Date Out:

Chemical Code:103601
DP Barcode:D191525

ENVIRONMENTAL FATE AND GROUND WATER BRANCH

Review Action

JUL 27 1993

To: Walter Waldrop, PM #71
Reregistration Division (H7505C)

From: Akiva Abramovitch, Section Head
Chemistry Review Section 3
Environmental Fate & Ground Water Branch/EFED (H7507C)

Thru: Henry Jacoby, Chief
Henry Jacoby 7/26/93
Environmental Fate & Ground Water Branch/EFED (H7507C)

Attached, please find the EFGWB review of...

Common Name:	Glyphosate	**Trade name:**	Rodeo,Accord,Roundup
Company Name:	Monsanto		
ID #:	103601		
Purpose:	To review a final terrestrial field dissipation study to be incorporated into the 1993 RED and storage stability data.		

Type Product:	Action Code:	EFGWB #(s):	Review Time:
Herbicide	627	93-0760	3.0 days

STATUS OF STUDIES IN THIS PACKAGE:

Guideline #	MRID	Status[1]
164-1	42765001	A

STATUS OF DATA REQUIREMENTS ADDRESSED IN THIS PACKAGE:

Guideline #	Status[2]
164-1	S

[1]Study Status Codes: A=Acceptable U=Upgradeable C=Ancillary I=Invalid.
[2]Data Requirement Status Codes: S=Satisfied P=Partially satisfied N=Not satisfied R=Reserved W=Waived.

2008915

Environmental Fate and Groundwater Branch/EFED

6. APPROVED BY:

Akiva Abramovitch, Ph.D., Chemist
Environmental Chemistry Review Section #3 Date: Akiva Abramovitch
Environmental Fate and Groundwater Branch/EFED

7. CONCLUSIONS:

STORAGE STABILITY: DER 1

The amount of glyphosate loss after a period of frozen storage for 500 days was minimal with percent recoveries ranging from 88 to 94%. AMPA appears to be stable in the Iowa and Oregon soils but decreased in recovery with increased storage time in the Georgia sand loam. The amount of AMPA loss after 500 days was less than parent glyphosate with 95% or greater being recovered. It was speculated that the decrease of recovery of glyphosate and AMPA in soils was due to increased adsorption to soil and binding to metallic cations that are present in soil.

TERRESTRIAL FIELD DISSIPATION: DER 2

1. Together studies MRID #42607501 (interim report) and MRID #42765001 (final report) completely satisfy the terrestrial field dissipation 164-1 data requirement for glyphosate.

2. a) **RESULTS FROM THE INTERIM REPORT:** The interim report results from the first 12 months of bareground field dissipation trials from eight sites show that the median half-life (DT_{50}) for glyphosate (Roundup) applied at maximum annual use rates (7.95 lb a.e./acre, 10.7 lb a.i./acre) was 13.9 days with a range of 2.6 (Texas) to 140.6 (Iowa) days. The results indicate that glyphosate and aminomethylphosphonic acid (AMPA) possess a very limited potential for vertical movement to ground water because the majority of all glyphosate residues remained in the 0-6 inch soil layer. Maximum average glyphosate levels in the 0-6 inch soil layer ranged from 1.82 ppm to 4.58 ppm and dissipated to levels ranging from 0.02 to 0.83 ppm at 12 months after application date. Maximum average aminomethylphosphonic acid (AMPA) levels in the 0-6 inch soil layer occurred 14 to 95 days after treatment and ranged from 0.27 ppm to 0.60 ppm, and then decreased to levels ranging from 0.12 ppm to 0.44 ppm at 12 months after application date. The final report will contain storage stability and data from the final months of the dissipation studies including estimates of the rate of dissipation of AMPA.

b) **RESULTS FROM THE FINAL REPORT:** The final report contains six additional months of data from the eight terrestrial field dissipation sites reviewed in the interim report. The median half-life (DT_{50}) (of eight sites) of glyphosate in the final report was 14.9 days (18 months of data) as opposed to 13.9 days (12 months of data) in the interim report. The median half-life for the

equilibrium studies glyphosate and glyphosate residues are expected to be immobile with $Kd_{(ads)}$ values ranging from 62 to 175. The mechanism of adsorption is unclear, however it is speculated that it may be associated with vacant phosphate sorption sites or high levels of metallic soil cations. The data indicate that chemical and photochemical decomposition is not a significant pathway of degradation of glyphosate in soil and water. However, glyphosate is readily degraded by soil microbes to aminomethyl phosphonic acid (AMPA), which is degraded to CO_2, although at a slower rate than parent glyphosate. Even though glyphosate is highly water soluble it appears that parent glyphosate and AMPA have a low potential to move to ground-water due to their strong adsorptive characteristics demonstrated in the laboratory and field studies. However, glyphosate does have the potential to contaminate surface waters due to its aquatic use patterns and erosion via transport of residues adsorbed to soil particles suspended in runoff water. If glyphosate were to reach surface water it would be resistant to hydrolysis and aqueous photolysis.

Based on the low vapor pressure of glyphosate, volatilization from soils will not be an important dissipation mechanism. The low octanol/water coefficient suggests that glyphosate will have a low tendency to accumulate in fish.

SUMMARY OF DATA REQUIREMENTS: (GLYPHOSATE)

The current status of environmental fate data requirements to support terrestrial food crop (field, vegetable, and tree fruit and nut crops), aquatic food crop (cranberries and rice), greenhouse nonfood crop, terrestrial nonfood crop (ornamental including turf), terrestrial nonfood (fallow and fence rows, highways and roadsides, railroad rights-of-way), aquatic non-food, domestic outdoor, and forestry (including Christmas tree plantations) sites is as follows:

Satisfied:

-Hydrolysis (161-1): File or reg # 524-308, Acc #00108192, 6/30/78; Stable at pH 3, 6, 9 at 5 and 35°C.

-Photodegradation in Water (161-2): EFGWB #90-0745, 92-0032, 90-0753,91-0356,92-0011,91-0506, MRID #41689101; Stable in pH 5, 7, and 9 buffered solutions under natural sunlight.

-Photodegradation on Soil (161-3): EFGWB # 90374, MRID #41335101; 6/28/90; Stable.

-Aerobic Soil Metabolism (162-1): EFGWB #92-1143,1144 and (EFGWB #90-0745, 92-0032, 90-0753,91-0356,92-0011,91-0506), MRID #42372501; half-life values of 1.85 and 2.06 days in the Kickapoo sandy loam and Dupo silt loam respectively were reported. AMPA was the major degradate.

-Anaerobic Aquatic Metabolism (162-3): EFGWB #92-1143,1144 and

#:92-0228, and #91-0763), MRID #40881601; Glyphosate dissipated from the water (irrigation source) with a registrant calculated half-life of 7.5 days and 120 days from the sediment of the farm pond in MO. MRID #41552801, In Michigan, Georgia and Oregon pond and stream water, the maximum glyphosate concentrations were measured immediately posttreatment and dissipated rapidly. Glyphosate accumulated in the pond sediment, and to a lesser extent in the stream sediments; glyphosate was present in pond sediment at ≥1 ppm in Michigan and Oregon at approximately 1 year posttreatment.

