

Economics of Pesticide Regulation on Sorghum Production in the U.S. and Texas

Eduardo Segarra*

Department of Agricultural Economics, Texas Tech University, and the Texas Agricultural Experiment Station, Lubbock, TX 79401.

Cris Gwinn

William P. Morrison

John R. Abernathy

Texas Agricultural Experiment Station, Lubbock, TX 79401.

ABSTRACT

Using a national pesticide use survey in sorghum production, a market framework was used to derive the short-run welfare impacts to consumers, and producers (users and non-users) of the removal of pesticides registered for use on sorghum. It was projected that the loss of atrazine would have the largest overall impact, with an estimated loss of \$266 million. Users of atrazine in the U.S. would be expected to lose \$122 million with users of atrazine in Texas losing \$42 million.

KEYWORDS: consumer impacts, producer (user and non-user) impacts, NAPIAP

Grain sorghum is an important crop to U.S. agricultural producers. This crop is generally cultivated in areas that are too dry or too hot for successful corn production (Bennett et al., 1990). Advancements in the chemical industry, tillage practices, and hybrid seed production have played a vital role in the development of sorghum as a major cereal crop in U.S. agriculture. Three areas of concern affecting yields are weeds, insects and diseases. Potential annual yield loss due to these pests is great and their control is important to the economic success of producers. Control or suppression is obtained by efficient use of technological advances. Good cultural practices, including proper selection of hybrids and judicious pesticide use, provides maximum yield potential for producers.

Programs such as the National Agriculture Pesticide Impact Assessment Program (NAPIAP) of the U.S. Department of Agriculture (USDA) have been developed to assess and inform regulatory agencies of the biologic and economic impacts of pesticide use in agriculture. Numerous studies have been and continue to be conducted on chemical use and alternatives in agriculture. Assessments such as the Biologic and Economic Assessment of Ethyl Parathion (USDA, 1989a), Oxydemeton-Methyl (Mayo, 1990), Carbofuran (USDA, 1989b), Chlorpyrifos (Rice, in press), and Phorate and Terbufos (Knutson, 1990) show the impacts of these chemicals to the producer and the environment as well as to the consumers of agricultural commodities.

Accepted 26 May 1994. Funding was provided by the National Agricultural Pesticide Impact Assessment Program of the USDA project number 92-EPIX-1-0100 entitled "Biologic and Economic Assessment of Pesticide Use in Grain Sorghum." *Corresponding author.

The Biologic and Economic Assessment of Oxydemeton-Methyl (Mayo, 1990) showed that use of this insecticide in sorghum was minimal. Registered on sorghum for the control of greenbugs, corn leaf aphid, yellow sugarcane aphid, and Banks grass mites, oxydemeton-methyl cost appears to be the main deterrent for its use. Alternative insecticides were generally considered to be equally effective as oxydemeton-methyl while the cost of this insecticide was 45 to 55% greater than other registered products.

Phorate is labeled on sorghum for the control of greenbugs, chinch bug, and Banks grass mites. Terbufos provides control of southern corn rootworms, wireworms, white grubs, nematodes, and early season greenbugs in sorghum. The Biologic and Economic Assessment of Phorate and Terbufos estimated that sorghum yields would be reduced 0 to 10% on a state-by-state basis should phorate and/or terbufos use be cancelled (Knutson, 1990). Carbofuran and terbufos could be substituted for phorate and the cancellation of terbufos would increase the use of carbofuran, chlorpyrifos, and phorate. Carbofuran was found to be the primary alternative insecticide used by sorghum producers should the registrations of terbufos and phorate be cancelled.

Carbofuran is a vital tool in the control of chinch bug. Kansas, Nebraska, Texas, Mississippi, Louisiana and Oklahoma are the primary users of carbofuran for chinch bug control. Central Texas and Kansas sorghum growers rely heavily on granular carbofuran and report that alternate compounds either are not effective for chinch bug control or are too expensive (USDA, 1989b). The granular carbofuran label was phased-down because of its toxicity to birds although no documented bird kill incidents from grain sorghum use have occurred (Brooks, 1992). The National Grain Sorghum Producers Association recommended that granular carbofuran be retained for use on sorghum in key states of Kansas, Nebraska, Texas, and Oklahoma. The Environmental Protection Agency (EPA) is presently examining the risk versus benefits of its use on sorghum.

