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To: Christine Rice, PM 52
Thomas Luminello, Jr., PM Team Reviewer
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Special Review and Reregistration Division (H7508W)

From: Elizabeth Behl, Head (acting)
Ground Water Technology Section
Environmental Fate & Ground Water Branch/EFED (H7507C)

Thru: Henry Jacoby, Chief
Environmental Fate & Ground Water Branch/EFED (H7507C)

Attached, please find the EFGWB review of...

Reg./File # : 114402

Chemical Name : Sodium 5-[2-chloro-4-(trifluoromethyl)-Phenoxy]-2-Nitrobenzoic Acid

Type Product : Herbicide

Product Name : Blazer® (Tackle®)

Company Name : BASF

Purpose : Review request to decommission retrospective ground-water monitoring studies.

Action Code : 635 EFGWB #(s): 91-0807 Total Review Time: 2 days

EFGWB Guideline/MRID Summary Table: The review in this package contains...

161-1	162-1	164-1	165-1	166-1
161-2	162-2	164-2	165-2	166-2 X
161-3	162-3	164-3	165-3	166-3
161-4	162-4	164-4	165-4	167-1
201-1	163-1	164-5	165-5	167-2
202-1	163-3			

1. CHEMICAL:

Chemical Name: Sodium 5-[2-chloro-4-(trifluoromethyl)-
Phenoxy]-2-Nitrobenzoic Acid
Common Name: Acifluorfen, Sodium salt
Trade Name: Blazer, Tackle, Galaxy, Storm
Structure: Not applicable

Physical/Chemical Properties:

Molecular Formula	C ₁₄ H ₇ ClF ₃ NNaO ₅ (sodium salt) C ₁₄ H ₇ ClF ₃ NO ₅ (acid)
Water Solubility	2.5 x 10 ⁵ mg/L @ 20 °C
K _d	1.0 ml/g silt loam
K _{oc}	
logK _{ow}	-4.85 (acid) (calculated)
pK _a	2.5

2. TEST MATERIAL

Not Applicable.

3. STUDY/ACTION TYPE:

Request to decommission Small-Scale Retrospective Ground-Water Monitoring Sites for acifluorfen-sodium (Blazer® and Tackle®) at Indiana, North Dakota, and North Carolina.

4. STUDY IDENTIFICATION/SUBMISSION IDENTIFICATION:

Letter to Mr. Thomas J. Luminello, dated December 17, 1991 from Karen R. Blundell.

Subject: Sodium Acifluorfen: Request to decommission three retrospective ground-water monitoring study sites.

Submission By: BASF Corporation
Agricultural Research Center
P.O. Box 13528
Research Triangle Park, NC 27709
BASF Corporation, Agricultural Chemicals

Action:	635
MRID:	
EFGWB#:	EFGWB # 91-0807
DP Barcode:	D166812
Case:	816452
DP Type:	102 Phase V Review
ID#:	114402-007969
Submission:	S39994

5. REVIEWED BY:

James K. Wolf
Soil Scientist

Signature: James K Wolf

OPP/EFGWB/Ground Water Section Date: June 1, 1992

6. APPROVED BY:

Elizabeth Behl
Acting Section Head

Signature: Eliz Behl

OPP/EFGWB/Ground Water Section Date: June 1, 1992

7. CONCLUSIONS:

The object of this review was to evaluate BASF's request to decommission the three remaining small-scale retrospective ground-water monitoring sites, located in Indiana, North Carolina, and North Dakota. The Tennessee and Virginia sites have previously received EPA approval, and have been decommissioned. More specific review comments and concerns are addressed in the review of the studies final report (USEPA, 1992c).

Background Site Characterization

Five study sites were originally selected by the registrant in representative use areas within major sales areas of herbicides containing the active ingredient acifluorfen-sodium. The sites were located in soybean growing areas in five states; Indiana, North Carolina, North Dakota, Tennessee, and Virginia. The acifluorfen use histories ranged from one year at the Indiana and North Dakota sites to four years at the North Carolina site. Acifluorfen was applied for an additional year at the Indiana and North Dakota sites, because of the limited history of previous use. Water table depths varied both between sites and seasonally within sites. Depths ranged from less than a foot (0.38 ft) at the North Carolina site to more than 15 feet (15.59) feet at the Tennessee site.

Persistence and Residues in Soil

Acifluorfen was somewhat persistent in soil, as residues were detected at levels between 0.011 to 0.057 $\mu\text{g/g}$ in the surface 12 inches at the Tennessee and North Dakota sites, prior to the 1989 acifluorfen applications (Hiscock and Cooper, 1991; USEPA, 1992b). Pre-1990 application analysis of the upper 6 inches of soil also detected acifluorfen residues at levels between 0.029 to 0.052 $\mu\text{g/g}$ at the North Dakota site and 0.013 $\mu\text{g/g}$ at the Indiana site.

