be several important new biotech crops that will occupy small, medium and large hectarages globally, featuring both agronomic and quality traits as single and stacked trait products. By far, the most important of the new biotech crops that are now nearing commercial approval and adoption is biotech rice. Golden Rice is expected to be available in 2013 in the Philippines and probably followed by Bangladesh, Indonesia and Vietnam (IRRI, 2010). Subject to commercial approval, Bt rice in China could be available in about three years from now. Rice is unique even amongst the three major staples (rice, wheat and maize) in that it is the most important food crop in the world and more importantly, it is the most important food crop of the poor in the world. Over 90% of the world's rice is grown and consumed in Asia by some of the poorest people in the world – the 250 million Asian households/families whose resource-poor rice farmers cultivate on average a meager half a hectare of rice.

Maize with Bt and herbicide tolerance, which has been well tested globally, is likely to be introduced in several developing countries in all three continents. Phytase maize is also likely to be available in China in about three years. Several other medium hectarage crops are expected to be approved before 2015 including: biotech potatoes, already approved in the EU for high quality starch, are being field tested for "late blight" disease resistance in the EU and in other developing countries; sugarcane with quality and agronomic traits; and disease resistant bananas. Some biotech orphan crops are also expected to become available: Bt eggplant approval is pending in India, and is in advance field testing in the Philippines and Bangladesh. Vegetable crops, such as biotech tomato, broccoli, cabbage and okra, which require heavy applications of insecticides (biotech can effect significant pesticide savings) are also under development. Pro-poor biotech crops such as biotech cassava, sweet potato, pulses and groundnut are also candidates. Several of these products are being developed by public sector national or international institutions in the developing countries. The development of this broad portfolio of new biotech crops augurs well for the continued global growth of biotech crops in the next five years.

The second decade of commercialization, 2006-2015, is likely to feature significantly more growth in Asia and Africa compared with the first decade, which was the decade of the Americas, where there will be continued strong growth in North and South America, and particularly strong growth in Brazil. Adoption of biotech soybean, maize and cotton in Brazil is expected to continue to climb as well as the introduction of new biotech crops such as sugarcane and beans. Brazil is emerging as the engine of growth in biotech crops in Latin America. As adoption of biotech crops advances globally, adherence to good farming practices with biotech crops, such as rotations and resistance management, is a must, as it has been during the first decade. Continued responsible stewardship must be practiced, particularly by the countries of the South, which are certain to be the major new deployers of biotech crops in the second decade of commercialization of biotech crops, 2006 to 2015.

The use of biotechnology to increase efficiency of first generation food/feed crops and second-generation energy crops for biofuels presents both opportunities and challenges. **Whereas biofuel strategies must be developed on a country-by-country basis, food security should always be assigned the first priority and should never be jeopardized by a competing need to use food and feed crops for biofuel.** Injudicious use of food/feed crops – sugarcane, cassava and maize for biofuels in food insecure developing countries could jeopardize food security goals if the efficiency of these crops cannot be increased through biotechnology and other means, so that food, feed and fuel goals can all be adequately met. The key role of crop biotechnology in the production of biofuels is to cost-effectively optimize the yield of biomass/biofuel per hectare, which in turn will provide more affordable fuel. However, by far, the most important potential role of biotech crops will be their contribution to the humanitarian Millennium Development Goals (MDG) of ensuring a secure supply of affordable food and the reduction of poverty and hunger by 50% by 2015.

The 2008 World Bank Development Report emphasized that, ***"Agriculture is a vital development tool for achieving the Millennium Development Goals"*** (World Bank, 2008) given that three out of every four peoplein developing countries live in rural areas, the majority of whom are dependent on agriculture. The report also**"recognizes that overcoming abject poverty cannot be achieved in Sub Saharan Africa without a revolutionin agricultural productivity for the millions of suffering subsistence farmers in Africa, most of them women."**Africa is home to over 900 million people representing 14% of the world population and is the only continentin the world where food production per capita is decreasing and where hunger and malnutrition afflicts at leastone in three Africans. Africa is recognized as the continent that represents by far the biggest challenge in termsof adoption and acceptance. It is noteworthy that there are now three countries (South Africa, Egypt and BurkinaFaso) benefiting from biotech crops in Africa, and that growth was registered in all three in 2010. The impressiveincrease of over 100% in Bt cotton from 115,000 hectares in 2009 to 260,000 hectares farmed by 80,000 farmersin 2010 in Burkina Faso is of strategic importance in neighboring countries and for the African continent. **There isnow a lead country commercializing biotech crops in each of the three principal regions of the continent:South Africa in southern and eastern Africa; Burkina Faso in west Africa; and Egypt in north Africa.** Thisbroad geographical coverage in Africa is of strategic importance in that it allows the three adopting countriesto become role models in their respective regions and for **more African farmers to become practitioners ofbiotech crops and to be able to benefit directly from "learning by doing", which has proven to be such an important feature in the success of Bt cotton in China and India.**

The President of Burkina Faso, Blaise Compaore offered the following guidance on biotech crops, duringNational Peasants Day 2010. ***"In a continent that is hungry, the GM debate should be very different. The technology provides one of the best ways to substantially increase agricultural productivity and thus ensure food security to the people. In the cotton sector, for example, Burkina Faso has succeeded in increasing its production under current conditions, but it will be difficult to exceed one million tonnes. But with falling prices, we have no choice but to produce in quantity. And biotechnology may allow us to reach 2 to 3 million tonnes."***

The Minister of Science and Environment, Ghana. Hon. Ms. Sherry Ayittey said ***"Africa may not be able to meet its 2015 Millennium Development Goals (MDG) for human poverty reduction if the application of biotechnology is not considered seriously. My personal vision for the application of biotechnology is to improve the economy, create jobs, reduce hunger and improve health delivery especially for the rural poor."***

The World Bank Report (World Bank, 2008) also highlights the fact that Asia is home to 600 million rural people (compared with the 800 million total population of Sub Saharan Africa) living in extreme poverty. It is a stark fact of life that poverty today is a rural phenomenon where 70%, of the world's poorest people are small and resource-poor farmers and the rural landless labor that live and toil on the land. The big challenge is to transform this problem of a concentration of poverty in agriculture into an opportunity for alleviating poverty by sharing with resource-poor farmers the knowledge and experience of those from industrial and developing countries who have successfully employed biotech crops to increase crop productivity, and in turn, income. **It is encouraging to witness the growing "political will" for biotech crops at the G8 and G20 international level and at the national level in developing countries. This growing political will and conviction of visionaries and lead farmers for biotech crops, is particularly evident in several of the lead developing countries highlighted in this Brief. Failure to provide the necessary political will and support for biotech crops at this time will risk many developing countries missing out on a one-time window of opportunity and as a result become permanently disadvantaged and non-competitive in crop productivity. This has dire implications for the hope of alleviating poverty for up to 1 billion resource-poor farmers and the rural landless whose livelihoods, and indeed survival, is largely dependent on improved yields of crops which are the principal source of food and sustenance for over 5 billon people in the developing world, a significant proportion of whom are extremely poor and desperately hungry – a situation that is morally unacceptable in a just society.**

Challenges and Opportunities

The importance of innovation

The word **innovation** comes from the Latin "Innovatus" and is defined as **"the ability to manage change as an opportunity, not as a threat."**

The future of global crop production will, to a significant extent, depend on **innovation** and how successful developers of biotech crops will be in pursuing innovation through a sequential **Three I Strategy – Ingenuity, Innovation and Implementation.** Innovation applies generically to all strategies and thus has implications for food security, food self-sufficiency and the alleviation of poverty of small resource-poor farmers and the landless poor. It is useful to take an example from a completely different sector to demonstrate the critical importance of innovation. A century ago, innovation allowed mass production of affordable cars in the USA and made it the number one country in the world in the car industry. Thirty years ago, the Japanese car industry overtook the American car industry to become the number one country in the world because it employed "frugal innovation" to redesign cars using a "lean manufacturing" approach that was successfully implemented to satisfy the changing needs and priorities of customers globally (The Economist, 15 April 2010).

Biotech crops are one of the most innovative approaches to crop technology and have resulted in the successful and unprecedented adoption of biotech crops, on one billion hectares in the last fifteen years, despite a politically and ideologically motivated opposition from the EU. **The unqualified success of biotech crops, which are the fastest adopted crop technology in the history of agriculture, was entirely due to innovation.** Similarly, the continued development and success of biotech crops on a global basis by current and future developers of biotech crops will also depend on the ability of the different developers **to innovate. Failure to innovate will result in diminished growth rates of crop productivity. The most recent OECD-FAO Outlook (FAO-OECD, 2010) projects that, for the period 2010 to 2019, net agricultural productivity in the EU will be "stagnant" growing at only 4%, compared with other countries, (such as the USA, Canada, Australia, China, India and countries in Latin America) practicing innovation with technologies like biotech crops, which are projected to grow at much higher rates of 15% to 40% over the same period. Mr. George**

Lyon, Member of the European Parliament (MEP), speaking at the January 2011 Oxford Conference on agriculture, cautioned that "*politicians were exploiting people's fears about GM for their own political advantage and advised a change in tack*" (Surman, 2011). In an impassioned speech Mr. Lyon, who is leading the European Parliament response to the Commission's proposal to reform the EU agricultural policy (CAP), said "*European farmers were being left behind as GM becomes the norm around the rest of the world.*" While recognizing that GM crops were not a silver bullet, Mr. Lyon said that "*GM crops were an essential technology... and that the impasse in Europe must be broken if we are not to fall further behind.*" He noted that "*organic and low input, low output farming had a role, but were certainly not the answer to meeting the challenges of doubling food production by 2050*" (Surman, 2011).

It is evident that the world's economic axis is shifting in favor of the emerging nations of the world, and this has implications for the development of all products, including biotech crops. Increased participation in innovative approaches in plant biotechnology is already evident in the lead developing countries of BRIC - Brazil in Latin America, and India and China in Asia. Emerging countries are no longer satisfied to have only low labor costs as their only comparative advantage, but operate dynamic incubators of innovation, producing new and competing products and employing innovation to redesign products for customers at significantly lower cost, to meet fast growing domestic and international demands. **Thus, "frugal innovation" is not only an issue of cheap labor but increasingly will apply to the designing and redesigning of more affordable products and processes which will require both technological and business innovation.**

All this implies that the western world may be losing out to the emerging countries, but this is not necessarily so. Of the Fortune 500 companies, 98 have R&D activities in China and 63 in India, and these include collaborative efforts on biotech crops with both public and private partners in their respective host countries. The philosophy underlying these investments by the multinationals in the developing country BRICs is that they will retain a comparative advantage in innovation, in addition to being well placed to participate in the new markets that will be developed to meet the needs of an increasingly wealthy population of more than 2.5 billion in their home countries. This compares with only 303 million in the US and 494 million in the 27 EU countries. **Given that the nature of innovation is to feed upon itself, "innovation in the emerging world will encourage rather than undermine innovation in the western world"** (The Economist, 15 April 2010).

The current unprecedented explosive growth and change occurring in the emerging countries will have enormous implications for the rest of the world, and will demand more innovative solutions from successful developers. The global share of the emerging world's GDP increased from 36% in 1980 to 45% in 2008 and is predicted to reach 51% by 2014. In 2009, productivity in China grew by 8.2% compared with 1.0% in the US and a decline of 2.8% in the UK. Emerging country consumers have outspent the US since 2007 and are currently at 34% of global spending versus 27% in the USA. Thus, emerging country consumers are, and will continue to demand a better quality of life including a better diet, with significantly more meat, which in turn drives increased demand for the principal biotech feed stocks, maize and soybean.

Consistent with other lead countries of the world, the policy guidelines of the EU strongly promote innovation as a general policy in science but it has chosen not to practice what it preaches when it is applied to biotech crops – one of the most innovative approaches to crop technology. If innovation is the key to success with crop technology this could seriously disadvantage the EU. Some multinationals involved in crop biotechnology have already reduced R&D activities in some EU countries and, where possible, are relocating activities to outside the EU because it does not provide a congenial environment for the development of biotech crops which are viewed in the EU as a threat and not as an opportunity.

