Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA (DP 5461)	1.4 pre		150	1+				14-CA-95-661
	0.56		187/222	2+				
	0.14		77/78	2+				
	0.56		80	1	3	0.07	Seed	
AZ (DPL 20)	1.4 pre		104	1+				14-AZ-95-662
	0.56		126/127	2+				
	0.14		79/80	2+				
	0.56		80	1	3	0.23	Seed	
						23	Gin byproduct	
OK (Paymaster HS200)	1.4 pre		136	1+				23-OK-95-663
	0.56		185/192	2+				
	0.14		69/68	2+				
	0.56		67	1	3	0.35	Seed	
						5.3	Gin byproduct	

B=control

Table 39. Paraquat residues in sunflower seed from supervised trials in the USA.

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
1988					0B*	<0.05	Pre-emergence	Roper 1989o
SD (Interstate 893)	5.6			1	84	<0.05	Forage	31SD-88-475
					131	<0.05	Seed	
ND (Pioneer 6445)	5.6		215	1	B*	<0.05	Forage	34ND-88-476
					74	<0.05	Seed	
					122	<0.05		
ND (Pioneer 6440)	1.1			1	74	<0.05	Forage	34ND-88-528
					122	<0.05	Seed	
SD (unknown)	1.1			1	84	<0.05	Forage	31SD-88-529
					131	<0.05	Seed	
MN (NK285)	1.1			1	76	<0.05	Forage	33MN-88-530
					111	<0.05	Seed	
TX (Texas Triumph 565)	1.1		210	1	41	<0.05	Forage	10TX-88-531
					118	<0.05	Seed	
1994					0B*	<0.05	Pre-emergence; post directed; & harvest aid	Roper 1995
ND (Pioneer DO 827)	1.12		142	1+			Seed	34ND-94-202
	0.70		59	1+				
	0.56		142	1	7	0.93		
SD, (Cargill 100)	1.12		142	1+				34SD-94-203
	0.70		59	1+				
	0.56		142	1	7	0.74	Seed	
1971					0B*	<0.01	Harvest aid	Chevron 1975a
CA (Peredovik)	0.28		374	1	0	0.08, 0.08	Seed	T-2185
					7	0.10, 0.11	Seed	
						0.23, 0.27	Hull	
						0.17, 0.12	Meal	
						<0.01, <0.01	Oil	
					14	0.11, 0.11	Seed	
	0.56		374	1	0	0.16, 0.16	Seed	
					7	0.35, 0.35	Seed	
						0.57, 0.67	Hull	
						0.54, 0.55	Meal	
						<0.01, <0.01	Oil	
					14	0.23, 0.23	Seed	
MS (NK-HO1)	0.28		46	1	0	0.05, 0.11	Seed	T-2186
					7	0.10, 0.31	Seed	
						1.3, 2.4	Hull	
						0.64, 1.2	Meal	
						<0.01, <0.01	Oil	
					14	0.38, 0.52	Seed	
	0.56		46	1	0	0.19, 0.19	Seed	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
					7	0.27, 0.34	Seed	
						2.2, 4.6	Hull	
						0.60, 0.71	Meal	
						<0.01, <0.01	Oil	
					14	0.49, 0.81	Seed	
1972					0B*	<0.01	Harvest aid	Chevron 1975a
MN (VNIIMK 8931)	0.28		47	1	7	0.05, 0.11	Seed	T-2392
						0.07, 0.08	Hulls	
						0.10, 0.14	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.13	Seed	
						0.07, 0.10	Hulls	
						0.17, 0.23	Meal	
						<0.01, <0.01	Oil	
					21	0.11, 0.12	Seed	
						0.07, 0.09	Hulls	
						0.11, 0.15	Meal	
						<0.01, <0.01	Oil	
	0.56		47	1	7	0.04, 0.04	Seed	
					14	0.32, 0.52	Seed	
					21	0.81, 0.42	Seed	
MN (VNIIMK 8931)	0.28		47	1	7	0.06, 0.06	Seed	T-2393
						0.06, 0.06	Hulls	
						0.02, 0.10	Meal	
						<0.01, <0.01	Oil	
					14	0.03, 0.04	Seed	
						0.04, 0.06	Hulls	
						0.05, 0.07	Meal	
						<0.01, <0.01	Oil	
					21	0.02, 0.04	Seed	
						0.02, 0.02	Hulls	
						0.04, 0.05	Meal	
						<0.01, <0.01	Oil	
	0.56		47	1	7	0.21, 0.27	Seed	
					14	0.37, 0.39	Seed	
					21	0.32, 0.60	Seed	
CA (HO-1)	0.28		206		7	0.12, 0.14	Seed	T-2394
						0.14, 0.16	Hulls	
						0.17, 0.20	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.11	Seed	
						0.11, 0.14	Hulls	
						0.17, 0.20	Meal	
						<0.01, <0.01	Oil	
					21	0.10, 0.11	Seed	
						0.08, 0.11	Hulls	
						0.18, 0.18	Meal	
						<0.01, <0.01	Oil	
	0.56		206		7	0.35, 0.51	Seed	
					14	0.40, 0.44	Seed	
					21	0.23, 0.26	Seed	
1973					0B*	<0.01	Harvest aid	Chevron 1975a
IA (Peredovik)	0.28		187	1	7	0.10, 0.13	Seed	T-2679
						0.30, 0.32	Hulls	
						<0.01, <0.01	Meal	
						<0.01, <0.01	Oil	
	1.1		187	1	7	0.18, 0.19	Seed	
						0.53, 0.54	Hulls	
						<0.01, 0.01	Meal	
						<0.01, <0.01	Oil	
						17, 18	Leaves	
						8.3, 8.4	Stalks	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
ND (Peredovik)	0.56		47	1	7	0.16, 0.16	Seed	T-2680
						0.56, 0.58	Hulls	
						<0.01, 0.01	Meal	
						<0.01, <0.01	Oil	
						8.1, 11	Leaves	
						4.8, 5.2	Stalks	
					14	0.10, 0.11	Seeds	
					21	0.05, 0.05	Seeds	
CA (RHA-271)	0.56		206	1	7	0.09	Seed	T-2681
						0.27	Hulls	
						<0.01	Meal	
						<0.01	Oil	
					14	0.05	Seed	
MS (HF-52)	0.56		47	1	7	0.12, 0.14	Seed	T-2682
						0.36, 0.40	Hulls	
						<0.01, <0.01	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.10	Seed	
					21	0.07, 0.09	Seed	
SD (Record)	0.63		23	1	14	0.15, 0.16	Seed	T-2683
						0.42, 0.50	Hulls	
						0.01, 0.02	Meal	
						<0.01, <0.01	Oil	
MN (Cargill 101)	0.56		47	1	9	0.20, 0.22	Seed	T-2684
						0.60, 0.64	Hulls	
						0.02, 0.02	Meal	
						<0.01, <0.01	Oil	
1974					0B*	<0.01	Harvest aid	Chevron 1975a
MN (Sputnik)	0.56		47	1	7	0.12, 0.16	Seed	T-3069
						0.25, 0.30	Hulls	
						0.08, 0.09	Meal	
						<0.01, <0.01	Oil	
ND (Sputnik)	0.56		47	1	7	0.24, 0.24	Seed	T-3070
						0.50, 0.59	Hulls	
						0.11, 0.14	Meal	
						<0.01, <0.01	Oil	
SD (Peredovik)	0.56		47	1	7	0.28, 0.32	Seed	T-3071
TX (sun Hi 372)	0.56		47	1	15	0.18, 0.19	Seed	T-3126
						0.39, 0.40	Hulls	
						0.09, 0.13	Meal	
						<0.01, <0.01	Oil	
					20	0.14, 0.16	Seed	
TX (Sun Hi 372)	0.56		47	1	17	0.12, 0.15	Seed	T-3127

B=control

Hops

Paraquat is recommended for the control of weeds pre-emergence or post-emergence directed between hop rows.

In Canada, a single post-emergence directed application of 1.12 kg ai/ha was made and green hops were harvested 42 days after application.

In residue trials in the USA in the States of Idaho and Washington, using three post-emergence directed applications of paraquat at 2.8 kg ai/ha green hops were harvested 13 to 14 days after the last application and processed into dried hops.

Table 40. Paraquat residues in hops from supervised trials in Canada and the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
BC, Canada, 1964 (Unknown)	2.24		702-935	1	0B*	<0.01	Post-emergence directed	McKenna 1966
					53	<0.01	Green hops	
ID, USA, 1988 (Hallertau Mittlefrueh)	2.8	9.03	31	3	B*	<0.05	Green hops	Roper 1989d 15ID88-591
						<0.1	Dried hops	
					14	<0.05	Green hops	
						≤0.1	Dried hops	
WA, USA, 1988 (L-1 Clusters)	2.8	9.03	31	3	B*	<0.05	Green hops	15WA88-592
						<0.1	Dried hops	
					13	<0.05	Green hops	
						≤0.1	Dried hops	
OR, USA, 1973					B*	<0.01	Green hops	Anon. 1975b
						<0.01	Dried hops	
	0.56			3	14	0.04	Green hops	T-2639
(Cascade)						0.05	Dried hops	
	1.12			3	14	0.05	Green hops	
						0.01	Dried hops	
(Fuggle)	0.56		374	1+				T-2640
	1.12			1	14	0.03	Green hops	
						0.03	Dried hops	
	1.12			1+				
	2.24			1	14	0.01	Green hops	
						0.02	Dried hops	
(Bullion)	0.56		467	3	14	0.04	Green hops	T-2958
						0.05	Dried hops	
	1.12			3	14	0.03	Green hops	
						0.07	Dried hops	
(Bullion)	1.12		187	3	31	<0.01	Dried hops	T-2967
						<0.01	Refuse	
	2.24			3	31	<0.01	Dried hops	
						0.06	Refuse	

*B: control

Tea. Table 41 shows application rates per season. Paraquat was applied as one initial blanket spraying plus 1, 3 or 5 spot treatments for weed-infested areas over a period of 5-7 months. Green leaf samples from each plot were taken 0-21 days after the first blanket treatment and at intervals after subsequent spot treatments, and processed into black tea by the orthodox (4NET) or CTC method (other than 4NET). The orthodox method consists of withering the leaves until the moisture is reduced to 20-25% and then repeatedly rolling the leaf in conventional three crank rollers. Leaves are then fermented at normal temperature. The fermentation is stopped by firing the leaves. In the CTC (crushing, tearing and curling) method the withered leaves as above are fed into a commercial machine consisting of two milled and chased rollers running at a ratio of 1:10. The leaves are then fermented under controlled temperature and humidity before firing in a drying machine.

Table 41. Paraquat residues in black tea from supervised trials in India.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha		water, l/ha	no.				
Jorhat, 1994	0		500		7	<0.05		Anderson &
(Khorijan &			(blanket)		21	<0.05		Agarwal 1996
Timgamira Jat)					7	<0.05		1 NET
					21	<0.05		
					7	<0.05		
	0.57	1 blanket			7	<0.05	after blanket treatment	
		3 spot			21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	<0.05	treatment	
					7	≤0.05	after blanket treatment	
							after 1st spot treatment	
	1.6	1 blanket			7	0.07	after last spot	
		3 spot			21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
					7	<0.05		
Rajmai, 1994	0		500		7	<0.05		2 NET
(Betjan			(blanket)		21	<0.05		
clone TVI)					7	<0.05		
					21	<0.05		
					7	<0.05		
	0.68	1 blanket			7	<0.05	after blanket treatment	
		3 spot			21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	0.07	treatment	
					7	<0.05	after blanket treatment	
							after 1st spot treatment	
	2.0	1 blanket			7	<0.05	after last spot	
		3 spot			21	<0.05	treatment	
					7	<0.05		
					21	0.05		
					7	<0.05		
Nagrakata, India	0		500	1	7	<0.05		3 NET
1994			(blanket)		21	<0.05		
(biclonal					7	<0.05		
selections)					21	0.05		
	0.56	1 blanket		1	7	<0.05	after blanket treatment	
		1 spot			21	<0.05	after 1st (last) spot	
					7	≤0.05	treatment	
					21	<0.05	after blanket treatment	
	1.7	1 blanket		1	7	<0.05	after 1st (last) spot	
		1 spot			21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
Darjeeling, 1994	0		500		7	<0.05		4 NET
(China hybrid)			(blanket)		21	<0.05		
					7	<0.05		
					21	<0.05		
					7	<0.05		
	0.57	1 blanket			7	<0.05	after blanket treatment	
		3 spot			21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	<0.05	treatment	
					7	≤0.05	after blanket treatment	
							after 1st spot treatment	
	1.7	1 blanket			7	<0.05	after last spot	
		3 spot			21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
					7	<0.05		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha		water, l/ha	no.				
Valpari, India	0		500		7	<0.05		5 ST
1994			(blanket)		21	<0.05		
(Upasi-17 clone)					7	0.13		
	0.56	1 blanket			7	0.09	after blanket treatment	
		5 spot			21	0.08	after last spot	
					7	0.07	treatment	
							after blanket treatment	
	1.7	1 blanket			7	0.09	after last spot	
		5 spot			21	0.08	treatment	
					7	0.07		
Munnar, India	0		500		7	<0.05		6 ST
1994			(blanket)		21	<0.05		
(China hybrid)					7	<0.05		
	0.56	1 blanket			7	<0.05	after blanket treatment	
		3 spot			21	0.12	after last spot	
					5	<0.05	treatment	
							after blanket treatment	
	1.7	1 blanket			7	<0.05	after last spot	
		3 spot			21	<0.05	treatment	
					5	<0.05		
Assam, India (Clone T3E3) Site I	0.25	0.06	400	1	5	0.05		Indian submission, 2004
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		

Animal feedingstuffs

Soya forage and hay or fodder

Table 42. Paraquat residues in soya beans from supervised trials in the USA.

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
1988					0B*	<0.025, <0.05	Pre-emergence	Roper 1989l
IN (Decalb CX324)	1.1				79	≤0.025	Forage	23IN-88-584
					96	≤0.05	Hay	
MS (Asgrow)	1.1				113	≤0.025	Forage	48MS-88-585
					113	≤0.05	Hay	
MN (Evans)	1.1				132	≤0.025	Forage	38MN-88-787
					147	≤0.05	Hay	
OH (unknown)	1.1				106	≤0.025	Forage	27OH-88-788
					106	≤0.05	Hay	
1987					OB*	<0.025	Pre-emergence, post-emergence directed	Roper 1989m
NE (Asgrow 3127)	1.1 pre			1+				92NB-87-560
	0.14 post			2	52	≤0.025	Forage	
					63	≤0.025	Hay or fodder	
					88	<0.025	Seed	
IL (William 82)	1.1 pre			1+				US04-87-561
	0.14 post			2	59	≤0.025	Forage	
					59	≤0.025	Hay or fodder	
					90	<0.025	Seed	

Year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no	PHI days	Paraquat mg/kg	Notes	References
IA (Pioneer 9271)	1.1 pre			1+				A1IA-87-562
	0.14 post			2	37	≤0.025	Forage	
					84	0.2	Hay or fodder	
					84	0.03	Seed	
LA (Yield King 613)	1.1 pre			1+				36LA-87-563
	0.14 post			2	19	0.05	Forage	
					48	0.1	Hay or fodder	
					63	<0.025	Seed	
MS (Centennial)	1.1 pre			1+				US05-87-564
	0.14 post			2	65	≤0.025	Forage	
					79	0.05	Hay or fodder	
					79	<0.025	Seed	
MO (Asgrow 3544)	1.1 pre			1+				48MO-87-565
	0.14 post			2	53	≤0.025	Forage	
					102	≤0.025	Hay or fodder	
					102	<0.025	Seed	
AR (DPL 504)	1.1 pre			1+				06AR-87-566
	0.14 post			2	74	≤0.025	Forage	
					41	≤0.025	Hay or fodder	
					109	<0.025	Seed	
AL (Braxton)	1.1 pre			1+				62AL-87-567
	0.14 post			2	70	≤0.025	Forage	
					138	≤0.025	Hay or fodder	
					138	<0.025	Seed	
GA (Kirby)	1.1 pre			1+				83GA-87-568
	0.14 post			2	34	≤0.025	Forage	
					79	0.04	Hay or fodder	
					79	<0.025	Seed	
De (Pioneer 9441)	1.1 pre			1+				44DE-87-569
	0.14 post			2	3	1.8	Forage	
					30	0.3	Hay or fodder	
					30	<0.025	Seed	
1997					0B*	<0.05	Pre-emergence	Spillner *et al.* 1999
NC(Hyperformer 574)	1.4			1	36	0.08	Forage	01-NC-97-610
TN(Hutachson)					30	0.28		50-TN-97-611
AR(AG5901)					23	≤0.05		49-AR-97-612
LA(Delta Pine					29	≤0.05		69-LA-97-613
DP3478)					36	0.07		63-IA-97-615
IA(Pella)					36	0.15		63-IA-97-616
IA(D260)					42	≤0.05		63-IA-97-617
IA(L2233)					44	≤0.05		04-IL-97-618
IL(Asgrow A3237)					42	0.06		60-IL-97-619
IL(Asgrow 4401)					44	≤0.05		60-IL-97-620
IL(Asgrow 2704 STS)					53	0.06		67-IN-97-621
IN(Pioneer 9342)					47	≤0.05		67-IN-97-622
IN(Alder 373)					36	≤0.05		37-KS-97-623
KS(Ciba 373)					40	≤0.05		36-MN-97-624
MN(ICI D162)					42	≤0.05		37-MO-97-625
MO(Ciba 3362)					50	≤0.05		89-OH-97-627
OH(Asgrow 3701)					47	≤0.05		34-SD-97-628
SD(Garst D210)					36	≤0.05		79-WI-97-629
WI(Asgrow XP19505)					27	0.06		05-MS-97-631
MS(Asgrow 5979)					30	0.06		68-NE-97-632
NE(Pioneer 9281)					36	≤0.05		79-WI-97-633
WI(Asgrow AG-2501)								
					0B*	<0.05	Pre-emergence, then two post-emergence directed then one spot application	Spillner *et al.* 1999

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
	1.40 pre			1+				
	0.56 post			2+				
NC(Hyperformer 574)	0.05 spot			1	46	<0.05	Hay	01-NC-97-610
TN(Hutachson)					28	0.70		50-TN-97-611
AR(AG5901)					21	1.36		49-AR-97-612
LA(Delta Pine					10	4.10		69-LA-97-613
DP3478)					14	0.79		63-IA-97-615
IA(Pella)					14	0.99		63-IA-97-616
IA(D260)					11	1.74		63-IA-97-617
IA(L2233)					8	3.21		04-IL-97-618
IL(Asgrow A3237)					11	1.15		
					14	1.19		
					18	0.74		
					25	0.49		
					26	0.88		60-IL-97-619
IL(Asgrow 4401)					22	0.67		60-IL-97-620
IL(Asgrow 2704 STS)					18	2.69		67-IN-97-621
IN(Pioneer 9342)					10	5.56		67-IN-97-622
IN(Alder 373)					18	0.09		37-KS-97-623
KS(Ciba 373)					22	0.82		36-MN-97-624
MN(ICI D162)					16	0.29		37-MO-97-625
MO(Ciba 3362)					27	1.04		68-NE-97-626
NE(Pineer 9281)					20	1.95		89-OH-97-627
OH(Asgrow 3701)					22	1.33		34-SD-97-628
SD(Garst D210)					8	0.33		05-MS-97-631
MS(Asgrow 5979)					29	0.34		
					32	0.57		
					35	0.18		
					43	0.49		
					18	0.33		79-WI-97-633
WI(Asgrow AG-2501)								
					0B*	<0.05	Pre-emergence; two post-emergence directed; one spot; one desiccation application	Spillner *et al.* 1999
1988					B*	<0.05	Forage	Roper 1989n
						<2	Hay	
						<0.05	Seed	
IL (Fayette)	2.24		38	1	0	20	Hay	22IL-88-458
					5	26	Forage	Ground
					10	24	Forage	application
					15	22	Forage	
					21	0.1	Seed	
IA (Pioneer 9271)	2.24		38	1	0	24	Forage	36IA-88-459
						45	Hay	Ground
					5	8	Forage	application
					10	9	Forage	
					15	9	Forage	
						0.05	Seed	
					B*	<25	Forage	
						<15	Hay	
						<0.05	Seed	
IN (Dekalb CX324)	2.24		38	1	0	78	Forage	23IN-88-460
					5	49	Forage	Ground
						70	Hay	application
					10	58	Forage	
					15	45	Forage	
						<0.05	Seed	

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
MS (DPL 506)	2.24		38	1	0	70	Forage	48MS-88-461
						124	Hay	Ground
					5	49	Forage	application
					10	88	Forage	
					15	73	Forage	
						0.05	Seed	
MO (Williams)	2.24		38	1	0	49	Forage	40MO-88-462
						29	Hay	Ground
					5	51	Forage	application
					11	54	Forage	
					15	43	Forage	
					20	0.1	Seed	
MN (Evans)	2.24		38	1	0	30	Forage	33MN-88-463
						16	Hay	Ground
					5	40	Forage	application
					10	29	Forage	
					15	24	Forage	
						0.1	Seed	
OH (unknown)	2.24		38	1	0	135	Forage	27OH-88-464
						140	Hay	Ground
					5	221	Forage	application
					10	125	Forage	
					15	161	Forage	
					36	2	Seed	
					B*	<0.05	Forage	
						<2	Hay	
						<0.05	Seed	
IL (Pioneer 9271)	2.24		38	1	0	20	Hay	22IL-88-536
					5	26	Forage	Aerial application
					10	24	Forage	
					15	22	Forage	
					21	0.1	Seed	
IA (Sieben SS-235)	2.24		38	1	0	0.12	Forage	36IA-88-537
						80	Hay	Aerial application
					5	10	Forage	
					10	15	Forage	
					15	9	Forage	
						0.2	Seed	
IN (Century)	2.24		38	1	0	29	Forage	24IN-88-538
					5	26	Forage	Aerial application
						23	Hay	
					10	25	Forage	
					15	13	Forage	
					25	<0.05	Seed	
MS (DPL 506)	2.24		38	1	1	38	Forage	48MS-88-539
						31	Hay	Aerial application
					5	27	Forage	
					10	47	Forage	
					15	33	Forage	
					15	0.2	Seed	
MO (Williams 82)	2.24		38	1	0	19	Forage	37MO-88-540
						38	Hay	Aerial application
					5	10	Forage	
					10	10	Forage	
					15	<5	Forage	
					19	0.1	Seed	
MN (BSR 101)	2.24		38	1	0	59	Forage	30MN-88-541
						2	Hay	Aerial application
					5	23	Forage	
					10	23	Forage	
					15	22	Forage	
					22	0.08	Seed	

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
OH (Asgrow 3427)	2.24		38	1	B*	<1	Forage	27OH-88-542 Aerial application
						<2	Hay	
						<0.05	Seed	
					0	15	Forage	
						6	Hay	
					5	19	Forage	
					10	8	Forage	
					15	1	Forage	
						0.08	Seed	

B*: control

Sugar beet tops

Table 43. Paraquat residues in beet from supervised trials in the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
UK, 1964 Beetroot (unknown)	1.68 pre 2.24 direct		N/A	1+ 2	112	<0.01 0.01	Root Tops	McKenna 1966
UK, 1964 Sugar Beet (Klein)	1.68 pre 2.24 direct		N/A	2+ 1	72	0.01 0.08	Root Tops	McKenna 1966
	1.68 pre 2.24 direct		N/A	2+ 1	84	<0.01 0.06	Root Tops	
USA, 1988 Sugar Beet (unknown)	1.12		N/A	1	0B*	<0.025	Pre-emergence	Roper 1989c
					136	<0.05 ≤0.025	Root Top	33MN88-405
					138	<0.05 ≤0.025	Root Top	33ND88-406
					151	<0.05 ≤0.025	Root Top	17CA88-403
					152	<0.05 ≤0.025	Root Top	34ND88-407
					160	<0.05 ≤0.025	Root Top	16ID88-404
					178	<0.05 ≤0.025	Root Top	73CA88-402