Acifluorfen-sodium was applied in 1989 to soybean fields at rates ranging from 0.21 to 0.43 pounds active ingredient per acre (lb ai/ac). Soil residue levels were

greatest immediately after application, and generally decreased with time. Pesticide residues were not detected in the surface sampling increment at the North Carolina and Indiana one month after the 1989 application, with a detection limit of 0.010 µg/g. Residues continued to be detected in the 0 to 12 inch soil samples 10 months after the 1989 application at the North Dakota site. Acifluorfen residues were also detected in the 12 to 24 inch soil samples 2-weeks after application at the North Dakota site, therefore, indicating a downward movement of the residues.

Acifluorfen was applied to the Indiana and North Dakota sites in 1990 at a rate of 0.25 pound active ingredient per acre. Residues were detected at levels greater than 0.010 µg/g in the 0 to 6 inch soil sampling increments at all sampling intervals up to 12 and 13 months after application (last samples collected) for the Indiana and North Dakota sites, respectively. Acifluorfen residues were also detected in some 6 to 12 inch sampling increments up to 9 and 12 months after application at the Indiana and North Dakota sites, respectively. This demonstrates the movement and persistence of acifluorfen residues within the soil.

Acifluorfen was more persistent at the Indiana and North Dakota sites in 1990 compared to 1989, even considering acifluorfen application rates were lower in North Dakota in 1990 compared to 1989. Field dissipation half-lives differed markedly between years at the Indiana site as values were estimated to be 7.6 days for 1989 and 38.1 days for 1990. Less variability between years was found for field dissipation half-lives at the North Dakota site; 66 days in 1989 and 59.7 days in 1990. Field dissipation half-lives values are also quite variable between sites, ranging from around five days at the North Carolina site to more than 66 days at the North Dakota site.

Residues in Ground Water

There were no detections of acifluorfen residues in any of the monitoring wells sampled in the five retrospective ground-water monitoring studies. Two detections reported at the North Carolina site were later classified by the registrant as "false positive" detections.

The retrospective ground water monitoring studies, in combination with the earlier prospective monitoring study, and the reported detection of acifluorfen residues by the Pesticides in Ground Water Database indicates to the EFGWB that acifluorfen residues may reach ground water under typical transport mechanisms. Acifluorfen appears to be quite persistent in certain soils, as it can be detected in soils for more than a year after application.

Characterization of Leaching Potential

The EFGWB believes, that due to the persistence of acifluorfen residues exhibited at sites like those in Indiana and North Dakota soils, and movement of these residues at sites such as North Dakota and Wisconsin, the potential for ground-water contamination from acifluorfen still exists.

The registrant stated that acifluorfen residues do not present a potential leaching problem at the test sites. The registrant also believes that the lack of residue detections in ground water supports their premise that acifluorfen will not leach to ground water. Their major rationale to support this contention was the limited number of residue detections below the surface soil sampling increment.

The resulting patterns of measurable acifluorfen residue levels in the soil samples at the five retrospective sites generally decreased in concentration over time and with depth, and were not detectable below 0.3 m (1 ft). Similar results were obtained at the Wisconsin prospective study site, where no acifluorfen residues were detected below 0.6 m (2 ft) in any of the soil samples collected. It should be noted that the detection limits achieved for the prospective study were much lower than for the retrospective study sites. The prospective study reported limits of detection for soil from 0.002 to 0.005 $\mu\text{g/g}$ (rather than 0.010 $\mu\text{g/g}$ as specified in the retrospective studies), and 0.05 to 0.10 $\mu\text{g/L}$ for water (rather than the 1 $\mu\text{g/L}$ specified in the retrospective study).

Although no acifluorfen residues were detected in soil samples below 0.6 meter, acifluorfen residues were detected to depths up to 3 meters (maximum depth of lysimeters) by the suction lysimeters at the Wisconsin site. Sixteen suction lysimeters (1, 1.5, 2, 3 m depths) were installed at the Wisconsin site. A total of 252 possible samples could have been collected; 64 of these samples had residue levels greater than detection limit (1 or 2 $\mu\text{g/L}$), 37 did not have enough sample for analysis, and remaining 151 were dry, so no sample was collected. The Branch believes that the utilization of suction lysimeters at the retrospective study sites would have resulted in the detection of residues at deeper soil depths, because of a lower detection limit (1.0 $\mu\text{g/L}$) in a water matrix compared to soil (0.010 $\mu\text{g/g}$). Thus a better assessment of the acifluorfen mobility, leaching and persistence could be conducted. It also should be noted that at the Wisconsin prospective ground-water monitoring site even with the lack of residues being detected in soil samples at depths greater than 0.6 m, acifluorfen residues were detected in ground water.

Request to terminate retrospective studies

The registrant has requested to discontinue monitoring and commence with the decommissioning of the Indiana, North Carolina, and North Dakota sites. The request for the decommissioning is recommended for approval with, the following stipulation (because of the persistence of the residues at Indiana and North Dakota): The registrant shall be required to collect 0 to 6 inch soil samples at the Indiana and North Dakota sites, and monitoring well water samples at the Indiana, North Carolina, and North Dakota sites concurrently (at the same time) with the site decommissioning. The soil samples and water samples shall then be analyzed. The resulting information shall then be submitted to the Agency.

