

SI Appendix A. Derivation of Chemical Input Parameter Values

SI Table A-1 Studies on dissipation of chlorpyrifos from soil under aerobic laboratory conditions

Location	Soil series or texture	O.C. (%)	pH	Temp (°C)	T½ (d) ^a	Source
Commerce, Mississippi	Loam	0.68	7.4	25	11	Bidlack (1979) ^b
Barnes, North Dakota	Loam	3.6	7.1	25	22	Bidlack (1979) ^b
Norfolk, Virginia	Loam	0.29	6.6	25	102	Bidlack (1979) ^b
Miami, Indiana	Silt loam	1.12	6.6	25	24	Bidlack (1979) ^b
Caitlin, Illinois	Silty clay loam	2.01	6.1	25	34	Bidlack (1979) ^b
Germany	2:3 Standard	1.01	5.4	25	141	Bidlack (1979) ^b
Stockton, California	Clay Adobe	1.15	5.9	25	107	Bidlack (1979) ^b
Marcham, UK	Sandy clay loam	1.7	7.7	20	43	(de Vette and Schoonmade 2001)
Charentilly, France	Silty clay loam	1	6.1	20	95	(de Vette and Schoonmade 2001)
Cuckney, UK	Sand	1.2	6	20	111	(de Vette and Schoonmade 2001)
Thessaloniki, Greece	Loam	0.8	7.9	20	46	(de Vette and Schoonmade 2001)
Catania, (south) Italy	Soil A 77% WHC ^c	1.5	8.3	30	2	(Finocchiaro et al. 2004)
Catania, (south) Italy	Soil A 38% WHC	1.9	8.2	30	3	(Finocchiaro et al. 2004)
Catania, (south) Italy	Soil B	1.9	8.2	30	2	(Finocchiaro et al. 2004)
Brookston	Sandy loam	NR	6.9	18.3-35	36	Thiegs (1966) ^b
Bergland	Clay loam	NR	6.8	18.3-35	58	Thiegs (1966) ^b
Kawkawlin	Sandy loam	NR	7.8	18.3-35	42	Thiegs (1966) ^b
Lake Charles	Clay	NR	6.3	18.3-35	51	Thiegs (1966) ^b
California	Silt	NR	9.1	18.3-35	17	Thiegs (1966) ^b
Willamette	Clay 0.1 mg/kg appln.	1.74	6.2	20	120	Freed et al. (1979) ^b
Willamette	Clay 1 mg/kg appln.	1.74	6.2	20	120	Freed et al. (1979) ^b
New York	Sandy loam	1.74	7.2-7.8	25	7-16	Tashiro and Kuhr (1978) ^b
Staden, Belgium	Sandy loam	0.48	5.35	23	142	Van de Steene et al. (1990) ^b
St. Katelijne Waver,	Sandy loam	1.92	5.4	23	146	Van de Steene et al. (1990) ^b

Location	Soil series or texture	O.C. (%)	pH	Temp (°C)	T½ (d) ^a	Source
Belgium						
Oppuurs, Belgium	Sandy loam	1.52	6.2	23	78	Van de Steene et al. (1990) ^b
Opdorp, Belgium	Sandy loam	1.6	5.16	23	109	Van de Steene et al. (1990) ^b
Kankakee County, Illinois.	Ada B sandy loam	0.8	5.7	25	8	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B2 sandy loam	0.6	6.6	25	4	McCall et al. (1984) ^b
Kankakee County, Illinois.	Gilford sandy clay loam	2.8	7	25	2	McCall et al. (1984) ^b
Kankakee County, Illinois.	Hoopeston sandy clay loam	1.3	6.5	25	4	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B sandy loam	0.8	5.7	25	61	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B2 sandy loam	0.6	6.6	25	22	McCall et al. (1984) ^b
Kankakee County, Illinois.	Gilford sandy clay loam	2.8	7	25	18	McCall et al. (1984) ^b
Kankakee County, Illinois.	Hoopeston sandy clay loam	1.3	6.5	25	28	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B sandy loam	0.8	5.7	25	37	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B2 sandy loam	0.6	6.6	25	25	McCall et al. (1984) ^b
Kankakee County, Illinois.	Gilford sandy clay loam	2.8	7	25	12	McCall et al. (1984) ^b
Kankakee County, Illinois.	Hoopeston sandy clay loam	1.3	6.5	25	25	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B sandy loam	0.8	5.7	35	19	McCall et al. (1984) ^b
Kankakee County, Illinois.	Ada B2 sandy loam	0.6	6.6	35	11	McCall et al. (1984) ^b
Kankakee County, Illinois.	Gilford sandy clay loam	2.8	7	35	5	McCall et al. (1984) ^b
Kankakee County, Illinois.	Hoopeston sandy clay loam	1.3	6.5	35	5	McCall et al. (1984) ^b
Chehalis	Clay loam	4.06	5.7	25	28	Getzin (1981a) ^b
Sultan	Silt loam	1.8	6.3	25	84	Getzin (1981a) ^b
Sultan	Silt loam	1.8	6.3	15	175	Getzin (1981a) ^b
Sultan	Silt loam	1.8	6.3	25	91	Getzin (1981a) ^b
Sultan	Silt loam	1.8	6.3	35	42	Getzin (1981a) ^b
Catlin	Silty clay loam	1.6-2.7	5.5-6.5	25	24-35	Racke et al. (1990) ^b

Location	Soil series or texture	O.C. (%)	pH	Temp (°C)	T½ (d) ^a	Source
Elburn	Silt loam	2.2-3.6	5.2-6.2	25	28-44	Racke et al. (1990) ^b
Hastings	Silt loam	1.7-2.0	5.2-6.3	25	28-40	Racke et al. (1990) ^b
Pembina, North Dakota	Loam	2.7	8	25	9	Racke et al. (1990) ^b
St. Thomas, North Dakota	Loam	3	8.1	25	6	Racke et al. (1990) ^b
Dewitt, Texas	Sandy clay loam	1.9	8	25	4	Racke et al. (1990) ^b
Medina, Texas	Clay loam	2.1	8.1	25	5	Racke et al. (1990) ^b
Ontario, Canada	Sandy loam	1.68	8	28	<<7	Miles et al. (1979) ^b
Ontario, Canada	NR	28.25	7.6	28	18	Miles et al. (1979) ^b
Plainfield	Sand	NR	NR	27	32	Chapman and Chapman (1986) ^b
Plainfield	Sand	NR	NR	27	50	Chapman and Chapman (1986) ^b
Ontario, Canada	NR	NR	NR	27	14	Chapman and Chapman (1986) ^b
Ontario, Canada	NR	NR	NR	27	39	Chapman and Chapman (1986) ^b
North Carolina	NR	NR	NR	25	56	Jones and Hastings (1981) ^b
Tampa, Florida	Sand	0.66	6.4	25	134	Racke et al. (1992) ^b
Tampa, Florida	Sand	0.66	6.4	25	205	Racke et al. (1992) ^b
Tampa, Florida	Sand	0.66	6.4	25	1575	Racke et al. (1992) ^b
Hawaii	Sandy loam	5.7	5.7	25	335	Racke et al. (1992) ^b
Phoenix, Arizona	Sandy loam	0.88	8.3	25	230	Racke et al. (1992) ^b
Medina, Texas	Clay loam	1.2	8	25	116	Racke et al. (1992) ^b
St. Petersburg, Florida	Sand	1.92	7.5	25	214	Racke et al. (1992) ^b

^aHalf-life rounded to the nearest day unless a range provided.

^bStudy referenced in (Racke 1993)

^cWCH = Water Holding Capacity

SI Table A-2. Studies on dissipation of chlorpyrifos from soil in terrestrial field environments

Location	Soil series or texture	DT50 (d) ^a	Source
Davis, CA (Yolo)	Loam	13	Fontaine et al. (1987) ^b
Geneseo, IL (Catlin)	Silt loam	19	Fontaine et al. (1987) ^b
Grebin, Germany	Loam	24	(Koshab et al. 1993)
Herford, Germany	Loamy silt	9	(Koshab et al. 1994)
Lauter, Germany	Loamy silt	9	(Koshab et al. 1994)
Tranent, Scotland	Sandy clay loam	48	(Reeves and Old 2002a)
Charentilly, France	Clay loam	42	(Reeves and Old 2002b)
Valtothori, Greece	Sandy silt loam	26	(Reeves and Old 2002c)
Tivenys, Spain	Clay loam	2	(Reeves and Old 2002d)
Metaponto, Italy	Silty clay (EC formulation)	8	(Montemurro et al. 2002)
Metaponto, Italy	Silty clay (WG formulation)	6	(Montemurro et al. 2002)
Illinois	Silty clay loam	13	McKellar et al. (1972) ^b
Illinois	Silty clay loam	6	McKellar et al. (1972) ^b
Nebraska	Silt loam	43	McKellar et al. (1972) ^b
Nebraska	Silt loam	30	McKellar et al. (1972) ^b
Ontario, Canada	Clay loam	12-14	Harris et al. (1988) ^b
Quebec, Canada	Clay loam	77	Elhag et al. (1989) ^b
Illinois	Silt loam	56	Fontaine et al. (1987) ^b
Michigan	Sandy loam	33	Fontaine et al. (1987) ^b
California	Loam	46	Fontaine et al. (1987) ^b
Georgia	Loamy sand	4	Wauchope et al. (1991) ^b
Illinois	Sandy loam	7	McCall et al. (1984) ^b
Illinois	Sandy loam	14	McCall et al. (1984) ^b
Illinois	Sandy loam	17	McCall et al. (1984) ^b
Soviet Union	Sandy loam	35-80	Novozhiov et al. (1982) ^b
Soviet Union	Sandy clay loam	24-44	Novozhiov et al. (1982) ^b
India	NR	34	Sirvastava and Jotwani (1980) ^b
Washington	Loam	48	Pike and Getzin (1981) ^b

