Valuing the Changes in Herbicide Risks Resulting from Adoption of Roundup Ready Soybeans by U.S. Farmers: An Empirical Analysis of Revealed Value Estimates

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Abstract: A revealed-preference approach is proposed for the evaluation of the impact of changed patterns of herbicide use on RR soybeans. The results indicate that farmers consider herbicide safety in their herbicide choices and associate positive values with safety improvements. The aggregate welfare impact of reduced risk for the U.S. soybean farmers was estimated to be $90.3 million in 2001.

Introduction

Pesticides are an integral part of modern agriculture. They provide a highly efficient, cost-effective, and flexible method of controlling pests and contribute to high yields and consistency of crop production. However, the widespread use of pesticides over the past several decades has led to social concerns over their potential human health and environmental impacts. Pesticides are often detected in surface and groundwater, and their use affects the quality and quantity of non-target species (Florax, Travisi, and Nijkamp). A link has also been established between pesticide exposure and human health (see Kafle).

As a response to the social concerns over pesticide safety, regulatory agencies at different levels are prompted to implement various pesticide risk management policies, which include command and control approaches, market-based instruments, and moral suasion (Travisi, Nijkamp, and Vindigni). During the assessment of any new pesticide policy, it is essential to evaluate the changes in social welfare resulting from the changes in pesticide human and environmental risks associated with this policy in addition to evaluation of the policy's direct economic impact. Without such an input, the policy assessment could suffer from serious biases and result in erroneous conclusions.

Pesticide risk evaluation procedures are complex because of the multidimensional nature of pesticide impacts. A number of studies have attempted to develop a methodological base for such an evaluation. The proposed methods include the cost of illness approach (Wilson), averting/defensive expenditure method (Antle and Pingali), the contingent valuation technique (Cuyno, Norton, and Rola; Higley and Wintersteen), and hedonic analysis (Beach and Carlson; Fernandez-Cornejo and Jans). Florax, Travisi, and Nijkamp, as well as Travisi, Nijkamp, and Vindigni, conduct a detailed review of the empirical valuation literature on pesticide risk exposure and conclude that existing knowledge is rather fragmentary and there is a high degree of variability in risk value estimates related to both employed valuation techniques and available data. Typically, stated preference approaches are used, and considerably fewer studies rely on revealed preference techniques which are often hampered by lack of data on the choice set considered by the actor and the actor's perception of risk. They also argue that the majority of studies are driven by interest in human health, and only few address pesticide environmental impacts.

The objective of this study is to propose an alternative method to estimate an economically consistent value of the marginal changes in pesticide safety that could be useful for future pesticide management policy assessments. The estimation of this value is based on farmers' revealed preferences. Because the degree of pesticide risk depends not only on its safety but also the intensity and duration of exposure (Antle and Pingali; Sivayoganathan et al.), the potential risks to pesticide applicators, farmers, or farm workers who are occupationally exposed to pesticides are likely to be more significant than the risks to someone in the general population exposed only to traces of pesticides in food and water, ceteris paribus. Farmers are also dealing with pesticides on an everyday basis. Therefore, it is reasonable to assume that they have more accurate knowledge of pesticide human and environmental risks compared to the general population. In addition, farmers are not only producers who use pesticides as productive inputs, but also consumers who are exposed to negative pesticide externalities. At the same time, we acknowledge that our value estimates are likely to underestimate the true social value of reduced risk from alternative pesticide management scenario which would also include the benefits to the general population.

The specific application of this method is to estimate the impact of Roundup Ready (RR) soybeans on the welfare of the U.S. farmers. Currently, these soybean varieties account for the largest share of total U.S. soybean acreage (91 percent in 2007) (U.S. Department of Agriculture). Because the adoption of RR soybeans results in the substitution of a single broad-spectrum herbicide characterized by favorable environmental properties (Malik, Barry, and Kishore) for a variety of more selective herbicides with varying levels of environmental effects, they may benefit human health and the environment (Carpenter et al.; Marra). If one considers herbicide relative toxicity information in addition to the information on the application volume and the number of applications, RR soybeans show an improvement in the environmental "footprint" brought about by their adoption (Nelson and Bullock; Qaim and Traxler), which should have an impact on the welfare of farmers.

