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The Honorable E (Kika) de la Garza
Chairman
The Honorable Pat Roberts
Ranking Minority Member
Committee on Agriculture
House of Representatives

As requested by your offices, this correspondence provides information on the Environmental Protection Agency's (EPA) assessments of the (1) risk posed to birds by agricultural uses of granular carbofuran,[1] including sorghum uses, and (2) economic impacts on growers of canceling sorghum uses of granular carbofuran. These assessments were part of EPA's "special review," or detailed analysis, of this pesticide, which was initiated in response to concerns about acute avian toxicity.

This correspondence also provides information on the views of other interested parties on EPA's assessments of the risk and economic impacts. These parties include the U.S. Fish and Wildlife Service (FWS) in the Department of the Interior, the U.S. Department of Agriculture (USDA), the FMC Corporation (the major producer and sole registrant of pesticide products containing carbofuran), and the National Grain Sorghum Producer's Association (NGSPA).

Specifically, your offices asked that we review EPA's risk assessment of granular carbofuran to identify the agency's conclusions on the (1) acute avian toxicity of this pesticide compared with alternative pesticides; (2) likelihood of avian exposure, including exposure resulting

[1]Carbofuran, an insecticide and nematicide, was registered by EPA for use on a variety of fruit and field crops, vegetables, tobacco, ornamental plants, and forest tree seedlings. EPA has canceled most of these uses, including sorghum uses. Carbofuran is produced in both a granular and flowable (liquid) formulation.

from birds' foraging patterns and the attractiveness of the granules; (3) risk to individual birds versus bird populations; and (4) acute and/or chronic human toxicity of carbofuran and its alternatives. Regarding EPA's assessment of economic impacts, your offices asked that we identify the agency's conclusions on the (1) costs of canceling sorghum uses of granular carbofuran and (2) effectiveness and cost of the pesticides that EPA has identified as alternatives to granular carbofuran for sorghum uses.

In summary, our review of EPA's risk assessment of granular carbofuran showed the following:

-- Comparative risk indices developed by EPA indicate that granular carbofuran is more toxic to birds than alternative pesticides: The ingestion of a single carbofuran granule is sufficient to kill a small bird.

-- Birds are likely to be exposed to carbofuran granules as a result of normal agricultural activity and the birds' foraging patterns, and they may be attracted to these granules, mistaking them for food or grit.[2]

-- EPA did not assess the risk to bird populations. Instead its conclusions on acute avian toxicity were based on the risk posed to individual birds.

-- Granular carbofuran and its principal alternatives for sorghum uses present similar acute (immediate) human health concerns, but some alternatives also present chronic (long-term) human health concerns for farmworkers accidentally exposed to these pesticides when applying them.

Our review of EPA's assessment of the economic impacts of canceling sorghum uses of granular carbofuran showed the following:

-- The cost to growers of canceling sorghum uses of granular carbofuran is estimated to be $2.6 million to $10.7 million annually because of increased production costs and/or yield losses. Also, canceling sorghum uses of this pesticide will minimally disrupt national sorghum supplies but may cause significant local impacts

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[2]Grit refers to small particles of rock or sand consumed by some birds to grind food contained in their crop (a pouched enlargement of the gullet).

in sorghum-growing areas that experience high infestations of pests.

-- Some alternative pesticides that EPA identified are nearly as effective as granular carbofuran in controlling sorghum pests, but these alternatives are generally more costly, have other disadvantages, and may not be available to growers in certain areas.

BACKGROUND

Whenever new information on a use or uses of a registered pesticide raises a specific concern about human health or the environment, EPA may initiate a special review of that pesticide. EPA's authority to conduct special reviews derives, in part, from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, which provides that a pesticide registered under the act must, among other things, perform its intended function without causing "unreasonable adverse effects on the environment."[3] FIFRA defines these effects as any unreasonable risk to human beings or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide.[4] If a registered pesticide causes such unreasonable adverse effects, EPA may cancel its registration under authority of section 6 of FIFRA. Enclosure I provides information on the risk criteria that EPA uses to initiate special reviews.

During a special review, EPA weighs the risks and benefits of a use or uses of a pesticide and decides whether to take regulatory action. These actions include canceling some or all uses, imposing restrictions on uses, and requiring changes to pesticide labels. According to EPA, the ultimate goal of a special review is to reduce the risks posed by a pesticide to an acceptable level while taking into consideration the benefits provided by the use of that pesticide.

On the basis of its special review of granular carbofuran, EPA determined that all agricultural uses of this pesticide, including sorghum uses, present serious risks of acute toxicity to birds. EPA also determined that the benefits of continued use of this pesticide did not outweigh these risks. Accordingly, EPA concluded that

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[3]FIFRA sect. 3(C)(5).

[4]FIFRA sect. 2(bb).

continued use of granular carbofuran posed unreasonable risks of acute avian toxicity and canceled most of these uses, including sorghum uses.[5]

EPA's special review of granular carbofuran was initiated in October 1985 and concluded in November 1991. The agency's assessment of avian risk was issued in the spring of 1991; the final assessment of the economic impacts of canceling sorghum uses of granular carbofuran was issued in October 1990. Both analyses were prepared by EPA's Office of Pesticide Programs. As of August 1994, EPA was reviewing comments it received in response to its notice in the Federal Register proposing to deny the FMC Corporation's request to reinstate sorghum uses of this pesticide.[6] Enclosure II provides further information on this special review.

EPA CONCLUDED THAT GRANULAR CARBOFURAN IS HIGHLY, ACUTELY TOXIC TO BIRDS AND THAT ITS USE IN AGRICULTURE LIKELY RESULTS IN THE DEATH OF MANY BIRDS

Our review of EPA's risk assessment showed that (1) this pesticide is highly, acutely toxic to birds and is generally more toxic than its alternatives; (2) birds are likely to be exposed as a result of the application of this pesticide on sorghum and other crops, either through direct ingestion of granules or ingestion of contaminated insects, and this exposure will result in the death of birds; (3) EPA did not analyze the effects of carbofuran-related poisonings on bird populations, but the assessment notes that such poisonings may have an additive effect on some species thought to be in decline; and (4) carbofuran and its alternatives present similar acute human health concerns, but some alternatives also present chronic health concerns. EPA based its conclusions on the "weight of evidence," which included the results of laboratory tests of acute avian toxicity, field studies, and documented incidents of bird kills. While FWS and others generally agreed with EPA's conclusions, USDA, the FMC Corporation,

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[5]Granular carbofuran remains registered for limited use on five minor crops--cranberries, bananas (Hawaii only), cucurbits (gourds), spinach grown for seed, and pine seedlings--because of a lack of effective alternative pesticides for these uses. EPA has also proposed to extend rice uses of granular carbofuran because of a lack of effective alternatives.

[6]59 FR 17530, Apr. 1994.

and NGSPA do not agree that sorghum uses of granular carbofuran present unreasonable risks to birds.

