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Economic Impacts of Pesticide Availability in U.S. Sorghum Production

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Abstract: *A national pesticide-use survey from sorghum producers and a survey of entomologists and weed scientists were used to determine the impacts of pesticide use on sorghum. A market framework was employed to derive the short-run welfare impacts to consumers and producers (users and non-users) of the removal of pesticides currently registered for use on sorghum. It was projected that the loss of atrazine, the most widely used pesticide in sorghum production, would have the largest overall impact, with an estimated total welfare loss between $58 and $65 million.*

Key words and Phrases: *Sorghum, Pesticide regulation, Consumer impacts, Producer (user and non-user) impacts, NAPIAP.*

Sorghum is an important crop in U.S. agriculture. This crop is generally cultivated in areas that are too hot or dry for successful corn production (Bennett et al.). Advancements in the chemical industry, tillage practices, and hybrid seed production have played a vital role in sorghum's development as one of the major U.S. cereal crops. Three areas of concern affecting sorghum production are insects, weeds and diseases. Annual yield losses due to these pests are potentially 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 and judicious pesticide use provide maximum yield potential for producers.

Programs such as the National Agriculture Pesticide Impact Assessment Program (NAPIAP) of the U.S. Department of Agriculture (USDA) 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 many agricultural commodities.

Objectives and Pesticide Use Background

NAPIAP pesticide-use-in-agriculture studies represent an effort to disentangle the horizontal relationships connected with the use of a particular pesticide across several crops. That is, most often an assessment examines a specific active ingredient (AI) 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 on consumers and producers (users and non-users) of the removal of pesticides presently registered for use on grain sorghum production.

Insecticides. Insects are major pests in sorghum production, and insecticides are often used to control economically damaging infestations. Biologic and economic assessments of several insecticides have shown the impacts of these chemicals on the producer, environment and consumers of sorghum (Knutson; Mayo; Rice; U.S. Department of Agriculture, 1989a and 1989b). The biologic and economic assessment of oxydemeton-methyl (Mayo) showed that use of this insecticide in sorghum was minimal. Registered for use on sorghum to control greenbugs, corn leaf aphid, yellow sugarcane aphid, and Banks grass mites, oxydemeton-methyl's cost appears to be the main deterrent to its use. Alternative insecticides were generally considered to be equally effective, but the cost of oxydemeton-methyl was 45 to 55 percent greater than other registered products.

Phorate is registered for use on sorghum to control greenbugs, chinch bug and Banks grass mites. Terbufos provides control of southern corn rootworms, wireworms, white grubs, nematodes and early season greenbugs in sorghum. In a biologic and economic assessment of phorate and terbufos on a state-by-state basis, Knutson estimated that sorghum yields would be reduced by 0 to 10 percent should phorate and/or terbufos use be canceled. Carbofuran and terbufos could be substituted for phorate, whereas the cancellation of terbufos would increase the use of carbofuran, chlorpyrifos and phorate. Carbofuran was found to be the primary alternative insecticide that would be used by sorghum producers should the registrations of terbufos and phorate be canceled.

Carbofuran is a vital tool for 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 (U.S. Department of Agriculture, 1989b). Granular carbofuran registrations have been greatly reduced because of general avian mortality concerns, although Brooks reported no documented bird kill incidents from use in sorghum. The National Grain Sorghum Producers Association (NGSPA) has 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 (U.S. Department of Agriculture, 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. Dimethoate and disulfoton are among the alternative insecticides for ethyl parathion. However, in the 1970s Texas reported insecticide resistance in greenbugs to dimethoate and disulfoton (U.S. Department of Agriculture, 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). 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 chlorpyrifos alternatives by survey respondents.

Herbicides. Weed control is an essential component of sorghum production. Weeds compete with sorghum for moisture, nutrients and light (Bennett et al.). Research has shown that only one pigweed per eight feet of sorghum row may reduce grain yields by 700 pounds per acre (Bennett et al.). Herbicides effectively and economically control competing plants in sorghum production (Abernathy). As would be expected, herbicide usage has been much greater than insecticide usage for all years in which surveys have been conducted. McCalla et al. reported that a herbicide was applied on 61 percent of the U.S. sorghum acreage. Of the six states surveyed in 1980, Nebraska reported the highest use of herbicides with 87 percent of the planted acres treated. Missouri, Kansas and Texas followed with 73, 68 and 48 percent, respectively, of the planted acres treated.