Theoretical Framework

There is an extensive literature that develops evaluation techniques for non-market goods, such as herbicide safety. Commonly used methods can be grouped under two broad categories of revealed and stated preference-based methods. For both, the main assumptions are that individuals trade health and environmental quality as if they were market goods and that individual preferences provide a valid basis for valuation. As mentioned previously, the majority of previous studies looking at pesticide risk valuation rely on stated preference information (Brethour and Weersink; Cuyno, Norton, and Rola; Foster and Mourato; Higley and Wintersteen; Press and Soderqvist). Such methods are often criticized for the hypothetical nature of the survey questions, answers to which may not be very informative about the actual preferences of the respondents (Kling). We argue that it is possible to use revealed preference information to estimate the value of the change in herbicide safety in order to avoid the biases often associated stated-preference based methods.

In the revealed preference methods the researcher observes respondents' behavior in well-developed markets for ordinary goods and services and extrapolates the results to the goods that are not traded explicitly in the market. Hedonic price analysis was used by Beach and Carlson and Soderqvist to investigate whether farmers value groundwater pollution risk and user toxicity of pesticides. Fernandez-Cornejo and Jans also use the hedonic analysis to adjust aggregate pesticide price indices for changes in pesticide toxicity. However, the hedonic method may not be appropriate for explaining marginal values of pesticide safety attributes for market segments with small shares, and the random utility approach could alternatively be used (Hubbell and Carlson). We follow this approach by assuming that the farmers reveal their values of herbicide safety by selecting a specific pesticide product out of the set of available product alternatives based on their observed attributes, including not only pesticide costs and effectiveness, but also safety. Our method also provides a flexible framework, allowing us to consider multiple pesticide human and environmental risks while attempting to capture the complex nature of pesticide impacts.

A Behavioral Model of Herbicide Choice

Herbicides are productive inputs affecting farm profits. Beach and Carlson also suggest considering the impact of some nonproductive herbicide attributes, such as water quality and user safety, on farmers' utilities. Farmers may be concerned about herbicide impacts on their own health and the health of family members and workers, as well as on the quality of on-farm environmental resources, such as soil and water. They may also derive utility from fishing, hunting, swimming, or some other recreational activities that are affected by herbicides or they may have some altruistic concerns for environmental preservation.

Therefore, the choice of a herbicide out of the set of available alternatives by a farmer can be represented as a utility maximization problem. Each herbicide product in the farmer's choice set is represented as a set of attributes h consisting of h^y, a vector of attributes affecting yields; h^c, herbicide product and application costs; and h^s, a vector of environmental and human safety attributes. The reduced-form, indirect utility function, U, of farmer i (i: $i=1,...,I$) associated with the attributes of the herbicide alternative j (j: $j=1,\ldots,J$) is:

$$(1) \qquad U_{ij} = \beta'_i h_{ij} + \varepsilon_{ij} ,$$

where h_{ij} are observed attributes of the herbicide alternative j for farmer i, including the herbicide application costs, effectiveness, and safety, and β_i is a vector of coefficients for farmer i. Finally, ε_{ij} is the stochastic portion of the utility function of farmer i associated with herbicide alternative j.