EPA's Analysis Indicates Granular Carbofuran Is More Toxic to Birds Than Alternatives Are

On the basis of laboratory analyses by various researchers, EPA concluded that granular carbofuran is highly, acutely toxic to birds and that a single granule of this pesticide may kill a small bird. Furthermore, EPA concluded that, in general, carbofuran poses a greater risk to birds than other pesticides, including its primary alternatives for sorghum uses. This conclusion was based on estimates of the number of median single lethal doses per square foot ($LD_{50}s/ft^2$)[7] of treated ground that would be expected for each pesticide when the pesticide was applied according to the rates and methods specified on its label. Moreover, both field studies of avian mortality and documented incidents of bird kills caused by the use of granular carbofuran confirm the agency's conclusion that this pesticide poses a very high risk. Enclosure III provides further information on EPA's use of $LD_{50}s/ft^2$ to compare the toxicity of carbofuran with that of its alternatives.

Officials in EPA's Office of Policy Analysis told us that they had reservations about the use, in the risk assessment, of $LD_{50}s/ft^2$ as risk indices, or indicators, for comparing the toxicity of granular carbofuran and its alternatives.[8] According to these officials, these indices are, at best, useful only for hazard identification because they do not include any exposure component. For example, the indices were not quantified with respect to the area of exposure, duration of exposure, or total number of birds exposed. According to these officials, it is difficult to relate laboratory data (calculations of LD_{50} doses using test species) to the field environment (actual exposure of birds): While laboratory testing may establish that a chemical is highly toxic to birds, the probability of birds being exposed to this chemical may in fact be very low.

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[7]An LD_{50} is the calculated median dose that kills 50 percent of a test population. This dose, administered orally, is measured in milligrams of pesticide per kilogram of body weight.

[8]The Office of Pesticide Programs was responsible for preparing EPA's risk assessment. In doing so, it consulted with other EPA offices, including the Office of Policy Analysis.

The FIFRA Scientific Advisory Panel[9] concluded that EPA's use of risk indices was conservative in assessing the actual risks posed by carbofuran and its alternatives because the number of birds foraging in a treated field will ultimately have more influence on mortality than the number of $LD_{50}s/ft^2$. According to the Panel, many granules would be available to birds over an entire field treated with either carbofuran or an alternative. In addition, in comments provided to EPA in 1989, the National Wildlife Federation and other environmental organizations found that EPA's use of $LD_{50}s/ft^2$ to characterize the toxicity of carbofuran was conservatively biased in favor of the pesticide's registrant. In part, these organizations said that EPA had underestimated the risks of carbofuran by ignoring the adverse impacts it would have on the most sensitive avian species and at the birds' most vulnerable developmental stages. They also said that EPA had not adequately considered the potential for mortality after a sublethal exposure to this pesticide.

According to EPA's risk assessment, the calculation of a risk index for each pesticide was not intended as a quantitative estimate of the number of birds that would be poisoned by use of that pesticide. Instead, EPA's calculations of relative risk were intended only for "gross-level" comparisons among different pesticides.

EPA also acknowledged in its assessment that the risk index does not provide a definitive value for the amount of pesticide that will be readily available to birds. For example, the number of $LD_{50}s/ft^2$ could vary widely, depending on the method used to apply the pesticide, the configuration and calibration of equipment, and field conditions. Also, factors such as the color, shape, and size of the granules may affect the likelihood of a bird's picking up and ingesting them. The species, age, condition, and presence of food in the digestive tract may also affect the toxicity of a pesticide to an individual bird.

EPA's conclusions about the avian risks posed by granular carbofuran were also based on the "full range of available

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[9]The Scientific Advisory Panel is a seven-member panel, established under section 25(d) of FIFRA, that reviews and comments on EPA's proposed actions on registered pesticides. The members represent disciplines such as toxicology, pathology, environmental biology, and related sciences.

data," including not only the acute toxicity of granular carbofuran and its alternatives and comparative risk indices but also field studies and documented incidents of bird kills. Enclosures IV and V provide detailed information on bird mortality noted in field studies and bird-kill incidents, respectively.

Agricultural Uses of Granular Carbofuran Can Result in Exposure and Death of Birds

According to EPA's risk assessment, regardless of regional variation, birds are expected to be present at sites where granular carbofuran is applied, and birds are likely to be exposed when this pesticide is applied. Furthermore, this conclusion has been confirmed by reports of bird kills caused by carbofuran poisoning in many states, in various seasons of the year, under a variety of growing conditions, and associated with many crops. However, according to EPA, a definitive exposure model is not currently available because of differences among bird species; the variety of bird feeding, mating, and migration behavior; and other factors.

According to EPA and FWS, birds may be exposed to granular carbofuran through several routes, including direct ingestion of granules, ingestion of contaminated food, and drinking or bathing in puddles that form on treated fields after rain or irrigation. Predatory or scavenging birds may be secondarily exposed to the pesticide by feeding on small birds or other animals poisoned by granular carbofuran. In addition, the disorientation and loss of coordination associated with sublethal exposure to granular carbofuran may have adverse effects on birds, including increased vulnerability to predators, inability to care for their young, and impaired flying that could result in fatal injury. For waterfowl, loss of coordination may lead to drowning.

According to EPA and FWS officials, the primary application of granular carbofuran on sorghum occurs during planting. Birds are present during planting because they are attracted by the presence of seed and insects exposed in the freshly tilled or otherwise disturbed soil. Some bird species will also probe below the soil's surface in search of these food sources. EPA noted that various researchers have observed that birds seem to be attracted to carbofuran granules, possibly because of the similarities between the granules and grit and certain foods such as seeds.

The FMC Corporation has proposed a number of measures to reduce avian exposure to granular carbofuran, including (1) reducing the maximum application rate from 4 pounds of active ingredient per acre to 1 pound per acre; (2) using an in-furrow application method that incorporates most of the pesticide granules into the soil; and (3) using a hydraulic cut-off device that prevents granules from escaping when planting machinery is lifted off the ground at the end of every row (turn-row). However, EPA concluded that although these measures may reduce the number of granules on the soil's surface, they do not proportionally reduce the risk to birds. EPA found that because granular carbofuran is so highly, acutely toxic to birds--one granule is sufficient to kill a small bird--substantial risk reduction was only possible if the probability that birds would consume even a single granule was reduced.

EPA cited documentation from both field studies and bird-kill incidents that confirms that bird deaths result from the proper application of 1 pound or less of active ingredient per acre, even with use of the in-furrow application method. For example, EPA cited a 1990 bird-kill incident in which a Virginia farmer applied granular carbofuran to a corn field at a rate of 0.45 pounds of active ingredient per acre using the in-furrow application method. Nevertheless, Virginia wildlife authorities recovered 200 dead songbirds of various species in this incident. Enclosure IV provides information on the results, both in terms of $LD_{50}s/ft^2$ and carcass counts, of field tests that employed risk reduction measures such as reduced application rates and the in-furrow application method, and field tests that did not employ these measures.

