January 7, 2000

Public Information and Records Integrity Division
Information Resources and Services Division (7502C)
Office of Pesticide Programs
Environmental Protection Agency
401 M Street S.W.
Washington, D.C. 20460

COMMENTS SUBMITTED TO DOCKET NUMBER OPP-50864: APPLICATION FOR AN EXPERIMENTAL USE PERMIT FOR CRY3Bb TRANSGENIC CORN

These comments are submitted on behalf of the Institute for Agricultural Trade and Policy[1], the Science and Environmental Health Network[2], and the Consumer Policy Institute/Consumers Union[3].

We agree with the EPA – the application from Monsanto Company for an EUP to test corn genetically modified to express the Cry3Bb protein for control of the corn rootworm complex of insects is indeed "of regional and national significance."

Corn rootworms are without doubt the major corn pest worldwide. Their management leads to the use of about 85 to 90 percent of all insecticide applied to corn, far more than the European corn borer. Market potential and economic stakes are enormous. University of Illinois corn IPM specialist Dr. Michael Gray has just presented an excellent, timely paper at the University's annual Crop Protection Technology Conference entitled "Prescriptive Use of Transgenic Hybrids for Corn Rootworms: An Ominous Cloud on the Horizon?"

The paper states that "farmers may eventually invest more than $400 million (annually) in transgenic technology fees…to prevent corn rootworm larval injury." (Gray, 2000). Gray bases his estimate on an average technology fee of $15.00 per acre, about

---

[1] The Institute for Agriculture and Trade Policy is based in St. Paul, Minnesota. Its mission is to create environmentally and economically sustainable rural communities and regions through sound agriculture and trade policy. See <http://www.iatp.org> for further information.
[2] The Science and Environmental Health Network is dedicated to the development of sound environmental and risk assessment policies, and is based in Windsor, North Dakota. See <http://www.sehn.org> for further information.
[3] Consumers Union is a nonprofit membership organization chartered in 1936 under the laws of the State of New York to provide consumers with information, education and counsel about goods, services, health, and personal finances and to initiate and cooperate with individual and group efforts to maintain and enhance the quality of life for consumers. Consumers Union's income is solely derived from the sale of *Consumer Reports*, its other publications and from noncommercial contributions, grants and fees. In addition to reports on Consumers Union's own product testing, *Consumer Reports* regularly carries articles on health, product safety, marketplace economics and legislative, judicial and regulatory actions that affect consumer welfare. Consumers Union's publications carry no advertising and receive no commercial support.

the average cost of a soil insecticide, and a projected 26.7 million acres planted to new transgenic hybrids. This investment in technology would be directed toward reducing the estimated $650 million in damage done by the corn rootworm each year (Gray, 2000).

The EPA seeks comments on what is clearly a major new biotechnology. Moreover, this application is the first of two closely related *Bt*-corn applications the agency will have to act on in just the next few months[4]. Within two years, there may be as many as four different transgenic corn technologies designed to control corn rootworms that are moving through the EPA review process. The same issues and questions should and no doubt will arise as subsequent applications and technologies move through the EPA review process.

Independent scientists and other stakeholders will need a similar, shared base of knowledge to intelligently participate in review and consultation processes. We recognize that providing such information will require changes in current EPA administrative policies and procedures and that such changes have been resisted vigorously in the past. Still, changes are necessary to work toward open, credible and ultimately convincing scientific review processes. We hope the biotechnology industry has come to share this view in light of recent developments.

Summary of Major Concerns and Recommendations

Clearly as a first step, the EPA needs to define the pertinent questions that must be answered prior to the approval of commercial-scale planting of transgenic corn varieties engineered to control a soil-borne insect such as the corn rootworm. It goes without saying that a prudent regulatory system would not sanction widespread use of such a technology until fundamental questions of need and safety are answered with a sufficient degree of certainty.

In addition to whether the technology is safe to humans and the environment, two such questions are obvious, although they fall outside EPA's typical review of an Experimental Use Permit –

> Is this technology needed to advance the efficacy, reduce the costs and lessen environmental impacts of corn rootworm management?
>
> If the answer to the first question is "Yes," how should the technology be deployed? Should EPA just open the door, or should farmers be required to use the technology only where needed and in conjunction with proven IPM practices and systems?[5]

---

[4] Dow AgroSciences is working with Pioneer Hybrid to bring to market *Bt*-corn varieties engineered to control the corn rootworm complex. Commercial introduction is planned for crop season 2001, pending regulatory approvals.
[5] Dr. Michael Gray's important new paper speaks directly to this issue (Gray, 2000).

