GLUFOSINATE-AMMONIUM (175)

EXPLANATION

Glufosinate-ammonium is a herbicide and desiccant. It was first evaluated for residues and toxicology by the 1991 JMPR and subsequently for residues in 1994.

Glufosinate-tolerant crops have now been developed with new use patterns necessitating revised MRLs. The manufacturer has provided many new reports for evaluation dealing with animal and plant metabolism, environmental fate in soil and water, methods of residue analysis, stability in stored analytical samples, supervised residue trials, animal transfer studies, fate of residues in processing and national residue limits.

The delegation of The Netherlands was requested by the 1996 CCPR to send their comments on the definition of the residue to the JMPR (ALINORM 97/24 para 73).

Information was provided to the Meeting by Germany, The Netherlands, Poland and the basic manufacturer.

METABOLISM AND ENVIRONMENTAL FATE

Information was made available on the metabolism and environmental fate of glufosinate in animals, crops, soils and water-sediment systems.

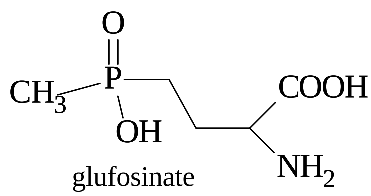
A variety of code numbers and abbreviations have been used for the metabolites and degradation products of glufosinate-ammonium. There are nine different code numbers for glufosinate itself, covering the salts and free acid, and the racemate and separate stereoisomers. Earlier publications used HOE numbers but they have recently been replaced by AEF, AEC or AE numbers. The names, structures and code numbers of glufosinate and its metabolites and degradation products are listed below.

In this evaluation “glufosinate” and the abbreviations NAG, MPP, etc. refer to the compounds without specifying their stereoisomerism or whether they are presents as salts or free acid. Where such extra information is important, e.g. because of molecular weight considerations, extra information will be given, e.g. “glufosinate, expressed as the free acid”.

Structures, names and code numbers of glufosinate, metabolites and degradation products

Glufosinate

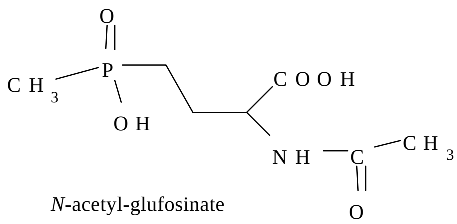
	racemate	L-isomer	R-isomer	MW
free acid	AE F035956	AE F057740	AE F090532	181.1
Ammonium salt	AE F039866	AE F058192	AE F093854	198.2
HCl salt	AE F035125	AE F057742	AE F057741	217.6



glufosinate

N-acetyl-glufosinate (NAG)

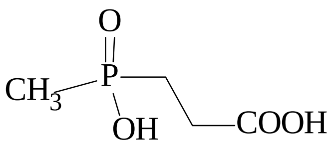
	racemate	L-isomer	R-isomer	MW
free acid	AE F085355	AE F099729	AE F124451	223.2
Disodium salt	AE F098412	AE F099730	AE F124450	267.2



N-acetyl-glufosinate

3-methylphosphinicopropionic acid (MPP)

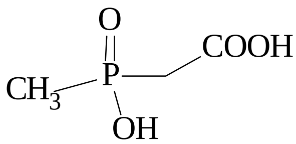
		MW
Free acid	AE F061517	152.1
Disodium salt	AE C527855	196.1



3-methyl-phosphinico-propionic acid

2-methylphosphinicoacetic acid (MPA)

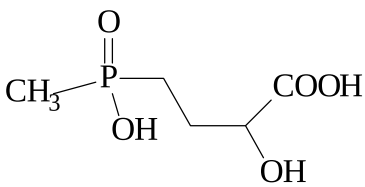
		MW
Free acid	AE F064619	138.1
Disodium salt	AE F159481	182.1



2-methyl-phosphinico-acetic acid

4-methylphosphinico-2-hydroxybutanoic acid (MHB)

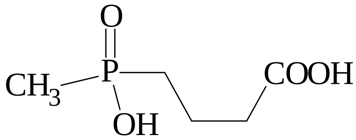
		MW
Free acid	AE F053705	182.1
Disodium salt	AE F042231	226.1



4-methyl-phosphinico-2-hydroxy-butanoic acid

4-methylphosphinicobutanoic acid (MPB)

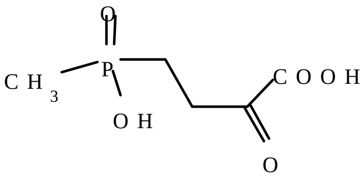
		MW
Free acid	AE F039046	166.1



4-methyl-phosphinico-butanoic acid

4-methylphosphinico-2-oxobutanoic acid

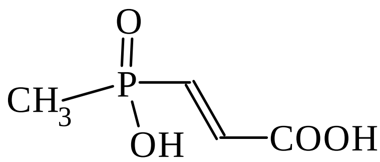
		MW
Free acid	AE F065594	180.1



4-methyl-phosphinico-2-
oxo-butanoic acid

3-methylphosphinico-acrylic acid

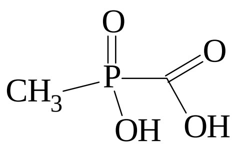
		MW
Free acid	AE 0015081	150.1



AE 0015081
3-methyl-phosphinico
acrylic acid

Methylphosphinico-formic acid

		MW
Free acid	AE F130947	124.0



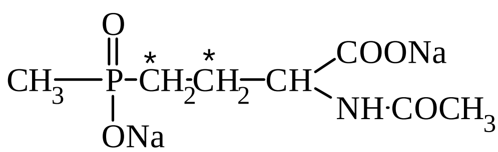
methylphosphinico-formic acid

Animal metabolism

Information on the metabolism of glufosinate-ammonium and NAG (*N*-acetyl-L-glufosinate) in laboratory rats, lactating goats and laying hens was reported. In summary, most of the administered dose of both compounds is rapidly excreted. NAG may be partially metabolized back to glufosinate.