General Observations

The registrant has previously suggested that macropore flow was the transport mechanism active at the Wisconsin study site. While data submitted does not preclude this route of transport, water movement through the vadose zone appears to be by conventional means (saturated/unsaturated) flow. Eleven of the 16 suction lysimeters had multiple acifluorfen residue detections. Many of the lysimeters within a cluster had several residue detections on the same sampling date. Had macropore flow been the primary or only mode of solute transport, the suction lysimeters would not have been as effective in collecting water samples with acifluorfen residues.

A suction lysimeter will only maintain suction down to about 60 to 80 centibars, thus, indicating a somewhat wet soil (0 centibars is a saturated soil and 1500 centibars is often used as an estimate of the suction at wilting point). Once the suction drops below (soil dries out) the 60 to 80 centibars the suction will "break", and no additional sample will be collected. It is unlikely that the suction lysimeters would have been able to collect residues, had macropores been involved. A lysimeter in contact with a macropore would only maintain suction when the macropore was full or nearly full of water, when the macropore empties out, suction would be broken.

Several soils and environmental conditions appear to have an influence on the leachability of acifluorfen to ground water. The three factors which appeared to have had the greatest influence on the acifluorfen residues leaching to the ground water at the Wisconsin site compared to the other five sites studied in the retrospective sites were: 1) high uniform sand content (93 to 97%) from the soils surface to 3.9 to 4.8 m below the surface, 2) application of irrigation water, 3) relatively lower soil temperatures.

The first apparent factor to influence the potential of acifluorfen to be leached to ground water is the clay and silt contents of the soil. The Wisconsin site had the lowest clay (4%) and silt (1 - 3%) and the highest sand (93 to 97%) throughout the total depths (3.9 - 4.8 m) of the four cores, used for site characterization. The five retrospective sites had comparable sand-silt-clay compositions in the subsoil (> 3' VA, > 2-4' TN, > 3' NC, > 2-4' IN, and > 2' ND). Particle size distributions above these depths generally contain more than 10% clay and more than 18% silt. For example, the Tennessee site contained less than 45% sand in the upper 2 feet of all four cores used in site characterization. Also the textural changes at some of the sites, due to the layering of finer textured soils overlying coarse textured soils can also act as a restricting layer under unsaturated conditions.

The Wisconsin site was the only study location identified to have received supplemental irrigation water. The soils would then be kept wetter than at the other sites by the regularly scheduled irrigations. Because of the low water holding capacity and wetter conditions of this soil, leaching could be enhanced by irrigation. At the other sites leaching would only be influenced by rainfall distributions, amounts, and intensity, and evapotranspiration.

The climatological conditions would also influence the field dissipation half-life. The half-lives ranged from around <6 days to $\approx$ 66 days. The warmer climates generally had shorter half-lives and colder climates had longer half-lives. The reported field dissipation half-life for the Wisconsin site was $\approx$ 15 days, whereas for the North Dakota site with somewhat similar climatic conditions the field dissipation half-life was around 56 to 66 days. The Wisconsin field dissipation half-life may be lower than at the North Dakota site, because the leaching component of dissipation was enhanced through the addition of irrigation water.

It appears that conditions favorable for acifluorfen being leached to ground water includes coarse textured soils without restricting layers, shallow aquifers, and irrigation sources of water or excessive amounts of rain (low intensity-long duration), or rainfall occurring when soils are saturated or nearly saturated. The data from Tennessee also suggests that when surface soils (upper 2 to 3 feet) are high in silt and clay content, and soil temperatures are warm, the likelihood of acifluorfen leaching to ground water may be reduced.

8. RECOMMENDATIONS:

1. EFGWB recommends that the registrants request to decommission the Indiana, North Carolina, and North Dakota retrospective study sites be approved. However, prior to decommissioning the Indiana, North Carolina and North Dakota sites, the registrant shall collect 0 to 6 inch soil samples and water samples from all monitoring wells for analysis. The registrant shall follow the procedures and protocol previously used, and continue to follow QA/QC practices. The results of the analysis shall be submitted to the Agency within 3 months of the decommissioning activities. The results can either be added to the final report or be submitted as a supplement to the final report (Hiscock and Cooper, 1991; USEPA, 1992b).

2. EFGWB recommends that a label advisory be added so as to advise users about the acifluorfen's potential to contaminate ground water, when soils are permeable and depth to the water table is shallow.

3. EFGWB also recommends that use restrictions be placed upon acifluorfen to prevent it from being used on soils which are highly permeable, such as sand and loamy sand textures, where depth to ground water is shallow, and irrigation is used.

9. BACKGROUND:

Acifluorfen is an active ingredient (a.i.) in Blazer herbicide, marketed by BASF. Blazer® is a selective pre- and post-emergence herbicide to control weeds and grasses in large seeded legumes, such as peanuts and soybeans (USEPA, 1989a). Application rates are between 0.25 and 0.75 lb a.i./acre (USEPA, 1990a). Rhone-Poulenc previously marketed the post-emergent herbicide Tackle® with acifluorfen as the active ingredient. Currently, the only source of acifluorfen is BASF. BASF assumed the responsibility associated with the studies in April 1990. Blasland and Bouck Engineers were contracted by BASF to take over and complete the retrospective studies originally started by Rhone-Poulenc's Special Environmental Programs for Rhone-Poulenc and BASF.

