6-7-85

DYNAMAC
CORPORATION

GLYPHOSATE

Final Report

Task 2: Environmental Fate and Exposure Assessment

Contract No. 68-01-6679

JUNE 7, 1985

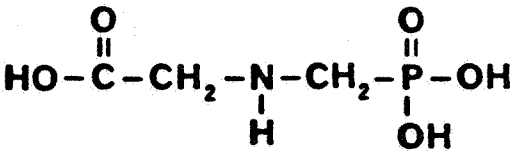
Submitted to:
Environmental Protection Agency
Arlington, VA 22202

Submitted by:
Dynamac Corporation
Enviro Control Division
The Dynamac Building
11140 Rockville Pike
Rockville, MD 20852

Environmental Fate and Exposure Assessment

Glyphosate

ROUNDUP



N-(phosphonomethyl)glycine

Glyphosate isopropylamine salt is a nonselective, postemergence systemic herbicide registered for use on a variety of terrestrial food crop (field, vegetable, and tree fruit and nut crops), aquatic food crop (cranberries and rice), greenhouse nonfood crop, terrestrial nonfood crop (ornamentals including turf), terrestrial noncrop (fallowland and fencerows, highways and roadsides, railroad rights-of-way), aquatic noncrop, domestic outdoor, and forestry (including Christmas tree plantations) sites. Application rates range from 0.19 to 3.75 lb ae/A. Glyphosate may be formulated with alachlor or acifluorfen. Single active ingredient formulations consist of 0.42, 3, and 4 lb ae/gal, and 5 and 6.6% SC/L; 0.5 0.96, and 1% RTU; and 0.75% PrL. Glyphosate may be applied foliarly, in a broadcast, using conventional ground equipment, hand-held and recirculating sprayers, and aerially. Applicators need not be certified or under the direct supervision of applicators certified to apply glyphosate.

Available data are insufficient to fully assess the environmental fate of glyphosate and the exposure of humans and nontarget organisms to glyphosate. Some of the following data (summaries) are preliminary, because they do not meet requirements for filling data gaps. Only the hydrolysis data are acceptable.

[^{14}C]Glyphosate (94% glyphosate, [redacted] and aminomethylphosphonic acid were stable in sterile buffered water at pH 3, 6, and 9 during 35 days of incubation in the dark at 5 and 35 C (Brightwell and Malik, 00108192). Slight degradation of [^{14}C]glyphosate was observed in two of three sterile, natural waters treated with [^{14}C]glyphosate (94% glyphosate, [redacted], at 0.1 ppm, and incubated in the dark at 30 C for 35 or 49 days. Aminomethylphosphonic acid was detected at maximum concentrations of 25.3 and 17.2 % of the applied 35 days posttreatment in the Cattail Swamp (pH 6.2) and Ballard Pond (pH 7.3) waters, respectively. No degradation was observed in Sphagnum Bog water (pH 4.2).

Under aerobic aquatic conditions, [^{14}C]glyphosate (94% glyphosate, [redacted] degraded in three natural waters at pH 4.2, 6.2, and 7.3, with 39-49% of the applied remaining at 49 days, 51-61% at 63 days, and 58-69% at 35 days, respectively (Brightwell and Malik, 00108192). Respective aminomethylphosphonic acid concentrations increased steadily at each sampling interval, reaching maximum concentrations in the Sphagnum Bog, Cattail Swamp, and Ballard Pond waters of 26.2, 30.2, and 23.1% of the applied radioactivity. A maximum of 29, 14.6, and 11.4% of the applied radioactivity evolved as $^{14}CO_2$ in the pH 4.2 (day 63), pH 6.2 (day 63), and pH 7.3 (day 35) waters, respectively. Addition of sediment to the system increased the dissipation of glyphosate and aminomethylphosphonic acid from water via adsorption to sediment. Evolution of $^{14}CO_2$ was not affected. All samples were maintained at 30 C in the dark.