Bremmer and Leist (1997) examined the possible conversion of NAG to glufosinate in rats. Up to 10% deacetylation occurred at a low dose of 3 mg/kg bw as shown by the occurrence of glufosinate in the faeces. The authors concluded however that most of the conversion was caused by bacteria in the colon and rectum although toxicity findings indicate partial bioavailability (Bremmer and Leist, 1998).

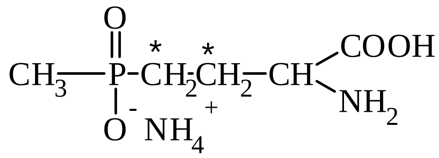
Kellner *et al.* (1993) showed that almost all the radiolabel was excreted in the faeces within 4 days when rats were dosed orally with single doses of [^{14}C]NAG disodium salt at 3 mg/kg body weight. The ^{14}C label was in positions 3 and 4.



Labelled AE F099730

Unchanged NAG was the main source of the radiolabel (85-89%) in faecal extracts from rats dosed orally with [^{14}C]NAG disodium salt at 1000 mg/kg body weight (Lauck-Birkel, 1995a). Small amounts (approx. 1%) of glufosinate were produced.

When [3,4-^{14}C]glufosinate-ammonium was administered in a single oral dose of 500 mg/kg bw to rats, 75% in males and 89% in females of the radiolabel was excreted in the faeces within 48 hours (Lauck-Birkel, 1995b) and 8-11% in the urine. Glufosinate was the principal labelled component in faecal extracts – 72% and 84% of the dose in males and females respectively.



Labelled glufosinate-ammonium

Lauck-Birkel (1996) identified the labelled compounds in urine and faeces from rats dosed orally with [3,4-^{14}C]glufosinate-ammonium at 2 mg/kg bw. The main compound in faecal extracts was glufosinate (77% of the dose); other identified components were NAG (7.5%), MHB (4.3%) and MPP (1.3%). The main components in the urine were glufosinate (4.3% of the dose) and MPP (0.8%).

Tissue, milk and excreta residues were measured in a lactating goat weighing 60 kg dosed orally twice daily for 4 consecutive days by capsule with [3,4-^{14}C]glufosinate at a rate equivalent to 101 ppm glufosinate-ammonium in the dry-weight diet and 3.0 mg/kg bw/day (Huang and Smith, 1995a). The feed intake was 1.8 kg/day. The animal was milked twice daily and slaughtered 15 hours after the final dose.

Most of the administered ^{14}C (69%) was excreted in the faeces with 2.9% in the urine and 11% in the GI tract with contents. Less than 0.1% and 0.02% of the dose was found in the tissues and milk respectively. The levels in the kidneys were higher than in other tissues (Table 1). Levels of ^{14}C reached a plateau in milk by day 2.

The parent compound was the main residue detected in the kidneys, liver and milk, with MPP forming a substantial part of the residue in the kidneys and liver (Table 2).

Table 1. Distribution of ^{14}C in the tissues and milk of a goat dosed twice daily for 4 days with [3,4-^{14}C]glufosinate (Huang and Smith, 1995a).

Sample	^{14}C as glufosinate-ammonium, mg/kg
Kidney	0.61
Liver	0.40
Muscle	0.007
Fat	0.004
Milk day 1, am and pm	0.003 0.009
Milk day 2, am and pm	0.016 0.020
Milk day 3, am and pm	0.022 0.020
Milk day 4, am and pm	0.020 0.014

Table 2. Compounds identified in the tissues and milk of a goat dosed twice daily for 4 days with [3,4-^{14}C]glufosinate (Huang and Smith, 1995a). Residue levels are expressed as glufosinate-ammonium equivalents.

Compound	Kidney		Liver		Milk	
	% of total ^{14}C	mg/kg	% of total ^{14}C	mg/kg	% of total ^{14}C	mg/kg
Glufosinate	49	0.30	53	0.21	49	0.010
NAG, L-isomer	4.2	0.026	not detected		2.2	<0.001
MPP	29	0.18	37	0.15	6.3	0.001
MPA	1.2	0.008	0.4	0.001	5.3	0.001

Tissue, milk and excreta residues were measured in a lactating goat weighing 36 kg dosed orally twice daily for 3 consecutive days by capsule with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt at a rate equivalent to 84 ppm in the dry-weight diet or 3.0 mg/kg bw/day (Huang and Smith, 1995b). The feed intake was 1.4 kg/day. The animal was milked twice daily and slaughtered 16 hours after the final dose.

Most of the administered ^{14}C was excreted in the faeces (68%) with 7.3% in the urine and 19% in the GI tract with contents. NAG and glufosinate accounted for 52% and 34% of the ^{14}C in the faeces respectively.

Only 0.2% of the administered dose was found in the tissues and blood, with <0.1% in the milk. Levels in the kidneys were higher than in other tissues (Table 3). Levels of ^{14}C reached a plateau in milk by day 2. Glufosinate was the main residue detected in the kidneys, liver and milk, with NAG (the administered material) and MPP forming a substantial part of the residue in the kidneys and liver (Table 4).

Table 3. Distribution of ^{14}C in the tissues and milk of a goat dosed twice daily for 3 consecutive days with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt (Huang and Smith, 1995b).

Tissue or milk	^{14}C as N-acetyl-L-glufosinate disodium salt, mg/kg
Kidneys	0.93
Liver	0.29
Muscle	0.007
Fat	<0.010
Milk day 1, am and pm	0.005 0.012
Milk day 2, am and pm	0.018 0.020
Milk day 3, am and pm	0.023 0.022

Table 4. Compounds identified in the tissues and milk of a goat dosed twice daily for 3 consecutive days with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt (Huang and Smith, 1995b). Residue levels are expressed as *N*-acetyl-L-glufosinate disodium salt equivalents.