Location	Soil series or texture	DT50 (d)^a	Source
Washington	Loam	69-90	Pike and Getzin (1981) ^b
India	Sandy loam	41	Agnihotri et al. (1981) ^b
Italy	Loam	30	Leoni et al. (1981) ^b
Soviet Union	Sandy clay	91	Andreev (1980) ^b
Soviet Union	Sandy clay	91	Andreev (1980) ^b
Soviet Union	Clay	91	Andreev (1980) ^b
Soviet Union	Sandy clay	56	Andreev (1980) ^b
Soviet Union	Sandy clay	28	Andreev (1980) ^b
Soviet Union	Clay	21	Andreev (1980) ^b
New York	Muck	35-42	Davis and Kuhr (1976) ^b
Ontario, Canada	Muck	120	Ritcey et al. (1991) ^b
Washington	Silt loam	58	Getzin (1985) ^b
Washington	Silt loam	22	Getzin (1985) ^b
Washington	Silt loam	19	Getzin (1985) ^b
Washington	Silt loam	6	Getzin (1985) ^b
British Columbia, Canada	Silt loam	17	Szeto et al. (1988) ^b
British Columbia, Canada	Silt loam	16	Szeto et al. (1988) ^b
British Columbia, Canada	Silt loam	17	Szeto et al. (1988) ^b
Belgium	Loamy sand	28-42	Rouchad et al. (1989) ^b
Belgium	Sandy loam	15-18	Rouchad et al. (1989) ^b
Belgium	Silt loam	27	Rouchad et al. (1989) ^b
Belgium	Sandy loam	23	Rouchad et al. (1989) ^b
Belgium	Sandy loam	22	Rouchad et al. (1989) ^b
Ontario, Canada	Sand	14	Chapman and Harris (1980) ^b
Ontario, Canada	Muck	56	Chapman and Harris (1980) ^b
Florida	Sand	1-4	Oliver et al. (1987) ^b
Indiana	Loam	9	Racke et al. (1992) ^b
Indiana	Loam	10	Racke et al. (1992) ^b
Florida	Sand	6	Racke et al. (1992) ^b

Location	Soil series or texture	DT50 (d) ^a	Source
Florida	Sand	8	Racke et al. (1992) ^b

^a Half-life rounded to the nearest day.

^b Study referenced in (Racke 1993)

SI Table A-3 Adsorption-desorption studies on chlorpyrifos in soil

Location	Soil series or texture	O.C. (%)	K _d	K _{oc}	Source
Kankakee County, IL	Hoopeston sandy clay loam	1.3	112	8600	McCall et al. (1984) ^a
Kankakee County, IL.	Ada B sandy loam	0.8	114	14000	McCall et al. (1984) ^a
Kankakee County, IL	Ada B2 sandy loam	0.6	97	16000	McCall et al. (1984) ^a
Kankakee County, IL	Gilford	2.8	247	8900	McCall et al. (1984) ^a
Faringdon, U.K.	Clay loam M549	3.5	98.8	2785	(Damon and Heim 2001)
Bedfordshire, U.K.	Sand M579	1.5	116	7965	(Damon and Heim 2001)
Carentilly, France	Loam M584	1	55.2	5582	(Damon and Heim 2001)
Marcham, U.K.	Sandy clay loam M585	1.6	67.9	4323	(Damon and Heim 2001)
Colrairie, Ireland	Sandy loam M601	4.3	295	6851	(Damon and Heim 2001)
Mississippi	Commerce	0.68	49.9	7300	McCall (1985) ^a
Indiana	Tracy	1.12	65.6	5860	McCall (1985) ^a
Illinois	Catlin	2.01	99.7	4960	McCall (1985) ^a
Nevada	Hectorite	0.09	1315	NC ^b	(Wu and Laird 2004)
Tennessee	Panther Creek	0.08	1069	NC	(Wu and Laird 2004)
Nevada	Saponite	0.04	1132	NC	(Wu and Laird 2004)
Mississippi	Amory	0.05	473	NC	(Wu and Laird 2004)
Mississippi	Polkville	0.04	89	NC	(Wu and Laird 2004)
California	Otay	0.03	45	NC	(Wu and Laird 2004)
West Virginia	Silty clay loam	0.48	78	16250	Macalady and Wolfe (1985) ^a
Sable	Silty clay loam	2.5	41.54	1662	McKenna et al. (1989) ^a
Canisteo	Canisteo clay loam	5.14	260	5060	McCall(1987) ^a
Tsukuba	Tsukuba clay	4.2	116.2	2740	Kanazawa (1989) ^a
Kanmuna	Kanuma clay	1.4	13.4	995	Kanazawa (1989) ^a
Pond sediment	Pond sediment	3	240	8000	McCall et al. (1984) ^a
Plainfield	Sand	0.4	18	4500	Sharom et al. (1979, 1980) ^a
Thurman	Loamy sand	1.07	46.88	4381	Felsot and Dahm (1979) ^a
Hanford	Sandy loam	0.22	68.7	31000	McCall (1987) ^a

Location	Soil series or texture	O.C. (%)	K _d	K _{OC}	Source
Muck	Sandy loam	43.7	1862	4261	Sharom et al. (1980) ^a
Creek Sediment	Sandy loam	1.6	139	8688	Sharom et al. (1980) ^a
Beverly	Sandy loam	1.5	118	7867	Sharom et al. (1980) ^a
Sarpy	Sandy loam	0.51	28.38	5565	Felsot and Dahm (1979) ^a
Clarion	Loam	2.64	161.81	6129	Felsot and Dahm (1979) ^a
Clermont	Silt loam	0.7	198	28286	Kaladivko et al. (1991) ^a
Harps	Silt loam	3.8	397.19	10452	Felsot and Dahm (1979) ^a
Catlin	Silt loam	2.23	82.1	3680	McCall (1987) ^a
Commerce	Silt loam	0.67	96.2	14400	McCall (1987) ^a
Tama	Silt loam	1.6	15.57	973	McKenna et al. (1989) ^a
Keomah	Silt loam	1	39.98	3998	McKenna et al. (1989) ^a
Clinton	Silt loam	1.2	41.32	3443	McKenna et al. (1989) ^a

^a Study referenced in (Racke 1993)

^b Not calculated because of the small concentrations of carbon in the clays.

SI Table A-4 Studies on dissipation of chlorpyrifos from crops

Plant/Crop	T $\frac{1}{2}$ (d)	Conditions	Location	Initial residues (mg kg ⁻¹)	Racke ^a	Reference
Soybean	3.95	Field	Egypt	14	Y	Abdel-All et al. (1990) ^a
Broadbean	3.12	Field	Egypt	12.7	Y	Abdel-All et al. (1990) ^a
Mustard	1.7-2.3	Field	India	5.2-8.5	Y	Dutta and Goswami (1982) ^a
Coastal Bermuda grass	1	Field	Georgia	13.2	Y	Leuk et al. (1968) ^a
Corn	1.5	Field	Illinois	118-145	Y	McCall et al. (1984) ^a
Soybean	1.5	Field	Illinois	147	Y	McCall et al. (1984) ^a
Corn	1	Field	Georgia	0.7-2.5	Y	Wauchope et al. (1991) ^a
Cotton	5-9	Field	Egypt	5.3-34.2	Y	Abdel-Megeed et al. (1981) ^a
Corn	<1	Growth chamber	Michigan	NR	Y	McCall et al. (1985) ^a
Tomato	0.78	Greenhouse	Israel	0.82 $\mu\text{g cm}^{-b}$	Y	Veierov et al. (1988a) ^a
Tomato	3.23	Greenhouse	Israel	1.05 $\mu\text{g cm}^{-b}$	Y	Veierov et al. (1988a) ^a
Tomato	<1-5.8	Greenhouse	Israel	0.9-16	Y	Veierov et al. (1988a) ^a
Cotton	<1-4	Field: potted	Israel	0.6-4.6	Y	Veierov et al. (1988a) ^a
Citrus	<1-2.4	Field	Israel	0.4-15	Y	Veierov et al. (1988a) ^a
Bluegrass	7	Field	New York	60-70	Y	Kuhr and Tashiro (1978) ^a
Bluegrass	7	Field	New York	20-30	Y	Kuhr and Tashiro (1978) ^a
Annual Bluegrass	7-14	Field: thatch and grass	Ontario, Canada	44.9	Y	Sears and Chapman (1979) ^a
Kentucky Bluegrass	2	Field	Ohio	0.5-0.7	Y	Hurto and Prinster (1992) ^a

^a Study referenced in (Racke 1993)

SI Table A-5 Dissipation of chlorpyrifos from aerobic aquatic systems

Location	Soil series and water source	O.C. (%)	Sand	Silt	Clay	p _{ka}	pH	Temp (°C)	T _{1/2} ^a	Source
Henry County, IL	Silty clay loam sediment from pond		5.2	63.6	31.2	16.74	7.7	24.9	30.5	(Kennard 1996)
	Pond water						7.1	24.9		
Brown Carrick	Sandy loam sediment from pond	2.5	58.1	24.8	17.1	13.78	5.7	20	22	(Reeves and Mackie 1993)
	Pond water	0.0016					7.4	20		
Auchingilsie Sediment	Clay loam sediment from pond	6.3	36.6	38	25.4	10.28	6.3	20	51	(Reeves and Mackie 1993)
	Pond water	0.00172					6.7	20		

^a The half-life is for the combined sediment-water system

SI Appendix B. Use pattern for formulations of CPY

To maintain consistency with uses and the labels of formulated products sold in the USA, rates of application of CPY are given in imperial units.