The farmer observes all elements of the model and chooses herbicide alternative *j* that maximizes his utility: $U_{ij} = Max\,(U_{i1}, U_{i2}, \ldots U_{iJ})$. If we also assume that the coefficients vary across farmers with density *f*(*β*), and ε_{ij} is an extreme value iid random term, we can model the probability of choosing herbicide alternative *j* among *J* alternatives by farmer *i* as the integral of the conditional choice probability for the herbicide alternative *j* by farmer *i* over all possible values of β_i:

$$(2) \qquad P_{ij} = \int \frac{exp\,(\beta' h_{ij})}{\sum_{j=1}^{J} exp\,(\beta' h_{ij})} f\,(\beta)\,d\,\beta$$

leading to the mixed logit model (Train). Estimated coefficients represent marginal utilities of different herbicide attributes to the farmer, and the farmer's willingness to pay (WTP) for the improvements in herbicide safety attribute *k* (*k*: *k*=1,…,*K*) can be calculated as the marginal rate of substitution between this herbicide safety attribute and application costs:

$$(3) \qquad WTP_{ik} = \frac{\partial U_{ij} / \partial h^{s}_{ijk}}{\partial U_{ij} / \partial h^{c}_{ij}} = \frac{\beta^{s}_{ik}}{\beta^{c}_{i}},$$

where β^{s}_{ik} is the estimated coefficient on herbicide safety attribute *k* and β^{c}_{i} is the coefficient on herbicide application costs. This value is the base for our estimation of the value farmers place on the changes in herbicide safety when RR soybeans are adopted.

Estimation of the Herbicide Choice Model

The data on herbicide use was obtained from a national, computer-aided telephone survey of soybean farmers in 2002 conducted by Doane's Market Research. Farmers selected to participate in the survey represent nineteen major soybean growing states. The number of survey respondents in each state was selected based on the state's share in national soybean acreage in 2001. The majority of respondents operated large farms and 45 percent of respondents were growing only RR soybeans in 2001. Thirty three percent of respondents were partial adopters of RR technology, and 22 percent of respondents were growing conventional soybeans only. The survey explored issues relevant to the comparative economic analysis of conventional and RR soybeans. In particular, it concentrated on differences in herbicide use. There were 1,769 individual herbicide choices made by 610 farmers participating in the survey. These choices were used as a basis for the estimation of the values farmers place on herbicide safety.

Attributes of the Herbicide Choices

A number of herbicide attributes may affect the farmer's choice of herbicide product. Since herbicides are designed to control weeds, their effectiveness in dealing with weeds is one of their most important attributes to the farmers. Herbicide effectiveness is measured as the percent of broadleaf and grass weed control calculated as an average percent control of a number of weeds within broadleaf and grass weed categories (calculations include all broadleaf or grass weeds for which information on percent control was available).[1] The costs associated with herbicide application, including the stage-specific herbicide application cost and materials cost per acre, determine profit and, therefore, should also affect the choice.

Herbicide human and environmental safety may also be important for the farmers. For example, Beach and Carson include herbicide user safety and water quality in a farmer utility function and find statistically significant impacts of these variables. In this study, we investigate the impact of an extended set of herbicide risk attributes for which information is available to the farmers from product label and Material Safety Data Sheet (MSDS).

Pesticides are strictly regulated in the United States through a complex system that leads to product registration and use. During the registration process, the EPA evaluates the information available for the pesticide and approves a product label and MSDS. The label and MSDS are intended to provide the farmers and the public with general, technical, risk, and safety information about pesticides. Pesticide labels and MSDSs follow established uniform standards for describing pesticide risks attributes and are used as informational sources for various pesticide risks in our study.

LD_{50} is the material dosage that would result in the death of 50 percent of a population of test species under stated conditions. It is the primary way of expressing acute effects of solids and liquids that are swallowed, or contaminate the skin and is usually expressed in terms of milligrams of material per kilogram of body weight (Rozman, Doull and Hayes). We apply a measure proposed by Nelson and Bullock, the number of LD_{50} doses in the herbicide recommended application rate, to represent a level of acute human risk from herbicide exposure. EPA's criteria assessing chronic human health risks are based on the results of tests evaluating carcinogenity and reproductive, birth, and developmental effects of pesticides that are also reported on product label and MSDS. We assume that a certain herbicide is considered to be a high risk to chronic human health if there is positive evidence of the presence of any of the above effects.