Ethyl parathion has been used to control sorghum insects since the 1950s (USDA, 1989a). Methyl parathion is not used on sorghum because it is phytotoxic to most hybrids. Ethyl parathion remains an important compound for control of greenbugs and occasional pests. In the 1970s, Texas reported insecticide resistance in greenbugs to dimethoate and disulfoton (USDA, 1989a). Other alternatives to parathion, such as chlorpyrifos, provide control of greenbugs but are often more expensive.

Chlorpyrifos is registered for use on sorghum to control both below-surface and above-surface insects. Research has shown that chlorpyrifos is one of the most effective insecticides against sorghum pests, but opinions expressed by NAPIAP survey respondents suggest that cancellation of this product would have minimal overall impact on future yields (Rice, in press). Alternatives available for chlorpyrifos include: carbofuran, parathion, dimethoate, carbaryl, and terbufos depending on the targeted pest. Greater expense, shorter residual control, greater human toxicity, and less effectiveness were listed as the greatest constraints of the alternatives of chlorpyrifos by the survey respondents.

These studies and others currently being conducted under NAPIAP, represent a good effort to disentangle the horizontal relationships with respect to the use of a particular pesticide across several crops. That is, most often an assessment examines a specific active ingredient and its uses on all agricultural enterprises. This study examines the use patterns of all herbicides and insecticides on sorghum. Seed treatment, fungicide and post-harvest storage pesticide uses were not included. In

particular, the objective of this study was to derive the short-run welfare impacts to consumers, and producers (users and non-users) of the removal of pesticides registered for use on grain sorghum production.

METHODS AND PROCEDURES

With a more environmentally conscious society, a popular approach followed by EPA has been the suspension or cancellation of registered pesticide use in agriculture (Ferguson et al., 1992; and Zilberman et al., 1991). The removal of a pesticide from the market affects the quality of the environment and reduces the associated human health risk while altering the production cost and supply available to the market (Knutson et al., 1990). However, in the decision-making process, policy makers need to consider not only the environmental impacts stemming from the suspension or cancellation of a registered pesticide, but also the associated economic impacts to consumers, and users and non-users of the pesticide.

As Lichtenberg et al. (1988) and Ferguson et al. (1992) showed, the short-run welfare impacts of the removal of a pesticide can be calculated by finding the changes in economic surpluses. Ferguson et al. (1992) developed a market model to estimate the short-run welfare impacts of a pesticide ban. This model was the framework used in this study to derive the short-run welfare impacts of the removal of pesticides registered for use on grain sorghum production, and it takes the following form:

$$D = D(P) \quad (1)$$

$$S^u = y^u A^u \quad (2)$$

$$S^n = y^n A^n \quad (3)$$

$$D = S^u + S^n \quad (4)$$

where D equals the quantity of crop demanded, P equals the crop price, S^u equals the quantity of crop supplied by pesticide users, y^u equals the crop yield per acre among pesticide users, A^u equals the crop acreage of pesticide users, S^n equals the quantity of crop supplied by pesticide non-users, y^n equals the crop yield per acre among pesticide non-users, and A^n equals the crop acreage of pesticide non-users. At equilibrium, crop price, quantity demanded, and quantity supplied by pesticide users and non-user are expressed as P_0 , D_0 , S_0^u , and S_0^n , respectively.

Given an initial sorghum demand function (D) and an initial sorghum supply function ($S_0^T = S_0^u + S_0^n$), the welfare implications on consumers and producers of the equilibrium price (P_0) and equilibrium quantity (D_0) are illustrated in Figure 1. Given the equilibrium price and the equilibrium quantity, the consumers' welfare measure (or consumers' surplus) is defined as the area above the equilibrium price and below the demand curve (area $A+B+C+D$ in Figure 1). The producers' welfare (or producers' surplus) is defined as the area below the equilibrium price and above the supply curve (area $E+F+G$ in Figure 1). The sum of these two areas ($A+B+C+D+E+F+G$) represents the overall welfare measure.

As a result of a pesticide ban, pesticide users' crop yield per acre changes to y_1^u , while production cost per acre changes from C_0^u to C_1^u . This is represented in Figure 1 by the shift of the supply function from S_0^T to S_1^T . In this study, it was assumed that no alternative was selected, thus the change in cost is equal to the reduction in cost due to not using the pesticide. Also, pesticide non-users yield per acre, y^n , and production cost per acre, C^n , were assumed to remain the same. Given these assumptions, the estimated short-run welfare impacts represent an upper bound of the impacts. At equilibrium after the pesticide ban, crop price, quantity demanded, and quantity supplied by pesticide users and non-users are expressed as P_1 , D_1 , S_1^u , and S_1^n , respectively.