Chemistry and fate data indicates that acifluorfen is both persistent and mobile in soil. In addition to the parent compound acifluorfen-sodium (salt-LS-80-1213), there also several degradates. These include acifluorfen (free acid-LS-82-5276), LS-82-5281 the primary degradate, a secondary metabolite LS-82-5283, the amino metabolite LS-82-5282, and acifluorfen-methyl LS-81-5875. The metabolites have been found in the laboratory to be less mobile than the

parent herbicide. The metabolites have only been detected at low levels. Only acifluorfen in the acid or sodium-salt form would be expected in ground water, and therefore required for analysis. (USEPA, 1989c).

The Pesticides in Ground Water Database reported that acifluorfen has been analyzed for in 885 wells from five states (USEPA, 1990). Detections of between 0.003 and 0.025 µg/L were reported in three wells in Virginia. Detections have also been reported in Wisconsin (Norris, 1988; USEPA, 1989b) and North Carolina.

The EPA issued a Data Call-In (DCI) Notices for ground-water monitoring data to Rhone-Poulenc Ag Company and BASF Corporation in September of 1987. The two companies agreed to jointly conduct several small-scale retrospective ground-water monitoring studies for herbicides with the active ingredient acifluorfen-sodium (Tackle® and Blazer®).

The studies were designed to monitor the residual acifluorfen levels in soils and ground water at five test sites where acifluorfen-sodium had been applied in one or several previous years. The registrant previously conducted a limited prospective study to monitor the dissipation and vertical movement (leaching) of acifluorfen in the soil-vadose zone (Norris, 1988; USEPA, 1989b). The specific objectives of the retrospective/limited prospective ground-water studies were to evaluate the rate of acifluorfen-sodium dissipation in the soil, the extent of residue mobility in soil, and the potential for acifluorfen to reach to ground water at each of the five test sites studied.

10. DISCUSSION:

Background

Small-scale retrospective/limited prospective ground-water monitoring studies for the herbicide acifluorfen-sodium were conducted at five locations; Tennessee¹, Indiana, North Carolina, North Dakota, and Virginia. The Tennessee and Virginia sites have previously received EPA approval, and have been decommissioned.

The five sites selected were located at representative use areas within major sales areas of herbicides containing the active ingredient acifluorfen-sodium. The sites were located in

¹ The detections in North Carolina were later defined as "false positive" detections by the registrant.

² Same as Arkansas site.

Shelby County, Tennessee; Knox County, Indiana; Columbus County, North Carolina; Ransom County, North Dakota; and Accomack County, Virginia.

The registrant stated that the five study sites met or exceeded EPA vulnerability criteria. Information used in site selection included; selected soil physical and chemical properties, site vulnerability rating, and application rates and use history. The only site with an adequate use history for a retrospective study was the North Carolina site, which had four acifluorfen applications prior to 1989 (1985 to 1988). The acifluorfen use history prior to 1989 at the four study sites were Indiana - 1 year, North Dakota - 1 year, Tennessee - 3 years, and Virginia - 2 years. The registrant identified this limitation, and justifies it, because of crop rotation practices, soybeans are rarely grown in successive seasons in the same field. Therefore, locating fields with a consecutive acifluorfen-sodium use was difficult. Sites were selected where acifluorfen-sodium was used the season prior to the first study season, rather than two out of the last three or three out of the last five seasons.

Several of the study areas were selected without, or prior to EFGWB approval. The surface layer(s) of several of the study areas had clay and silt contents greater than what the Branch generally considers suitable for these types of studies.

The five study plots were divided into four subplots. Soil samples were collected from each of the subplots and analyzed for acifluorfen residues. All soil samples analyzed, with the exception of the 1989 pre-application soil samples, were conducted on soil cores composited by equal depth increment for each of the four subplots. Pre-application (1989) soil samples were collected to a depth of 6 feet in North Dakota and Virginia sites, and to a depth of between 7 and 8 feet at the Indiana (8 ft), North Carolina (7 ft) and Tennessee (8 ft) sites.

Immediately following the 1989 applications of acifluorfen-sodium, soil samples were collected and analyzed to a maximum depth of 6 inches for all sites, except Tennessee where samples were collected to a maximum of 8 inches. Soil samples were collected to a maximum of 2 feet (4 feet in Tennessee) in 1 foot increments approximately two weeks after the 1989 application.

Following the two week 1989 post-application sampling interval, soil samples were collected and analyzed, at monthly intervals (after application), in 12-inch increments to a depth of 24 inches, and then a 24-inch increment to a depth of 48 inches.

Soil samples continued to be collected and analyzed until the residue levels were no longer detectable (detection limit

<0.010 ppm) in all depth increments analyzed. Soil sampling was conducted through one month after application the 1989 for the Indiana, Tennessee, and Virginia sites, and through two months after application at the North Carolina site. Soil samples were collected at 1-, 2-, 4-, and 10-months after the 1989 application at the North Dakota site. Acifluorfen residues were detected in the 0 - 12 inch sampling increment through the 10th month after application at North Dakota; residues were less than (<0.010 µg/g) in all sampling increments below 12 inches. Ground-water samples were generally collected monthly after the 1989 application of acifluorfen.