Herbicide usage increased from 1980 to 1987. In 1987 herbicides were used on about 82 percent of the sorghum planted in the United States (U.S. Department of Agriculture, 1988). The percentage of acres treated by individual surveyed states in 1987 remained relatively consistent with the 1980 usage patterns. Missouri, Nebraska, Kansas and Texas treated 89, 87, 84 and 75 percent, respectively, of their planted acres (U.S. Department of Agriculture, 1988).

The *1991 Field Crops Summary* indicated 78 percent of the U.S. sorghum acreage was treated with an herbicide (U.S. Department of Agriculture, 1992a). The three states surveyed in the 1991 summary were Kansas, Nebraska and Texas. Nebraska producers reported the highest percentage of planted acres treated at 91 percent. Kansas and Texas reported 80 and 70 percent, respectively, of the sorghum acres receiving at least one application of a herbicide.

Pre-emergence herbicides are applied before or during planting to aid in the control of weeds. Pre-emergence herbicides labeled for use on sorghum include atrazine, alachlor, propachlor, metolachlor and propazine (allowed under Section 18 for use in Texas only for the 1993 crop year and in other states in 1994). In 1988, Ciba-Geigy requested voluntary cancellation from EPA for all products containing propazine due to the high cost associated with re-registration of the product. Griffin Corporation and NGSPA worked together with the EPA to obtain a Section 18 to allow its use in several sorghum-producing states until the re-registration process could be completed. Post-emergence herbicides, such as 2,4-D, bromoxynil, dicamba and atrazine, are applied to control broadleaf plants after sorghum has established a stand.

Selection of an herbicide depends upon soil types, target weeds and toxicity to the crop. Some herbicides require a special seed treatment to protect young seedlings from injury by the herbicide, e.g., the use of metolachlor and alachlor. Also, herbicides may be applied as a single treatment with one AI per treatment, or as a tank mix with two or more AI's per treatment.

McCalla et al. identified atrazine as the most widely used herbicide. The 1980 survey indicated that atrazine was applied to 19 percent of the acres while propazine was applied to 9 percent. 2,4-D, propachlor, dicamba, terbutryn and glyphosate were used to treat 6, 3, 1, 1 and 0.5 percent, respectively, of the U.S. sorghum acres.

The USDA (1988) reported that atrazine was the most widely used herbicide in 1987 with 28 percent of the sorghum acreage being treated. Propazine was used on 15 percent of the sorghum acres, followed by 2,4-D on 12 percent (U.S. Department of Agriculture, 1988).

The *1991 Field Crops Summary* reported that atrazine was used to treat 68 percent of the surveyed sorghum acres (U.S. Department of Agriculture, 1992a). Other herbicide usage patterns as a percent of surveyed acres were: metolachlor (20 percent); 2,4-D (9 percent); alachlor (8 percent); propachlor (6 percent); and glyphosate (4 percent). Bromoxynil, cyanazine and dicamba were each applied to 2 percent of the surveyed acres.

Conceptual Framework

As a result of a more environmentally conscious society, a popular public policy approach followed by EPA has been the suspension or cancellation of registered pesticide use in agriculture (Ferguson et al.; Zilberman et al.). 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.). 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, as well as users and non-users, of the pesticide.

As Lichtenberg et al. and Ferguson et al. 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. developed a market model to estimate the short-run welfare impacts of a pesticide ban. This model provided 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 is described as follows:

$$D=D(P) \tag{1}$$

$$S^{u}=y^{u}A^{u} \tag{2}$$

$$S^{n}=y^{n}A^{n} \tag{3}$$

$$D=S^{u}+S^{n} \tag{4}$$

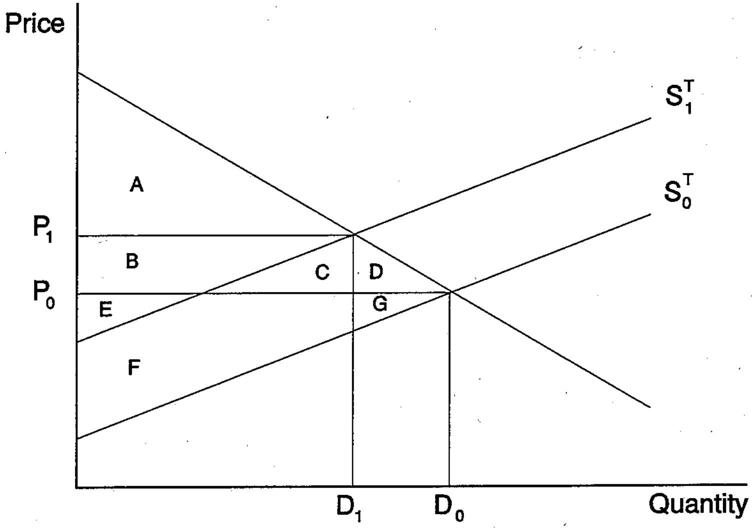
where D equals the quantity of crop demanded, P equals the crop price, S^u equals the quantity of crop supplied by pesticide users, y^u equals the crop yield per acre among pesticide users, A^u equals the crop acreage of pesticide users, S^n equals the quantity of crop supplied by pesticide non-users, 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 for 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 given 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 the case in which no pesticide alternative is used, the change in cost is equal to the reduction in cost due to not using the pesticide. However, in the case in which an alternative pesticide(s) is (are) used to replace the pesticide being banned, the change in cost is equal to the difference in cost of using the replacement pesticide(s) instead of the pesticide being banned. Pesticide non-users yield per acre, y^n, and production cost per acre, C^n, are assumed to remain the same. Furthermore, it is important to point out that the case depicted in Figure 1 represents the case in which there is a "net" reduction in the level of production. That is, the banning of a particular pesticide has a definite negative impact on the level of production regardless of the alternative pesticide(s) used. There is a possibility that "net" increases in production could be achieved if, after banning a pesticide, a "better" one(s) is (are) used instead. 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_0^n, respectively.

As shown in Figure 1, given the 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

Figure 1.
Illustration of the Short-run Welfare Impacts of a Pesticide Ban



upon 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. On the one hand, non-users of the pesticide being banned will not be negatively affected by the ban and, in fact, will benefit from it because of the increased price of sorghum. On the other hand, users of the pesticide being banned will be affected negatively if the impact on the yield reduction is stronger than the price effect. If the increase in price of sorghum is strong enough, there is a possibility that the users of the pesticide being banned could benefit. We recognize that the short-run nature of this model does not consider structural changes in production or the dynamics of both market forces and pests which might result from the banning of pesticides. However, we believe that this model does provide a relevant point of departure in the evaluation of the 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 can be estimated as follows:

$$I^c=-[(P_1-P_0)D_1+.5(P_1-P_0)(D_0-D_1)] \tag{5}$$

$$I^u=[P_1y_1^u-P_0y_0^u]A^u+(C_0^u-C_1^u)A^u \tag{6}$$

$$I^n=[P_1-P_0]y^nA^n \tag{7}$$

Methods and Procedures

Through a national pesticide usage survey of sorghum producers conducted in 1993 for the crop year 1992, yields per acre, per acre pesticide use rates, and percent of acres treated with a pesticide were obtained from respondents. Working in close cooperation with NGSPA, a questionnaire was developed and sent, after pilot testing, to the association's entire membership (1,671). Some of the questions included in the survey were drawn from previous surveys used to obtain similar information (U.S. Department of Agriculture, 1980; Spradley, 1991, and U.S. Department of Agriculture, 1992a). The survey methodology was designed and implemented following the guidelines of Dillman. Of the 1,671 surveys mailed, 720 were returned for an overall response of 43 percent. Survey responses were classified into three categories: 1) complete, 2) incomplete, and 3) unusable. Surveys were considered complete if respondents indicated number of acres used for sorghum production, per acre sorghum yield, and pesticide(s) used. Surveys that lacked one or more of the three previous items were classified incomplete. Unusable surveys came from respondents that did not produce sorghum in 1992. Overall, 452 surveys were returned completed, 105 surveys were classified as incomplete, and 163 were considered unusable. Thus, there were 557 "usable" surveys (complete plus incomplete surveys) for an overall "usable" response rate of slightly above 33 percent upon which this study was based.