As shown in Figure 1, given this new equilibrium, the consumers' welfare is represented by area A and the producers' welfare is represented by the area B+E. Thus, as a result of the pesticide ban, the overall reduction of welfare to both consumers and producers equals area C+D+F+G in Figure 1. The consumers' welfare loss equals area B+C+D. It is important to note, however, that area B represents a transfer to producers from consumers, and that the loss to producers will be dependent on the relative magnitudes of areas B and F+G. If area B > F+G the ban would represent a gain to producers, but if B < F+G the ban would represent a loss to producers. Furthermore, because not all sorghum producers are users of the banned pesticide, it is important to evaluate what the distributional impacts of this ban would be on both, users and non-users of the pesticide in question. Non-users of the banned pesticide will not be negatively affected by the ban, and in fact they will benefit from it, because of an increase in the price of sorghum. Users of the pesticide being banned will be affected negatively if the impact on the reduction of yields is stronger than the price effect. If the increase in price of sorghum is strong enough, users of the pesticide being banned could benefit.

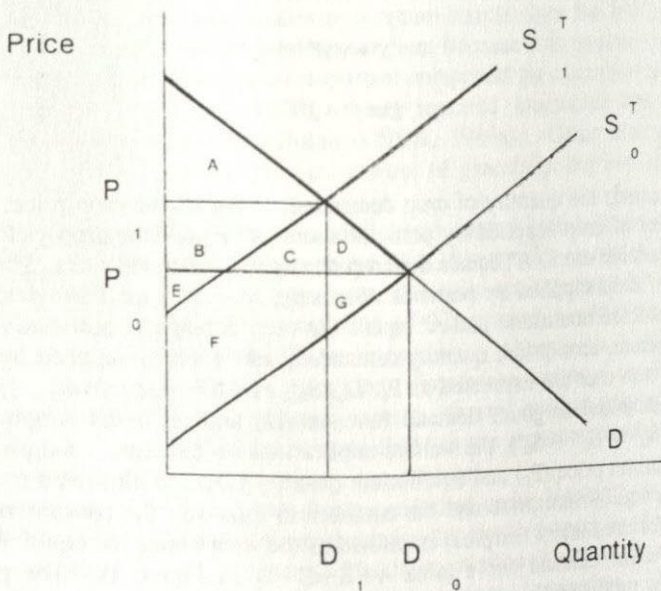


Figure 1. Illustration of the short-run welfare impacts of a pesticide ban.

Given the model above, the consumer, I^c , pesticide users, I^u , and non-users, I^n , short-run welfare impacts were estimated as follows:

$$F = -(P_1 - P_0)D_1 + .5(P_1 - P_0)(D_0 - D_1) \quad (1)$$

$$I^u = [P_1 y_1^u - P_0 y_0^u]A^u + (C_0^u - C_1^u)A^u \quad (2)$$

$$I^n = [P_1 - P_0]y^n A^n \quad (3)$$

Through a pesticide usage survey conducted in 1993 for the crop year 1992, yields per acre, per acre rates, percent of acres treated with a pesticide, and perceived yield loss due to the cancellation of pesticides were obtained from respondents. The number of sorghum acres planted for 1992 was obtained from the USDA Agricultural Statistics (USDA, 1992a). The cost per pound of active ingredient of the pesticides were obtained from Agricultural Resources: Inputs Situation and Outlook Report (USDA, 1992b). The application cost per acre was obtained using Texas Custom Rates Statistics (Texas Agricultural Statistics Service, 1992). This information was applied to the above market model to estimate the economic impact of ban of a given pesticide. Also, the Food and Agricultural Policy Research Institute (FAPRI) national sorghum demand model was used to estimate the change in P_0 , crop price at equilibrium before a pesticide ban, and P_1 , crop price at equilibrium after a pesticide ban (Adams, 1992).