SI Table B-1 Use patterns for the application of Lorsban 15G (granular chlorpyrifos Dow AgroSciences 2008a)

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Alfalfa (Missouri only)	In-furrow (at-plant)	1	1	1	--	At plant
Asparagus (California only)	Band (postplant); cover with soil the day of application	1.5	2	3	--	180-d PHI ^a
Citrus orchard floors	Broadcast uniformly to soil; no incorporation or covering with soil	1	3	3 (including foliar)	10	28-d PHI
Cole crop (<i>Brassica</i>) leafy vegetables ^b , rutabaga, and turnip	T-band (at-plant); shallow incorporation	2.25	1(15 G); foliar as on foliar label	2.25	10 (foliar chlorpyrifos)	At plant
Corn (field corn and sweet corn, including corn grown for seed) ^c	T-band (at-plant) or in-furrow (at-plant); incorporate T-band ½-1 inch; split band on either side of row (postplant) and covered with soil; or aerial or ground broadcast (postplant) into whorls of ears	1.3 (ground); 1 (aerial)	2 (15G); (might apply 3 total chlorpyrifos)	2.3	10	At plant in furrow or T-band; unspecified for post-plant split band; broadcast (aerial or ground) when ear whorls have formed

^a Pre-harvest Intervals (PHI) are intended for the protection of consumers and do not basically relate to ecological exposure and effects. However, they do provide information on when, during a crop cycle, chlorpyrifos might be applied ecological exposure and effects.

^b Brassica leafy vegetables include bok choy, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, Chinese broccoli, Chinese cabbage, collards, kale, and kohlrabi.

^c Aerial applications of Lorsban 15G to corn not permitted within 150 feet of water (rivers, natural ponds, lakes, etc.)

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Ginseng (24c MI, WI)	Broadcast with incorporation (pre-plant); Bed-directed (prior to seeding); Broadcast with overhead watering (postemergence bed-directed)	2	1	2	--	Preplant or post-emergent; 365-d PHI
Onion (dry bulb)	In-furrow (at-plant); or (in CO, ID, WA, OR only) in 5-7 inch band with shallow incorporation	1	1 (of any formulation)	1	--	At plant
Peanut	6-12 inch Band (at-plant, postplant preventative) 10-18 inch band (postplant rescue) Incorporate at plant band 1 inch	4	2 (15 G)	4 (all chlorpyrifos)	10	21-d PHI
Radish	In-furrow (at-plant)	2.75	1	2.75	--	At plant
Sorghum - grain sorghum (milo)	6-8 inch T-band (at-plant); incorporate ½ to 1 inch ("absolutely necessary")	1.5	1 (15 G)	1.5 (no label limits on other formulations)	10 d before application of liquid chlorpyrifos	At plant
Soybean	4-10 inch T-band (at-plant, postplant)); incorporate ½ to 1 inch	2 (at-plant); 1 (postplant)	1 (15G); 3 (all chlorpyrifos)	2	10 d before application of liquid chlorpyrifos	At plant; postplant not specified, 28-d PHI
Sugarbeet	Band (at-plant or postemergence); incorporate ½ to 1 inch	2	1 (15G); 3 (all chlorpyrifos)	2 (maximum 3 lb. a.i. total chlorpyrifos)	10 d before application of liquid chlorpyrifos	At plant or before 4-leaf stage
Sunflower	7 inch T-band (at-plant); incorporate 1 inch	1.3	1 (15G); 3 (all chlorpyrifos)	2 (maximum 3 lb. a.i. total chlorpyrifos)	10 d before application of liquid chlorpyrifos	At plant

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Sweet potato	Broadcast with 4-6 inch incorporation (pre-plant)	2	1 (of any chlorpyrifos formulation)	2	--	1-14 d pre-plant; 150 d PHI
Tobacco	Broadcast with 2-4 inch incorporation (pre-plant)	2	1 (of any chlorpyrifos formulation)	2	--	1 week before transplanting; 7 d PHI

SI Table B-2 Use patterns for the application of Lorsban Advanced (flowable chlorpyrifos Dow AgroSciences 2009, 2010)

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Alfalfa (not for use in MS)	Broadcast aerial or ground spray, or sprinkler chemigation (foliar application)	0.94	4 (but maximum of 1 app /cutting)	3.76 (of any chlorpyrifos product)	10	7-21-d PHI
Almond orchard floor (24c CA)	Individual mound treatment	4	2	8	14	14-d PHI
Apple tree trunk (east of Rockies only)(not for use in MS)	One application per year directed to lower 4 feet of apple tree trunk from a distance of no more than 4 feet away. No rate per acre given, but 2.82 lbs. a.i./100 gal of spray Not to contact foliage or fruit.					Post bloom; 28-d PHI
Asparagus ^d	Broadcast foliar spray by ground	0.94	3	2.82	10	1-d PHI
Bok Choy, broccoli raab, Chinese broccoli (24c CA)	Broadcast spray to soil by ground only	2.11	1	2.11	--	30-d PHI
<i>Brassica</i> (cole) leafy vegetables and radish, rutabaga, and turnip (Section 3 federal label including 24 c label for CA) ^{ef}	Pre-plant broadcast spray to soil with 2-4 inch incorporation (pre-plant)	Cauliflower: 1.9	1 soil of any kind	Cauliflower: 1.9	10 (for other chlorpyrifos foliar)	30-d PHI; preplant or after establishment
	Four-inch banded soil application at plant or directed spray to base of plant after transplant; or postemergent sidedress for broccoli & cabbage	Broccoli, Brussels sprouts, leafy brassica, turnip, rutabaga: 2.1		Broccoli, Brussels sprouts, leafy brassica, turnip, rutabaga: 2.1		
	Apply as drench in seed furrow at planting	Radish: 2.6		Radish: 2.6		

^d For use on asparagus only in Arizona, California, Idaho, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oregon, South Dakota, Washington and Wisconsin.

^e California has a 24 c label that has the same provisions for this as the federal label, except that it allows two treatments 10 d apart for cauliflower broccoli and Brussels sprouts, but the total maximum soil application rate for the year is the same. This 24c label has slightly different directions also for rutabaga and cabbage which do not alter the exposure potential.

^f On the federal label, crops include broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, collards, kale, kohlrabi, mizuni, mustard greens, and rape greens.

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Brussels sprout	Four-inch banded soil application at plant or directed spray to base of plant after transplant; or foliar application	0.94	3	2.82	10	21-d PHI
Carrots for seed (24c OR, WA)	Foliar broadcast	0.94	1	0.94	--	As needed
Christmas trees (plantations) (not for use in MS)	Foliar ground broadcast power spray (postplant); cut stump drench	0.94	3	2.82	7	As needed
Christmas trees (plantations) (24c WA)	Broadcast foliar spray (aerial)	0.94	3	2.82	7	As needed
Christmas trees (plantations) (24c OR)	Broadcast foliar spray (aerial-helicopter only)	0.94	3	2.82	7	As needed
Citrus fruits ^g (not for use in MS)	Foliar broadcast; directions imply air-blast but aerial not precluded	3.3 except CA & AZ	2 (not including orchard floor)	7.04	30 (any foliar)	21 to 35-d PHI; "To avoid excessive ridging, do not apply Lorsban 4-E to citrus fruit from December 1 up to the initiation of bloom"
		5.6 in AZ & Fresno, Tulare, Kern, Kings and Madera Counties, CA				
		4.0 in other CA counties				
Citrus (red scale only) (24c CA)	Foliar broadcast spray with ground equipment	5.64	2	7.04	30	35-d PHI; "To avoid excessive ridging, do not apply Lorsban 4-E to citrus fruit from December 1 up to the initiation of

^g Citrus fruits on label include calamondin, chironja, citrus citron, citrus hybrids, grapefruit, kumquat, lemon, lime, mandarin (tangerine), pummel, Satsuma mandarin, sour orange, sweet orange, tangelo, tangor