Regarding the use of the cut-off device, EPA noted that while this device may help to minimize the release of granules at turn-rows at a field's edge, granules are still present throughout a treated field. Moreover, field studies and reports of bird-kill incidents have documented that birds are poisoned throughout treated fields, not just along the edges.

Although FWS supports EPA's conclusions on these risk reduction proposals, USDA, the FMC Corporation, and NGSPA have said that EPA's conclusion presumes a standard of acceptable risk that is too strict.[10] For example, in

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[10]EPA selected one LD_{50}/ft^2 as the cutoff level of concern because data from field studies indicated that pesticide applications resulting in at least one LD_{50}/ft^2 had resulted

written comments provided to EPA in 1989, USDA stated that the risk reduction proposals were summarily rejected by EPA because a proposed change in application of the pesticide or an altered parameter might still result in the death of birds. According to USDA, if EPA's ultimate criterion for deciding the fate of a pesticide rests on zero bird deaths compared with the benefits, rather than on reasonable risk compared with the benefits, the adverse impact of EPA's special reviews on U.S. agriculture will be serious.

EPA Focused on Toxicity to Individual Birds, Not Effects on Bird Populations

EPA's risk assessment focused on toxicity to individual birds rather than the effects on bird populations. However, according to EPA and FWS, the bird deaths attributable to carbofuran poisoning may be an additional factor contributing to the population status of some species, including species thought to be in decline. Moreover, raptor species such as eagles and hawks commonly produce only a few young per year and are slow to reach sexual maturity. Thus, the death of any member of these species could have important consequences for a localized population.

FWS officials added that bird poisonings due to granular carbofuran may subject the user to prosecution under the Migratory Bird Treaty Act, the Endangered Species Act, or the Bald and Golden Eagle Protection Act. According to these officials, under these acts, a user can be held accountable for poisonings caused by carbofuran even if the product is used in compliance with the instructions on the pesticide's label. Similarly, the FIFRA Scientific Advisory Panel said that it was appropriate for EPA to take regulatory action on granular carbofuran to mitigate the risks that this pesticide presents to species protected by these acts.

Officials in EPA's Office of Pesticide Programs stated that their risk assessment did not focus on the effects on bird populations because, under FIFRA, EPA is not required to demonstrate these effects before finding that a pesticide presents unreasonable risks. These officials pointed to the decision in Ciba-Geigy Corporation v. U.S. EPA[11] as

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in bird deaths. In some cases, bird deaths were documented at applications of less than one LD_{50}/ft^2.

[11]874 F.2d 277 (5th Cir. 1989).

confirmation of the agency's position. This case dealt with EPA's proposed cancellation of certain uses of diazinon (a pesticide) because of concerns about acute avian toxicity. The court held, in part, that EPA had discretion under FIFRA to determine that recurring bird kills are an unreasonable effect, even if they do not significantly reduce bird populations. The court found that even if EPA was required to consider the effects of diazinon on bird population alone, the agency would be required to find only a risk to that population, not an actual reduction in it.

Others believe that the effects on bird populations should be considered, however. According to USDA's 1989 Biologic and Economic Assessment of Carbofuran, USDA found little or no evidence to document that granular carbofuran, when applied and incorporated according to label instructions, causes anything other than incidental killing of wildlife. Therefore, agricultural uses of granular carbofuran pose little hazard to populations of birds or other wildlife. The FMC Corporation and NGSPA officials also maintain that relatively few birds are killed following applications of granular carbofuran and that this level of mortality does not have a significant impact on avian populations. As evidence, these officials said that there had been only one documented bird-kill incident associated with sorghum uses of granular carbofuran in over 20 years of usage.

In addition, officials in EPA's Office of Policy Analysis said that, when compared with the total U.S. bird population and the total number of birds dying from all causes each year, bird deaths caused by carbofuran seem incidental. They explained that the annual U.S. bird population is about 20 billion birds and that annual bird deaths number about 10 billion. In contrast, the number of documented bird deaths resulting from carbofuran poisoning traceable to corn uses totaled about 1,150 for the 21-year period 1972-92.[12] These officials acknowledged that (1) reports of bird-kill incidents may significantly underestimate the actual number of carbofuran-related deaths occurring and (2) using the aggregate number of birds reported killed in these reports without reference to the species may ignore the adverse impacts of killing even a few birds of some species. Nevertheless, these officials

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[12]Incidents related to corn uses of granular carbofuran were selected because corn is the major agricultural use for this pesticide. EPA estimated in November 1991 that about 65 percent of granular carbofuran is used on corn.

said that 1,150 bird deaths due to carbofuran compared with an estimated 210 billion bird deaths from all causes during the same period does not seem significant. Even if the actual number of deaths caused by carbofuran were one million times greater (1.15 billion), this would still represent only 0.5 percent of all bird deaths in the United States during this 21-year period.

Officials in EPA's Office of Pesticide Programs said that they were familiar with the views of officials in the Office of Policy Analysis about the effects on avian populations. However, these officials said that because (1) FIFRA does not require that effects on populations be demonstrated; (2) the actual number of birds being poisoned is much higher than the carcass counts in field tests and incident reports; and (3) poisonings due to carbofuran may have an additive effect on the population status of some species, EPA's overall conclusion that the agricultural uses of this pesticide should be canceled was appropriate.

Acute Human Health Concerns Are Similar for Carbofuran and Its Alternatives, But Some Alternatives Also Present Chronic Concerns

According to EPA, the principal alternatives to granular carbofuran for sorghum uses are aldicarb, carbaryl, flowable (liquid) carbofuran, chlorpyrifos, disulfoton, parathion, and terbufos. Generally speaking, granular carbofuran and these alternatives present similar acute human health concerns for farmworkers in the event of accidental exposure. However, some of these alternatives also present chronic health concerns for farmworkers. These chronic concerns include carcinogenic, mutagenic, and teratogenic (developmental) effects. Enclosure VI provides information on the acute and chronic human toxicity concerns associated with each of these pesticides and EPA's conclusions on the suitability of each alternative as a substitute for carbofuran in terms of human toxicology.

EPA officials said that all pesticides are potentially hazardous to farmworkers if they do not heed the label's instructions and warnings on the handling and application of these chemicals. For example, because granular carbofuran is poisonous if swallowed and may be fatal or harmful as a result of contact with the skin or eyes or inhalation of its dust, the label for this pesticide warns users to wear long-sleeved clothing and gloves when handling it and to wash their hands and face before eating and smoking.