Survey respondents were asked to provide the top three herbicides and insecticides in their sorghum operations. Along with the top three herbicides and insecticides, respondents provided their perceived yield loss, if the respective chemical was no longer available for sorghum production and the mean of the perceived yield loss was calculated. These perceived yield losses should be considered the upper bound because no alternatives were taken into consideration. It is likely that an alternative pesticide or another means of control could be used instead of the cancelled product. However, due to the lack of information with respect to both the product that could be used and the impact on yields, for this study, three yield losses were used in estimating the economic impacts of a pesticide ban.

The first yield reduction used the mean of the perceived yield loss as reported by the survey respondents. In the second reduction, the mean perceived yield loss was reduced by one-third. The third used a two-thirds reduction of the original perceived yield loss.

After the percentage of yield loss due to the cancellation of a product was established, it was applied to three groups of sorghum yields. The first yield per acre figure used came from the elicited yield per acre of the survey respondents. Survey respondents were asked to provide their 1992 yield per acre for their irrigated and/or non-irrigated fields. Their responses were averaged for both irrigated and non-irrigated categories. Survey respondents' yields per acre for irrigated and non-irrigated were 11 to 31 percent, respectively, higher than the average USDA yield for 1992. The second yield used was the 1992 actual yield per acre for irrigated and non-irrigated farms in Kansas, Nebraska, Texas, and other states as reported by the USDA. Since all other sorghum producing states were grouped together for the purpose of this study, other states yield per acre was estimated by dividing total production of the other states by total acres harvested as

reported by the USDA Agricultural Statistics (USDA, 1992a).

The third yield per acre figure used was also elicited from surveyed respondents. Respondents were asked to provide their expected lowest, mostly likely, and highest yield per acre. The mean of these responses (implicitly assuming a triangular probability density function of sorghum yields) can be considered as an estimate of the long-term expected average yield per acre. These calculated long-term yields per acre for irrigated and non-irrigated crops were 6% lower to 29% higher than the average USDA yields for 1992.

Given the three perceived yield losses and the three yield levels used, a total of nine possible scenarios were analyzed in deriving the short-run welfare impacts of the removal of registered pesticides in the production of sorghum. Scenario 1 depicts the short-run welfare impacts by using the survey yields reduced by the full perceived yield loss. Scenario 2 used the USDA yields reduced by the full perceived yield loss. Scenario 3 used the long-term yields reduced by the full perceived yield loss.

In Scenarios 4 to 6, the same survey, USDA, and long-term yields were used, but the perceived yield loss was set at two-thirds of the full perceived loss (medium level of yield loss). In Scenarios 7 to 9, the perceived yield loss was reduced to one-third of the full perceived yield loss (low level of yield loss).

RESULTS

The economic impact of the loss of a pesticide depends upon the percent of acres treated and the expected yield loss due to the absence of the chemical. As pointed out above, in this study no pesticide alternatives were taken into consideration; thus, the resulting impact represents an upper bound estimate of the impact.

Tables 1 to 3 present the economic impacts to consumers, users and non-users of banning herbicides or insecticides in sorghum production in the U.S. Tables 4 to 6 present the economic impacts to user and non-users of banning herbicides or insecticides in sorghum production in Texas. Table 1 shows the impacts on consumers, users, non-users, and the overall impact of the ban of a select group of herbicides and insecticides under Scenarios 1 to 3. The loss of atrazine, the most widely used pesticide in sorghum production, would be expected to have the largest overall impact under the survey, USDA, and long term yields with an overall estimated loss of \$266, \$217, and \$233 million, respectively. The loss to consumers due to the absence of atrazine was estimated to be \$443, \$269, and \$316 million under the survey, USDA, and long term yields, respectively. These losses would be expected to result due to the increase in the price of sorghum.

The loss to users of atrazine was expected to be \$122 million under the survey yields, and \$130 million under the USDA and long term yields. Non-users of atrazine would be expected to gain \$299, \$181, and \$213 million under the survey, USDA, and long term yield scenarios, respectively.

In evaluating the results in Tables 1 to 3 with respect to the banning of insecticides, it should be noted that the use and the value of using insecticides vary greatly from year to year, due to the outbreak of different pests. The lack of the proper insecticide to control selected pests during severe outbreaks could be devastating to producers and could result in greater than the estimated losses in Tables 1 to 3. Taking this into consideration, the loss of esfenvalerate showed the

Table 1. Short-run welfare impacts of eliminating pesticides registered for use on sorghum in the US, assuming the full reduction of elicited perceived yield loss, 1992.