Compound	Kidneys		Liver		Milk	
	% of total ^{14}C	mg/kg	% of total ^{14}C	mg/kg	% of total ^{14}C	mg/kg
Glufosinate	40	0.37	33	0.095	40	0.009
NAG, L-isomer	32	0.30	19	0.054	9.2	0.002
MPP	20	0.19	21	0.060	14	0.003
MPA	1.6	0.015	2.0	0.006	4.8	0.001

Tissue, eggs and excreta residues were measured in 6 laying hens weighing 1.27-1.67 kg dosed orally twice daily for 14 consecutive days by capsule with [3,4-^{14}C]glufosinate-ammonium at a rate equivalent to 25 ppm glufosinate-ammonium in the diet (it was not clear whether the feeding level was expressed on a fresh-weight or dry-weight basis) or 2.0 mg/kg bw/day (Huang and Smith, 1995c). The feed intake was 120 g/bird/day. Eggs were collected twice daily and the birds were slaughtered 16 hours after the final dose .

92% of the administered dose was excreted with 1.3% remaining in the GI tract. Glufosinate-ammonium accounted for 81% of the ^{14}C in the faeces.

Less than 0.02% of the administered dose was present in the edible tissues. Levels of ^{14}C as glufosinate-ammonium in the liver, muscle and fat were 0.11, <0.004 and 0.003 mg/kg respectively. Those in the eggs are shown in Table 5. ^{14}C in egg whites reached a plateau by day 6, but in the last 3 days there was again a small increase. The levels in egg yolks increased very slowly throughout the 14 days.

MPP was the main residue identified in the liver with glufosinate-ammonium also a substantial component (Table 6). Glufosinate constituted most of the residue in eggs.

Table 5. ^{14}C in eggs from hens dosed orally twice daily for 14 consecutive days by capsule with [3,4-^{14}C]glufosinate- (Huang and Smith, 1995c).

Collection day	Mean ^{14}C, mg/kg as glufosinate-ammonium	
	Egg white	Egg yolk
1	<0.003	<0.003
2	0.004	<0.003
3	0.034	0.005
4	0.053	0.009
5	0.049	0.012
6	0.057	0.015
7	0.056	0.016
8	0.056	0.017
9	0.058	0.019
10	0.059	0.021
11	0.058	0.021
12	0.067	0.021
13	0.065	0.022
14	0.067	0.024

Table 6. Compounds identified in the tissues and eggs from hens dosed orally twice daily for 14 consecutive days with [3,4-^{14}C]glufosinate-ammonium (Huang and Smith, 1995c). Residues are expressed as glufosinate-ammonium equivalents.

Compound	Liver		Egg white (day 14)		Egg yolk (day 13)	
	% ^{14}C in liver	mg/kg	% ^{14}C in egg white	mg/kg	% ^{14}C in egg yolk	mg/kg
glufosinate	31	0.036	78	0.052	53	0.012
NAG, L-isomer	4.9	0.006	not detected		2.4	0.001
MPP	44	0.050	1.3	0.001	4.1	0.001
MPA	3.5	0.004	not detected		3.1	0.001

Tissue, eggs and excreta residues were measured in 6 laying hens weighing 1.27-1.60 kg dosed orally twice daily for 14 consecutive days by capsule with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt equivalent to 27 ppm *N*-acetyl-L-glufosinate disodium salt in the diet (it was not clear whether the feeding level was expressed on a fresh- or dry-weight basis) or 2.2 mg/kg bw/day (Huang and Smith, 1995d). The mean feed intake was 116 g/bird/day. Eggs were collected twice daily and the birds were slaughtered 15 hours after the final dose.

86% of the administered dose was excreted with 1.0% remaining in the GI tract. *N*-acetyl-L-glufosinate disodium salt accounted for 73% of the ^{14}C in the faeces with glufosinate and MPP accounting for 13% and 8.6% respectively.

Less than 0.1% of the administered dose was present in the edible tissues and blood. Levels of ^{14}C (as *N*-acetyl-L-glufosinate disodium salt) in the liver, muscle and fat were 0.076, 0.013 and 0.011 mg/kg respectively. Those in eggs are shown in Table 7. Levels in egg whites were slightly above the LOD throughout the study; those in egg yolks increased slowly but steadily throughout the 14 days.

NAG (the administered material) was the main residue identified in liver and egg yolk (Table 8). Glufosinate and MPP were also substantial components of the liver residue. Glufosinate was the main identified residue in egg whites, but the levels in eggs were quite low, making further identification difficult.

Table 7. ^{14}C in eggs from hens dosed orally twice daily for 14 consecutive days with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt (Huang and Smith, 1995d).

Collection day	Mean ^{14}C level, mg/kg as N-acetyl-L-glufosinate disodium salt	
	Egg white	Egg yolk
1	<0.009	<0.002
2	<0.009	<0.002
3	<0.009	0.012
4	0.010	0.020
5	0.010	0.027
6	0.011	0.035
7	<0.009	0.037
8	0.012	0.040
9	0.014	0.042
10	0.012	0.045
11	0.012	0.046
12	0.013	0.050
13	0.015	0.049
day 14 sac	0.014	0.052
necropsy	<0.009	0.056

Table 8. Compounds identified in the tissues and eggs from hens dosed orally twice daily for 14 consecutive days with [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt (Huang and Smith, 1995d). Residues are expressed as *N*-acetyl-L-glufosinate disodium salt equivalents.

Compound	Liver		Egg white (day 13)		Egg yolk (necropsy)	
	% ^{14}C	mg/kg	% ^{14}C	mg/kg	% ^{14}C	mg/kg
Glufosinate	15	0.011	14	0.002	2.8	0.002
NAG, L-isomer	27	0.020	5.1	0.001	13	0.007
MPP	17	0.013	2.0	<0.001	2.2	0.001
MPA	not detected		1.1	<0.001	0.6	<0.001