Climate change and the role of biotech crops

Given that the annals of history of the first half of the 21st Century are likely to record that climate change was the defining scientific challenge of the time, it is imperative that the role of biotech crops be fully realized as a contributor to the formidable challenges associated with climate change. The Science Alliance stated that "*The two biggest issues facing the world population today are the threat of food insecurity and the possible negative implications of climate change,*" (Scientific Alliance, 1 October, 2010). The Alliance noted that ***"climate change mitigation policy is increasingly favoring sustainable intensive agriculture, including the use of GM crops. In this case, climate policy and food security needs are perfectly aligned."*** The Alliance concluded that the challenge of feeding the world of 2050 is ***"an undeniable reality"*** for the following logical reasons. With a population of 9.2 billion by 2050, and limited opportunities for expanding crop hectarage beyond the current 1.5 billion hectares, and wealthier emerging nations consuming more meat, (which is much less efficient than plant protein), the inescapable conclusion is that the world will require at least 70% more food by 2050 – this is reality. In contrast, unlike food security, the Alliance has concluded that ***"the impacts of climate change are now just projections from computer models which may be right, they may be wrong, but the fact is, they are based on the supposed dominance of a single factor: the known warming effect of increasing levels of carbon dioxide in the atmosphere, amplified by positive feedback effects. Deep cuts in CO_2 emissions worldwide are prescribed as the only way to avoid a future catastrophe. We have one quite clear and imminent problem (food security) and one credible but unproven hypothesis which could conceivably wreak havoc later in the century (anthropogenic global warming)."***

Given that agriculture is a significant contributor (14%) of greenhouse gases (GHG) and therefore part of the problem in climate change, it is appropriate that biotech crops also be part of the solution. There is credible, peer reviewed and published evidence that biotech crops are already contributing to the reduction of CO2 emissions in the following ways:

- Biotech crops require fewer pesticide sprays which results in savings of tractor/fossil fuel and thus CO2 emissions.
- Increasing productivity on the same current 1.5 billion hectares of crop land, makes biotech crops a land saving technology and reduces deforestation and CO2 emissions – a major bonus for climate change.
- Herbicide tolerant biotech crops encourage zero or no-till, which in turn significantly reduces the loss of soil carbon and CO2 emissions.
- Herbicide tolerant biotech crops reduce ploughing, which enhances the conservation of water substantially, reduces soil erosion significantly, and builds up organic matter which locks up soil carbon and reduces CO2 emission.
- Biotech crops can overcome abiotic stresses (through drought and salinity tolerance) and biotic stresses (weed, pest and disease resistance) in environments made unproductive by climate change because of variations in temperature and water level which preclude the growing of conventionally bred crops (for example several countries have discontinued conventional cotton in some areas due to excessive losses from bollworm).
- Biotech crops can be modified faster than conventional crops – thus allowing implementation of a "speeding the breeding" strategy to meet the more rapid changes required by more frequent and severe changes associated with climate change.

Whereas in general environmentalists have been opposed to biotech crops, climate change specialists, tasked with cutting CO2 levels as the only remedy to avoid a future catastrophe, are becoming increasingly supportive of biotech crops because they are viewed as a pragmatic remedy, where the twin goals of food security and climate change can be enjoined in one thrust that "kills two birds with one stone." Readers are referred to the section on sustainability in this Brief which documents the quantitative contribution that biotech crops are already making to sustainability, and in turn to climate change – the potential for the future is enormous. Indeed, former leaders of the green movement, such as Mark Lynas and colleagues, now acknowledge that the green movement opposition to biotech crops is out of sync with current knowledge and this has precluded biotech crops from optimizing contributions for the benefit of society in the strategic areas of food security and climate change (Ecologist, 15 Nov 2010). Lynas and colleagues concluded that the same is true for nuclear power where opposition by the green movement has exacerbated, rather than helped the situation, where the alternate option to nuclear, coal fired power plants, have now become major CO2 generators and polluters, thereby exacerbating, rather than solving, the problems associated with climate change.

One of the few successes of the Copenhagen Summit on Climate Change was the initiative known as REDD (Reducing Emissions from Deforestation and Forest Degradation) which, as the name suggests, aims to reduce deforestation. Whereas agriculture is a cause of deforestation, emitting about 14% of global GHG, crops also absorb CO2 with soils acting as a carbon sink. The Global Research Alliance on Agriculture Greenhouse Gases was established on 16 December 2009 with US$150 billion in pledges to investigate and develop potential opportunities which could reward farmers in poor countries for locking up carbon in their crops and soils under the aegis of the Clean Development Mechanism discussed in Copenhagen (The Economist, 30 December 2009).

Golden Rice and the humanitarian price of overregulation

Golden Rice is expected to be approved for release in 2013 (IRRI, 2010) after an unnecessarily long and costly process during which victims of VAD have been denied a remedy that would have relieved their suffering. **In a recent article, Ingo Potrykus (2010) concluded that biotech crops (GM) *"could save millions from starvation and malnutrition, if they can be freed from excessive regulation."*** He reached this conclusion from his experience over the past 11 years chairing the Golden Rice Humanitarian project (http://www.goldenrice.org), and after a meeting hosted by the Pontifical Academy of Sciences at the Vatican last year on biotech crops for food security in the context of development (Potrykus and Amman, 2010). Golden Rice contains two genes (phytoene synthase and phytoene double-desaturase) that produce up to 35 micrograms of Vitamin A precursor (beta carotene) per gram of edible rice. For Vitamin A deficient rice eating populations in the developing countries, Golden Rice can provide sufficient Vitamin A to reduce substantially the 6,000 deaths a day due to Vitamin A deficiency, and save the eyesight of hundreds of thousands of people per year, unnecessarily suffering from this disease. Conventional breeding cannot increase Vitamin A, so Golden Rice is possible only with biotech crops. Golden Rice was stalled for more than ten years because of unnecessary and unjustifiable delays, whilst millions were condemned to suffering. Golden Rice will probably reach the market in 2013, but it was ready in the laboratory in 1999. Potrykus concluded that the lag was entirely due to unjustified regulatory processes discriminating against biotech crops versus conventional crops. Hence, Potrykus holds that ***"the regulation of genetic engineering is responsible for the death and blindness of thousands of children and young mothers."*** He estimated that it generally takes about ten times more money and ten years longer to bring a biotech crop to market compared to a conventional crop, and de-facto, because of the higher costs, precludes the participation of public research institutions in the development of biotech crops. However, biotech crops have enormous potential to alleviate poverty and hunger and contribute to food security in the developing countries of the world.

Countless international agencies and national academies have endorsed the science underpinning biotech crops and have challenged the subjective and scientifically unsubstantiated views of critics, recognizing that new conventional crops created by traditional breeding methods are also genetically modified. Ironically, these conventional crops require no safety data, only evidence that they perform as well, or better, than current commercial conventionally bred crops. It is evident that with about one billion people suffering from hunger and poverty, which is morally unacceptable, it is more just to utilize public support to feeding the world's growing population than on unnecessary and unjustified bureaucratic regulations. **ISAAA Brief 41 for 2009 (James, 2009b) drew similar conclusions to Potrykus and highlighted that inappropriate over-regulation was the major constraint to more widespread adoption of biotech crops in developing countries.** The challenge for a lead developing country with first-hand experience and political will for adopting biotech crops is to appropriately reduce the current regulatory burden and implement a model system that is both responsible and time- and cost-effective. It is important to note that this can be achieved without in any way compromising biosafety. Importantly, it would also allow that lead nation to exercise leadership and become a model for other developing countries to embark on a humanitarian mission, growing biotech crops to become more self-sufficient in food, feed and fiber and contribute to the alleviation of poverty which currently pervasively pollutes the lives of approximately one billion people – this is morally unacceptable.

Technological advances in crop biotechnology – some of which pose regulatory dilemmas

Some new advances in molecular biotechnology do not fall within the scope of regulatory authority since they do not insert foreign genes. They include: **oligonucleotide-directed mutagenesis or "Rapid Trait Development System" (RTDS); "Targeted mutation"**, also referred to as **"zinc fingers"**, or **"meganucleases"** – these novel techniques do not involve a **"transgene"** or foreign gene but direct mutations in DNA using the natural DNA repair mechanism and hence are quite different to regulated GM technology (New York Times, 16 November 2010). In fact they are akin to conventional radiation and chemical-based mutation breeding which is not regulated. Cibus Global (www.cibus.com) from the USA has used **oligonucleotide-directed mutagenesis** or RTDS--which has already been approved by APHIS as a non-regulated technology – to develop a herbicide tolerant canola with a planned release in 2012. At this time it is not clear how regulatory agencies will classify other similar technologies but **given that no foreign gene is involved, there is logic in the view that they should not be regulated, consistent with traditional mutations.** Scientists hope that this class of technologies can be the catalyst that will allow global society to practice what it preaches about embracing innovation in science, by not classifying these similar but not identical technologies as regulated crop technologies. USDA/APHIS will continue its consideration of its regulatory authority over such technologies and judgments are expected on specific technologies in the future when more products from these novel technologies are hopefully approved and released as non-regulated technologies.

Novel ways to control bacterial phytopathogens in crops are being developed to reduce the significant annual losses due to plant diseases – estimated at 16% of global crop production (Oerke, 2006). Innovative crop biotechnology strategies could result in a significant and humanitarian contribution to food security in a world that has almost one billion people suffering from hunger, malnutrition and poverty – all three of which are inextricably linked. Pattern recognition receptors (PRRs) are capable of detecting pathogens by recognizing pathogen associated molecular patterns (PAMPs), which up until now have not been demonstrated to confer resistance to bacterial plant pathogens. Lacombe et al, (2010) report progress in detecting PRR activity after its transfer from a cruciferous plant *Arabidopsis thaliana* to two Solanaceous species, *Nicotiana benthamiana* and tomato, which conferred resistance to several phytopathogenic bacteria from different genera. The study suggests that expression of PAMPs could be used to confer broad-based disease resistance to bacterial pathogens of crops that cause significant productivity losses in crops globally.

The Millennium Development Goals (MDG) – cut poverty by 50% by 2015, optimizing the contribution of biotech crops in honor of the legacy of ISAAA's founding patron and Nobel Peace Laureate, Norman Borlaug

The MDG targets were set 10 years ago in 2000, with 1990 as the starting benchmark and 2015 as the target year. Given that two-thirds of the 15 year period has already expired, it is appropriate to take stock of progress (The Economist, September 2010). World leaders met in New York in late September 2010 to discuss what progress has been made to-date. Analysis by the UN shows that progress has been made regarding the major goal of alleviating poverty by cutting the percentage of poor in developing countries by 50%. **In 1990 on a global basis, poverty, expressed on a percent basis in the developing countries was 46% (World Bank estimate), and by 2005 had decreased to 27% – thus, 23% seems feasible by 2015, five years from now.** However, whereas the percentage of poor (poverty is defined as earnings under US$1.25 per day at PPP) has decreased, the absolute number of poor, hungry and malnourished, (in contrast to percentage) remains at an unacceptably high level of 925 million globally. It is noteworthy that whereas in 1990, 90% of the poor were in the poorest countries, in 2010, almost three quarters of the world's poor people now live in middle income developing countries such as India, Pakistan, Indonesia and Nigeria, and only a quarter live in Africa (The Economist, October 2010; Summer, 2010). A significant increase in poverty resulted from the price hikes of food commodities in 2008, which in turn led to riots in 30 developing countries and the fall of two governments. Many economists are predicting further price hikes of food in the near future. In addition to alleviating poverty by 50% the MDG also calls for malnutrition to be cut by half from 20% in 1990 to 10% in 2015 – it had reached 16% by 2008.

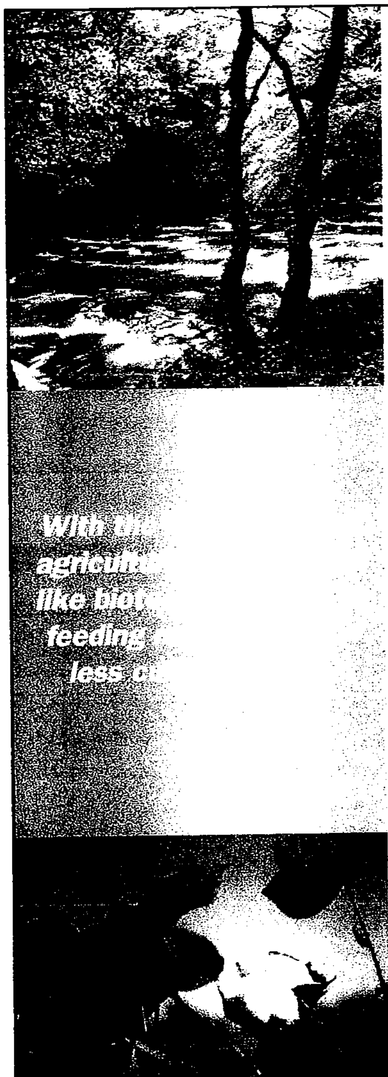
Many observers have cautioned that success in halving the percentage of poor people in the developing world should not be attributed to the UN MDG initiative alone, but principally to **China for decreasing**

its poverty rate from 60% in 1990 to 16% in 2005 – an impressive 72% reduction. Given that China and India, (the two most populous countries in the world with a combined population of almost 2.5 billion) accounted for 62% of the world's poor in 1990, changes in percent poverty globally are highly dependent on China and India. Thus, the global percentage of poor is not an appropriate indicator for gauging progress in smaller countries; this is exacerbated by the lack of data on poverty in many small poor countries. For example, 28 of the poorest countries have only recorded poverty levels once between 1990 and 2008. Nevertheless, it is estimated that 15 poor countries have already cut poverty in half, and of the top 10 achievers (listed in descending order, according to annual decline in poverty), encouragingly, six are African countries that include Gambia, Mali, Senegal, Ethiopia, the Central African Republic and Guinea.

