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OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

Memorandum

Subject: Final Usage Analysis for terbufos RED

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TERBUFOS USAGE

Terbufos is currently registered for use on 5 crops which are either produced or imported into the US; field corn, sweet/pop corn, sugar beets, sorghum, and banana. Terbufos use per crop as a percentage of total terbufos use is; sweet corn (0.7%), sorghum (2.0%), sugar beets (8.2%), banana (8.9%), and Field corn (79.9%). Field corn is by far the major use for terbufos while sweet corn and sorghum have minimal impact on total terbufos usage in the US.

Terbufos is available in 2 granular formulations (Counter 15G and Counter CR) for use on field corn, field corn grown for seed, popcorn, sweet corn, sugar beets and grain sorghum in the U.S. and an additional formulation (Terbulox) is available for use on banana in South America. Terbufos is registered for use either as a foliar application (at cultivation) or as an at-bedding/at-plant application (banded or in-furrow). However, the predominant application method across all crops is at-plant or post-emergence soil incorporation. Comparison of application rates in Table 1 with those noted in the following crop discussions indicate that substantially lower application rates are actually used in the field. The following crop discussions provide both suggested application rates, as determined from numerous sources (ie. Insect Control Handbook, State Recommendations, etc.) and maximum labeled rates (American Cyanamid).

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Table 1. Usage analysis of Terbufos.

Site	Acres Grown (000)	Acres Treated (000)		% of Crop Treated		LB AI Applied (000)			Average Application Rate			States of Most Usage (% of total lb ai used on this site)
		Wtd Avg	Est Max	Wtd Avg	Est Max	Wtd Avg	Est Max	% Total Terbufos Use	lb ai/acre/yr	#appl / yr	lb ai/A/appl	
Sweet Corn	784	40	50	5%	6%	55	83	0.7%	1.366	1.0	1.34	FL WI MN IL PA ID 63%
Sorghum	11280	249	413	2%	4%	190	344	2.0%	0.763	1.0	0.73	TX KS NM 81%
Corn	71264	5700	7000	8%	10%	6530	8980	79.9%	1.146	1.1	1.08	IA NE IL IN WI CO 67%
Sugar Beets	1415	500	610	35%	43%	670	890	8.2%	1.34	1.0	1.32	MN ND ID WY 87%
Banana	-	-	-	26%	-	729	-	8.9%	4.2	1.0	4.20	Imports

COLUMN HEADINGS

Wtd Avg = Weighted average--the most recent years and more reliable data are weighted more heavily.
 Est Max = Estimated maximum, which is estimated from available data.
 Average application rates are calculated from the weighted averages.
 % Total Terbufos Use = crop use (wtd avg)/sum of all crop (wtd avg)

NOTES ON TABLE DATA

Usage data primarily covers 1987 - 1996. Calculations of the above numbers may not appear to agree because they are displayed as rounded;
 1) to the nearest 1000 for acres treated or lb. a.i. (Therefore 0 = < 500) or
 2) to the nearest whole percentage point for % of crop treated. (Therefore 0% = < 0.5%)
 A dash (-) indicates that information on this site is NOT available in EPA sources or is insufficient.

SOURCES: EPA data, USDA, and National Center for Food and Agricultural Policy

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Corn (Field/Sweet/Pop)

Terbufos Usage:

Terbufos application in corn represents 79.9% of total annual terbufos use. Terbufos is applied to 6% of sweet/pop corn acreage and 8% of field corn acreage. However, as a result of the high acreage in corn production (72 million acres), corn still represents the largest use of terbufos (6,530,000 lbs AI). Terbufos may only be applied once a year in corn production. Application timing may be at planting (banded or in-furrow), at cultivation (over the whorl), or post-emergence incorporated. Regardless of application timing, suggested terbufos application rate is 1.2 oz. AI / 1000 ft. row (ie. 8 oz.15G/1000 ft. row or 6 oz CR/1000ft. row) and not to exceed a labeled maximum of 1.3 lb AI/A. However, a supplemental terbufos label exists for first year corn with a rate of 1 lb AI/A. In addition, a Special Local Needs (SLN) label does allow a maximum rate of 2.6 lb AI/A in North Carolina for Billbug control. The terbufos CR formulation (Lock'n'Load closed handling system) has become the dominant product formulation for use in corn. Although terbufos can be applied as a foliar insecticide, the primary timing of application in corn is at-plant to control ground insects. The key pests that drive terbufos usage in both field corn and sweet/pop corn are Corn rootworm, Wireworms, White grubs, and Billbugs. Terbufos also has use in control of Cutworms but is not as efficacious against this pest. Terbufos is also effective against Seedcorn maggot but the pest is minor.