*B: control

Maize forage and fodder

Table 44. Paraquat residues in maize forage and fodder from supervised trials in Canada, Italy, South Africa, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1993					0B*	<0.05	Pre-emergence	Anderson & Lant 1994
(Pioneer 3471)	0.92		521	1	104 136	<0.05 <0.05	Silage Cob	IT10-93-H385
(Pioneer 3471)	0.92		483	1	104 136	<0.05 <0.05	Silage Cob	IT10-93-H386
USA, 1987					0B*	<0.025	Pre-emergence followed by 2 post-emergence directed sprays	Roper, 1989f A1IA-87-538
IA (Pioneer 3295)	1.12pre 0.31post			1+ 2	43	≤0.025 <0.025	Forage Silage	
					79	<0.025 ≤0.025	Kernels Fodder	

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
MI (Jacques)	1.12pre			1+				71MI-87-539
	0.31post			2	36	0.09	Forage	
						0.04	Silage	
					83	<0.025	Kernels	
						0.06	Fodder	
MD (Dekalb 524)	1.12pre			1+				64SD-87-540
	0.31post			2	39	<0.025	Forage	
					41	<0.025	Silage	
					95	<0.025	Kernels	
					95	<0.025	Fodder	
NB (NK9540)	1.12pre			1+				92NB-87-541
	0.31post			2	33	<0.025	Forage	
					47	<0.025	Silage	
					93	<0.025	Kernels	
						<0.025	Fodder	
WI (High Lysine 32)	1.12pre			1+				A1WI-87-543
	0.31post			2	51	<0.025	Forage	
						<0.025	Silage	
					86	<0.025	Kernels	
						<0.025	Fodder	
IL (Pioneer 3540)	1.12pre			1+				US04-87-544
	0.31post			2	28	<0.025	Forage	
					49	<0.025	Silage	
					80	<0.025	Kernels	
					80	<0.025	Fodder	
GA (Pioneer 3165)	1.12pre			1				83GA-87-557
	0.31pos			2	30	<0.025	Forage	
					41	<0.025	Silage	
					70	<0.025	Kernels	
					70	<0.025	Fodder	
NC (Pioneer 3369A)	1.12pre			1				61NC-87-558
	0.31pos			2	35	<0.025	Forage	
					35	<0.025	Silage	
					71	<0.025	Kernels	
					71	<0.025	Fodder	
TX (Pioneer 3380)	1.12pre			1				72TX-87-559
	0.31pos			2	63	<0.025	Forage	
					63	<0.025	Silage	
					93	<0.025	Kernels	
					93	<0.025	Fodder	
USA, 1988					B*	<0.025	Post-emergence directed	Roper 1989g 35IN-88-440
IA (Garst 8383)	0.56			1	0	2	Forage	
					7	2		
					14	0.5		
					21	0.6		
					22	0.3	Silage	
	0.56			2	48	<0.025	Kernels	
						1	Fodder	
NE (NC+511)	0.56			2	0	0.6	Forage	41NB-88-442
					26	0.3		
					29	0.2	Silage	
					35	<0.025	Kernels	
						0.2	Fodder	
OH (unknown)	0.56			2	0	1	Forage	25OH-88-443
					7	3		
					14	0.1		
					21	0.08		
					34	0.07	Silage	
					76	<0.025	Kernels	
					76	0.03	Fodder	
SC (Pioneer 3165)	0.56			2	14	<0.025	Kernels	46SC-88-444
						6	Fodder	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
NC (Pioneer 3165)	0.56			2	0	0.3	Forage	47NC-88-445
					6	2		
					14	0.1		
					21	0.1		
					6	0.05	Silage	
					47	<0.025	Kernels	
					47	0.05	Fodder	
SC (Pioneer 3165)	0.56			2	14	<0.025	Kernels	46SC-88-446
					14	2	Fodder	
US, 1972					0B*	<0.01	Harvest aid	Chevron 1975b
GA (Coker 71)	0.56		47	1	7	0.03	Grain	T-2228
						3.2	Fodder	(pre-emergence x1)
	1.12		47	1	3	0.05	Grain	
					7	0.04	Grain	
						5.6	Fodder	
IL (Dekalb XL-66)	0.56		93	1	8	0.04	Grain	T-2231
						2.5	Fodder	
	1.12		93	1	3	0.05	Grain	
					8	0.03	Grain	
						4.4	Fodder	
USA, 1973					0B*	<0.01	Harvest aid	
IL (unknown)	0.56		23	1	7	<0.01	Grain	T-2789
						7.4	Fodder	
MS (Funks G-4761)	0.56		187	1	7	<0.01	Grain	T-2790
						7.8	Fodder	
						<0.01	Cobs (w/o kernel)	
GA (Coker 67)	0.56		47	1	7	0.01	Grain	T-2791
						1.1	Fodder	
IL (Funks G-4646)	0.56		28	1	7	0.01	Grain	T-2792
					8	6.8	Fodder	
					7	<0.01	Refined oil	

*B: control

Sorghum forage (green) and straw and fodder, dry

Table 45. Paraquat residues in sorghum forage (green) and straw and fodder, dry, from supervised trials in the USA.

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
1967					0B*	<0.01	Post-emergence directed	Kalens *et al.* 1971
MS (BR-62)	0.56		280	1	48	<0.01	Forage	T-1286
					105	<0.01	Grain	
						<0.01	Fodder	
OK (RS 612)	0.56		280	1	35	0.01	Forage	T-1287
					105	<0.01	Grain	
						<0.01	Fodder	
TX (RS 671)	0.56		374	1	75	<0.01	Forage	T-1288
					106	<0.01	Grain	
						<0.01	Fodder	
MS (unknown)	0.56		280	1	49	<0.01	Forage	T-1289
					106	<0.01	Grain	
						<0.01	Fodder	
1971					0B*	<0.01	Pre-emergence followed by post-emergence directed	Kalens *et al.* 1971
MS (Funks BR 79)	0.28 pre 0.28 post		234	1+ 1	36	<0.01	Forage	T-2155
					86	<0.01	Grain	
						<0.01	Fodder	

Year, location (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	No.	PHI days	Paraquat mg/kg	Notes	References
	0.56 pre		234	1+	36	<0.01	Forage	
	0.56 post			1	86	<0.01	Grain	
						0.01	Fodder	
TX (RS 671)	0.28 pre		206	1+	63	<0.01	Forage	T-2156
	0.28 post			1	131	<0.01	Grain	
						<0.01	Fodder	
	0.56 pre		206	1+	63	<0.01	Forage	
	0.56 post			1	131	0.01, 0.01	Grain	
						0.02, 0.02	Fodder	
TX (DeKalb E 56)	0.56 pre		206	1+	40	<0.01	Forage	T-2157
	0.28 post			1	131	<0.01	Grain	
						<0.01	Fodder	
TX (NK 222)	0.56 pre		206	1+	40	<0.01	Forage	T-2159
	0.56 post			1	67	<0.01	Grain	
						<0.01	Fodder	
1973					0B*	<0.01	Harvest aid	Anon 1975a
IA (unknown)	0.43		28	1	7	2.0	Grain	T-2778
						10	Fodder & Forage	(air)
NE (Pioneer 878)	0.43		28	1	8	2.5	Grain	T-2779
						0.10	Flour	(air)
						6.0	Bran	
						8.4	Shorts	
						0.86	Germ	
						5.6	Fodder	
IL (unknown)	0.43		131	1	7	28	Fodder	T-2780
NE (various)	1.12		234	1	24	0.16, 0.28, 0.22, 0.19, 0.26, 0.15	Grain	T-2977
						0.85, 0.49, 1.3, 0.69, 0.52, 0.91	Fodder	
	1.12		234	1	40	0.05	Grain (broadcast)	
						0.22	Fodder (broadcast)	
						0.06	Grain (direct)	
						0.18	Fodder (direct)	
					49	0.07	Grain (broadcast)	
						0.30	Fodder (broadcast)	
						0.07	Grain (direct)	
						0.26	Fodder (direct)	
1974					0B*	<0.01	Harvest aid	Anon 1975a
KA (Pioneer)	0.43pre		28	1+	7	1.3	Grain	T-3129
	0.43			1		3.7	Fodder	(air)
KA (Pioneer)	0.56 pre		28	1+	7	2.1	Grain	T-3130
	0.43			1		5.0	Fodder	(air)
NE (Prairie Valley 500)	0.43		28	1	7	2.0	Grain	T-3131
						4.8	Fodder	(air)
1987					0B*	<0.025	Pre-emergence and then post-emergence directed	Roper 1989k
TX (Pioneer 8493)	1.12 pre			1+				
	0.56 post			2	52	≤0.025	Forage	72TX-87-570
						0.025	Silage	
						<0.025	Hay	
					86	≤0.025	Fodder	
						<0.025	Grain	
NE (DeKalb DK41V)	1.12 pre			1+				92NB-87-571
	0.56 post			2	48	≤0.025	Forage	
						0.025	Silage	
					62	0.06	Hay	
					73	0.03	Fodder	
						<0.025	Grain	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
KS (Paymaster	1.12 pre			1+				48KS-87-572
1022)	0.56 post			2	20	0.025	Forage	
						0.04	Silage	
					25	<0.025	Hay	
					72	0.06	Fodder	
						<0.025	Grain	
SD (Sokota	1.12 pre			1+				64SD-87-573
910GS)	0.56 post			2	22	0.025	Forage	
						0.025	Silage	
						<0.025	Hay	
					67	0.03	Fodder	
						<0.025	Grain	
NE (NC+172)	1.12 pre			1+				92NB-87-574
	0.56 post			2	29	0.06	Forage	
						0.04	Silage	
					41	0.09	Hay	
					65	<0.025	Fodder	
						<0.025	Grain	
MO (Stauffer	1.12 pre			1+				06MO-87-575
530)	0.56 post			2	44	0.04	Forage	
						0.2	Hay	
					56	<0.025	Fodder	
						<0.025	Grain	
AZ (Funks	1.12 pre			1+				38AX-87-576
G522DR Hybrid)	0.56 post			2	35	≤0.025	Forage	
						<0.025	Silage	
						0.04	Hay	
					61	<0.025	Fodder	
						<0.025	Grain	
AL (Funks	1.12 pre			1+				62AL-87-578
GB125)	0.56 post			2	23	≤0.025	Forage	
						<0.025	Hay	
					70	≤0.025	Fodder	
						<0.025	Grain	
AR (Stauffer	1.12 pre			1+				06AR-87-579
530)	0.56 post			2	35	≤0.025	Forage	
						<0.025	Hay	
					59	≤0.025	Fodder	
						<0.025	Grain	
NC (Northrup	1.12 pre			1+				US01-87-580
King 2660)	0.56 post			2	36	0.025	Forage	
						0.025	Silage	
						0.04	Hay	
					61	0.05	Fodder	
						<0.025	Grain	
IL (Pioneer 6790)	1.12 pre			1+				US04-87-581
	0.56 post			2	32	≤0.025	Forage	
						<0.025	Hay	
					39	<0.025	Silage	
					71	≤0.025	Fodder	
						<0.025	Grain	
AZ (Dekalb	1.12 pre			1+				
DK42V)	0.56 post			2	28	0.2	Forage	
						0.34	Silage	
						0.2	Hay	
					48	0.1	Fodder	
						<0.025	Grain	
2000					0B*	<0.02 grain <0.5 stover	Pre-emergence followed by a harvest aid desiccation	Carringer & Yuen 2001
NC (DK36)	1.12pre		184	1+	3	14	Grain	PARA-00-MR
	1.12post		184	1		18	Stover	-01-343

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
IL (Northrup King KS585)	1.12pre 1.12post		193 195	1+ 1	3	4.5 18	Grain Stover	PARA-00-MR-01-345
NE (NK 1486)	1.12pre 1.12post		93 91	1+ 1	3	4.6 23	Grain Stover	PARA-00-MR-01-346
NE (NK 1486)	1.12pre 1.12post		321 313	1+ 1				PARA-00-MR-01-347
					1	8.4 24	Grain Stover	
					3	6.7 19	Grain Stover	
					7	6.0 15	Grain Stover	
					14	4.1 9.9	Grain Stover	
KS (NC+6B70)	1.12pre 1.12post		280 280	1+ 1	3	1.9 16	Grain Stover	PARA-00-MR-01-348
OK (Mycogen 730B)	1.12		243	1	3	5.6 40	Grain Stover	PARA-00-MR-01-349
TX (Sprint)	1.12pre 1.12post		237 236	1+ 1	3	4.9 39	Grain Stover	PARA-00-MR-01-350
NE (NK 1486)	1.12pre 1.12post		235 235	1+ 1	3	12 14	Grain Stover	PARA-00-MR-01-351
OK (TR432)	1.12pre 1.12post		279 279	1+ 1	3	5.2 33	Grain Stover	PARA-00-MR-01-352
TX (Cherokee)	1.12pre 1.12post		96 98	1+ 1	3	4.1 44	Grain Stover	PARA-00-MR-01-353
TX (9300)	1.12pre 1.12post		187 189	1+ 1	3	2.8 43	Grain Stover	PARA-00-MR-01-354

*B: control

Rice straw and fodder, dry

Table 46. Paraquat residues in rice straw and fodder, dry, from supervised trials in Guatemala, Italy and the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1993					0B*	<0.05	5 days Pre planting	Anderson *et al* 1995
(Loto)	0.92		400	1	119	<0.05 <0.05	grain straw	IT10-93-H370 IT10-93-H371
(Koral)	0.92		400	1	151	<0.05 <0.05	grain straw	
CA, USA, 1978					0B*	<0.01 grain <0.02 straw	Pre-emergence	Anon 1985
(Calrose)	0.56		187	1	217	<0.01 <0.06	Grain Straw	M209-4642
(Calrose)	0.56		187	1	230	<0.01 <0.05	Grain Straw	M209-4641
CA, USA, 1982					0B*	<0.01 grain <0.02, <0.03 straw	Pre-emergence	Anon 1985
(M-9)	0.56		93.5	1	163	<0.01 <0.03	Grain Straw	M209-5650
(M-301)	0.56		93.5	1	166	<0.01 <0.02	Grain Straw	M209-5651
	1.12		187	1	166	<0.01 <0.02	Grain Straw	
(M-101)	0.56		93.5	1	167	<0.01 0.04	Grain Straw	M209-5649
	1.12		187	1	167	<0.01 <0.03	Grain Straw	
(Labelle)	1.12		187	1	106	<0.01 <0.02	Grain Straw	M209-5583

*B: control

Almond hulls

Table 47. Paraquat residues in almond hulls from supervised trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and reference	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, USA					0B*	<0.01		Chevron 2001
1964 (Non Pareil)	1.12		935	3	3	0.01	Whole nuts	T-603
					3	0.04	Whole terminals	Number in ():
(Texas)				4	26	<0.01	Hulls	application
					26	<0.01	Kernels	number in 1963
					26	0.01	Terminals	
(Non Pareil)				2	52	<0.01	Hulls, less shells	
					52	<0.01	Kernels	
(Non Pareil)	2.24		935	3(2)	3	0.02	Whole fruit	
					3	0.07	Whole terminals	
(Texas)				4(2)	26	<0.01	Kernels	
					26	<0.01	Hulls	
					26	<0.01	Terminals	
(Non Pareil)				2(2)	52	<0.01	Hulls, less shells	
					52	0.01	Kernels	
1966 (Nonpareil)	1.12		206	4(1)	1	<0.01	Hulls	T-1088 Number in ():
					1	<0.01	Nuts	application number in 1964
(Non pariel)	1.12		34	4(1)	1	0.07	Hulls	T-1089
					1	0.02	Meat	nuts knocked to treated ground
(Non pariel)	1.12		34	4(1)	1	0.22	Hulls	T-1090
					1	0.01	Meat	nuts knocked to treated ground

*B: control

Cotton

Table 48. Paraquat residues in cotton from supervised trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1963 (Acala 4-42)					0B*	<0.01	Pre-emergence	Chevron 1967 T-383
	1.12		468	1	121	<0.01	Seed	
						<0.01	Trash	
						<0.01	Lint	
CA, 1964 (Acala 4-42)	1.12		468	1	30	<0.01, <0.01	Whole plant	T-614
					60	<0.01, <0.01		
					154	<0.01, <0.01		
TX (Blightmaster)	0.56			1	9	0.97, 0.97, 1.28, 1.76	Cotton (including trash & bolls)	T-654
					9	0.08, 0.09, 0.10, 0.18	Fuzzy seed	
					9	<0.01, <0.01, <0.01, <0.01	Acid-delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Mechanically delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Hulls	
					9	<0.01, <0.01, <0.01, <0.01	Crude oil	
					9	<0.01, <0.01, <0.01, <0.01	Meal	

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
TX (Rex)	0.56			1	1 5 10 5 10 10 10 10 10 10 10	15, 15 2.1, 2.6 2.0, 2.1 0.11, 0.13 0.18, 0.18 0.05, 0.051 0.08, 0.08 2.8, 3.3 0.13, 0.13 <0.01, <0.01 0.02, 0.02	Cotton (including trash & bolls) Fuzzy seed Acid-delinted seed Mechanically delinted seed Lint cotton Hulls Crude oil Meal	T-653
1989					0B*	<1.0	Harvest aid Gin trash	Roper 1990
TX (Paymaster 145)	0.56			1	14	11	Gin trash	10TX-89-481
TX (Paymaster 145)	0.56			1	14	7.3	Gin trash	10TX-89-482
TX (DPL 50)	0.56			1	17	6.2	Gin trash	11TX-89-483
TX (DPL 50)	0.56			1	17	5.9	Gin trash	12TX-89-484
OK (Tamcot CD-3H)	0.56			1	14	12	Gin trash	13OK-89-485
AZ (D&PL 61)	0.56			1	14	5.2	Gin trash	14TX-89-486
AZ (D&PL 61)	0.56			1	14	9.4	Gin trash	14TX-89-487
CA (GC510)	0.56			1	13	32	Gin trash	19CA-89-488
CA (GC510)	0.56			1	13	34	Gin trash	19CA-89-489
USA, 1995					0B*	<0.05	Pre-emergence followed by post-emergence, harvest aid	Roper & Elvira 1996
LA (DPL 5415)	1.4 pre 0.56 0.14 0.56		124 214 90 91	1+ 2+ 2+ 1	 3 3	 0.46 18	 Seed Gin byproduct	69-LA-95-652
TX (Paymaster 145)	1.4 pre 0.56 0.14 0.56		137 215/218 79/76 80	1+ 2+ 2+ 1	 3	 2.0 12	 Seed Gin byproduct	23-TX-95-658
TX (Paymaster HS200)	1.4 pre 0.56 0.14 0.56		137 215/225 79/78 75	1+ 2+ 2+ 1	 3	 0.50 8.0	 Seed Gin byproduct	23-TX-95-659
CA (Acala GC510)	1.4 pre 0.56 0.14 0.56		139 270/257 90/92 89	1+ 2+ 2+ 1	 3	 0.49 69	 Seed Gin byproduct	02-CA-95-660
AZ (DPL 20)	1.4 pre 0.56 0.14 0.56		104 126/127 79/80 80	1+ 2+ 2+ 1	 3	 0.23 23	 Seed Gin byproduct	14-AZ-95-662
OK (Paymaster HS200)	1.4 pre 0.56 0.14 0.56		136 185/192 69/68 67	1+ 2+ 2+ 1	 3	 0.35 5.3	 Seed Gin byproduct	23-OK-95-663

B: control

FATE OF RESIDUES IN STORAGE AND PROCESSING

In processing

The Meeting received information on processing studies on the following **commodities.**

Crop	**Studied processed products**
Orange:	Juice
Plum:	Dried prunes
Grape:	Dried grapes and grape juice
Olive:	Washed fruit, oil and press cake
Tomato:	Juice, wet pomace, dry pomace and ketchup
Sugar Beet:	Molasses and refined sugar
Potato:	crisps, dried potato and granules
Maize:	germ, starch, grits, meal, flour and oil
Sorghum:	Bran, starch, grits and flour
Cotton seed:	Trash/gin by-products and oil
Sunflower seed:	Meal and oil
Hop:	Dried hop and beer

In order to investigate the degradation of paraquat residues during processing, typical processing studies were conducted. As the standard analytical methods for paraquat involve a rigorous acid reflux extraction (0.5M sulphuric acid reflux for 5 hours), the stability of paraquat to hydrolysis has been demonstrated. Studies showed paraquat to be stable the pH range of 5-9.

For those crops where paraquat is applied pre-emergence, post-emergence, or directly between crops, paraquat must not have direct contact with the crop, so and for this reason, under these applications, the extent the exposure of the crop to paraquat is minimal. The supervised field trials demonstrated the absence of, or very low residues of, paraquat in these crops, which would make processing studies unnecessary.

However, with harvest aid desiccant uses, the direct application of paraquat to the crop may result in much higher levels of residues, while in some cases orchard fruit under unusual conditions may come in contact with sprayed weeds. In these cases, processing studies were needed, to determine whether residues of paraquat are transferred and concentrated in the processed products.

The transfer factors are calculated by dividing the residues measured in the processed commodity by the residues measured in the raw agricultural commodity. The residue data used for the calculations are uncorrected for recovery values and expressed in mg paraquat cation/kg.

<u>Processing of oranges</u>

The fate of paraquat residue in oranges during juicing was investigated in studies in California and Florida, USA, with exaggerated application rates of 4.48 to 20.2 kg ai/ha as directed broadcast between the rows (Chevron, 2001). These rates are 4 to 18 times the highest permitted rate in US GAP. Oranges were collected between 0 and 177 days after application and processed to juice as described in Figure 6.

Table 49 shows that even at an exaggerated rate of application, no quantifiable residues of paraquat were found in any processed sample (limit of quantification: 0.01 mg/kg for peel and juice).

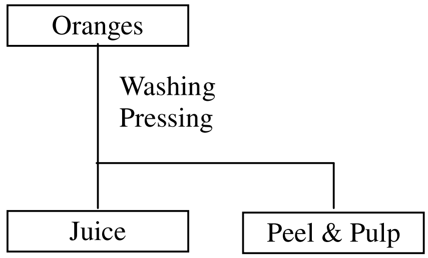

Figure 6. Processing of oranges to juice.

Table 49. Paraquat residues in oranges and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1962 (Navel)	2.8	0.12		2	0B*	<0.01		Chevron 2001 T-326
					0	<0.01	Juice (procedural recovery, 45%)	
					7	<0.01		
					15	<0.01		
					28	<0.01		
					0	<0.01	Pulp (procedural recovery, 67%)	
					7	<0.01		
					15	<0.01		
					28	<0.01		
FL, 1965 (Valencia)					0B*	<0.01		T-631 Broadcast spray around each tree on an area of 100 sq ft.
	1.12	0.054		4	177	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
	2.24	0.054		9	31	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
		0.11		4	177	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
FL, 1965 (Hamlin)	2.44	0.12		1	0B*	<0.01		T-903
					3	0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	

B*: control

Since the residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably calculated.

Processing of plums

Two plum trials were used to obtain field-incurred residues in plums for processing into dried plums. In two trials conducted in the USA, paraquat was applied to the ground round plum trees as a broadcast directed spray three times during the season at 4.48 kg/ha (Roper, 1989a). This rate is 4 times the highest label rate in the USA. The fruit were harvested 28 days after treatment. Some of these fresh prunes were dried for 16 hours in a commercial fruit drier to produce dried prunes (Figure 7). Residues were measured in fresh plums and dried prunes and the results are shown in Table 50.