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
						bloom"
Citrus (Argentine ants, fuller rose beetle) (24c CA)	Broadcast spray to soil at base of trees (ants only)	1.0	3	3	10	28-d PHI
	Apply to fiberglass band of insulation wrapped around tree trunk (beetle and ants)	2.5		7.5	Not specified	Not specified
Citrus orchard floors (not for use in MS)	Broadcast spray to orchard floor or sprinkler chemigation to soil around trees	1	3	2.82	10	28-d PHI
Clover for seed (24c OR) (expires Dec 2012)	Broadcast spray to soil with 2-4 inch incorporation (pre-plant); Broadcast foliar spray (postplant)	1.88	1	1.88	--	Not specified
Corn (field, sweet, seed)	Broadcast spray to ground surface in "Conservation Tillage"(pre-plant, pre-emergence, at-plant); foliar spray by air (except MS) or ground (postplant)	1	3 (any chlorpyrifos)	3.0	10	21-d PHI
Corn (sweet) (24c CO, FL)	Foliar broadcast spray by air, ground, or chemigation	0.5	3 (foliar) + 1 preplant soil	3	10 CO 5 FL	7-d PHI
Cotton (not for use in MS)	Foliar broadcast spray by air, ground, or chemigation	0.94	3	2.82	10	14-d PHI
Cottonwood, poplar trees for pulp (24c OR –expires Dec 2011 & WA-expires Dec 2012)	Foliar or dormant/delayed dormant spray by ground or air	1.88	3	5.64	7	
Cranberry (not for	Broadcast foliar or	1.41	2 (any	2.82	10	60-d PHI; do not

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
use in MS)	sprinkler irrigation (postplant)		chlorpyrifos)			apply until winter flood water has been removed, nor when bogs are flooded
Fig (CA only)	Broadcast spray to soil surface with three inch incorporation (dormant)	1.88	1	1.88	--	217-d PHI; apply late winter
Grape (east of the continental divide only) (not for use in MS)	Soil surface spray (4 ft. circle around base of vine); or spray drench to soil (prebloom)	Soil surface 2.12/100 gal to treat 3000 sq ft; Prebloom 0.94	1	Soil surface 2.12; Prebloom 0.94	--	35-d PHI: apply prior to bloom
Grape (mealybugs) (24c CA)	Broadcast spray to all above ground parts of plant	1.88	2	1.88 (all chlorpyrifos)	Not specified but 1 before budbreak and 1 after harvest	35-d PHI; do not apply between budbreak and harvest
Grape (mealybug, cutworms) (24c WA, ID, CO)	Band at base of vine (cutworms);	0.94	2	1.88	Not specified but 1 prebloom and 1 dormant	35-d PHI; do not apply after bloom stage
	Broadcast spray to all above ground parts of plant	1.88				
Grape (Argentine ants) (24c CA)	Spray basal one-foot of vines and surrounding soil	0.94	3	2.88	Not specified	76-d PHI
Grass for seed (perennial) (24c OR, WA, ID, NV)	Foliar broadcast spray by ground (all states), or by air (WA, ID) or by chemigation (OR)	0.94	3	WA 2.5; OR, ID, NV 2.82	WA: 10; OR, ID, NV: not specified	Apply early April (billbugs), spring & fall (cutworms), as colonies form before grass seed heading (aphids), or for webworms in OR only - September

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Legume vegetables ^h (succulent or dried), all except soybean (not for use in MS)	Broadcast spray to soil with 1-3 inch incorporation (pre-plant); or 3-5 inch T-band with ½-1 inch incorporation recommended (at-plant)	0.94	1	0.94	--	Preplant or at plant.
Onion (dry bulb)	Soil drench in 2-4 inch band with shallow incorporation at-plant; directed spray to seedling base postplant	0.94	2 (at-plant plus postplant)	1.88	At plant to seedling stage	60-d PHI; apply at or before seedling stage
Peanut	Aerial (except MS) or ground broadcast spray to soil with 3-4 inch incorporation (pre-plant)	1.88	1	4.0 (all chlorpyrifos products)	--	21-d PHI; preplant
Pear (California, Oregon and Washington only)	Airblast spray postharvest	1.88	1	1.88	--	After harvest
Peppermint and spearmint (not for use in MS)	Foliar ground broadcast spray or sprinkler irrigation; or pre-plant soil spray with 2-4 inch incorporation; or postharvest soil spray, watered-in or via chemigation	1.88	Apparently 3 (1 "during growing season"; 1 preplant; 1 postharvest)	5.64	Specified as stages of crop	90-d PHI; preplant for symphylans; Might-June for cutworms; postharvest for borers
Pineapple (nonbearing) (24c HI)	Foliar broadcast spray with ground equipment	1.88	3	5.64	30	365-d PHI; apply only within 3 months of planting
Radish for seed (24c)	Foliar broadcast spray	0.94	1	0.94	--	Apply in spring

^h Legume vegetables on label include adzuki bean, asparagus bean, bean, blackeyed pea, broad bean (dry and succulent), catjang, chickpea, Chinese longbean, cowpea, crowder pea, dwarf pea, edible pod pea, English pea, fava bean, field bean, field pea, garbanzo bean, garden pea, grain lupin, green pea, guar, hyacinth bean, jackbean, kidney bean, lablab bean, lentil, lima bean, moth bean, mung bean, navy bean, pea, pigeon pea, pinto bean, rice bean, runner bean, snap bean, snow pea, southern pea, sugar snap pea, sweet lupin, sword bean, tepary bean, urd bean, wax bean, white lupin, white sweet lupin, yardlong bean.

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
OR)						
Sorghum – grain sorghum (milo)	Broadcast foliar spray, aerial (except MS) or ground; or sprinkler irrigation (postemergence)	0.94	3	1.41	10	30-60-d PHI
Soybean (not for use in MS)	Soil spray at plant in 4-6 inch band; postemergent spray in 6-12 inch band over or 9-12 inch band at the side of the base, depending upon plant size; or foliar spray by ground, air, or sprinkler chemigation	0.94	3	2.82	14	28-d PHI; soil applications pre-to-early post plant; foliar as needed including after pod set
Strawberry (not for use in MS)	Preplant broadcast spray to soil with incorporation (depth not specified); broadcast foliar spray at budbreak; or directed spray to crown postharvest	Preplant: 1.88 foliar, postharvest: 0.94	3 total (Preplant: 1 foliar + postharvest: 2)	3.76	Foliar: 10 Postharvest: 14	21-d PHI; do not apply when berries are forming or present
Sugarbeet (not for use in MS)	Banded soil application with 1-2 inch incorporation at or before planting; aerial broadcast or at-plant soil application in 10 inch band; or postemergent banded or broadcast foliar spray by air or ground or via chemigation	0.94	3	2.82	10	30-d PHI; treatment throughout season
Sugarbeet for seed (24c ID)	Ground broadcast spray to soil with unspecified incorporation in fall after harvest	1.88	1	2.82 (to include basic label applications)	--	Apply in fall after harvest

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Sugarbeets for seed and table beets for seed, (24c OR)	Broadcast spray to soil with 2-4 inch incorporation (pre-plant); banded spray with 2+ inch incorporation (at-plant)	1.88	1	1.88	--	Prior to or at planting
Sunflower (not for use in MS)	Ground broadcast spray with 2-4 inch incorporation (pre-plant); aerial or ground foliar broadcast (postemergence)	Pre-plant soil incorporated: 1.88 Postemergent foliar: 0.94	3 (any chlorpyrifos)	2.82	10	42-d PHI
Sweet potato	Aerial (except MS) or ground broadcast spray to soil with 4-6 inch incorporation (pre-plant)	1.88	1	1.88	--	125-d PHI; apply up to 14 d before planting
Sweet potato (24c NC, MS, LA)	Same as above except 60-d PHI					
Tobacco	Aerial (except MS) or ground broadcast spray to soil with 2-4 inch incorporation (pre-plant)	1	1	1	--	Apply 24-48 h before bedding or transplanting
Tobacco (24c KY, VA, GA, NC)	Broadcast spray to soil with 2-4 inch incorporation (pre-plant)	1.88	1	1.88	--	Apply 24-48 h before bedding or transplanting

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Tree fruits (apple, cherry, nectarine, peach, pear, plum, prune), almond ⁱ and walnut (dormant/delayed dormant sprays) (not for use in MS)	Broadcast spray (air blast implied, but aerial not precluded) to cover "foliage"	1.88	1 of any chlorpyrifos for apples; 1 dormant/delayed dormant for others	1.88 as dormant/delayed dormant	10 d to any foliar	After winter rains and before budbreak
Tree fruits (cherry, nectarine, peach) ^j and almond (trunk spray) (not for use in MS)	Apply to tree trunks and lower branches with coarse spray	1.41	Peaches, nectarines 1; almonds not specified	1.41	--	14-d PHI
			Cherries 3	4.23	14 d for 2 nd application, post harvest for 3rd	21-d PHI
Tree nuts (foliar sprays) (almond, filbert, pecan, walnut)	Aerial (except MS) or ground foliar broadcast spray	1.88	Almonds, filberts, pecans:3, walnuts: 2	3.76 as foliar spray	10	28-d PHI for pecans; 14-d PHI for others
Tree nuts (almond, pecan, walnut) orchard floors (not for use in MS)	Ground broadcast spray to soil or sprinkler irrigation, not to contact foliage	Pecans: 1.88	2	3.76	10	14-d PHI
		Almonds and walnuts: 3.76				
Turfgrass grown for sod (not for use in MS)	Broadcast spray	3.76	Not specified – apparently 1, except 2 applications indicated, as needed, for two specific pests	Apparently 3.76	7	Any time depending upon pest
Wheat ^k	Aerial or ground foliar	0.47	2	0.94	Not specified	14-d PHI

ⁱ Not for use on almonds in Butte, Colusa, Glenn, Solano, Sutter, Tehama, Yolo, and Yuba counties, California

^j Might also be used as dip for peach and nectarine trees prior to planting (no exposure).