In comments submitted later this month in response to Monsanto's application for a full Section 3 registration (see <http://www.epa.gov/fedrgstr/EPA-PEST/1999/December/Day-22/p33163.htm>), we will suggest and discuss a more complete set of pertinent questions. These will, in turn, lead to the establishment of a set of data requirements and criteria governing the decision process and the ongoing evaluation of actual impacts and performance in the field. Given the importance of this new technology, we envision the need for what amounts to an "Environmental Impact Assessment" augmented by full consideration of impacts on the economics of corn production, trade, and utilization of animal feeds and corn-based products and byproducts.

Generating data needed to answer such key questions with at least a minimal level of certainty should also factor prominently in the specification of conditions in the event this EUP application is approved.

Four Conditions for Approval

The proposed new biotechnology raises profound environmental, soil quality and human health concerns that are qualitatively distinct from any past risks arising from application of foliar *Bt* products.

We outline new risk concerns below but wish to emphasize here that **the EPA has a very slim, and in some key areas virtually non-existent science base to evaluate new risks posed by the proposed Cry3Bb transgenic corn.** Indeed we suspect that no regulatory authority, company or scientific institution have such data, given our poor understanding of soil ecology. In many respects, soil ecology is worse than a black box. Science cannot define its shape or the factors that govern its always-changeable contents. Accordingly, we urge the EPA to deny this application for an EUP unless and until the agency can assure farmers, researchers and all concerned citizens that four conditions are and will continue to be met.

First, the EPA must find convincing evidence that both predicted and unforeseen risks arising from these experiments will be modest, contained and reversible. This evidence, if it exists, must be found in the proprietary data submitted with this EUP application. Since there is so little information in the public arena, the EPA bears a heavy responsibility to bring this data into the open and assure that its implications are fully considered.

Second, the experiments sanctioned under the EUP will be carried out, data collected and analyzed, and results reported in an open, transparent and credible fashion. Furthermore, throughout its review and decision-processes, the EPA will seek and assure careful, in-depth review by independent experts of all data and arguments submitted in response to this and subsequent applications leading to commercial use of this technology.

Third, the EPA must insist that the applicant extend an invitation to collaborate in EUP-sanctioned study design, the collection of field data, and analyses of results to Land

Grant University corn IPM experts in the states where the experiments are carried out. It is critical that university-based corn pest management experts be given a chance to participate in these trials in light of the major effort underway to gain full approval and widespread commercial use as early as crop season 2001. Given that the new varieties might be planted on 30 to 40 million acres within just a few years, it is essential for independent university researchers to begin work on these new varieties. Their only chance in crop year 2000 will be as part of these EUP-sanctioned trials.

Fourth, the EPA should make it clear that approval for commercial use will not be granted until all outstanding questions are addressed and resolved to EPA's satisfaction through an open process drawing on experts from the grower, IPM, university, conservation, and environmental and consumer communities. Plus, the EPA should ask the applicant to post a performance bond of sufficient size to cover the costs of dealing with any unforeseen problems or adverse impacts. While EPA apparently lacks the authority to require a performance bond, the willingness of the applicant to agree to the posting of such a bond should be a factor taken into account in the approval process.

Transparent and Open Processes Are Essential

In the review of this and other GMO-related EUP and registration applications, the agency must take seriously the need for much more thorough and transparent stakeholder consultation and scientific review processes.

For people to carry out credible reviews and participate in meaningful consultations, they require access to a shared base of preferably peer-reviewed information describing in some detail the characteristics and performance of the technologies under review. This is far from the case with the current Cry3Bb corn application.

The December 8, 1999 Federal Register Notice provides essentially none of the pertinent information anyone will need who wishes to evaluate this technology. The notice provides little or no information on –

- The complete identity of the transgene;
- The method and/or composition and source of the vectors used to move the new genetic material into maize germplasm;
- The nature of the truncated protein being expressed (e.g. presence of post-translational processing, as well as 3-D structure);
- Levels of expression in roots and root exudates and temporal dynamics of expression;
- Environmental fate in the soil;
- Resistance management plans;
- Levels of expression in pollen, leaf tissue and grain;
- Likelihood of gene flow to organic and non-engineered corn varieties; and
- Likelihood of gene flow to soil microorganisms and impacts on soil life and ecological processes.