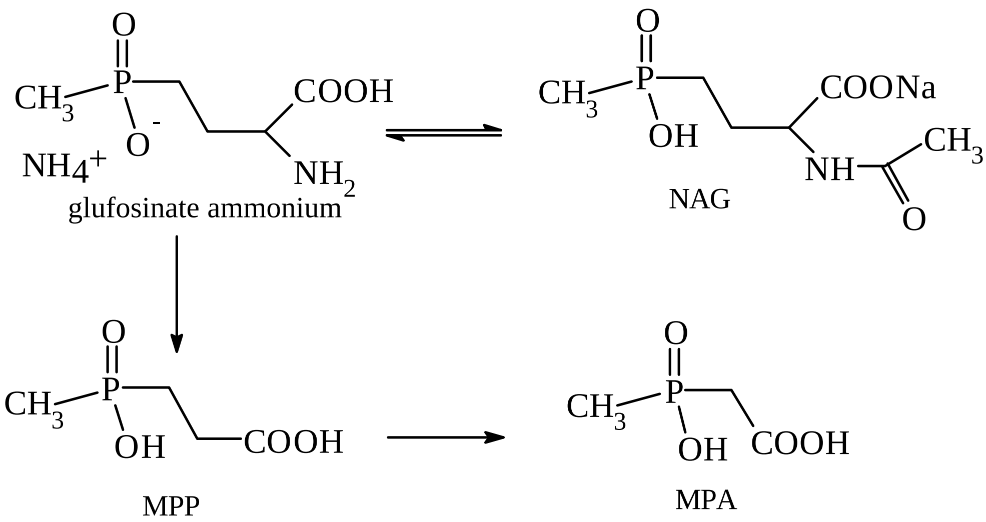
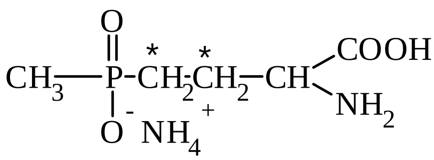


Figure 1. Proposed metabolic pathways of glufosinate and *N*-acetyl glufosinate in ruminants and poultry.

Plant metabolism

Information was reported on the metabolism of glufosinate-ammonium in genetically modified rape (canola), sugar beet, maize, soya and tomatoes. The studies examined the disposition of the residue throughout the plant and its composition. In some cases the metabolism of glufosinate-ammonium in genetically modified and unmodified crops was compared.

Stumpf *et al*. (1995b) placed cut rape plants, genetically modified and unmodified, in a nutrient solution containing 4.7 mg/l of [3,4-^{14}C]glufosinate-ammonium for 6 days. In the genetically modified plants the ^{14}C represented NAG (57%) and glufosinate-ammonium (36%). In the unmodified plants the ^{14}C was mainly due to unchanged glufosinate-ammonium (80%) with 16% MPP. The experiment demonstrated the rapid acetylation of glufosinate in genetically modified rape.



Labelled glufosinate-ammonium

Tshabalala (1993) treated canola plants (*var* 19-2XACS-N3) at the 3-5 leaf stage once with [3,4-^{14}C]glufosinate-ammonium at a rate equivalent to 0.75 kg ai/ha and collected samples for radio-analysis on days 1, 21 and 120. The results are shown in Table 9.

The levels in the top-growth and roots were much the same after 21 days, but at maturity were much higher in the roots than in other plant parts. The residues in the canola seed were investigated by two HPLC systems but the low residue levels made further identification difficult. Glufosinate and MPP were the main constituents with considerably lower levels of NAG.

Table 9. Levels of ^{14}C in canola plants treated once with [3,4-^{14}C]glufosinate-ammonium at 0.75 kg ai/ha (Tshabalala 1993).

Sample	Time since treatment	^{14}C as glufosinate-ammonium, mg/kg
whole plant	1 hour	145
topgrowth	21 days	5.3 3.2
roots	21 days	3.8 5.2
topgrowth	120 days	0.058 0.064 0.024 0.021
roots	120 days	0.22 0.13 0.15 0.19
hulls	120 days	0.12 0.26 0.11 0.076
seed	120 days	0.054 0.11 0.056 0.045

Thalacker (1994) applied [^{14}C]glufosinate-ammonium to glufosinate-tolerant canola and samples were taken after 1 hour and 21 days. After 1-hour 73% of the ^{14}C was in glufosinate and 18% in NAG, and after 21-days 60, 21 and 7% of the ^{14}C corresponded to NAG, glufosinate-ammonium and MPP respectively. Again, genetically modified rape seed (canola) produced NAG very rapidly from glufosinate-ammonium.

In another trial, genetically modified sugar beets were treated twice (22 days interval) with [3,4-^{14}C]glufosinate-ammonium at rates equivalent to 0.6 kg ai/ha (Allan, 1996). The leaves and beets (when formed) were harvested 0, 8 and 15 days after the first treatment and 0, 21 and 146 days after the second. The leaves were rinsed with water to separate surface residues from absorbed residues

The residues after the first treatment are shown in Table 10. The glufosinate isomer composition was unchanged in the surface residue, but in the absorbed residue L-glufosinate was metabolized to NAG (*N*-acetyl-L-glufosinate).

The composition of the residue after the second treatment is shown in Table 11. Identified residues accounted for 93-98% of the total ^{14}C in leaves + rinses and roots. After the first treatment NAG was the main identified residue except in the leaves on the day of treatment, but even after 146 days glufosinate accounted for 19% of the ^{14}C in the roots and 26% in the leaves. The reason is presumably that L-glufosinate is rapidly converted to NAG, but D-glufosinate remains unchanged.

Table 10. Identified residues in genetically modified sugar beets after a single treatment with [3,4-^{14}C]glufosinate-ammonium.

Time after treatment	Sample	Residue as % of total ^{14}C in the sample			
		Glufosinate	D-glufosinate	L-glufosinate	NAG
3 hours	rinse	41	20	21	
8 days	rinse	18	9	9	
15 days	rinse	14	7	7	
3 hours	leaves	45.1	24.6	20.5	9.0
8 days	leaves	35.6	28.4	5.5	39
15 days	leaves	29.3	25.2	3.3	49

Table 11. Identified residues in genetically modified sugar beets after 2 treatments with [3,4-^{14}C]glufosinate-ammonium (Allan, 1996).