^k For use on wheat only in Arizona, California, Colorado, Idaho, Kansas, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington and Wyoming.

Crop	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
	broadcast spray or chemigation					

SI Table B-3 Use patterns for the application of Lorsban 4E (emulsifiable concentrate Dow AgroSciences 2004, 2008b)

Crop ¹	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Alfalfa (not for use in MS)	Broadcast aerial or ground spray, or sprinkler chemigation (foliar application)	1.0	4 (but maximum of 1 app /cutting)	4 (of any chlorpyrifos product)	10	7-21-d PHI
Asparagus ^m	Ground broadcast foliar spray	1.0	3 (1 preharvest; 2 postharvest)	3	10	
Christmas trees (plantations) (not for use in MS)	Ground broadcast foliar spray (can also be applied as cut stump drench; lower rate calculated based on spray volume)	1.0	3	3.0	7	When needed
Citrus fruits (not for use in MS)	Broadcast foliar spray; air blast recommended, but aerial not precluded	3.5 except 6.0 in AZ & Fresno, Tulare, Kern, Kings and Madera Counties, CA; 4.0 in the rest of CA	2 of any chlorpyrifos product (not including orchard floor applications)	7.5	30	21 to 35-d PHI "To avoid excessive ridging, do not apply Lorsban 4-E to citrus fruit from December up to the initiation of bloom"
Citrus orchard floors (fire ant & other ant control) (Not for use in MS)	Ground broadcast spray directed to floor of orchard or sprinkler chemigation around base of tree (do not contact foliage or fruit)	2.0	3	3.0	10 (including foliar apps)	None specified

¹ Lorsban 4E can only be used in Mississippi in accordance with a 24c SLN label for corn (all), onions (dry bulb), peanuts, pecans, sorghum, tobacco, sweet potatoes, and vegetables (all Brassica). Directions in this table apply except that only ground applications are allowed. Aerial and chemigation applications are prohibited.

^m For use on asparagus only in the Midwest (not defined) and Pacific Northwest states

Crop¹	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Corn (field, sweet, seed)	Ground broadcast spray with 2-4 inch incorporation (pre-plant, pre-emergence, at-plant); aerial (except MS) or ground foliar broadcast spray or sprinkler chemigation (postemergent)	3.0 preplant, preemergent or at plant; 1.0 postemergent	3 (4E)	3.0 (all chlorpyrifos)	10	35-d PHI
Cotton (not for use in MS)	Broadcast foliar spray, aerial or ground (except AZ & CA) or sprinkler irrigation (postplant)	1.0	3	3.0	10	Foliar; 14-d PHI
Cranberry (Not for use in MS)	Broadcast foliar or sprinkler irrigation (postplant)	1.5	2	--	10	Do not apply when fields are flooded to avoid contamination of flood water. 60-d PHI
Fig (CA only)	Broadcast spray to soil surface with three inch incorporation (dormant)	2.0	1	--	--	Dormant season, 7-month PHI
Grape (east of the continental divide only) (not for use in MS)	Soil surface spray (4 ft. circle around base of vine); Soil drench (prebloom)	Soil surface 2.25/100 gal to treat 3000 sq ft; Prebloom 1.0	1	Soil surface 2.25/100 gal to treat 3000 sq ft; Prebloom 1.0	--	Prior to bloom; 35-d PHI
Grape (mealybug, cutworms) (24c, ID, CO)	Ground broadcast to soil; prebloom or dormant	1.0 prebloom; 2.0 dormant	2	2.0	--	90-d PHI ID; 35-d PHI CO
Grape (cutworms) (24c, OR)	Aerial or ground broadcast spray	1.0	1	1.0	--	Do not harvest in the year of application
Grass for seed (perennial) (24c, ID, NV)	Ground (ID, NV) or aerial (NV) broadcast spray	1.04	3 (ID), not specified (NV)	3.0 (on ID label only)	Not specified	Do not harvest grass seed in year of application

Crop¹	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Mint (not for use in MS)	Foliar ground broadcast spray or sprinkler irrigation; or pre-plant soil spray with 2-4 incorporation; or postharvest soil spray, watered-in or via chemigation	2.0	1 (of any kind)	2.0	--	Preplant, foliar, or postharvest; 90-d PHI
Onion (dry bulb)	In-furrow drench at plant (incorporate 1-2 inches); directed soil drench to base of seedlings or transplants	1.0	2 (at-plant plus postplant)	2.0--	Not specified (but 1 st is preplant and 2 nd is to seedlings)--	Preplant and early season; 60-d PHI
Peanut	Broadcast spray to soil with 3-4 inch incorporation (pre-plant)	2.0 (4E)	1 (4E)	4 (pre-plant and postplant, all chlorpyrifos products)	--	Preplant (21-d PHI)
Sorghum – grain sorghum (milo)	Broadcast spray, aerial (except MS) or ground; or sprinkler irrigation; foliar or directed at base of young plants	1.0	3	1.5	10	Post-emergent; 30-d PHI
Soybean (not for use in MS)	Soil spray at plant in 4-6 inch band; postemergent spray in 6-12 band over or at the side of the base, depending upon plant size; or foliar spray by ground, air, or sprinkler chemigation	1.0	3	3.0	10	From at plant to 28-d PHI

Crop¹	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Strawberry (Not for use in MS)	Preplant broadcast spray to soil with incorporation (depth not specified); broadcast foliar spray at budbreak; or directed spray to crown postharvest	Preplant: 2.0 Foliar, postharvest: 1.0	Preplant: 1 Foliar, postharvest: 2, Total 3	3.0	Foliar: 10 Postharvest: 14	Do not apply when berries are present; 21-d PHI
Sugarbeet (not for use in MS)	Preplant soil application with 1-2 inch incorporation or at-plant soil application in 10 inch band; postemergent banded or broadcast foliar spray by air or ground	1.0	3	3.0	10	30-d PHI
Sugarbeet for seed (24c ID)	Ground broadcast spray with incorporation (pre-plant)	2.0	1	2.0	--	Preplant in fall (after harvest)
Sunflower (not for use in MS)	Ground broadcast spray with 2-4 inch incorporation (pre-plant); aerial or ground foliar broadcast (postemergence)	Pre-plant: 2.0 Postemergence: 1.0 (in table, but specific use restrictions indicate maximum single application of 1.5)	3	3.0	10	42-d PHI
Sweet potato	Broadcast spray to soil with 4-6 inch incorporation (pre-plant)	2.0	1	2.0	--	125-d PHI
Table beets for seed, sugarbeets for seed (24c OR)	Broadcast spray to soil with 2-4 inch incorporation (pre-plant); or banded spray to soil with incorporation at least 2 inches (at-plant)	2.0 broadcast or 1.0 band	1	2.0	--	Apply in fall for protection the following year
Tobacco	Broadcast spray to soil with 2-4 inch incorporation (pre-plant)	2.0	1	2.0 (all chlorpyrifos)	--	Preplant

Crop¹	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Tree fruits and nuts (apple, almond, cherry, nectarine, peach, pear plum, and prune) (dormant/delayed dormant sprays) (not for use in MS)	Broadcast spray with air blast implied but aerial not precluded (not for almond use in Butte, Colusa, Glenn, Solano, Sutter, Yolo, and Yuba counties, CA)	2.0	1 as dormant	2.0 for dormant (additional foliar OK)	--	Preplant (or pretransplant)
Tree nuts (foliar sprays) (almonds, filberts, pecans, walnuts)	Aerial (except MS) or ground foliar spray	2.0	3, except for walnuts which has a limit of 2 applications	4.0 for foliar; (one additional dormant OK)	10	14-d PHI, except 28-d PHI for pecans
Tree nuts (almonds, pecans, walnuts) orchard floors (for fire and other ants) (Not for use in MS)	Ground broadcast spray to soil or sprinkler irrigation, not to contact foliage	4.0	2 (to orchard floor; other OK)	4.0	10	14-d PHI
Vegetables (broccoli, cabbage, Chinese cabbage, collard, kale, kohlrabi, rutabaga, turnip)	Four-inch banded soil application at plant or directed spray to base of plant after transplant; or postemergent sidedress for broccoli & cabbage	2.25	1 soil appl/crop	2.25 of 4E	10 (for foliar chlorpyrifos products)	30-d PHI
Vegetables (Brussels sprouts)	Four-inch banded soil application at plant or directed spray to base of plant after transplant; or foliar application	2.25	1 soil or 3 total/crop (of any chlorpyrifos)	2.25 soil	10 (for any chlorpyrifos product)	30-d PHI ground; 21-d PHI for foliar
Vegetables (cauliflower)	Four-inch banded soil application at plant or directed spray to base of plant after transplant	2.0	1 soil appl/crop	2.0 of 4E	10 (for foliar chlorpyrifos products)	
Vegetables (radish)	In furrow drench application at plant	2.75	1 soil appl/crop	2.75 of 4E	10 (for foliar chlorpyrifos products)	

Crop^l	Method of application	Maximum single application rate (lbs. a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs. a.i./A)	Minimum retreatment interval (d)	Timing
Wheat ⁿ	Foliar broadcast spray - aerial, ground, or sprinkler irrigation	0.5	2	1.0	--	14-d PHI

ⁿ For use on wheat only in Arizona, California, Colorado, Idaho, Kansas, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington and Wyoming.