	Full reduction of survey yields			Full reduction of USDA yields			Full reduction of long-term yields				
	Consumer	User	Total	Consumer	User	Total	Consumer	User	Total		
	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000		
Herbicides											
Atrazine	-443015	-121935	298797	-266730	-129689	181451	-216968	-315732	-129962	212574	-233120
2,4-D	-97104	-41420	86968	-59302	-37311	53007	-43606	-68826	-38584	61618	-45791
Metolachlor	-110875	-38055	101562	-87629	-32294	61918	-38007	-78277	-33846	71772	-40350
Glyphosate	-58625	-24420	55361	-36145	-21229	34115	-23258	-40774	-21396	38527	-23643
Metolachlor+Atrazine	-57847	-23268	55676	-35600	-19666	34248	-21018	-40141	-19910	38668	-21383
Alachlor	-56327	-23184	54456	-34625	-19558	33462	-20721	-39261	-19966	37982	-21245
Bromoxynil	-23059	-9191	22403	-14305	-7812	13889	-8228	-15795	-7685	15364	-8116
Dicamba	-16156	-7709	15920	-9881	-6553	9736	-6697	-11400	-6625	11233	-6991
Alachlor+Atrazine	-16215	-5919	15964	-9918	-4764	9764	-4918	-11383	-4992	11207	-5168
Cyanazine	-6506	-2709	6447	-4063	-2302	4026	-2339	-4391	-2196	4352	-2235
Insecticides											
Esfenvalerate	-30727	-16698	30303	-17989	-13800	17750	-14039	-23047	-15995	22711	-16331
Carbofuran	-34550	-15106	33750	-20870	-12502	20374	-12996	-24791	-13563	24202	-14172
Chlorpyrifos	-25168	-12197	24792	-14934	-10009	14716	-10227	-18556	-11397	18269	-11684
Terbufos	-23422	-10508	23043	-13744	-8361	13529	-8576	-17501	-9941	17204	-10238
Parathion	-19763	-9978	19510	-11885	-8378	11734	-8530	-14277	-9128	14092	-9313
Disulfoton	-1360	-676	1359	-796	-543	795	-544	-1020	-642	1019	-644

Table 2. Short-run welfare impacts of eliminating pesticides registered for use on sorghum in the US, assuming the elicited yield loss at 2/3 of the original value, 1992.

	Medium reduction of survey yields			Medium reduction of USDA yields			Medium reduction of long-term yields		
	Consumer	User	Total	Consumer	User	Total	Consumer	User	Total
	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000
Herbicides									
Atrazine	-301660	-55510	-157971	-182977	-65863	-120967	-215005	-64459	-137748
2,4-D	-65011	-24597	-31697	-39703	-22071	35338	-46078	-22868	-27867
Metolachlor	-74276	-17854	-24423	-45306	-14293	41277	-52437	-15263	-19852
Glyphosate	-39182	-13584	-15859	-24158	-11531	22744	-27250	-11632	-13197
Metolachlor+Atrazine	-38662	-12232	-13776	-23793	-9904	22832	-26826	-10056	-25779
Alachlor	-37643	-12368	-13707	-23141	-10020	22308	-26237	-10280	-11103
Bromoxynil	-15388	-4824	-14936	-9546	-3916	9260	-10540	-3830	-4127
Dicamba	-10778	-4589	-4754	-6592	-3824	6490	-7605	-4004	-4120
Alachlor+Atrazine	-10818	-2792	-2967	-6616	-2028	6509	-7594	-2179	-2301
Cyanazine	-4339	-1448	-1488	-2710	-1178	2684	-2928	-1107	-1134
Insecticides									
Esfenvalerate	-20512	-10699	-11010	-12008	-8791	11833	-15386	-10242	-10487
Carbofuran	-23068	-8459	-9040	-13934	-6750	13583	-16552	-7462	-7880
Chlorpyrifos	-16797	-7311	-7580	-9987	-5867	9811	-12385	-6786	-6991
Terbufos	-15630	-5976	-6244	-9172	-4558	9019	-11680	-5604	-5815
Parathion	-13186	-6140	-6320	-7930	-5083	7823	-9527	-5579	-5711
Disulfoton	-907	-410	-411	-531	-321	530	-680	-367	-360

Table 3. Short-run welfare impacts of eliminating pesticides registered for use on sorghum in the US, assuming the elicited yield loss at 1/3 of the original value, 1992.