Time after 2nd treatment, days	Sample	Glufosinate		MPP		NAG	
		% of ^{14}C in (rinse + leaves) or roots	mg/kg as glufosinate-ammonium	% of ^{14}C in (rinse + leaves) or roots	mg/kg as glufosinate-ammonium	% of ^{14}C in (rinse + leaves) or roots	mg/kg as glufosinate-ammonium
0	rinse	59	12	-	-	-	-
0	leaves	25	5.1	0.4	0.07	13	2.7
0	roots	31	0.62	2.2	0.04	64	1.3
21	rinse	14	1.7	-	-	-	-
21	leaves	28	3.4	1.1	0.13	55	6.8
21	roots	31	2.1	2.0	0.14	63	4.3
146	rinse	2.3	0.05	0.3	0.006	0.2	0.005
146	leaves	24	0.49	2.7	0.055	67	1.4
146	roots	19	0.18	6.0	0.055	68	0.63

In another trial transgenic maize plants were treated twice (40 cm and 60 cm growth stages) with [3,4-^{14}C]glufosinate-ammonium at rates equivalent to 0.50 kg ai/ha (Burnett, 1994). Plants were sampled on the days of treatment and at intervals until 102 days after the second treatment. The levels of ^{14}C as glufosinate-ammonium were 23 and 5.8 mg/kg 1 hour and 5 days after the first treatment respectively and 14.5 and 9.9 mg/kg 1 hour and 5 days after the second.

Glufosinate-ammonium was generally a minor component of the residue whereas the main component in the forage, silage and fodder was NAG and the main component in the grain, cobs and husks was MPP. 73-83% of the residue was identified except in the grain where the very low residue level made further identification difficult.

A sub-sample of the maize forage was analysed by a GLC enforcement analytical method (Czarnecki and Bertrand, 1994), in which samples are extracted with distilled water, and after clean-up which includes ion-exchange chromatography, the residues are derivatized with trimethyl orthoacetate for GLC analysis. The enforcement method and the radiolabel method were in reasonable agreement (Table 13).

Table 12. Identified residues in grain and animal feeding commodities from transgenic maize treated twice with [3,4-^{14}C]glufosinate-ammonium (Burnett, 1994). Forage and silage were sampled 28 and 55 days respectively after the second treatment and other commodities after 102 days.

Compound	Residue components as % of ^{14}C in the sample and as mg/kg glufosinate-ammonium											
	Forage		Silage		Fodder		Grain [1]		Cobs		Husks	
	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg
Glufosinate	13	0.35	11	0.20	9.9	0.20	1.5	0.002	2.6	0.006	2.1	0.018
MPP	12	0.32	12	0.21	11	0.22	33	0.043	44	0.10	41	0.36
NAG	52	1.4	55	0.98	54	1.1	9.1	0.012	20	0.046	19	0.17
MPA	4.6	0.12	3.9	0.070	2.9	0.058	4.4	0.006	12	0.028	11	0.097
Identified	82	2.2	82	1.5	76	1.6	58	0.076	79	0.18	73	0.64
Total		2.6		1.8		2.0		0.13		0.25		0.87

[1] MPB accounted for 9.8% of the ^{14}C in the grain, equivalent to 0.013 mg/kg of glufosinate-ammonium.

Table 13. Comparison between analysis of maize forage from [3,4-^{14}C]glufosinate-ammonium-treated maize by an enforcement GLC method (Czarnecki and Bertrand, 1994) and the ^{14}C HPLC method (Burnett, 1994).

Analyte	Residue, mg/kg as glufosinate-ammonium		
	HPLC ^{14}C	GLC enforcement, not adjusted for recovery	Spike recovery, %, GLC enforcement
Glufosinate	0.366	0.256	113
MPP	0.304	0.185	69.5
NAG	1.43	1.42	105

In another trial transgenic soya bean plants were treated twice at third trifoliate leaf and full bloom growth stages with [3,4-^{14}C]glufosinate-ammonium at rates equivalent to 0.50 kg ai/ha (Rupprecht and Smith, 1994). Forage was sampled just before the second application and the mature crop was harvested 85 days after the second treatment.

NAG was the main residue in all the samples. The levels of MPP were greater than those of glufosinate in the pods and beans. 90-94% of the residue was identified in all the samples. The results are shown in Table 14. They were also reported by Rupprecht *et al*. (1996b).

The samples were extracted with distilled water or acetonitrile + water and analysed by the method of Czarnecki and Bertrand (1994). The GLC and HPLC radiolabel methods produced similar results (Table 15) at the higher levels but at low levels those from the enforcement method were lower.

Table 14. Identified residues in beans, pods, forage and straw from transgenic soya plants treated twice with [3,4-^{14}C]glufosinate-ammonium (Rupprecht and Smith, 1994).

Compound	Identified residue components as % of ^{14}C in the sample and as glufosinate-ammonium, mg/kg							
	Forage		Straw		Pods		Beans	
	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg
Glufosinate	23	0.45	19	0.58	5.8	0.29	6.2	0.091
MPP	6.5	0.13	14	0.42	22	1.1	16	0.23
NAG	60	1.2	53	1.7	63	3.1	61	0.89
MPA	0.7	0.014	5.7	0.18	2.9	0.142	7.1	0.10
Identified	91	1.8	91	2.8	94	4.6	90	1.3
Total		1.9		3.2		4.7		1.4

Table 15. Comparison between analysis of samples from [3,4-^{14}C]glufosinate-ammonium-treated soya beans by an enforcement GLC method (Czarnecki and Bertrand, 1994) and the ^{14}C HPLC method (Rupprecht and Smith, 1994)

Sample			Residue, mg/kg as glufosinate-ammonium		
	Extract	Method	Glufosinate	NAG	MPP
Forage	water	^{14}C HPLC	0.364	0.962	0.101
Forage	water	GLC	0.321	1.04	0.053
Straw	water	^{14}C HPLC	0.542	1.58	0.404
Straw	water	GLC	0.348	1.89	0.202
Pods	water	^{14}C HPLC	0.250	2.88	1.02
Pods	water	GLC	0.238	3.23	0.781
Beans	water	^{14}C HPLC	0.073	0.687	0.187
Beans	water	GLC	0.034	0.605	0.129
Forage	acetonitrile + water	^{14}C HPLC	0.084	0.195	0.025
Forage	acetonitrile + water	GLC	0.046	0.156	0.022

Köcher and Becker (1991) applied [^{14}C]glufosinate-ammonium at the 7-leaf stage to the leaves of glufosinate-resistant and unmodified tomato plants. After intervals of 1 and four days foliar absorption of the ^{14}C was the same in both types of plant, but translocation of the ^{14}C from the treated leaves to shoots, other leaves and roots was approximately four times as high in the resistant plants.