If this technology is marketed before science has a chance to ask and answer key questions, the producer community will, in effect, be asked to "bet the farm" when planting Cry3Bb transformed corn hybrids. Healthy soil is the one universal prerequisite for profitable farming. When soil quality is degraded through erosion, compaction, contamination or other mechanisms, there are significant and essentially unavoidable impacts on average attainable corn yields, a linkage documented for over 50 years. Hence, it is vital that research more fully document this technology's impacts on soil macro- and microarthropod complexes, microbial communities and interactions, nutrient cycling, microbial biocontrol and plant immune response and productivity.

The EPA and biotechnology industry must develop a mutually acceptable way to modify current policies and public consultative and scientific review processes so that necessary technical and scientific information is widely available ***before*** people are asked to review the consequences or impacts of new technology.

Therefore, in taking final action on this EUP application, the EPA must provide for both complete disclosures of the details of the proposed technology and more thorough and open reviews of its likely and possible impacts. Lacking either, public skepticism of biotechnology and marketplace opposition will surely gain momentum.

Specific Questions, Concerns and Areas in Need of Further Research

Nature of the Transgene

The EUP application covers three different vectors: Vectors ZMIR12L, ZMIR13L, and ZMIR14L. The application offers no information how theses vectors differ, why Monsanto is seeking approval for the use of three vectors, when and under what conditions each of the vectors might be used, and how the different vectors alter expression of the Cry3Bb protein in corn plants.

Some inferences on the nature of the transgene and these vectors can be made from the June 9, 1998 U.S. patent number 5,763,241 granted to Monsanto covering its *Bt.t.* technology. This patent is hereafter referred to as the "Monsanto *Bt.t.* patent"; the full text is accessible on the Internet via the U.S. Patent Office. Based on review of this patent, the gene construct used to produce Cry3Bb transformed corn hybrids probably deploys the CaMV 35S promoter and an antibiotic marker gene (kanamycin). The applicant's and EPA's failure to disclose these obviously essential details is regrettable and contrary to the basic purpose of the Notice.

To allow an informed review of this technology, information is needed on the nature of each vector and element of the genetic cassette including –

- How the gene construct was engineered into corn germplasm;

- The source of the genes producing the Cry3Bb protein;
- The structure of the expressed, truncated Cry3Bb protein and presence of any post-translational processing;
- The base sequence of at least 10kbp of flanking host genome DNA on either side, including changes in methylation patterns;
- The complete nucleotide base sequence for the entire insert;
- The promoter(s) used to trigger expression of the transgene;
- Identity of all other elements (e.g. marker genes, enhancers, termination signals, non-coding regions, introns, leader sequences, plasmid sequences, linkers, T-DNA borders, etc);
- Location of each insert and whether it is organelle or chromosomal, and the precise position of each insert;
- Structure of each insert (i.e. whether duplicated, deleted, rearranged, etc);
- Codon substitution and amplification; and
- Degree and method of truncation and physiological consequences of the truncation.

In addition, we understand there is uncertainty and/or disagreement in some quarters regarding the source of the genetic material coding for production of Cry3Bb protein toxins covered by this EUP application. Any such uncertainty must be definitively resolved given that the identity of the parent organism is fundamental in predicting and monitoring the specificity and impacts of the transgene.

Cry3Bb Corn Varieties are Very Different from Other *Bt*-Corn Varieties and Must be Assessed with the Benefit of New Studies

According to Monsanto's *Bt.t.* patent –

> "Although the Coleopteran-type toxins and the Lepidopteran-type toxins are derived from *Bacillus thuringiensis*, there are significant differences between the toxin genes and the toxin proteins of the two types…
>
> "…although [the] genes may be evolutionarily related, they are quite distinct in both nucleotide and amino acid sequence."

Moreover, the patent explains that the codon-amplifaction process is very different compared to Cry1*Bt* transgenics, focusing on deletions in a different terminus and leading to "… substantially different properties." Moreover, "A deletion of only 4 amino (pMON5448) acids resulted in complete loss of activity." Monsanto states that these results are "directly contrary to the reported literature with respect to Lepidopteran-type *B.t.* toxins." If the deletion of just 4 amino acids can completely eliminate toxicity, it is reasonable to explore whether an equally modest movement of amino acids among *Bacillus* species might dramatically enhance toxicity or expand the range of organisms impacted.