-Forestry Dissipation (164-3): EFGWB # 91-0763, MRID #41552801; aerially applied at 3.75 lb/A to forested sites in Michigan, Oregon, and Georgia, glyphosate averaged 652-1273 ppm in tree foliage immediately posttreatment, then declined rapidly with half-lives of <1 day at the Michigan and Georgia sites and <14 days at the Oregon site.

The forestry dissipation study results demonstrate that when used under normal silviculture practices according to label directions, the maximum combined glyphosate and AMPA residue level in soil is less than 5 ppm. Glyphosate and AMPA residues in soil dissipate with time. The average half-life for the dissipation of glyphosate was 100 days, and ranged from 35 to 158 days. The average half-life for the dissipation of AMPA was 118 days, and ranged from 71 days to 165 days.

-Accumulation in Confined Rotational Crops (165-1): (EFGWB #90-0745, 92-0032, 90-0753,91-0356,92-0011,91-0506) MRID #41543201 and MRID #41543202; Glyphosate residues (**expressed as fresh weight**) accumulated in lettuce, carrots, and barley planted 30, 119, and 364 days after sandy loam soil was treated with glyphosate at 3.71 lb ai/A. Accumulation decreased as the length of the rotation increased. In crops planted at 30 days posttreatment, [^{14}C]residues at harvest were 0.097 ppm in lettuce, 0.051 and 0.037 ppm in carrot tops and roots, respectively, and 0.188 and 0.175 ppm in barley grain and straw, respectively. In immature lettuce harvested at 40 and 60 days postplanting, [^{14}C]residues were 0.108 and 0.048 ppm, respectively (Table 7). In crops planted at 119 days posttreatment, [^{14}C]residues at harvest were 0.037 ppm in lettuce, 0.028 and 0.017 ppm in carrot tops and roots, respectively, and 0.078 and 0.056 ppm in barley grain and straw, respectively. In immature lettuce harvested at 28 and 48 days postplanting, [^{14}C]residues were 0.059 and 0.055 ppm, respectively (Table 7). In crops planted at 364 days posttreatment, [^{14}C]residues at harvest were 0.028 ppm in lettuce, 0.018 and 0.0096 ppm in carrot tops and roots, respectively, and 0.047 and 0.061 ppm in barley grain and straw, respectively. In immature lettuce harvested at 35 and 61 days postplanting, [^{14}C]residues were 0.057 and 0.043 ppm, respectively; in barley forage harvested at 48 days postplanting, [^{14}C]residues were 0.056 ppm.

-Accumulation in Irrigated Crops (165-3) MRID #40541305 (EFGWB #90-0745, 92-0032, 90-0753,91-0356,92-0011,91-0506); Alfalfa, corn (grain and forage), grass (fescue or sudan) and lettuce were

Glyphosate, isopropylamine salt (N-(Phosphonomethyl)glycine isopropylamine salt) is sold as a soluble concentrate/liquid, liquid ready to use, and a pressurized liquid. Trade names: Roundup, Rodeo, Roundup L&G, Shackle, Shakle C. The isopropylamine salt is used as a terrestrial food crop, terrestrial food + feed, terrestrial non-food + outdoor residential, aquatic food crop, aquatic non-food/outdoor industrial, forestry, greenhouse food, and indoor non-food. It is used throughout the United States and various other parts of the world. Applications vary from when needed to seasonal and the maximum application rate is 7.95 lbs. per acre.

Roundup, Rodeo and Accord contain glyphosate (N-phosphonomethylglycine) formulated as an aqueous solution of its isopropylamine salt at a concentration of 41.0%, 53.8% and 41.5% respectively.

10. DISCUSSION:
See attached DERS.

11. COMPLETION OF ONE-LINER:
Attached.

12. CBI INDEX:
Not Applicable.

MATERIALS AND METHODS:

Three control soils from Climax, Georgia (sand loam, 76% sand, 14% silt, 10% clay, CEC 2.3 meq/100g, pH 4.7, %OM 1.1) Danville, Iowa (silt loam, 20% sand, 54% silt, 10% clay, CEC 17.8 meq/100g, pH 6.0, %OM 4.4), Corvallis, Oregon sediment (56% sand, 23% silt, 21% clay, CEC 18.2 meq/100g, pH 5.8, %OM 7.2) were stored frozen at -17°C in the dark. At approximately every 6 months three samples were removed from frozen storage then fortified with glyphosate and AMPA then returned to the freezer. Three samples were removed from frozen storage and analyzed in sets consisting of unfortified samples. Only two of the three samples were analyzed to save one for backup analysis. After the initial chromatography the extracts were stored at (3-6°C) in the dark. After a period of 35 to 42 days extraction samples were analyzed to determine whether there was a storage stability problem after extraction and storage.

Glyphosate and AMPA were extracted from the soils with 0.5N KOH and eluted through a Chelex 100 resin. The retained glyphosate and iron salts were eluted with 6 N HCL. The isolated glyphosate and AMPA were then passed through an anion exchange column to remove iron and isolate the free acids of glyphosate and AMPA. The HCL is removed by dryness and the samples were redissolved in water and analyzed by HPLC. Glyphosate and AMPA were quantitated by fluorescence detection by derivatizing with o-phthaladehyde. This method was validated to 0.05 ppm for glyphosate and AMPA.

RESULTS:

1. The results indicate that recoveries of glyphosate decrease with increasing storage time for the soils and sediment used. The amount of glyphosate loss after a period of frozen storage for 500 days was minimal with percent recoveries ranging from 88 to 94%. AMPA appears to be stable in the Iowa and Oregon soils but decreased in recovery with increased storage time in the Georgia sand loam. The amount of AMPA loss after 500 days was less than parent glyphosate with 95% or greater being recovered. It was speculated that the decrease of recovery of glyphosate and AMPA in soils was due to increased adsorption to soil and binding to metallic cations.

2. The average recoveries of glyphosate and AMPA residues from soils fortified with 1.0 ppm ranged from 0.65 to 0.85 ppm. The amount recovered from the Georgia check soil fortified on Day 0 was 0.82 to 0.80 ppm, from the Iowa check soil 0.76 to 0.73 ppm, and the Oregon check sediment were 0.81 and 0.80 ppm for glyphosate and AMPA respectively.

3. After 39 days past the initial chromatography the stored extract samples showed glyphosate recoveries decreased by 1.77% and AMPA recoveries increased by 3.50%.

4. A statistical analysis of the storage data indicated that % remaining of glyphosate in soil samples ranged from 88 to 94% and for AMPA it was 95% or above.