Stumpf *et al.* (1995a) treated genetically modified tomato plants at the 7-8 leaf stage with [3,4-^{14}C]glufosinate-ammonium at a rate equivalent to 0.8 kg ai/ha. Samples of plants were taken on the day of treatment and subsequently at intervals up to maturity, 74 days after treatment. The composition of the surface residues (in the rinse) and absorbed residues is shown in Table 16.

The major part (83-97%) of the surface residue in the rinse was glufosinate itself, even after long intervals. Glufosinate was very rapidly converted to NAG once absorbed into the tomato leaves and eventually accounted for about half of the residue, which is in accord with the rapid conversion of L-glufosinate and the stability of both D-glufosinate and NAG. The composition of the residue in the stems followed a similar pattern except that NAG accumulated to almost 70% of the residue and glufosinate fell to about 30%.

There were no detectable residues on the tomato fruit surface, probably because the plants were sprayed before any fruit were formed. NAG accounted for about 90% of the residue in the fruit, with glufosinate itself at essentially negligible levels. MPP was a minor residue in the fruit. NAG is evidently sufficiently mobile to translocate to the fruit, but D-glufosinate is not.

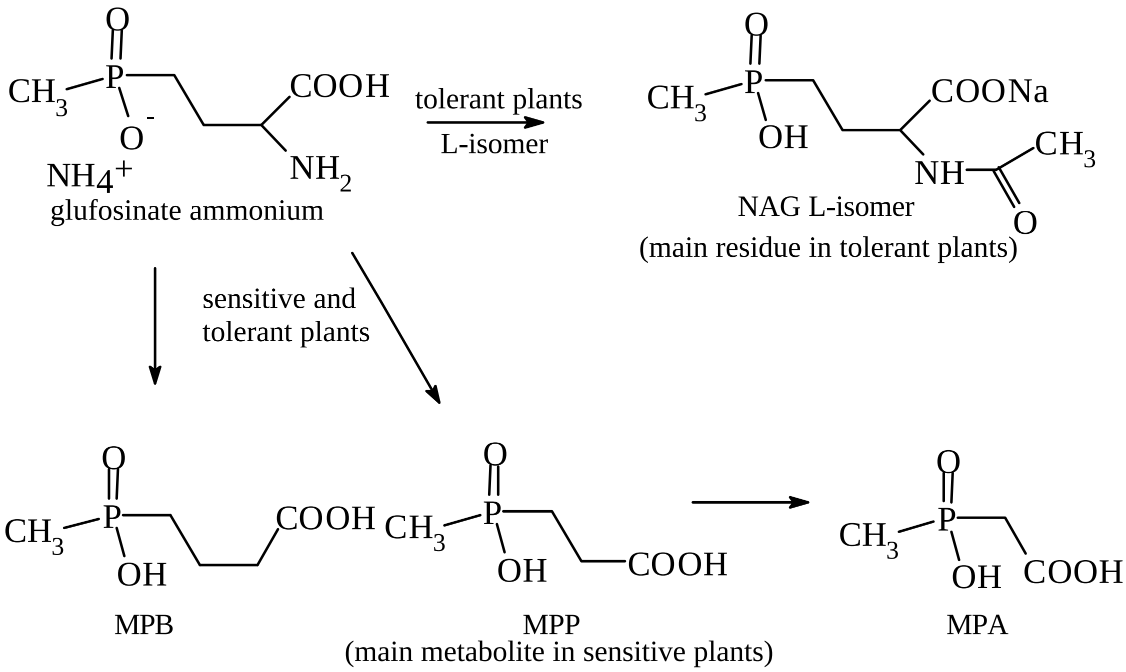
The composition of the glufosinate surface residue on the tomato leaves and stems on day 74 was shown to consist essentially of equal amounts of D- and L-glufosinate. The composition was quite different in the absorbed residue in the leaves (90% D- and 10% L-glufosinate) and in the stems (86% D- and 14% L-glufosinate), showing that within the tissue the L-isomer was more rapidly metabolized

In a separate experiment Stumpf *et al.* (1995a) placed genetically modified and normal tomato plants in solutions of labelled glufosinate for 2 days and examined the uptake and composition of the residue in the plants. The genetically modified plants took up much more glufosinate and converted about half of it to NAG. In the normal tomato plants about 4% was converted to MPP and the D- and L-glufosinate remained approximately equal.

Table 16. Residues in genetically modified tomato plants at the 7-8 leaf stage after treatment with [3,4-^{14}C]glufosinate-ammonium (Stumpf *et al.*, 1995a).