Most past *Bt*-related environmental effects and human health studies have been carried out with either foliar *Bt* products (environmental effects, human health studies) or with components of transgenic corn varieties expressing the Cry1a protein in leaf tissues and pollen (some ecological impacts). There is very limited data on the selectivity and environmental fate of *Bt* subspecies *tenebrionis* (hereafter *Bt.t.*), what we believe is the source of the Cry3Bb protein covered in this EUP application.

Therefore, to the extent there are data accessible to EPA to evaluate the non-target impacts, human health and environmental fate of the proposed new Cry3Bb corn varieties, that data must have been developed and submitted to the agency in association with this application. In evaluating human health impacts and toxicological experiments, the Cry3Bb protein as expressed in corn plants should be used, not the protein toxin as expressed in bacteria.

New Risk Concerns

The proposed Cry3Bb based corn varieties may pose several new risks. The most worrisome are adverse impacts on water quality and aquatic ecosystems, and on soil food webs and communities.

A major disadvantage of foliar *Bt* products has held back their commercial development – when exposed to sunlight, foliar *Bt* sprays break down quickly and become ineffective within 48 hours to a few days. This is both an ecological advantage, in that it reduces selection pressure and non-target impacts and also a disadvantage, since growers may need to apply other pesticides, adopt more complex IPM systems or make multiple *Bt* applications to assure season-long control.

Engineering *Bt* into plant tissues helped solve the problem of breakdown in sunlight. Varieties that express *Bt* underground in roots and through root exudates will assure even slower breakdown of *Bt* proteins. Indeed the important work of Stotzky and colleagues reported in *Nature* shows that *Bt* proteins are exuded from the roots of *Bt* corn and can bind with clay soil particles or humic acid and retain their toxicity for over 120 days in the soil (Saxena et al., 1999). This work needs to be repeated with Cry3Bb corn varieties expressing *Bt.t.* to see if they exude Cry3Bb protein toxin and whether it too binds to soil particles. The implications of the resulting findings must then be fully considered.

To gain control of the corn rootworm, a tough pest to manage, young corn plants will have to express *Bt.t.* at a relatively high level in roots and possibly through root exudates, especially in the 6 to 8 weeks after emergence. Since the genetic modification will presumably lead to continuous production of *Bt.t* in the root system throughout the period when corn plants are vigorously growing, levels of *Bt.t* could build in the soil for several weeks through at least late summer.

Thus, it is crucial to determine if the Cry3Bb toxin is present in root exudates and if so, at what levels. We assume that if Cry3Bb is present in root exudates, it will be present at roughly the same concentration as in roots. We also assume that a high dose strategy for resistance management is being proposed, so that the level of Cry 3Bb in roots, and perhaps root exudates will be over an order of magnitude higher than the LD-90 for corn rootworm larvae.

Consequently, throughout this period there will be a significant quantity of *Bt.t* in the root zone, surely far more than under any natural conditions (concentrations perhaps two or more orders of magnitude greater). Since this toxin is known to be water soluble, some leaching can be expected. Once *Bt.t.* moves below the root zone, there will be lessened chance of further microbial breakdown and some *Bt.t.* may reach underground aquifers and hence appear in drinking water. *Bt* isolates have already been found in pockets of groundwater at a depth up to 26 feet (Martin, 1994).

Stotzky's research has shown that *Bt* proteins can bind to clay particles and humic acids and become very stable in the soil (Saxena et al., 1999). In some farming systems and on certain soils, bound *Bt* may move off fields with eroding soil and enter streams, ponds and lakes, and aquatic ecosystems. The environmental fate and movement of such bound residues of *Bt.t.* will require careful research since conditions periodically will arise leading to a release of the *Bt.t.* as organic matter in sediment breaks down. This could produce a short-term flush of *Bt.t.* entering species-rich and fragile ecosystems during critical time periods when microbial activity and food webs are at peak levels and growth processes are most robust.