It is noteworthy that the major reason for success, notably in China, but also to a lesser extent in Africa, is not due to an increase in public spending but to faster national economic growth which has become the engine of economic growth in the rural areas, where most of the world's poor reside. However, taking India as an example, it is evident that economic growth alone is not a panacea for poverty. Almost half (48%) of all under 5 children in India suffer from malnutrition, and they number over 60 million. This is one of the highest rates in the world and is the highest absolute number for any country in the world, equivalent to over a third of the 150 million malnourished under 5s in the world. India at a rate of 48% compares with the following countries which have the most chronically malnourished children under 5: Ethiopia at 51%, Congo 46%, Tanzania 44%, Bangladesh 43%, Pakistan 42%, Nigeria 41%, Indonesia 37%, Philippines 34%, and notably, by contrast, China at only 15%.

The international community involved with biotech crops from the public and private sector in the North and the South, as well as the donor community has not taken full advantage of the MDG in 2015 to demonstrate to the world at large the important contribution that biotech crops can make to food security and the alleviation of poverty. Given Norman Borlaug's strong advocacy of biotech crops this initiative would be the most appropriate and noble way to honor his rich and unique legacy in a global program entitled **"Knowledge, Biotechnology and the Alleviation of Poverty"– A partnership that would engage the North, South, East and West, embracing both public and private sectors, in a collective and noble effort to optimize the contribution of biotech crops to productivity, using less resources, and helping to alleviate poverty by 2015 and beyond.** There is no better way to contribute to the MDG goal of alleviating poverty, hunger and malnutrition, by 2015, which coincidentally marks the end of the second decade of the commercialization of biotech crops, 2006 to 2015 – Norm Borlaug would approve.

SUPPORTING SUSTAINABLE SOLUTIONS IN AGRICULTURE



Concerns about growing populations, increased food scarcity and the environment have led researchers, farmers, non-profit organizations, governments and industry representatives to work together to help find sustainable solutions to meet the world's growing demand for food, fuel and water. Now more than ever, agricultural practices need to get more from cultivated land with a lighter environmental footprint, and in an economical way.

The Keystone Alliance for Sustainable Agriculture – a diverse group of growers, conservation organizations, and companies throughout the agriculture and food supply chain – defines sustainable agriculture as follows:

- Meeting the needs of the present while improving the ability of future generations to meet their own needs;
- Increasing productivity to meet future food demands;
- Decreasing impacts on the environment;
- Improving human health; and
- Improving the social and economic well-being of agricultural communities.

ENVIRONMENTAL SUSTAINABILITY

According to the Keystone Alliance for Sustainable Agriculture, over the past decade, since the commercial adoption of biotech crops such as corn, soybeans and cotton, the United States has seen gains in productivity (yield) per acre, while improving agriculture's efficiency in its use of resources such as land, energy and water.

Every year, population growth is putting a heavier strain on the planet's land and water resources. To conserve natural resources for future generations, it is necessary to use sustainable agricultural practices to produce enough food, fuel, feed and fiber for ourselves and for generations to come.

Agricultural biotechnology can increase protection against weeds, insects and diseases, and has the potential in the future to help plants better tolerate stresses like droughts, floods, excessive cold, and salt. The use of pest-resistant crops means that farmers can use more targeted crop protection products, which helps further reduce agriculture's environmental footprint.

CONSERVING LAND

Biotech-derived crops allow for higher productivity on land currently under cultivation, preventing the conversion of tropical forests and land used for other, non-agricultural purposes to farmland. If biotech-derived crops had not been used to produce the 229 million tons of food, feed and fiber that farmers produced globally from 1996-2009, farmers would have had to convert an estimated 185 million additional acres to farmland (Brookes and Barfoot, 2011).

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CONSERVING WATER

New developments will help American farmers produce crops that use water more efficiently, thus reducing the negative consequences of drought such as yield or total crop loss. Drought-tolerant corn is expected to be available in the United States in 2012 (James, 2010). Field trials of drought-tolerant wheat in Australia have shown up to a 20 percent yield increase compared with conventional varieties (James, 2010)

REDUCING CARBON EMISSIONS

With the adoption of biotech crops, farmers have reduced the tilling needed to control weeds, resulting in better containment of carbon in the soil (sequestration) and less tractor fuel needed to plow the land. In 2009, the combined savings of carbon emissions attributable to biotech crops was equivalent to removing almost eight million cars from the road (James, 2010).

ECONOMIC SUSTAINABILITY

Biotech crops enhanced farm income in the United States by $29.8 billion from 1996 to 2009 (Brookes and Barfoot, 2011).

Of the 15.4 million farmers who grew biotech crops in 2009, 93 percent were small-holder or resource-poor farmers from developing countries (James, 2010).

The economic benefits to farmers are a result of increased yields and lower production costs, such as fewer pesticides needed and increased income from more crops sold to meet demand (Brookes and Barfoot, 2009).

CITATIONS:

Brookes, G. & Barfoot, P. GM crops: Global Socio-economic and Environmental Impacts 1996-2007, PG Economics Ltd, Dorchester, UK, 2009. http://www.pgeconomics.co.uk/index.htm

Brookes, G. & Barfoot, P. GM crops: Global Socio-economic and Environmental Impacts 1996-2009, PG Economics Ltd, Dorchester, UK., 2011.

James, Clive. International Service for the Acquisition of Agri-Biotech Applications (ISAAA). Global Status of Commercialized Biotech /GM Crops, 2010.

Keystone Center. Field to Market: The Keystone Alliance for Sustainable Agriculture – Environmental Resource Indicators for Measuring Outcomes of On-Farm Agricultural Production in the U.S., First Report, 2009. http://keystone.org/spp/env-sustain_ag.html

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ABOUT THE COUNCIL FOR BIOTECHNOLOGY INFORMATION

The Council for Biotechnology Information communicates science-based information about the benefits and safety of agricultural biotechnology and its contributions to sustainable agricultural solutions that are economically viable. In the United States, agricultural biotechnology has the potential to make additional contributions in the future, through renewable biofuels to help meet energy needs; drought-tolerant plants to help manage water resources; and improved crop productivity and higher quality crops grown on existing farmland to help feed the United States and the world's growing population.

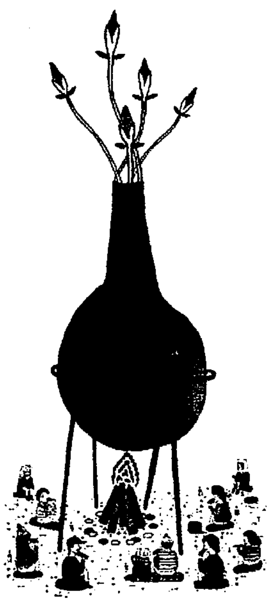
CBI members are the leading agricultural biotechnology companies.

OP-ED CONTRIBUTOR

Engineering Food for All

By NINA V. FEDOROFF
Published: August 18, 2011

Washington


John Malta

FOOD prices are at record highs and the ranks of the hungry are swelling once again. A warming climate is beginning to nibble at crop yields worldwide. The United Nations predicts that there will be one to three billion more people to feed by midcentury.

Yet even as the Obama administration says it wants to stimulate innovation by eliminating unnecessary regulations, the Environmental Protection Agency wants to require even more data on genetically modified crops, which have been improved using technology with great promise and a track record of safety. The process for approving these crops has become so costly and burdensome that it is choking off innovation.

Civilization depends on our expanding ability to produce food efficiently, which has markedly accelerated thanks to science and technology. The use of chemicals for fertilization and for pest and disease control, the induction of beneficial mutations in plants with chemicals or radiation to improve yields, and the mechanization of agriculture have all increased the amount of food that can be grown on each acre of land by as much as 10 times in the last 100 years.

These extraordinary increases must be doubled by 2050 if we are to continue to feed an expanding population. As people around the world become more affluent, they are demanding diets richer in animal protein, which will require ever more robust feed crop yields to sustain.

New molecular methods that add or modify genes can protect plants from diseases and pests and improve crops in ways that are both more environmentally benign and beyond the capability of older methods. This is because the gene modifications are crafted based on knowledge of what genes do, in contrast to the shotgun approach of traditional breeding or using chemicals or radiation to induce mutations. The results have been spectacular.

For example, genetically modified crops containing an extra gene that confers resistanc certain insects require much less pesticide. This is good for the environment because to pesticides decrease the supply of food for birds and run off the land to poison rivers, lak and oceans.

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The rapid adoption of genetically modified herbicide-tolerant soybeans has made it easier for farmers to park their plows and forgo tilling for weed control. No-till farming is more sustainable and environmentally benign because it decreases soil erosion and shrinks agriculture's carbon footprint.

In 2010, crops modified by molecular methods were grown in 29 countries on more than 360 million acres. Of the 15.4 million farmers growing these crops, 90 percent are poor, with small operations. The reason farmers turn to genetically modified crops is simple: yields increase and costs decrease.

Myths about the dire effects of genetically modified foods on health and the environment abound, but they have not held up to scientific scrutiny. And, although many concerns have been expressed about the potential for unexpected consequences, the unexpected effects that have been observed so far have been benign. Contamination by carcinogenic fungal toxins, for example, is as much as 90 percent lower in insect-resistant genetically modified corn than in nonmodified corn. This is because the fungi that make the toxins follow insects boring into the plants. No insect holes, no fungi, no toxins.

Yet today we have only a handful of genetically modified crops, primarily soybeans, corn, canola and cotton. All are commodity crops mainly used for feed or fiber and all were developed by big biotech companies. Only big companies can muster the money necessary to navigate the regulatory thicket woven by the government's three oversight agencies: the E.P.A., the Department of Agriculture and the Food and Drug Administration.

Decades ago, when molecular approaches to plant improvement were relatively new, there was some rationale for a cautious approach.

But now the evidence is in. These crop modification methods are not dangerous. The European Union has spent more than $425 million studying the safety of genetically modified crops over the past 25 years. Its recent, lengthy report on the matter can be summarized in one sentence: Crop modification by molecular methods is no more dangerous than crop modification by other methods. Serious scientific bodies that have analyzed the issue, including the National Academy of Sciences and the British Royal Society, have come to the same conclusion.

It is time to relieve the regulatory burden slowing down the development of genetically modified crops. The three United States regulatory agencies need to develop a single set of requirements and focus solely on the hazards — if any — posed by new traits.

And above all, the government needs to stop regulating genetic modifications for which there is no scientifically credible evidence of harm.

Nina V. Fedoroff, who was the science and technology adviser to the secretary of state from 2007 to 2010, is a professor of biology at Pennsylvania State University.

A version of this op-ed appeared in print on August 19, 2011, on page A23 of the New York edition with the headline: Engineering Food for All.

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Ms. Rella Abernathy

City of Boulder Parks & Recreation Department

3198 Broadway
Boulder, CO 80304

Dear Ms. Abernathy:

I would like to address some concerns I have read about recently regarding the decision by the City of Boulder to stop using Roundup branded herbicide until an environmental and safety assessment is completed. My colleague, Lisa Drake, State Government Affairs Lead, who lives in Denver, and I understand you have asked for comprehensive information about a Roundup branded herbicide and its active ingredient as you assess whether to continue its use.

Please know that the World Health Organization (1), and regulatory agencies around the world including the United States Environmental Protection Agency (EPA) (2), the European Commission (3), along with independent researchers (4), have thoroughly evaluated glyphosate, the active ingredient in Roundup herbicide. Among herbicides, glyphosate has an unsurpassed overall human health and environmental profile.

Glyphosate has a long history of safe use. Glyphosate is registered in more than 100 countries, has been in the market for more than thirty-five years and is backed by one of the most extensive worldwide human health, safety and environmental databases ever compiled for a pesticide product. This herbicide has been thoroughly reviewed and registered by regulatory agencies around the world. When properly used and applied, glyphosate-based herbicides do not produce any long term effects on human health. The only well-documented effects are transient minor skin or eye irritation in some individuals following direct exposure to these products (5).

Glyphosate has favorable environmental properties - tight binding to soil particles so it is highly unlikely to move into groundwater; lack of residual herbicidal effects in soil; and low oral and dermal acute toxicity (EPA Category III/IV) - make it the herbicide of choice for a variety of uses at home, on the farm, in the general community, and even in sensitive areas (for example, Roundup branded herbicides have been used by habitat restoration groups in the Galapagos Islands).

Notably, there are no credible studies linking glyphosate to any form of cancer, reproductive effects or neurological disorders. In fact, EPA, following a thorough review of all toxicology data available, concluded that glyphosate should be classified in Category E ("Evidence of Non-carcinogenicity in Humans"), the most favorable category possible, and concluded there were no effects suggesting that glyphosate disrupts reproductive processes or the nervous system.

Several examples of recent claims are contradicted by an extensive worldwide human health, safety and environmental database on glyphosate:

- The results reported from the Paganelli et al., experiments with frog and chicken embryos are not predictive of birth defects or any other effects in humans or wildlife. On August 9, 2010, an article by Paganelli et al., was published on the Chemical Research in Toxicology website claiming glyphosate-based herbicides produce craniofacial malformations in frog and chicken embryos. This paper is co-authored by Dr. Andrés Carrasco. Last year, Dr. Carrasco publicized similar findings in an Argentine national newspaper, Página 12.