Terbufos use in corn is generally incorporated as part of a larger IPM, Integrated Pest Management Program. The control strategy used for the key pests identified above include crop rotation, rapid seedling establishment and early planting, scouting, and at-plant insecticide and post-emergence insecticide application. Terbufos is generally only applied at-plant as a preventative in areas of significant crop risk, particularly in relation to crop rotation and development of previously fallow land. Furthermore, growers are reluctant to spend dollars on insecticide use unless there is a demonstrated risk, especially in low profit margin crops such as field corn. It must also be considered that each pest may be sporadic in distribution, both time and space. While these pests may not be of value in a single year there are some years when they can be very important.

Terbufos Alternatives:

Alternative insecticides for terbufos (both OP and non-OP) are available which provide adequate control for most key pests in corn. The only exception is billbug.

Billbugs are generally only a major pest in North Carolina. While crop rotation is a useful tool in managing this annual pest, crop rotation alone is generally not a sufficient remedy. It must be considered that terbufos is not only used to reduce crop injury in the current crop season but is also used to limit population build-up in the next year. Failure to reduce billbug numbers in subsequent years will increase both crop loss and dramatically increase insecticide use. The only OP other than terbufos which is efficacious against billbugs is chlorpyrifos. However, chlorpyrifos is not an acceptable alternative as it is rapidly bound by the high organic soils which occur in this area making it unavailable for extended billbug control. Carbofuran is also known to be effective in controlling billbugs but it is not currently labeled at a rate adequate to be effective at-plant. No alternative chemistries have been identified at this time which could replace terbufos for control of billbugs.

Corn rootworm is not an important pest in relation to terbufos. Numerous alternative OP's are available with equal efficacy against this pest (chlorpyrifos, phorate, tebufos, imidacloprid,

and chorethoiphos). Non-OP alternatives for terbufos include carbofuran (carbamate) and tefluthrin (a synthetic pyrethroid). Furthermore, tefluthrin provides greater efficacy than any other insecticide available for use against Corn rootworm.

Wireworms can be controlled using either OP or non-OP insecticides. OP's which are as equally effective against wireworm as terbufos include phorate and tebupirimiphos. Alternative chemistries available for wireworm control include tefluthrin (synthetic pyrethroid) and fipronil. Tefluthrin appears to be equally effective as terbufos for control of wireworms. Fipronil is largely unproven in large scale use at this time.

White grubs can be controlled equally effectively using tefluthrin, a synthetic pyrethroid, as a terbufos replacement. OP's which have lesser efficacy against white grubs than terbufos include chlorpyrifos, and phorate.

Sugar Beets

Terbufos Usage:

Terbufos application in sugar beets represents 8.2% of total annual terbufos use. Terbufos is applied to 35% of sugar beet acreage grown in the U.S. Only one application of terbufos may be used per year. Application timing may be at planting (banded, modified in-furrow, or knifed-in) or post-emergence (banded). Counter CR and Counter 15G are both recommended for sugar beet pest control.

Four pests drive terbufos usage in sugar beets (Sugar beet root maggot, Wireworms, White grubs, and Cutworms). Suggested application rate to control Sugar beet root maggot, wireworms and white grubs in sugar beets is 0.6-1.2 oz. AI/1000 ft row with a minimum 20-inch row with a labeled maximum rate of 1.96 lb AI/A. While a rate of 1.96 lb AI/A is labeled for cutworms, this rate only provides suppression of this pest. Terbufos is not the primary pesticide for cutworm in sugar beet but can be important in fields rotated out of summer wheat such as occur in Colorado. Although terbufos can be applied post-emergence, this application is a banded soil incorporation of the material as a systemic soil insecticide. An additional pest which terbufos is used to control in sugar beets is nematodes at a rate of 1.96 lb AI/A. It should be noted, due to the expense of use in sugar beets, terbufos is only used in conjunction with a scouting program.

Terbufos Alternatives:

Sugar beet root maggot can be controlled using alternate OP's (chlorpyrifos, phorate, and diazinon) and aldicarb (a carbamate). While all of these pesticides will provide control, aldicarb provides protection equivalent to terbufos against Sugar beet root maggot. However, effectiveness of control using aldicarb can be severely reduced during wet springs as a result of its greater water solubility.

Cutworm pests of Sugar beets can be alternately controlled using post-emergence applications of carbaryl, chlorpyrifos, or carbaryl baits. In addition, although terbufos appears to have a high market share for cutworm control, state recommendations indicate that it is registered but not generally recommended for cutworm control. Carbaryl provides better cutworm control in Sugar beets.