According to EPA documents, however, liquid-formulated pesticides are generally more difficult to work with than granular formulations. Granular pesticides were developed in the 1960s as an alternative to liquid formulations in order to reduce farmworkers' exposure when applying pesticides. By their nature, liquid formulations are more susceptible to spills or splashes that could result in contact with the skin. Also, the spraying of liquid formulations raises concerns about exposure resulting from inhalation of or contact with the skin and eyes with drifting pesticide mist. For example, the label for flowable carbofuran warns users to wear an approved pesticide respirator and goggles or a face shield as well as protective clothing when applying the pesticide. In addition, drifting pesticide mist may present a hazard to others living or working near treated fields.

Alternative pesticides may also present other problems, according to EPA and FMC Corporation documents. For example, carbofuran is a carbamate (carbamic-acid-containing) pesticide, whereas several of its alternatives are organophosphate (phosphorus-containing) pesticides.[13] Both carbamates and organophosphates are neurotoxicants. In general, the neurotoxicity produced by exposure to carbamates is more readily reversible than that resulting from similar exposure to organophosphates.[14] In addition, the difference between the dosage of carbofuran resulting in minimal toxic effects and the lethal dose is relatively large, providing an opportunity for a farmworker to be aware of exposure and to take appropriate action. In contrast, organophosphate pesticides generally produce symptoms only at dosages that are close to lethal. Consequently, accidental exposure to carbofuran is more likely to be detected and treated before the onset of severe or lethal effects than is accidental exposure to an organophosphate.

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[13]Alternative pesticides for sorghum uses that are organophosphates are listed in enclosure VI.

[14]EPA officials said that carbamate poisoning may be reversible within hours of exposure, while organophosphate poisoning may take weeks to reverse.

EPA CONCLUDED THAT THE ECONOMIC IMPACTS OF CANCELING SORGHUM USES OF GRANULAR CARBOFURAN WOULD BE MINIMAL

In its assessment of economic impacts, EPA concluded that the cost to growers[15] of canceling sorghum uses of granular carbofuran would be relatively low, ranging from $2.6 million to $10.7 million annually,[16] depending on the severity of pest infestation problems in a given year.[17] In addition, EPA concluded that the overall effect on U.S. sorghum production of this cancellation would be minimal, with annual losses amounting to less than 1 percent of national production. However, both USDA and the FMC Corporation have estimated significantly higher costs to growers of canceling sorghum uses. USDA has estimated these costs at $18.1 million annually, while the FMC Corporation predicts that these costs would range from $64.6 million to $65.3 million per year. Enclosure VII provides information on how each determined its estimate.

Economic Impacts of Cancellation Vary Regionally With Level of Pest Infestation Problems

Although EPA views the overall costs of canceling sorghum uses of granular carbofuran as being relatively low, it noted that the economic effects may be significant in

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[15]According to EPA, the costs of canceling the sorghum uses of granular carbofuran derive, in part, from the increased production costs that growers would experience as they turned to more expensive alternative pesticides that, in some cases, might also require more frequent application. The costs also derive from diminished revenues if growers use less-effective alternative pesticides and have lower yields as a result.

[16]Using data from crop year 1988, EPA estimated that the value of U.S. sorghum production was in excess of $1 billion.

[17]EPA viewed the overall effect on sorghum consumers to be negligible. According to the agency's assessment, sorghum is an important source of feed for the livestock industry. As a result, feedlots located in areas of major chinch bug infestation could be affected by reductions in local sorghum production attributable to canceling sorghum uses of granular carbofuran. For example, these feedlots may have to pay more for sorghum because of the increased costs of transporting this grain product from other parts of the country.

sorghum-growing regions that experience periodically high infestations of the chinch bug.[18] EPA estimated the economic impact of canceling sorghum uses on each of four major sorghum-producing areas in the United States: (1) tall grass prairie; (2) Mississippi Valley states; (3) coastal and east central Texas; and (4) short grass prairie. According to EPA, these four regions include about 9 million acres of sorghum and account for approximately 87 percent of all U.S. sorghum acreage.

EPA concluded that the economic impacts of canceling sorghum uses of granular carbofuran are highest in the tall grass prairie region. This region, which includes eastern Kansas, southeastern Nebraska, and eastern Oklahoma, experiences very high infestations of chinch bugs, particularly during droughts. EPA estimated the annual costs of the cancellation in the tall grass prairie region to be $8.9 million during peak infestation years. In contrast, these costs would be only about $0.8 million in low infestation years. EPA also noted that in high infestation years, this region accounts for about 75 percent (by weight) of all granular carbofuran applied to sorghum acreage nationwide.

Enclosure VIII provides further information on EPA's estimates of the economic impacts of canceling sorghum uses of granular carbofuran on each of the major sorghum-producing regions. Enclosure IX provides further information on the use of granular carbofuran by region.

Some Alternatives Are Nearly as Effective as Granular Carbofuran, but They May Also Have Disadvantages

Some of the alternative pesticides[19] identified in EPA's

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[18]The primary use of granular carbofuran on sorghum is to prevent and control chinch bug infestations. The pesticide is also used to control other sorghum pests, including the greenbug, yellow sugarcane aphid, and southern corn rootworm.

[19]In addition to chemical alternatives, sorghum growers may also employ nonchemical measures to help control pest infestations. These include barrier strips between fields to reduce chinch bug migration, delayed planting, and the planting of sorghum varieties with greater resistance to pests. EPA concluded, however, that because the economic returns of sorghum farming are relatively low, growers

assessment of economic impacts are nearly as effective as granular carbofuran in controlling sorghum pests, but they are generally more costly. Among the alternatives to granular carbofuran, EPA concluded that aldicarb and flowable carbofuran are as effective as granular carbofuran in controlling the chinch bug when these pesticides are applied at planting time. However, EPA also noted that aldicarb was almost twice as expensive as granular carbofuran and that flowable carbofuran was over a third more costly than its granular formulation.

Besides expense, EPA cited other possible disadvantages of the alternatives to granular carbofuran. For example, sorghum growers who chose flowable carbofuran as an alternative to the granular formulation would have to retrofit their planting machinery to properly dispense the liquid. According to EPA, a retrofit would involve a one-time cost of about $1,000. An FMC Corporation official estimated, however, that a retrofit would cost $3,000. This official concluded that this cost may be too great for sorghum growers with small farms (100 to 200 acres). FMC Corporation and NGSPA officials also said that some sorghum growers, aware that flowable carbofuran is being assessed by EPA for avian toxicity risks,[20] may be hesitant to make this investment because they anticipate regulatory action by EPA against this pesticide in the future.

In addition, EPA observed that because granular carbofuran has such a large market share in the tall grass prairie and Mississippi Valley states regions, sorghum growers in these areas have very little experience with alternative pesticides. For example, sorghum growers opting to use flowable carbofuran as an alternative may find this pesticide more difficult (and potentially more hazardous)

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already employ many of these measures to keep their production costs down. As a result, nonchemical controls cannot fully replace the use of pesticides.