DISCUSSION:

1. Study MRID #42765002 may be used as ancillary data to the previously reviewed terrestrial field dissipation studies. Storage stability is not a required guideline study and does not specifically satisfy a given data requirement.

Table 2.

Residues of Glyphosate and AMPA in Georgia Soil After Frozen Storage.

Fortification Rate (ppm)	Days in Storage	Glyphosate (ppm)	AMPA (ppm)
0.00	0	0.0000	0.0000
		0.0000	0.0067
1.00	0	0.8001	0.7778
		0.8365	0.8152
1.00	65	0.8246	0.8046
		0.8314	0.8115
1.00	247	0.7866	0.7588
		0.8351	0.7905
1.00	429	0.7928	0.7689
		0.8411	0.8098
1.00	611	0.7376	0.7100
		0.7431	0.7278
1.00	793	0.6768	0.6639
		0.7284	0.6983
1.00	975	0.7770	0.7623
		0.7928	0.7730

Table 4.

Residues of Glyphosate and AMPA in Oregon Sediment After Frozen Storage.

Fortification Rate (ppm)	Days in Storage	Glyphosate (ppm)	AMPA (ppm)
0.00	0	0.0000	0.0000
		0.0000	0.0000
1.00	0	0.7943	0.7944
		0.8208	0.8033
1.00	65	0.8723	0.8361
		0.8975	0.8504
1.00	247	0.7909	0.7997
		0.8321	0.8110
1.00	429	0.5946	0.6216
		0.6863	0.7014
1.00	611	0.7122	0.7663
		0.7623	0.8567
1.00	793	0.5816	0.6714
		0.6712	0.7891
1.00	975	0.6931	0.7944
		0.7249	0.8779

Table 6.

Percentage Glyphosate Remaining at Selected Timepoints Based on Statistical Analysis of Results.

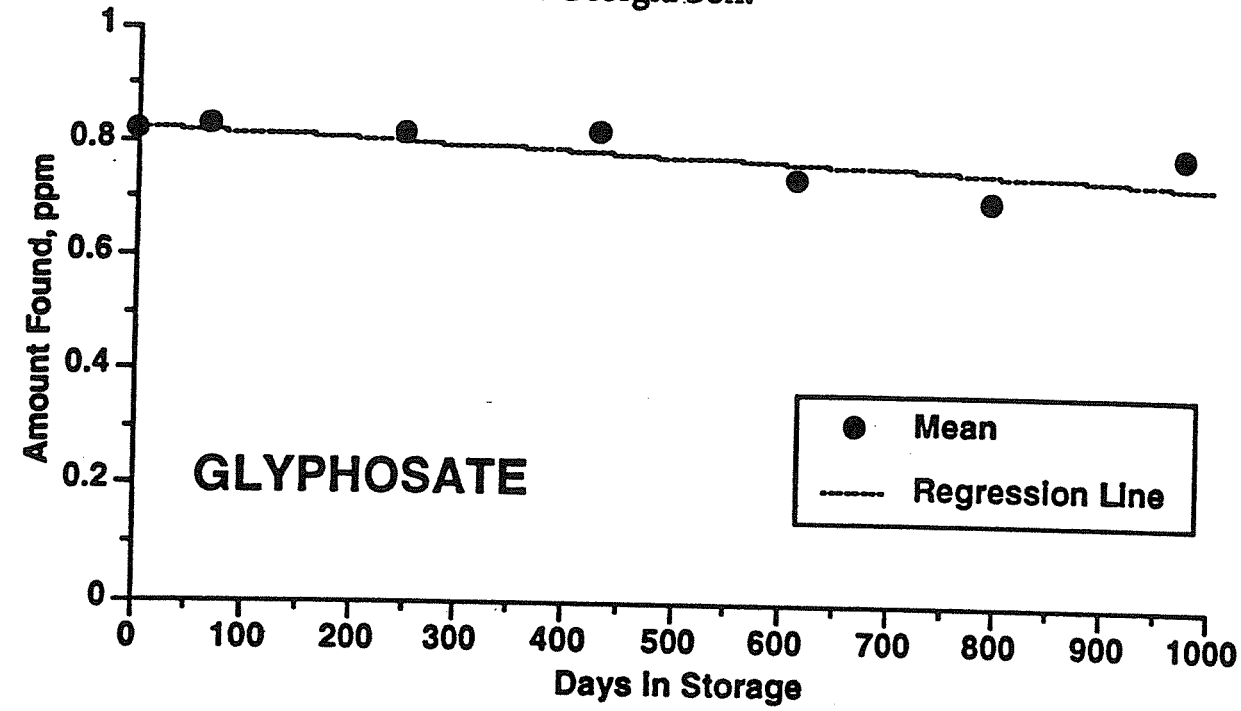
	Georgia Soil	Iowa Soil	Oregon Sediment
Slope (β)	–0.000116	–0.000183	–0.000251
PR_{100} (1)	98.8	98.2	97.5
PR_{300}	96.6	94.7	92.7
PR_{500}	94.4	91.2	88.2
PR_{750}	91.7	87.2	82.8
PR_{1000}	89.0	83.3	77.8

(1) PR_t = Percentage Remaining at time t (in days; i.e. PR_{300} = percentage remaining after 300 days in storage), calculated using the equation $PR_t = \exp(\beta t) \times 100\%$

IX. FIGURES:

Figure 2.

Effect of Length of Storage on Recovery of Glyphosate and AMPA from Georgia Soil.