It is known that *Bt* species and the toxin proteins they produce readily adapt to their environment in order to stay one step ahead of their also-adapting prey. The ability to conjugate and transform through various mechanisms has been selected for through natural evolution. New heretofore-unrecognized mechanisms might also emerge as important. For example, soil bacteria can change as they pass through the digestive tracks of earthworms (Clegg et al., 1995). Earthworms can bioaccumulate protein toxins in decaying organic matter as well as those emitted as root exudates from transgenic corn. Earthworms can also serve as the vector for these novel proteins and their associated DNA to enter the digestive systems of organisms up the food chain such as birds and fish, eventually reaching humans. Along the way enzymatic action will transform the proteins in various ways and opportunistic microorganisms might take up some of the transgenic DNA through one or more mechanisms, with largely unknown consequences (Tappeser et al., 1998).

Modes of Action

For a variety of reasons it is critical to understand the mode or modes of action through which Cry3Bb corn varieties control corn rootworms. How Cry3Bb works is central in evaluating how and why resistance might emerge, as well as the possible efficacy of various resistance management plans. Moreover, it is possible that different modes of action will come into play at various larval instars.

The Cry3Bb protein is most likely to be overtly toxic to early instars but may still have some impact on population levels at later stages of development through alternative mechanisms. The efficacy of resistance management plans may be no greater than the "weakest link" in the resistance management plan, or indeed some complex aggregation of several "weaker" links.

Non-target impacts of the Cry3Bb protein will also need to be understood mechanistically in order to evaluate their consequences. The impact on non-target organisms will obviously be a function of the organisms within the soil profile and how different management practices have shaped microbial communities as plant growth progresses. It is well established that soil type, tillage systems, rainfall levels and irrigation systems (if any), fertilization practices, micronutrient levels, corn genetics and a number of other factors can have profound short, and in some cases long term impact on soil microbial communities.

The added impacts of Cry3Bb proteins on various production systems and soil types in years with normal, excessive, or less than normal moisture or heat units will be incredibly variable, dynamic and difficult to predict prior to widespread planting. It will be equally hard to sort out these factors in the field as the acreage planted to Cry3Bb hybrids expands. For this reason, early understanding of the mechanisms likely to come into play under various combinations of circumstances will be useful in order to evaluate and monitor field performance and unintended consequences. Hence our suggestion that EPA build into approval of this EUP requirements that teams of university-based researchers be allowed to start the process of sorting out these linkages and interactions in crop year 2000.

Resistance Management

Few insects are resistant to more insecticides than the corn rootworm. Populations are resistant to chemicals in all major classes of insecticides and resistance management is a major concern whenever a new product is registered for corn rootworm control.

The potential for resistance to *Bt*-corn varieties will be significant. According to Dr. Michael Gray –

> "I suggest that the potential for resistance development by corn rootworms is much more acute than for European corn borer, *Ostinia nubilalis* (Hubner)…
>
> "Even with [resistance management] strategies in place, in my opinion, resistance will develop eventually…
>
> "Corn rootworms have shown repeatedly that they are superbly capable of adapting to a variety of insecticides and even to a cultural practice. Any notion

> that they will not develop resistance to transgenic insecticidal cultivars at some point is foolhardy." (Gray, 2000).

As an adult, the corn rootworm is the cucumber beetle, a common vegetable pest that thrives on a number of crops other than corn. While soil-applied *Bt.t.* products have not yet been commercialized for control of rootworm larvae, interest is bound to grow in developing and marketing such products, especially if and as organophosphate and carbamate products are driven off the market by the Food Quality Protection Act (FQPA).

It is well known that corn rootworms, like other beetles, are most susceptible to *Bt.t.* and other toxins during early instars in the larval stage. Most soils in the Midwest have some level of *Bt.t.* in the soil profile as a result of natural populations. It is not known what role, if any this and other natural *Bt*s play in moderating populations of corn rootworms under various soil, farming system and climatic conditions.

It is also not known whether and to what extent the flush of *Bt.t.* expected in fields planted to Cry3Bb corn varieties will lead to displacement of other *Bt*s and soil microorganisms in the root zone. But some major shifts in microbial communities are virtually inevitable. The consequences of such shifts are hard to predict since they might arise through secondary or tertiary food chain, niche competition, and microbial biocontrol mechanisms. In addition, if and as resistance emerges, rootworms might become an even more common and costly problem to manage.

This and related soil ecology-related information is obviously critical in evaluating potential impacts of Cry3Bb corn. USDA should sponsor and EPA should require that several field-monitoring studies determine both background levels of *Bt.t.* in soils across the country, as well as baseline levels of susceptibility to *Bt.t.* In addition, the mechanics of the resistance process need to be fully elucidated.