The new online publication reports the results of petri dish experiments that examined the effects of direct injection of glyphosate or a glyphosate-based herbicide on frog and chicken embryos. In one experiment, two doses of glyphosate were directly injected into 2-cell frog embryos. In another experiment, the 2-cell frog embryos were bathed in three concentrations of Roundup Classic herbicide (glyphosate with surfactant). In the third experiment, fertilized chicken eggs were injected with two concentrations of Roundup Classic via a small opening in the egg shell.

The observations of abnormal embryonic development are not surprising given the unrealistic exposure scenarios. In fact, caffeine has been shown to cause malformations in chick embryos under similar exposure conditions (Kobayashi et al., 1995) (6). The results with caffeine in this experimental model provide important context. Caffeine, in its natural and added forms, is found in coffee, tea, cola beverages, energy drinks, chocolate and even some medicines, but does not illicit concerns about reproductive effects. The results of the studies reported by Paganelli et al. have a similar lack of relevance to the human and environmental safety of glyphosate and Roundup branded herbicides.

Regulatory and independent expert reviews of the results of GLP (good lab practices) studies according to accepted standard methodology have concluded that glyphosate does not cause adverse reproductive effects in adults or birth defects in offspring of these adults exposed to glyphosate, even at very high doses.

Based on the findings reported in the Página 12 newspaper article in 2009, a non-governmental organization requested an injunction from the Argentinean Supreme Court seeking the suspension of glyphosate spraying in Argentina while authorities analyze the evidence in more detail. The Chamber for Agricultural Safety and Fertilizers (CASAFE) of Argentina has publicly refuted Dr. Carrasco's assertions that glyphosate is responsible for adverse health effects on people living near where glyphosate-based products are used. CASAFE stated (i) glyphosate has been used in more than 100 countries and for more than 30 years; (ii) when glyphosate-based herbicides are used properly they do not produce harmful effects on human heath; and (iii) his findings should be addressed and dismissed by the scientific community promptly.

Furthermore the European Commission's Standing Committee on the Food Chain and Animal Health (see attached – page 4) concluded that these studies were conducted under artificial conditions; the alleged effects have not been observed in studies in animals or reported in epidemiology studies; and these findings do not put into question the EU's evaluation on glyphosate-based products and does not provide a basis to ban or restrict the use of glyphosate in the European Union.

- Another example is the Seralini et al. study sensationalized in a press release claiming that glyphosate was an endocrine disruptor based on effects in human tumor cells in an in vitro experiment (7). The cells used in this study were taken from a human placental tumor, put into a petri dish, and covered with culture media containing high concentrations of Roundup herbicides or other test materials for 18 hours. This direct exposure of high concentrations of chemicals to isolated cells is vastly different than what would occur in a human or animal body, i.e. - the concentration of Roundup herbicide reported to have caused an effect was orders of magnitude greater than would result from the highest possible human exposure under real conditions. The direct exposure used in this study intentionally bypasses normal processes limiting absorption and cellular exposure and avoids normal metabolism, digestion and excretion that would protect cells from the minute amounts of chemical. The study has no relevance to a living animal. The implications of this in vitro experiment are contradicted by extensive live animal data and field studies reflecting real-world conditions.

- See Monsanto's statement about retired Purdue University professor Don Huber's claims of discovery of a new plant pathogen: http://www.monsanto.com/newsviews/Pages/huber-pathogen-roundup-ready-crops.aspx

- See Monsanto's Crop Protection Update on glyphosate and micronutrients: http://www.monsanto.com/newsviews/Documents/CPU_roundup_ready_crops_glyphosate_and_micronutrients.pdf

- Scientists at Purdue and other universities recently provided a response to Huber's recent claims, See "Glyphosate's Impact on Field Crop production and Disease Development" :http://www.btny.purdue.edu/weedscience/2011/GlyphosatesImpact11.pdf

- See "Glyphosate's Impact on Animal Health?", William Shulaw, DVM http://corn.osu.edu/newsletters/2011/2011-05/#1 and three related articles regarding recent concerns surrounding the use of glyphosate in the March 11-18 OSU Extension Agronomic Crops Team C.O.R.N. newsletter 2011-05. The articles and links include "Glyphosate Effects on the Occurance and Development of Soybean Diseases", "Trying to Sift Through the Current Wealth of Information (and Misinformation) About Glyphosate", and "Glyphosate Application Effects on Soybean Manganese Nutrition".

- See "Use Facts to Make Glyphosate and Glyphosate Resistant Crop Decisions"" Iowa State University Weed Science, http://www.extension.iastate.edu/CropNews/2011/0225hartzler.htm

Herbicides like glyphosate are important tools that allow farmers to produce abundant, healthy food while stewarding the environment and enable homeowners to maintain healthy and attractive gardens. Schools and communities also use Roundup branded herbicides as an important part of an environmentally responsible pest control strategy.

In conclusion, throughout the world there is a strong consensus among credible scientific bodies that glyphosate-based herbicides, when used according to label directions, will not cause any unreasonable adverse effects on human health or the environment.

Monsanto takes the safety and stewardship of our products seriously. Our scientists review new publications related to the safety of our products, promptly and carefully. For more information on the health and environmental safety profile of glyphosate and Monsanto's Roundup® branded products, see: http://www.monsanto.com/products/Pages/roundup-safety-background-materials.aspx.

Please don't hesitate to contact me if you or any of the council members have questions or would like additional information.

Sincerely,

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Donna R. Farmer

Donna R. Farmer, Ph.D.
Global Chemistry Stewardship Lead
Monsanto Company
800 North Lindberg Boulevard, Mail Zone C3S
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cc: Jane S. Brautigam, City Manager

ProtectionUpdate

Technology Development by MONSANTO

The Science of Roundup Ready® Technology, Glyphosate and Micronutrients

Part 1 - Glyphosate Chemistry, Efficacy and Interaction with Micronutrient Foliar Applications

Recently, some researchers have suggested a relationship between the use of glyphosate, Roundup Ready® crops, micronutrient deficiencies, and yield reductions. A variety of claims and multiple theories to explain their reported results have been presented. These theories range from reduced micronutrient uptake by Roundup Ready® soybean plants, to the binding of micronutrients by glyphosate inside the plant, as well as many additional themes. With this in mind, a series of questions and science-based answers are presented below to address these claims and also present a basic understanding of how glyphosate interacts with materials in the spray solution.

How Does Hard Water Affect Glyphosate Efficacy?

A chelator is a polydentate compound that can form more or less reversible complexes with polycationic metal ions. Sometimes metal cations, such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}) and Iron (Fe^{2+}/Fe^{3+}), are found in what is commonly known as "hard water." Glyphosate in formulated products is negatively (-) charged when dissolved in water at pH 4.6 and its mild chelating properties allow it to form reversible complexes with the Ca^{2+} and Mg^{2+} in hard water. This can result in a mild <10% reduction in the performance of the herbicidal effects of glyphosate[10] when used at recommended use rates. Water hardness is usually expressed as parts per million (ppm) of $CaCO_3$ or as grains per U.S. gallon (one grain per gallon = 17.1 ppm). Water with a hardness of 200 ppm or more is considered "hard" and can slightly reduce glyphosate performance. In areas where hard water is used in mixing glyphosate, ammonium sulfate (AMS) is recommended to be used with Roundup® agricultural herbicides. AMS conditions hard water because the sulfate anion can effectively compete with glyphosate for free Ca^{2+} and allow the free glyphosate to enter plant cells for normal herbicide activity.

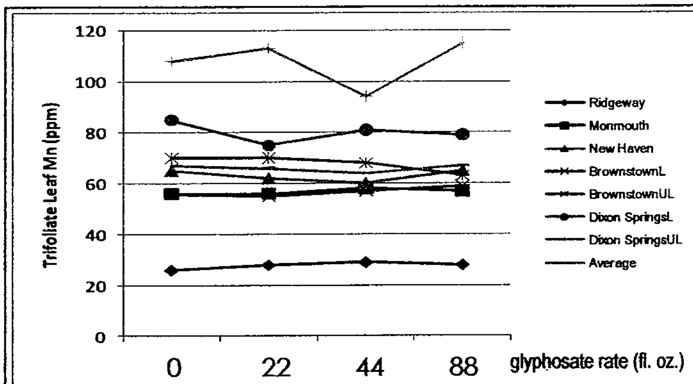

Figure 1. Trifoliate leaf Manganese concentration across three rates of glyphosate in 7 experiments in Illinois in 2004. L= field limed; UL= field un-limed. Ebelhar [6].

Are Tank Mixes of Glyphosate with Micronutrient Foliar Sprays a Good Idea?

Foliar sprays of micronutrients are used in crops, such as foliar manganese (Mn^{2+}) fertilizer in soybeans. Other micronutrients that may be applied in foliar sprays include boron (B), copper (Cu^{2+}), iron (Fe^{3+}), molybdenum (Mo^{2+}) and zinc (Zn^{2+}), which are positively (+) charged when dissolved in water. Since many foliar sprays are applied around the time of glyphosate treatments in Roundup Ready® crops, there is interest in tank-mixing glyphosate and micronutrients. As with the cations in hard water, glyphosate may reversibly complex the positively charged micronutrients in the spray solution. When this happens, glyphosate herbicidal performance may be slightly affected because the glyphosate-micronutrient complex may decrease the amount of free glyphosate[2]. Monsanto does not recommend tank-mixing glyphosate herbicides with micronutrients containing polycationic metal ions or foliar fertilizers; instead, if a micronutrient application is needed, Monsanto recommends making two separate applications: one for micronutrient application and another for weed control.

Does Glyphosate Affect the Availability of Micronutrients When Applied Separately?

Research studies in replicated plots evaluating combinations of manganese fertilization and glyphosate herbicide programs have been performed by numerous universities over a period of thirteen years. Several of these trials involve many combinations of glyphosate rates, timings and formulations, as well as different application variables for Mn^{2+}. Pennsylvania State University[5], The Ohio State University[4], Purdue University[13], University of Illinois[6], Virginia Tech[1] and University of Minnesota[11], all demonstrated no significant differences in yield responses between the various combinations of treatments when labeled rates of glyphosate were used. In addition to these studies that compared yields, trials done by University of Illinois[7] and Purdue University[13] showed no effect on in-plant Mn^{2+} levels across the various glyphosate treatments (Figure 1). To complement the university research, Monsanto has conducted similar field trials and investigations during 2008 and 2009. Three different varieties of Roundup Ready® soybeans were planted and two different herbicide regimes were applied either at V3 alone or at V3 and R1/R2, and two levels of Mn^{2+} were applied at V8 and R4. When compared to the initial levels of Mn^{2+} in the plants, foliar applied Mn^{2+} increased leaf concentrations of Mn^{2+} across all soybean varieties irrespective of glyphosate rates (Figure 2). Glyphosate did not reduce Mn^{2+} in the plants and there were no significant differences in leaf Mn^{2+} concentration resulting from glyphosate treatment regimes for any variety at both Mn^{2+} rate regimes evaluated. When looking at the yield results from the field studies in 2008 and 2009, there were no significant differences in soybean yields due to germplasm, Mn^{2+} rates or glyphosate applications (Figure 3). Within a Mn^{2+} rate regime, there were no significant differences in seed Mn^{2+} concentration when the unsprayed check treatment was compared to the two glyphosate treatments (data not shown). *This two-year study conducted by Monsanto reached the same conclusions as the studies conducted by multiple universities – glyphosate applications in Roundup Ready® soybeans do not reduce Mn^{2+} uptake, availability or utilization in the plant.* In addition, these studies corroborate previous research findings that suggest soybean germplasm often responds differently to the availability of mineral elements. It is also important to note that micronutrient levels vary naturally across different soybean varieties as seen in numerous Monsanto and university studies. Consequently, the data demonstrate that soybean varieties respond differently to micronutrient fertilization. Nutrient deficient soils can negatively affect soybean yield potential. Where Roundup Ready® soybeans are grown on nutrient deficient or nutrient limiting soil, Monsanto recommends appropriate fertilization.

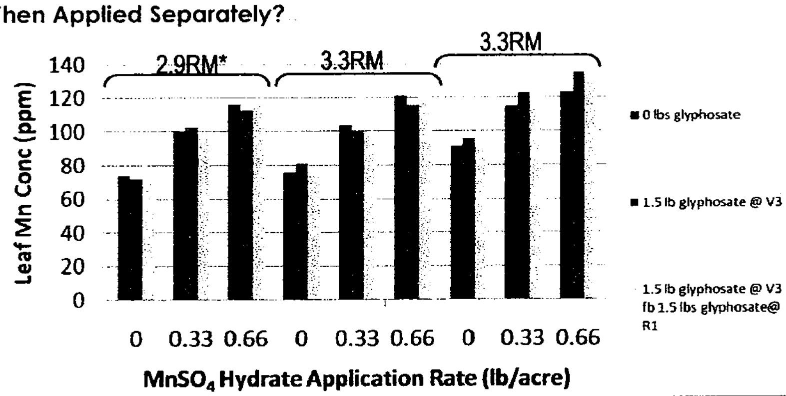

Figure 2. Leaf Mn concentration 14 days after the 2nd Mn application for 2.9, 3.3, and 3.3RM Roundup Ready © Soybeans. *RM=Relative Maturity

The Science of Roundup Ready® Technology, Glyphosate and Micronutrients

Part 1 - Glyphosate Chemistry, Efficacy and Interaction with Micronutrient Foliar Applications

Are there micronutrient differences in Roundup Ready® crops compared to their non-GMO isogenic lines?