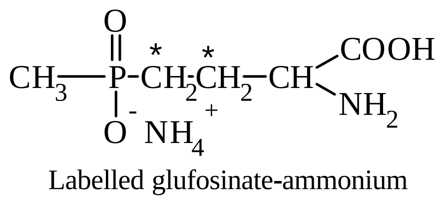
Sample		Days after treatment	% of ^{14}C, mg/kg as glufosinate-ammonium					
			glufosinate-ammonium		MPP		NAG	
			^{14}C %	mg/kg	^{14}C %	mg/kg	^{14}C %	mg/kg
leaves	Rinse	0 (2 h)	94		1.8		0.0	
leaves	Rinse	0 (4 h)	94		1.5		0.0	
leaves	Rinse	1	95		1.5		0.0	
leaves	Rinse	4	94		1.6		0.3	
leaves	Rinse	6	93		1.8		0.6	
leaves	Rinse	32	93		1.4		1.2	
leaves	Rinse	74	86		4.1		3.3	
leaves	Rinse	74	83		7.2		3.9	
leaves	After rinsing	0 (2 h)	69		0.0		27	
leaves	After rinsing	0 (4 h)	61		0.0		36	
leaves	After rinsing	1	64		0.0		33	
leaves	After rinsing	4	52		1.0		42	
leaves	After rinsing	6	53		2.4		41	
leaves	After rinsing	32	57		3.5		37	
leaves	After rinsing	74	44		5.6		51	
leaves	After rinsing	74	42	2.2	2.5	0.13	50	2.6
leaves	Not rinsed	12	30		1.6		65	
leaves	not rinsed	14	17		0.0		83	
leaves	not rinsed	27	0.0		0.0		100	
leaves	not rinsed	32	75		2.7		20	
leaves	not rinsed	74	51	4.4	2.5	0.22	42	3.6
stems	rinse	0 (2 h)	95		1.0		0.0	
stems	rinse	0 (4 h)	97		0.5		0.0	
stems	rinse	1	93		1.9		1.2	
stems	rinse	4	94		1.1		2.0	
stems	rinse	6	94		1.1		2.3	
stems	rinse	32	88		2.1		5.7	
stems	rinse	74	87		2.2		7.4	
stems	rinse	74	92		0.0		7.7	
stems	after rinsing	0 (2 h)	75		0.0		16	
stems	after rinsing	0 (4 h)	61		0.0		39	
stems	after rinsing	1	58		0.0		39	
stems	after rinsing	4	42		0.0		58	
stems	after rinsing	6	45		0.0		53	
stems	after rinsing	32	32		6.4		61	
stems	after rinsing	74	31		-		69	
stems	after rinsing	74	26	0.51	3.8	0.07	67	1.3
stems	not rinsed	12	8.6		0.0		91	
stems	not rinsed	14	7.2		0.0		93	
stems	not rinsed	27	0.0		0.0		100	
stems	not rinsed	32	47		3.6		49	
stems	not rinsed	74	37	0.95	2.6	0.07	57	1.5
fruit	rinse	74	0		0		0	
fruit	after rinsing	74	0.0	-	6.2	0.009	94	0.14
fruit	not rinsed	74	0.0	-	9.5	0.02	85	0.17
fruit, green	not rinsed	32	1.7		4.6		88	
fruit, red	not rinsed	60	0.0		0.0		100	
fruit, red	not rinsed	74	0.0		0.0		100	

Figure 2. Proposed metabolic pathways of glufosinate-ammonium in plants.



Environmental fate in soil

Aerobic degradation



Allan (1995) studied the aerobic degradation of [3,4-^{14}C]glufosinate-ammonium in a sandy loam soil (pH 6.0, organic carbon 1.8%) both when applied directly to the soil at 2 mg/kg and when incorporated as a residue in bushbean leaves which, having been desiccated with labelled glufosinate-ammonium, contained ^{14}C equivalent to 76 mg/kg of glufosinate-ammonium. The bean leaves (1.66 g) were added to 50 g of soil giving a theoretical level of 2.5 mg/kg. The soil was adjusted to 40% of maximum water holding capacity and incubated at 20°C in the dark. The results are shown in Table 17.

Glufosinate disappeared very quickly with a half-life of 3-6 days (Table 18). The main product was MPP, reaching its peak after about 14 days. MPA was also an important product and in the absence of plant material became the main residue after long intervals. NAG was a very minor soil residue.

Table 17. Distribution of ^{14}Cfrom [3,4-^{14}C]glufosinate-ammonium incubated aerobically in a soil in the dark or incorporate-d into the soil as a plant-metabolized residue (Allan 1995).

Days incubated	Residues and evolved $^{14}CO_2$ expressed as % of applied ^{14}C.					
	Soil treatment			Plant incorporation		
	extractable	Unextractable	$^{14}CO_2$	extractable	Unextractable	$^{14}CO_2$
0	106	1.8	-	97	9.7	0
1	80	8.3	0.6	90	14	0.1
3	82	11	1.5	87	17	0.4
7	77	15	5.6	80	20	1.8
14	70	21	11	75	21	4.1
21	61	21	17	69	24	7.6
28	60	20	23	68	28	8.6
41	46	19	26	58	20	9.5
59	32	24	43	32	26	22
90	8.7	25	57	23	29	26
120	5.6	21	62	18	23	31

Table 18. Composition of residues resulting from aerobic incubation of [3,4-^{14}C]glufosinate-ammonium in a soil in the dark or incorporated into the soil as a plant-metabolized residue (Allan 1995).

Days incubated	% of applied ^{14}C							
	Soil treatment				Plant incorporation			
	glufosinate	MPP	NAG	MPA	glufosinate	MPP	NAG	MPA
0	104	-	-	-	75	14	3.2	-
1	77	11	2.3	-	70	18	-	-
3	56	19	2.4	2.1	47	30	4.8	2.2
7	32	31	2.2	6.4	15	52	-	7.3
14	18	37	0.7	11	2.9	62	-	6.3
21	7.8	33	0.4	15	0.6	56	-	9.2
28	3.3	34	-	19	-	61	-	6.9
41	0.9	22	0.3	20	-	55	-	0.3
59	0.5	13	-	17	-	30	-	-
90	0.1	1.4	-	6.8	-	23	-	-
120	0.5	1.6	-	1.6	-	17	-	-

Field dissipation

In a 1-year field dissipation study in California Belcher (1996a) applied glufosinate-ammonium three times to bare ground at rates of 1.7 kg ai/ha between rows in a level vineyard. The soil was a coarse sandy loam. Irrigation supplemented rainfall and followed the growers' standard practices. Soil samples were analysed for glufosinate, MPP and MPA, the main residues. The results are shown in Table 19.

Glufosinate dissipated rapidly, possibly owing to increasing soil moisture and temperature, with calculated half-lives of 15, 7.2 and 2.7 days after the first, second and third applications respectively.

The maximum MPP residues were 0.11, 0.16 and 0.14 mg/kg on days 30, 10 and 5 after the first, second and third applications respectively and the estimated half-lives were 38, 14 and 16 days from these times. The estimated half-lives for MPA were 25, 19 and 7 days for the successive applications. MPA residues reached their highest levels of 0.06, 0.06 and 0.04 mg/kg on days 60, 10 and 5 after the first, second and third applications respectively.