A major downside of this technology is that corn rootworm populations will be exposed to *Bt.t.* selection pressure for much longer periods of time than the days or perhaps weeks when *Bt.t.* levels will be high enough to bring about acceptable control of early instar larvae. This drawback will surely accelerate the emergence of resistance and in the end may be ample reason alone for EPA to deny approval of this technology.

Differential expression of the Cry3Bb protein in root systems and exudates can also be expected based on experience with *Bt.t.* potatoes and other *Bt*-transgenics. Expression may be uneven within the architecture of the root system itself or over time as the plant grows. Uneven expression in just parts of the root zone will enhance the odds of resistance emerging and will also make it much more difficult to devise effective resistance management plans. For this reason, the EPA should review carefully data submitted in support of this EUP application to determine whether there is a basis to judge that the expression of the Cry3Bb protein will be sufficiently stable and consistent to bring about a high level of control.

This review is not necessary to assess the likelihood of product efficacy. It is possible for Cry3Bb transgenic corn varieties to "work" well from the perspective of the grower for a few years while nonetheless quickly selecting for genes within a population of rootworm that lead to stable resistance. This evolution of resistance might proceed regardless of resistance management plans. In fact, the circumstances on just one farm, with only one field planted for just one or two years (even under an EUP), could set in motion a genetic response that after five, 10 or perhaps 20 years could confer resistance to *Bt.t.* across the Midwest. This is why the EPA must take very seriously its responsibility to review this EUP and not approve if it there appears a plausible chance that such a scenario could be set in motion.

While we believe the emergence of resistance genes from just a single field is a plausible scenario, it remains impossible to predict its significance given information now in the public arena. To do so science must first elucidate the importance of natural sources of *Bt.t.* in the regulation of corn rootworm populations and how Cry3Bb corn varieties will impact soil microbial communities and the many critical interactions between soil microorganisms and growing plants.

Commonsense dictates that the applicant must possess such knowledge before asking EPA to approve this technology. Sound regulatory science and decision-making would require EPA to seek such evidence from the applicant, which presumably has been submitted as part of the package supporting this EUP application. These studies and data should be carefully reviewed and the above scenario must be dismissed as implausible before allowing the technology to go forward. We await access to such studies and results and the EPA's evaluation of them.

Impacts on Microbial Communities

In a review of the survival and spread of GMOs in the environment and the likelihood of gene flow, Tappeser and colleagues highlight the unique complexity and diversity of soil environments. They state that "…less than 10% of [soil bacteria] are cultivable using current techniques and only around 1% have been characterized to date." (Tappeser et al., 1998). While data are limited, they cite a number of studies showing that GMO bacteria can be surprisingly persistent in the soil, lasting weeks if not months. Plus, genetically transformed bacteria can be surprisingly mobile, moving in one experiment up to 2 cm per day (Tappeser et al., 1998).

Within the largely unknown complex of organisms within the soil, there is a vast diversity of *Bacillus* species, including considerable variability in *Bt* subspecies and strains. Most *Bt* species emit protein toxins that are toxic to two or more orders of insects but some appear non-toxic to insects. According to Dr. Phyllis Martin, a USDA expert on soil microbiology, "*Bt* has a broad environmental distribution that is not related to the distribution of the target insect(s)." (Martin, 1994, page 88). It is found all over the world, at all elevations and soil conditions, and both where insects are plentiful and rare. It is generally not found in beach sand and at depths greater than 10 cm. Population levels are known to fluctuate daily, but are generally higher in the spring and fall and lower in the summer. Phenotypes also can change dramatically over short periods.

In a key field experiment described by Martin in her 1994 *American Entomologist* review article, a foliar applied *Bt* product raised the population of the strain in the product to a maximum level of 100,000 cfu/g of wet leaf weight. Just one day after application, the population had dropped to pre-treatment levels. As long as 21 days post-treatment, the applied *Bt* strain could still be detected at very low levels. But significantly, the applied *Bt* strain had apparently displaced the indigenous *Bt* species on the surface of leaf tissues, and there had been an overall shift from *Bt* species to bacteria other than *Bacillus* species (Martin, 1994).