Survey respondents indicated that the average number of acres in sorghum production on their farm was 578. Dryland and irrigated acres constituted 81 and 19 percent, respectively. Most (88 percent) sorghum produced was for normal elevator sales with smaller acreages being devoted to forage and seed production. The average 1992 yields reported for dryland and irrigated production were 82 and 114.7 bushels per acre, respectively.

Sorghum producers 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, whether the respective chemical was still 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. However, it is likely that an alternative pesticide(s) or another means of control would be used to replace the canceled product. For this reason, a survey of expert entomologists and weed scientists on the impacts of pesticide use on sorghum yields was conducted to determine: (1) what the "best" alternative(s) is (are) to a particular pesticide, and (2) what the "net" impact on sorghum yields would be from using the alternative pesticide(s) (Morrison et al.).

A percentage of net yield change (loss or gain) due to the cancellation of a particular pesticide was established and applied to three groups of sorghum yields to derive the economic impacts. The first yield-per-acre level used in the study was obtained from the elicited yield per acre of sorghum producers surveyed. Survey respondents were asked to provide their 1992 yield per acre for their irrigated and/or non-irrigated fields. Overall, survey respondent yields per acre for irrigated and non-irrigated were 11 and 31 percent, respectively, higher than the average USDA yield for 1992 (Morrison et al.). The second yield level was the 1992 actual yield per acre for irrigated and non-irrigated farms in Kansas, Nebraska, Texas and other states as reported by USDA. Since all other sorghum producing states were grouped together for the purpose of this study, other states' yields per acre were estimated by dividing total production of the other states by total acres harvested as reported by the USDA Agricultural Statistics (U.S. Department of Agriculture, 1992b).

The third yield-per-acre level was a long-term expected yield figure derived from the sorghum producers surveyed. Respondents were asked to provide, based on their experience, their lowest, mostly likely, and highest expected yield per acre. Using this information and implicitly assuming a triangular probability density function of sorghum yields, an estimate of the long-term expected average yield per acre was derived (Young). These calculated long-term yields per acre for irrigated and non-irrigated were from 6 percent lower to 29 percent higher than the average USDA yields for 1992. This long-term yield scenario is relevant because it provides insight into the expected robustness of the economic impacts of a pesticide ban across favorable and unfavorable sorghum growing seasons.

Table 1 depicts the estimated pesticide usage in sorghum production by location, while Table 2 depicts the main pesticides used and their application rates. Overall, the sorghum producers survey showed that in 1992 almost one pound AI of pesticide per acre was applied in sorghum production. The producers survey also revealed that 96 and 31 percent of the sorghum acreage was treated with herbicides and insecticides, respectively. Atrazine was found to be the most widely used pesticide in sorghum production (Table 2). Atrazine was applied to almost 38 percent of the sorghum acreage. Tables 3 and 4 depict the expected percent net sorghum yield losses and the best alternative(s) by state elicited from weed scientists and entomologists due to the elimination of herbicides and insecticides, respectively. As can be seen in Tables 3 and 4, both the net yield impact and alternative(s) to a particular pesticide vary quite significantly from state to state. Morrison et al. provide a detailed description of the methods and procedures used in the producers' and experts' surveys and a comprehensive discussion of other results from their study.

The number and distribution of sorghum acres planted for 1992 were obtained from USDA Agricultural Statistics (U.S. Department of Agriculture, 1992b). The cost per pound AI of pesticides was obtained from *Agricultural Resources: Inputs Situation and Outlook Report* (U.S. Department of Agriculture, 1992c). The Food and Agricultural Policy Research Institute (FAPRI) national sorghum 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. FAPRI's sorghum model is a multimarket econometric model with regional, national and international trade supply and demand components. For a detailed description of FAPRI's sorghum model see Adams. This information was applied to the above market model to estimate the economic impact of the ban of a given pesticide.