[^{14}C]Glyphosate (94% glyphosate, [redacted] was adsorbed to Drummer silty clay loam, Ray silt, Spinks sandy loam, Lintonia sandy loam, and Cattail Swamp sediment with Freundlich K values of 62, 90, 70, 22, and 175, respectively (Brightwell and Malik, 00108192). The maximum percentages of applied glyphosate desorbed were 5.3, 3.7, 3.6, 11.5, and 0.9%, respectively. Sphinx sandy loam soil, treated with [^{14}C]glyphosate at ~0.1 µCi/g, adsorbed 16.5 nMoles/g of [^{14}C]glyphosate (test substance uncharacterized) during 4 hours of mixing in a 15:1 water:soil slurry (Sprankle, et al., 00076493). The addition of various concentrations of phosphate to the soil had no discernible effect on glyphosate adsorption. [^{14}C]Glyphosate (purity unspecified) at concentrations ranging from 0.21 to 50.1 ppm, was highly adsorbed to five soils with organic matter contents ranging from 2.40 to 15.50% (Monsanto Co.,

Inert Ingredient Information has been deleted

00108140). Adsorption of glyphosate ranged from 71% (Soil E, 2.4% organic matter, pH 7.29) to 99% (Soil C, 15.5% organic matter, pH 5.35).

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[^{14}C]Glyphosate (94% glyphosate, [redacted] was slightly mobile to relatively immobile with <7% of the applied ^{14}C detected in the leachate from 30-cm silt, sand, clay, sandy clay loam, silty clay loam, and sandy loam soil columns eluted with 20 inches of water (Brightwell and Malik, 00108192). Aged (30 days) [^{14}C]glyphosate residues were relatively immobile in silt, clay, sandy clay loam soils with <2% of the radioactivity detected in the leachate following elution with 20 inches of water. Both glyphosate and aminomethylphosphonic acid were detected in the leachate of aged and unaged soil columns.

Neither glyphosate nor aminomethylphosphonic acid were detected (<2.5 ppb) in two canal waters flooded ~6 months following treatment of glyphosate (test substance uncharacterized), at 5 lb ai/A, to two earthen-bottom dry canals located in Washington (Kramer, 00039381-A). Soil samples taken the day before the canals were filled (~6 months posttreatment) contained ~0.35 and 0.8 ppm glyphosate and aminomethylphosphonic acid, respectively, in each canal. Glyphosate (4 lb/gal, formulation unspecified) dissipated from a pond in Florida, treated at 460 ppb, with a half-life of between 14 and 21 days (Blackburn, 00039381-E). Less than 1% of the applied was detected in the pond water 127 days posttreatment. Glyphosate was detected at a maximum concentration of 0.46 ppb in bottom sediments sampled 63 days posttreatment. The glyphosate degradate aminomethyhlphosphonic acid was not detected (<2.5 ppb) in bottom sediments.

Glyphosate and aminomethylphosphonic acid concentrations, during the 55 days after treatment with glyphosate (test substance uncharacterized) at 3.0 lb ai/A, ranged from <0.05 to 0.77 ppm (exposed soil); <0.05 to 1.28 ppm (covered soil); <0.05 to 0.55 ppm (sediment); <0.002 to 3.22 ppm (drip water); <0.002 to 0.15 ppm (stream water samples); 0.17 to 89.00 ppm (foliage); and 0.20 to 11.00 ppm (leaf litter) (Danhaus, et al., 00093922; Edwards, 00084657). N-nitrosoglyphosate was not detected in any samples, except the stream water, where 0.002 ppm were detected in all samples.

[^{14}C]Glyphosate residues in 4-week-old soybeans grown in aged (16-weeks) water-extracted and unextracted silt, sandy loam, and silty clay loam soils treated

with [^{14}C]glyphosate (purity ~96%) at 4 ppm ranged from 0.76 to 4.12 ppb (Rueppel, et al., 00108182; Henshall, et al., 00108183). Glyphosate residues in the soil during the growing period ranged from 0.64 to 3.72 ppm.