Monsanto is required by U.S. and International regulatory agencies to conduct numerous crop compositional analysis studies on Roundup Ready® crops. In these studies a glyphosate-treated Roundup Ready® crop is compared with an untreated isogenic control that does not contain the transgene but is otherwise genetically similar (Figure 4). There are often multiple commercial varieties in these trials for comparison. Micronutrient analysis is typically included in these studies and no trends in micronutrient differences across these studies have been established when comparing the transgenic variety to the non-transgenic control for any Monsanto biotechnology-derived traits. Figure 5 also demonstrates that the levels of zinc, iron and manganese have stayed within their expected ranges as the acreage of GMO soybeans have increased in the U.S. from 2000-2009.

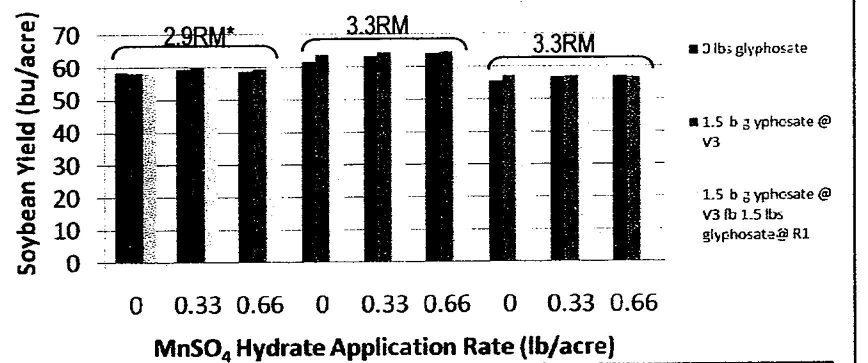

Figure 3. Soybean Yield (bu/acre) for 2.9, 3.3, and 3.3RM Roundup Ready® Soybeans. *RM=Relative Maturity

So, what does all this mean?

Roundup® brand agricultural herbicides have been widely used for weed control in crops for over 30 years and growers' experiences have been extremely positive, including excellent weed control and increased profits. Speculation that glyphosate could affect micronutrient availability has received attention but no causal relationship with glyphosate has ever been established based on scientific studies. Recent chelation modeling studies showed that glyphosate does not effectively compete with natural plant chelators for the various micronutrients in plants[8]. Consequently, the micronutrient bioavailability within plants treated with glyphosate is within the expected natural range of these metals in plants without glyphosate treatment. Where Roundup Ready® crops are grown on nutrient deficient or limiting soil that can negatively affect yield potential, Monsanto recommends the appropriate fertilization. A thorough review of university research, confirmed by Monsanto trials, demonstrates that the Roundup Ready® soybean system with glyphosate does not negatively impact manganese uptake or accumulation or soybean yield potential. This conclusion is further reinforced by a recent Purdue University publication that concludes, "To date, there is limited scientific research data that suggest that plant diseases have increased in GM crops due to the use of glyphosate. Most importantly, the impact of these interactions on yield has not been demonstrated."[16] In summary, Monsanto's recommendations are in accord with the Purdue University report and a recent Iowa State University publication by Dr. Bob Hartzler in which he states, "The best recommendation remains to manage Roundup Ready® soybean similar to conventional varieties in terms of fertility management[9]."

	1998		1999		
Component	NK603 mean (range)	non-GMO mean (range)	NK603 mean (range)	non-GMO mean (range)	commercial hybrids tolerance interval (range)
calcium (% dry wt.)	0.0047 (0.0037-0.0056)	0.0046 (0.0033-0.0058)	0.0053 (0.0050-0.0058)	0.0053 (0.0050-0.0058)	0.0028, 0.0082 (0.0039-0.0076)
copper (ppm)	1.79 (1.19-2.37)	1.90 (1.50-2.33)	1.89 (1.77-1.99)	1.83 (1.69-1.97)	0.45, 3.16 (1.16-2.78)
iron (ppm)	22.71 (19.08-25.94)	22.95 (18.77-26.62)	22.73 (17.43-26.91)	21.81 (18.52-25.87)	10.60, 33.63 (15.42-29.34)
magnesium (% dry wt.)	0.12 (0.11-0.13)	0.12 (0.11-0.13)	0.12 (0.096-0.13)	0.11 (0.10-0.12)	0.079, 0.16 (0.089-0.15)
manganese (ppm)	6.47 (4.64-9.63)	6.55 (4.96-8.83)	6.73 (5.18-7.90)	6.42 (5.63-7.32)	2.50, 12.03 (3.86-10.47)
phosphorus (% dry wt.)	0.36 (0.32-0.39)	0.36 (0.32-0.39)	0.36 (0.31-0.39)	0.35 (0.32-0.37)	0.27, 0.42 (0.27-0.39)
potassium (% dry wt.)	0.36 (0.35-0.39)	0.36 (0.34-0.41)	0.36 (0.34-0.38)	0.38 (0.36-0.39)	0.31, 0.45 (0.32-0.45)
zinc (ppm)	28.35 (20.23-33.17)	28.72 (23.47-33.26)	23.78 (15.95-31.45)	23.21 (17.87-29.88)	9.89, 31.52 (13.51-27.98)

Figure 4. Compostional analysis of Roundup Ready® Corn 2 (NK603) compared with a non-GMO isogenic line.[12]

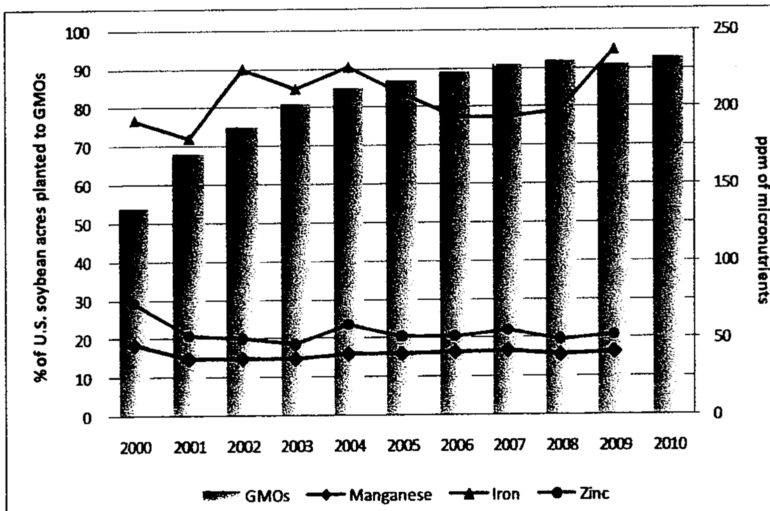

Figure 5. Percentage of GMO soybeans planted in the U.S. and concentrations of manganese, iron and zinc in soybean meal evaluated from 2000-2009.[14, 15]

References: 1. Bailey, William A., D.H. Poston, H.P. Wilson, and T.E. Hines. 2002. Glyphosate interactions with manganese. Weed Technology 16:792-799. 2. Bernards, M.L., K.D. Thelen, D. Penner, R.B. Muthukumarin, and J.L. McCracken. 2005. Glyphosate interaction with manganese in tank mixtures and its effect on glyphosate absorption and translocation. Weed Science. 53:787-794. 3. Camberato, J., K.Wise, and B. Johnson. 2010. Glyphosate – Manganese, Interactions and Impacts on Crop Production: The Controversy. Purdue Extension Weed Science. http://www.btny.purdue.edu/weedscience/ 4. Diedrick, K., Mullen, R., and Loux, M. Foliar Manganese on Glyphosate Tolerant Soybeans. C.O.R.N. Newsletter. 2010-05, March 9 2010 – March 23, 2010. http://agcrops.osu.edu 5. Ebelhar, S.A., E.C. Varsa, and C.D. Hart Soil pH and Manganese Effects On Yield of Roundup Ready® Soybeans. Illinois Fertilizer Conference Proceedings. January 24-26, 2005. http://frec.cropsci.illinois.edu/ 6. Ebelhar, S. A., E. A. Adee and C.D. Hart. 2007. Soil pH and Manganese Effects on Roundup Ready Soybeans. University of Illinois. North Central Extension-Industry Soil Fertility Conference. Volume 23:88-101. Des Moines, IA. http://www.soils.wisc.edu/extension/wcmc/ 7. Fry, K. 2009 . Soybean Yield Responses to Foliar Fertilizers Applied with Glyphosate. Field Crop News March 9, 2010 Vol. 10:03. http://fcn.agronomy.psu.edu/ 8. Harris, W.R., D.R. Sammons, R.C. Grabiak, M.S. Bleeke & A. Mehrsheikh. Manuscripts in preparation. 9. Hartzler 2010. Glyphosate-Manganese Interactions in Roundup Ready Soybean. www.weeds.iastate.edu 10. Messersmith, C.G, 2007. North Dakota State University. Improving Glyphosate Performance. Proceedings of the 2007 CPM Shor course and MCPR Trade Show 11. Lamb, John. 2007. Effectiveness of Preplant and Foliar Mn on Soybean. Nutrient Management Extension Specialist, University of Minnesota. Proc. Of the 2008 Wisconsin Fertilizer, Aglime & Pest Management Conference, Volume 47. 12. Ridley, W.P., R.S. Sidhu, P.D. Pyla, M.A. Nemeth, M.L. Breeze, and J.D. Astwood. 2002. Comparison of the Nutritional Profile of Glyphosate-Tolerant Corn Event NK603 with That of Conventional Corn (Zea mays L.). J. Agric. Food Chem. 50:7235-7243. 13. Xia, Y., J.J. Camberato, and T.J. Vyn. 2009 Effects of glyphosate application and manganese fertilization on leaf manganese concentration and yield of glyphosate-resistant soybeans. North Central Extension-Industry Soil Fertility Conference. Des Moines, IA. Vol. 25. 147-154. 14. DairyOne Feed Composition Library. http://www.dairyone.com/forage/feedcomp/mainlibrary.asp . 15. USDA Economic Research Service. http://www.ers.usda.gov/. 16. Glyphosate's Impact on Field Crop Production and Disease Development. 2011. Camberato, J., S. Casteel., P. Goldsbrough, B. Johnson, K. Wise, C. Woloshuk, *Purdue University.* http://www.btny.purdue.edu/weedscience/2011/GlyphosatesImpact11.html .

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Backgrounder
Glyphosate and Environmental Fate Studies
Updated April 2005

Before a herbicide can be registered for use, it must undergo rigorous studies to determine what happens to the compound after it is released into the environment, either from an intended use or an accidental release, such as a spill. These studies, referred to as "environmental fate" studies, are reviewed by the U.S. Environmental Protection Agency (EPA) and regulators in other world areas and are designed to provide answers to the following questions:

Does the herbicide:

- degrade after application? If so, what degradation products are formed after application?
- persist in soil?
- have residual herbicidal activity in soil?
- persist in water or sediment?
- leach through soil to reach groundwater?
- move from treated areas as runoff?
- move from treated areas as a vapor?
- accumulate in tissues of animals?

Laboratory and field studies have been conducted with glyphosate and glyphosate herbicides (such as Roundup UltraMax, Roundup Pro, and AquaMaster™) to address these questions. The overall results of these environmental fate studies are summarized below

Degradation processes and products

The processes by which a herbicide is degraded must be understood before the U.S. EPA and other regulatory agencies will register the herbicide. Some products break down by chemical processes, others through photodegradation, and others by microbial activity or a combination of several processes. Glyphosate is primarily degraded by microbes and fungi in the soil or in surface water. Photodegradation in water and soil are not expected to contribute significantly to glyphosate degradation.

The identity and characteristics of the compounds that are formed as a herbicide degrades must also be determined. The primary environmental degradate of glyphosate in soil and water is aminomethylphosphonic acid (AMPA). AMPA is further degraded to naturally-occurring substances such as carbon dioxide and phosphate. Acute oral and dermal toxicity studies with rats and mice in the laboratory demonstrate that AMPA has very low acute toxicity to mammals (Williams *et al.*, 2000). A number of ecotoxicology studies have been conducted to assess AMPA's toxicity to aquatic and terrestrial species. Based on the results, AMPA can be characterized as having little toxicity to non-target organisms (Giesy *et al.*, 2000).

Degradation in soil

Studies must also be performed to determine how much of the herbicide would be expected to remain in soil following normal use, and the rate of degradation. Research shows that glyphosate is degraded over time by soil microorganisms. The degradation rate of chemical compounds is measured by their half-life (the time required for half of the applied compound to degrade). The average half-life for glyphosate, based on 47 agricultural and forestry studies conducted in diverse geographic locales, is 32 days (Giesy *et al.*, 2000). In most cases, over 90% of the applied glyphosate is expected to dissipate within six months after application.

Binding to soil

Glyphosate binds very tightly to most soils and sediments in the environment. Studies show that the soil-binding potential of glyphosate is stronger than that of nearly any other herbicide. A ratio known as the "soil adsorption coefficient" (K_{oc}) measures the soil-binding capacity of chemical compounds, with higher numbers meaning greater adsorption of the compound to soil.