Herbicide residues may also contaminate surface and groundwater. Generally, all methods used to assess the impact of herbicides on the quality of water resources concentrate on leaching and runoff potential determined by the herbicides' persistence, water solubility, and mobility. We consider a herbicide a high risk if its label contains a special surface or groundwater advisory, for example, “This product has properties and characteristics associated with chemicals detected in groundwater” or “Under some conditions, this product may have a high potential for runoff into surface water.”

In addition, we consider the impact on birds and aquatic organisms. Similar to the human acute effect, herbicide risk to birds is expressed in terms of LD_{50} doses. A herbicide is considered a high risk to aquatic organisms when its reported LC_{50} value (lethal concentration of the material in water that would result in the death of 50 percent of a population of test species under stated conditions) is below 1 ppm (Whitford). Since a given herbicide does not affect all species at the same rate, the final risk level is assigned as the highest risk among all species for which information is reported.[2]

Finally, the herbicide application rate may affect the farmer’s perception of herbicide safety. Between two equally toxic herbicides, one that requires a higher application rate is considered a higher risk. In addition, it is possible that application rate affects the farmer’s perception of product effectiveness. We account for these possible impacts in the choice model by including the herbicide recommended label rate of application measured as the volume of herbicide active ingredients (AI) applied per acre, converted into pounds per acre.

Estimation Results

The herbicide choice model was estimated using the Multinomial Discrete Choice (MDC) procedure available in the SAS software package. Table 1 presents the summary statistics of the attributes of herbicide choices made by the farmers and expected impacts of the attributes on the choice probability. Estimation results (Table 2) show that, in addition to the production-related attributes, farmers considered herbicide human and environmental safety when making their product choices. The coefficient means on herbicide acute and chronic health risks, and surface water contamination potential are different from zero at standard levels of significance. The coefficient standard deviations also indicate that the farmers exhibit some random preference variations over the impact of herbicide application costs and grass weed effectiveness on herbicide choices.[3]

Valuation of the Changes in Herbicide Safety after RR Soybean Adoption

As mentioned previously, a ratio of the coefficient mean for each of the herbicide safety attributes to the coefficient mean on herbicide application costs represents farmers' WTP for a one-unit improvement in this safety attribute on per acre basis (Train). Estimated coefficients are also used to generate the standard errors of WTP estimates by the bootstrapping technique (Krinsky and Robb), in which the estimated parameter vector, $\hat{\beta}$, and the variance-covariance matrix, $\hat{\Sigma}$, are used to generate 1,000 random draws from a multivariate normal distribution with mean $\hat{\beta}$ and variance-covariance matrix $\hat{\Sigma}$. The resulting value estimates are presented in Table 3. The results indicate that the farmers were willing to pay $9.99 per acre per year to avoid high risk to chronic human health, $3.35 per acre per year to avoid a high risk of surface water pollution, and $0.004 per acre per year for a one-LD_{50} dose risk reduction to human health by acute exposure.

To estimate the impact of changed patterns of herbicide use on RR soybeans on farmers' welfare, we need to explore how adoption of RR soybeans affects herbicide safety (Table 3). To control for some possible spatial, temporal, and managerial variations in herbicide use patterns, we selected a subsample of survey responses consisting of 199 observations representing all participating farmers who were partial adopters of RR technology and planted both RR and conventional soybeans in 2001. Based on the results of the t-tests, this subsample is representative of the complete sample with respect to farmers' mean age, number of years as principal farm operator, education, yearly household income, farm acreage, and the percent of time spent in crop production. All original soybean growing states are represented.