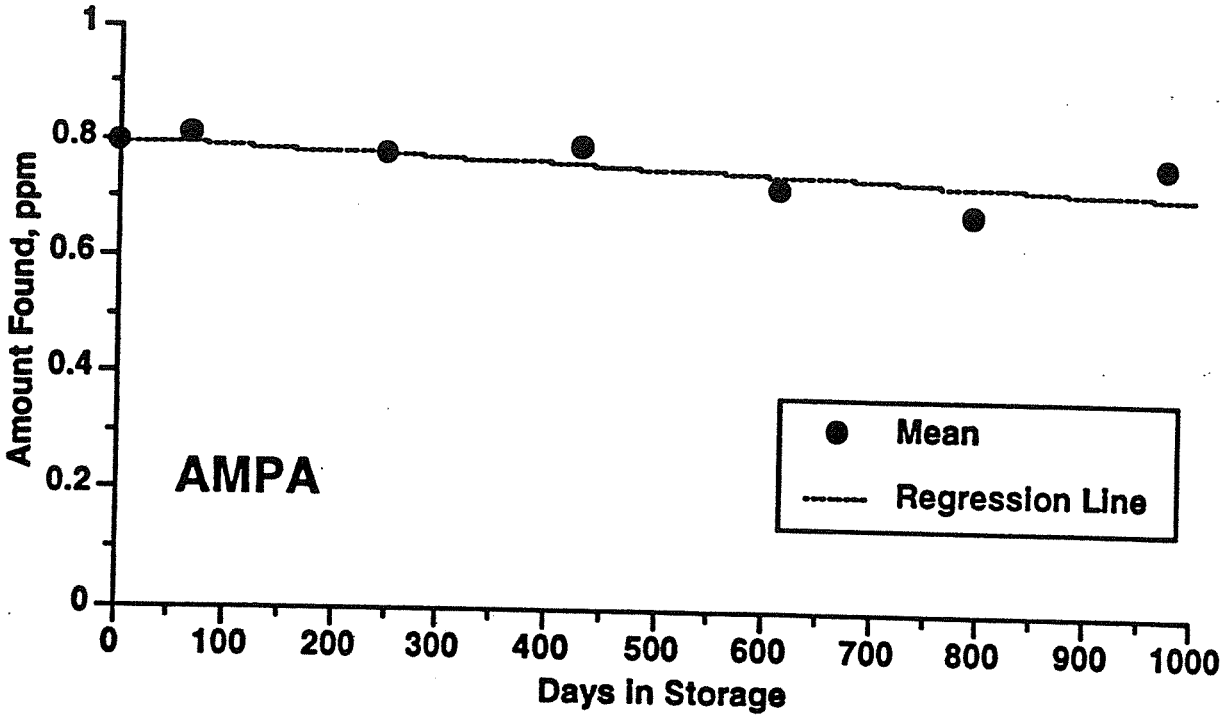
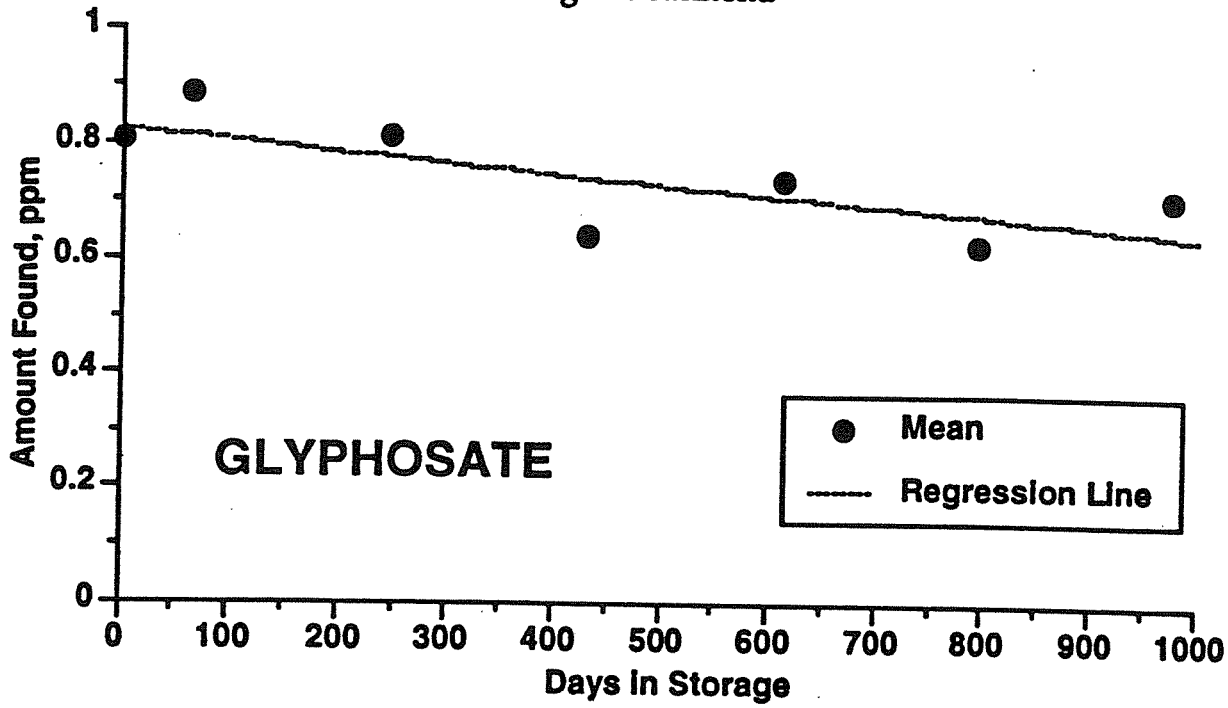


Figure 4.

Effect of Length of Storage on Recovery of Glyphosate and AMPA from Oregon Sediment.



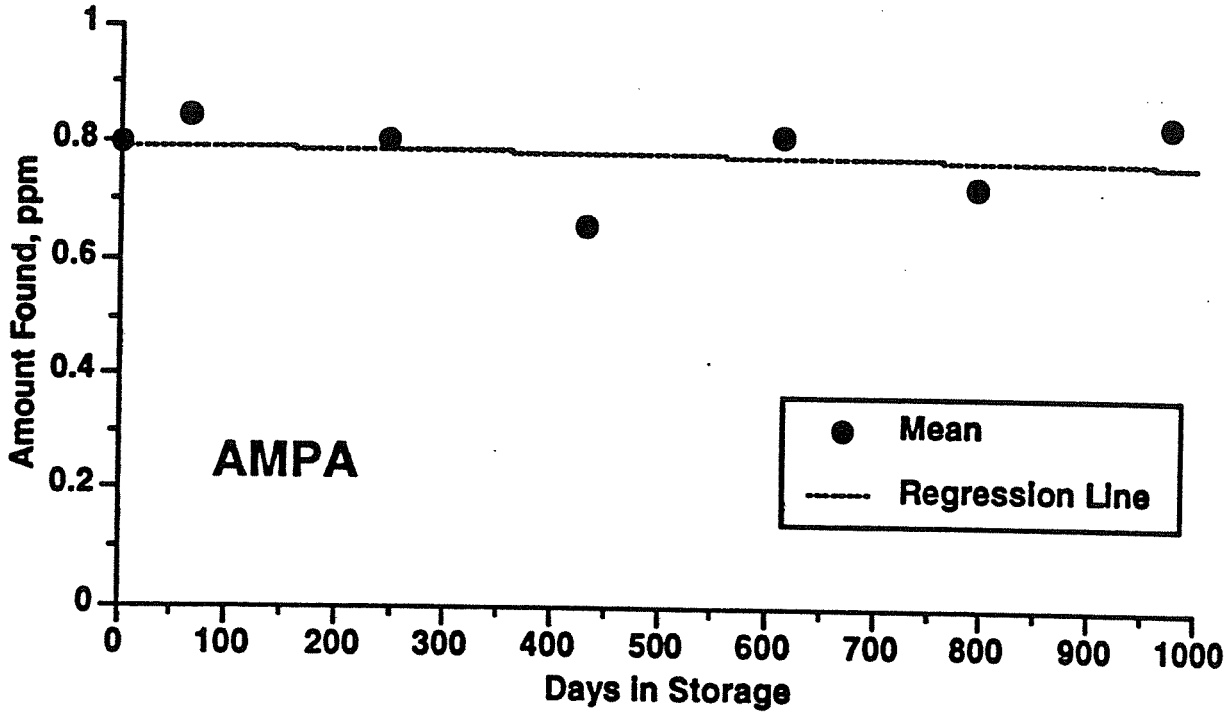


Table 1.