The following table shows representative K_{oc} values for several herbicides, as reported by Wauchope *et al.* (1992):

Active ingredient	K_{oc} (L/kg)
2,4-D esters	100
Atrazine	100
Alachlor	170
Metolachlor	200
Pendimethalin	5,000
Trifluralin	8,000
Glyphosate	24,000
Oxyfluorfen	100,000

Herbicidal activity of residues in soil

Because of its strong soil-binding properties in most soils, glyphosate is not available for uptake by roots of nearby plants, and therefore poses negligible risk to non-target plants with roots in the application zone. Further evidence of this is provided by the fact that even susceptible, conventional crops may be planted directly into fields that were recently treated with a glyphosate herbicide. Studies also show that glyphosate herbicides, when used according to label directions, are not harmful to soil microbes, earthworms or other soil-dwelling organisms (Giesy *et al.*, 2000).

Degradation in water

Both field and laboratory studies have reported microbial degradation of glyphosate in aquatic environments (Giesy *et al.*, 2000). Analysis of available data representing many studies indicates that the typical aquatic half-life of glyphosate ranges from 7 to 14 days . Studies have established that microorganisms in surface waters break down glyphosate over time. Also, because of its strong affinity for soil, glyphosate binds to suspended sediment particles that are present in natural waters. As the particles settle to the bottom, microbial degradation continues. Toxicology studies show that glyphosate levels that might occasionally be detected in surface waters following terrestrial application are sufficiently low so that there is negligible risk to aquatic organisms. In situations where a glyphosate herbicide is applied to weeds growing in water, the exposure of non-target aquatic species is expected to be reduced due to interception by target vegetation and dissipation over time via binding to sediment and microbial degradation.

Leaching and runoff

Two primary factors determine whether a chemical is likely to leach through soil to groundwater or be subject to movement into surface water via runoff -- the rate of degradation in the soil, and the chemical's tendency to bind to soil. Slow degradation and a low tendency to bind to soil can result in leaching and runoff of a chemical, whereas higher degradation rates and tight binding to soil both limit the movement of a chemical by leaching and runoff.

With its combination of degradability and strong binding to soil, glyphosate has extremely low potential to move through the soil profile and has rarely been detected in groundwater. In addition, only limited amounts of glyphosate move to surface water as runoff. A three-year study of glyphosate transport from agricultural fields showed that less than 1 percent of glyphosate applied was typically lost as runoff. In one case, a loss of 1.85 percent of applied glyphosate was observed for a field treated at twice the recommended application rate, with more than 99 percent of the total runoff occurring during a severe rainstorm that occurred the day after application (Edwards *et al.*, 1980). If soil particles containing glyphosate are washed or blown into lakes or streams, the vast majority of the glyphosate will remain adsorbed to the soil and settle to the bottom as sediment. In sediment, glyphosate is degraded over time by microorganisms. Studies also show that sediment-dwelling organisms are not adversely affected by glyphosate (Simenstad *et al.*, 1996).

Bioaccumulation

Aquatic Species: In laboratory studies conducted with several aquatic species, glyphosate bioconcentration factors were less than or equal to 12, indicating that glyphosate has a low potential for bioaccumulation in aquatic animals (Giesy *et al.*, 2000). The low bioconcentration factors are a result of glyphosate being readily soluble in water, and therefore subject to rapid elimination from organisms in water.

Terrestrial Species: Studies conducted with laboratory mammals indicate that glyphosate is poorly absorbed when ingested; any absorbed glyphosate is rapidly eliminated, resulting in minimal tissue retention (Williams *et al.*, 2000). Feeding studies with chickens, cows and pigs have shown extremely low or non-detectable residues in meat and fat following repeated exposures. Negligible residues have also been reported in wild animals such as voles, chipmunks, hares and moose after feeding in treated areas.

Vapor and drift

The active ingredients in some herbicides are volatile, meaning that they can move as vapors to non-target areas after application. This can result in unintended consequences to sensitive plant species outside the treated area. Several laboratory studies show that glyphosate has extremely low vapor pressure and thus there is a negligible risk of glyphosate movement through volatility (Giesy *et al.*, 2000).

However, it is possible, as with any sprayed substance, that spray droplets could drift off-target during application. Research has demonstrated that application procedures and equipment can be optimized to significantly reduce spray drift in most circumstances. Spray drift can be minimized by taking into account spray droplet size, wind speed, other environmental factors and application equipment design. When drift does occur, there is a rapid decline in surface deposition with increasing distance from the target site for both ground and aerial applications.

Conclusions

The key properties of glyphosate that determine glyphosate's environmental fate are its:

- Microbial degradability in soil and water
- Strong binding to most soil types
- High water solubility
- Very low volatility

Glyphosate is microbially degraded over time to naturally occurring substances such as carbon dioxide and phosphate. There is minimal herbicidal activity from residues of glyphosate in soil, and glyphosate residues are not likely to move to groundwater. Glyphosate that reaches surface water either by intentional application, spray drift, runoff, or soil erosion is adsorbed to sediment and degraded over time. Glyphosate is unlikely to move offsite during or after application due to volatilization. Available data indicate that glyphosate is not likely to bioaccumulate in the tissues of non-target organisms.

References

Edwards WM, Triplett Jr GB, Kramer RM. (1980) A watershed study of glyphosate transport in runoff. *Journal of Environmental Quality* 9(4): 661-665

Giesy JP, Dobson S, Solomon KR. (2000) Ecotoxicological Risk Assessment for Roundup Herbicide. *Reviews of Environmental Contamination & Toxicology* 167: 35-120.

Seeling B. (1994) An Assessment System for Potential Groundwater Contamination from Agricultural Pesticide Use in North Dakota — Technical Guideline. Extension Report No 18, North Dakota State University Extension Service. http://www.ag.ndsu.nodak.edu

Simenstad CA, Cordell JR, Tear L, Weitkamp LA, Paveglio FL, Kilbride KM, Fresh KL, Grue CE. (1996) Use of Rodeo and X-77 Spreader to control smooth cordgrass (*Spartina alterniflora*) in a southwestern Washington estuary: 2. Effects on benthic microflora and invertebrates. *Environmental Toxicology & Chemistry* 15(6): 969-978.

U.S. EPA. (1993) Reregistration eligibility decision (RED): Glyphosate. Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances, Washington, D.C. http://www.epa.gov/oppsrrd1/REDs/old_reds/glyphosate.pdf

Wauchope R D, Butler TM, Hornsby AG, Augustijn-Beckers PWM, Burt JP. (1992) The SCS/ARS/CES pesticide properties database: Select values for environmental decision making. *Reviews of Environmental Contamination & Toxicology* 123: 1-164. As cited by Seeling 1994.

Williams GM, Kroes R, Munro IC. (2000) Safety evaluation and risk assessment of the herbicide Roundup® and its active ingredient, glyphosate, for humans. *Regulatory Toxicology and Pharmacology* 31(2): 117-165. http://dx.doi.org/10.1006/rtph.1999.1371

Related Documents:

- Backgrounder: Authoritative Sources for Glyphosate Information
- Backgrounder: Glyphosate Half-life in Soil
- Backgrounder: Glyphosate and Drift
- Backgrounder: Glyphosate and Water Quality
- Backgrounder: Formaldehyde is not a major degradate of glyphosate in the environment
- Backgrounder: Summary of Ecotoxicological Risk Assessment for Roundup® Herbicide

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Glyphosate Effects on the Occurance and Development of Soybean Diseases

- Anne Dorrance

Recent claims on blogs and press releases have made the following statements:

"It is well-documented that glyphosate promotes soil pathogens and is already implicated with the increase of more than 40 plant diseases;......"

Based on the number of acres I've walked, the samples we have received, the talks and literature I have attended and read; and our own research here at the OARDC, this statement just isn't true. I cannot document that there has been an increase in over 40 diseases in this state, nor in the north central region since 1998 when roundup ready soybeans were first widely planted in Ohio. Glyphosate inhibits a key enzyme which is involved in the synthesis of key amino acids in the plant, and many fungi and bacteria also have this same pathway. In plants, aromatic amino acids are the building blocks for many of the defense compounds such as glyceollin in soybean as well as suberin and lignin. When round-up ready soybeans were first planted this was one concern that was soon alleviated. Few studies have evaluated the development of specific diseases in response to glyphosate applications, but in those that have, the results did not support this claim.

One of these studies was done by a group at Southern Illinois University, which compared round-up ready soybean cultivars with and without glyphosate for the development of SDS. There were no significant differences in the level root infection, SDS symptom development, nor colonization of roots between the sprayed and unsprayed plots of the same variety. Their primary conclusion was that the development of SDS in their region on round-up ready soybeans was due to the lack of resistance to this pathogen and NOT due to glyphosate applications. We have witnessed this in Ohio as well. Specifically during 2009, Ohio had widespread occurrence of SDS. One field in particular still stands out in my mind, where the producer ran out of soybeans of one variety and filled the planter with another variety – and to the row, the SDS was in all of the plants of one variety and none of the other. Same planting date, same herbicide program, same environment – only the variety was different.

Since 2003, this lab has sampled a great number of fields for soybean and corn seedling blight pathogens, including Pythium spp., Phytophthora sojae, and Fusarium graminearum. These have been sampled across conventional corn, soybean, as well as fields that receive predominately a round-up ready program. There are many very reasonable explanations that we have been able to attribute to the development of these pathogens: changes in resistance levels in varieties, increase in inoculum due to soil conservation practices and changes in seed treatment chemistry. We have plots on our farms that have not had Round-up as a routine part of the management, we can achieve the same level of disease today (no greater-no less) as previous researchers working on the same pathogen in these very same fields. One of the strengths of the land grant university system is the ability to maintain these long-term study plots which can monitor effects such as these.

In the scouting we have done, during the last 10 years, the outbreaks of Phytophthora sojae, Frogeye leafspot and Sclerotinia stem rot have directly led to a reduction/or lack of resistance to these pathogens in the varieties. These were not due to the application of round-up. A group at the University of Illinois/USDA-ARS screened glyphosate tolerant cultivars for their response to bacterial pustule. They identified that approximately 30% of the cultivars were susceptible while the rest were resistant in a greenhouse screen. Again, it was the inherent resistance level in the variety and not glyphosate tolerance that resulted in the development of this disease. We have seen the same trends when we evaluate varieties for their response to *Phytophthora sojae* each year for the Performance Trials. When the glyphosate tolerant lines first entered the trials, there levels of partial resistance were quite low but as time increased, more and more lines had higher levels of resistance. Much of the resistance that we use in field crops is governed by multiple genes. It takes a lot of crosses to get that resistance combined with the high yielding genes and many of these resistant traits do not have the best tightly linked markers.

In addition, glyphosate applications have been shown to reduce fungal growth in plates and as a result of applications in the field. No, we are not going to start recommending glyphosate as a fungicide. Don't even think about it. But in two cases, studies of soybean rust in Florida and wheat stem rust at Washington State University, researchers were able to show in experimental systems that there was indeed a reduction. And this makes sense since this enzyme is present in plant and fungi.

Lastly, every year, soybean pathologists from around the world complete a survey that examines the yield losses in soybean due to plant pathogens. Alan Wrather at Univ. of Missouri has coordinated this effort for the past 20 years. These surveys are based on actual field stops, diagnostic samples, and research plots. These summaries have also not shown an increase in disease. The following table is a summary of these surveys and the different diseases. The yield loss recorded for each disease group fluctuates based on the incidence and severity of specific diseases due to the widespread planting of susceptible varieties and/or environmental factors that favor infections.

Yield loss in metric tons (x10^3) per year

Disease group	1999	2000	2001	2002	2003	2004	2005
Leaf	91.4	201.0	46.1	86.9	23.7	62.8	199.8
Stem	706.9	708.2	1,114.7	455.0	768.9	2,381.9	848.9
Root	1,785.5	3,414.9	2,419.5	2,784.6	3,674.5	2,519.5	1,831.1
Seedling	261.3	495.0	772.1	502.9	644.5	1,023.3	762.6
Seed	99.3	20.9	30.1	106.7	27.2	6.9	83.9
Nematode	4,132.2	3,393.3	3,568.4	3,350.4	2,586.9	3,198.2	1,718.3
Virus	208.3	926.0	380.7	754.3	170.4	44.0	31.3

Leaf diseases = bacterial diseases, brown spot, downy mildew, frogeye leaf spot.

Stem diseases = anthracnose, brown stem rot, pod and stem blight, Sclerotinia stem rot, stem canker.

Root diseases = charcoal rot, Fusarium root rot, Phytophthora root rot, sudden death syndrome.

There is also a statement concerning the occurrence of a "new" pathogen that can be found in soybean and wheat meal that has negative impacts on animal health. I can't comment on this new pathogen as there is very little data and a lot of speculation, including that wheat was treated with glyphosate, which at this point wheat is not treated. For this part, we will have to wait to see what the evidence truly is and what methods were used to identify this "new" pathogen.