SI Table B-4 Use patterns for the application of Lorsban 75WG (Gowan 2011)

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Alfalfa (not for use in MS)	Broadcast foliar spray by air, ground, or chemigation	1.0	4 (but maximum of 1 app /cutting)	4.0 (of any chlorpyrifos product)	10	7-21-d PHI
Apple tree trunk, (east of Rockies only) (not for use in MS)	One application per year directed to lower 4 feet of apple tree trunk from a distance of no more than 4 feet away. No rate per acre given, but 1.5 lbs a.i./100 gal of spray Not to contact foliage or fruit.					Post bloom; 28-d PHI
Asparagus ^o	Broadcast foliar spray by ground	1.0	3	3.0	10	1-d PHI; 1 application preharvest; 2 applications post harvest
<i>Brassica</i> (cole) leafy vegetables and radish, rutabaga, and turnip ^p	Broadcast with 2-4 inch incorporation (pre-plant)	Cauliflower: 2.0	1 soil	Cauliflower: 2.0	10 (for other chlorpyrifos foliar)	30-d PHI; preplant or after establishment
	Spray to soil in band over seed row at planting time	Broccoli, Brussels sprouts, leafy brassica, turnip, rutabaga: 2.25		Broccoli, Brussels sprouts, leafy brassica, turnip, rutabaga: 2.25		
	Apply as drench in seed furrow at planting	Radish: 2.75		Radish: 2.75		
<i>Brassica</i> (cole) leafy vegetables only	Foliar broadcast spray by air or ground	1.0	3	3.0	10	21-d PHI
Christmas trees (plantations) (not for use in MS)	Foliar ground broadcast power spray (postplant); cut stump drench	1.0	3	3.0	7	As needed

^o For use on asparagus only in Arizona, California, Idaho, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oregon, South Dakota, Washington and Wisconsin.

^p Labeled crops include broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cavalo broccoli, Chinese broccoli, Chinese cabbage, collards, kale, kohlrabi, mizuna, mustard greens, mustard spinach, and rape greens.

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Citrus fruits ^q (not for use in MS)	Foliar broadcast; directions imply air-blast but aerial not precluded	3.5 except CA & AZ 6.0 in AZ & Fresno, Tulare, Kern, Kings and Madera Counties, CA 4.0 in other CA counties	2 (not including orchard floor)	7.5	30 (any foliar)	21 to 35-d PHI; "To avoid excessive ridging, do not apply Lorsban 4-E to citrus fruit from December up to the initiation of bloom"
Citrus orchard floors (not for use in MS)	Broadcast spray to orchard floor or sprinkler chemigation to soil around trees	1	3	3.0	10	28-d PHI
Corn (field, sweet, seed)	Broadcast to surface in "Conservation Tillage"(pre-plant, pre-emergence, at-plant); foliar spray by air (except MS) or ground (postplant)	1	3 (any chlorpyrifos)	3.0	10	21-d PHI
Cotton (not for use in MS)	Foliar broadcast by air, ground, or chemigation	1.0	3	3.0	10	14-d PHI
Cranberry (not for use in MS)	Foliar broadcast spray or chemigation	1.5	2 (any chlorpyrifos)	3.0	10	60-d PHI; do not apply until winter flood water has been removed, nor when bogs are flooded
Fig (CA only)	Dormant ground spray with 3 inch incorporation	2.0	1	2.0	--	217-d PHI; apply late winter

^q Citrus fruits on label include calamondin, chironja, citrus citron, citrus hybrids, grapefruit, kumquat, lemon, lime, mandarin (tangerine), pummel, Satsuma mandarin, sour orange, sweet orange, tangelo, tangor

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Grape (east of the continental divide only) (not for use in MS)	Soil surface spray (4 ft. circle around base of vine); or spray drench to soil (prebloom)	Soil surface 2.25; prebloom 1.0	1	2.25	--	35-d PHI; apply prior to bloom
Legume vegetables ^r (succulent or dried), all except soybean (not for use in MS)	Broadcast spray to soil with 1-3 inch incorporation (pre-plant); or 3-5 inch T-band with ½-1 inch incorporation recommended (at-plant)	1.0	1	1.0	--	Preplant or at plant.
Onion (dry bulb)	Soil drench in 2-4 inch band with shallow incorporation at-plant; directed spray to seedling base postplant	1.0	2 (at-plant plus postplant)	2.0	At plant to seedling stage	60-d PHI; apply at or before seedling stage
Peanut	Aerial (except MS) or ground broadcast to soil with 3-4 inch incorporation (pre-plant)	2.0	1	4.0 (all chlorpyrifos products)	--	21-d PHI; preplant
Pear (California, Oregon and Washington only)	Airblast spray postharvest	2.0	1	--	--	After harvest
Peppermint and spearmint (not for use in MS)	Ground broadcast to soil with 2-4 inch incorporation (pre-plant) or watered in (postharvest); or foliar spray/chemigation (postplant)	2.0	Apparently 3 (1 "during growing season"; 1 preplant; 1 postharvest)	6.0	Specified as stages of crop	90-d PHI; preplant for symphylans; Might-June for cutworms; postharvest for borers

^r Legume vegetables on label include adzuki bean, asparagus bean, bean, blackeyed pea, broad bean (dry and succulent), catjang, chickpea, Chinese longbean, cowpea, crowder pea, dwarf pea, edible pod pea, English pea, fava bean, field bean, field pea, garbanzo bean, garden pea, grain lupin, green pea, guar, hyacinth bean, jackbean, kidney bean, lablab bean, lentil, lima bean, moth bean, mung bean, navy bean, pea, pigeon pea, pinto bean, rice bean, runner bean, snap bean, snow pea, southern pea, sugar snap pea, sweet lupin, sword bean, tepary bean, urd bean, wax bean, white lupin, white sweet lupin, yardlong bean.

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Peppers (unspecified) 24c FL	Broadcast foliar spray with power-operated ground equipment	1.0	8	8.0	10 (any chlorpyrifos)	7-d PHI
Sorghum – grain sorghum (milo)	Aerial (except MS) or ground foliar spray or chemigation (postemergence)	1.0	3	1.5	10	30-60-d PHI
Sour cherry and tree fruits (almond, filbert, pecan, walnut) foliar sprays ^s (not for use in MS, except on cherries)	Apply as a foliar spray by air blast (preferable) or aerial (except no aerial in MS) to cover foliage and crop	2.0	2 (walnuts); 3 (almonds, pecans, filberts); 8 (cherries)	4.0 (walnuts); 6.0 (almonds, pecans, filberts); 12.0 (cherries)	10	14-d PHI (almonds, filberts, sour cherry) or 28-d PHI (pecans)
Soybean (not for use in MS)	Ground broadcast to soil or band at plant with light incorporation; postemergent directed spray in 9-12 inch band to base of plant; foliar spray or chemigation for foliar pests	1.0	3	3.0	14	28-d PHI; soil applications pre-to-early post plant; foliar as needed including after pod set
Strawberry (not for use in MS)	Broadcast with unspecified incorporation (pre-plant); broadcast foliar when buds appear; directed spray to crown after harvest	Preplant: 2.0; foliar, postharvest: 1.0	3 total (Preplant: 1; foliar + postharvest: 2)	4.0	Foliar: 10 Postharvest: 14	21-d PHI; do not apply when berries are forming or present

^s Might also be used as dip for peach and nectarine trees prior to planting (no exposure).

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Sugarbeet (not for use in MS)	Banded soil application with 1-2 inch incorporation at or before planting; aerial broadcast or banded foliar spray or chemigation after emergence	1.0	3	3.0	10	30-d PHI; treatment throughout season
Sunflower (not for use in MS)	Broadcast spray to soil with 2-4 inch incorporation (pre-plant); foliar broadcast aerial or ground spray (postemergence)	Pre-plant soil incorporated: 2.0; Postemergent foliar: 1.0	3 (any chlorpyrifos)	3.0	10	42-d PHI
Sweet potato	Aerial (except MS) or ground broadcast spray to soil with 4-6 inch incorporation (pre-plant)	2.0	1	2.0	--	125-d PHI; apply up to 14 d before planting
Tobacco	Aerial (except MS) or ground broadcast spray to soil with 2-4 inch incorporation (pre-plant)	1.0	1	1.0	--	Apply 24-48 hours before bedding or transplanting
Tree fruits (apple, cherry, nectarine, peach, pear, plum, prune), almond ^t and walnut (dormant/delayed dormant sprays) (not for use in MS)	Broadcast spray to completely cover "foliage"	2.0	1 of any chlorpyrifos for apple tree trunks/entire year; 1 dormant/delayed dormant for others	2.0 as dormant/delayed dormant	10 d to any foliar	After winter rains and before budbreak

^t Not for use on almonds in Butte, Colusa, Glenn, Solano, Sutter, Tehama, Yolo, and Yuba counties, California

Crop	Method of application	Maximum single application rate (lbs a.i./A)	Maximum number of applications per season	Maximum seasonal application rate (lbs a.i./A)	Minimum retreatment interval (d)	Timing
Tree fruits (cherry, nectarine, peach) ^u and almond (not for use in MS)	Apply to tree trunks and lower branches with coarse spray	3.0 lb a.i./100 gal of spray; no acreage-related limit	Peaches, nectarines 1; cherries 3; almonds not specified	No acreage-related limit	--	14-d PHI
Tree nuts (almond, pecan, walnut) orchard floors (not for use in MS)	Ground broadcast spray uniformly to soil	Pecans: 2.0	2	4.0	10	14-d PHI
		Almonds and walnuts: 4.0				
Wheat ^v	Aerial or ground foliar broadcast spray or chemigation	0.5	2	1.0	Not specified	14-d PHI

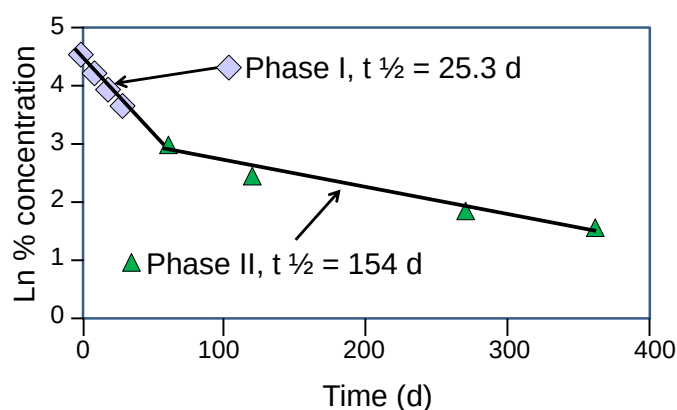
^u Might also be used as dip for peach and nectarine trees prior to planting.