Residues Levels of Glyphosate and AMPA in Arizona Soil Following Treatment with Roundup® at 8.08 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
-1	0-6"	0.00	0.00	0.00
-1	6-12"	0.00	0.00	0.00
-1	12-18"	0.00	0.00	0.00
-1	18-24"	0.00	0.00	0.00
-1	24-30"	0.00	0.00	0.00
-1	30-36"	0.00	0.00	0.00
-1	36-42"	-0.01	0.00	-0.01
-1	42-48"	0.00	0.00	0.00
0	0-6"	1.91	0.11	2.08
0	6-12"	0.01	0.00	0.01
0	12-18"	0.00	0.00	0.00
0	18-24"	0.00	0.00	0.00
1	0-6"	2.06	0.14	2.27
1	6-12"	0.01	0.00	0.01
1	12-18"	0.00	0.00	0.00
1	18-24"	0.00	0.00	0.00
7	0-6"	2.23	0.23	2.58
7	6-12"	0.08	0.01	0.10
7	12-18"	0.01	0.00	0.01
7	18-24"	0.00	0.00	0.00
14	0-6"	0.59	0.18	0.86
14	6-12"	0.00	0.00	0.00
14	12-18"	0.00	0.01	0.02
14	18-24"	0.00	0.01	0.02
21	0-6"	1.91	0.56	2.76
21	6-12"	0.01	0.00	0.01
21	12-18"	0.00	0.00	0.00
21	18-24"	0.05	0.06	0.14

Table 1 Continued.

Residues Levels of Glyphosate and AMPA in Arizona Soil Following Treatment with Roundup® at 8.08 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
28	0-6"	0.77	0.34	1.29
28	6-12"	0.00	0.00	0.00
28	12-18"	0.00	0.00	0.00
28	18-24"	0.00	0.00	0.00
64	0-6"	0.34	0.46	1.04
64	6-12"	0.01	0.02	0.04
64	12-18"	0.00	0.00	0.00
92	0-6"	0.14	0.28	0.57
92	6-12"	0.00	0.00	0.00
92	12-18"	0.00	0.00	0.00
92	18-24"	0.00	0.00	0.00
122	0-6"	0.13	0.36	0.68
122	6-12"	0.00	0.00	0.00
122	12-18"	0.00	0.00	0.00
122	18-24"	0.00	0.00	0.00
184	0-6"	0.05	0.26	0.45
184	6-12"	0.03	0.03	0.08
184	12-18"	0.00	0.00	0.00
184	18-24"	0.00	0.00	0.00
364	0-6"	0.04	0.17	0.30
364	6-12"	0.00	0.00	0.00
364	12-18"	0.00	0.00	0.00

Table 2.

Residues Levels of Glyphosate and AMPA in California Soil Following Treatment with Roundup® at 8.83 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
-8	0-6"	0.00	0.00	0.00
-8	6-12"	0.00	0.00	0.00
-8	12-18"	0.01	0.00	0.01
-8	18-24"	0.01	0.00	0.01
-8	24-30"	0.01	0.00	0.01
-8	30-36"	0.01	0.00	0.01
-8	36-42"	0.00	0.02	0.03
-8	42-48"	0.00	0.00	0.00
0	0-6"	1.12	0.13	1.32
0	6-12"	0.30	0.00	0.30
0	12-18"	0.21	0.01	0.23
0	18-24"	0.10	0.02	0.13
0	24-30"	0.04	0.00	0.04
0	30-36"	0.00	0.00	0.00
0	36-42"	0.00	0.00	0.00
1	0-6"	1.94	0.14	2.15
1	6-12"	0.05	0.00	0.05
1	12-18"	0.01	0.00	0.01
1	18-24"	0.00	0.00	0.00
7	0-6"	1.24	0.31	1.71
7	6-12"	0.03	0.00	0.03
7	12-18"	0.01	0.00	0.01
7	18-24"	0.00	0.00	0.00
14	0-6"	1.09	0.36	1.64
14	6-12"	0.00	0.01	0.02
14	12-18"	0.01	0.00	0.01
14	18-24"	0.01	0.01	0.03

Table 2 Continued.

Residues Levels of Glyphosate and AMPA in California Soil Following Treatment with Roundup® at 8.83 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
456	0-6"	0.04	0.35	0.57
456	6-12"	0.01	0.04	0.07
456	12-18"	0.00	0.00	0.00
550	0-6"	0.02	0.31	0.49
550	6-12"	0.00	0.04	0.06
550	12-18"	0.00	0.02	0.03

The glyphosate and AMPA residue levels in the above table are the average of the replicate composited sample results found in Appendix E.

The 'Total Residues' column is calculated using the following equation:

Total Residues = PPM Glyphosate + (PPM AMPA x 1.523)

where 1.523 is the ratio of the molecular weights of glyphosate to AMPA (169.07/111.04).

Recoveries from Quality Control samples (Sponsor fortified check soil) spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 87.11% for glyphosate (ranged from 71.34% to 136.99%) and 86.96% for AMPA (ranged from 67.92% to 118.59%).

Recoveries from fortified check soil samples spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 84.66% for glyphosate (ranged from 52.17% to 120.51%) and 85.75% for AMPA (ranged from 59.40% to 127.92%).

Treated field samples were stored at <0° C for 50 to 433 days prior to analysis.

Table 3 Continued.

Residues Levels of Glyphosate and AMPA in Georgia Soil Following Treatment with Roundup® at 7.99 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
31	0-6"	0.56	0.34	1.08
31	6-12"	0.02	0.00	0.02
31	12-18"	0.01	0.00	0.01
31	18-24"	0.00	0.00	0.00
61	0-6"	0.44	0.60	1.35
61	6-12"	0.00	0.01	0.02
61	12-18"	0.00	0.00	0.00
94	0-6"	0.19	0.46	0.89
94	6-12"	0.00	0.00	0.00
94	12-18"	-0.02	0.00	-0.02
94	18-24"	0.01	0.00	0.01
123	0-6"	0.10	0.32	0.59
123	6-12"	0.01	0.00	0.01
123	12-18"	0.00	0.00	0.00
123	18-24"	0.02	0.00	0.02
188	0-6"	0.18	0.53	0.99
188	6-12"	0.00	0.00	0.00
188	12-18"	0.01	0.00	0.01
188	18-24"	0.01	0.00	0.01
368	0-6"	0.10	0.44	0.77
368	6-12"	0.00	0.03	0.05
368	12-18"	0.00	0.01	0.02

Table 4.