One final thought or maybe this is a reality check. Ohio producers, as well as those worldwide, need to double the world food supply within the next 20 years due to predicted changes in the world population. Our 2 to 3 bushel per year is not going to cut it. We will need every single tool, approach and tactic to make this happen and in my opinion includes genetically modified strategies. We are reaching the limits of doing this via breeding and for some plant diseases, no resistance to the pathogen has been identified; thus novel genetically modified means are going to be the way that we can produce the food for the future. I would like to say that it is in some plant somewhere but to get the resistance from one plant to another – a gene transformation procedure can make this happen in 2 years vs 20. If there are claims on safety – let's get the data out there so we can adapt, put corrections in place and keep moving forward. We have a lot of food to produce for a hungry world. It must be safe and healthy to eat, sustainable to produce and affordable for the consumer.

Glyphosate's Impact on Animal Health?

- William Shulaw, DVM

The USDA's recent decision to approve Roundup Ready® alfalfa has rekindled the controversy over the use of genetically modified organisms in the food chain. A letter addressed to Agriculture Secretary Tom Vilsak has been cited or reproduced on numerous web pages and blogs and has heightened the controversy. (http://farmandranchfreedom.org/gmo-miscarriages accessed 3/1-11) The letter announces the discovery of a new pathogenic life form supposedly associated with Roundup Ready® corn or soybeans, or possibly glyphosate itself, and warns of potentially devastating consequences of this new pathogen on plant and animal health.

The letter describes this new life form as being previously unknown, a "micro-fungal-like organism" having the size of a medium-sized virus, and present in "high concentrations" in Roundup Ready® soybean meal and corn, distillers' meal, pig stomach contents, and pig and cattle placentas. Furthermore, the letter indicates that this organism has been found in a variety of livestock that have had spontaneous abortions and infertility and that preliminary experiments have shown that it can cause abortions in a clinical setting. The letter also alludes to a supposed escalation in the frequency of abortions and infertility in US livestock over the past few years, and speculates that this new pathogen may be responsible.

As near as we can determine, this new organism has not yet been described in scientific publications or in oral presentations at scientific meetings. Results from research demonstrating its ability to cause abortions or other negative health consequences in animals have not been presented in these settings either. It is very unusual that preliminary experiments that demonstrate an ability of an organism to cause abortion could already be competed without some description of the organism itself being presented to scientists in written or oral communications. The discovery of a new organism, especially a pathogen, is usually revealed to the scientific community first for review of the findings by one's peers and to encourage further research on the organism and any potential consequences of the findings on human, animal, or plant health. If such a new organism, especially one with the potential detrimental effects on livestock health as described in some of these internet postings, has been discovered, the relevant information should be immediately available for review by scientists and veterinary diagnosticians and practitioners.

These postings also refer to the "escalating frequency" of abortions and infertility in livestock in the US. It is true that abortion and infertility are important causes of decreased animal health and economic loss, and indeed, there are many potential causes of livestock abortion and infertility. However, we are unaware of any documented "escalation" in their frequency over the last several decades during which time glyphosate or Roundup Ready® varieties of crops have been available and used widely.

Until such time as the claims of a new pathogen and increased levels of animal disease associated with it or glyphosate use, such as described in these recent internet postings, have been subjected to scientific review, farmers and livestock owners should be very cautious about attaching credibility to them. Good record keeping, preventive health measures, and timely diagnostic procedures and laboratory submissions are the foundation of maintaining animal health.

Trying to Sift Through the Current Wealth of Information (and Misinformation) About Glyphosate

- Mark Loux,
- Robert Mullen,
- Anne Dorrance

Recent claims about the possible negative impacts of glyphosate have many growers asking whether they are overusing this herbicide and causing deleterious effects to their crops. Extension specialists across the Midwest have been asked about these claims for the past year or so, and have responded in part with newsletter articles and similar pieces recently to address the issue. These include articles by Purdue scientists and Iowa State weed scientist Bob Hartzler found at the following links, as well as the two accompanying articles in this issue of C.O.R.N.

http://www.btny.purdue.edu/weedscience/2011/GlyphosatesImpact11.pdf

http://www.weeds.iastate.edu/mgmt/2010/glyMndisease.pdf

Dr. Hartzler makes an extremely relevant conclusion in his article, which applies to the core problem with interpretation of some of the claims about glyphosate problems. In reference to claims about the effect of glyphosate on rhizophere organisms, Dr. Hartzler states, "*It is well documented that the presence of glyphosate in the soil can significantly impact microbial* *populations. Due to the complexity of the processes that occur within the root zone, it is impossible to completely rule out negative effects of glyphosate on mineral nutrition or disease development in GR crops. However, results from field research and our widespread experience with glyphosate on GR crops for over a decade do not indicate widespread negative impacts of glyphosate on these factors.*" This last point can be applied to the micronutrient and disease issues as well.

A major problem we have with the negative glyphosate story being told is the almost complete lack of appropriately designed and repeated field research studies that validate the concerns that are being raised. The meaning of "appropriately designed" here is that the treatments are designed to accurately assess the effect of one or more factors. This and the treatment replication within studies, and the repetition of studies, is what allow scientists to draw valid conclusions. In our opinion, growers trying to evaluate the glyphosate issue should be asking the developers of the negative glyphosate story to show results of this type of field research. There appears to be instead a lot of discussion of physiological processes and how glyphosate can or does interact with these processes. Without the appropriate follow up field research there is however no evidence that any of this is occurring in the field or more importantly, that it's affecting crop yields. The broader perspective here is that weather still has the most impact on determining crop yields given satisfactory management of the variables that can be controlled by growers, and crop yields continue to increase where weather has been favorable.

In at least one case where the negative glyphosate story contains a reference to field research, the research is inadequate to support the conclusions that are being drawn. The research does not appear to have an appropriate treatment design, or to be repeated over sites or years (and we assume it's not from a reviewed and published article). The following data have been shown for postemergence application of glyphosate and/or various MN sources (means are significantly different when they have different letters).

Treatment	**Rate**	**Yield**	**% weed control***
No herbicide	None	46 a	0 a
Glyphosate**	24 oz/A	57 b	100 e
Glyphosate + $MnCO_3$	0.5# Mn/A	75 d	91 de
Glyphosate + $MnSO_4$	0.5# Mn/A	70 cd	93 e
Glyphosate + Mn EDTA	0.25# Mn/A	72 cd	100 e
Glyphosate + Mn AA	0.15# Mn/A	67 c	85 d

We assume that these data are used to support the conclusion that glyphosate reduces MN availability in the plant, because yield increased where MN was added. However, this cannot be concluded without additional treatments where the MN sources were applied in the absence of glyphosate. It's possible that the glyphosate had no effect on MN processes, and the soybeans just responded to the addition of MN because they were deficient. This is also an example of a confounded study, because the researcher failed to isolate the effect on individual factors on crop yield. Yield here could be affected by both the absence or presence or MN and weed control, because the study was not conducted under weed free conditions. In the end it's impossible to determine the effect of any one factor on crop yield from these data. The work that Robert Mullen and colleagues have conducted on this is an example of a much more complete approach, due to appropriate treatment design, repetition over sites and years, and determination of tissue MN levels.

All of us that conduct field research, advise growers, or do the actual growing make daily observations about crop growth and the effect of myriad factors on it. We can therefore draw rough conclusions that can be reinforced when we make the same observation over time. Growers also observe trends in yields over time that can help them determine the effect of specific management decisions. However, it's certainly possible to draw the wrong conclusion where general observations are made, but the effects of factors are not separated and tested appropriately. A good example of this comes from a recent article (www.responsibletechnology.org/blog/664) that is largely in support of the negative glyphosate story. In the article, a situation is described where one section of an Iowa soybean field was suffering from Sudden Death Syndrome (SDS) while the rest of the field was healthy. The SDS-affected area had been planted to alfalfa the previous year, and the alfalfa was killed with glyphosate at the end of the season. The part of the field without SDS had been planted to sweet corn the previous year and no glyphosate was used. The conclusion was that the use of glyphosate in the alfalfa was responsible for the SDS in the soybeans the following year. This conclusion obviously ignores the vast differences between alfalfa and corn, their effect on soil structure or tilth, and their susceptibility to or ability to host various diseases. In short, the soybeans had been planted into what were likely two vastly different environments based on the previous crop. This is not to say that the glyphosate could not have had a role, but without further research, the conclusion that it was responsible for the SDS was erroneous.

A similar example occurs later in the same article where an agronomist in Iowa is quoted as saying that whereas a decade ago corn plants stayed green and healthy well into September, corn has been turning yellow and then brown about 8 to 10 days earlier each season over the past three years. Yield losses due to this early death were apparent in at least one of these years, and the phenomenon was attributed to increased use of glyphosate. These observations were apparently not based on field research but instead on general observations. It's somewhat difficult to buy that this is a widespread yield-reducing phenomenon based on the high corn yields of the past several years. As for the previous example, it should be possible to conduct field research to determine whether there is an actual effect of glyphosate on the time of corn death, especially if the phenomenon really is occurring as frequently as the agronomist claims (it's really just as simple as having replicated strips within multiple fields, where half the strips in each field receive a POST glyphosate application and half don't). In both of these situations, we see no evidence of replicated field research, and in the end the reader is left to decide whether he believes a conclusion based on faulty reasoning or observation not supported by research. This is not to say that the phenomena are not occurring, just that there is a way to concretely prove whether they are or not through well-designed field research, and this has not been done.

In the end, the best thing we can do here is to urge growers to use caution in interpreting the information about glyphosate that is being presented. Whether this information is applicable to actual crop production situations is debatable and largely unproven. It's likely that some valid concerns are being raised, but overall this is just difficult to assess. Some of the information does appear to be false or based on extreme extrapolation from narrow focus studies, with little to support it in the way of valid field research that investigates specific factors in a complex production system. We believe it's important for growers to always accumulate as much valid information about a subject as possible prior to making management changes, and the glyphosate issue is no exception to this. We probably speak for most of the weed scientists across the corn belt when we state that we would be thrilled if glyphosate was used less frequently in current production systems, but only if this occurs for the right reasons (e.g. herbicide resistance issues). We agree with the conclusion of the Purdue scientists in their analysis of the issue, which was: "*We encourage crop producers, agribusiness personnel, and the general public to speak with University Extension personnel before making changes in crop production practices that are based on sensationalist claims instead of facts*".

Glyphosate Application Effects on Soybean Manganese Nutrition

- Robert Mullen,
- Mark Loux,
- Anne Dorrance

Just in case you had not heard, there has been some concern expressed by a few researchers regarding the impact of glyphosate application on glyphosate tolerant soybeans and manganese nutrition. We have addressed this issue indirectly in a previous CORN Newsletter articles (here), but we wanted to discuss this topic further as our research into the promoted phenomenon has increased.

Data has been shared showing exudation of glyphosate from soybean roots may impact microbial communities in a lab setting. The shift in the microbial community is from an environment dominated by manganese releasing organisms to an environment dominated by manganese fixing organisms. While this has been demonstrated in a lab setting, does any field data exist to validate that glyphosate application can impact soybean manganese uptake? The answer is yes. There are published studies that have shown that application of glyphosate can result in decreased manganese concentration in soybean tissue. Conversely, data collected from Ohio over 4 site-years has not shown that application of glyphosate (even at rates well in excess of the labeled rate) has influenced soybean manganese tissue concentration even two weeks after application.

The next question is, if application of glyphosate does impact manganese availability (and our data locally does not clearly indicate this), does it require manganese supplementation to alleviate the induced "manganese deficiency"? Field experiments documenting positive impacts of manganese applications with or following glyphosate application are limited, so Ohio State University initiated its own research into the phenomenon four years ago. Based upon 8 site-years of experimentation, we found one site-year (Northwest Research Station 2007) that showed a positive response to foliar manganese application, and that site tends to have lower manganese tissue levels (indicating greater probability of response to foliar manganese). At the Western Research Station, we have actually documented yield losses due to application of foliar manganese (2007 and 2009). Tissue concentrations at the Western Research Station tend to be higher than 60 ppm, well above what is considered sufficient.

Based upon our research into the phenomenon, we are not currently promoting the application of manganese on every acre with or following a glyphosate application (even if you are growing glyphosate tolerant soybeans). If you are producing soybeans on a soil that tends to be manganese deficient (high soil pH, droughty, high organic matter) then application of manganese is something you should consider. We recommend that you monitor tissue concentrations to give you some indication as to whether or not you should be making an application. Tissue concentrations that consistently hover around the lower end of the sufficiency range (<30 ppm) are more likely to show a positive yield benefit, and just as importantly they are less likely to result in a yield decrease due to the application of manganese. Tissue concentrations well into the sufficiency range (<50 ppm) are unlikely to benefit from manganese supplementation, and there is some risk of yield loss due to the application of manganese (most likely due to toxicity).

If you do decide to make an application of manganese, our recommendation is to tank-mix the products and use an EDTA chelated form of manganese. This does not influence manganese uptake associated with the application (from our data here in Ohio), but salt forms of manganese can decrease the efficacy of glyphosate.