[20]In addition to flowable carbofuran, other alternative pesticides being assessed by EPA for avian toxicity risks are terbufos and parathion. The agency's initial assessments of these risks could lead to the initiation of formal special reviews of these chemicals. Aldicarb is currently in special review because of concerns about groundwater contamination. EPA officials cautioned, however, against making any assumptions about possible regulatory actions against any of these pesticides.

to work with because of their lack of familiarity with carbofuran's liquid formulation.

EPA also determined that the preferred alternatives in the tall grass prairie region--aldicarb and flowable carbofuran--are not available to Nebraska growers whose farms lie in this region. State authorities have restricted the use of aldicarb because of concerns about groundwater contamination. Nebraska growers also cannot use flowable carbofuran for in-furrow application on sorghum because the state has not issued a special local needs registration under FIFRA section 24 (c)[21] for this use.

Because aldicarb is not available to Nebraska growers and they cannot apply flowable carbofuran using the in-furrow method, these growers will have to use other pesticides and/or application methods that are less effective, including foliar application of carbaryl, chlorpyrifos, and flowable carbofuran.[22] EPA concluded that use of these pesticides would lead to a 10- to 25-percent loss in yields for these growers.

EPA cited fewer problems in finding effective and economical alternatives for granular carbofuran in the other sorghum-growing regions. For example, in the coastal and east central Texas region, many growers will probably use terbufos as an alternative, although some will opt for flowable carbofuran applied in furrow. In the short grass prairie region, parathion would probably be the preferred alternative. However, in the Mississippi Valley states region, EPA estimated that growers who opt to use foliar-applied alternatives, such as carbaryl, chlorpyrifos, and flowable carbofuran, would incur a 4- to 7-percent reduction in yields. (See enclosure VII for additional information on the alternatives that growers are likely to use, including the views of USDA and the FMC Corporation on this subject.)

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[21]A section 24 (c) registration may be granted by a state to provide for an additional use of a federally registered pesticide to meet special local needs.

[22]Nebraska has issued a section 24 (c) registration for the foliar (spray) application of flowable carbofuran.

SCOPE AND METHODOLOGY

To obtain information on EPA's assessments of the risk and economic impacts, we reviewed copies of these assessments and related documents from EPA's Office of Pesticide Programs' public docket.[23] We also interviewed and obtained relevant documentation from responsible EPA program officials in both the Office of Pesticide Programs and the Office of Policy Analysis.

To obtain the views of other interested parties on EPA's assessments, we interviewed and obtained documentation from responsible officials representing FWS' Division of Environmental Contaminants and Division of Law Enforcement, USDA's National Agricultural Pesticide Impact Assessment Program, the FMC Corporation, and NGSPA. We also reviewed copies of relevant comments submitted to EPA's Office of Pesticide Programs' public docket by various state, environmental, and ornithological organizations.

We conducted our review during June and July 1994 in accordance with generally accepted government auditing standards. We did not independently validate data obtained from EPA's risk and economic impact assessments or other documentation; hence, we have not drawn any independent conclusions on the validity of those data or the related analyses.

We discussed the contents of this correspondence with officials representing EPA, FWS, and the FMC Corporation. They agreed that the positions and data attributed to them in this correspondence were accurate. In a few instances, they provided new or clarifying information that we incorporated as appropriate.

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[23]EPA's special review docket contains notification letters, position documents, scientific reports, and Federal Register notices issued during the course of a special review. The docket also contains comments, correspondence, and any other materials submitted to EPA by outside parties after a special review is initiated.

If you have any questions, please contact me at (202) 512-5138 or Julie Gerkens of my staff at (202) 512-9824. Major contributors to this correspondence were Julie Gerkens, Jim Jones, and Isidro Gomez of the Resources, Community, and Economic Development Division in Washington, D.C.

for Robert A. Robinson

John W. Harman
Director, Food and
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Enclosures - 9

CRITERIA FOR INITIATING SPECIAL REVIEW

The Environmental Protection Agency's (EPA) criteria for initiating special reviews is contained in the U.S. Code of Federal Regulations (40 C.F.R. part 154.7). In part, this regulation provides that the EPA Administrator may conduct a special review of a pesticide use if the Administrator determines, on the basis of a validated test or other significant evidence, that the use of the pesticide may

-- result in residues in the environment of nontarget organisms at levels that equal or exceed concentrations acutely or chronically toxic to such organisms, or at levels that produce adverse reproductive effects in such organisms, as determined from tests conducted on representative species or from other appropriate data;

-- pose a risk to the continued existence of any endangered or threatened species designated by the Secretary of the Interior or the Secretary of Commerce under the Endangered Species Act of 1973; or

-- otherwise pose a risk to humans or the environment that is of sufficient magnitude to merit a determination of whether the use of the pesticide product offers offsetting social, economic, and environmental benefits that justify initial or continued registration.

In determining that a pesticide use satisfies one of the criteria for initiating special review, the regulation provides that the EPA Administrator shall consider available evidence on both the adverse effect in question and the magnitude and scope of exposure of humans and nontarget organisms resulting from use of the pesticide.

CHRONOLOGY OF EPA'S SPECIAL REVIEW OF GRANULAR CARBOFURAN

Oct. 1985	EPA initiates its special review of granular carbofuran because of concerns about acute avian toxicity.
Feb. 1989	EPA presents its avian risk assessment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Science Advisory Panel.
Jan. 1989	EPA proposes canceling all uses of granular carbofuran because of its finding that the risks of continued use outweigh the benefits.
Oct. 1990	EPA issues Final Benefit Analysis of Granular Carbofuran Use on Sorghum.
Spring 1991	EPA issues Hazard to Birds Associated with Granular Formulations of Carbofuran.
May 1991	EPA signs an agreement in principle with the FMC Corporation. This agreement provides for phasing out 99 percent of the agricultural uses, including sorghum uses, of granular carbofuran over the following four growing seasons (by Aug. 31, 1994). The agreement also provides that the FMC Corporation will have the opportunity to present new information on risks and benefits to EPA before completion of the phase-out period, which could lead to continued use of granular carbofuran on some or all sites where sorghum is grown (to be determined by EPA).
Nov. 1991	EPA issues Granular Carbofuran, Conclusion of Special Review, Technical Support Document. This final determination concludes the special review.
Oct. 1993	FMC Corporation representatives met with EPA officials to present, among other things, new information in support of reinstating sorghum uses of granular carbofuran. After reviewing this and other new information, EPA concludes that sorghum uses of this pesticide continue to present an unreasonable risk of acute avian toxicity.

Apr. 1994	EPA issues a Federal Register notice proposing to deny FMC Corporation's request for reinstatement of sorghum uses of granular carbofuran.[1] However, this notice also invites further comments from interested parties regarding EPA's proposed decision; the deadline for submitting comments is July 12, 1994.
Aug. 1994	As of August 22, 1994, EPA officials indicate that they are still assessing the comments received in response to the agency's proposal to deny reinstatement of sorghum uses of granular carbofuran.

[1]59 FR 17530.