Results

The economic impact of a pesticide ban depends upon the percent of acres treated and the expected yield loss (gain) due to the absence of the chemical. Table 5 presents the estimated impacts that a ban on the most important herbicides and insecticides will have on consumers, users and non-users. In general, the expected economic impacts of banning herbicides are larger than that of banning insecticides in sorghum

Table 1.
Pesticide Usage and Pounds Active Ingredient (AI) Used in 1992

Location	Acres Planted[a] x1000	Herbicides % Acres Treated[b]	Herbicides Total lbs AI x 1000	Insecticides % Acres Treated[b]	Insecticides Total lbs AI x 1000	All Pesticides % Acres Treated[c]	All Pesticides Total lbs AI[d] x1000
Kansas	3,300	94.57	3,333.9	20.65	143.3	95.65	3,477.2
Nebraska	1,700	99.30	2,342.8	12.68	56.5	99.30	2,399.4
Texas	4,750	94.44	3,234.7	51.39	714.3	97.22	3,949.0
Other states	3,527	96.88	3,444.1	22.92	189.1	97.92	3,633.1
U.S.	13,277	96.15	11,851.3	31.14	1321.0	97.62	13,172.3

[a] *USDA Agricultural Statistics,* 1992.
[b] Based upon survey respondents.
[c] Some areas treated with both herbicides and insecticides.
[d] Extrapolated location-wide based upon combined herbicides and insecticide usage of respondents.

Table 2.

Main Pesticides Used Nationally in Grain Sorghum Production from Producer Survey, 1992[1]

Pesticide[b]	% Area Applied	Number Appl./Acres	Pounds Active Ingredient/Acre Rate/Appl.[c]	Pounds Active Ingredient/Acre Rate/Crop Year[d]	Total lbs AI x 1000	No. Acres Treated x 1000
Herbicides						
Atrazine	37.80	1.4	1.10	1.01	5078.8	5018.1
2,4-D	9.38	1.2	0.40	0.42	525.3	1244.8
Metolachlor	9.30	1.1	1.78	1.74	2143.4	1235.2
Glyphosate	4.98	1.2	0.62	0.53	348.9	661.8
Metolachlor + Atrazine	4.14	1.2	2.60	2.37	1303.1	549.3
Alachlor	3.47	1.2	1.93	1.99	914.1	460.5
Insecticides						
Dimethoate	4.78	1.3	0.31	0.43	270.1	634.3
Terbufos	2.80	1.0	0.74	0.76	283.8	371.4
Chlorpyrifos	2.36	1.1	0.52	0.55	172.8	313.5
Carbofuran(G)[e]	2.32	1.1	0.90	0.87	267.2	307.9
Esfenvalerate[f]	1.93	1.1	0.02	0.02	5.5	256.5
Parathion	1.66	1.2	0.81	0.87	191.9	221.0

[a] USDA reported 13,277 million acres planted in sorghum for 1992.[b] The following pesticides were reported but infrequently used: Herbicides: Alachlor + atrazine, alachlor + glyphosate, bromoxynil + atrazine, cyanazine, dicamba, dicamba + atrazine, glyphosate + 2,4-D, paraquat, pendimethalin, propachlor + atrazine, propazine, trifluralin. Insecticides: Aldicarb, carbaryl, carbofuran(L), disulfoton, methomyl, oxydemeton-methyl, permethrin, phorate.

[c] Mean rate applied.

[d] Calculated by dividing total lbs. AI. applied by the number of acres treated.

[e] Granular formulation of carbofuran.

[f] Available in some states only under Section 18.

production. This is due primarily to the fact that in sorghum production, herbicides are applied to a greater number of acres than insecticides (Table 1).

The loss of atrazine, the most widely used pesticide in sorghum production, would be expected to have the largest overall impact (Table 5). The expected total welfare loss, using the best alternative(s) to atrazine, ranges from $58 to $65 million, depending on the sorghum yield level used in the analysis. Also, it is important to point out that when looking at the distribution of the expected losses, consumers would be expected to incur the majority of the estimated loss. That is, expected consumer losses range from $53 to $87 million, depending on sorghum yield levels used. Furthermore, considering the various yield scenarios, consumer expected losses are much higher than the expected losses of producers who use atrazine.

In evaluating the results in Table 5 for other herbicides, the reader should not expect welfare impacts to be negative in all cases. In cases in which the best herbicide alternative(s) is (are) used, welfare increases could result. For example, in the case of 2,4-D, use of the best alternative(s) would increase overall welfare because the alternative(s) would be more effective in controlling the target pests. Given this, sorghum production would increase, sorghum prices would decrease, and the end result would be an increase in overall welfare.

The results depicted in Table 5 imply that the most critical herbicides are: atrazine, glyphosate, metolachlor + atrazine, and alachlor + atrazine. This is because even if the best alternative(s) is (are) used, welfare losses would still be expected to occur.