[^{14}C]Glyphosate residues (uncharacterized) accumulated in catfish exposed to N-phosphonomethyl-labeled [^{14}C]glyphosate (~98% pure) for 28 days, with a maximum bioconcentration factor of 1.87x and 13.75x in edible and visceral tissue, respectively (Monsanto Co., 00108173-A). Accumulated [^{14}C]glyphosate residues were depurated fairly rapidly with ~76% of the residues detected after 28 days of exposure being eliminated after 28 days in untreated water. [^{14}C]Glyphosate residues (uncharacterized) accumulated in the whole-body tissue of marsh clams with a maximum bioconcentration factor of ~31x in a static exposure system containing N-phosphonomethyl-labeled [^{14}C]glyphosate (>97% pure) (Monsanto Co., 00108173-E). Only 25% of the accumulated [^{14}C]glyphosate residues were eliminated after a 21-day depuration period.

Dermal, ocular, and inhalation exposures to workers may occur during application. The primary potential for exposure from the SC/L formulation is during mixing and loading where both dermal and ocular exposure can occur via splashing. Inhalation and dermal exposure may occur during application of RTU and PrL formulations. Application from aircraft increases the potential for exposure of humans and nontarget organisms to glyphosate due to spray drift and volatilization. Exposure to all formulations during application is expected to be mainly dermal. The use of protective clothing during handling, mixing, and application operations should minimize the potential for exposure to all formulations. However, data are not available to assess such exposures. Currently, no federal or state reentry intervals have been established for glyphosate.

Reported pesticide incidents involving glyphosate alone between 1966 and 1980 included 91 involving human exposure (84 people received medical attention), 2 involving domestic animals, and 1 involving environmental contamination. Most incidents occurred at agricultural and home/domestic sites. Agricultural site incidents occurred primarily during mixing/loading or ground spraying, while incidents at home/domestic sites primarily involved accidental ingestion of the pesticide. Commonly reported exposure syptoms included dermal irritation, nausea, and dizziness.

In summary, glyphosate and its degradate aminomethylphosphonic acid are stable to hydrolysis in sterile, buffered water at pH 3, 6, and 9. In three natural waters (pH 4.2, 6.2, and 7.2), glyphosate degraded with half-lives of <50, ~63, and >35 days, respectively. Addition of sediment to the three natural water systems increased the rate of dissipation of glyphosate from water via sorption to sediment. Glyphosate dissipated in pond water with a half-life of between 14 and 21 days. In two canal waters, glyphosate was not detected ~6 months posttreatment. Glyphosate and aminomethylphosphonic acid dissipation rates and concentrations in treated forests soils are extremely variable, ranging from <0.002 ppm in stream water samples to 89 ppm in foliage samples. Based on available data that indicate glyphosate is strongly adsorbed to soil, the potential of glyphosate to contaminate groundwater is expected to be low. Glyphosate has a potential to contaminate surface waters because of applications to aquatic sites. Glyphosate residues have a low potential to bioaccumulate in the edible and visceral tissue of catfish, or in the whole-body tissue of clams. Glyphosate residues do have the potential to accumulate in soybean seedlings.

The following data are required (EPA Data Requirements for Registering Pesticides) to fully assess the environmental fate and transport of, and the potential exposure to glyphosate: photodegradation studies in water, on soil, and in air; aerobic and anaerobic soil metabolism studies; aerobic and anaerobic aquatic metabolism studies; adsorption/desorption studies; laboratory and possibly field volatility studies; terrestrial, forestry, and possibly long-term field dissipation studies; accumulation studies on rotational and irrigated crops, fish, and possibly aquatic nontarget organisms; and reentry studies.