Wireworms in Sugar beets can be controlled using either OP or non-OP insecticides. OP's which are also recommended include diazinon and chlorpyrifos. While chlorpyrifos only

aids in control, diazinon is effective against Wireworms in Sugar beets. However, due to the high rates and consequent high costs, the use of diazinon and dyfonate would be impractical except for treating hot spots. Non-OP alternatives which may be effective for wireworm control include aldicarb and carbofuran.

White grubs are most effectively controlled in Sugar beets by terbufos. Only thimet provides some control of White grubs in this crop.

Tefluthrin, a synthetic pyrethroid, may be an effective alternative against wireworms and white grubs, and possibly root maggot, but is only registered for use on corn at this time.

Banana

Terbufos Usage:

Terbufos application in banana represents 8.9% of total annual terbufos use. Terbufos is applied to 26% of banana acreage. Bananas imported to the U.S. are overwhelmingly for the fresh market. Countries that collectively supply 97%, by weight, of the bananas to the U.S. are Costa Rica (27%), Ecuador (26%), Columbia (16%), Honduras (13%), Guatemala (12%), and Mexico (6%). Bananas are also produced in Hawaii and Puerto Rico for the U.S. market. Average number of applications of terbufos is one per plant with each plant producing a single crop per year. Only one application of terbufos may be used per year at a rate of 3 to 4.5 lbs. AI/A. Terbufos treatment in banana is either a soil or base of plant application. The target pest for terbufos in banana are nematodes (*Heliocotylechus spiral*, *Radopholus reniform*, *Pratylenchus* lesion, and *Meloidogyne* root knot). Studies in Puerto Rico indicate that failure to control nematodes would result in a 25% crop reduction and estimated loss of 10 million dollars in revenue. In Central America, nematodes can disrupt productivity by 10 to 50% dependent upon severity of infestation and other factors. Even relatively low numbers of nematodes (*Radopholus sp.*) can have an important effect in reducing the weight of the bunch.

Terbufos Alternatives:

There are numerous OP and non-OP alternatives to control nematodes in banana. The OP's which are available for use include; ethoprop, cadusafos, fenamiphos, isazofos, diazinon and chlorpyrifos (strips and impregnated bags). Non-OP alternatives available for nematode control include 2 carbamates, oxamyl and carbofuran, and sincocin (natural plant extract). All alternative pesticides, OP and non-OP, provide excellent control of nematodes in banana. However, sincocin is still in the investigative stage and should probably best be considered as a pipe line product for pest control in banana. In addition, while non chemical alternatives (soil fumigation, flooding, and solarization) can also be used in nematode control, these strategies are generally not possible in commercial production.

Sorghum

Terbufos Usage:

Terbufos application in sorghum represents 2.3% of total annual terbufos use. Terbufos is applied to 2% of sorghum acreage. Average number of applications of terbufos is once per year.

All pests that drive terbufos usage in sorghum are controlled at bedding or at plant. The pests which drive usage are; Aphids (particularly Sorghum greenbug), Wireworm, Cutworm, Corn rootworm, and Chinch bug. Suggested application rate to control these pests in sorghum 1.2 oz. AI/1000 ft row with a minimum 20-inch row with a labeled maximum rate not to exceed 1.96 lb AI/A..

Terbufos Alternatives:

Alternative pesticides are available for use on pests which attack sorghum. However, few non-OP alternatives are available for a number of pests which are targeted for control using terbufos.

Aphids may also be controlled using a variety of OP's and non-OP's. The OP's which are used in Aphid control at-plant are disulfoton, methidathion, and phorate. Non-OP alternatives include aldicarb and imidacloprid (including Gaucho seed treatment). Rescue foliar applications to control aphids may also include malathion and methyl parathion.

Corn root worm, Wireworm, and Chinch bug control in sorghum is largely dependent upon terbufos. However, chlorpyrifos can be used as an alternative OP against these pests. In addition, phorate (OP) may also be used to control Chinch bug. Non-OP alternatives for wireworm control include imidacloprid and lindane. Carbofuran is the only non-OP recommended for at plant control of corn rootworm.

Cutworm control at-plant using terbufos is probably not warranted. Recommended controls include foliar application of carbaryl, cyfluthrin, chlorpyrifos and lambda-cyhalothrin.

Sources:

1. EPA Proprietary data.
2. EPA QUA. 1999.
3. EPA Crop Matrices - Corn, Sorghum, Sugar beets, Banana. 1998-99. US EPA BEAD/HIB.
4. Agricultural Statistics 1998. National Agricultural Statistics Service. USDA.
5. Insect and Disease Control Guide. 1999. Meister Publishing Company.

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