If you would like to read a little bit more on the subject check out the following links:

Iowa State University http://www.weeds.iastate.edu/mgmt/2010/glymn.pdf

Purdue University http://www.btny.purdue.edu/weedscience/2010/GlyphosateMn.pdf

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Frost Seeded Clover in Wheat

- Alan Sundermeier,
- Robert Mullen

Farmers following a three crop rotation (corn-soybean-wheat) who are considering the use of a cover crop after their wheat this summer, may want to consider frost-seeding red clover this spring. The legume seed can be mixed with liquid or dry fertilizer and applied while topdressing wheat. The freezing and thawing action of the soil will then help the legume seed move into the soil and begin growth once temperatures begin to warm up. The legume continues to grow as the wheat crop matures. By late fall or early spring, the legume can be destroyed by herbicides or tillage. Corn is then planted to take advantage of any natural nitrogen in the soil which was produced by the legume or some other rotational benefit associated with the red clover stand.

The debate among farmers and scientists has centered on how much nitrogen the legume actually captures and how much of that is released to a subsequent corn crop. The economics of the investment of legume seed and extra production management need to be outweighed by the amount of nitrogen generated.

A successful establishment of legumes requires favorable weather conditions which provide enough moisture throughout the growing season. Hot, dry weather in the summer can greatly reduce legume growth and potential nitrogen contribution.

Once a legume has been established, it is difficult to predict the amount of nitrogen that will be available to the following corn crop. As the legume decays after tillage or herbicide treatment, the conversion into nitrate nitrogen usable for the corn crop will occur when soil moisture and temperature are favorable.

There are other benefits of legumes in a three crop rotation like corn-soybeans- wheat including the ability to reduce compaction, the reduction in soil losses through erosion, and the creation of a more favorable habitat for soil micro/macro-organisms. Even if no additional nitrogen was produced by legumes, these soil benefits alone may improve corn yields. From our own research at the Northwest Research Station, we have found corn yield increases in a no-till system when red clover was frost-seeded in wheat prior to corn in 2 out of 3 site-years. Red clover may also be harvested as forage creating another revenue stream for your operation.

Take home message – our data does not suggest dramatically cutting nitrogen rates when a cover crop is established (perhaps 30 pounds of nitrogen), and we have not identified conditions when the nitrogen contribution is more likely to occur. It does appear that in the poorly drained soils of northwest Ohio that a rotational benefit is likely to be observed when a legume cover crop is established after wheat.

10 Tips to Get the Most out of Your Sprayer

- Erdal Ozkan

Spraying season is just around the corner. Just take a moment to review some common sense ideas I will mention here to get the most out of those expensive pesticides you will be spraying. The following "Top Ten" list will help you improve the performance of your sprayer and keep it from failing you:

1) Applying chemicals with a sprayer that is not calibrated and operated accurately could cause insufficient weed, insect or disease control which can lead to reduced yields. Check the gallon per acre application rate of the sprayer. This can only be determined by a thorough calibration of the sprayer. Use clean water while calibrating to reduce the risk of contact with chemicals. Read OSU Extension Publication AEX-520 for an easy calibration method (http://ohioline.osu.edu/aex-fact/0520.html).

2) How the chemical is deposited on the target is as important as the amount applied. Know what kind of nozzles are on your sprayer and whether or not their patterns need to be overlapped for complete coverage. Make sure the nozzles are not partially clogged. Clogging will not only change the flow rate, it also changes the spray pattern. Never use a pin, knife or any other metal object to unclog nozzles.

3) In addition to clogging, other things such as nozzle tips with different fan angles on the boom, and uneven boom height are the most common causes of non-uniform spray patterns. They can all cause streaks of untreated areas that result in insufficient pest control and economic loss.

4) Setting the proper boom height for a given nozzle spacing is extremely important in achieving proper overlapping. Conventional flat-fan nozzles require 30 to 50% overlapping of adjacent spray patterns. Check nozzle catalogs for specific recommendations for different nozzles.

5) Know your actual travel speed, and keep it steady as possible. Increasing the speed by 20% may let you cover the field quicker, but it also cuts the application rate by 20%. Similarly, a reduction of speed by 20% causes an over application of pesticide by 20%; an unnecessary waste of pesticides and money.

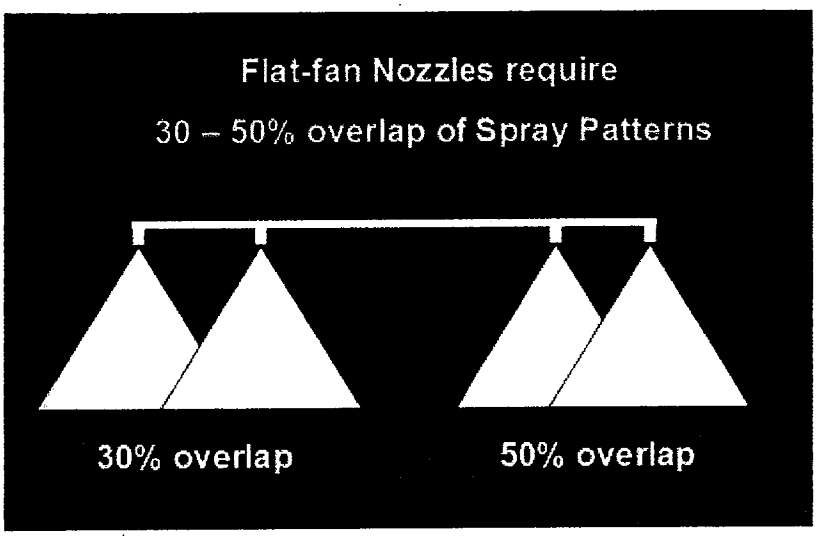
6) Pay attention to spray pressure. Variations in pressure will cause changes in application rate, droplet size and spray pattern. At very low pressures, the spray angle will be noticeably narrowed, causing insufficient overlap between nozzle patterns and streaks of untreated areas. High pressure will increase the number of drift-prone droplets.

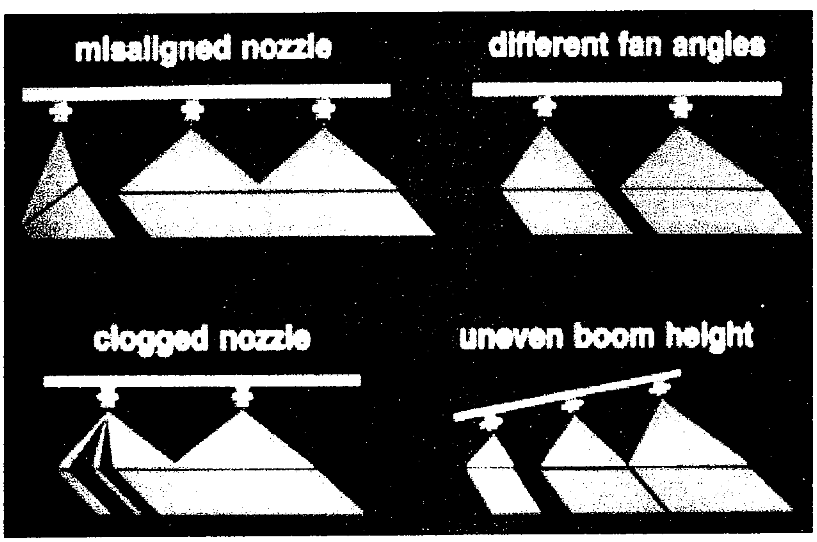
7) Don't waste your chemical. After all, you have paid for it. Spray drift wastes more chemicals than anything else. Don't spray when the wind speed is likely to cause drift. Don't take the risk of getting sued by your neighbors because of the drift damage to their fields. Keep the spray pressure low if it is practical to do so, or replace conventional nozzles with low-drift nozzles. Use other drift reduction strategies: keep the boom close to the target, use drift retardant adjuvants, and spray in early morning and late afternoon when drift potential is less.

8) Carry extra nozzles, washers, other spare parts, and tools to repair simple problems quickly in the field.

9) Calibrate your sprayer periodically during spraying season to keep it at peak performance. One calibration per season is never enough. For example, when switching fields, ground conditions (tilled, firm, grassy) will affect travel speed which directly affects gallon per acre application rate.

10) Be safe. Read the chemical and equipment instructions and follow them. Wear protective clothing, rubber gloves and respirators when calibrating the sprayer, doing the actual spraying and cleaning the equipment.





Be well informed about the specific recommendations for a given pesticide, and follow the laws and regulations on pesticide application. Carefully read the product label to find out the specific recommendations.

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Corn Flea Beetle and Stewart's Leaf Blight

- Ron Hammond,
- Pierce Paul,
- Andy Michel,
- Dennis Mills

The adult corn flea beetle is the vector and means for spread of the bacterium that causes Stewart's bacterial wilt and leaf blight. Flea beetle adults that overwinter become active in the spring when the soil temperatures reach 65 F, and are most active on sunny, warm, windless days. Those adults that fed on corn plants with Stewart's disease in the late summer or fall may acquire and carry the bacterium from one growing season to another. By feeding on young plants in the spring, they may spread the bacterium which in turn causes seedling wilt and leaf blight. The occurrence of Stewart's bacterial disease is totally dependent on the level of bacteria-carrying flea beetle survival over the winter.

For many years the winter temperatures have been used to predict the risk of Stewart's disease because higher populations of the flea beetle survive during mild winters than during cold winters. An index is developed that helps to predict the likelihood of the disease threat. This 'flea beetle index' is calculated as the sum of the average temperatures (Fahrenheit) of December, January and February. We checked the average temperature for various locations in Ohio to determine the risk level according to the 'flea beetle index' for 2011. The locations and the corresponding indexes developed were: Wooster (OARDC) 75.7, Ashtabula 77.9, Hoytville (Northwest Research Station) 71.4, South Charleston (Western Research Station) 77.6, Jackson 88.6, and Piketon 90.1.

The flea beetle index is uses as such:
- Index values less than 90 indicate negligible disease threat,
- 90-95 indicate low to moderate levels,
- 95-100 indicate moderate to severe and
- values over 100 predict severe disease threat.

Compared with last year, it appears that northern Ohio was slightly cooler while southern Ohio was similar in terms of the index. Although the overall risk of Stewart's bacterial leaf blight should remain low in much of Ohio, with only southern Ohio (Piketon) again considered to have a low to moderate threat, we would still recommend that growers scout for flea beetles, especially if they have planted a hybrid that is susceptible to Stewart's disease. For growers wishing to take preventive action against flea beetle, commercially applied insecticide seed treatments are labeled for flea beetles. You can see pictures of flea beetle injury and Stewart's bacterial blight, and get additional information on Stewart's disease of corn, on the Ohio Field Crop Disease web site at http://www.oardc.ohio-state.edu/ohiofieldcropdisease/corn/stewarts.htm. Additional information on the flea beetle can be obtained from OSU Extension Fact Sheet CV-1000-94.

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Wheat Production Workshop

- Alan Sundermeier

The Wheat Production Workshop will be held on March 31, 2011 at the O.A.R.D.C. Northwest Ag Research Station, 4240 Range Line Road, Custar, Ohio. Registration cost $50.00 includes materials and lunch. This workshop offers plant disease and insect samples for participants to learn identification skills. As a result of attending this workshop, field scouts will be equipped to accurately determine wheat pests and recommend controls. Also, current fertility, crop production, and genetic practices will be presented.

Certified Crop Advisor CEU = 0.5 NM, 1.5 CM, 0.5 PM credits.

Commercial Pesticide Recertification CEU = 2.0 hours Category 2A

Registration flyer at www.wood.osu.edu

Registration Deadline is March 24. Call Alan Sundermeier at 419-354-9050 for more details.

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Southwest Ohio Corn Growers Association Winter Meeting

- John Yost

The Southwest Ohio Corn Growers Association will hold their annual winter meeting at the Leesburg Firehall in Leesburg, Oh on March 9, 2011. This year's presenter is Dr. Ron Hammond, OSU Extension Entomologist. Dr. Hammond will be discussing "what corn hybrid traits really do". Dwayne Seikman, Executive Director of the Ohio Corn and Wheat Growers Association, will provide an organizational update. The program begins at 6:30 PM. There is no cost for the event, and dinner is provided by the SWOCGA. For more information contact John Yost (740-335-1150 or yost.77@osu.edu) or you can find more information on the OSU Extension -Fayette County Website (here)

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2011 Southern Ohio Agronomy Day

- David Dugan

The 2011 Southern Ohio Agronomy Day will be held on March 23 at the Hillsboro Ponderosa Banquet Hall, located on SR 62 in Hillsboro, OH. This year's program features presentations by Anne Dorrance, Robert Mullen, Andy Michel, and Mark Loux. Registration begins at 9:30 AM, and the program is free. Interested producers are asked to call the Brown County Extension Office (937-378-6716), Adams County Extension Office (937-544-2339), or the Highland County Extension Office (937-393-1918) to place a reservation.

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C.O.R.N. is a summary of crop observations, related information, and appropriate recommendations for Ohio Crop Producers and Industry. C.O.R.N. is produced by the Ohio State University Extension Agronomy Team, State Specialists at The Ohio State University and Ohio Agricultural Research and Development Center. C.O.R.N. Questions are directed to State Specialists, Extension Associates, and

Agents associated with Ohio State University Extension and the Ohio Agricultural Research and Development Center at The Ohio State University.

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