	Low reduction of survey yields				Low reduction of USDA yields				Low reduction of long-term yields			
	Consumer		User		Consumer		User		Consumer		User	
	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000	x1000
Herbicides												
Atrazine	-153988	-1716	99599	-56105	-93400	-9286	60484	-42203	-109761	-7991	70858	-46894
2,4-D	-32643	-8325	28956	-12012	-19936	-7167	17669	-9434	-23136	-7540	20539	-10137
Metolachlor	-37318	1627	33854	-1837	-22763	3268	20639	1144	-26344	2815	23924	395
Glyphosate	-19641	-2947	18454	-4134	-12110	-1957	11372	-2696	-13659	-2002	12842	-2819
Metolachlor+Atrazine	-18379	-1389	18559	-2209	-11927	-261	11416	-772	-13446	-332	12889	-888
Alachlor	-18867	-1735	18152	-2450	-11599	-595	11154	-1040	-13150	-720	12661	-1209
Bromoxynil	-7701	-487	7468	-721	-4778	-39	4630	-187	-5275	4	5121	-149
Dicamba	-5393	-1484	5307	-1570	-3298	-1104	3245	-1157	-3805	-1194	3744	-1254
Alachlor+Atrazine	-5413	320	5321	229	-3311	699	3255	643	-3800	624	3736	560
Cyanazine	-2170	-190	2149	-210	-1355	-55	1342	-68	-1464	-20	1451	-33
Insecticides												
Esfenvalerate	-10270	-4755	10101	-4923	-6012	-3812	5917	-3907	-7704	-4531	7570	-4685
Carbofuran	-11551	-1880	11243	-2187	-6977	-1039	6791	-1225	-8289	-1391	8067	-1612
Chlorpyrifos	-8407	-2461	8264	-2604	-4989	-1747	4905	-1850	-6199	-2203	6090	-2312
Terbufos	-7823	-1475	7681	-1617	-4590	-772	4510	-853	-5846	-1292	5735	-1404
Parathion	-6599	-2325	6503	-2420	-3968	-1801	3911	-1856	-4767	-2047	4697	-2117
Disulfoton	-453	-143	453	-144	-265	-99	265	-99	-340	-132	340	-133

largest overall impact using the survey yields with a loss of \$17 million. Consumer and user losses were expected to be \$31 and \$17 million, respectively, with non-users gaining \$30 million under the survey yields scenario. It should be noted that in 1992 esfenvalerate was used predominately by sorghum producers in Texas, whose production of sorghum was up because some, otherwise cotton and/or corn producers, lost their cotton and/or corn crops in 1992.

Under the USDA and long term yield scenarios, esfenvalerate was also found to be the insecticide with the largest associated impact if cancelled. The overall loss in the absence of esfenvalerate was estimated to be \$14 and \$16 million under the USDA and long term yield levels, respectively. Carbofuran, showed the second largest impact for an insecticide under the survey, USDA, and long term yield levels with estimated total losses of \$16, \$13, and \$14 million, respectively.

Table 2 presents the welfare impacts under the survey, USDA, and long term yield levels with the medium reduction of yields. As expected, the overall estimated impacts are lower under these three scenarios, with the order of the impacts remaining basically the same as the previous three scenarios. Under this yield reduction scenario, the cancellation of atrazine would result in an estimated net loss of \$158, \$128, and \$138 million under the survey, USDA, and long term yield levels, respectively. In these three scenarios, the absence of esfenvalerate was again found to have the largest expected losses for an insecticide with \$11, \$9, and \$10.5 million under the survey, USDA, and long term yields levels, respectively.

The economic impacts presented in Table 3 shows the expected losses assuming the low reduction of yield for the survey, USDA, and long term yields levels. There were few changes in the ranking of the impacts. A ban of atrazine would still be expected to cause an overall loss of \$56, \$42, and \$47 million across yield levels. Esfenvalerate remained the insecticide with the greatest expected loss at \$5, \$4, and \$5 million across yield levels.

The economic impact figures presented above are important in evaluating the overall impacts due to the elimination of selected pesticides registered for use on sorghum production in the U.S. However, it is important to find out what these results mean to important sorghum producing states, Texas in particular. For this reason, in Tables 4 to 6 the impacts to users and non-users of pesticides on sorghum production in Texas are presented.