In evaluating insecticide results in Table 5, it should be noted that the use of insecticides can vary greatly from year to year due to the outbreak of different pests. The lack of proper insecticides to control selected pests during severe outbreaks could be devastating to producers and could result in greater than the estimated losses depicted in Table 3. Considering this caveat, the banning of esfenvalerate appeared to have the largest overall impact. If the best alternative(s) to esfenvalerate is (are) used, the overall welfare loss would be expected to be between $2.7 and $3 million, again depending on the sorghum yield source used (Table 5).

As in the case of herbicides, the results in Table 5 for insecticides show that welfare impacts would not be expected to be negative in all cases if the best insecticide alternative(s) is (are) used. In some cases welfare increases could be experienced if the insecticide alternative(s) is (are) used. The results depicted in Table 5 imply that the most critical insecticides are: esfenvalerate, chlorpyrifos, dimethoate, carbofuran and disulfoton.

Table 3.
Percent Net Sorghum Yield Losses and Best Alternative(s) by State Elicited from Weed Science Experts Due to the Elimination of Selected Herbicides Registered for Use on Sorghum Production in the U.S.

	% Net Sorghum Yield Losses[a]			
	Texas	Kansas	Nebraska	Other States
Atrazine[b]	2.70 (j)	10.00 (g)	10.00 (c)	5.00 (d,f,j)
Metolachlor	2.70 (e)	-10.00 (e)	0.00 (e)	-3.33 (e,e,e)
2,4-D	2.70 (g)	-30.00 (g)	0.00 (g)	-5.00 (d,f,g)
Glyphosate	0.80 (g,c)	5.00 (m)	5.00 (m)	1.67 (a,d,m)
Metolachlor + Atrazine	3.62 (j,k)	-3.00 (e)	13.00 (b)	5.00 (e,f,h)
Alachlor	2.57 (b)	-10.00 (b)	0.00 (b)	-3.33 (d,b,b)
Bromoxynil	-5.40 (g,c)	-25.00 (g)	0.00 (c)	-8.33 (a,d,c)
Dicamba	2.70 (c)	-2.00 (c)	0.00 (c)	-3.33 (c,d,f)
Alachlor + Atrazine	4.70 (j)	-3.00 (d)	13.00 (e)	5.00 (b,f,d)
Cyanazine	-10.00 (j)	-40.00 (a)	-10.00 (a)	-10.00 (a,d)

[a] Positive numbers represent % net sorghum yield losses. Negative numbers represent % net sorghum yield gains.

[b] The letter(s) in parenthesis below the % net sorghum yield losses or gains represent the best alternative(s) according to: a=atrazine; b=metolachlor; c=2,4-D; d=metolochlor + atrazine; e=alachlor; f=bromoxynil; g=dicamba; h=alachlor + atrazine; i=cyanazine; j=propazine; k=propazine + atrazine, l=glyphosate; and m=mechanical cultivation.

Table 4.

Percent Net Sorghum Yield Losses and Best Alternative(s) by State Elicited from Entomology Experts Due to the Elimination of Selected Insecticides Registered for Use on Sorghum Production in the U.S.

	% Net Sorghum Yield Losses[a]			
	Texas	Kansas	Nebraska	Other States
Dimethoate	-1.62 (c,b)	-0.50 (c)	--	-13.00 (c)
Esfenvalerate[b]	4.00 (c)	--	--	--
Carbofuran	0.35 (d,g)	2.50 (h)	0.00 (c)	3.50 (c)
Chlorpyrifos	4.58 (b,e)	-2.50 (b)	0.00 (b)	-2.00 (b,e)
Terbufos	-0.46 (b,c)	-10.00 (b)	0.00 (c)	2.50 (i)
Parathion	4.21 (c,g)	0.00 (c)	0.00 (c)	-4.50 (c,g)
Disulfoton	-0.10 (c,g)	-3.00 (e)	0.00 (c)	-20.00 (c)

[a] Positive numbers represent % net sorghum yield losses. Negative numbers represent % net sorghum yield gains.

[b] The letter(s) in parenthesis below the % net sorghum yield losses or gains represent the best alternative(s) according to: a=esfenvalerate; b=carbofuran; c=chlorpyrifos; d=terbufos; e=parathion; f=disulfoton; g=dimethoate; h=aldicarb; and i=phorate.