Residues Levels of Glyphosate and AMPA in Iowa Soil Following Treatment with Roundup® at 7.94 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
-1	0-6"	0.01	0.00	0.01
-1	6-12"	0.00	0.00	0.00
-1	12-18"	0.01	0.00	0.01
-1	18-24"	0.00	0.00	0.00
-1	24-30"	0.00	0.00	0.00
-1	30-36"	0.00	0.00	0.00
-1	36-42"	0.00	0.01	0.02
-1	42-48"	0.00	0.00	0.00
0	0-6"	1.89	0.05	1.97
0	6-12"	0.04	0.00	0.04
0	12-18"	0.02	0.00	0.02
0	18-24"	0.00	0.00	0.00
1	0-6"	2.34	0.07	2.45
1	6-12"	0.04	0.00	0.04
1	12-18"	0.01	0.00	0.01
1	18-24"	0.01	0.00	0.01
7	0-6"	1.99	0.12	2.17
7	6-12"	0.06	0.00	0.06
7	12-18"	0.02	0.00	0.02
7	18-24"	0.00	0.00	0.00
14	0-6"	1.71	0.11	1.88
14	6-12"	0.12	0.02	0.15
14	12-18"	0.03	0.00	0.03
14	18-24"	0.01	0.00	0.01
21	0-6"	1.49	0.15	1.72
21	6-12"	0.07	0.01	0.09
21	12-18"	0.02	0.00	0.02
21	18-24"	0.00	0.00	0.00

Table 4 Continued.

Residues Levels of Glyphosate and AMPA in Iowa Soil Following Treatment with Roundup® at 7.94 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
366	0-6"	0.83	0.54	1.65
366	6-12"	0.01	0.02	0.04
366	12-18"	0.00	0.00	0.00
458	0-6"	0.45	0.58	1.33
458	6-12"	0.02	0.02	0.05
458	12-18"	0.00	0.01	0.02

The glyphosate and AMPA residue levels in the above table are the average of the replicate composited sample results found in Appendix E.

The 'Total Residues' column is calculated using the following equation:

Total Residues = PPM Glyphosate + (PPM AMPA x 1.523)

where 1.523 is the ratio of the molecular weights of glyphosate to AMPA (169.07/111.04).

Recoveries from Quality Control samples (Sponsor fortified check soil) spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 67.29% for glyphosate (ranged from 51.80% to 92.89%) and 72.94% for AMPA (ranged from 44.32% to 94.13%).

Recoveries from fortified check soil samples spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 64.95% for glyphosate (ranged from 46.92% to 84.19%) and 80.96% for AMPA (ranged from 31.56% to 95.76%).

Treated field samples were stored at <0° C for 32 to 398 days prior to analysis.

Table 5 Continued.

Residues Levels of Glyphosate and AMPA in Minnesota Soil Following Treatment with Roundup® at 8.05 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
71	0-6"	0.22	0.40	0.83
71	6-12"	-0.01	0.00	-0.01
71	12-18"	0.00	0.00	0.00
95	0-6"	0.27	0.43	0.92
95	6-12"	0.01	0.02	0.04
95	12-18"	0.00	0.01	0.02
129	0-6"	0.21	0.41	0.83
129	6-12"	0.02	0.01	0.04
129	12-18"	0.01	0.00	0.01
179	0-6"	0.13	0.33	0.63
179	6-12"	0.01	0.02	0.04
179	12-18"	0.00	0.00	0.00
372	0-6"	0.04	0.15	0.27
372	6-12"	0.00	0.00	0.00
372	12-18"	0.00	0.00	0.00
475	0-6"	0.06	0.23	0.41
475	6-12"	0.00	0.00	0.00
475	12-18"	0.00	0.02	0.03

The glyphosate and AMPA residue levels in the above table are the average of the replicate composited sample results found in Appendix E.

The 'Total Residues' column is calculated using the following equation:

Total Residues = PPM Glyphosate + (PPM AMPA x 1.523)

where 1.523 is the ratio of the molecular weights of glyphosate to AMPA (169.07/111.04).

Recoveries from Quality Control samples (Sponsor fortified check soil) spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 75.64% for glyphosate (ranged from 55.18% to 95.78%) and 86.79% for AMPA (ranged from 74.99% to 119.18%).

Recoveries from fortified check soil samples spiked with glyphosate and AMPA over the range of 0.05 to 5.00 ppm and analyzed concurrently with the field treated samples averaged 78.71% for glyphosate (ranged from 56.64% to 116.53%) and 87.46% for AMPA (ranged from 65.76% to 174.00%).

Treated field samples were stored at <0° C for 29 to 476 days prior to analysis.

Table 6 Continued.

Residues Levels of Glyphosate and AMPA in New York Soil Following Treatment with Roundup® at 7.84 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
30	0-6"	2.65	0.43	3.30
30	6-12"	0.09	0.06	0.18
30	12-18"	0.00	0.01	0.02
30	18-24"	0.01	0.00	0.01
61	0-6"	1.62	0.27	2.03
61	6-12"	0.03	0.03	0.08
61	12-18"	0.01	0.01	0.03
61	18-24"	0.00	0.00	0.00
90	0-6"	1.98	0.48	2.71
90	6-12"	0.07	0.04	0.13
90	12-18"	0.02	0.04	0.08
90	18-24"	0.01	0.00	0.01
120	0-6"	1.15	0.33	1.65
120	6-12"	0.03	0.04	0.09
120	12-18"	0.02	0.03	0.07
120	18-24"	0.01	0.00	0.01
180	0-6"	1.32	0.43	1.97
180	6-12"	0.03	0.04	0.09
180	12-18"	0.02	0.03	0.07
180	18-24"	0.02	0.00	0.02
362	0-6"	0.51	0.20	0.81
362	6-12"	0.02	0.03	0.07
362	12-18"	0.00	0.00	0.00

Table 7.

Residues Levels of Glyphosate and AMPA in Ohio Soil Following Treatment with Roundup® at 8.14 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
-1	0-6"	0.01	0.01	0.03
-1	6-12"	0.00	0.00	0.00
-1	12-18"	0.00	0.00	0.00
-1	18-24"	0.00	0.00	0.00
-1	24-30"	0.01	0.00	0.01
-1	30-36"	0.00	0.00	0.00
-1	36-42"	0.00	0.00	0.00
-1	42-48"	0.00	0.00	0.00
0	0-6"	2.01	0.34	2.53
0	6-12"	0.00	0.00	0.00
0	12-18"	0.00	0.00	0.00
1	0-6"	1.83	0.35	2.36
1	6-12"	0.00	0.00	0.00
1	12-18"	0.00	0.01	0.02
7	0-6"	0.66	0.56	1.51
7	6-12"	0.00	0.00	0.00
7	12-18"	0.00	0.00	0.00
14	0-6"	0.51	0.43	1.16
14	6-12"	0.02	0.04	0.08
14	12-18"	0.00	0.00	0.00
21	0-6"	0.70	0.60	1.61
21	6-12"	0.02	0.03	0.07
21	12-18"	0.01	0.00	0.01
30	0-6"	0.59	0.55	1.43
30	6-12"	0.02	0.02	0.05
30	12-18"	0.00	0.00	0.00
61	0-6"	0.12	0.37	0.68
61	6-12"	0.01	0.02	0.04
61	12-18"	0.00	0.00	0.00
90	0-6"	0.08	0.26	0.48
90	6-12"	0.01	0.01	0.03
90	12-18"	-0.01	0.00	-0.01

Table 8.