EPA'S USE OF MEDIAN SINGLE LETHAL DOSES TO COMPARE THE TOXICITY OF GRANULAR CARBOFURAN WITH THAT OF ITS ALTERNATIVES

In its assessment of the risk to birds, EPA calculated indices of the relative risk of granular carbofuran and alternative pesticides. For most of these alternatives, data were available to describe the median single lethal dose (LD_{50})[2] for representative species, including waterfowl, upland game birds, and songbirds.[3] The manner of exposure (ingestion of granules) is comparable to that used in LD_{50} toxicity testing in a laboratory setting (i.e., a discrete oral dose, such as one granule). EPA therefore concluded that the use of LD_{50} values was an appropriate toxicity parameter for assessing the hazard to birds of granular pesticides.

EPA then compared the acute toxicity (the number of granules equivalent to an LD_{50} dose) to estimates of exposure (the number of granules exposed and available to birds per unit area) for granular carbofuran and its alternatives. These comparisons, or risk indices, were expressed as the number of LD_{50}s per square foot ($LD_{50}s/ft^2$) of treated ground. On the basis of this analysis, EPA concluded that granular carbofuran generally poses a greater risk to birds than its alternatives.

In developing these indices, EPA made certain assumptions. For example, it calculated the exposure resulting from application of nongranular (liquid) alternatives as if all the applied pesticide would be available to the birds via oral exposure. While this approach may overestimate the potential exposure via ingestion of the liquid formulation, EPA pointed out that the use of nongranular formulations can result in other forms of exposure for birds, such as inhalation, absorption through the skin, and oral exposure resulting from preening.

EPA also had to work within certain limitations in the data. These limitations included the lack of data for each granular

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[2]This is the calculated median dose that kills 50 percent of a test population. This dose, administered orally, is measured in milligrams of pesticide per kilogram of body weight.

[3]According to 40 C.F.R. 158.490(a), EPA considers the mallard duck and bobwhite quail the preferred species for avian LD_{50} testing. No particular songbird species is identified. In its risk assessment, EPA used these species in assessing the acute avian toxicity of granular carbofuran versus that of alternative pesticides.

formulation of each pesticide. Also, data were not available for all formulations of a given pesticide. For example, data on the toxicity for granular carbofuran were only available for the "10G" (10-percent active ingredient) formulation. Because of these limitations, EPA used data on the toxicity of the technical grade of each pesticide (before combination with inert ingredients) or other formulation with a high percentage of the active ingredient to standardize the selection criteria among chemicals and formulations.

MORTALITY DOCUMENTED BY FIELD STUDIES

According to EPA's risk assessment, it is well established that birds receive lethal doses of granular carbofuran under actual field conditions. This has been verified by the results of eight field studies conducted on the use of this pesticide on three crops (corn, rice, and pine seedlings) in 10 states. Six of these studies were done on sites where corn was planted. No field studies have been done on sorghum sites. EPA officials said, however, that corn and sorghum uses of this pesticide are comparable, so the potential risk to birds at both sites is comparable.

According to EPA, all of these field studies consistently resulted in the death of birds regardless of the application rate or methods, including methods designed to incorporate pesticide granules into the soil. A diversity of avian species were affected, including waterfowl, upland game birds, shorebirds, predatory birds, and songbirds. In several studies, the death of nonavian wildlife due to carbofuran poisoning was also observed.

The following table provides information on each of the field studies done on corn sites, including the method and rate of application, the number of dead birds found, and the estimated number of median single lethal doses per square foot ($LD_{50}s/ft^2$) occurring on the soil surface[4] for each of three representative species.

[4]The number of $LD_{50}s/ft^2$ will depend on both the rate and method of application.

ENCLOSURE IV

Table IV.1: Summary of Field Studies for Corn Uses of Granular Carbofuran

Field study location	Year	Formulation[a]	Application method	Pounds active ingredient per acre	Number of carcasses	Risk indexes in treated acres[b]		
						Songbird	Game bird	Waterfowl
Utah	1982	10G & 15G	Band[c]	4	877	1,179	29	61
Maryland	1980	10G	In-furrow[d]	1	10	62	1	3
Maryland	1980	10G	In-furrow	1	23	62	1	3
Illinois	1986	10G & 15G	Band	1	92	401	9	20
Iowa	1986	10G & 15G	Band	1	32	401	9	20
Texas	1986	10G & 15G	In-furrow	1	58	62	1	3
Florida[e]	1986	10G & 15G	In-furrow	1	--	--	--	--
Illinois	1990	15G	Band	1	92	401	9	20
Illinois	1990	15G	T-band[f] with cut-off device	1	82	222	5	11

[a]Carbofuran's granular formulations include 10G (10-percent active ingredient) and 15G (15-percent active ingredient). In both cases, a silica-based granular carrier is impregnated with the pesticide.

[b]EPA calculated risk indices on the basis of the number of median single lethal doses (LD_{50}s) of granular carbofuran per square foot for each of three representative species. A given number of granules on a square foot of treated ground would include more LD_{50}s for a songbird than for a larger game bird or waterfowl; for some songbirds, ingestion of a single granule is fatal. The total number of granules per square foot is determined by the method and rate of application.

[c]Refers to placing a strip of pesticide granules over and adjacent to the seed furrow. EPA estimates that approximately 15 percent of the granules remain on the soil's surface.

[d]Refers to dropping pesticide granules directly into the seed furrow. EPA estimates that about 1 percent of the granules remain on the soil's surface.

[e]According to EPA, this study was disrupted by unrelated agricultural activities that precluded the opportunity for birds to be exposed to carbofuran.

[f]Incorporates band and in-furrow applications: Granules are spread in a band over an open furrow. EPA estimates that approximately 7 percent of the granules remain on the soil's surface.

Source: Hazard to Birds Associated with Granular Formulations of Carbofuran, EPA, Spring 1991.

MORTALITY DOCUMENTED BY REPORTS OF BIRD-KILL INCIDENTS

EPA's risk assessment includes information on many incidents of bird kills due to carbofuran poisoning.[5] Reports of these incidents show that poisonings have occurred throughout the United States and Canada during all four seasons of the year. Data from these reports also show that nearly 100 different species of birds have been poisoned, including waterfowl, shorebirds, upland game birds, songbirds, and raptors. The number of birds poisoned in each incident ranges from 1 to nearly 2,000. While most of these incidents involved normal agricultural uses of granular carbofuran, some involved a misuse of this pesticide. EPA's risk assessment also notes that the documentation for individual incidents typically underrepresents the number of birds poisoned because these reports reflect only those birds collected and/or submitted for laboratory analysis.

Bird-Kill Incidents Include Both Direct and Secondary Carbofuran Poisonings

EPA's risk assessment describes both direct and secondary bird poisonings due to carbofuran. While most of these incidents involved the use of granular carbofuran, others were associated with the flowable formulation of this pesticide. For some incidents, it was not possible to determine whether the granular or liquid formulation was involved.