The economic impacts to users and non-users of pesticides on sorghum production in Texas (Tables 4 to 6), show that when comparing the U.S. figures (Tables 1 to 3) to Texas figures, if pesticides are banned on sorghum production, users (non-users) of herbicides in Texas would tend to bear (capture) roughly a third of the losses (gains). Notice that when looking at the insecticides figures, the users' losses are proportionally higher, and the non-users' gains are proportionally lower. This points to the fact that insecticide availability in Texas seems to be more important than in the rest of the U.S. However, it should be pointed out that although herbicide availability may not be as important in Texas as it is in other sorghum producing states, their economic value on sorghum production in Texas is very significant and in many instances greater than the economic value of insecticides.

Table 4. Short-run welfare user and non-user (\$) impacts due to the elimination of selected pesticides registered for use on sorghum in Texas, assuming the full reduction of elicited perceived yield loss, 1992.

	Full reduction of survey yields		Full reduction of USDA yields		Full reduction of long-term yields	
	User x1000	Non-user x1000	User x1000	Non-user x1000	User x1000	Non-user x1000
<u>Herbicides</u>						
Atrazine	-42268	89988	-43482	52578	-48800	67730
2.4-D	-4428	31064	-3773	18276	-4398	23247
Metolachlor	-12919	33779	-10288	19849	-12567	25177
Glyphosate	-1663	18983	-1316	11276	-1626	13938
Metolachlor + Atrazine	-3795	18666	-3025	11067	-3651	13674
Alachlor	-3770	18248	-3007	10807	-3614	13428
Bromoxynil	-457	7553	-349	4514	-434	5463
Dicamba	-1454	5247	-1142	3091	-1382	3909
Alachlor + Atrazine	-1290	5262	-1008	3100	-1227	3900
Cyanazine	335	2118	328	1274	330	1509
<u>Insecticides</u>						
Esfenvalerate	-16698	9570	-13800	5396	-15995	7580
Carbofuran	-7363	11012	-5868	6408	-7015	8344
Chlorpyrifos	-8661	7969	-6968	4555	-8255	6205
Terufos	-10129	7280	-8031	4115	-9628	5744
Parathion	-4425	6385	-3595	3699	-4224	4871
Disulfoton	-682	445	-549	251	-649	352

Table 5. Short-run welfare user and non-user (\$) impacts due to the elimination of selected pesticides registered for use on sorghum in Texas, assuming the elicited yield loss at 2/3 of the original value, 1992.

	Medium reduction of survey yields		Medium reduction of USDA yields		Medium reduction of long-term yields	
	User x1000	Non-user x1000	User x1000	Non-user x1000	User x1000	Non-user x1000
<u>Herbicides</u>						
Atrazine	-18352	59992	-21087	35052	-23852	45153
2.4-D	-2614	20709	-2201	12184	-2609	15498
Metolachlor	-6421	22519	-4760	13233	-6244	16785
Glyphosate	-805	12655	-581	7517	-785	9292
Metolachlor + Atrazine	-2080	12444	-1579	7378	-1993	9116
Alachlor	-2108	12166	-1611	7205	-2012	8952
Bromoxynil	-229	5036	-157	3010	-214	3642
Dicamba	-805	3498	-599	2061	-758	2606
Alachlor + Atrazine	-699	3508	-512	2067	-658	2600
Cyanazine	329	1412	325	850	326	1006
<u>Insecticides</u>						
Esfenvalerate	-10699	6380	-8791	3598	-10242	5054
Carbofuran	-4237	7342	-3254	4272	-4013	5562
Chlorpyrifos	-5157	5313	-4039	3037	-4892	4136
Terufos	-5760	4853	-4375	2743	-5433	3830
Parathion	-2726	4257	-2177	2466	-2594	3247
Disulfoton	-416	296	-327	167	-393	235

Table 6. Short-run welfare user and non-user (\$) impacts due to the elimination of selected pesticides registered for use on sorghum in Texas, assuming the elicited yield loss at 1/3 of the original value, 1992.