Soil and ground-water samples were collected prior to the 1990 acifluorfen applications at the Indiana and North Dakota sites. Soil samples were taken to a depth of 6 inches immediately following application for analysis. Soil samples for analysis were then collected in 6-inch increments to a depth of 24 inches at two weeks, 1-, 5- 9-, 13-months, and in 6-inch increments to 18-inches at 2-, 3-, 4-, 10-, 11- and 12-months, after the 1990 application. Soil samples were not collected due to weather, at the Indiana site for months 6, 7, and 8 post application, and at North Dakota for months 6, 7, 8, 9 after application.

Ground-water samples were collected monthly after the 2-week sampling for 12 months after application the 1990 for the Indiana site, and 13 months after 1990 application for North Dakota. Water samples were not collected at the North Dakota site for the 7th month after application. There were no acifluorfen residues detected in any to the samples collected at Indiana, North Carolina, and North Dakota.

Previously, a small-scale prospective acifluorfen study was conducted by the registrant in central Wisconsin. Acifluorfen residues up to 46 µg/L were found in the ground water at the Wisconsin site (USEPA, 1989d). There were no detections of acifluorfen residues in any of the five small-scale retrospective ground-water monitoring study.

Soil and Ground-Water Residue Analysis

Soil and ground-water residue analysis were conducted by Rhone-Poulenc and BASF. Soils were analyzed by Rhone-Poulenc Method 1002 and Method 1002 with modifications, and water samples were analyzed by Rhone-Poulenc Method 1001 and Method 1001 with modifications. The registrant reports that the detection limit

³ Acifluorfen residues were detected at the North Carolina site, but were determined by the registrant to be "false positive" detections.

for acifluorfen residues in soil was 0.010 $\mu\text{g/g}$ (10 ng/g) and in water 1.0 $\mu\text{g/L}$ (1.0 ppb).

SMALL-SCALE RETROSPECTIVE STUDIES

The limited discussions concerning the five retrospective studies are summarized below (see USEPA, 1992c).

North Carolina The North Carolina site was defined by the registrant to be "ultra" vulnerable, the most vulnerable of the five sites evaluated during the study. Acifluorfen was applied to soybeans four years (1985, 1986, 1987, and 1988), prior to the initiation of the monitoring study in 1989. The soil series occurring at the 4.4 acres site was reported as the Echaw loamy sand. The average water table depth was 2.28 feet and ranged between 0.38 to 4.68 feet.

Pre-application acifluorfen residues were not detected in any of the soil cores. Acifluorfen was applied at a rate of 0.23 lb ai/acre (0.26 kg ai/ha). Immediately after sampling, residues were detected in four 0-6 inch soil cores. The values ranged from 0.019 to 0.052 $\mu\text{g/g}$, with a mean of 0.041 $\mu\text{g/g}$ of acifluorfen. The theoretical application rate for 1989 was 0.15 $\mu\text{g/g}$. Two weeks after application, residue levels at 0.010 $\mu\text{g/g}$ were detected in the two out of four 0 to 12 inch cores. The two remaining 0 to 12 inch cores, and four 12 to 24 inch from the 2 week sampling, and soil cores for the one month after application sampling were all less than the reported detection limit of 0.010 $\mu\text{g/g}$. Soil dissipation half-lives for the North Carolina site were found to be between 5 and 15 days. There were no acifluorfen detections in any of the monthly ground-water samples collected for up to 12 months after application.

Indiana The 9.9 acre Indiana site reportedly has the Lomax loam soil series, and an average water table depth of 8.0 feet (range 4.0 to 10.9 feet). The site was defined by the registrant as highly vulnerable. This site had one year prior history of acifluorfen use prior to the initiation of the study in June 1989. Acifluorfen was also applied in July 1990.

All soil samples analyzed for acifluorfen residues prior to the 1989 application were less than detection limit of 0.010 $\mu\text{g/g}$. The acifluorfen application rate in 1989 was 0.21 lb ai/acre (0.24 kg ai/ha). The mean acifluorfen residues in the 0 to 6 inch soil increment immediately following the 1989 application was 0.096 $\mu\text{g/g}$ (ranged from 0.090 to 0.101 $\mu\text{g/g}$),

⁴ Detections of acifluorfen residues (1 and 2 $\mu\text{g/L}$) were detected in two samples collected during the 7 month sampling. These detections were later classified as "false positive" (MRID 414485-00 and 414485-01).

with a theoretical application concentration of 0.13 $\mu\text{g/g}$. Residues ranging between 0.020 to 0.031 $\mu\text{g/g}$ (mean 0.023 $\mu\text{g/g}$) were detected in the upper 0 to 12 inch soil increment 2 weeks after application. There were no acifluorfen residues detected at 12 to 24 inches at two weeks, and 0 to 12, 12 to 24, and 24 to 48 inches at one month after application. Soils were not sampled after the one month sampling after the 1989 application.