Acute human health risk and bird toxicity from herbicides used in RR and conventional soybean production systems are calculated as the sum of LD_{50} doses of all herbicides used by a farmer on each soybean variety adjusted for the proportion of acreage treated by this herbicide and the number of applications, where higher values indicate higher risk. Chronic health risk, surface and groundwater risks, and aquatic toxicity are measured as a proportion of herbicides that are considered as high risk in each category that were applied by the farmer on each variety, also adjusted for the proportion of acreage treated by this herbicide and the number of herbicide applications. The results (Table 3) indicate that adoption of RR soybeans, on average, resulted in an on-farm herbicide risk reduction in all risk categories considered for our sample of farmers. The extent of risk reduction varies from 22 to 91 percent for different risk categories.[4]

Finally, we can calculate the impact of changed patterns of herbicide use on RR soybeans compared to conventional soybeans on the welfare of the farmers in the sample. The product of the average on-farm change in risk estimated for our sample of farmers and expressed in risk units per acre (LD_{50} doses or proportion of high risk herbicides) and farmers' valuation of the one-unit reduction in this risk is the value per acre per year farmers place on herbicide risk reduction associated with RR soybeans (Table 3). Presented values are calculated based on 1,000 drawings from a multivariate normal distribution with mean $\hat{\beta}$ and variance-covariance $\hat{\Sigma}$ of the herbicide choice model. The farmers are willing to pay $.50 per acre per year for the acute human risk reduction of herbicides due to RR soybean adoption, $.93 per acre for chronic human risk reduction, and $.33 per acre for surface water risk reduction. Even though the farmers also experienced reductions in other risks (groundwater risk, herbicide bird and aquatic toxicity), the results of the herbicide choice model indicate that reduction in these risks would not have a significant impact on the welfare of this sample of farmers.

The farmers who participated in the survey planted, on average, 467 acres of soybeans in 2001, out of which 59.5 percent of acres were planted to RR varieties. Given this, our previous value estimates would translate into a welfare gain of about $489 per farm per year due to reduced risk from the herbicides associated with RR soybeans ($139 in reduced acute health risk, $258 in reduced chronic health risk, and $92 in reduced surface water risk). Finally, the value of nation-wide benefits to the farmers from reduced risk of herbicides used on RR soybeans, which were planted on 51.3 million acres in 2001 (U.S. Department of Agriculture) is estimated to have been about $90.3 million, out of which $25.6 million is due to improved acute human safety, $47.7 million due to improved chronic health, and $16.9 million due to reduced risk to surface water.

Conclusions

This paper develops a methodology for the assessment of the welfare gains to farmers associated with alternative pesticide management policies. Improvement on previous methods developing non-market valuation methods for pesticide risk changes was achieved by relying on revealed preference information resulting in improved reliability of value estimates relative to estimates obtained from previous methods which were based on stated preference information. We rely on revealed preference information while assuming that the farmers reveal the values they place on different aspects of pesticide safety by selecting a specific pesticide product out of the set of available product alternatives based on their attributes, which include not only pesticide costs and effectiveness, but also human and environmental safety. Our method presents a flexible framework allowing considering various human health and environmental risks of pesticides in the analysis capturing complex multidimensional nature of pesticide impacts.

The specific application of this method is to evaluate the impact of changed patterns of herbicide use on RR soybeans on the welfare of the U.S. soybean farmers. In our analysis, the farmer associated positive values with reduced herbicide risk to human health, as well as with reduced risk of surface water pollution. Because RR soybean adoption, on average, results in on-farm reduction in these risks, we expect some positive impact on the welfare of the farmers. The aggregate impact on the welfare of U.S. soybean farmers was estimated to have been a little over $90 million in 2001 alone.

The proposed methodology can be applied for the assessment of the impact of any new policy introducing alternative pesticide management procedures which may affect pesticide safety. When such policies are introduced, it is essential to evaluate the changes in the social welfare resulting from the changes in pesticide human and environmental risks associated with these policies in addition to evaluation of their direct economic impact. Without such an input, the policy assessments could suffer from serious biases and result in erroneous conclusions.