Hydrolysis studies: One study (Brightwell and Malik, 00108192) was reviewed and considered scientifically valid and fulfills data requirements by providing information on the hydrolysis of glyphosate and the glyphosate degradate aminomethylphosphonic acid in sterile, buffered water at pH 3, 6, and 9 at 5 and 35 C.

Photodegradation studies in water: No data were submitted, but all data are required.

Photodegradation studies on soil: No data were submitted, but all data are required.

Photodegradation studies in air: No data were submitted, but all data are required.

Aerobic soil metabolism studies: One study (Monsanto Co., 00108140) was reviewed and considered scientifically invalid because the sampling protocol was inadequate to accurately assess the decline of glyphosate and the formation and decline of degradates in soil. In addition, this study would not fulfill data requirements because the study was not run at a constant temperature, complete analytical methods were not reported, complete soil characteristics were not reported, and the test substance was not completely characterized. All data are required.

Anaerobic soil metabolism studies: One study (Monsanto Co., 00108140) was reviewed and is considered scientifically invalid because the sampling protocol was inadequate to accurately assess the decline of glyphosate and the formation and decline of degradates in soil. In addition, this study would not fulfill data requirements because the study was not run at a constant temperature, complete analytical methods were not reported, complete soil characteristics were not reported, and the test substance was not completely characterized. All data are required.

Aerobic aquatic metabolism studies: Two studies were reviewed. One study (Brightwell and Malik, 00108192) is considered scientifically valid; however, this study does not fulfill data requirements because the test waters were not mixed with sediment or soil (Experiment 1), complete water characteristics were not provided, and data on the characterization of radioactivity were not provided for all sampling intervals. The second study (Rueppell, et al., 00108181) is scientifically invalid because the data were too variable to assess the decline of glyphosate and patterns of formation and decline of degradates in water. In addition, this study would not fulfill data requirements because the soil was only sampled at one interval and the water was not characterized. All data are required.

Anaerobic aquatic metabolism studies: One study (Rueppel, et al., 00108181) was reviewed and is scientifically invalid because the data were too variable to assess the decline of glyphosate and patterns of formation and decline of degradates in water. In addition, this study would not fulfill data requirements because the soil was only sampled at one interval, the flooded soil was not aged for 30 days before treatment, and the water was not characterized. All data are required.

Leaching and adsorption/desorption studies: Six studies were reviewed. Two studies (Henshall and Brightwell, 00039943; Edwards, 00039381-C) could not be considered scientifically valid because pretreatment and immediate posttreatment soil samples were not analyzed to confirm glyphosate application rates. In addition, these studies would not fulfill data requirements because the method was not one of the three (i.e., soil TLC, soil columns, batch equilibrium) recommended for determining pesticide mobility in soils, and complete soil characteristics were not presented, and the formulation of the test substance was not reported (00039381-C). Two studies (Monsanto Co., 00108140; Sprankle, et al., 00076493) were considered scientifically valid but neither fulfills data requirements because complete soil characteristics were not reported, the test substance was not characterized, the study was not conducted in a calcium ion solution, incubation conditions were not specified (00108140), K_d values were not reported, desorption of glyphosate was not assessed (00076493), and the test substance was not completely characterized (00076493). The remaining two studies (Brightwell and Malik, 00108192) are valid and partially fulfill data requirements by providing information on the adsorption/desorption of glyphosate in silty clay loam, silt, and two sandy loam soils; and on the mobility of glyphosate (unaged) in sand, silt, clay, sandy clay loam, silty clay loam, and two sandy loam soils and on the mobility of glyphosate residues (aged) in silt, clay, and sandy clay loam soils. In order to fulfill data requirements, complete characteristics for the Cattail Swamp sediment used in the adsorption/desorption experiment in 00108192 or an additional adsorption/desorption experiment using a representative sediment must be submitted.

Laboratory volatility studies: No data were submitted, but all data are required.

Field volatility studies: No data were submitted; however, the requirement for data is deferred pending the receipt of laboratory volatility data.