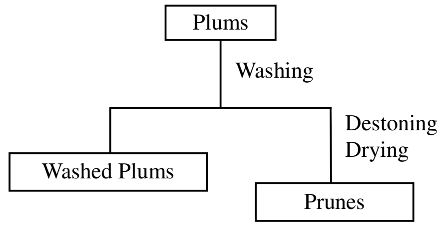

Figure 7. Processing of plums to prunes.

Table 50. Paraquat residues in plums and dried prunes from trials in the USA.

Location, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1987 (Prune, French)	4.48	1.93		3	B*	<0.01	Fresh	Roper 1989a
						<0.05	Dried	45CA-87-523
					28	<0.01	Fresh	
						<0.05	Dried	
	4.48	1.93		3	B*	<0.01	Fresh	45CA-87-599
						<0.05	Dried	
					28	<0.01	Fresh	
						<0.05	Dried	

B*:control

Since residues of paraquat in all the samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of grapes

One residue trial in grapes was conducted during 1997 in California, USA (Spillner, 1998). Paraquat was applied once at an exaggerated rate of 5.6 kg/ha as a broadcast between the rows. This rate is 5 times the highest application rate on labels. Grapes were collected on the day of application and processed into sun-dried grapes (sun-dried for 21 days) and grape juice simulating industrial practice as closely as possible. The paraquat residues in grapes, dried grapes and juice were determined. The processing of fresh grapes into dried grapes and juice is shown in Figure 8. Residues measured in grapes, raisins, and juice are shown in Table 51. The limit of quantification was 0.01 mg/kg for grapes and grape juice, and 0.05 mg/kg for dried grapes.

No quantifiable residues of paraquat were found in any treated or untreated sample.

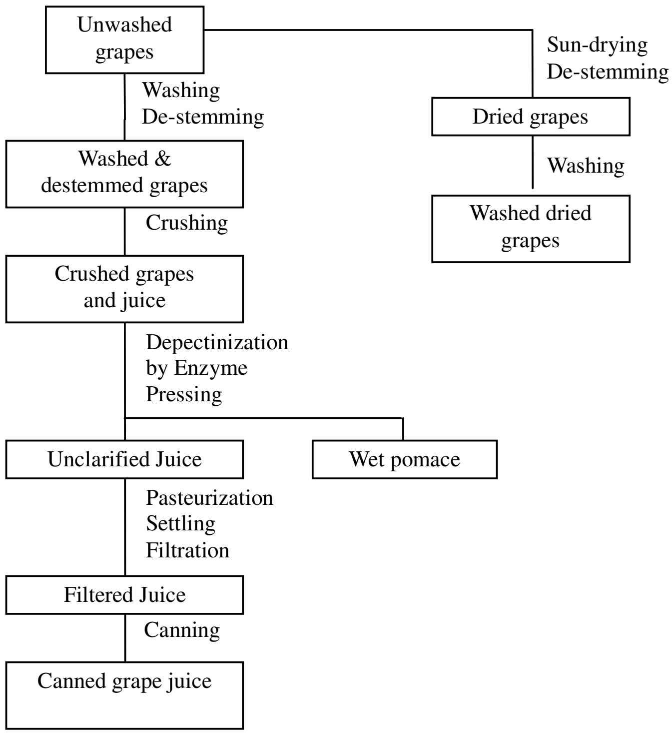

Figure 8. Processing of grapes to dried grapes and grape juice.

Table 51. Paraquat residues in grapes, dried grapes and juice from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1997 (Thompson Seedless)	5.6		45.6	1	B*	<0.01	Berries	Spillner *et al.* 1998 02CA-97-601
						<0.01	Juice	
						<0.05	Dried grapes	
					21	<0.01	Berries	
						<0.01	Dried grapes	
						<0.05	Processed Juice	

B*=control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of olives

Olives destined for oil production are often harvested from the ground and paraquat may occasionally be applied directly to the fallen fruit when used to control weeds growing through the collection nets on the ground. These whole fruits will contain some paraquat residue, either through transfer from treated vegetation or through direct exposure. Studies were therefore conducted to investigate paraquat residues in oil and cake processed from olive fruits.

In a US trial in 1988, paraquat was applied four times at 5.6 kg ai/ha (a total of 22.4 kg ai/ha) to the soil at the base of the trees and olives were harvested 13 days after the last application. The application rate is five times the highest application rate on US labels (Roper, 1989i).

Two residue trials were carried out on olives in Italy in 1993 in which a single application of paraquat at a rate of 1.56 kg ai/ha and diquat at 0.78 kg ai/ha was applied for inter-row weed control. Olives were harvested 7 days after treatment to determine residues in olives and oil (Dick *et al.*, 1995a).

In these studies none of the samples of olives or contained paraquat residues above the limit of quantification.

Two new trials were conducted on olive trees in Spain during 2001 and 2002 (Devine *et al.*, 2003). Three or seven days before normal harvest, paraquat was applied once at a nominal rate of 1.1 kg ai/ha to fallen olives and the harvesting area around the base of the trees in two treated plots. Olive fruit samples for residue analysis were taken at normal harvest. Olive fruits for processing were taken from the untreated plant and the plots treated 3 days before harvest. These samples (unwashed olives) were processed into washed olives, virgin oil and refined oil, which were then analysed.

A flow chart for olive processing is shown in Figure 9 and the results of analysis in Table 52.

In the trial in the USA, paraquat was applied four times at an exaggerated rate (5.6 kg paraquat/ha; 22.4 kg/ha total) and the fruit were harvested from the trees for processing into oil and cake. In other trials in Spain, mature olives were sprayed directly on the ground with paraquat at rates from 0.36 to 1.3 kg/ha. The fruit were analysed after 3-17 days and the residue of paraquat ranged from 0.08 to 4.4 mg/kg.

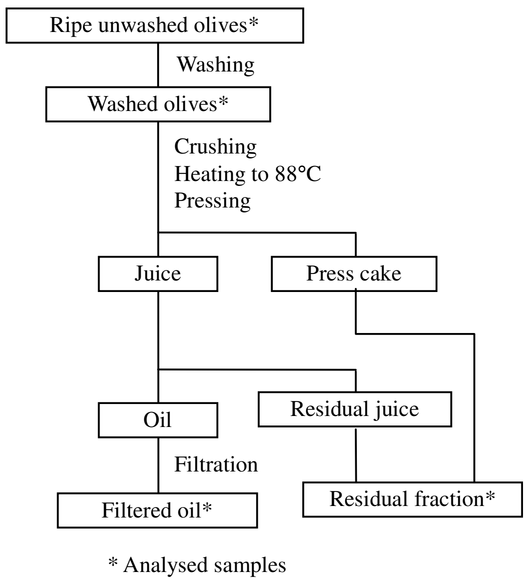

Figure 9. Processing of olives to oil.

Table 52. Paraquat residues in olives and their processed products from trials conducted in Italy, Spain, and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
USA 1988 (Manzanilla)	5.6			4	B*	<0.05, <0.05	Fruit	Roper 1989i 73CA88-526
						<0.05	Residual fraction	
						<0.05	Oil	
					13	<0.05, <0.05	Fruit	
						<0.05	Residual fraction	
						<0.05	Oil	
Latina, Italy, 1993 (Frantoio)	1.56		1000	1	B*	<0.10	Fruit	Dick *et* al. 1995a IT10-93-H338
						<0.05	Oil	
					7	<0.10	Fruit	
						<0.05	Oil	
Foggia, Italy 1993 (Coratina)	1.56		1000	1	B*	<0.10	Fruit	IT10-93-H339
						<0.05	Oil	
					7	<0.10	Fruit	
						<0.05	Oil	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Andalucia, Spain, 2001/2002 (Hojiblanca)	1.09		347	1			Mean % of treated olives: 24%	Devine *et* al. 2003 ES051-01-S013
					B*	<0.05		
					3	0.45	Fresh fruit	
					3	0.18	Unwashed fruit	
					3	0.11	Washed fruit	
					3	<0.05	Virgin oil	
					3	<0.05	Refined oil	
Catalonia, Spain, 2001/2002 (Arbequina)	1.05		192				Mean % of treated olives: 10%	ES060-01-S113
					B*	<0.05		
					3	0.09	Fresh fruit	
					3	0.06	Unwashed fruit	
					3	<0.05	Washed fruit	
					3	<0.05	Virgin oil	
					3	<0.05	Refined oil	

B*: control

The procedural recoveries in the analysis of virgin oil and refined oil were relatively low at 66 and 62% respectively.

Processing factors were calculated from the Spanish trials where residues in the fresh fruit were above the limit of quantification. The results are shown in Table 53.

Table 53. Processing factors from olives to oil.

Product	ES051-01-S013		ES051-01-S113	
	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
Fresh Olive	0.38		0.09	
Unwashed olives before processing	0.18	0.47	0.06	0.67
Washed olives before processing	0.11	0.29	<0.05	<0.56
Virgin Oil	<0.05	<0.13	<0.05	<0.56
Refined oil	<0.05	<0.13	<0.05	<0.56

Paraquat is not transferred into the oil. Washing reduces paraquat residues to a certain extent.

Processing of tomatoes

In a study in the USA in 1988 whole tomatoes were treated with one pre-emergence broadcast application of paraquat at a rate of 1.12 kg ai/ha followed by three directed applications at 2.8 kg ai/ha (about 5 times the highest current application rate). Ripe tomatoes were harvested 30 days after the last application and processed according to normal commercial practice. The limits of quantification were 0.005 mg/kg for whole tomatoes and juice; 0.025 mg/kg for ketchup and wet pomace, and 0.05 mg/kg for dry pomace (Roper, 1989q).

A flow diagram outlining the processing is shown in Figure 10 and the results of residue analysis in Table 54. All residues of paraquat in all samples were below the limit of quantification.

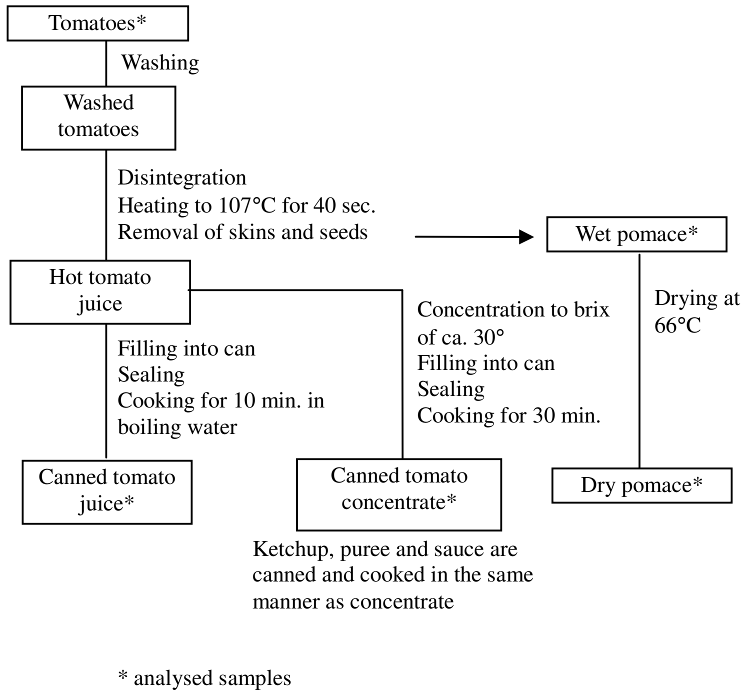

Figure 10. Processing of tomatoes to canned juice, canned tomatoes, canned concentrate, and wet and dry pomace

Table 54. Paraquat residues in tomatoes and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
CA, 1988 (Jackpot)					B*	<0.005	Unwashed tomato	Roper 1989q 18CA88-789
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12		38.2	1				
	2.8			3	30	<0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
CA, USA, 1988 (Jackpot)					B*	<0.005	Unwashed tomato	18CA88-790
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12		38.2	1				
	2.8			3	30	<0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	

B*=control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of sugar beet

A study was conducted in the USA to determine paraquat residues in dehydrated pulp, molasses and refined sugar produced from sugar beet treated with one pre-emergence broadcast application of paraquat at a rate of 5.6 kg ai/ha, which is five times the normal rate in the USA. The beets were harvested at normal harvest, 137 days after treatment, and processed according to normal commercial practice. The limits of quantification were 0.05 mg/kg for roots, dry pulp and molasses, and 0.025 mg/kg for wet pulp and sugar (Roper, 1989c). A flow chart for sugar beet processing is shown in Figure 11 and the results of residue analysis are shown in Table 55.

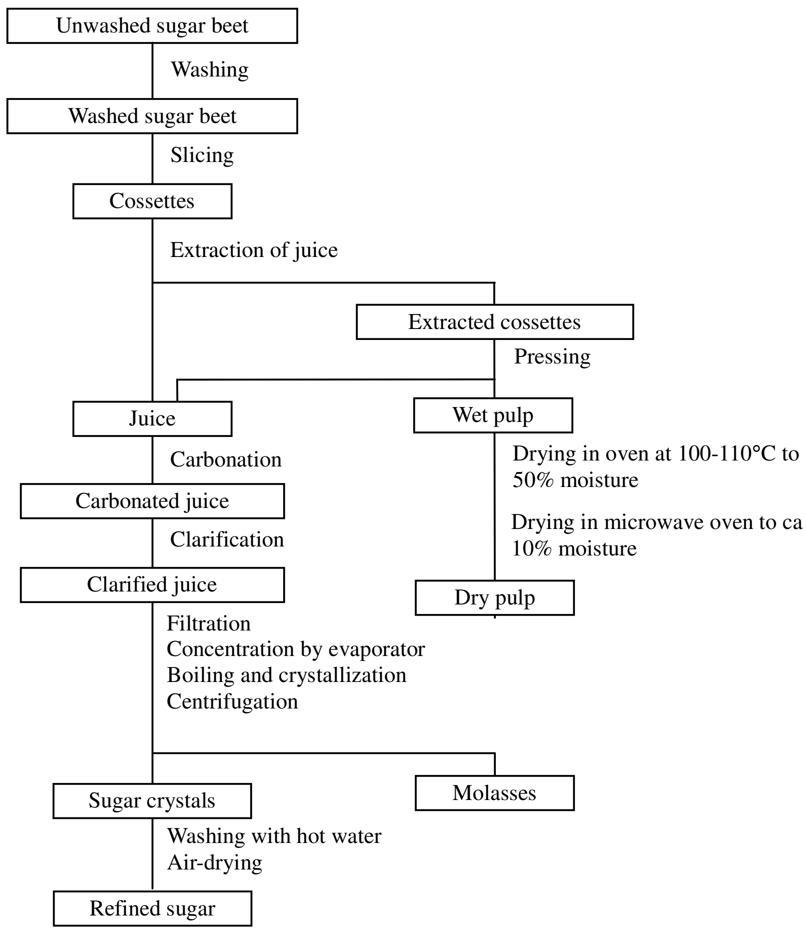

Figure 11. Processing of sugar beet to refined sugar, molasses and wet and dry pulp.

Table 55. Paraquat residues in sugar beet and processed products from a trial in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, 1988	5.6		31	1	B*	<0.05	Unwashed roots from field	Roper 1989c 16ID88-599
						<0.05	Washed roots	
						<0.025	Wet pulp	
						<0.05	Dry pulp	
						<0.05	Molasses	
						<0.025	Sugar	
					137	<0.05	Unwashed roots from field	
						<0.05	Washed roots	
						<0.025	Wet pulp	
						<0.05	Dry pulp	
						<0.05	Molasses	
						<0.025	Sugar	

B*: control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of potatoes

A study was conducted in Idaho and Maine, USA, to determine paraquat residues in potato tubers, wet and dried peel, crisps (chips) and granules from potatoes from plants treated with one broadcast spray of paraquat as a pre-harvest desiccant at 2.8 kg ai/ha seven days prior to harvest. Samples of unwashed potato tubers were washed and processed into potato crisps (chips) and granules according to the process described in Figure 12. The limits of quantification were 0.025 mg/kg for washed potatoes, peeled potatoes and potato crisps, 0.05 mg/kg for unwashed potatoes, peel and granules, and 0.025 mg/kg for dried peel (Roper, 1989b). The analytical results are shown in Table 56.

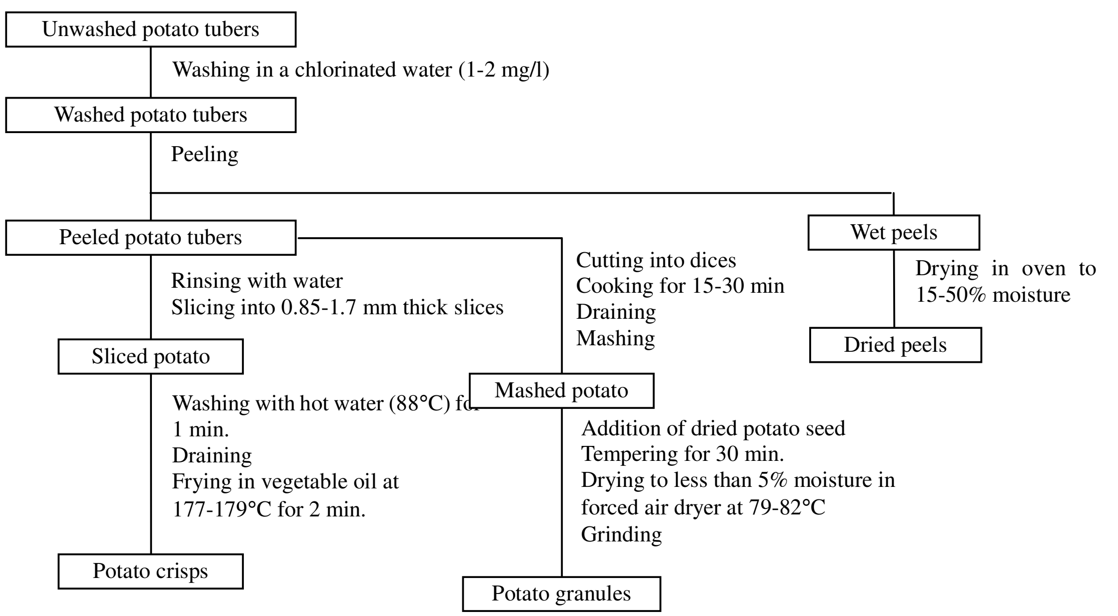

Figure 12. Processing of potatoes to crisps, granules and wet and dried peels.

Table 56. Paraquat residues in potatoes and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, 1988 (Russet Burbank)	2.8		31	1	B*	<0.05	Unwashed tuber from field	Roper 1989b 16ID88-400
						<0.025	Washed tuber	
						<0.05	Wet peels	
						<0.125	Dry peels	
						<0.025	Peeled potatoes	
						<0.025	Crisps	
						<0.05	Granules	
					7	<0.05	Unwashed ber from field	
						0.05	Washed tuber	
						0.13	Wet peels	
						0.45	Dry peels	
						<0.025	Peeled potatoes	
						0.05	Crisps	
						0.15	Granules	
ME, 1988 (Superior)	2.8		31	1	B*	<0.05	Unwashed tuber from field	56ME88-401
						<0.025	Washed tuber	
						<0.05	Wet peels	
						<0.125	Dry peels	
						<0.025	Peeled potatoes	
						<0.025	Crisps	
						<0.05	Granules	
					7	0.11	Unwashed tuber from field	
						0.10	Washed tuber	
						0.13	Wet peels	
						1.3	Dry peels	
						0.03	Peeled potatoes	
						0.10	Crisps	
						0.26	Granules	

B*=control.

Processing factors calculated are shown in Table 57.

Table 57. Processing factors for processed products of potatoes.

Product	16ID88-400		56ME88-401	
	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
Whole unwashed tuber from field	<0.05	-	0.11	
Whole washed tuber from processor	0.05	>1	0.10	0.91
Wet peel	0.13	>2.6	0.13	1.2
Dry peel	0.45	>9	1.3	12
Peeled potato	<0.025	-	0.03	0.27
Crisps	0.05	>1	0.1	0.09
Granules	0.15	>3	0.26	2.4

Processing of maize

A study was conducted in Iowa, USA, in 1988 to determine paraquat residues in crude and refined oils and milled fractions from maize treated with one broadcast application (harvest aid use) of paraquat at a rate of 2.8 kg ai/ha and harvested 7 days after the application. Maize grains (kernels) were processed as shown in Figure 13. The results of residue analysis are shown in Table 58. The limit of quantification was 0.05 mg/kg for all samples (Roper, 1989g).

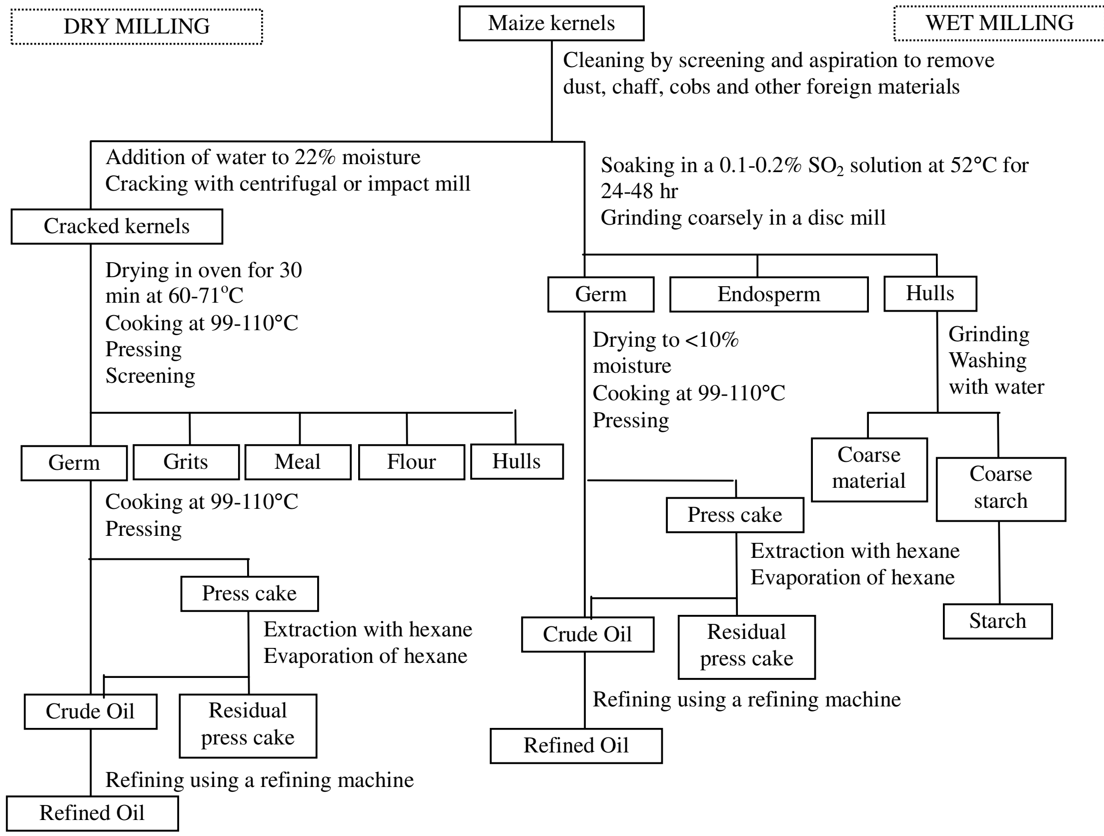

Figure 13. Processing of maize to oil, starch and milling fractions.

Table 58. Paraquat residues in maize and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
IA, 1988 (Pioneer 3471)	2.8		31	1	B*	<0.05	All the uncontrolled samples	Roper 1989g
					7	0.4	Kernels from field	36IA88-791
							DRY MILLING	
						0.2	Kernels from processor	
						0.05	Large grits	
						0.09	Medium grits	
						0.1	Small grits	
						0.2	Coarse meal	
						0.1	Meal	
						0.3	Flour	
						1	Hulls	
						0.06	Germ	
						0.1	Expeller press cake	
						0.1	Extraction press cake	
							Expeller crude oil	
						<0.05	Refined oil	
						<0.01	WET MILLING	
						0.2	Kernels from processor	
							Hulls	
						<0.05	Germ	
						<0.05	Course starch	
						<0.05, 0.05	Starch	
						<0.05	Expeller press cake	
						0.06	Extraction press cake	
						<0.05	Expeller crude oil	
							Refined oil	
						<0.05		
						<0.05		

B*: control

Processing factors calculated are shown in Table 59. There was no detectable transfer to oil.