Given the results in Table 5, one might ask why sorghum producers are not currently using only those pesticides that would be more economically beneficial. There are several reasons why alternatives are sometimes used, including: preharvest intervals and/or grazing restrictions; crop rotation limitations or provisions of the farm program that may limit the use of a preferred pesticide; relative toxicity of pesticides farmers are applying themselves vs. commercial application; preference based upon successful, personal use history; existing personal inventories and general retail

Table 5.

Welfare Impacts Due to the Elimination of Selected Pesticides Registered for Use on Sorghum Production in the U.S, Assuming That the Best Alternative is Used, 1992

	Survey Yields (x $1000)				USDA Yields (x $1000)				Long-term Yields (x $1000)			
	Consumer	User	Non-user	Total	Consumer	User	Non-user	Total	Consumer	User	Non-user	Total
Herbicides												
Atrazine	-87,364	-33,638	56,004	-64,998	-53,757	-38,913	34,508	-58,162	-60,770	-36,950	38,870	-58,850
2,4-D	48,512	13,230	-42,589	19,152	30,101	12,236	-26,399	15,938	33,448	11,805	-29,394	15,860
Metolachlor	12,503	6,601	-11,270	7,834	7,912	6,325	-7,127	7,110	8,336	5,937	-7,523	6,750
Glyphosate	-7,575	-6,183	7,106	-6,652	-4,695	-5,830	4,402	-6,123	-5,212	-5,788	4,893	-6,107
Metolachlor + Atrazine	-9,804	-6,350	9,378	-6,776	-6,037	-5,791	5,771	-6,057	-6,732	-5,773	6,445	-6,060
Alachlor	7,467	4,151	-7,160	4,458	4,626	3,749	-4,434	3,942	5,155	3,732	-4,947	3,940
Bromoxynil	14,498	9,383	-14,018	9,863	9,046	8,612	-8,741	8,918	9,884	8,455	-9,570	8,769
Dicamba	882	438	-867	452	534	388	-545	397	601	375	-591	385
Alachlor + Atrazine	-4,382	-2,918	4,308	-2,993	-2,681	-2,612	2,635	-2,658	-3,062	-2,661	3,010	-2,713
Cyanazine	9,573	5,374	-9,467	5,480	5,949	4,767	-5,882	4,834	6,553	4,705	-6,482	4,776
Insecticides												
Dimethoate	2,292	-279	-2,222	-208	1,351	-465	-1,311	-425	1,707	-330	-1,651	-275
Esfenvalerate[a]	-2,768	-2,999	2,720	-3,047	-1,620	-2,747	1,593	-2,774	-2,076	-2,940	2,038	-2,978
Carbofuran	-1,912	-298	1,858	-351	-1,177	-179	1,144	-212	-1,335	-192	1,298	-229
Chlorpyrifos	-1,733	-1,196	1,702	-1,227	-1,001	-1,028	984	-1,045	-1,321	-1,176	1,297	-1,200
Terbufos	324	157	-318	163	190	128	-186	132	243	150	-238	155
Parathion	175	17	-172	20	127	21	-125	23	96	11	-95	12
Disulfoton	4	-24	-4	-24	2	-25	-2	-25	3	-24	-3	-24

[a] Available in some states by Section 18 only.

availability at the time of need; and influence of neighbors, dealers and salespersons.

Conclusions

The economic impacts derived in this study are short run in nature and caution must be used in their interpretation. The total long-run effects of a pesticide ban may not be known with certainty. Many factors, some ofwhich cannot be accounted for, are involved in obtaining an accurate assessment of the impacts of a pesticide. Insecticides are a prime example. As mentioned earlier, the use of an insecticide is a function of the target pest and the degree of infestation. Careful consideration should be given to pesticide regulations. Issues related to managing pesticide resistance need to be addressed in the policy making process.

The economic impacts estimated in this study must be bound by the limitations imposed upon their derivation. That is, these impacts are short-run welfare impacts that ignore possible structural changes in production, the long-run implications and the dynamics of both market forces and pests. The welfare estimates derived can be used as a rough estimate of the short-term levels of the expected impacts, however we believe the impacts of banning several pesticides at the same time could be underestimated significantly by these results.

Notes

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