Footnotes

[1] The survey did not contain information on the specific weeds the farmers were trying to control. The true herbicide effectiveness measure depends on weed populations particular to the location. Therefore, our average effectiveness measures are only proxies for the true measure.

[2] Some of the previous risk evaluation studies also considered pesticide risk to beneficial arthropods and non-target insects. Since the risk to insects from all herbicides included in our choice set was very low, this risk category was not considered in our analysis.

[3] Our data did not allow controlling for possible variations in some farmer and farm characteristics that may affect herbicide product choice. Therefore, we assume that the coefficients of the random components in the mixed logit estimation results capture some of the effects of these unobservable characteristics.

[4] Some weed resistance to *glyphosate*, which is the main component of Roundup, was found in few small areas in the U.S. indicating that there could have been an increase in risk on RR soybeans since 2001 from possible additional applications of Roundup. However, our data do not allow us to consider it in the analysis, and the empirical risk reduction results using our data may be somewhat overstated compared to what they might be today.

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Table 1. Summary Statistics of the Attributes of Herbicides Choices and Expected Impact of the Attributes on the Probability of Herbicide Choice by a Farmer (N=1,769)

Herbicide Attribute	Expected Impact[a]	Mean	Standard Deviation
Grass Weed Efficiency (%)	+	67.16	28.52
Broadleaf Weed Efficiency (%)	+	61.46	25.78
Herbicide Application Costs ($/acre)	-	15.13	5.17
Application Rate (lbs of AI/acre)	+/-	0.72	0.55
Acute Health Risk by Ingestion (LD_{50} dozes)	-	244.78	392.46
Chronic Health Risk (dummy, 1 if high risk)	-	0.10	0.30
Surface Water Risk (dummy, 1 if high risk)	-	0.12	0.32
Groundwater Risk (dummy, 1 if high risk)	-	0.33	0.47
Bird Toxicity (LD_{50} dozes)	-	202.97	317.17
Aquatic Toxicity (dummy, 1 if high risk)	-	0.43	0.50

[a] "+" ("-") indicate that the higher value of the herbicide attribute would increase (decrease) the probability that the herbicide is chosen.

Table 2. Mixed Logit Estimation Results of the Herbicide Choice Model (N=1,769)

Herbicide Attribute	Coefficient Mean[a]	Coefficient Standard Deviation
Grass Weed Efficiency (%)	0.026*** *(0.003)*	0.038*** *(0.004)*
Broadleaf Weed Efficiency (%)	0.012*** *(0.002)*	0.009 *(0.013)*
Herbicide Application Costs ($/acre)	-0.129*** *(0.010)*	0.138*** *(0.019)*
Application Rate (lbs of AI/acre)	0.815*** *(0.072)*	0.079 *(0.651)*
Acute Health Risk by Ingestion (LD_{50} dozes)	-0.001*** *(0.000)*	0.000 *(0.000)*
Chronic Health Risk (dummy, 1 if high risk)	-1.270*** *(0.112)*	0.067 *(0.644)*
Surface Water Risk (dummy, 1 if high risk)	-0.426*** *(0.103)*	0.058 *(0.734)*
Groundwater Risk (dummy, 1 if high risk)	-0.022 *(0.088)*	0.011 *(0.586)*
Bird Toxicity (LD_{50} dozes)	-0.001 *(0.000)*	0.000 *(0.000)*
Aquatic Toxicity (dummy, 1 if high risk)	0.069 *(0.104)*	0.732 *(0.703)*
Log-Likelihood Value	-5,931	

[a] Asterisks (***) indicate coefficients significantly different from zero at α=0.01. The first number is the coefficient and the number in parentheses, its standard error.