Table 59. Processing factors for maize products.

Product	Wet milling		Dry milling	
	Paraquat (mg/kg)	Processing Factor	Paraquat (mg/kg)	Processing Factor
Whole kernel from processor	0.2		0.2	
Hulls	<0.05	<0.25	1	5
Germ	<0.05	<0.25	0.06	0.3
Large grits			0.05	0.25
Medium grits			0.09	0.45
Small grits			0.1	0.5
Coarse meal			0.2	1
Meal			0.1	0.5
Flour			0.3	1.5
Coarse starch	<0.05	<0.25		
Starch	<0.05	<0.25		
Expeller press cake	0.06	0.30	0.1	0.5
Extraction press cake	<0.05	<0.25	0.1	0.5
Expeller Crude oil	<0.05	<0.25	<0.05	<0.25
Refined oil	<0.05	<0.25	<0.01	<0.05

Processing of sorghum

Studies were conducted in Texas, California and Nebraska, USA in 1973/1974 to determine paraquat residues in milling fractions of sorghum. Sorghum was treated with one aerial application as a post-emergence harvest aid at a rate of 0.21 kg ai/ha (Texas and California) or 0.43 ka ai/ha and harvested 7-24 days after treatment. Grain was processed to flour, bran and shorts (byproduct of milling consisting of bran, germ and course meal). The results of residue analysis are shown in Table 60 (Anon., 1975a).

In more recent studies in Texas and Nebraska in 1988 and 1989 sorghum was treated with one broadcast application as a post-emergence harvest aid at a rate of 2.8 kg ai/ha, equivalent to five times the normal rate permitted in the USA, and harvested 3 or 7 days after treatment. Whole sorghum grain was processed into hulled grain, wet and dry milled bran, coarse grits, starch, and flour by both dry and wet milling as indicated in Figure 14. The results of residue analysis are shown in Table 60. The limits of quantification were 1 mg/kg for whole grain and grits, 10 mg/kg for bran and 0.5 mg/kg for starch and flour (Roper, 1989j).

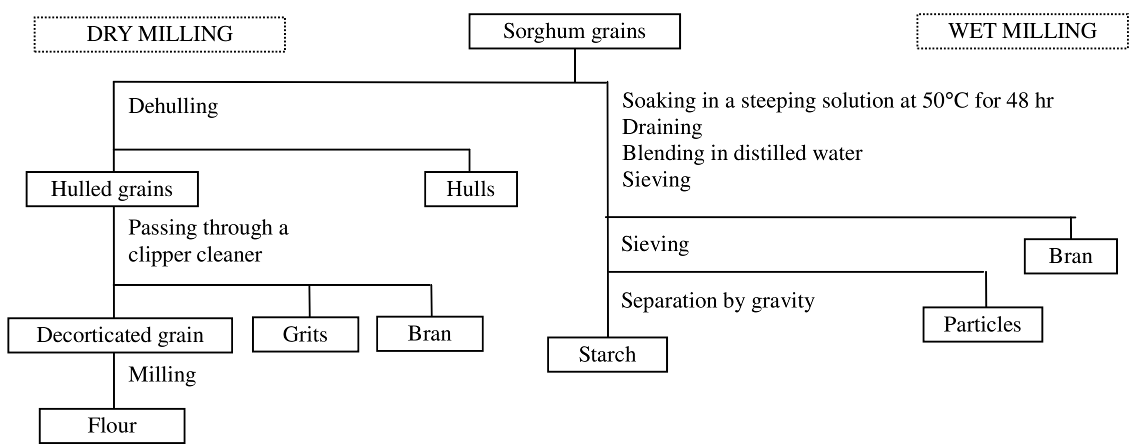

Figure 14. Processing of sorghum to hulled grains, bran, grits and flour.

Table 60. Paraquat residues in sorghum and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1988	2.8				B*	<1	Grain, whole & hulled	Roper, 1989j
(Golden Acres T-E							Coarse grits	11TX88-793
Y-75)						<1	Bran	
						<10	Starch	
						<0.5	Flour	
						<0.5	Grain from field	
					3	12.5	Grain from processor	
						10.4	Dry milled bran	
							Coarse grits	
						69.7	Flour	
						3.3	Wet milled bran	
						3.6	Starch	
						44.8		
						1.4		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
NE, 1989	2.8				B*	<1	Grain, whole & hulled	41NB88-794
(NK 2230)							Grits	
						<1	Bran	
						<10	Starch	
						<0.5	Flour	
						<0.5	Grain from field	
					7	26.4	Grain from processor	
						9.2	Hulled grain	
							Dry milled bran	
						1.8	Coarse grits	
						51.6	Flour	
						2.2	Wet milled bran	
						2.5	Starch	
						23.8		
						0.7		
TX, 1970	0.21		7.7	1	7	0.61	Grain	Anon 1975a
						0.08	Flour	T-2004
						3.3	Bran	
						1.1	Shorts	
					24	0.33	Grain	
						0.07	Flour	
						1.4	Bran	
						0.53	Shorts	
CA, 1970	0.21		7.7	1	7	0.83	Grain	T-2005
						0.41	Flour	
					21	0.50	Grain	
						0.30	Flour	
NE, 1973	0.43		4.6	1	8	2.7	Grain	T-2779
						0.10	Flour	
						6.8	Bran	
						9.1	Shorts	
						1.4	Germ	

B*: control

Processing factors calculated are shown in Table 61.

Table 61. Processing factors for sorghum .

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	11TX88-793		41NB88-794	
Whole grain from field	12.5		26.4	
Whole grain from processor	10.4	0.83	9.2	0.35
Hulled grain			1.8	0.07
Dry milled bran	69.7	5.6	51.6	2.0
Coarse grits	3.3	0.26	2.2	0.08
Flour	3.6	0.29	2.5	0.09
Wet milled bran	44.8	3.6	23.8	0.90
Starch	1.4	0.11	0.7	0.03
	T-2004 (PHI: 7 days)		T-2779	
Grain	0.61		2.7	
Flour	0.08	0.13	0.10	0.04
Bran	3.3	5.4	6.8	2.5
Shorts	1.1	1.8	9.1	3.4
Germ			1.4	0.52

Processing of cotton

In a study Texas in 1964 cotton was treated once with paraquat as a harvest aid desiccant at a rate of 0.56 kg ai/ha, harvested 1-10 days after application, and processed. Processed fractions were analysed with the results shown in Table 62. The limit of quantification was 0.01 mg/kg (Chevron, 1966).

Another study was conducted in Texas, Arizona, Oklahoma and California to determine the paraquat residue levels of cotton gin trash. Mature cotton received one broadcast application of paraquat at a rate of 0.56 kg ai/ha as a harvest aid desiccant. In one site in Texas, cotton was treated by aerial application. Cotton bolls were harvested after 13 days (2 trials in California), 14 days (5 trials in Texas, Arizona and Oklahoma) and 17 days (2 trials in Texas). Cotton bolls were passed through a cotton gin and the gin trash collected for analysis. The residues in the gin trash were 32 and 34 mg/kg 13 days after treatment; 5.2, 7.3, 9.4, 11 and 12 mg/kg 14 days after treatment; 7.3 and 11 mg/kg from aerial application; and 5.9 and 6.2 mg/kg 17 days after treatment. However, no information on the paraquat levels in cotton was available for estimating processing factors.

A flow chart for cotton processing is shown in Figure 15.

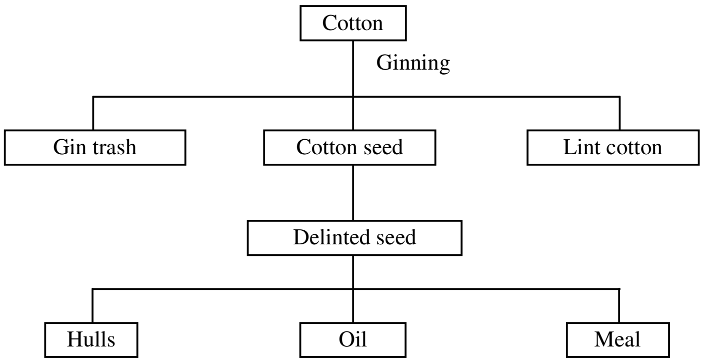

Figure 15. Flow chart for cotton processing.

Table 62. Paraquat residues in cotton and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1964 (Blightmaster)	0.56			1	B*	<0.05		Chevron 1966 T-653
					10	2.03	Cotton (including trash & bolls)	
						0.18	Fuzzy seed	
						0.05	Acid-delinted seed	
						0.08	Mechanically reginned seed	
						3.07	Lint cotton	
						0.13	Hulls	
						<0.01	Crude oil	
						0.02	Meal	

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1964 (Rex)	0.56			1	9	1.37	Cotton (including trash & bolls)	T-654
						0.09	Fuzzy seed	
						<0.01	Acid-delinted seed	
						<0.01	Mechanically reginned seed	
						0.01	Hulls	
						<0.01	Crude oil	
						<0.01	Meal	
							BIS(METHYSULFATE) SALT**	
						1.13	Cotton (including trash & bolls)	
						0.14	Fuzzy seed	
						<0.01	Acid-delinted seed	
						0.01	Mechanically reginned seed	
						<0.01	Hulls	
						<0.01	Crude oil	
						<0.01	Meal	

B*: control ** dichloride salt used

Processing factors calculated are shown in Table 63.

Table 63. Processing factors for cotton products.

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	T-653		T-654	
Cotton (trash & bolls)	2.03		1.37	
Fuzzy seed	0.18	0.09	0.09	0.07
Acid delinted seed	0.05	0.02	<0.01	<0.007
Mechanically delinted seed	0.05	0.02	<0.01	<0.007
Lint cotton	3.07	1.5		
Hulls	0.13	0.06	0.01	0.007
Crude oil	<0.01	<0.005	<0.01	<0.007
Meal	0.02	0.01	<0.01	<0.007

<u>Sunflower</u>

A study was conducted in California, Iowa, Minnesota, Mississippi, North Dakota, South Dakota and Texas, USA, to determine paraquat residues in sunflower oil and meal prepared from sunflower seed. Sunflowers received one application of paraquat as a harvest aid desiccant at rates from 0.28 to 1.12 kg ai/ha (ground application in 5 of 16 tests and aerial application in the others). Mature seeds were harvested 1-3 weeks after treatment and processed to oil, meal and hulls. The results of residue analysis are given in Table 64. The LOQ was 0.01 mg/kg (Chevron, 1975a).

Table 64. Paraquat residues in sunflower products from trials in the USA.

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
CA, 1971 (Peredovik)	0.28		61	1	B*	<0.01		Chevron 1975a T-2185 (ground appl.)
					7	0.11	Mature seed	
						0.25	Hulls	
						0.15	Meal	
						<0.01	Oil	
	0.56		61			0.35	Mature seed	
						0.62	Hulls	
						0.55	Meal	
						<0.01	Oil	

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
MS, 1971 (NK-HO1)	0.28		7.5	1	7	0.21	Mature seed	T-2186 (ground appl.)
						1.9	Hulls	
						0.92	Meal	
						<0.01	Oil	
	0.56		7.5			0.31	Mature seed	
						3.4	Hulls	
						0.66	Meal	
						<0.01	Oil	
MN, 1972 (VNIIMK 8931)	0.28		7.7	1	7	0.08	Mature seed	T-2392 (aerial appl)
						0.08	Hulls	
						0.12	Meal	
						<0.01	Oil	
					14	0.11	Mature seed	
						0.09	Hulls	
						0.20	Meal	
						<0.01	Oil	
					21	0.12	Mature seed	
						0.08	Hulls	
						0.13	Meal	
						<0.01	Oil	
MN, 1972 (VNIIMK 8931)	0.28		7.7	1	7	0.06	Mature seed	T-2393 (aerial appl)
						0.06	Hulls	
						0.06	Meal	
						<0.01	Oil	
					14	0.04	Mature seed	
						0.05	Hulls	
						0.06	Meal	
						<0.01	Oil	
					21	0.03	Mature seed	
						0.02	Hulls	
						0.05	Meal	
						<0.01	Oil	
CA, 1972 (HO-1)	0.28		34	1	7	0.13	Mature seed	T-2394 (ground appl)
						0.15	Hulls	
						0.19	Meal	
						<0.01	Oil	
					14	0.10	Mature seed	
						0.13	Hulls	
						0.19	Meal	
						<0.01	Oil	
					21	0.11	Mature seed	
						0.10	Hulls	
						0.18	Meal	
						<0.01	Oil	
IA, 1973 (Peredovik)	0.56		31	1	7	0.12	Mature seed	T-2679 (ground appl.)
						0.31	Hulls	
						<0.01	Meal	
						<0.01	Oil	
	1.12		31			0.19	Mature seed	
						0.54	Hulls	
						0.01	Meal	
						<0.01	Oil	
ND, 1973 (Peredovik)	0.56		7.7	1	7	0.16	Mature seed	T-2680 (aerial appl.)
						0.57	Hulls	
						0.01	Meal	
						<0.01	Oil	
CA, 1973 (RHA-271)	0.56		34	1	7	0.09	Mature seed	T-2681 (ground appl.)
						0.27	Hulls	
						<0.01	Meal	
						<0.01	Oil	
MS, 1973 (HF-52)	0.56		7.7	1	7	0.13	Mature seed	T-2682 (aerial appl)
						0.38	Hulls	
						<0.01	Meal	
						<0.01	Oil	

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
SD, 1973 (Record)	0.63		3.8	1	14	0.16 0.46 0.02 <0.01	Mature seed Hulls Meal Oil	T2683 (aerial appl)
MN, 1973 (Cargill 101)	0.56		7.7	1	9	0.21 0.62 0.02 <0.01	Mature seed Hulls Meal Oil	T-2684 (aerial appl)
MN, 1974 (Sputnik)	0.56		7.7	1	7	0.14 0.28 0.09 <0.01	Mature seed Hulls Meal Oil	T-3069 (aerial appl)
ND, 1974 (Sputnik)	0.56		7.7	1	7	0.24 0.55 0.13 <0.01	Mature seed Hulls Meal Oil	T-3070 (aerial appl)
TX, 1974 (Sun Hi 372)	0.56		7.7	1	15	0.19 0.40 0.11 <0.01	Mature seed Hulls Meal Oil	T-3126 (aerial appl)

B*: control

Processing factors calculated from the results obtained with an application rate of 1.12 kg ai/ha are shown in Table 65.

Table 65. Processing factors from sunflower seed to processed commodities

Product	Paraquat (mg/kg)	Processing factor
	T-2679	
Mature seed	0.19	
Hulls	0.54	2.8
Meal	0.01	0.05
Oil	<0.01	<0.05

In some trials with lower application rates, higher paraquat residues (0.35, 0.31 and 0.24 mg/kg) were observed in mature seeds. However, the paraquat concentrations in the oil samples, prepared from these mature seeds with higher paraquat residues, were below the limit of detection of 0.01 mg/kg.

Hops

A study was conducted in the states of Idaho and Washington, USA, to determine paraquat residues in spent hops and a methylene chloride extract from dried hops. Hop vines were treated three times with a directed spray of paraquat at a rate of 2.8 kg ai/ha, five times the normal rate in the USA. Green hop cones were harvested 13 or 14 days after the last treatment. Bulk samples of green hops were dried according to commercial practice. Dried hops were processed into spent hops and methylene chloride extract as shown in Figure 16. The results of residue analysis are shown in Table 66. The limit of quantification was 0.05 mg/kg for green hops, 0.1 mg/kg for dried and spent hops, and 0.0125 mg/kg for methylene chloride extract (Roper, 1989).

Another study was conducted in Oregon, USA, to determine paraquat residues in beer. The hop vines received three applications except one trial in which only two applications were made, at 0.56, 1.12 or 2.24 kg ai/ha each time. Green cones were harvested 14 days after the last application. A portion of the cones were dried and used to make beer. No detailed description of beer brewing process was provided. The results of residue analysis are given in Table 67. The LOQ was 0.01 mg/kg for green hops, dried hops and beer (Anon., 1975).

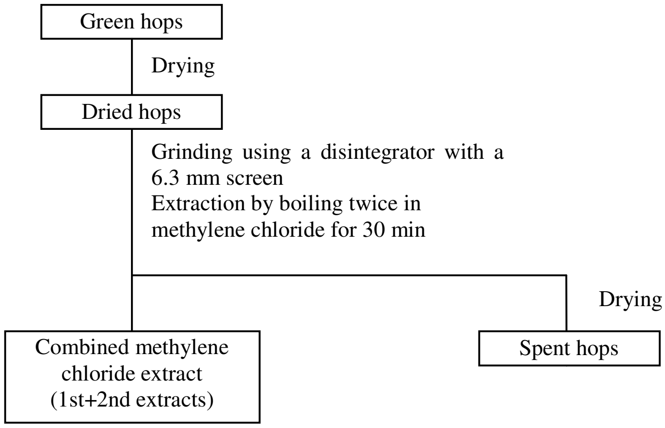

Figure 16. Processing of green hops to dried hops, spent hops and methylene chloride extract of hops.

Table 66. Paraquat residues in hops and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, USA, 1988 (Hallertau Mittelfrueh)	2.8		31	3	B*	<0.05	Green hops	Roper 1989d 15ID88-591
						<0.1 (0.04)	Dried hops	
						<0.1 (0.05)	Spent hops	
						<0.0125	Mehylene chloride extract	
					14	<0.05 (0.04)	Green hops	
						<0.1 (0.06)	Dried hops	
						<0.1 (0.06)	Spent hops	
						<0.0125	Mehylene chloride extract	
WA, USA, 1988 (L-1 Clusters)	2.8		31	3	B*	<0.05	Green hops	15WA88-592
						<0.1	Dried hops	
						<0.1 (0.04)	Spent hops	
						<0.0125	Mehylene chloride extract	
					13	<0.05 (0.02)	Green hops	
						<0.1 (0.06)	Dried hops	
						<0.1 (0.03)	Spent hops	
						<0.0125	Mehylene chloride extract	
OR, USA, 1973 (Cascade)					B*	<0.01	Green hops	Anon. 1975b T-2639
						<0.01	Dried hops	
						<0.01	Beer	
	0.56			3	14	0.04	Green hops	
						0.05	Dried hops	
						0.01	Beer	
	1.12			3	14	0.05	Green hops	
						0.01	Dried hops	
						<0.01	Beer	
OR, USA, 1973	1.12			2	14	0.03	Green hops	T-2640
						0.03	Dried hops	
						<0.01	Beer	
	2.24			2	14	0.01	Green hops	
						0.02	Dried hops	
						<0.01	Beer	
OR, USA, 1973	0.56			3	14	0.04	Green hops	T-2958
						0.05	Dried hops	
						<0.01	Beer	
	1.12			3	14	0.03	Green hops	
						0.07	Dried hops	
						<0.01	Beer	

B*: control

In the study on processing green hops to dried hops, spent hops and methylene chloride extract, residues were all below the limit of quantification, so processing factors could not be reliably calculated. Processing factors were calculated for brewing beer and are shown in Table 67. Drying green hops to dried hops does not cause much increase in the concentration of paraquat which indicates some degradation of paraquat during drying.

Table 67. Processing factors from green hops to hops and beer.

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	T-2639 (0.56 kg ai/ha)		T-2958 (0.56 kg ai/ha)		T-2639 (1.12 kg ai/ha)	
Green cones	0.04		0.04		0.05	
Dry cones	0.05	1.3	0.05	1.3	0.01	0.2
Beer	0.01	0.25	<0.01	<0.25	<0.01	<0.2
	T-2958 (1.12 kg ai/ha)		T-2640 (1.12 kg ai/ha)		Mean processing factor	
Green cones	0.03		0.03			
Dry cones	0.07	2.3	0.03	1	1.2	
Beer	<0.01	<0.33	<0.01	<0.33	<0.28	

Maximum application rate in the USA: 0.55 kg ai/ha.

RESIDUES IN ANIMAL COMMODITIES

Farm animal feeding studies

In animal metabolism studies on a goat and hens, paraquat residue concentrations were measured in tissues, milk and eggs (see Tables 7-9). No additional animal feeding studies were submitted.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

In the residue monitoring data from the Australian National Residue Survey (2001-2002), 18 samples of macademia nuts were analysed for paraquat by an HPLC method. No residues were detected above the limit of reporting of 0.02 mg/kg.

NATIONAL MAXIMUM RESIDUE LIMITS

National MRLs in Argentina, Brazil, Czech Republic, European Union, Peru and the USA were reported by the manufacturer. The information on MRLs in Japan was obtained from the official web site of the Ministry of Environment. The information on MRLs in Australia and tolerances in the USA was provided by the governments of Australia and the USA respectively.

Table 68. National maximum residue limits.