Terrestrial field dissipation studies: No data were submitted, but all data are required.

Aquatic field dissipation studies: Six studies were reviewed and two are scientifically valid. The first study (Kramer and Blackburn, 00101561) is scientifically invalid because the analytical methods were inadequate to accurately assess the decline of glyphosate in an aquatic environment. In addition, this study would not fulfill data requirements because the test substance was not completely characterized, complete field test data were not reported, the patterns of formation and decline of degradates other than aminomethylphosphonic acid were not addressed, the sediment was not characterized, the analytical methodology was not reported, and more than one compound was applied to the pond. The second study (Dubelman and Steinmetz, 00077238) is scientifically invalid because the sampling protocol was inadequate to accurately assess the dissipation of glyphosate and the pattern of formation and decline of degradates in water. In addition, this study would not fulfill data requirements because the test substance was not characterized, complete field test data were not reported, sediments were not sampled or characterized, and the patterns of formation and decline of degradates other than aminoethylphosphonic acid were not addressed. The third study (Monsanto Co., 00108140) is scientifically invalid because the test duration and the sampling protocol were inadequate to accurately assess the dissipation of glyphosate and the patterns of formation and decline of degradates in water. In addition, this study would not fulfill data requirements because the test substance was not characterized and soil and sediment samples were not taken. The fourth study (Comes, 00039381) is scientifically invalid because the recovery of glyphosate from fortified water samples was too variable to accurately assess the dissipation of glyphosate from flowing irrigation canal water. In addition, this study would not fulfill data requirements because the test substance was not characterized, soil samples were not analyzed, complete field test data were not reported, and the formation and decline of degradates other than aminomethylphosphonic acid was not addressed. The fifth study (Kramer, 00039381-C) is scientifically valid but does not ful-

fill data requirements because the test substance was not characterized, soil samples were not characterized, complete water characteristics were not reported, rainfall data were not presented, and the formation and decline of degradates other than aminomethylphosphonic acid was not addressed. The sixth study (Blackburn, 00039381-E) is scientifically valid but does not fulfill data requirements because pond water and sediment were not characterized, the pattern of formation and decline of the degradate aminomethylphosphonic acid could not be determined because the data were illegible, more than one pesticide was applied to the test site and may have affected the dissipation of glyphosate from water, and the pattern of formation and decline of degradates other than aminomethylphosphonic acid was not addressed. All data are required.

Forestry dissipation studies: One study (Danhaus, et al., 00093922; Edwards, 00084657) was reviewed and considered to be scientifically valid. This study does not fulfill data requirements because complete soil characteristics were not presented, complete field test data were not reported, the test substance was not characterized, and the duration of the study was inadequate to assess the decline of glyphosate and patterns of formation and decline of degradates in a forest ecosystem. All data are required.

Dissipation studies for combination products and tank mix uses: Five studies were reviewed and three are scientifically invalid. In the first study, three hardcopies (Monsanto Co., 00108176; Ballantine and Herman, 00017701; Schnappinger, 00017706) were combined into one review because they contain data on the same dissipation study. Hardcopies 00108176 and 00017701 contained the analytical method and meteorological data, respectively, for the dissipation study presented in hardcopy 00017706. This study and two others (Schnappinger, 00017703; Kern and Staniforth, 00010704) are scientifically invalid because the data were too variable to accurately assess the dissipation of glyphosate from soil when applied alone or in combination tank mixes. The remaining two studies (Monsanto Co., 00037690; Monsanto Co., 00023979) could not be validated because the analytical methods were not described. No data are required because currently data requirements for combination products and tank mix uses are not being imposed for this Standard.

Long-term field dissipation studies: No data were submitted, but all data may be required based on the results from aerobic soil metabolism/terrestrial field dissipation studies.