^v For use on wheat only in Arizona, California, Colorado, Idaho, Kansas, Minnesota, Montana, Nebraska, New Mexico, Nevada, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington and Wyoming.

SI Appendix C. Derivation of Chemical Input Parameter Values for Dissipation of CPY in Soil

Background

As noted in the discussion of the environmental fate of chlorpyrifos, the aerobic laboratory soil degradation study results show a clearly defined bi-phasic behavior in most soils. The DT50 values reported by Bidlack were calculated using a two compartment kinetic model, but the goodness of fit details were not provided in the report (Bidlack 1979). The graph of log concentration vs. time shows two linear sections, a faster initial degradation followed by a slower phase. An example of this behavior, prepared using the data from the Barnes soil (Bidlack 1979) is shown in (SI Fig. C1). The Initial phase rate constant was 0.0245 and the half-life was 25.3 days. The second phase rate constant 0.0045 and half-life 154 days. Regression Correlation coefficients R^2 were 0.9979 and 0.9689 respectively. This biphasic behavior is not as apparent for the soils in the report by de Vette and Schoonmade, in which the half-lives were calculated using simple first order kinetics (de Vette and Schoonmade 2001).



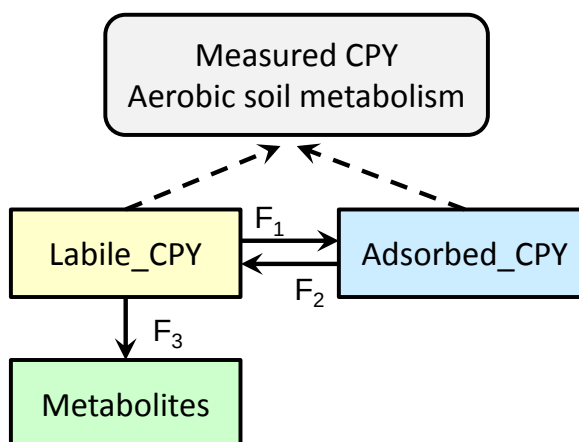
SI Fig. C-1. Biphasic pattern of degradation (data for Barnes soil (Bidlack 1979))

A hypothetical dissipation model was set up with two compartments for the parent compound: one adsorbed in such a manner that is not available for biological degradation or abiotic hydrolysis; and the other in which these processes can occur (SI Fig. C2). It is known that CPY partitions between soil and soil pore water and that this reaches equilibrium within hours (Racke 1993), whereas the biphasic degradation process observed for CPY occurs over a period of several days (SI Fig. C1). The two compartments were identified as Labile_CPY and Adsorbed_CPY. This model has advantages over older two-compartment models in that all available data are used, simple first order equations are used and the rate constants are not concentration-dependent (Nash 1988)

Reversible movement of parent CPY between these compartments was represented as two simple first order processes shown by arrows F1 and F2 in SI Fig. C2, with rate constants k_{ads} and k_{des} . Since the reported concentrations of CPY in the soil include nearly all the radiolabelled CPY residue present, these data represents the sum of the amounts in these two compartments at each time point as shown in SI Fig. C1. The sum

of processes that degrade CPY was also set up as a first order kinetic process F3, but was non reversible. The rate constant for this process was designated k_m . The resulting set of three first order equations was integrated numerically using Model-Maker Version 4.0 software from Cherwell Scientific Software Ltd. UK. Metabolism study data from 11 soils reported in two studies (Bidlack 1979; de Vette and Schoonmade 2001) were fit to this model.

When the model is set with 100% of the residue in the labile compartment at time zero, the degradation rate is initially controlled by k_m . When a significant proportion of the parent compound partitions into the adsorbed compartment, the rate limiting step in the degradation process shifts to k_{des} , and this represents the biphasic behavior. Note that when k_{des} is rapid relative to k_m , the model approaches a simple first order degradation model. While the ratio of k_{ads} and k_{des} appears to be related to the adsorption coefficient, these rate constants include other factors such as uptake by microorganisms and depuration rates and represent an entirely different time scale as noted above



SI Fig. C-2. Schematic diagram of 2-compartment kinetic model for degradation of CPY in soil.

Setup of the model

The Model-Maker software requires an initial approximation of the values of the rate constants, and initial values for the concentration in each compartment. The Adsorbed_CPY and the metabolites compartments were set to zero and the Labile_CPY compartment was set to the initial measured value except for the Charentilly and Cuckney soils, for which the intercept of the simple first order regression, 96.9 and 98.2% respectively were used. The first and second phase rate constants in the biphasic degradation curve were used as initial approximate values for k_m and k_{des} . The initial value of k_{ads} was set slightly higher than k_{des} . In some cases these values were adjusted to obtain a closer visual fit to the data so that the regression process would converge on an optimum set of rate constants. An example of the set-up used for each soil type is shown in SI Table C-1. This includes the differential equations used. The time-0 values are entered and the experimental data into a data Table. When the model is run, the software first integrates the set of differential equations. Five integration methods (Euler, Mid-Point, Runge-Kutta, Bulirsch-Stoer and Gear's method) are available in the software. The default Runge-Kutta method was used for all sites. After integration, a least squares optimization process was run to

obtain the values of k_{ads} , k_{des} and k_m that best fit the data, and these values were output along with the goodness of fit statistics. The Marquardt Method with ordinary least squares optimization was used for all soils except the Catlin soil, which required the weighted least squares procedure.

SI Table C-1 Example ModelMaker software set-up for Barnes soil

compartment: Adsorbed_CPY Unconditional Universal
$d\text{Adsorbed_CPY}/dt = +F1-F2$
Initial Value = 0.0
compartment: Dissolved_CPY Unconditional Universal
$d\text{Dissolved_CPY}/dt = -F1+F2-F3$
Initial Value = 96.8
flow: F1 Unconditional Universal
Flow from Dissolved_CPY to Adsorbed_CPY
$F1 = k_{ads} \times \text{Dissolved_CPY}$
flow: F2 Unconditional
Flow from Adsorbed_CPY to Dissolved_CPY
$F2 = k_{des} \times \text{Adsorbed_CPY}$
flow: F3 Unconditional
Flow from Dissolved_CPY to Metabolites
$F3 = k_m \times \text{Dissolved_CPY}$
variable: Measured_CPY Unconditional
Commerce Soil
$\text{Measured_CPY} = \text{Adsorbed_CPY} + \text{Dissolved_CPY}$
compartment: Metabolites Unconditional Universal
$d\text{Metabolites}/dt = +F3$
Initial Value = 0.0

Results of the model

The results of the linear regression optimization of the rate constants are listed in SI Table C-2 and an example of the model output graph is shown in SI Fig. C-3. The resulting rate constant represent the entire data set optimized simultaneously and provide a better representation of the half-life than the values in the original reports for most soils and represent a consistent model across all the soils. It is possible to consider the data in two groups; one group of soils has half-lives >30 d, which are pH dependent and the other group has shorter half-lives with much weaker correlation to pH. The correlation to pH in the range from pH 5 to 8 is given by Equation SI C-1 for Group 1 and SI C-2 for Group 2.