Country	**Commodity**	**MRL (mg/kg)**
Argentina	Cotton oil	0.05
	Cotton seed	0.2
	Potato	0.2
Australia	Cereal grains [except maize; rice]	0.05*
	Cotton seed	0.2
	Cotton seed oil, edible	0.05
	Edible offal (mammalian)	0.5
	Eggs	0.01*
	Fruits (except olives)	0.05*
	Hops, dry	0.2
	Maize	0.1

Country	**Commodity**	**MRL (mg/kg)**
	Meat (mammalian)	0.05*
	Milks	0.01*
	Olives	1
	Peanut	0.01*
	Peanut, whole	0.01*
	Potato	0.2
	Poultry, Edible offal of	0.05*
	Poultry meat	0.05*
	Pulses	1
	Rice	10
	Rice, polished	0.5
	Sugar cane	0.05*

Country	Commodity	MRL (mg/kg)
	Tree nuts	0.05*
	Vegetables (except potato; pulses)	0.05*
Brazil	Banana	0.05
	Corn	0.1
	Cotton	0.2
	Fruits (various)	0.05
	Grapes	0.05
	Potato	0.2
	Rice	0.5
	Sorghum	0.5
	Soya bean	0.1
	Vegetables (various)	0.05
	Wheat	0.01
Czech R.	Hop, Dried	0.2
European Union	Fruits (various; including tree fruits, vine and strawberries)	0.05
	Hops, dry	0.1
	Oilseeds (various)	0.05
	Tea	0.1
	Tree nuts (various)	0.05
	Vegetables (various; including some herbs)	0.05
Japan (withholding limits)	Asparagus	0.05
	Barley	0.05
	Broccoli	0.05
	Burdock	0.05
	Cabbage	0.05
	Carrot	0.05
	Cauliflower	0.05
	Cucumber	0.05
	Eggplant	0.05
	Fruits (of any fruit tree)	0.05
	Japanese radish	0.05
	Konjac	0.05
	Lettuce	0.05
	Melons	0.05
	Oat	0.05
	Onion, bulb	0.05
	Peppers, sweet	0.05
	Potato	0.05
	Pumpkin	0.05
	Rice, hulled	0.1
	Rye	0.05
	Spinach	0.05
	Strawberry	0.05
	Sweet potato	0.05
	Tomato	0.05
	Watermelon	0.05
	Welsh onion	0.05
	Wheat	0.05
	Yam	0.05
Peru	Banana	0.05
	Cocoa	0.5
	Coffee	0.05
	Grape	0.05
	Oil palm	0.05
	Orange	0.05
	Potato	0.05
	Rice	0.05

Country	Commodity	MRL (mg/kg)
	Sugar cane	0.5
	Tea	0.05
USA	Acerola	0.05
	Alfalfa	5
	Almond, hulls	0.5
	Apple	0.05
	Apricot	0.05
	Artichoke, globe	0.05
	Asparagus	0.5
	Avocado	0.05
	Banana	0.05
	Barley, grain	0.05
	Bean, dry, seed	0.3
	Bean, forage	0.1
	Bean, hay	0.4
	Bean, lima, succulent	0.05
	Bean, snap, succulent	0.05
	Beet, sugar	0.5
	Beet, sugar, tops	0.5
	Birdsfoot trefoil	5
	Broccoli	0.05
	Cabbage	0.05
	Cabbage, Chinese	0.05
	Cacao bean	0.05
	Carrot, roots	0.05
	Cattle, fat	0.05
	Cattle, kidney	0.3
	Cattle, meat	0.05
	Cattle, meat byproducts, except kidney	0.05
	Cauliflower	0.05
	Cherry	0.05
	Clover	5
	Coffee bean	0.05
	Collards	0.05
	Corn, field, forage	3.0
	Corn, field, grain	0.1
	Corn, field, stover	10.0
	Corn, fresh (inc sweet corn), kernel plus cob with husks removed	0.05
	Corn, pop, grain	0.1
	Corn, pop, stover	10.0
	Cotton, undelinted seed	0.5
	Cucurbits	0.05
	Egg	0.01
	Endive	0.05
	Fig	0.05
	Fruit, citrus	0.05
	Goat, fat	0.05
	Goat, kidney	0.3
	Goat, meat	0.05
	Goat, meat byproducts, except kidney	0.05
	Grass, pasture	5
	Grass, range	5
	Guar bean	0.5
	Guava	0.05
	Hog, fat	0.05
	Hog, kidney	0.3
	Hog, meat	0.05

Country	Commodity	MRL (mg/kg)
	Hog, meat byproducts, except kidney	0.05
	Hop, dried cone	0.2
	Horse, fat	0.05
	Horse, kidney	0.3
	Horse, meat	0.05
	Horse, meat byproducts, except kidney	0.05
	Kiwifruit	0.05
	Lentil, seed	0.3
	Lettuce	0.05
	Milk	0.01
	Mint, hay	0.5
	Mint, hay, spent	3.0
	Nectarine	0.05
	Nut	0.05
	Olive	0.05
	Onion, dry bulb	0.05
	Onion, green	0.05
	Papaya	0.05
	Passionfruit	0.2
	Pea, dry, seed	0.3
	Peach	0.05
	Peanut	0.05
	Peanut, hay	0.5
	Pear	0.05
	Pea (succulent)	0.05
	Pea, field vines	0.2
	Pea, field, hay	0.8

Country	Commodity	MRL (mg/kg)
	Persimmon	0.05
	Pineapple	0.05
	Pistachio	0.05
	Plum, prune, fresh	0.05
	Potato	0.5
	Rhubarb	0.05
	Rice, grain	0.05
	Rice, straw	0.06
	Safflower, seed	0.05
	Sheep, fat	0.05
	Sheep, kidney	0.3
	Sheep, meat	0.05
	Sheep, meat byproducts, except kidney	0.05
	Small fruit	0.05
	Sorghum, forage	0.05
	Sorghum, grain	0.05
	Soybean	0.05
	Soybean forage	0.05
	Strawberry	0.25
	Sugarcane, cane	0.5
	Sunflower, seed	2
	Turnip, greens	0.05
	Turnip, roots	0.05
	Vegetable, fruiting	0.05
	Wheat	0.05

APPRAISAL

Paraquat, a non-selective contact herbicide, was first evaluated by the JMPR for toxicology and residues in 1970. Subsequently, it was reviewed for toxicology in 1972, 1976, 1982, 1985 and 1986 and for residues in 1972, 1976, 1978 and 1981. The Meeting reviewed paraquat toxicologically within the periodic review programme in 2003 and established an ADI of 0–0.005 mg/kg bw and an ARfD of 0.006 mg/kg bw as paraquat cation. Currently, there are 22 Codex MRLs for plant commodities, their derived products and animal commodities.

The CCPR at its Thirty-second Session identified paraquat as a priority for periodic review by the 2002 JMPR, but residue evaluation was postponed to the present Meeting.

Paraquat is usually available in the form of paraquat dichloride or paraquat bis(methylsulfate). The Meeting received data on metabolism, environmental fate, analytical methods, storage stability, supervised field trials, processing and use patterns.

Metabolism

Animals

The WHO Expert Group of the 2003 JMPR reviewed studies on the the excretion balance of paraquat in *rats* given a single dose of 1 or 50 mg/kg bw [1,1´-^{14}C-dimethyl]paraquat dichloride or 14 daily doses of 1 mg/kg bw unlabelled paraquat dichloride followed by 1 mg/kg bw of the labelled compound. They also evaluated studies of the biotransformation of paraquat in rats given the same doses of radiolabelled paraquat and other studies of metabolism and toxicity in rats. They concluded that orally administered paraquat is not well absorbed. Excretion was rapid, with 60–70% in faeces and 10–20% in urine; 90% was excreted within 72 h. Paraquat was eliminated largely unchanged: 90–95% of radiolabelled paraquat in urine was identified as the parent compound.

When 23 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride were administered through a rumen fistula to one *sheep*, all the administered radiolabel was excreted within 10 days in urine (4%) and faeces (96%), indicating that residues of orally administered paraquat would not remain or accumulate in sheep tissues. Most of the radiolabel in urine and faeces was attributed to unchanged paraquat and 2–3% to paraquat monopyridone. Less than 1% 4-carboxy-1-methylpyridinium ion, paraquat dipyridone and monoquat were found.

When 0.92 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride was administered subcutaneously to a sheep, paraquat was again excreted rapidly. Over 80% of the administered radioactivity was excreted in urine, 69% 1 day after treatment. Unchanged paraquat accounted for most of the radiolabel. The monopyridone was present at 2–3% and monoquat as a trace metabolite. The excretion patterns in the two sheep were virtually identical, regardless of the route of administration.

A *pig* weighing about 40 kg was fed twice daily with a diet containing [1,1´-^{14}C-dimethyl]paraquat ion at a rate equivalent to 50 mg/kg for 7 days. At sacrifice, 69% of the administered radiolabel had been excreted in faeces and 3.4% in urine; 13% was present in the stomach contents and viscera. All the radiolabel found in tissues, except in liver, was attributed to paraquat. About 70% of the radiolabel in the liver was identified as paraquat, with 7% as monoquat ion and about 0.6% as monopyridone ion. This result indicates that there is no significant metabolism of paraquat in pigs.

In a similar study, a pig was fed a diet containing [2,2´,6,6´-^{14}C]paraquat ion at a rate equivalent to 50 mg/kg for 7 days. At sacrifice, 72.5% of the administered radiolabel had been excreted in faeces and 2.8% in urine. In the liver, about 70% of the radiolabel was identified as paraquat and 4% as monoquat ion.

A Friesian *cow* weighing 475 kg given a single dose of about 8 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride from a balling gun excreted 95.6% of the administered radioactivity in faeces within 9 days; 89% was excreted within the first 3 days. Analysis indicated that 97–99% of the radioactivity in 1–4-day faeces and 100% of that in 5–6-day faeces co-chromatographed with paraquat. A total of 0.7% of the administered dose was excreted in urine, 80% of which was excreted within the first 2 days. Paraquat accounted for 90% of the radiolabel in urine on day 1, 70% on day 3 and 62% on day 5. The remaining activity was attributed to paraquat monopyridone and monoquat. Only 0.0032% of the administered radiolabel was recovered from milk within 9 days. The traces of radioactivity in milk (a maximum of 0.005 mg/l as paraquat ion equivalent milk taken in the morning of day 2) were attributed mainly to paraquat and its monopyridone and to a naturally occurring compound which appeared to be lactose. The residue level of any one compound in milk was ≤ 0.002 mg/kg.

When a lactating *goat* was dosed with [2,2´,6,6´-^{14}C]paraquat dichloride twice daily at each milking for 7 days at a total daily rate equivalent to approximately 100 mg/kg in the diet, 50.3% of the administered radioactivity was excreted in faeces, 2.4% in urine and 33.2% in stomach contents by the time of sacrifice. The total radioactivity, expressed in paraquat ion equivalents, in milk increased during the experimental period, reaching a maximum of 0.0092 mg/kg (equivalent to 0.003% of the daily dose) 4 h before slaughter. Of this radioactivity, 75.7% was attributed to paraquat, and 15.8% did not show a cationic character. There appeared to be no significant metabolism of paraquat in any tissue, except liver and peritoneal fat, where about half the radiolabel was attributed to paraquat, < 5% as monopyridone ion and 5% as monoquat ion.

Warren laying *hens* given [2,2´,6,6´-^{14}C]paraquat ion in gelatin capsules at a rate equivalent to 30 mg/kg normal diet for 10 days had excreted 99% of the administered radiolabel in faeces at the time of sacrifice; 96.6% of the radiolabel was attributed to unchanged paraquat. The amount of radiolabel in egg albumen did not exceed 0.0014 mg/kg in paraquat ion equivalents throughout the experimental period, while that in the yolk was < 0.001 mg/kg on day 1 and increased gradually to 0.18 mg/kg (in one bird) on day 8. All the radiolabel in yolk was identified as paraquat.

The studies on the fate of orally administered paraquat show that most is excreted unchanged, mainly in faeces and to a much smaller extent in urine. Excretion of paraquat was rapid in all the species studied, hens showing the most efficient excretion. Little paraquat was absorbed from the gastrointestinal tract, and the small amount absorbed was not significantly metabolized. Less than 0.05 mg/kg of paraquat was found in muscle, milk and eggs, even at the high dose rates used in these studies. These findings indicate that no significant bioaccumulation of paraquat is expected to occur in these species.

The metabolism of paraquat in these species was similar. Four metabolites were identified: monoquat, paraquat monopyridone, 4-carboxy-1-methylpyridinium ion and paraquat dipyridone. In all tissues except liver of all the species tested and in goat peritoneal fat, 80–100% of the total radiolabel was attributable to the parent compound, paraquat. In liver and goat peritoneal fat, 50–80% of the radiolabel was associated with paraquat, and absorbed paraquat was metabolized to monoquat and paraquat monopyridone and to a much smaller extent to 4-carboxy-1-methylpyridinium ion. The metabolism of paraquat involves oxygenation of one pyridine ring to form paraquat monopyridone and desmethylation of one pyridine ring to form monoquat. Cleavage of the pyridine–pyridine linkage produces 4-carboxy-1-methylpyridinium ion. The other *N*-methylpyridine moiety would produce carbon dioxide and methylamine.

Plants

When paraquat is used as a directed spray before sowing, before planting, before emergence and after emergence, it is present in soil as residues, but no direct contact occurs with crops. Sandy loam soil in pots in which *lettuce* and *carrots* were sown was sprayed with [U-^{14}C-bipyridyl]paraquat ion immediately after sowing at rates equivalent to 14.3 kg ai/ha for lettuce and 14.7 kg ai/ha for carrots, which are 13 times the highest current application rates for those crops, and maintained in a greenhouse. The radiolabel in mature lettuce and carrots harvested 65 and 96 days after treatment represented 0.0034 and 0.0048 mg/kg in paraquat ion equivalents, respectively. This result confirms the lack of significant translocation of residues of paraquat from treated soil to lettuce leaves or carrot roots.

Paraquat is also used as a crop desiccant and harvest aid, when it is in direct contact with crops. The foliage of *potatoes* and *soya beans* growing in pots in a greenhouse was treated with ^{14}C-paraquat at rates equivalent to 8.7 or 8.8 kg ai/ha (potato) and 8.2 kg ai/ha (soya beans), 14–16 times the highest current use for desiccation on potato and soya beans. The average TRR, expressed in paraquat ion equivalents, in soya and potato plants harvested 4 days after treatment were 638 mg/kg in soya foliage, 0.747 mg/kg in soya beans and 0.082 mg/kg in potato tuber. In all the samples, 89–94% of the TRR was identified as paraquat. The rest of the radioactive residue consisted of two or three fractions, none of which exceeded 10% of the respective TRR. In soya foliage extracts, small amounts of 4-carboxy-1-methylpyridinium ion (0.3% TRR) and monoquat (0.3 % TRR) were found. The latter is a known photodegradation product of paraquat.

As paraquat is strongly adsorbed by soil (see above), its uptake by plants after pre-emergence or post-emergence directed use is insignificant, even at exaggerated application rates. When paraquat was applied as a desiccant to potato and soya bean at a rate > 10 times the highest recommended application rate, with a 4-day PHI, the main component in potato tuber, soya beans and soya foliage was paraquat. In soya foliage, monoquat and 4-carboxy-1-methylpyridinium ion were also found. Although the latter is a known photodegradation product and was not found in soya beans or potato tuber, biotransformation cannot be excluded because the TRR was too low for reliable identification. As the fate of paraquat in soya foliage appears to involve photodegradation, its fate is considered to be common among plants.

The metabolism of paraquat involves desmethylation of one pyridine ring to form monoquat. 4-Carboxy-1-methylpyridinium ion appears to be produced by photolysis of monoquat, with breakdown of the pyridine–pyridine linkage, but involvement of biotransformation cannot be excluded. Paraquat monopyridone and dipyridone, which are found in animals, were not found in plants even at much higher than normal application rates. The transformation of paraquat in plants is similar to its metabolism in animals.

Environmental fate

Soil

Paraquat was applied to slurries of loam, loamy sand, silty clay loam or coarse sand in 0.01 mol/l aqueous calcium chloride at rates higher than normal, to give 0.01 mg/l in the equilibrium solution after a 16-h equilibration. The calculated adsorption coefficients ranged from 480 in the coarse sand to 50 000 in the loam. At normal application rates, the concentration of paraquat in the equilibrium solution could not be determined (< 0.0075 mg/l). No significant desorption was observed.

A field survey of 242 agricultural soils in Denmark, Germany, Greece, Italy, The Netherlands and the United Kingdom showed that paraquat was strongly adsorbed to all the soil types studied. The adsorption coefficients calculated at application rates much higher than normal ranged from 980 to 400 000, and those adjusted for the organic carbon content of soil were 8400–40 000 000. Adsorption coefficients could not be calculated at normal application rates because the concentration in equilibrium solution was below the limit of determination (0.01 mg/l). On the McCall scale, paraquat was classified as ‘immobile’ in all these soils, without leaching.

[2,6-^{14}C]Paraquat was applied to sandy loam soil in pots at a nominal rate of 1.05 kg/ha and incubated in the dark at 20 ± 2 °C under aerobic conditions in order to study the aerobic degradation of paraquat. After 180 days of incubation, paraquat accounted for > 93% of the applied radiocarbon, with no detected degradation products. Less than 0.1% of the applied radioactivity evolved as $^{14}CO_2$ over the 180-day incubation period. The half-life of paraquat in soil under aerobic conditions could not be estimated, although a long half-life in soil was implied by the results of the study.

In long-term field dissipation studies conducted on cropped plots in Australia, Malaysia, The Netherlands, Thailand, the United Kingdom and the USA, the location had no major effect on the field dissipation rate. Generally, paraquat residue levels had declined to about 50% 10–20 years after the start of the studies. This implies a DT_{50} of 10–20 years after application of single, large doses of paraquat to soil. The DT_{90} could not be estimated in these studies, however, as the experimental periods were too short.

Conventional laboratory studies could not provide useful information on the route or rate of degradation of paraquat in soil because of its strong adsorption to soil minerals and organic matter. In order to obtain information, microbiological degradation studies were conducted with microorganisms isolated from soil. The most effective soil organism for decomposing paraquat was a yeast species, *Lipomyces starkeyi*. When incubated with radiolabelled paraquat, the yeast culture or cultures originating from two sandy loam soils decomposed most of the paraquat, released CO_2 and formed oxalic acid at 24–25 °C.

An unidentified bacterium isolated from soil metabolized [1,1´-^{14}C]paraquat to monoquat and 4-carboxy-1-methylpyridinium ion. Extracts of *Achromobacter* D were found to produce CO_2, methylamine, succinate and formate as metabolites of 4-carboxy-1-methylpyridinium ion. The results showed that the CO_2 originated from a carboxyl group, methylamine from the *N*-methyl group and the carbon skeletons of formate and succinate from the C-2 and C-3–C-6 atoms of the pyridine ring, respectively. These results indicate that the pyridine ring is split between C-2 and C-3.

The degradation rate of paraquat in soil was determined by cultivating 10 mg/kg [U-^{14}C-dipyridyl]paraquat with *Lipomyces* and mixed cultures derived from two soils. The degradation of paraquat was rapid, with a DT_{50} between 0.02 and 1.3 days after a lag phase of about 2 days, accompanied by rapid mineralization to CO_2 and the formation of several unidentified minor polar metabolites.

The photolysis of [2,2´,6,6´-^{14}C]-paraquat was studied by applying it to the surface of a highly sandy soil which was exposed to natural sunlight. The proportion of paraquat in samples declined during 85 weeks, at which time paraquat represented 86.6–89.5% of the total radiolabel found in unmixed and mixed soil samples. Thin-layer chromatographic analysis of the 6 mol/l HCl extracts of mixed and unmixed soils contained monoquat ion, paraquat monopyridone ion and an uncharacterized compound, which accounted for 1.4–2.4%, 1.2–1.3% and 1.8–2.4%, respectively, of the total radioactivity after 85 weeks. Photodegradation on the soil surface is not considered to be a major environmental degradation process for paraquat.

Water–sediment systems

Aqueous photolysis of paraquat was examined by maintaining ring-labelled paraquat in sterilized 0.01 mol/l phosphate buffer solution (28 mg/l) at 25 °C under light. After 36 days of irradiation simulating summer sunlight in Florida (USA), most of the recovered radioactivity was attributed to paraquat, with 0.13% as CO_2 and no photodegradation products. When solutions of radiolabelled paraquat were exposed to unfiltered ultraviolet light, no paraquat remained after 3 days, with formation of CO_2, methylamine and 4-carboxy-1-methylpyridinium ion; the last metabolite further degraded to CO_2 and methylamine. These results indicate that, while paraquat appears to be stable to photolysis at pH 7, it readily degrades into CO_2 and methylamine when exposed to unfiltered ultraviolet light.

[U-^{14}C-dipyridyl]Paraquat in deionized water was applied to the water surface of two continuously aerated sediment–water systems at a rate equivalent to 1.1 kg ai/ha. Paraquat was strongly adsorbed to the sediment in both systems, even immediately after treatment. After 100 days of incubation, 0.1–0.2% of the applied radioactivity was found in the aqueous phase, 92.9–94.9% in extracts from sediment fractions and 4.2–4.5% in unextracted sediment fractions. Most of the radiolabel recovered from the aqueous phase and sediment extract was attributed to paraquat, while no degradation products were detected. The DT_{50} or the DT_{90} could not be estimated as no significant degradation of paraquat was observed during the experimental period.

Residues in succeeding crops

Seeds of wheat, lettuce and carrot were sown into individual pots containing a sandy loam soil 0, 30, 120 and 360 days after treatment of the soil with [2,2´,6,6´-^{14}C]paraquat at an application rate equivalent to 1.05 kg ai/ha, and were maintained in a glasshouse until maturity. Over the course of the study, the TRR in soil represented an average of 99.2% of the applied radioactivity. ^{14}C-Paraquat accounted for 72.7–99.3% of the TRR in soil extracts and no other radioactive compounds were detected in any soil sample. Radioactive residues, expressed in paraquat ion equivalents per kilogram, were below the LOQ in most crop samples sown 0, 30 and 120 days after treatment. The highest radioactive residue level, 0.009 mg/kg in paraquat ion equivalents, was found in wheat straw sown 30 days after treatment.

Seeds of lettuce and carrot were sown in pots containing sandy loam soil, and the soil was treated immediately afterwards with [U-^{14}C-dipyridyl]paraquat at exaggerated rates of 14.3 and 14.7 kg/ha respectively, corresponding to approximately 13 times the highest current application rate. The lettuce was harvested 65 days after treatment and the carrots 96 days after treatment. The levels of radioactive residues in lettuce leaf and carrot root at harvest were 0.0034 and 0.0048 mg/kg in paraquat ion equivalents, respectively. There is therefore no significant uptake of paraquat into rotational crops, even when the soil is treated at exaggerated rates.

Methods of analysis

With the long history of registration of paraquat in many countries, many analytical methods have been developed and used for measuring residues in plant and animal commodities. All the methods provided to the Meeting were for analysis of paraquat only. Some analytical methods allow separate determination of paraquat and diquat in a sample.

Samples of plant origin

Six analytical methods for the determination of paraquat in plant commodities and oil and oil cake were submitted.

Three of the methods involve extraction of paraquat by refluxing homogenized or comminuted samples in 0.5 mol/l sulfuric acid for 5 h; filtration, cation-exchange chromatography from which paraquat is eluted with saturated ammonium chloride, conversion of paraquat to its coloured free radical with 0.2% (w/v) sodium dithionite in 0.3 mol/l NaOH and spectrophotometric measurement. The methods differ only in the spectrophotometric measures used: absorption of the free radical in the range 360–430 nm measured against a control solution or absorption in the range of 380–430 nm measured in second derivative mode against a paraquat standard.

In the most recent method, the eluate from cation-exchange chromatography is further cleaned up on a C18 SepPak solid phase extraction cartridge, and the second 5-ml eluate is analysed by reverse-phase ion-pair HPLC with ultraviolet detection at 258 nm.

Two other methods developed for the determination of paraquat in liquid samples, such as oil, also involve second derivative spectrophotometry (360–430 nm), but they do not involve extraction with sulfuric acid. Reverse-phase ion-pair HPLC is also used as the confirmatory method.

All these methods were validated in one or several laboratories for vegetables and fruits, cereal grains and seed, grass and straw, sugar-cane juice, oil seeds, oil and oil cake. The LOQ of these methods ranged from 0.01 to 0.05 mg/kg, except for oil cake, for which the LOQ was 0.5 mg/kg. The mean procedural recoveries were 61–107% at fortification rates reflecting both the LOQ and the actual levels of incurred residues. In general, lower recoveries were made from oil and oil cake. The mean recovery from rape-seed oil cake and olive oil was 67% and that from coffee beans was 61%; those from other commodities were > 70%. The relative standard deviation of recoveries ranged from 2% to 19%.

Samples of animal origin

Three analytical methods for the determination of paraquat in animal products were submitted.

Two methods, including the most recent, for determining paraquat in milk, eggs and animal tissues involve extraction of paraquat by homogenizing samples in 10% trichloroacetic acid, centrifugation, dilution with water, application to a cation-exchange column, sequential washing, elution of paraquat with saturated ammonium chloride, determination by reverse-phase ion-pair HPLC with ultraviolet detection at 258 nm. Fat in milk, skin with subcutaneous fat and fat samples must be removed by hexane extraction before cation exchange.

A method for analysing liquid samples, including milk, does not involve acid extraction or defatting, and milk is mixed directly with cation exchange resin before packing. Otherwise, this method is the same as those described above.

The LOQs were reported to be 0.005 mg/kg for milk, eggs and bovine, ovine and chicken tissues. The mean procedural recoveries were 75–105%, with a relative standard deviation of 2–13%.

The currently used methods for plant and animal samples were found to be suitable for quantification of paraquat in plant and animal commodities for enforcement purposes. The methods are fully validated and include confirmatory techniques. The earlier methods for quantification of paraquat in plant and animal samples were also found to be suitable in validation; however, a mean recovery < 70% was seen for rape-seed cake, olive oil and coffee beans analysed by one of the methods.

Stability of residues in stored analytical samples

Investigations were reported of the stability of residues in ground samples of prunes, banana, cabbage, potato, carrot, tomato, maize (grain, forage, fodder and silage), wheat grain, coffee beans, birdsfoot trefoil (forage and hay), meat, milk and eggs stored in a deep freezer at a temperature < –15 °C for 1–4 years.

No decrease in residue levels of paraquat, whether fortified or incurred, was observed in any of the crop matrices during the test period, the longest being 46 months. The exception was a slight decrease in birdsfoot trefoil forage that had been treated at a rate equivalent to 0.54 kg ai/ha and contained incurred residues at 57 mg/kg.