Confined accumulation studies on rotational crops: One study (Rueppel, et al., 00108182; Henshall, et al., 00108183) was reviewed and considered scientifically valid. This study does not fulfill data requirements because the plant growth and growing conditions were not completely described and glyphosate residues in the soybeans and the soils were not characterized. All data are required.

Field accumulation studies on rotational crops: No data were submitted; however, the requirement for data is deferred pending receipt of data for confined accumulation studies on rotational crops.

Accumulation studies on irrigated crops: No data were submitted, but all data are required.

Laboratory studies on pesticide accumulation in fish: Five studies were reviewed; two are scientifically valid. The first valid study (Monsanto Co., 00108173-A) does not fulfill data requirements because a flow-through exposure system was not used; [^{14}C]glyphosate residues in soil, water, and test organisms were not characterized; residues in whole fish were not determined; and the test substance was aged. The second valid study (Monsanto Co., 00108173-E) does not fulfill data requirements because radioactive residues were not characterized, radioactive residues in visceral and edible tissue were not analyzed, a flow-through exposure system was not used, and the experiment was not conducted using fish. The third study (Sleight, 00039381-C) could not be validated because insufficient data were presented to support the reported results. In addition, this study would not fullfill data requirements because the purity of the test substance was not reported, radioactive residues were not characterized, cumulative fish mortality was not reported, and radioactive residues in viscera, whole-body tissue, and exposure water, were not provided. The fourth study (Monsanto Co., 00108173) is scientifically invalid because the sampling protocol was inadequate to assess the accumulation of glyphosate in fish. In addition, this study would not fulfill data requirements because a flow-through exposure system was not used, the test organisms were incompletely

described, and the accumulation period was not long enough. The remaining study (Monsanto Co., 00108173-C) is scientifically invalid because the experimental design was inappropriate to assess the accumulation of glyphosate in fish. In addition, this study would not fulfill data requirements because the test substance was not characterized, and data were not reported for the water samples. All data are required.

Field accumulation studies on aquatic nontarget organisms: No data were submitted; however, no data will be required unless data in the laboratory fish accumulation study demonstrate accumulation of glyphosate by fish.

Reentry studies: No data were submitted and no data are required because of the low toxicity and exposure (use) pattern.

Label Restrictions

Pending the submission of rotational crop data do not use ~~pendimethalin~~ glyphosate on rice fields in which crayfish and catfish farming included in the cultural practice, and do not plant crops other than those with registered pendimethalin uses for food or feed in pendimethalin-treated soil.

Pending the submission of irrigated crop data do not use water containing ~~pendimethalin~~ glyphosate residues from rice cultivation to irrigate crops used for food or feed which are not registered for use with ~~pendimethalin~~ glyphosate.

References (Studies Reviewed by the Dynamac Corporation)

Ballantine, L.G., and M.M. Herman. 1979. Bicep plus Roundup or paraquat and Dual/Princep plus Roundup or Paraquat tank mix soil dissipation studies: Report No. ABR-79101. Summary of studies 232193-J, 232193-K, 241545-K, 241545-L and 241545-N. (00017701)

Blackburn, R.D. 1975. Dissipation of glyphoste from pond water. In Determination of residues of glyphosate and its metabolite in aquatic use of Roundup herbicide. (00039381-E)

Brightwell, B., and J. Malik. 1978. Solubility, volatility, adsorption and partition coefficients, leaching, and aquatic metabolism of MON 0573 and MON 0101: Report No. MSL-0207. (00108192)

Comes, R.D. 1975. Residues and persistence of glyphosate in irrigation water. In Determination of residues of glyphosate and its metabolite in aquatic use

use of Roundup herbicide. (00039381-D)

Danhaus, R.G., C.M. Lottman, and J.R. Steinmetz, et al. 1979. Roundup Forest Ecosystem: Part II: Residues of glyphosate, aminomethylphosphonic acid and N-nitrosoglyphosate in forest foliage and litter and on mylar spray interceptors, following aerial application of Roundup herbicide: MSL-1974. (00093922)