The assessment describes over 100 bird-kill incidents involving direct carbofuran poisoning through ingestion of carbofuran granules or contaminated insects. Only documented incidents, in which bird carcasses were recovered and analyzed, are included in this tally. This documentation typically included (1) a postmortem examination to determine the cause of death, (2) a chemical screen to determine the presence of carbofuran residues, (3) an examination of brain tissues to ascertain possible neurotoxic effects, and (4) an investigation by state or federal wildlife authorities describing the circumstances of the incident.

EPA also has information on over 40 bird-kill incidents involving secondary exposure to carbofuran. These incidents involve predatory and scavenging birds that are exposed to carbofuran from eating contaminated prey, including small birds and other wildlife. Many, but not all of these incidents were documented as described above; in other cases, circumstantial

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[5]A neurotoxicant, carbofuran kills by inhibiting an organism's normal neurological function.

evidence led to the conclusion that carbofuran poisoning was the cause.

Although EPA has information on many documented bird-kill incidents, only one of these incidents--a bird-kill involving starlings in Texas--involved sorghum uses of this pesticide. EPA officials said, however, that given the difficulty of detecting, diagnosing, and reporting bird kills, the lack of documentation of such kills cannot be construed as evidence that no poisonings have occurred. Moreover, these officials said that numerous documented bird kills have been associated with corn uses of granular carbofuran and that these uses are very similar to those for sorghum.

Some Bird-Kill Incidents Involve Misuse of Carbofuran

EPA also cited bird-kill incidents resulting from the misuse of granular carbofuran. By EPA's estimate, about 25 percent of the direct poisonings involved a misuse, such applying the pesticide contrary to the label's instructions or restrictions. EPA noted, however, that a significant number of secondary poisonings resulted from the deliberate and illegal misuse of granular carbofuran to poison bait (such as animal carcasses or other meat) intended for nuisance predators.[6] For example, some ranchers have used carbofuran-laced bait to control coyotes. Predatory and scavenging birds have also been fatally poisoned by eating this bait.

EPA officials stated that they included information on misuses in their risk assessment because these incidents are so numerous as to be considered a "widespread and commonly recognized practice"[7] under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. When such a practice "generally causes unreasonable adverse effects on the environment,"[8] EPA can initiate action to cancel the registration of the pesticide involved. These officials said, however, that EPA's cancellation of most uses of granular carbofuran was not based simply on this pesticide's misuse, but on a preponderance of evidence that indicated that legitimate

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[6]According to EPA officials, carbofuran is not registered for use as a predacide.

[7]Section 6(b).

[8]Section 6(b).

agricultural uses of this pesticide presented unreasonable risks of avian toxicity.[9]

Reports of Bird-Kill Incidents May Understate Actual Deaths

According to EPA and FWS officials, reporting on bird-kill incidents is a poor indicator of the extent of deaths caused by granular carbofuran. These officials cited the lack of a national system for reporting incidents, the difficulty of finding bird carcasses, and the reluctance of some farmers to report bird-kills as factors that lead to significant undercounting of the actual number of birds being killed by this pesticide.

Currently, a comprehensive national system for collecting data on bird kills does not exist. EPA and FWS officials said that although bird kills are sometimes investigated and reported by state-level wildlife agencies to their federal counterparts, this reporting varies considerably in frequency and comprehensiveness from state to state. Because of the lack of a national clearinghouse for reporting bird-kill incidents, EPA and FWS officials said that it is difficult to determine the true number of poisonings caused by granular carbofuran that may be occurring.[10]

According to EPA and FWS documents, bird carcasses, especially those of small birds, are difficult to find when searching a field. These carcasses are not large enough to be conspicuous and, especially in a no-till field,[11] their natural camouflage makes them difficult to spot. Moreover, birds that move into woods or overgrowth bordering fields before dying are

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[9]EPA's risk assessment did not address whether removing granular carbofuran from the market would discourage perpetrators of illegal baiting, or whether they would simply use other chemicals to continue this activity.

[10]To address this problem, FWS, in consultation with EPA and state authorities, has proposed establishing a Mortality Incident Assessment Program. Among other goals, this national program would create a central repository for data on bird-kill incidents and on kills of other wildlife species. The program would also establish a standardized approach to investigating, documenting, and reporting kills. According to FWS officials, as of July 1994, funding to implement this program had not been authorized.

[11]A no-till field is one in which old plant growth has not been turned under before seeding.

virtually impossible to find. According to these officials, the difficulty of finding bird carcasses has been demonstrated in simulated field tests, in which carcasses have been placed in fields and border vegetation for purposes of training field monitors. Even after being given detailed instructions on how to conduct searches, these monitors still miss most of the carcasses. For example, EPA cited a simulated field test in which only 12 percent of the bird carcasses placed in a field were found by trained monitors. Virtually none of the carcasses placed in overgrowth along the field's edge were discovered by these monitors.

EPA and FWS documents also indicate that bird carcasses are difficult to find because predators and scavengers--both birds and mammals--quickly remove these carcasses from fields. For example, FWS officials estimated that about 90 percent of the carcasses disappear within 24 hours of a poisoning incident. Also, these officials said that many sick birds will instinctively go into hiding because of their vulnerability to predators, making their carcasses virtually impossible to find.

Although the label for granular carbofuran directs users to contact their state wildlife agency or FWS if they find dead birds or other animals that may have been poisoned by this pesticide, EPA and FWS officials said that some farmers may be reluctant to do so because they fear possible prosecution under statutes protecting wildlife. For example, the label for granular carbofuran warns users that it is a federal offense to use any pesticide in a manner that results in the death of a member of an endangered species.

In addition, FWS officials said that discovery of a bird-kill incident often depends on "dumb luck." For example, dead birds lying on a field may be noticed and reported to authorities by passersby, such as hikers or hunters. In one case, an eagle killed by carbofuran in Virginia was discovered by a Civil War buff prospecting with a metal detector; this person was drawn to the carcass because the eagle carried a metal band previously applied by wildlife authorities. Moreover, because scavengers remove carcasses rapidly, timing is crucial to the coincidental discovery of a bird-kill incident. A passersby walking near a field 2-3 days after a poisoning incident may not see any carcasses.

ENCLOSURE VI

EPA'S QUALITATIVE TOXICOLOGICAL ASSESSMENT OF CARBOFURAN AND ALTERNATIVE PESTICIDES FOR SORGHUM USES

Pesticide	Chemical family	Acute toxicity	Chronic toxicity	Toxicology conclusion for alternative[a]
Aldicarb	Carbamate (granular)	Yes, highly	Teratogenic (developmental effects); groundwater contamination	Poor candidate
Carbaryl	Carbamate (flowable)	Yes, low to moderate	Weak mutagenic[b]	Good candidate
Carbofuran	Carbamate (granular and flowable)	Yes	No	Not an alternative[c]
Chlorpyrifos	Organophosphate (granular and flowable)	Yes, moderately	Possible mutagenic	Good candidate
Disulfoton	Organophosphate (granular and flowable)	Yes, highly	Highly mutagenic; reproductive effects; effects on eyes	Poor candidate
Parathion	Organophosphate (flowable)	Yes, highly	Possible carcinogenic; eye lesions	Poor candidate
Terbufos	Organophosphate (granular)	Yes	No	Good candidate

[a]"Toxicology conclusion for alternative" refers to the suitability of a chemical as an alternative to carbofuran, based on a comparison of the potential human heath effects associated with each according to available data on toxicity to animals.