No decrease in the levels of residues of paraquat in animal commodity matrices over time was observed under storage for up to 28 months. The test matrices represented a diverse selection of animal tissues, and the studies demonstrate the stability of paraquat under various storage conditions.

Definition of the residue

Paraquat is usually available as the dichloride salt or the bis(methylsulfate) salt but is determined as paraquat ion in analysis. Paraquat is known to adsorb strongly to soil, and most of the small amount incorporated into plant remains as paraquat (90%). Its metabolites were not found when paraquat was applied at normal rates. When it was applied post-emergence, most of the applied compound remained, with minimal amounts of photodegradation products, indicating the involvement of photolysis in the transformation of paraquat. The residue of concern in plants is paraquat ion.

In studies of metabolism in rats, cattle, goats, pigs and hens, the metabolic pathway was similar, producing minor levels of oxidized metabolites. The metabolic pathways in animals and plants are similar. In animals, the residue of concern is also paraquat ion.

The definition of the residue in all countries that provided national MRLs to the Meeting was paraquat ion.

All the identified metabolites have been covered by toxicological evaluations, owing either to their occurrence in rats or in independent studies. The ADI recommended by the JMPR is for paraquat cation.

The Meeting therefore agreed that the definition of residues for plant and animal commodities should be: Paraquat cation (for both compliance with MRLs and estimation of dietary intake).

Results of supervised trials on crops

When used for weed control, paraquat is not sprayed directly onto crops and is strongly adsorbed to soil. Therefore, little paraquat is expected to be found in harvested crops. After pre-emergence application, no residues were expected to be detected in the harvested crops, although some samples contained residues. After use as a harvest aid desiccant, however, paraquat is in direct contact with crops, and the residue levels tend to be much higher than when it is used for weed control.

The Meeting agreed that data from trials of pre-plant and pre-emergence application should be evaluated against any GAP available to the Meeting, regardless of the country or region; while data on trials of post-emergence application and harvest aid desiccation should be evaluated against GAP of the country in which the trials were conducted or of a neighbouring country.

As degradation of paraquat on the surface of crops appears to involve photolysis, residue levels are expected to be similar in all crops, justifying estimation of group MRLs for paraquat.

For estimating STMR from the results of two or more sets of trials with different LOQs in which no residues exceeding the LOQs are reported, the lowest LOQ should be used, as stated in the 2002 *FAO Manual*, unless the residue level can be assumed to be essentially zero. The size of the trial database supporting the lowest LOQ was taken into account in making decisions in these cases.

Since maximum residue levels were estimated for a number of vegetable groups in which the levels were below the LOQ, the Meeting decided to withdraw the previous recommendation for vegetables (except as otherwise listed) of 0.05 * mg/kg.

In Germany, information is required on the possible contamination of fruits that have fallen onto ground treated with pesticides. Therefore, tests were carried out on apples, stone fruits, grapes and olives to simulate the residue situation in fruit used for juice and other processed products. Nevertheless, direct consumption of fruit picked up from the ground is regarded as inappropriate.

Citrus fruit

Numerous supervised residue trials have been carried out over several seasons and in several locations on orange in Italy and in California and Florida, USA, and on lime, lemon and grapefruit in Florida.

Paraquat is registered for the control of weeds around the base of citrus fruit trees at a maximum rate of 1 kg ai/ha as an inter-row spray, with no PHI, in Italy and at a maximum rate of 1.14 kg ai/ha as a directed spray, with no PHI, in the USA.

The residue levels of paraquat in whole mature *oranges* in trials in Italy and the USA were below the LOQs of 0.01, 0.02 or 0.05 mg/kg, even when paraquat was applied at twice or 30 times the maximum application rate, except in two trials. In one trial with an application rate of 2.44 kg ai/ha, mature fruit from one plot contained paraquat residues at a level of 0.01 mg/kg. In a trial with an application rate of 1.12 kg ai/ha, residue levels of 0.06 and 0.08 mg/kg were found in whole fruit. In this trial, however, the lower fruit-bearing branches were deliberately sprayed, the fruit fell onto sprayed weeds, and they were picked up from the ground within 3 days of spraying for analysis. Even though this represents the worst-case scenario, it does not reflect GAP in any country and is therefore inappropriate for use in estimating a maximum residue level. The residue levels in whole mature oranges in valid trials were, in ranked order: < 0.01 (15), 0.01, < 0.02 (two) and < 0.05 mg/kg (one).

In one trial in the USA, both juice and pulp were analysed for paraquat residues. Although the levels were below the LOQ of 0.01 mg/kg, the procedural recovery was too low for the results to be regarded as reliable.

In trials in the USA on *grapefruit*, *lemon* and *lime* in 1970 and 1972, with application rates reflecting GAP in the USA, the paraquat residue levels were < 0.01 (one) and < 0.05 mg/kg (three).

As the residue situation in oranges and other citrus fruits is similar and GAP is recommended for citrus fruits as a group in Italy and the USA, the Meeting considered it appropriate to establish a group maximum residue level for citrus fruits. The combined residue levels, in ranked order, were: < 0.01 (16), 0.01, < 0.02 (two) and < 0.05 (four) mg/kg. The Meeting estimated a maximum residue level of 0.02 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.02 mg/kg for paraquat in citrus fruits. The value of 0.02 mg/kg covers only the finite residue level found at 0.01 mg/kg.

Pome fruit

Trials were carried out on apples in Canada, Germany and the United Kingdom and on pears in Canada and Germany.

Paraquat is registered for use to control weeds around the base of pome fruit trees at a maximum rate of 0.66 kg ai/ha with one application and no PHI in the United Kingdom and at a maximum rate of 1.14 kg ai/ha with no PHI in the USA. No information on GAP was available for Canada or Germany, but the results of trials conducted in those countries were reviewed against the GAP of the USA and United Kingdom, respectively.

Trials on *apple* were conducted at rates of 1.12–4.48 kg ai/ha, and in one trial in the United Kingdom at a highly exaggerated rate of 12.3 kg ai/ha, about 20 times the maximum rate permitted in that country. In the latter trial, paraquat was applied directly to the bark of the trees to simulate worst-case conditions. In some cases, two applications were made, in the same or subsequent years. Apples were harvested 0–780 days after the last application. In trials on *pear*, paraquat was applied at rates of 1.0–4.48 kg ai/ha once or twice, and pears were harvested 0–77 days after the last application. Paraquat residue levels were below the LOQ of 0.01 mg/kg in all apples and pears taken from trees, even after treatment at rates as high as 20 times the maximum GAP rate.

In the trials in Germany, apples and pears taken from the trees were placed on the ground 6–7 days after application and collected about 7 days later for analysis. Residue levels of paraquat of 0.02–0.19 mg/kg were found in the apples, which could be attributed to the transfer of paraquat from the sprayed weed. The Meeting concluded that these data are not appropriate for use in estimating a maximum residue level.

As the residue situations in apples and pears are similar, and GAP is recommended for pome fruits or orchard fruits as a whole in all the countries that provided information on GAP, the Meeting considered it appropriate to establish a group maximum residue level for pome fruits. As the paraquat residue levels in all the valid trials were below the LOQ, even after application at exaggerated rates, the Meeting estimated a maximum residue level for pome fruits of 0.01* mg/kg, an STMR of 0 mg/kg and a highest residue level of 0 mg/kg.

Stone fruit

Trials were carried out on peaches, plums, apricots and cherries in Canada, Germany, the United Kingdom and the USA.

Paraquat is registered for use to control weeds around the base of stone fruit trees at a maximum rate of 0.66 kg ai/ha, with one application and no PHI for stone fruits in the United Kingdom and at a maximum rate of 1.14 kg ai/ha, with three applications and a 28-day PHI for stone fruits other than peaches in the USA; the PHI for use on peach trees in the USA is 14 days. No information on GAP was available from Canada or Germany, and the results of trials conducted in those countries were reviewed against the GAP of the USA and the United Kingdom, respectively.

The application rates in the supervised trials ranged from 0.22 to 4.48 kg ai/ha, applied to the base of the fruit trees up to three times in a season; the fruit was harvested from the trees 0–103 days after the last application. No residues of paraquat above the LOQ of 0.01 or 0.05 mg/kg were found in fruit harvested directly from the trees in any trial, even after spraying three times at a rate four times the maximum permitted rate. In most of the US trials, paraquat was applied one or two times instead of the maximum of three, but because of the higher application rates, the total amount applied was higher than the maximum allowed by GAP.

In trials on plums in the United Kingdom, paraquat was applied directly to suckers at rates of 0.22–1.34 kg ai/ha. No residues were found above the LOQ of 0.01 mg/kg in fruit harvested 21 or 55 days later.

In the trials in Germany, fruit were placed on sprayed weeds and collected for analysis about 1 week later. Small amounts of paraquat residues were found (0.02 and 0.04 mg/kg on peach, < 0.01 mg/kg on plum and 0.07 mg/kg on cherry) in the fruit samples, due to transfer from the sprayed weeds. As stone fruit intended for juice production is usually grown in orchards in which herbicides are rarely used, these data were not used for estimating a maximum residue level.

As the residue situations in stone fruits are similar and GAP is recommended for stone fruits or similar GAPs are established for peach and stone fruits excluding peach, the Meeting considered it appropriate to establish a group maximum residue level for stone fruits. As the paraquat residue levels were below the LOQ, even when applied at exaggerated rates and the methods of analysis in most of the trials had a LOQ of 0.01 mg/kg, the Meeting estimated a maximum residue level for stone fruits of 0.01* mg/kg and STMR and highest residue values of 0 mg/kg.

Berries and small fruit

Grape

Trials on residues in grapes have been conducted in Canada, Japan, Switzerland and the USA at rates of 0.3–4.4 kg ai/ha applied one to five times. Grapes were harvested from the vines at maturity 0–196 days after the last application. Four trials were conducted in Germany in which paraquat was applied between the rows of established vines at a rate of 1.0 kg ai/ha and grapes were sampled from the vines 0–14 days after application.

Paraquat is registered for weed control around grape vines at a maximum rate of 0.72 kg ai/ha, with five applications and a 30-day PHI in Japan and a maximum rate of 1.14 kg ai/ha, with the number of applications and the PHI unspecified in the USA. No information on GAP was available from Canada, Germany or Switzerland, but the results of trials in Canada were reviewed against US GAP.

In all trials in Canada, Japan and the USA reviewed against respective GAP, grapes obtained directly from the vine did not contain paraquat residues at levels above the LOQ of 0.01 or 0.02 mg/kg, even when applied at five times the recommended rate or with a shorter PHI.

In the German trials, bunches of grapes were also placed on the sprayed weed a few days after application and collected 7 days later for analysis. Small amounts of paraquat residues (0.04, 0.07, 0.09, 0.10, 0.13 and 0.17 mg/kg) were found in the grapes due to transfer from the sprayed weeds. When the fruits were sampled directly from the vine, the levels of residues were always below the LOQ of 0.01 mg/kg (six trials), which supports the results of the trials conducted in Canada, Japan and the USA.

The residue levels of paraquat in grapes in the trials that met the respective GAP or were conducted at higher rates were: < 0.01 (16), < 0.02 (three) and < 0.05 (two) mg/kg.

Cane fruit

Trials on residues were conducted in Canada on red and blackcurrants, blueberries, loganberries, gooseberries and raspberries at rates of application of paraquat of 0.56–2.24 kg ai/ha. Paraquat was applied once and the fruit was harvested 20–111 days after application.

GAP for cane fruit in the USA is a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified.

Even at double the application rate, cane fruit did not contain paraquat residues at levels above the LOQ of 0.01 mg/kg. The residue levels in 25 trials following GAP or conducted at higher rates were < 0.01 mg/kg.

Strawberry

Supervised trials were conducted in France, Germany and the United Kingdom in which paraquat was used to control runners of strawberry plants at rates of 0.42–1.32 kg ai/ha once or twice. Berries were harvested 47–226 days after the last application. Three trials in Germany were conducted in plastic greenhouses.

GAP in the United Kingdom for strawberries is a maximum rate of 0.66 kg ai/ha, with one application and PHI unspecified.

The residue levels of paraquat in strawberries in trials following GAP or conducted at higher application rates were < 0.01 (six) and < 0.05 mg/kg.

As the samples analysed in all the trials except that in which grapes were kept and taken from the ground did not contain paraquat residues at levels above the LOQs and the application rate in the respective GAP is similar, the Meeting decided to propose a group maximum residue level for small fruits and berries. The residue levels in these fruits, in ranked order, were: <u>< 0.01</u> (47), < 0.02 (three) and < 0.05 mg/kg (three). The Meeting, considering that use of modern analytical methods would enable lower LOQs, agreed to disregard residue levels of < 0.05 mg/kg and < 0.02 mg/kg and estimated a maximum residue level of 0.01* mg/kg and STMR and highest residue values of 0 mg/kg.

Olive

Trials on residues in olives have been carried out in Greece, Italy, Spain and the USA (California).

Paraquat is registered for controlling weeds around the base of olive trees at a maximum rate of 1 kg ai/ha, with the number of applications unspecified and a 40-day PHI in Italy and at a maximum rate of 1.14 kg ai/ha, with four applications and a 13-day PHI in the USA. The results of trials conducted in Greece and Spain were reviewed against GAP in Italy.

In trials in Italy, paraquat was applied at rates of 0.54–1.8 kg ai/ha to the base of trees, and olives were harvested from the ground or trees 7–21 days after application. Although the delay was shorter than the recommended PHI of 40 days, the residue levels in the olives were < 0.05 and < 0.1 (two) mg/kg, indicating that at a PHI of 40 days the levels are likely to be < 0.1 mg/kg. No residues (< 0.05 mg/kg) of paraquat were detected in the oil from these fruits.

In one trial in the USA, paraquat was applied four times at an exaggerated rate (5.6 kg ai/ha; 22.4 kg/ha total) and the fruit was harvested from the trees 13 days later for analysis. The residue levels of paraquat were below the LOQ of 0.05 mg/kg, as were the levels in oil and cake prepared from the olives.

In six trials in Spain, olives were harvested from the ground 0, 1 and 7 days after application of paraquat at 0.60 kg ai/ha, simulating the worse-case scenario of collecting olives intended for oil production. In these trials, the application rate was 60% of the maximum allowed in Italy, but the olive fruit were harvested much earlier than the PHI of 40 days. The residue levels in whole fruit were 0.64–10 mg/kg, indicating that there had been transfer of paraquat from the sprayed weeds to the olives. In all the oil produced from these samples, however, the maximum residue levels of paraquat were 0.06 mg/kg, indicating that paraquat is not extracted into oil, as might be expected from its chemical nature.

In other trials in Spain, mature olives were sprayed directly on the ground with paraquat at rates of 0.36–1.3 kg/ha, and the fruit was analysed 3–17 days after application. The residue levels of paraquat in the olives were 0.08–4.4 mg/kg. Residues of paraquat did not transfer to extracted oil, and washing appeared to reduce the levels on the fruit.

In one trial in Greece, mature olives were sprayed directly with paraquat at a rate of 1.0 kg ai/ha to simulate direct spraying on fallen fruit in collection nets during weed control. No residues were found at levels above the LOQ (0.05 mg/kg) in oil extracted from treated fruit harvested 5 days after application.

Olives for oil production are often harvested from the ground and paraquat used for weed control may occasionally be applied directly to the fallen fruit on the ground. The whole fruit will contain some paraquat residue, either through transfer from treated vegetation or through direct spraying. Although the olives may contain relatively high levels of paraquat, no transfer of paraquat to oil occurs. This practice is not in compliance with GAP for olives.

The residue levels in olives taken directly from trees were: < 0.05 and < 0.10 mg/kg (two). In another trial, the level was < 0.05 mg/kg in olives taken from ground that had not been directly sprayed. The residue levels in one US trial conducted at five times the usual rate were below the LOQ of 0.05 mg/kg, indicating that when paraquat is applied in accordance with GAP no residues are expected to occur in olive fruit. The Meeting estimated a maximum residue level of 0.1 mg/kg to replace the previous recommendation for olive at 1 mg/kg. The Meeting also estimated an STMR of 0.05 mg/kg and a highest residue level of 0.1 mg/kg.

Assorted tropical fruits minus inedible peel

Trials on residues were carried out on *passion fruit* in Hawaii, USA, at an application rate of 1.12–4.48 kg ai/ha, to control weeds. Fruit was harvested 1–28 days after application. GAP in the USA for use on passion fruit is a maximum rate of 1.05 kg ai/ha, with an unspecified number of applications and PHI. The residue level in whole fruit in a trial complying with the maximum GAP was 0.13 mg/kg. After application at a rate higher than the maximum GAP, residue levels of up to 0.19 mg/kg were found in whole fruit. The levels in the edible pulp of all passion fruits analysed in the trials, regardless of PHI, ranged from < 0.01 to 0.02 mg/kg at 1.12 kg ai/ha and from < 0.01 to 0.06 mg/kg at higher rates. Higher levels were found in peel than in the edible portion.

Trials on residues were carried out on *kiwifruit* in California, USA, at an application rate of 0.56–2.24 kg ai/ha, three times, to control weeds. Fruit was harvested 7–14 days after the last application. The US GAP for kiwifruit is a maximum rate of 1.14 kg ai/ha, with the number of applications unspecified and a 14-day PHI. The residue level in kiwifruit in one trial conducted in accordance with the maximum US GAP was < 0.01 mg/kg. Even at a higher application rate or a shorter PHI, the levels were below the LOQ of 0.01 mg/kg.

Trials on *guava* were carried out in two locations in Hawaii, USA, with three different application rates of 1.12–4.48 kg ai/ha at each location. Fruit was harvested 1–28 days after application. The US GAP for guava is identical to that for passion fruit. The residue levels of paraquat in all edible pulp and peel analysed were below the LOQ of 0.01 mg/kg at the maximum GAP rate and at rates up to four times the maximum GAP. No residue was found at levels above the LOQ of 0.01 or 0.02 mg/kg in juice, discarded skin or seed obtained from guava treated at 1.12 or 4.48 kg/ha with a 6-day PHI. Although no information was available on residues in whole fruit, levels above the LOQ were not expected in whole fruit in view of the residue situation in pulp, peel and other fractions.

Trials were carried out on *banana* in Honduras, with three applications of paraquat at 1.4 kg ai/ha or a single application at double this rate, to control weeds in established plantations. Fruit was harvested 0–90 days after the last application. As no information was available on GAP in Honduras, the data were reviewed against GAP of the USA (maximum rate of 1.14 kg ai/ha). The residue levels of paraquat in flesh (0- and 3-day PHI) and whole fruit (≥ 7-day PHI) were below the LOQ (0.01 mg/kg) in three trials, except in skin from fruit harvested immediately after application.

Except in the trials on passion fruit, the residue levels in tropical fruits in 10 trials conducted according to the respective GAP were all below the LOQ (< 0.01 mg/kg). The Meeting estimated a maximum residue level for paraquat in assorted tropical fruits with inedible peel, excluding passion fruit, of 0.01* mg/kg. The Meeting decided to withdraw the previous recommendation for passion fruit.

The residue levels in edible portions of these fruit were below the LOQ: ≤ 0.01 (11) mg/kg. The Meeting estimated STMR and highest residue values for paraquat in assorted tropical fruits minus inedible peel, excluding passion fruit, of 0.01mg/kg.

Bulb vegetables

Trials on residues were conducted on *onion* in Canada, Germany and the United Kingdom in the 1960s. Paraquat is registered in the USA for pre-plant or pre-emergence application to onion in a limited number of states at a maximum rate of 1.14 kg ai/ha, with one application and a 60-day PHI (200 days in California). Uses on bulb vegetables are not included in the label in the United Kingdom.

In one Canadian trial at twice the GAP rate and with a shorter PHI (36 days), the residue levels were below the LOQ of 0.01 mg/kg. In another Canadian trial at an application rate of 1.12 mg/kg, the levels were also < 0.01 mg/kg, but the PHI was 143 days.

Trials were conducted in Germany for post-emergence directed application and for harvest aid uses, but there was no related GAP.

In one trial conducted in the United Kingdom of pre-emergence application on spring onion, the residue level was 0.02 mg/kg, but the application rate was > 30% higher than the maximum rate allowed in the USA. A further trial on spring onion involved directed post-emergence application, for which no information on GAP was available.

The Meeting concluded that there were insufficient data to recommend a maximum residue level for paraquat in onion bulb or bulb vegetables.

Brassica vegetables

Residue trials were carried out on *broccoli* in Canada; *Brussels sprouts* in The Netherlands (harvest aid); *cabbage* in Canada, Japan, Spain and the USA; and *cauliflower* in Canada. Paraquat was applied once or twice at 0.67–2.2 kg ai/ha for inter-row weed control, and the crop was harvested 5–52 days after the last application.

Paraquat is registered for use in the cultivation of *Brassica* vegetables during seed-bed preparation as a pre-plant or pre-emergence treatment, or applied as a post-emergence directed or guarded spray for inter-row weed control. GAP in Japan is a maximum rate of 0.36 kg ai/ha, with three applications and a 30-day PHI, for broccoli, cabbage, cauliflower and Chinese cabbage as pre-plant inter-row applications. GAP in the USA is a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified, for *Brassica* vegetables as pre-plant, pre-emergence treatment.

In trials conducted on broccoli, cabbage and cauliflower in Canada, the residue levels were below the LOQ of 0.01 mg/kg, even when applied at double the rate. The exception was one trial in Canada in which cabbage harvested 51 days after treatment at twice the rate contained a residue level of 0.06 mg/kg. The residue levels were < 0.01 (two) and 0.06 mg/kg.

In two trials conducted on cabbage in Japan, the residue levels were below the LOQ of 0.03 mg/kg even after application at a higher rate of 0.96 kg ai/ha and a shorter PHI of 5 days. At a highly exaggerated rate of 19.2 kg ai/ha but with only one application and a longer PHI of 52 days, the residue levels were also < 0.03 mg/kg.

No information was available on GAP that would allow evaluation of trials conducted in Spain.

Trials on Chinese cabbage were conducted in the USA in which paraquat was applied once as pre-emergence treatment at 1.05 kg ai/ha, followed by three post-emergence directed applications at 0.56 kg ai/ha. The residue levels were < 0.05 and 0.07 mg/kg. The US label allows only pre-plant and pre-emergence applications.

Trials on Brussels sprouts in The Netherlands involved a direct harvest aid application to the vegetable. In these trials, the unwashed vegetable contained a residue level of 7.3 mg/kg after 31 days, while washed vegetable had a reduced level of 1.6 after 31 days. Harvest aid desiccation was not, however, included in the labels provided to the Meeting.

The residue levels in these crops in trials that followed GAP and in trials that showed residue levels below the LOQ were, in ranked order: < 0.01 (two), < 0.03 (two) and 0.06 mg/kg. The Meeting concluded that there were insufficient data for estimating a maximum residue level for *Brassica* vegetables.

Fruiting vegetables

Numerous residue trials were carried out on tomatoes in Canada and the USA, on cucumbers, melons and summer squash in the USA and on peppers in Canada and the USA.

Paraquat is registered in the USA for use on tomatoes for pre-plant or pre-emergence application at a maximum rate of 1.14 kg ai/ha, with an unspecified number of applications and a 30-day PHI; on tomatoes for post-emergence directed spray at a maximum rate of 0.55 kg ai/ha, with an unspecified number of applications and a 30-day PHI; on peppers by directed spray application at a maximum rate of 0.55 kg ai/ha, with three applications and no PHI; and on other fruiting vegetables for pre-plant or pre-emergence application at a maximum rate of 1.14 kg ai/ha, with unspecified number of applications and PHI.