Dubelman, S., and J.R. Steinmetz. 1981. Glyphosate residues in water following application of Roundup herbicide to flowing bodies of water: MSL-1486. Final rept. Includes method dated Sep. 4, 1980. (00077238)

Edwards, W.M. 1975. Field runoff of glyphosate from Coshocton watersheds. In Determination of residues of glyphosate and its metabolite in aquatic use of Roundup herbicide. (00039381-C)

Edwards, G.A. 1981. Roundup herbicide forest ecosystem study: Part I: Residues of glyphosate, aminomethylphosphonic acid and N-nitrosoglyphosate in forest soil and water following aerial application of Roundup herbicide: Special Report MSL-1830. (00084657)

Henshall, A. and B.B. Brightwell. 1972. Final report on MON-0573, residue and metabolism; Part 7: Runoff of MON-0573 from inclined soil beds. Agricultural Research Report No. 275. (00039943)

Henshall, A., B. Brightwell, and J. Marvel. 1972. Final Report On MON-0573, residue and metabolism: Part 5. Soil binding and phytotoxicity of MON-0573 and its metabolites on soils: Agricultural Research Report No. 274. (00108183)

Kern, C.L. and D. Staniforth. 1978. Metolachlor (Dual 8E) + atrazine (AAtrex) + Glyphosate (Roundup 4E): AG-A No. 4780 I-II. (00010704)

Kramer, R., and R. Blackburn. 1974. Glyphosate dissipation--pond test. (00101561)

Kramer, R.M. 1975. Residues and persistence of glyphosate applied to a dry

irrigation ditch. In Determination of residues of glyphosate and its metabolite in aquatic use of Roundup herbicide. (00039381-A)

Monsanto Co. 1975. Residue and metabolism studies in sugarcane and soils. (00108140)

Monsanto Co. 1975. Residue studies and methods of analysis for preemergent use of glyphosate in cotton. (00108176)

Monsanto Co. 1978. Residue studies for use of Roundup herbicide in aquatic situations. (00108173)

Monsanto Co. 1978. Residue studies for use of roundup herbicide in aquatic situations. (00108173-A)

Monsanto Co. 1978. Residue studies for use of Roundup herbicide in aquatic situations. (00108173-C)

Monsanto Co. 1978. Residues for use of Roundup herbicide in Aquatic Situations. (00108173-E)

Monsanto Company. 19??. The soil dissipation of glyphosate, alachlor and simazine herbicides. (00023979)

Monsanto Company. 19??. Soil dissipation of Roundup, Lasso and cyanazine herbicides. (00037690)

Rueppel, M., B. Brightwell, and A. Henshall, et al. 1972. Final Report on MON-0573, residue and metabolism: Part 4. The rate of dissipation of MON-0573 in soil: Agricultural Research Report No. 271. (00108182)

Rueppel, M., B. Brightwell, and J. Marvel, et al. 1972. Final Report on MON-0573, residue and metabolism: Part 3. The degradation and metabolism of MON-0573 in soil: Agricultural Research Report No. 269. (00108181)

Schnappinger, M.G. 1979. Metolachlor (Dual 8E); simazine (Princep 4L); paraquat (paraquat 2CL); glyphosate (Roundup 4E): AG-A No. 6061 I-VII. (00017706)

Schnappinger, M.G. 1978. Metolachlor (Dual 8E) + Atrazine (AAtrex 80 W) + Glyphosate (Roundup 4E): AG-A No. 4597 I-IV. (00017703)

Sleight III, B.H. 1975. Exposure of fish to Roundup, accumulation, distribution, and elimination. In Determination of residues of glyphosate and its metabolite in aquatic use of Roundup herbicide. (00039381-C)

Sprankle, P., D. Penner, and W.F. Meggitt. 1973. Adsorption and degradation of Glyphosate in the soil. (00076493)