Table 3. Herbicide Risk by Category on Conventional and RR Soybeans and On-Farm Risk Change on RR Soybeans, and Farmers' WTP for Herbicide Risk Reduction on RR Soybeans in 2001

	Acute Health Risk	Chronic Health Risk	Surface Water Risk	Groundwater Risk	Bird Toxicity	Aquatic Toxicity
Herbicide Risk Estimates[a]						
RR Soybeans (risk units/acre)	367.65	0.01	0.06	0.09	318.03	0.13
	(684.66)	*(0.07)*	*(0.18)*	*(0.21)*	*(547.01)*	*(0.25)*
Conventional Soybeans (risk units/acre)	496.14	0.11	0.16	0.40	406.49	0.53
	(827.82)	*(0.23)*	*(0.37)*	*(0.46)*	*(689.45)*	*(0.77)*
On-Farm Change in Risk (risk units/acre)[b]	-128.49**	-0.09***	-0.10***	-0.31***	-88.46*	-0.40***
	(801.35)	*(1.23)*	*(0.38)*	*(0.47)*	*(666.12)*	*(0.77)*
On-Farm Reduction in Risk (%)	25.90	90.91	62.50	77.50	21.76	75.47
Value of Herbicide Risk ($/risk unit)[c]	0.01***	9.99***	3.35***	NS	NS	NS
	(0.00)	*(1.20)*	*(0.87)*			
Value of Risk Change on RR Soybeans ($/acre)	0.50***	0.93***	0.33***	-	-	-
	(3.14)	*(2.31)*	*(1.30)*			

[a] Average risk estimates are calculated for 199 farms where both conventional and RR soybeans were grown in 2001. The first number is the mean and the number in parentheses, its standard deviation.

[b] Asterisks (***, **, and *) indicate a number significantly different from zero at $\alpha=0.01$, $\alpha=0.05$, and $\alpha=0.1$, correspondingly.

[c] Risk value estimates are calculated based on 1,000 drawings from a multivariate normal distribution with mean $\hat{\beta}$ and variance-covariance $\hat{\Sigma}$.

The estimated pattern of change in herbicide use over time is consistent with the emergence of glyphosate weed resistance. Keywords. Agriculture economics.Â Data on pesticide use and GE crop adoption in U.S. soybeans and maize are shown in Fig. 1 . For maize, the share of varieties containing the GT trait (whether alone or stacked with IR traits) is reported separately from the share of varieties embedding one or more IR traits (henceforth Bt maize) (Fig. 1A).Â A clear result that emerges from our analysis is the change in differential herbicide use by GT adopters relative to non-GT adopters over time. What are the sources of such significant and persistent upward trends? The broad-spectrum herbicide glyphosate (common trade name â€œRoundupâ€) was first sold to farmers in 1974. Since the late 1970s, the volume of glyphosate-based herbicides (GBHs) applied has increased approximately 100-fold.Â We highlight changes in the scope and magnitude of risks to humans and the environment stemming from applications of glyphosate-based herbicides (GBHs).Â However, from an analysis of their assessment, it is difficult to understand the basis on which the German regulators are making this recommendation, since they still rely on the same proprietary, industry-supplied dataset that led to setting a lower ADI (0.3 mg/kg/day) in 2002. A newly published scientific consensus statement on Roundup herbicide reveals exposure to this ubiquitous toxicant is increasing and valid research proving it safe is still nowhere to be found.Â The study also identified a key regulatory problem associated with increased glyphosate exposure: â€œTo accommodate changes in GBH [glyphosate based herbicide] use patterns associated with genetically engineered, herbicide-tolerant crops, regulators have dramatically increased tolerance levels in maize, oilseed (soybeans and canola), and alfalfa crops and related livestock feeds.â€ Roundup Ready Crops (RR Crops) are genetically engineered crops that have had their DNA altered to allow them to withstand the herbicide glyphosate (the active ingredient of Monsanto's herbicide Roundup). They are also known as "glyphosate tolerant crops." RR crops deregulated in the U.S. include: corn, soybeans, canola, cotton, sugarbeets, and alfalfa. When planting Glyphosate Tolerant crops, a farmer can spray the entire crop with glyphosate, killing only the weeds and leaving the crop alive