The trials in Canada on *tomatoes* were for pre-emergence or pre-planting weed control, in which paraquat was used at a low rate of 0.11 kg ai/ha. Trials on tomatoes in the USA involved post-emergence directed application at 0.56–2.24 kg/ha and an exaggerated single high pre-emergence application at a rate of 11.2 kg ai/ha or pre-emergence application of 1.12 kg ai/ha followed by three inter-row directed applications at 2.8 kg ai/ha. Although samples were harvested 21 days after treatment, 30% shorter than the PHI in US GAP of 30 days, the residue levels in tomatoes were below the LOQ of 0.01 mg/kg after application at 0.56 kg ai/ha for post-emergence directed application, except in one trial in which levels up to 0.04 mg/kg were found. After application at exaggerated rates, the residue levels were still below the LOQ of 0.005 or 0.01 mg/kg or at a maximum of 0.02 mg/kg.

The residue levels in trials following GAP or conducted at higher application rates were, in ranked order: < 0.005 (two), < 0.01 (seven) and 0.04 mg/kg.

The trials on *sweet peppers* were for use of paraquat in inter-row weed control at 0.56–2.2 kg ai/ha. The residue levels in trials at maximum GAP were < 0.01 and 0.01 mg/kg. The levels after exaggerated application rates were either below the LOQ of 0.01 mg/kg, 0.03 mg/kg (once at 1.12 kg ai/ha pre- emergence and four times at 1.12 or 2.24 kg ai/ha post-emergence applications) or 0.02 mg/kg (one trial).

The Meeting considered it appropriate to evaluate residues in tomato and peppers together for estimating the maximum residue level for fruiting vegetables, other than cucurbits. The combined levels were: < 0.005 (two), < 0.01 (eight), 0.01 and 0.04 mg/kg. The Meeting estimated a maximum residue level for fruiting vegetables, other than cucurbits, of 0.05 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.04 mg/kg.

In trials on *cucumbers*, *melons* and *summer squash* in California (USA), paraquat was applied at 1.12 kg ai/ha pre-emergence, followed by three inter-row applications at 0.56 kg ai/ha. While US GAP allows pre-emergence application at a maximum of 1.12 kg ai/ha, the residue levels of paraquat in all 12 trials were below the LOQ of 0.025 mg/kg. The Meeting estimated a maximum residue level for cucurbits of 0.02 mg/kg and STMR and highest residue values of 0 mg/kg.

Leafy vegetables

Trials for residues were conducted on lettuce in Canada, Germany, Spain, the United Kingdom and the USA, on kale in France, Italy and the United Kingdom and on turnip greens in the USA.

Paraquat is registered for pre-emergence application on collard and lettuce in the USA at a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified. Uses on leafy vegetables are not included on labels in Italy or the United Kingdom.

Trials on residues on *lettuce* were conducted in Canada, Germany, Spain, the United Kingdom and the USA at application rates of 0.42–2.24 kg/ha; lettuce was sampled 0–147 days after application. In trials conducted in Canada and the USA following US GAP, the residue levels in untrimmed head or bunch were 0.01, 0.04 and 0.05 mg/kg.

The results of trials in the United Kingdom were evaluated against US GAP, as the uses were similar in trials in the two countries. The residue levels in unwashed lettuce head in trials following US GAP were < 0.01, 0.01 and 0.02 mg/kg.

Residue levels up to 1.4 mg/kg were found in German trials on lettuce harvested immediately after one or two applications of paraquat for post-emergence inter-row weed control. The residues were believed to have derived from spray drift onto the outer leaves. In most of these trials, the whole lettuce head was analysed without removal of outer wrapper leaves that were yellow and withered. The residue levels had declined to close to the LOQ (< 0.01 mg/kg) by 21 days after harvest. The results of trials in Germany and Spain could not be evaluated as no information on GAP in Europe was available.

Residue trials on *kale* were carried out in France, Italy and the United Kingdom at rates of 1.0–2.24 kg/ha, and kale was sampled 0–147 days after application. As no information was available on GAP in Europe, these data were not evaluated.

Six trials on *turnip greens* were carried out in the USA at a rate of 1.12 kg/ha, with sampling 55–128 days after application. The levels of paraquat residue were < 0.025 (three), 0.03, 0.04 and 0.05 mg/kg.

As the US GAPs for collard and lettuce are identical and the residue situations for these crops were similar, the Meeting considered it appropriate to combine the results for estimating a maximum residue level for leafy vegetables. The combined residue results, in ranked order were: < 0.01, 0.01 (two), 0.02, <u>< 0.025</u> (three), 0.03, 0.04 (two) and 0.05 (two) mg/kg. The Meeting estimated a maximum residue level for paraquat in leafy vegetables of 0.07 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 0.05 mg/kg.

Legume vegetables and pulses

Residue trials were conducted on beans (with pod and dry) in Canada, Germany, Italy, The Netherlands and Spain, on broad beans in Spain, on peas in Australia, Canada and the USA, and on soya beans in Brazil and the USA.

Paraquat is registered for weed control and harvest aid on legume vegetables and pulses in Australia, Brazil and the USA as follows:

Country	Maximum rate (kg ai/ha)	No. of applications	PHI (days)	Crop	Type of application
Australia	0.2		14	Chickpea	Over-the-top spray
	0.2		14	Field pea	Over-the-top spray
	0.43			Soya bean	Pre-plant
Brazil	0.6	1	7	Soya bean	Pre-plant
	0.5	1	7	Soya bean	Desiccation

Country	Maximum rate (kg ai/ha)	No. of applications	PHI (days)	Crop	Type of application
USA	1.14		–	Beans (lima, snap)	Pre-plant, pre-emergence
	1.14		–	Pea	Pre-plant, pre-emergence
	0.55	2	7	Pulses	Harvest aid
	1.14		–	Soya bean	Pre-plant or pre-emergence
					Should not exceed 1.9 l per season
	0.14	2	–	Soya bean	Post-emgence directed spray
					Second and final application 7–14 days later if needed
	0.28		15	Soya bean	Harvest aid

Uses on legumes and pulses were not included in the European labels provided to the current Meeting.

Residue trials were carried out on *dry beans* (genus *Phaseolus*) in Germany, Italy, The Netherlands and Spain, in which paraquat was used for pre-emergence weed control at single application of 0.56 or 2.24 kg ai/ha or post-emergence directed inter-row weeding at rates of 0.28–1.12 kg ai/ha. In trials in Europe, young pods were harvested 0–7 days after treatment and analysed. The residue levels in beans in pods were < 0.05–0.10 mg/kg (five trials). As no related GAP was available, these results were not used in estimating a maximum residue level. The Meeting concluded that there were insufficient data to estimate a maximum residue level for legume vegetables.

The residue levels of paraquat in dry beans in Canadian trials after pre-emergence application following GAP were < 0.01 (two), < 0.05 and 0.07 mg/kg.

Residue trials were conducted on *broad beans* in Spain after post-emergence directed spray. The residue levels in seeds harvested on the day of application were < 0.05 mg/kg (two); however, no information was available on related GAP.

Residue trials were carried out on *peas* in Canada and the United Kingdom with paraquat used for pre-emergence weed control at single applications or post-emergence directed inter-row weeding at rates of 0.14–1.68 kg ai/ha and harvesting 55–152 days after application. The residue levels of paraquat in seeds were below the LOQ of 0.01 or 0.05 mg/kg in trials with post-emergence application; however, no GAP was available for post-emergence application on peas.

Paraquat was applied at 0.20 or 1.12 kg ai/ha to field peas and chick peas as a harvest aid desiccant in Australia and the USA, with samples taken 1–38 days after application. The resulting residues of paraquat in seed in trials following GAP were found at levels of: 0.05, 0.15, 0.23, 0.25, 0.31 and 0.41 mg/kg.

A number of trials were conducted on *soya beans* in Brazil between 1981 and 1983 with a harvest aid desiccation application of paraquat at 0.25–0.80 kg/ha and sampling 2–21 days after application. The residue levels of paraquat in seed in trials following GAP in Brazil were: < 0.02, 0.03 (two), < 0.05 (two), 0.07, 0.08, 0.09, 0.10, 0.11 (two), 0.13, 0.16 (two) and 0.28 (three) mg/kg.

In trials conducted in the USA with pre-emergence application with or without a post-emergence directed application at 0.14–1.4 kg/ha, the residue levels of paraquat in soya beans harvested 3–147 days after the last application in trials following GAP were < 0.025 (nine) and 0.03 mg/kg.

Other trials were conduced in the USA on harvest aid desiccation application at 0.28 or 0.56 kg/ha and sampling 6–36 days after application. The residue levels of paraquat in seeds in trials following GAP were: < 0.01, 0.02 (four), 0.03 (two), 0.04 (two), 0.05, 0.06, 0.07, 0.08 (two), 0.09, 0.12 and 0.13 mg/kg. The hulls of treated soya beans contained higher residues than seeds.

The results of these trials clearly indicate that the levels of residues arising from harvest desiccant uses are higher than those from pre-emergence or post-emergence application.

The Meeting considered it appropriate to combine the results of trials on field peas and chick peas in Australia and on soya beans in Brazil and the USA in which paraquat was used as a harvest aid desiccant to estimate a group maximum residue level for pulses. The combined residue levels in seeds were, in ranked order: < 0.01 (two), < 0.02, 0.02 (four), 0.03 (four), 0.04 (two), < 0.05 (two), 0.05 (two), 0.06, 0.07 (two), 0.08 (three), 0.09 (two), 0.10, 0.11 (two), 0.12, 0.13 (two), 0.15, 0.16 (two), 0.23, 0.25, 0.28 (three), 0.31 and 0.41 mg/kg. The Meeting estimated a maximum residue level of 0.5 mg/kg to replace the previous recommendation for soya bean and an STMR of 0.08 mg/kg and a highest residue level for pulses of 0.41 mg/kg.

Root and tuber vegetables

Paraquat is registered for use at a maximum rate of 0.36 kg ai/ha with three applications and a 30-day PHI in Japan for pre-plant, inter-row application on carrot and in the USA at a maximum rate of 1.14 kg ai/ha for pre-emergence treatment of root and tuber vegetables excluding potatoes.

Two residue trials carried out on *beetroot* in Canada and the United Kingdom for pre-emergence application in compliance with US GAP resulted in residue levels of < 0.01 and 0.03 mg/kg.

Residue trials were conducted in the United Kingdom on beetroot and *sugar-beet* in which paraquat was used pre-sowing or pre-emergence at 1.68 kg ai/ha, followed by two directed inter-row applications at 2.24 kg ai/ha after crop emergence. No information was available, however, on GAP for post-emergence application from Europe.

In trials conducted in four states of the USA with pre-emergence application at 1.12 kg ai/ha, the residue levels in sugar-beet roots harvested 136–178 days after application were < 0.05 mg/kg (six) after a single pre-emergence application at 1.12 kg ai/ha. After application at an exaggerated rate of 5.6 kg ai/ha, the residue levels in unwashed root were < 0.05 mg/kg.

Residue trials on *carrots* with use of paraquat for pre-emergence or inter-row weed control have been carried out in Canada, Japan, Germany and the United Kingdom. The residue levels of paraquat in carrot in the Japanese trials after both pre-emergence and inter-row applications were all below the LOQ of 0.03 mg/kg, despite a shorter PHI or use of a highly exaggerated rate of 19.2 kg ai/ha. The residue levels in carrot in four trials following GAP or conducted at higher rates or shorter PHI were < 0.03 mg/kg. In Canadian trials, the residue levels were below the LOQ of 0.01 mg/kg, even in one trial in which the rate was doubled and the PHI shorter.

As no information was available on GAP in Europe, the data from German trials with post-emergence application were not considered in estimating the maximum residue level.

Residue trials were carried out on *parsnips* and *swedes* in the United Kingdom and on *turnips* in Canada and United Kingdom with use of paraquat for pre-emergence weed control (Canada) or pre-emergence followed by inter-row weed control (United Kingdom). The rates of application were 0.56–2.24 kg ai/ha. Turnip, swede and parsnip roots were harvested 49–122 days after application. The residue levels of paraquat in turnips in two Canadian trials that followed US GAP were < 0.01 mg/kg. No information on GAP was available for post-emergence application in Europe.

One trial was conducted in France on *black salsify*, in which paraquat was applied as an inter-row treatment at 0.5 and 0.8 kg ai/ha. There were no residues (< 0.02 mg/kg) in salsify roots harvested 8 and 80 days after treatment; however, no information on GAP was available.

The combined residue levels in beetroot, sugar-beet, carrots and turnips were, in ranked order: < 0.01 (four), < 0.03 (four), 0.03 (two) and < 0.05 (six) mg/kg.

Potato

Trials were carried out on potatoes in Canada, Germany, the United Kingdom and the USA for pre-emergence, post-emergence and harvest aid applications of paraquat.

Paraquat is registered in the United Kingdom for pre-emergence use at a maximum rate of 0.66 kg ai/ha with one application. It is registered in the USA for pre-plant and pre-emergence broadcast application at a maximum rate of 0.55 kg ai/ha and for broadcast application for pre-harvest vine killing and weed dessication at a maximum rate of 0.42 kg ai/ha with a 3-day PHI. The latter application is restricted to fresh market produce, with a restriction of 2.3 l/ha per season; split applications must be applied a minimum of 5 days apart.

Trials were carried out in Germany with post-emergence directed application. The residue levels were below the LOQ of 0.01 mg/kg.

Several residue trials were carried out in Canada and the USA in which paraquat was applied for weed control by pre-emergence or post-crop emergence application at a rate of 0.20–1.12 kg ai/ha. The residue levels in the tubers in trials following US GAP were < 0.01 (eight) and 0.02 mg/kg. At double the application rate, the residue levels were below the LOQ of 0.01 mg/kg.

Trials were also carried out on harvest aid desiccant use in Canada, the United Kingdom and the USA. The US label allows use of paraquat for vine killing and weed desiccation at a maximum of 0.42 kg ai/ha, with a PHI of 3 days, but in these trials rates equivalent to or higher than twice the maximum rate or a much longer PHI were used. Harvest aid use is not included in the United Kingdom label.

The residue levels in trials of pre- and post-emergence application were < 0.01 (eight) and 0.02 mg/kg. The levels in trials with double the application rate in the USA and in trials conducted in Germany were all below the LOQ.

The Meeting decided to combine the results from trials on beetroot, sugar-beet, carrot, turnip and potato. The combined residue levels, in ranked order, were: < 0.01 (12), <u>0.02</u>, < 0.03 (four), 0.03 (two) and < 0.05 (six) mg/kg. The Meeting estimated a maximum residue level of 0.05 mg/kg, an STMR of 0.02 mg/kg and a highest residue level of 0.05 mg/kg for root and tuber vegetables. The maximum residue level replaces the previous recommendation for potato.

Stem vegetables

Residue trials have been carried out on asparagus, celery and globe artichokes in Canada and the USA with use of paraquat for post-emergence directed inter-row weeding at rates of 1.12–3.25 kg ai/ha in a single application. Three applications of 1.12 or 1.35 kg/ha on artichokes were also tested.

Paraquat is registered in the USA for *asparagus* at a maximum rate of 1.14 kg ai/ha for pre-plant and pre-emergence broadcast or banded over-row application and at the same maximum rate with a 6-day PHI for asparagus more than 2 years old by broadcast or banded over-row application. The residue levels were < 0.02 (two) and < 0.05 mg/kg.

Although trials were conducted on *celery* in Canada and on *artichoke* in the USA, no information on GAP for these crops was available. The Meeting concluded that the data were insufficient for estimating a maximum residue level for asparagus.

Cereal grains

1.1 Maize

Residue trials were conducted on maize in Canada, Italy, the United Kingdom and the USA with pre- and post-emergence applications and harvest aid uses.

Paraquat is registered for use in the USA at a maximum rate of 1.14 kg ai/ha for pre-plant or pre-emergence broadcast of banded over-row applications and at a maximum rate of 0.55 kg ai/ha for post-emergence directed spray. Residue trials were conducted with use of paraquat for pre-emergence weed control or for post-emergence directed spray in Canada and the USA at rates of 0.28–1.12 kg ai/ha.

In a series of trials in the USA in 1987, one pre-emergence application at 1.12 kg ai/ha and two post-emergence applications at 0.31 kg ai/ha were made. Although the post-emergence application rate was not as high as the maximum rate, the pre-emergence application rate was the maximum allowed for pre-emergence application. The Meeting considered that these trials were conducted in accordance with US GAP. The residue levels in trials in Canada and the USA conducted in accordance with US GAP were: < 0.01 (eight) and < 0.025 mg/kg (16). In trials with higher application rates (up to four times), the residue levels were below the LOQ. The levels in maize cobs were also below the LOQ of 0.01 mg/kg (two trials).

In two residue trials in Italy, paraquat was applied pre-emergence at 0.92 kg ai/ha. The residue levels in cob were < 0.05 mg/kg; however, no analysis of kernels or grain was reported.

Trials were conducted in South Africa and the United Kingdom with post-emergence application; however, owing to the lack of relevant GAP for South Africa and the fact that post-emergence application is not included on the label in the United Kingdom, the results of these trials could not be evaluated by the Meeting.

Several trials were conducted in the USA on use of paraquat as a harvest aid desiccator at rates of 0.56–1.12 kg/ha. This use is not included in US GAP, although it is allowed in Argentina, Brazil and Uruguay.

On the basis of the residue levels in maize grain in trials with paraquat applied pre- or post-emergence in Canada and the USA, < 0.01 (eight) and < <u>0.025</u> mg/kg (16), the Meeting estimated a maximum residue level of 0.03 mg/kg to replace the previous recommendation for maize and STMR and highest residue values of 0.025 mg/kg.

Sorghum

A number of residue trials were conducted in the USA, where paraquat is registered for use on sorghum at a maximum rate of 1.14 kg ai/ha, with a PHI of 48 days for grain and 20 days for forage, for pre-plant or pre-emergence broadcast application, and at a maximum rate of 0.55 kg ai/ha in two applications with the same PHIs for post-emergence directed spray. In the latter application, the applications must not exceed 2.5 l per season.

Several residue trials were carried out in the USA in several years and locations, in which paraquat was applied for weed control, either pre-emergence, post-crop emergence directed or as a harvest aid, at rates of 0.21–7.8 kg ai/ha. Samples were taken 20–131 days after pre-emergence or post-emergence directed application. The residue levels in grain in 12 trials conducted in accordance with maximum GAP for pre-emergence or post-emergence applications were all <u>< 0.025</u> mg/kg. When both pre- and post-emergence applications were made, if the post-application rate was in compliance with GAP, the residue results were taken into consideration in estimating the maximum residue level. In one trial with one pre-emergence application at 0.56 kg ai/ha followed by a post-emergence application at 0.56 kg ai/ha, a residue level of 0.01 mg/kg was found.

In harvest aid desiccation applications, paraquat was applied at a rate of 0.21–2.8 kg/ha, and sorghum was sampled 7–49 days after application. Harvest aid desiccant use is not included on the US label.

The Meeting estimated a maximum residue level of 0.03 mg/kg to replace the previous recommendation and STMR and highest residue values of 0.025 mg/kg for sorghum.

Rice

Trials on residues of paraquat on rice were conducted in Guatemala, Italy and the USA. Paraquat is registered for use on rice in the USA by pre-plant or pre-emergence broadcast at a maximum rate of 1.14 kg ai/ha, with no PHI specified.

Two trials were conducted in Italy in 1993, in which paraquat was applied at a rate of 0.92 kg ai/ha to the seed bed 5 days before rice was sown. Rice grain and straw samples taken at harvest did not contain residues of paraquat at levels above the LOQ of 0.05 mg/kg.

Three residue trials were conducted in Guatemala in 1983 in which paraquat was applied as a pre-emergence treatment at rates of 0.30 and 1.0 kg ai/ha to rice. Rice grain and straw samples were taken at harvest. The residues in de-husked rice in one trial conducted in compliance with the maximum rate in US GAP were < 0.05 mg/kg, but residues in rice grain were not analysed.

Residue trials were conducted in the USA in 1978 and 1982 in which paraquat was applied as a pre-emergence treatment at rates of 0.56 and 1.12 kg ai/ha to rice. In trials conducted at the maximum GAP, the residue levels in rice grain were below the LOQ of 0.01 (two) or 0.02 mg/kg. No trials were conducted at rates higher than the maximum allowed in US GAP for rice.

The Meeting concluded that there were insufficient data to estimate a maximum residue level and withdrew the previous recommendation for rice and rice, polished.

Tree nuts

It is common practice to harvest nuts from the ground, and this may result in residues of paraquat in the nuts.

Supervised residue trials were carried out over a number of years in Italy on *hazelnuts* and in the USA on *almonds* (California), *macadamia nuts* (Hawaii), *pecans* (Alabama and Texas), *pistachio nuts* (California) and *walnuts* (California).

Paraquat is registered for use on hazelnuts in Italy at a maximum rate of 1 kg ai/ha with a 40-day PHI and on walnuts at the same maximum rate but with no PHI specified. In the USA, paraquat is registered for use on pistachio nuts at a maximum rate of 1.14 kg ai/ha with a 7-day PHI, with the proviso that no more than two applications should be made after the nuts have split. It is registered for use in the USA on other tree nuts at the same maximum rate with no specification of the number of applications or PHI.

Two trials were conducted in Italy in which hazelnuts were harvested from the ground 1–10 days after treatment around the base of the trees at rates of 0.54–1.8 kg ai/ha. Although the PHI was shorter than 40 days, the residue levels in shelled nuts were below the LOQ of 0.05 mg/kg in one trial. At almost twice the maximum application rate and with a shorter PHI of 10 days, the levels were still below the LOQ.

In a trial in the USA, paraquat was applied at rates of 0.56–4.5 kg ai/ha one to eight times, to control weeds under mature nut trees. In some cases, applications were made over 2 years. Nuts were harvested, in some cases immature, 1–171 days after the last application. The residue levels in shelled nuts in trials following GAP were: < 0.01 (seven), 0.01, 0.02 and < 0.05 (three) mg/kg.

The combined results of all the trials, in ranked order, were: < 0.01 (seven), 0.01, 0.02 and < 0.05 (four) mg/kg. The Meeting estimated a maximum residue level for paraquat in tree nuts of 0.05 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.05 mg/kg.

Oil seeds

Cotton-seed

Paraquat is registered for use on cotton in the USA at a maximum rate of 1.14 kg ai/ha, with no specification of the number of applications of PHI, for pre-plant or pre-emergence treatment, and at a maximum rate of 0.55 kg ai/ha, with repeated application if necessary and a 3-day PHI as a harvest aid, with the proviso that a total of 1.5 l should not be exceeded in this use.

Residue trials were conducted in the USA over several years and locations, involving pre-emergence applications at 1.12 kg/ha and harvesting 4–176 days after application. The residue levels in fuzzy seed in trials at the maximum GAP were < 0.01 (four) and 0.04 mg/kg.

In numerous trials with pre-emergence application followed by harvest aid desiccation application or a single application as harvest aid desiccant, the residue levels of paraquat in fuzzy seed in trials following maximum GAP were: 0.07, 0.09, 0.15, 0.16 (two), 0.18, 0.21, 0.23, 0.30, 0.34, 0.35, 0.38, 0.44, 0.46, 0.49, 0.50, 0.58 and 2.0 mg/kg. On the basis of residue levels arising from harvest aid uses, the Meeting estimated a maximum residue level for cotton-seed of 2 mg/kg, to replace the previous recommendation, an STMR of 0.34 mg/kg and a highest residue level of 2 mg/kg.

Sunflower seed

In the USA, paraquat is registered for use on sunflower at a maximum rate of 1.14 kg ai/ha with no PHI specified for pre-plant or pre-emergence broadcast or banded over-row application and at a maximum rate of 0.55 kg ai/ha with a 7-day PHI for dessication use.

Trials were conducted with pre-emergence application to sunflowers at 1.12 or 5.6 kg/ha and sampling 41–131 days after application. The residue levels in seeds in four trials conducted in compliance with maximum GAP were < 0.05 mg/kg. When paraquat was applied at five times the maximum recommended rate, the levels were still below the LOQ of 0.05 mg/kg.