Residues Levels of Glyphosate and AMPA in Texas Soil Following Treatment with Roundup® at 7.85 lb a.e./acre.

Days After Application	Depth of Sample	Glyphosate (ppm)	AMPA (ppm)	Total Residues (ppm)
-1	0-6"	0.00	0.01	0.02
-1	6-12"	0.01	0.00	0.01
-1	12-18"	0.00	0.00	0.00
-1	18-24"	0.00	0.00	0.00
-1	24-30"	0.01	0.00	0.01
-1	30-36"	0.01	0.00	0.01
-1	36-42"	0.00	0.03	0.05
-1	42-48"	0.00	0.00	0.00
0	0-6"	1.93	0.11	2.10
0	6-12"	0.06	0.03	0.11
0	12-18"	0.00	0.01	0.02
0	18-24"	0.00	0.00	0.00
1	0-6"	1.60	0.12	1.78
1	6-12"	0.03	0.01	0.05
1	12-18"	0.00	0.00	0.00
1	18-24"	0.00	0.00	0.00
11	0-6"	1.11	0.27	1.52
11	6-12"	0.01	0.00	0.01
11	12-18"	0.00	0.00	0.00
11	18-24"	0.00	0.00	0.00
14	0-6"	0.01	0.00	0.01
14	6-12"	0.01	0.00	0.01
14	12-18"	0.00	0.01	0.02
14	18-24"	0.00	0.00	0.00
27	0-6"	0.13	0.15	0.36
27	6-12"	0.00	0.00	0.00
27	12-18"	0.00	0.00	0.00
27	18-24"	0.00	0.00	0.00
30	0-6"	0.15	0.27	0.56
30	6-12"	0.00	0.00	0.00
30	12-18"	0.00	0.00	0.00
30	18-24"	0.00	0.01	0.02

Table 9.

Glyphosate Dissipation: Length of Time for 50% of the Initial Concentration of Glyphosate to Dissipate.

Location	DT_{50} (days)
Arizona	17.1
California	12.6
Georgia	8.3
Iowa	141.9
Minnesota	24.7
New York	114.3
Ohio	7.3
Texas	1.7

Median[1]:	14.9 days
Arithmetic Mean[2]:	41.0 days
Geometric Mean[3]:	17.5 days

[1] Median: a value in an ordered set of values below and above which there is an equal number of values or which is the arithmentic mean of the two middle values if the is no one middle number.

[2] Arithmetic Mean: a value that is computed by dividing the sum of a set of values by the number of values.

[3] Geometric Mean: a value that is computed by taking the *n*th root of the product of *n* values.

Table 11.

Average, Minimum, and Maximum Percentage Recoveries of Recovery Samples.

Location	Glyphosate Recovery Average, %	Glyphosate Recovery Minimum, %	Glyphosate Recovery Maximum, %	AMPA Recovery Average, %	AMPA Recovery Minimum, %	AMPA Recovery Maximum, %
Arizona	72.70	44.02	104.27	85.79	64.80	138.37
California	84.66	52.17	120.51	85.75	59.40	127.92
Georgia	88.76	62.52	116.27	85.48	58.77	123.81
Iowa	64.95	46.92	84.19	80.96	31.56	95.76
Minnesota	78.71	56.64	116.53	87.46	65.76	174.00
New York	79.61	55.23	99.67	85.04	48.92	140.74
Ohio	78.66	63.06	91.93	85.95	73.61	110.26
Texas	74.98	52.27	101.84	86.96	74.44	105.77

Table 13.

Closure Calculations for Total Residues Found at the Sampling Event with the Highest Average Residues.

Location	Application Rate (lb/acre)	Application Rate ($\mu g/cm^2$)	Highest Concentration DAT	GLY Residues Measured ($\mu g/cm^2$)	AMPA Residues Measured ($\mu g/cm^2$)	Total Residues Measured ($\mu g/cm^2$)	Closure Percent
Arizona	8.08	90.561	21 DAT	34.349	10.839	50.857	56.2
California	8.83	98.967	1 DAT	44.658	3.115	49.403	49.9
Georgia	7.99	89.552	0 DAT	72.829	1.506	75.122	83.9
Iowa	7.94	88.992	1 DAT	37.846	1.046	39.439	44.3
Minnesota	8.05	90.225	15 DAT	31.093	3.789	36.863	40.9
New York	7.84	87.871	14 DAT	79.901	8.704	93.156	106.0
Ohio	8.14	91.234	0 DAT	33.752	5.700	42.432	46.5
Texas	7.85	87.983	0 DAT	37.919	2.677	41.996	47.7

GLY (glyphosate) and AMPA residues measured ($\mu g/cm^2$) = $R_{it} = C_{it} \times D_i \times L_i$

Where: R_{it} = Mass (per unit surface area applied in $\mu g/cm^2$) in layer i at sampling time t.

C_{it} = Average concentration (ppm) of analyte in soil layer i at sampling time t.

D_i = Soil density (g/cm^3) for soil layer i.

L_i = Thickness (cm) of soil layer i (15.24 cm).

Application Rate ($\mu g/cm^2$) = [Application Rate (lb a.e./acre) x 453590000 μg/lb x 1 acre/40470000 cm^2]

Total Residues = GLY Residues + (AMPA Residues x 1.523):

Where: 1.523 = molecular weight of glyphosate÷molecular weight of AMPA (169.08 ÷ 111.04).