Prior to the 1990 application, acifluorfen residues were found at 0.013 $\mu\text{g/g}$ in one of four soil cores from 0 to 6 inches, but not at the 6 to 12 and 12 to 18 inch sampling increments. Acifluorfen was applied at a rate of 0.25 lb ai/acre (0.28 kg/ha) for 1990. Immediately after the 1990 acifluorfen application, multiple soil samples were collected to a depth of 6 inches. Acifluorfen residues levels ranged from less than the detection limit (0.010 $\mu\text{g/g}$) to 0.160 $\mu\text{g/g}$, and a mean of about 0.078 $\mu\text{g/g}$. The theoretical application concentration for 1990 was 0.16 $\mu\text{g/g}$. Residues were collected by 6-inch increments to a depth of 24 inches two weeks after application, and then by monthly time increments. The residue levels in the 0 to 6 inch increment generally decrease with time. Values ranged from <0.010 $\mu\text{g/g}$ to 0.160 $\mu\text{g/g}$. Residue levels were less than the detection limit of 0.010 $\mu\text{g/g}$ for the 12 to 18 and 18 to 24 sampling increments. Soil dissipation half-life values reported were about 7 days for 1989 and more than 38 days for 1990.

Acifluorfen residues appear to be somewhat persistent at the Indiana site, as residue values were detected prior to the 1990 (0.013 $\mu\text{g/g}$) acifluorfen application. There were no detections of acifluorfen in the ground-water samples collected at the Indiana site with a detection limit of 1.0 $\mu\text{g/L}$.

North Dakota The 3.5 acre study area, in Ransom County, North Dakota, was defined as extremely vulnerable by the registrant. The soil mapping unit indicated that the dominant soils were the Ulen-Hecla sandy loam/loamy sand. The water table fluctuated about 4.8 feet over the period of the study. Shallowest depth was 1.6 feet below the land surface and the deepest was about 6.4 feet below the land surface. Acifluorfen was applied twice (0.50 and 0.63 lb ai/acre) to the site in 1988, one year prior to the initiation of study.

Four soil samples, one per subplot, were collected prior to the 1989 and 1990 applications, immediately after, and two weeks after application. One sample per subplot was also collected after month 1-, 2-, 4-, 10-month following the 1989 application, and month 1, 2, 3, 4, 5 and 10 months following the 1990 application. Sampling was curtailed for several months, because of winter weather conditions.

Acifluorfen residues appear to be relatively persistent at the North Dakota study site. Acifluorfen residues ranging from

<0.010 $\mu\text{g/g}$ to 0.057 $\mu\text{g/g}$ (mean = 0.027 $\mu\text{g/g}$) were detected in the 0 to 12 inch increment of soil samples collected prior to the 1989 application of the test chemical. Residues were not detected in soil samples collected from 12 to 72 inches in three 24-inch increments for the pre-application sampling. This suggests that residues at detectable levels remained in the soil from the previous year's two applications (0.50 and 0.63 lb ai/acre).

Acifluorfen was applied at rate of 0.43 lb ai/acre (0.48 kg ai/ha) in 1989. Acifluorfen residues in 6 inch soil samples collected immediately after application ranged between 0.155 and 0.204 $\mu\text{g/g}$, with a mean of 0.173 $\mu\text{g/g}$ and a theoretical application concentration of 0.28 $\mu\text{g/g}$. Residues were detected in all 0 to 12 inch soil samples collected 2-weeks, 1-, 2-, 4-, and 10- months, and in the 12 to 24 inch sampling increment 2-weeks after the 1989 acifluorfen application. Values ranged between 0.010 and 0.057 $\mu\text{g/g}$ in the surface increments, and between <0.010 to 0.026 $\mu\text{g/g}$ in the lower increment.

Acifluorfen concentrations ranging between 0.029 to 0.052 $\mu\text{g/g}$ (mean = 0.039 $\mu\text{g/g}$) were present in the 0 to 6 inch sampling interval, prior to the 1990 herbicide application. Soil samples, were also collected in three 6-inch increments to a depth of 18-inches, prior to the 1990 acifluorfen-sodium application. Residues were only detectable in the upper 6-inch increment. The 1990 application rate of acifluorfen was 0.25 lb ai/acre (0.28 kg ai/ha). Acifluorfen residues in 0 to 6 inches soil samples collected immediately after application ranged from 0.041 to 0.287 $\mu\text{g/g}$, with a theoretical application concentration of 0.16 $\mu\text{g/g}$. Thus, residue concentration levels were greater than the theoretical concentration levels, indicating possible residue accumulation. Residues were detected in the 0 to 6 inch sampling increment at 2-weeks, 1-, 2-, 3-, 4-, 5-, 11- and 13-months after the 1990 application. Acifluorfen residues were also detected in the 6 to 12 inch sampling increment at 2-weeks, 1-, and 5-months after the 1990 application.

The data suggest that acifluorfen residues are quite persistent at the North Dakota site, as residues are still present at detectable concentrations one year following application. An interesting trend (Figure 1) which can be seen is that although acifluorfen application rates decreased from 1988 through 1990, the residue concentration remaining in the surface sampling (0 to 6 inches) increment is greater 13 months after the 1990 application than one year after the 1989 application (pre-1990 application).