In further trials, paraquat was applied as a harvest aid desiccator at 0.28–1.12 kg/ha, and sunflower seeds were harvested 7–21 days after application. The residue levels of paraquat in seeds in trials conducted at maximum GAP were: 0.09, 0.14, 0.15, 0.16 (three), 0.19, 0.22, 0.24, 0.32, 0.35, 0.51, 0.60, 0.74, 0.81 (two) and 0.93 mg/kg. The Meeting used the residue levels arising from harvest aid uses to estimate a maximum residue level for sunflower seed of 2 mg/kg, an STMR of 0.22 mg/kg and a highest residue level of 0.81 mg/kg.

Hops

Residue trials were conducted in Canada and the USA. Paraquat was registered in the USA for use as a directed spray or for suckering and stripping on hops at a maximum rate of 0.55 kg ai/ha in three applications with a 14-day PHI; no more than two applications or applications at no more than 1.5 l/ha were recommended.

In a trial in Canada, a single post-emergence directed application of 1.12 kg ai/ha, which is double the maximum recommended dose, resulted in residue levels of < 0.01 mg/kg in green hops harvested 53 days after application.

In the USA, trials were conducted in the states of Idaho, Oregon and Washington with three post-emergence directed applications of paraquat at 2.8 kg ai/ha. The residue levels of paraquat in dried hops prepared from hops harvested 14 days after the last of three directed application at the maximum GAP rate were 0.05 mg/kg in two trials. At double this rate, the levels in dried hops prepared from green hops harvested 13 or 14 days after the last treatment were below the LOQ of 0.1 mg/kg (0.01 and 0.07 mg/kg). Two applications at higher rates than that of maximum GAP resulted in 0.02 and 0.03 mg/kg in dried hops.

The residue levels in dried hops were 0.05 mg/kg (two). In view of the low levels of residues in the other trials, the Meeting estimated a maximum residue level of 0.1 mg/kg, to replace the previous recommendation, and STMR and highest residue values of 0.05 mg/kg for hops, dry.

Tea, green, black

Residue trials on tea were conducted in India, where paraquat is registered for use for pre-emergence or post-emergence directed application between rows at a maximum rate of 0.75 kg ai/ha in one application, with no PHI specified.

Six trials were conducted at a total application rate of 0.57–2.0 kg ai/ha over 5–6 months. Green tea leaves were harvested 7 or 21 days after blanket application (after the first or last spot application) and processed into black tea, which was analysed. The residue levels of paraquat in black tea from tea plants treated in accordance with GAP in India or at higher rates were almost always below the LOQ of 0.05 mg/kg. In trials conducted in accordance with GAP, the levels in black tea were: < 0.05 (three), 0.07, 0.09 and 0.12 mg/kg.

In other trials in India, with application rates of 0.05–0.06 kg ai/ha, black tea samples from green tea leaves harvested 5 or 7 days after application contained 0.05 mg/kg (one) or < 0.05 mg/kg. As the application rate was much lower than the maximum, these results were not considered in estimating the maximum residue level.

The Meeting estimated a maximum residue level for teas, green, black of 0.2 mg/kg and an STMR of 0.06 mg/kg.

Animal feedstuffs

Soya forage and hay or fodder

Paraquat is registered for use in Australia, Brazil and the USA for weed control andas a harvest aid on soya beans. In the USA, it is registered for use at a maximum rate of 1.14 kg ai/ha for pre-plant or pre-emergence treatment, not to exceed 1.9 l per season, at a maximum rate of 0.14 kg ai/ha as a post-emergence directed spray with a second and final application 7–14 days later; it can also be used at a maximum rate of 0.28 kg ai/ha with a 15-day PHI as a harvest aid.

The residue levels in forage in trials conducted in the USA in accordance with US GAP were: < 0.025 (12), < 0.05 (13), 0.05, 0.06 (four), 0.07, 0.08, 0.15, 0.28 and 1.8 mg/kg, expressed on a dry weight basis.

The Meeting estimated a maximum residue level for soya bean forage (green) of 2 mg/kg, an STMR of 0.05 mg/kg and a highest residue level of 1.8 mg/kg.

The residue levels in hay or fodder in trials conducted in accordance with US GAP were: < 0.025 (five), 0.04, < 0.05 (four), 0.05, 0.1, 0.2 and 0.3 mg/kg, on a dry weight basis. The Meeting estimated a maximum residue level for soya bean fodder of 0.5 mg/kg, an STMR of 0.05 mg/kg and a highest residue level of 0.3 mg/kg.

Sugar-beet tops

Trials were conducted on beet and sugar-beet in the United Kingdom and the USA. The residue levels in sugar-beet tops in six trials conducted in accordance with US GAP were < 0.025 mg/kg, on a fresh weight basis. The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.11 mg/kg. On the basis of 23% dry matter and a highest residue level on a fresh weight basis of 0.025

mg/kg, the Meeting calculated the highest residue level on a dry weight basis to be 0.11 mg/kg. As there is no code for sugar-beet tops, the maximum residue level was recommended for fodder beet leaves and tops.

Maize forage and fodder

Trials were conducted in Italy and the USA. The residue levels in maize forage in trials in the USA conducted in accordance with US GAP were < 0.025 (eight), 0.09, 0.6, 2 (two) and 3 (two) mg/kg on a dry weight basis. The Meeting estimated a maximum residue level for maize forage of 5 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 3 mg/kg.

The levels of residues in silage were mostly below the LOQ of 0.025 or 0.05 mg/kg, except in one trial in which levels up to 0.04 mg/kg were found.

The residue levels in maize fodder in trials in the USA conducted in accordance with US GAP were: < 0.025 (eight), 0.03, 0.05, 0.06, 0.2, 1, 2 and 6 mg/kg on a dry weight basis. The Meeting estimated a maximum residue level for maize fodder of 10 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 6 mg/kg.

Sorghum forage (green) and straw and fodder, dry

In trials conducted in the USA in accordance with GAP, the residue levels in sorghum forage were: < 0.025 (six), 0.025 (three), 0.04, 0.06 and 0.2 mg/kg. The Meeting estimated a maximum residue level for sorghum forage (green) of 0.3 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 0.2 mg/kg.

The residue levels in sorghum fodder or hay (whichever gave higher levels) in trials conducted in accordance with GAP were: < 0.025 (four), 0.03, 0.04, 0.05, 0.06 (two), 0.09, 0.1 and 0.2 mg/kg. The Meeting estimated a maximum residue level for sorghum straw and fodder, dry, of 0.3 mg/kg, an STMR of 0.035 mg/kg and a highest residue level of 0.2 mg/kg.

Rice straw and fodder, dry

The Meeting concluded that there were insufficient data for estimating a maximum residue level for rice straw and fodder, dry.

Almond hulls

In three trials conducted in the USA in accordance with GAP, the residue levels in almond hulls were < 0.01 mg/kg. The Meeting estimated maximum residue, STMR and highest residue values of 0.01 mg/kg.

Cotton fodder

The Meeting concluded that there were insufficient data for estimating a maximum residue level for cotton fodder.

Fate of residues during processing

Numerous studies of residue levels after processing conducted in conjunction with supervised trials were submitted. Residue levels found after processing of raw agricultural commodities into animal feedstuffs are described in the section above. Some processed commodities for which maximum residue levels and STMR-Ps were estimated are also described in that section.

In this section, processing factors from raw commodities to processed food products and by-products are discussed. Information on processing was provided for orange, plum, grape, olive, tomato, sugar-beet, maize, sorghum, cotton-seed, sunflower seed and hop. Processing factors could not be reliably calculated for the processing of orange, plum, grape, tomato and sugar-beet because the paraquat residue levels in both raw commodities and processed products were all below the respective LOQs.

Processing factors were calculated for olive (oil), potato (crisps and granules), maize (milling fractions and oil), sorghum (milling fractions), cotton-seed (trash, gin products and oil), sunflower seed (oil) and hop (dried hop and beer) and are shown below.

Commodity	Processing factor	STMR-P (mg/kg)
Olive		0.05
Unwashed olives before processing	0.57	
Washed olives before processing	< 0.43	
Virgin oil	< 0.35	0.018
Refined oil	< 0.35	0.018
Potato		0.02
Wet peel	> 1.9	0.04
Dry peel	> 11	0.22
Peeled potato	0.27[a]	0.01
Crisps	> 0.95	0.02
Granules	> 2.7	0.05
Maize		0.025
Wet milling		
Coarse starch	< 0.25[a]	0.006
Starch	< 0.25[a]	0.006
Crude oil	< 0.25[a]	0.006
Refined oil	< 0.25[a]	0.006
Dry milling		
Germ	0.3[a]	0.0075
Grits	0.25–0.5[a]	0.0006–0.013
Coarse meal	1[a]	0.025
Meal	0.5[a]	0.013
Flour	1.5[a]	0.038
Crude oil	< 0.25[a]	0.006
Refined oil	< 0.05[a]	0.001
Sorghum		0.025
Hulled grain	0.07[a]	0.002
Dry milled bran	3.9	0.097
Coarse grits	0.17	0.004
Flour	0.14	0.004
Wet milled bran	2.3	0.058
Starch	0.07	0.002
Shorts	2.6	0.065
Germ	0.52[a]	0.013
Cotton (from cotton including trash and bolls)		
Fuzzy seed	0.08	0.34
Crude oil	< 0.006	0.01[b]
Meal	< 0.009	0.04
Sunflower seed		0.3
Hulls	2.8[a]	0.64
Meal	0.05[a]	0.01
Oil	< 0.05[a]	0 [b]
Hop		

Commodity	Processing factor	STMR-P (mg/kg)
Dry cones	1.2	0.05 [b]
Beer	< 0.28	0.0001[c]

[a] Based on only one trial.
[b] Estimated from supervised trials
[c] Calculated from a factor of 0.0001

The STMR values for processed products from raw commodities with no residues or for which the results of many supervised trials were available were estimated on the basis of supervised trials.

In four trials in the USA, orange fruit was processed into juice, and the paraquat residues were measured; in all cases, the levels were below the LOQ of 0.01 mg/kg. The residue levels in *orange juice*, including those in trials conducted at rates higher than the maximum application rate, were all below the LOQ of 0.01 mg/kg. The Meeting estimated an STMR-P for orange juice of 0 mg/kg.

No residues of paraquat were found at levels above the LOQ of 0.05 mg/kg in *dried prunes* prepared from plums in two trials. The STMR-P for dried prunes was estimated to be 0 mg/kg.

In a number of trials, olives were processed into oil for analysis of residues. *Olive oil* prepared from olive fruits harvested directly from trees did not contain levels above the LOQ of 0.05 mg/kg. Most samples of olive oil prepared from olive fruits picked up from ground or sprayed directly did not contain paraquat residues at levels above the LOQ; however, in some samples, paraquat residues were found at levels up to 0.06 mg/kg, and fruit harvested at the same time contained 6.8 mg/kg of paraquat residues. As paraquat is unlikely to be transferred into oil owing to its chemical and physical characteristics, its STMR-P is calculated from the processing factor to be 0.018 mg/kg.

Tomato juice and *ketchup* prepared from tomato in trials conducted at an exaggerated rate did not contain paraquat residues at levels above the respective LOQ (0.005 mg/kg for juice and 0.025 mg/kg for ketchup). The STMR values for these products were estimated to be 0 mg/kg.

The residue levels in oil prepared from soya bean treated with paraquat as a harvest aid desiccant in accordance with GAP were below the LOQ of 0.01 mg/kg in five trials. The Meeting estimated an STMR-P for *soya bean oil* of 0.01 mg/kg.

The residue levels in cotton-seed oil, crude, were below the LOQ of 0.01 mg/kg in two trials. The Meeting estimated an STMR-P for *cotton-seed oil* of 0.01 mg/kg and decided to withdraw the previous recommendation for cotton-seed oil, edible.

The residue levels in *sunflower seed oil* obtained from sunflower seed in eight trials conducted at the maximum GAP were < 0.01 mg/kg. Oil obtained from sunflower seed in a trial at double the rate did not contain residues at levels above the LOQ of 0.01 mg/kg. The Meeting estimated an STMR-P for sunflower seed oil of 0 mg/kg and decided to withdraw the previous recommendation for sunflower seed oil, crude and edible.

The residue levels of paraquat in *cotton gin by-product* in trials for harvest aid uses were (including results for cotton harvested 13–17 days after treatment): 5.2, 5.3, 5.9, 6.2, 7.3, 8.0, <u>9.4</u>, <u>11</u>, 12 (two), 18, 23, 32, 34 and 69 mg/kg. The Meeting estimated an STMR-P of 10.2 mg/kg for cotton gin by-products.

As *maize flour* contained a higher concentration of paraquat residues than maize grain in one trial, the Meeting estimated a maximum residue level of 0.05 mg/kg.

Residues in animal commodities

Dietary burden of farm animals

The Meeting estimated the dietary burden of paraquat residues for farm animals on the basis of the diets described in Appendix IX to the *FAO Manual* (FAO, 2002), by summing the contribution of each feed to the residue.

Estimated maximum dietary burden of farm animals

Crop	Residue (mg/kg)	Basis	Group	Dry matter (%)	Residue/ Dry matter (mg/kg)	Dietary content (mg/kg)			Residue contribution (mg/kg)		
						Beef cattle	Dairy cows	Poultry	Beef cattle	Dairy cows	Poultry
Sugar-beet tops	0.025	HR	AV	23	0.11						
Cotton-seed	2	HR	SO	88	2.27	25	25		0.57	0.57	
Cotton gin by-product	10.2	STMR-P		90	11.3	20	20		2.27	2.27	
Maize grain	0.025	HR	GC	88	0.03			80			0.023
Maize forage	3	HR	AF		3	40	50		1.2	1.5	–
Potato, wet peel	0.04	STMR-P	VR	15	0.27						
Sorghum grain	0.025	HR	GC	86	0.03				–		–
Sorgum forage	0.2	HR	AF	–	0.20				–		–
Soya bean	0.41	HR	VD	89	0.46			20			0.092
Soya bean, forage	1.8	HR	AL	–	1.8	15	5		0.27	0.09	–
Soya bean, hay	0.3	HR	AL	–	0.3				–		–
Sunflower meal	0.011	STMR-P	AL	92	0.01	–	–	–	–	–	–
Turnip tops	0.05	HR	VL	30	0.17						
Total									4.30	4.43	0.11

Estimated maximum dietary burden of farm animals

Crop	Residue (mg/kg)	Basis	Group	Dry matter (%)	Residue/ Dry matter (mg/kg)	Dietary content (mg/kg)			Residue contribution (mg/kg)		
						Beef cattle	Dairy cows	Poultry	Beef cattle	Dairy cows	Poultry
Sugar-beet tops	0.025	STMR	AV	23	0.11						–
Cotton-seed	0.34	STMR	SO	88	0.39	25	25		0.098	0.098	
Cotton gin by-product	10.2	STMR-P		90	11.3	20	20		2.27	2.27	
Maize grain	0.025	STMR	GC	88	0.028			80			0.02
Maize forage	0.025	STMR	AF		0.03	40	50		0.010	0.013	–
Potato wet peel	0.55	STMR-P	VR	15	0.27						
Sorghum grain	0.025	STMR	GC	86	0.03				–		–
Sorgum forage	0.025	STMR	AF		0.03				–		–
Soya bean	0.08	STMR	VD	89	0.09			20			0.02
Soya bean, forage	0.05	STMR	AL		0.05	15	5		0.008	0.003	–
Soya bean, hay	0.05	STMR	AL		0.05				–		–
Sunflower meal	0.011	STMR-P	AL	92	0.01	–	–	–	–		–
Turnip tops	0.025	STMR	VL	30	0.08						
Total									2.39	2.38	0.04

The dietary burdens of paraquat for estimation of MRL and STMR values for animal commodities are: beef cattle, 4.30 and 2.39 ppm; dairy cattle, 4.43 and 2.38 ppm; and poultry, 0.11 and 0.04 ppm.

Feeding studies

In a study of metabolism in goats (see above), one goat was dosed at a rate equivalent to 100 mg/kg of total diet. This is considerably higher than the estimated maximum dietary burden for cattle of 4.30 or 4.43 mg/kg. At 100 mg/kg of diet, the maximum TRRs, expressed in paraquat ion equivalents, found in milk and edible goat tissues were 0.009 mg/kg in milk, 0.12 mg/kg in meat, 0.03 mg/kg in fat, 0.56 mg/kg in liver and 0.74 mg/kg in kidney. In milk, 75.9% of the radiolabel was identified with paraquat.

At the estimated maximum animal burden of 4.30 or 4.43 mg/kg, the levels of paraquat residues were calculated to be < 0.005 mg/kg in milk, 0.005 mg/kg in meat, 0.025 mg/kg in liver and 0.033 mg/kg in kidney. The Meeting estimated maximum residue levels of 0.005* mg/kg for milks, 0.005 mg/kg for mammalian meat and 0.05 mg/kg for edible mammalian offal. These levels replace the previous recommendations for related animal commodities. The STMR values were estimated to be 0.0002 mg/kg for milk, 0.003 mg/kg for meat and 0.0018 mg/kg for edible offal; and the highest residue level values were estimated to be 0.005 mg/kg for meat and 0.033 mg/kg for edible offal.

In the study of metabolism in hens (see above), birds were dosed at a rate equivalent to 30 mg/kg of total diet, which is considerably higher than the estimated maximum dietary burden for poultry of 0.11 mg/kg. At 30 mg/kg diet, the maximum TRRs, expressed in paraquat ion equivalents, found in eggs and edible chicken tissues were 0.18 mg/kg in egg yolk, 0.001 mg/kg in egg albumen, 0.05 mg/kg in meat, 0.05 mg/kg in fat and 0.09 mg/kg in liver.

At the estimated maximum animal burden of 0.11 mg/kg, the maximum residue levels were calculated to be far below the LOQ of 0.005 mg/kg in eggs and other tissues. The Meeting estimated the maximum residue levels to be 0.005* mg/kg for eggs, poultry meat and edible poultry offal. The STMR and highest residue level values were estimated to be 0 for these commodities.

RECOMMENDATIONS

On the basis of the data from supervised trials the Meeting concluded that the residue levels listed below are suitable for establishing maximum residue limits and for IEDI and IESTI assessment.

Plant commodities and animal commodities

Definition of the residue for compliance with MRLs: paraquat cation

Definition of the residue for estimation of dietary intake: paraquat cation

Commodity		Recommended MRL mg/kg		STMR/ STMR-P[1)] mg/kg	HR/HR-P[1)] mg/kg
CCN	Name	New	Previous		
AM 0660	Almond hulls	0.01 (*)			
FI 0030	Assorted tropical fruits – inedible peel (except passion fruit)	0.01 (*)		0.01	0.01
FB 0018	Berries and other small fruits	0.01 (*)		0	0
MO 1280	Cattle kidney	W	0.5		
FC 0001	Citrus fruits	0.02	-	0.01	0.02
JF 0004	Orange juice			0	
SO 0691	Cotton seed	2	0.2	0.34	
OC 0691	Cotton seed oil, crude			0.01	
OR 0691	Cotton seed oil, Edible	W	0.05 (*)		
MO 0105	Edible offal (mammalian)	0.05		0.018	0.033
MO 0097	Edible offal of cattle, pigs & sheep	W	0.05 (*)		
PE 0112	Eggs	0.005 (*)	0.01 (*)	0	0
AV 1051	Fodder beet leaves or tops	0.2 (dry wt)			
VC 0045	Fruiting vegetables, cucurbits	0.02		0	0
VO 0050	Fruiting vegetables, other than cucurbits	0.05		0.01	0.04
JF 0448	Tomato juice			0	
	Ketchup			0	

Commodity		Recommended MRL mg/kg		STMR/ STMR-P[1)] mg/kg	HR/HR-P[1)] mg/kg
CCN	Name	New	Previous		
DH 1100	Hops, Dry	0.1	0.2	0.05	0.05
	Beer			0.0001	
VL 0053	Leafy vegetables	0.07		0.025	0.05
GC 0645	Maize	0.03	0.1	0.025	
CF 1255	Maize flour	0.05		0.038	
	Maize germ			0.0075	
	Maize grits/meal			0.013	
OC 0645	Maize oil, crude			0.006	
	Corn starch			0.006	
AS 0645	Maize fodder	10 (dry wt.)			
AF 0645	Maize forage	5 (dry wt.)			
MM 0095	Meat (from mammalian other than marine mammals)	0.005		0.003	0.005
MM 0097	Meat of cattle, pigs & sheep	W	0.05 (*)		
ML 0106	Milks	0.005*	0.01 (*)	0.0002	
FT 0305	Olives	0.1	1	0.05	0.1
OC 0305	Olive oil, virgin			0.018	
FI 0351	Passion fruit	W	0.2		
MO 1284	Pig kidney	W	0.5		
FP 0009	Pome fruits	0.01 (*)	-	0	0
VR 0589	Potato	W	0.2		
	Potato crisps			0.02	
	Potato granules			0.05	
PO 0111	Poultry, Edible offal of	0.005 (*)		0	0
PM 0110	Poultry meat	0.005 (*)		0	0
VD 0070	Pulses	0.5		0.08	
GC 0649	Rice	W	10		
CM 1205	Rice, Polished	W	0.5		
VR 0075	Root and tuber vegetables	0.05		0.02	0.05
MO 1288	Sheep kidney	W	0.5		
GC 0651	Sorghum	0.03	0.5	0.025	
	Sorghum flour			0.004	
	Sorghum germ			0.013	
AF 0651	Sorghum forage (green)	0.3			
AS 0651	Sorghum straw and fodder	0.3			
VD 0541	Soya bean (dry)	W	0.1		
AL 0541	Soya bean fodder	0.5 (dry wt.)			
AL 1265	Soya bean forage (green)	2 (dry wt.)			
OC 0541	Soya bean oil, crude			0.01	
FS 0012	Stone fruits	0.01 (*)		0	0
DF 0014	Prune			0	
SO 0702	Sunflower seed	2	2	0.23	
OC 0702	Sunflower seed oil, Crude	W	0.05 (*)	0	
OR 0702	Sunflower seed oil, Edible	W	0.05 (*)		
DT 1114	Tea, green, black	0.2		0.06	
TN 0085	Tree nuts	0.05		0.01	0.05
AO1 0002	Vegetables (except as otherwise listed)	W	0.05 (*)		

DIETARY RISK ASSESSMENT

Long-term intake

The IEDIs were calculated for the five GEMS/Food regional diets from the STMR values for fruit, vegetables, maize, sorghum, cotton-seed, sunflower, hops, tea and animal commodities and the STMR-P values for their processed products, as estimated by the current Meeting (Annex 3 of the Report). The ADI is 0–0.005 mg/kg bw, and the calculated IEDIs were 2–5% of the ADI. The Meeting concluded that the intake of residues of paraquat resulting from uses considered by the current JMPR was unlikely to present a public health concern.

Short-term intake

The IESTIs of paraquat by the general population and by children were calculated for commodities for which STMR or STMR-P values had been estimated by the current Meeting when information on consumption was available (Annex 4 of the Report). The ARfD is 0.006 mg/kg; the calculated IESTIs for children up to 6 years range from 0 to 50% and those for the general population from 0 to 20% of the ARfD. The Meeting concluded that the short-term intake of residues of paraquat from uses considered by the current Meeting was unlikely to present a public health concern.

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ANNEX 1

Reports and other documents resulting from Joint Meetings of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and WHO Expert Groups on Pesticide Residues

1. Principles governing consumer safety in relation to pesticide residues. Report of a meeting of a WHO Expert Committee on Pesticide Residues held jointly with the FAO Panel of Experts on the Use of Pesticides in Agriculture. FAO Plant Production and Protection Division Report, No. PL/1961/11; WHO Technical Report Series, No. 240, 1962.
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