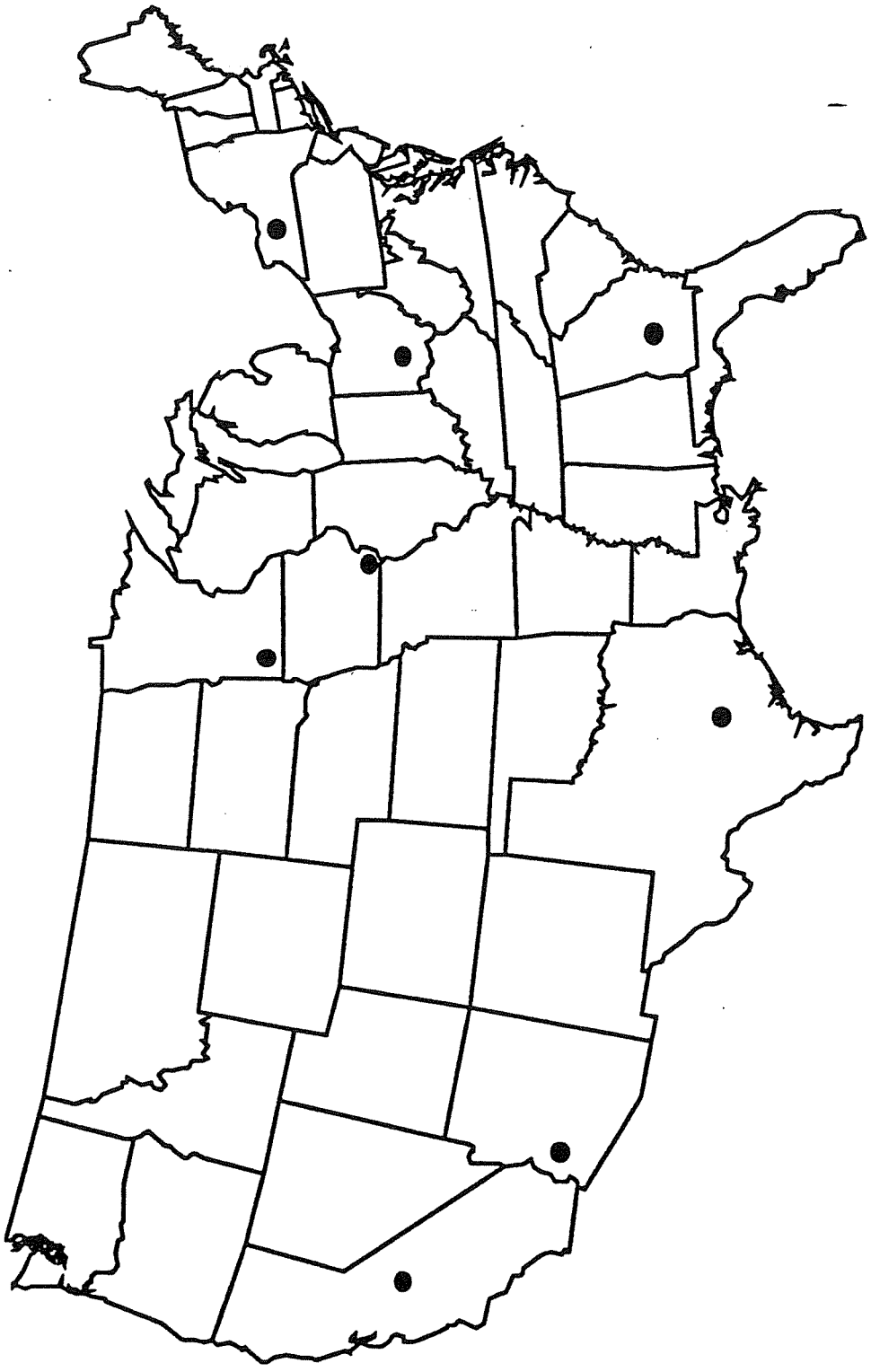


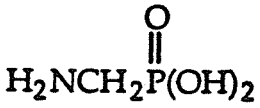
Figure 1. Field Locations for Glyphosate Terrestrial Soil Dissipation Study

Figure 2.

Structures of Glyphosate and AMPA

Glyphosate as acid

Molecular Weight = 169.08



AMPA

Molecular Weight = 111.04

Isopropylamine salt of glyphosate
active ingredient in formulated product

Formula Weight = 228.19

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PESTICIDE ENVIRONMENTAL FATE ONE LINE SUMMARY
GLYPHOSATE
Last Update on July 13, 1993
[V] = Validated Study [S] = Supplemental Study [U] = USDA Data

Photolysis (161-2, -3, -4)
[V] Water:Stable at pH 5,7,9 sunlight, 14.7-28.6 C (calc.half-life
[ ] : >410 days)
[ ] :
[ ] :

[V] Soil :90.2 day half-life in sandy loam, irradiated, 96.3 non-irr.
[ ] Air :

Aerobic Soil Metabolism (162-1)
[V] T 1/2= < 1 day SdLm
[V] T 1/2= 1-3 day SiLm
[ ]
[ ]
[ ]
[ ]
[ ]

Anaerobic Soil Metabolism (162-2)
[ ] See anaerobic aquatic metabolism.
[ ]
[ ]
[ ]
[ ]
[ ]
[ ]

Anaerobic Aquatic Metabolism (162-3)
[S] AT pH 4.2, T1/2 = 5 WEEKS
[S] " " 6.3, " = 7 WEEKS
[V] T 1/2= 8.1 days in silty clay loam sediment, major degradate was
[ ] AMPA.
[ ]
[ ]
[ ]

Aerobic Aquatic Metabolism (162-4)
[S] IN pH 6.2 NATURAL WATER, 51-
[ ] 61% REMAINED AFTER 63 DAYS.
[V] T 1/2= 7 days SiClLm, AMPA was the major degradate.
[ ]
[ ]
[ ]
[ ]

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Long-Term Soil Dissipation (164-5)
[ ]
[ ]

Accumulation in Rotational Crops, Confined (165-1)
[V] 0.028 to 0.108 ppm, lettuce;0.018 to 0.051 ppm carrot tops,0/0096
[ ] to 0.037 ppm(roots) at 3.71 lbs.ai/A,30,119,364 days after treat.

Accumulation in Rotational Crops, Field (165-2)
[ ]
[ ]

Accumulation in Irrigated Crops (165-3)
[V] At 21.3ppm int.conc. then 0.46 at 1 day posttreatment alfalfa,
[ ] corn, grass did not acc. residues. Lettuce was at 0.06 ppm gly.

Bioaccumulation in Fish (165-4)
[V] Max conc. in bluegillsunfish, exposed to 12 ppm for 35 days, 0.38
[ ] X edible tissue, 0.63X nonedible tissue, 0.52X for whole fish

Bioaccumulation in Non-Target Organisms (165-5)
[ ]
[ ]

Ground Water Monitoring, Prospective (166-1)
[ ]
[ ]
[ ]
[ ]

Ground Water Monitoring, Small Scale Retrospective (166-2)
[ ]
[ ]
[ ]
[ ]

Ground Water Monitoring, Large Scale Retrospective (166-3)
[ ]
[ ]
[ ]
[ ]

Ground Water Monitoring, Miscellaneous Data (158.75)
[ ]
[ ]
[ ]

Environmental Fate & Effects Division
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Comments

Glyphosate dissipated in pond water with T1/2 of 14-21 days; none detectable after 129 days. Sediment conc. increased from 190 ppb at day 7 to 680 ppb at day 127.
Residues in 4-wk old soybeans grown in aged water extracted soils treated at 4 ppm ranged from .76 to 4.12 ppb; residues in the soil during the growing period ranged from .64 to 3.72 ppm.

References: WSSA 83, EFGWB Reviews
Writer : PJH,KLP