SI Table C-2 Results of Model-Maker runs for the 2-compartment model

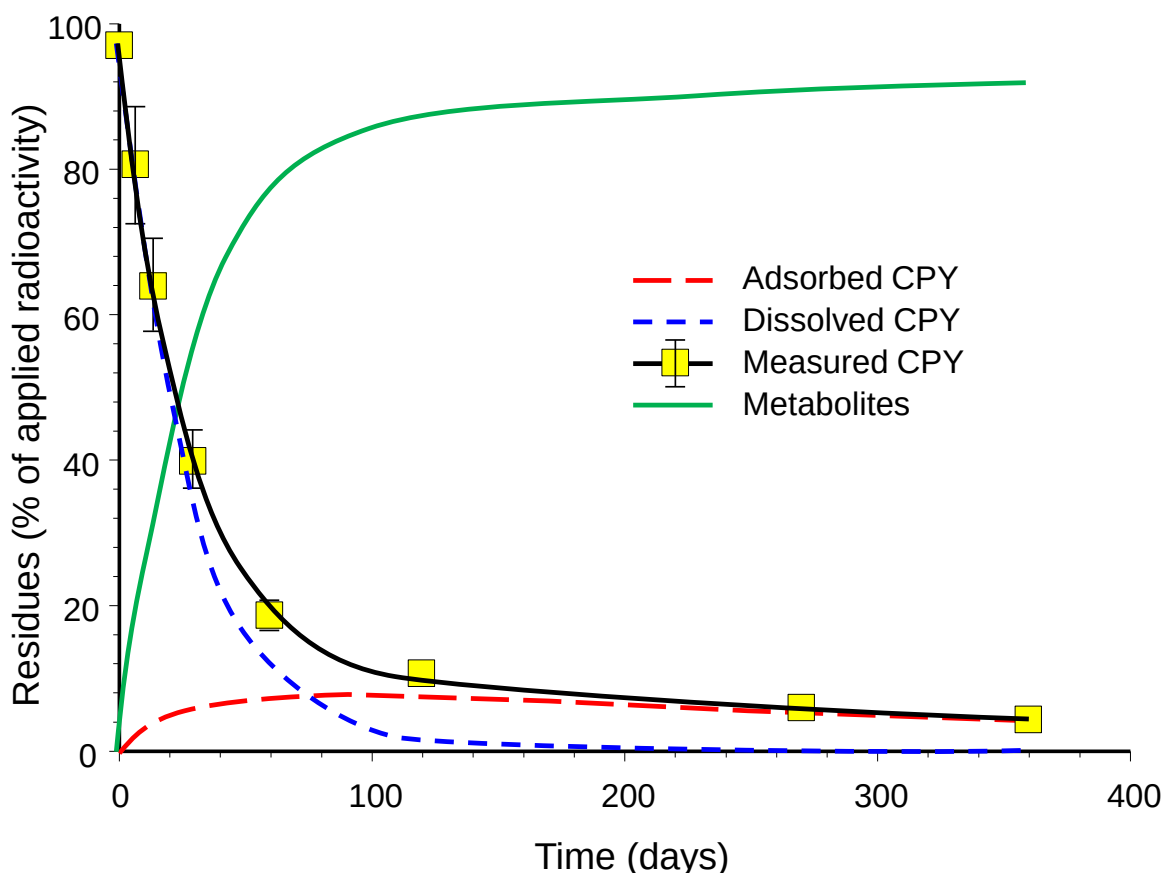
Soil	Optimized parameters			Optimization statistics			
	Parameter	Optimized value	Half-life (d)	Estimation error	Regression Coeff. (r^2)	F ratio	Group
German 2:3	k_{ads}	0.0124	55.9	0.0143	0.9973	918.5	1
	k_{des}	0.0211	32.9	0.0143			
	k_m	0.0070	99.1	0.00148			
	k reported		141				
Stockton	k_{ads}	0.0031	227.3	0.00128	0.9987	1871	1
	k_{des}	0.0021	338.1	0.00219			
	k_m	0.0072	96.3	0.000420			
	k reported		107				
Charentilly	k_{ads}	0.0125	55.5	0.144	0.9678	105.0	1
	k_{des}	0.287	2.4	3.50			
	k_m	0.00749	92.5	0.0065			
	k reported	0.00731	94.8		0.9538	214.8	
Cuckney	k_{ads}	0.036	19.3	0.499	0.9512	68.2	1
	k_{des}	0.104	6.7	0.760			
	k_m	0.00821	84.4	0.0150			
	k reported	0.00624	111.1		0.9337	147.2	
Norfolk	k_{ads}	0.0129	53.7	0.0046	0.9987	1883	1
	k_{des}	0.0125	55.5	0.00309			
	k_m	0.0122	57.0	0.00108			
	k reported		102				
Thessaloniki	k_{ads}	0.0206	33.6	0.0116	0.9873	309.9	1
	k_{des}	0.00467	148.4	0.0113			
	k_m	0.02256	30.7	0.00287			
	k reported	0.0150	46.2		0.9427	187.3	
Catlin	k_{ads}	0.00315	220.3	0.00118	0.9904	258.6	2
	k_{des}	0.00386	179.6	0.00133			
	k_m	0.0246	28.2	0.00229			
	k reported		34.0				
Barnes	k_{ads}	0.00344	201.5	0.000967	0.9989	2350	2
	k_{des}	0.00245	282	0.00148			
	k_m	0.0310	22.4	0.00110			
	k reported		22				
Miami	k_{ads}	0.01805	38.4	0.0164	0.9966	737.5	2
	k_{des}	0.0312	22.2	0.0246			
	k_m	0.0395	17.5	0.00544			
	k reported		24				
Commerce	k_{ads}	0.00753	92.1	0.00103	0.9997	7342	2
	k_{des}	0.00702	99	0.00144			
	k_m	0.0613	11.3	0.00125			
	k reported		11				
Marcham	k_{ads}	0.0908	7.6	0.0211	0.9894	373.6	2
	k_{des}	0.0154	45.0	0.00446			
	k_m	0.0789	8.8	0.00855			
	k reported	0.0163	42.5		0.8369	46.2	

Group 1 half-life = $267 - 30.14 \times \text{pH}$ ($r^2 = 0.92$) (SI C-1)

Group 2 half-life = $93.5 - 10.86 \times \text{pH}$ ($r^2 = 0.76$) (SI C-2)

The mean half-life in the Group-1 was 17.6 d with a 90th centile of 25.9 d and for Group-2 was 77.7 d with a 90th centile of 97.7 d.

There were only two US soils in the Group-2, and it was considered less common. The highest half-life among the US soils in each group was selected as a conservative value



SI Fig. C-3. Example of ModelMaker optimization results – Barnes soil

to represent the group in the PRZM/EXAMS model runs. These values were 96 d from the Stockton soil and 28 d from the Catlin soil (SI Table C-2)

The placement of the soils into these groups does not appear to be based on the physical properties of the soil. It is more likely to be related to the biological activity of the soil during the study, and the relative importance of abiotic and metabolic hydrolysis in the degradation. The group of soils with the longer half-lives has a greater contribution from abiotic hydrolysis, which is pH-dependent.

The two compartment model used for this analysis successfully described the behavior of chlorpyrifos in soil, but unfortunately there is no measured soil parameter that would allow the selection of a rate constant from the two groups for a particular soil. Therefore the PRZM/EXAMS modeling was carried out using the US soils with the longest half-

lives in each of the 2 groups: These were Stockton, from California and Catlin, from Illinois, with half-lives of 96 and 28 days respectively (Williams et al. 2013). No attempt was made to run the two compartment model described above on available field study data, but this can be done either within the growing season or by using the appropriate corrections for soil moisture and temperature.

The movement of material between the two compartments in the typical two compartment kinetic model has been considered to be a kind of pseudo-partition coefficient (Nash 1988), but this assumes an equilibrium. As noted previously, the adsorption/desorption equilibrium is established within hours, whereas the transition from the rapid degradation to slower degradation governed by k_{ads} and k_{des} occurs over many days and the system may not be at equilibrium. Moreover, the ratio does not predict the proportion of the residue that is available for leaching movement; both compartments of the two compartment model are fixed on the soil. These parameters are variable among soil types but neither the individual values nor the ratio of k_{ads} to k_{des} is related to the soil adsorption coefficient, K_d or K_{OC} , or to other soil physical properties. It is likely that the labile phase is comprised of the biologically active component of the soil organic matter. This living component consists of a complex and variable collection of many different species, present as both biofilm and individual cells (Burmølle et al. 2007). Since the standard measures of microbial viability, e.g., evolution of CO_2 do not correlate to the ability of a soil to metabolically transform a compound such as chlorpyrifos, there is no readily available measure for applying the model to a soil other than the ones tested. The adsorbed compartment is likely to be comprised of the soil particle surface, vacuoles, cell membranes and other micro-environments, which are not accessible to degradation enzymes or have a lower pH than the bulk soil. In any case the model compartments have a physical form in the soil, and the release of CPY from the adsorbed phase becomes the rate limiting step in the degradation in the second phase of the biphasic degradation process.

The following conclusions can be drawn from the DT50s and soil properties listed in SI Table C-2 from these two studies:

1. The half-life was significantly longer at 10°C or near the wilting point at 10% field moisture capacity (FMC) compared to the same soil at 20°C and 40% FMC. This shows that temperature is a significant factor and that moisture can be limiting under extremely dry conditions.
2. Sterile conditions reduced the production of CO_2 in the Marchand soil from the de Vette study, but the sterile conditions did not reduce the degradation rate of parent CPY. This shows that abiotic hydrolysis can be a major degradation pathway in soil.

- 163 3. The model results gave a good fit to the data. The resulting rate constants were
164 not correlated to soil properties, but could be divided into two groups, one in
165 which the metabolic half-life was >30 d and was correlated with the soil pH and
166 the other in which the correlation to pH was much weaker and the half-life was
167 <30 d. Otherwise the rate constants found do not appear to be predictable based
168 upon the physical properties of the soil.
- 169 4. It is likely that the rate constants k_{ads} , k_{des} and k_m are related to the movement
170 between biologically active and inert environments in the soil. At present there is
171 no independent measure of the movement of material between these
172 compartments. However, it may be that the soils that show a faster hydrolysis
173 rate are those with a microbiome capable of biologically accelerated hydrolysis.
174

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