This finding suggests that in some circumstances, bacteria and microorganisms other than *Bt* species can react more quickly to fill ecological niches left by perturbations affecting mostly *Bt* species. Such perturbations might include the planting of a Cry3Bb corn variety. If this phenomenon holds true in some soil ecosystems, the consequences could be profound for nutrient cycling and availability, microbial biocontrol of a large range of insects, the triggering of plant immune response and what farmers refer to as "soil quality."

The diversity of *Bt* species is testament to the need of *Bt* species to continuously evolve in response to the defenses insects have evolved to combat them. There are over 100 known *Bt* strains, and no one knows how many are yet to be discovered or have become extinct. This process of adaptation will no doubt continue within microbial communities and the *Bt* species within them. Hence the most profound unknown associated with the use of this technology may prove to be how it will affect these processes of adaptation and what consequences will unfold as a result.

Implications on Farmers and Corn Production

Over time this technology could trigger major shifts in soil life and hence the efficiency of basic services provided by healthy soils to farmers and society. The stakes are huge – nutrient cycling and uptake, groundwater contamination with nitrogen, the emergence of new diseases, impaired plant immune response, and new strains of even-harder-to-control corn rootworms. If any of these potential impacts actually occur, even to a modest degree, any economic advantage gained by farmers from this technology will prove ephemeral at best.

It is likely that the impacts of this technology will extend well into the soil web of life via root exudates. Flushing the soil with *Bt.t*. in the spring and early summer will no doubt have significant impacts on nontarget organisms, for example many beneficial and parasitic nematode species. As the *Bt.t.* toxin is modified by enzymatic action in the soil, or via the digestive processes of worms or other soil invertebrates, new forms could be evolve with dramatically different ranges of activity or toxicity. Detailed, multidisciplinary work will be needed to sort through these interactions and it should start immediately if the EPA decides to approve this EUP.

There is also considerable potential for the marketing push behind this technology to lead to more extensive use than justified by rootworm populations and damage potential. Given that all major pesticide-seed companies are working on one or more transgenic corn technologies for rootworm control, it is possible that a sizable majority, if not most corn hybrids will contain a set of genes targeting rootworm control within the next five to 10 years. According to Gray's recent paper –

> "Research to date indicates very clearly that the investment in a transgenic insecticidal cultivar for corn rootworm control will not pay dividends on all planted corn acres."

Yet in the case of today's GMO corn varieties, the marketplace and company marketing efforts have demonstrated no capacity or inclination to restrict actual use to where there is a need or chance for an economic return. Nor has the EPA displayed much interest to date in placing constraints on where and under which circumstances GMO varieties can be planted.

We wish to thank the EPA for the opportunity to submit these comments and look forward to further dialogue as the review of this important technology unfolds.

Sincerely,

Charles Benbrook
Consultant to IATP/SEHN

Mark Ritchie
IATP

Carolyn Raffensperger
SEHN

Michael Hansen
CPI/CU

References

Clegg, C.D., Anderson, J.M., Lappinscott, H.M., VanElsas, J.D., and J.M. Jolly. "Interaction of a genetically modified *pseudomonas flourescens* with the soil-feeding earthworm *Octolasion cyaneum*," *Soil Biology and Biochemistry*, Vol. 27: 1423-1429.

Gray, M. "Prescriptive Use of Transgenic Hybrids for Corn Rootworms: An Ominous Cloud on the Horizon?', Proceedings of the Year 2000 Crop Protection Technology Conference, University of Illinois at Champaign-Urbana, January, 2000.

Fischhoff, D. et al., U.S. Patent Number 5,763,241, granted to Monsanto Company, June 9, 1998.

Martin, P. "An Iconoclastic View of *Bacillus thuringiensis* Ecology," *American Entomologist*, Vol. 40, Summer 1994: pages 85-90.

Saxena, D., Flores, S., and G. Stotzky. "Insecticidal toxin in root exudates from Bt corn," *Nature*, Vol. 402, December 2, 1999: page 480. Accessible on *Ag Biotech InfoNet* at <http://www.biotech-info.net/risks.html#soil>.

Tappeser, B., Jager, M., and C. Eckelkamp. "Survival, Persistence, Transfer – An Update on Current Knowledge on GMOs and the Fate of Recombinant DNA," Institute for Applied Ecology, Germany, May 1998, accessible at <http://www.oeko.de/english/gentech/gmo.htm>.