The leaching of acifluorfen residues from the surface sampling increment to deeper sampling increments is also apparent, as acifluorfen residues were detected in some of the deeper soil sampling increments. It is also suspected that had

Acifluorfen Residues North Dakota Surface Layer

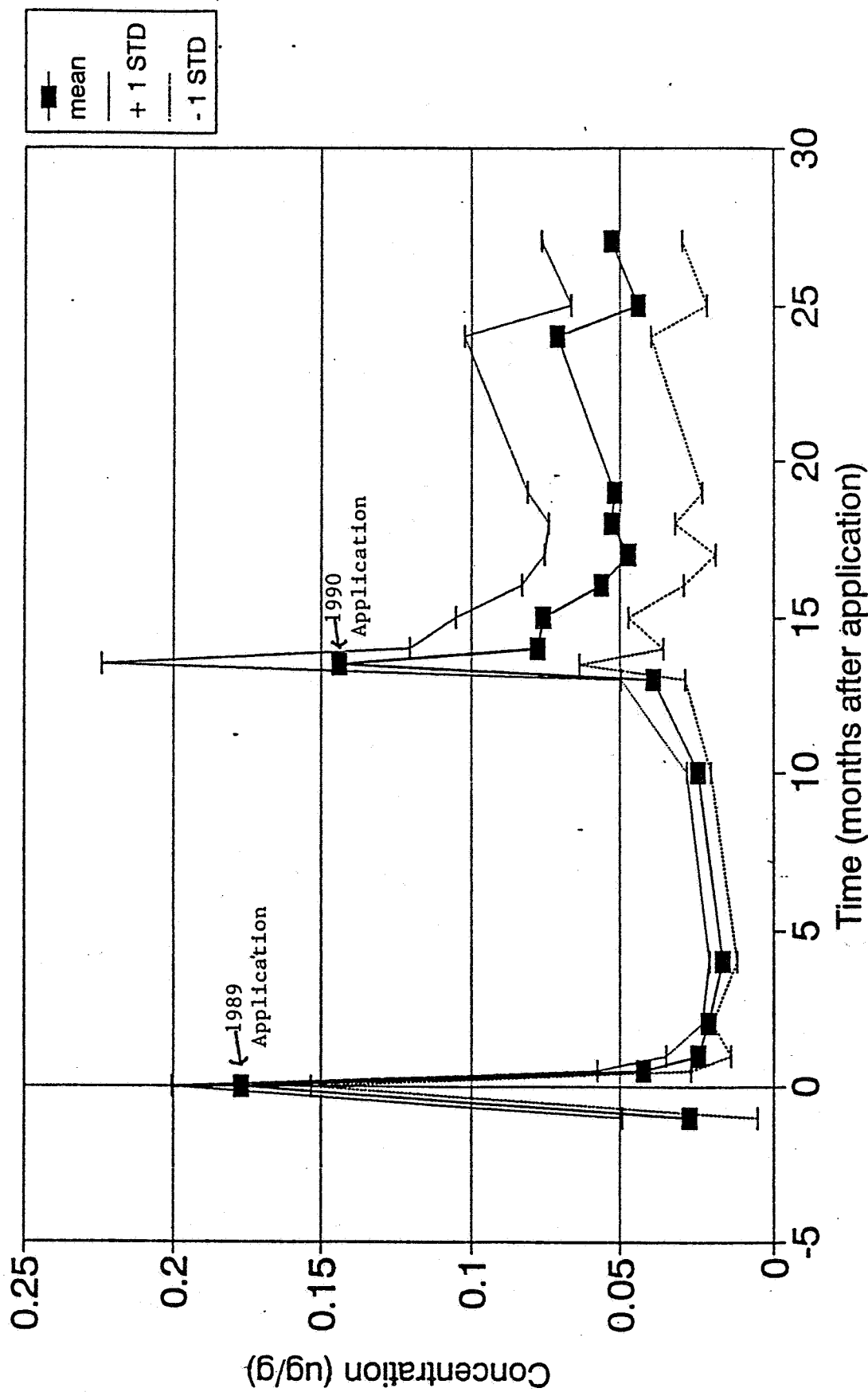


Figure 1. Acifluorfen residues at the North Dakota Study site. All sampling increments after month 10 and on the day of the 1989 application were 6 inches. At the other sampling intervals increments were 12 inches.

shorter sampling increments been used, or soil pore water collected with suction lysimeters (as done in the Wisconsin study) additional detections of acifluorfen residues with depth would have been observed. This is due to lower detection limits for water samples (1 $\mu\text{g/L}$, or 1 ppb) than for soil samples are 10 (10 ng/g, or 10 ppb).

There were no detections of acifluorfen residues in any of the ground-water samples collected at the North Dakota site. Ground-water samples were generally collected monthly, except during the winter months, as described in preceding paragraphs.

Climatological Data

Climatological data were collected at NOAA weather stations which were located anywhere from 8 to 36 miles away from the study sites. Therefore precipitation may have been significantly different at the study sites compared to the NOAA sites. Differences in amounts, frequency, and duration of precipitation between years at the site may have influenced the fate and transport acifluorfen residues. Resulting in higher soil concentrations remaining in the surface soil layer during 1990 compared to 1989.