[b]In the Status of Pesticides in Reregistration and Special Review (EPA, June 1994), this pesticide was also considered a possible carcinogenic and teratogenic.

[c]EPA's assessment of the economic impacts of canceling sorghum uses of granular carbofuran indicated that flowable carbofuran will likely be used by sorghum growers as an alternative to granular carbofuran.

Source: Memorandum, "Toxicology Profiles and Qualitative Assessments of Alternatives to Carbofuran," EPA, Health Effects Division, Apr. 1990.

ENCLOSURE VII

COMPARISON OF ECONOMIC IMPACT ASSESSMENTS OF CANCELING SORGHUM USES OF GRANULAR CARBOFURAN PREPARED BY EPA, USDA, AND THE FMC CORPORATION

Attribute	EPA	USDA	The FMC Corporation
Annual economic impact	$2.6 million to $10.7 million, depending on pest infestation	$18.1 million	$64.6 million to $65.3 million, depending on pest infestation
Estimated acreage covered	600,000 to 1.3 million sorghum acres; years with low and high pest infestation, respectively.	391,000 sorghum acres	600,000 sorghum acres
Target pests	Chinch bug Greenbug Southern corn rootworm Yellow sugar cane aphid	Chinch bug	Chinch bug Greenbug
Alternative pesticides	Aldicarb Carbaryl Chlorpyrifos Disulfoton Flowable carbofuran Parathion Terbufos	Aldicarb Carbaryl Chlorpyrifos Flowable carbofuran Terbufos	Aldicarb Terbufos
Basic assumptions	Considered four sorghum-growing regions and estimated yield impacts on the basis of use of seven alternative pesticides. Estimated that use would vary by region but concluded that aldicarb and flowable carbofuran would most likely be used as alternatives. Analysis focused on tall grass prairie region because of higher use of granular carbofuran during high infestations of chinch bugs. Estimated that highest losses in sorghum yields occur in portions of Nebraska in this region (10 to 25 percent) and in Mississippi Valley states region (4 to 7 percent).	Estimated losses for six sorghum-producing states (Kansas, Louisiana, Mississippi, Nebraska, Oklahoma, and Texas), with highest losses expected in Kansas and Nebraska. Areas considered in analysis are similar but not the same as those in EPA's analysis. Identified five pesticides as alternatives to granular carbofuran but did not evaluate their impact on yields. Concluded that unavoidable losses due to chinch bug damage would occur without the use of granular carbofuran.	Projected estimated impacts to all sorghum acreage but did not make regional distinctions. Analysis considered only aldicarb and terbufos as practical alternatives to granular carbofuran. Assumed that 75 percent of all sorghum growers would use terbufos and 25 percent would use aldicarb. Also assumed that aldicarb would cause a 20-percent yield reduction, while terbufos would cause a 62-percent yield loss. On the basis of these substitution rates and yield reductions, estimated that a 52-percent loss in yields would occur overall.
Data used in analysis	Analysis based on data from 1988 state agricultural statistics, USDA's 1989 crop data, and expert opinion.	Analysis based on questionnaire responses, computer model, and USDA's 1986-88 crop data.	Analysis adopted USDA computer model and used USDA's 1990-92 crop data.

Sources: Final Benefit Analysis of Granular Carbofuran Use on Sorghum, EPA, Oct. 1, 1990; The Biologic and Economic Assessment of Carbofuran, USDA, Dec. 22, 1989; Analysis of the Economic Benefits of Granular Carbofuran, the FMC Corporation, Aug. 1993.

EPA'S ESTIMATES OF THE REGIONAL ECONOMIC IMPACTS OF CANCELING SORGHUM USES OF GRANULAR CARBOFURAN

Region	Region's production value (1988 dollars in millions)	Estimated annual impact (1988 dollars in millions)	Impact as percentage of production value
Tall grass prairie[a]	$420	low[e] $0.8 to high[f] $8.9	low[e] <0.5% to high[f] 2.0%
Mississippi Valley states[b]	186	1.8	1.0
Coastal and east central Texas[c]	92	0.26	<0.3
Short grass prairie[d]	392	(0.25)	<0

Note: According to EPA, these four regions include about 9 million acres of sorghum and account for approximately 87 percent of all U.S. sorghum acreage.

[a]Includes eastern Kansas, southeastern Nebraska, and eastern Oklahoma. This region experiences very high infestations of chinch bugs, which are most pronounced during droughts.

[b]Includes Missouri, Arkansas, Louisiana, and Mississippi. This region does not experience wide variations in chinch bug infestations.

[c]This region does not experience wide variations in chinch bug infestations, but areas of this region are affected by other pests.

[d]Includes western parts of Kansas, Oklahoma, and Texas, as well as parts of western and northeastern Nebraska and southern Texas. Sorghum growers in this region are primarily concerned with the greenbug.

[e]Estimate for years with low infestations of chinch bugs.

[f]Estimate for years with high infestations of chinch bugs.

Source: Final Benefit Analysis of Granular Carbofuran Use on Sorghum, EPA, Oct. 1, 1990.

EPA'S ESTIMATES OF ANNUAL USE OF GRANULAR CARBOFURAN BY SORGHUM-PRODUCING REGION

Region	Granular carbofuran usage (thousands of pounds)		Regional usage as a percent of U.S. usage	
	Chinch bug infestation		Chinch bug infestation	
	Low	High	Low	High
Tall grass prairie[a]	232	933	43%	75%
Mississippi Valley states[b]	131	131	24	11
Coastal and east central Texas[c]	78	78	15	6
Short grass prairie[d]	85	85	16	7
Rest of U.S.	13	13	2	1
Total	539	1,240	100%	100%

[a]Includes eastern Kansas, southeastern Nebraska, and eastern Oklahoma. This region experiences very high infestations of chinch bugs, which are most pronounced during droughts.

[b]Includes Missouri, Arkansas, Louisiana, and Mississippi. This region does not experience wide variations in chinch bug infestations.

[c]This region does not experience wide variations in chinch bug infestations, but areas of this region are affected by other pests.

[d]Includes western parts of Kansas, Oklahoma, and Texas, as well as parts of western and northeastern Nebraska and southern Texas. Sorghum growers in this region are primarily concerned with the greenbug.

Source: Final Benefit Analysis of Granular Carbofuran Use on Sorghum, EPA, Oct. 1, 1990.

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