	Low reduction of survey yields		Low reduction of USDA yields		Low reduction of long-term yields	
	User x1000	Non-user x1000	User x1000	Non-user x1000	User x1000	Non-user x1000
<u>Herbicides</u>						
Atrazine	-933	29996	-1397	17526	-2390	22577
2,4-D	-858	10355	-664	6092	-863	7749
Metolachlor	-150	11260	-633	6616	-91	8392
Glyphosate	-36	6328	-145	3759	-44	4646
Metolachlor + Atrazine	-396	6222	-152	3689	-356	4558
Alachlor	-475	6083	-232	3602	-431	4476
Bromoxynil	-2	2518	-34	1505	-5	1821
Dicamba	-158	1749	-57	1030	-137	1303
Alachlor + Atrazine	-111	1754	-18	1033	-91	1300
Cyanazine	324	706	321	425	322	503
<u>Insecticides</u>						
Esfenvalerate	-4755	3190	-3812	1799	-4531	2527
Carbofuran	-1144	3671	-659	2136	-1035	2781
Chlorpyrifos	-1679	2656	-1126	1518	-1549	2068
Terufos	-1422	2427	-736	1372	-1261	1915
Parathion	-1036	2128	-764	1233	-971	1624
Disulfoton	-149	148	-105	84	-138	117

CONCLUSION

The economic impacts derived in this study are short-term in nature and caution must be used in their interpretation. The total long-term effects, of a ban of a pesticide may not be truly known. Many factors are involved in obtaining an accurate assessment of the impacts of a pesticide, some of which cannot be accounted for. Insecticides are a prime example of this fact. As mentioned earlier, the use of an insecticide is a function of the type of target pest and the rate of infestation. Careful considerations must be taken into account in policy-making for pesticide use. Questions such as the possibility of insect resistance to particular chemicals need to be addressed in the policy-making process.

The use of economic impacts estimated in this study must be bound by the limitations imposed by their derivation. That is, these impacts are short-run welfare impacts that ignore the dynamics of both market forces and pests. These estimates can be used as good upper bound short-run levels of the expected impacts of banning certain pesticides; but, the banning of several pesticides at the same time could be significantly underestimated by these results.

REFERENCES

- Adams, G. 1992. Documents of US sorghum models. Document no. CNFAP 36-92. Food and Agricultural Policy Research Institute, Univ. of Missouri, Columbia.

- Bennett, W.F., B. Tucker, and B. Maunder. 1990. Modern Grain Sorghum Production. Iowa State University Press, Ames.
- Brooks, H.L. 1992. Carbofuran granular insecticide. p. 11-17. In Grain sorghum pesticide position papers. National Grain Sorghum Producers, Abernathy, TX.
- Ferguson, W.L., L.J. Moffitt, and R.M. Davis. 1992. Short-run welfare implications of restricting fungicide use in vegetable production. *Journal of Agribusiness* 10:41-50.
- Knutson, A.E. 1990. Phorate and terbufos use on sorghum. p. 55-60. In the Biologic and economic assessment of phorate and terbufos. USDA, National Agricultural Pesticide Assessment Program, Washington, DC.
- Knutson, R.D., C.R. Taylor, J.B. Penson, and E.G. Smith. 1990. Economic impacts of reduced chemical use. Knutson Associates, College Station, TX.
- Lichtenberg E., D.D. Parker, and D. Zilberman. 1988. Marginal analysis of welfare costs of environmental policies: the case of pesticide regulation. *American Journal of Agricultural Economics* 70:867-874.
- Mayo, Z.B. 1990. Oxydemeton-methyl use on field crops. p. 86-89. In the Biologic and economic assessment of oxydemeton-methyl. USDA, National Agricultural Pesticide Assessment Program, Washington, DC.
- Rice, M.E. (In press). In the Biologic and Economic Assessment of Chlorpyrifos. USDA, National Agricultural Pesticide Assessment Program, Washington, DC.
- Texas Agricultural Statistics Service. 1992. Texas custom rates statistics. Texas Department of Agriculture, Austin.
- USDA. 1989a. The biologic and economic assessment of ethyl parathion. National Agricultural Pesticide Assessment Program, Washington, DC.
- USDA. 1989b. The biologic and economic assessment of carbofuran. National Agricultural Pesticide Assessment Program, Washington, DC.
- USDA. 1992a. Agricultural statistics, 1992. US Government Printing Office, Washington DC.
- USDA. 1992b. Agricultural resources: inputs situation and outlook report. Economic Research Service, Washington, DC.
- Zilberman, D., A. Schmitz, G. Casterline, E. Lichtenberg, and J.B. Siebert. 1991. The economics of pesticide use and regulation. *Science* 253:518-522.