SUMMARY

Five small-scale retrospective ground-water monitoring studies were conducted in five states, which are representative of the soil and hydrogeologic conditions, in soybean growing areas in the United States. The acifluorfen use history prior to 1989 at the five study sites varied from one year at Indiana⁵ and North Dakota to four years at North Carolina. There were no detections of acifluorfen residues in any of the five small-scale retrospective/limited prospective ground-water monitoring study. The registrant previously detected acifluorfen residues up to 46 µg/L in ground water, during a small-scale prospective study in central Wisconsin.

The registrant ranked the vulnerability (most vulnerable to least vulnerable) as North Carolina, Virginia, North Dakota, Indiana, and Tennessee. Several of the sites were found not to possess the necessary acifluorfen use history normally required for retrospective ground-water monitoring studies. The registrant partially alleviated this limitation by conducting the study for a second year by adding a second application of acifluorfen. Water table depths were suitable, ranging from less than a foot (0.38 ft) at the North Carolina site to more than 15 feet (15.59) feet at the Tennessee site. Thus depth to water table was acceptable for the five sites.

Several limitations have previously been noted in earlier reviews. EFGWB, as noted in previous reviews (USEPA, 1990a), does not concur with the registrant focusing on the texture of the subsoil (sandy) and not taking into account the texture of the surface soil. The Branch believes that the soil texture and organic matter content of the surface layers are also important (perhaps the most important), as these layers represent the most active (biologically and chemically) portion of the soil.

Soil sampling increments were also too large (Recommendation 4; USEPA, 1990a). Confusion continued to exist concerning the number of cores collected, as this varies from one to four, and was therefore, not in agreement with the Protocol.

The studies were conducted using a protocol that did not have EFGWB approval. Protocol modifications were also implemented without Agency approval. The registrant has already received Agency approval to discontinue and decommission the Tennessee and Virginia study sites. Two of the sites (North Dakota and Tennessee) were also initiated without EFGWB approval, and the Indiana site only had tentative approval.

⁵ Acifluorfen residues were detected at the North Carolina site, but were determined by the registrant to be "false positive" detections.

Soil and ground-water samples were collected prior to the 1989 acifluorfen application at all study sites. Acifluorfen residues were detected in one pre-1989 application soil sample from the Tennessee site and three samples from the North Dakota. There were no pre-application acifluorfen detections in ground-water.

Post-application soil samples were collected immediately after 1989 application, two weeks after application, and then monthly at each site until residue levels were not detectable (detection limit for soil was $0.010 \mu\text{g/g}$) in all depth increments analyzed. Soil samples were collected through month 1 at Indiana, Tennessee, and Virginia and through month 2 at the North Carolina site. Sampling continued through the 10 month after the 1989 acifluorfen application at the North Dakota site. Residues were greatest in the surface 6-inch⁶ soil sampling increment collected immediately after the 1989 application ranged between 0.019 and $0.204 \mu\text{g/g}$. Residues were detected in soil samples collected (0 to 12 inches) two weeks after application in one core at the Virginia site, two at the North Carolina site, three at the Tennessee site, four (0.020 to $0.031 \mu\text{g/g}$) at the Indiana site and at the North Dakota site. There were no acifluorfen residues in soil one month after the 1989 application at any of the sites, with the exception of North Dakota. Residues ranging between 0.010 to $0.057 \mu\text{g/g}$ were detected in the 0 to 12 inch sampling increment at the North Dakota site for all sampling intervals (1, 2, 4, and 10 months after 1989 application).

Soil samples were collected at the Indiana and North Dakota sites prior to the 1990 application of acifluorfen. One pre-application 0 to 6 inch core at the Indiana site had a detectable level of $0.013 \mu\text{g/g}$ of acifluorfen. All four of the 6-inch surface increment at the North Dakota site had detectable levels of acifluorfen residues.

Acifluorfen-sodium was applied for a second year at the Indiana and North Dakota study sites. Detectable ($\geq 0.010 \mu\text{g/g}$ to $0.287 \mu\text{g/g}$) levels of acifluorfen residues were measured in nearly all of the post-application 0 to 6 inch sampling increments for the North Dakota (up to 388 days after application) and Indiana (up to 373 after application) sites. Downward movement of acifluorfen residues were noted at both sites. Residues were identified in the 6 to 12 inch increment for the 2-week, 1-month, 5-month, and 13-month samplings for North Dakota, and 2-week, 1-month, 5-months, and 9-month samplings at Indiana. A greater numbers of acifluorfen detections would probably have occurred had the detection limit

⁶ The surface sampling increment at Tennessee was 8-inches for the soil increment collected immediately after the 1989 application, rather than 6 inches.

be lowered. It is also probable that had suction lysimeters been installed at the sites, and soil water samples collected with a lower detection limit, acifluorfen residues would have been detected at deeper sampling increments.

There were no acifluorfen residues detected (detection limit = 1.0 $\mu\text{g/L}$) in ground water at the Indiana, North Carolina, North Dakota, Tennessee, Virginia sites.

⁷ Acifluorfen residues were detected in two wells 7 months after application, registrant determined that these were "false positive" results.

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