No residues were detected below the 45-60 cm depth segment. Glufosinate was detected once at the analytical LOD (0.01 mg/kg) after the first application and at 0.02 mg/kg 5 and 10 days after the final application in the 45-60 cm samples. Glufosinate was detectable at low levels 5 and 10 days after application in the 30-45 cm samples, but not at other times. MPP occurred in the 30-45 cm segment on several occasions at 0.01-0.02 mg/kg. MPP was detected only once in the 45-60 cm depth segment, 10 days after the final application at 0.01 mg/kg. MPA was not detected in any sample from 30-45 cm or deeper.

Glufosinate and its soil degradation products have some mobility but their further degradation ensures that travel down the soil profile is limited.

Table 19. Residues of glufosinate and its degradation products at intervals after three applications of glufosinate-ammonium at 1.7 kg ai/ha to bare ground in a level California vineyard (Belcher, 1996a).

Interval after application days	Residues, mg/kg as glufosinate free acid, in soil					
	glufosinate		MPP		MPA	
	soil 0-15 cm	soil 15-30 cm	soil 0-15 cm	soil 15-30 cm	soil 0-15 cm	soil 15-30 cm
Application 1						
0	0.34	<0.01	0.01	<0.01	<0.01	<0.01
5	0.26	<0.01	0.04	<0.01	<0.01	<0.01
10	0.13	<0.01	0.06	<0.01	0.01 <0.01	<0.01
15	0.16	0.05 <0.01	0.07	<0.01	0.02	<0.01
28	0.1	<0.01	0.10	<0.01	0.03	<0.01
47	0.04	<0.01	0.10	<0.01	0.04	<0.01
65	0.02	<0.01	0.05	0.02	0.05	<0.01
93	<0.01	<0.01	0.02	0.02	0.04	<0.01
124	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Application 2						
0	0.47	<0.01	0.03	<0.01	0.02	<0.01
5	0.10	0.07	0.09	0.03	0.03	<0.01
10	0.02	0.08	0.08	0.04	0.05	0.01
15	0.02	0.03	0.06	0.03	0.05	0.01
30	<0.01	0.02 <0.01	0.03	0.02	0.02	0.01
45	<0.01	0.01	0.01	0.03	0.01 <0.01	0.01 <0.01
59	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
90	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
119	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Application 3						
0	0.41	<0.01	0.02	<0.01	<0.01	<0.01
5	0.03	0.04	0.06	0.04	0.03	0.01
10	0.01	0.01	0.04	0.02	0.02	0.02
15	0.01	<0.01	0.03	0.01	0.01	0.01
30	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
45	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
60	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
93	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Stumpf (1993a) incubated 3.6 mg/kg [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt in a sandy loam soil (pH 5.8, organic carbon 1.1%) in the dark at 20°C under aerobic conditions for 62 days. The results are shown in Table 20.

N-acetyl-L-glufosinate was very rapidly degraded to L-glufosinate, which was then further degraded. The degree of mineralization (40%) and the level of bound residues (21%) in 62 days parallel the 43% mineralization of glufosinate-ammonium and 24% unextractable residues in 59 days reported by Allan (1995), and suggest that the degradation pathway for NAG is through glufosinate.

Table 20. Aerobic soil degradation of [3,4-^{14}C]*N*-acetyl-L-glufosinate disodium salt in soil (Stumpf, 1993c).

Day	Residues and evolved $^{14}CO_2$ expressed as % of applied ^{14}C and as NAG mg/kg										
	$^{14}CO_2$	NAG		L-glufosinate		MPP		MPA		bound residues	
	%	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg	%	mg/kg
0.1	0	47	1.7	47	1.7	2.1	0.08	1.0	0.04	0.7	0.03
1	0.5	8.7	0.31	80	2.9	6.7	0.24	1.3	0.05	1.5	0.05
3	1.0	3.1	0.11	69	2.5	20	0.73	3.4	0.12	1.0	0.04
23	15	1.4	0.05	16	0.57	40	1.4	9.5	0.34	11	0.38
41	24	1.6	0.06	4.7	0.17	39	1.4	9.9	0.36	13	0.44
62	40	0	0	1.5	0.05	27	0.98	9.9	0.36	21	0.75

Stumpf *et al.* (1995c) incubated 0.5 mg/kg [2-^{14}C]2-methylphosphinicoacetic acid (MPA) in a sandy loam (pH 5.8, organic carbon 1.1%) and a loamy sand (pH 4.9, organic carbon 2.4%) in the dark at 20°C under aerobic conditions for 122 days and measured the rate of degradation and mineralization (Table 21). No important degradation products other than CO_2 were identified.

In the sandy loam bound residues accounted for 22% and 25% of the applied ^{14}C on days 28 and 122 respectively. Estimated decline and mineralization half-lives were 24 and 74 days respectively, but the curves were not simple first-order and the rates were slower at longer intervals. The rates in the loamy sand were much slower, with only 20% mineralization after 122 days and a decline half-life of 120-160 days. Bound residues again accounted for about 25% of the applied ^{14}C throughout the study.

Table 21. Aerobic soil degradation of [2-^{14}C]2-methylphosphinicoacetic acid (Stumpf *et al.* 1995c).

day	loamy sand			sandy loam		
	$^{14}CO_2$	MPA		$^{14}CO_2$	MPA	
	% of applied ^{14}C	% of applied ^{14}C	mg/kg	% of applied ^{14}C	% of applied ^{14}C	mg/kg
0		87	0.47		99	0.54
3	0.7	89	0.48	4.0	90	0.49
7	1.8	86	0.47	6.6	89	0.49
14	4.2	76	0.42	14.5	77	0.42
28	7.9	69	0.38	31	47	0.26
60	17	62	0.34	63	45	0.25
94	23	53	0.29	75	3.8	0.002
122	20	56	0.30	75	3.5	0.002

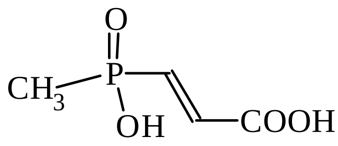
Stumpf *et al.* (1995d) incubated [3,4-^{14}C]glufosinate-ammonium at 1.9 mg/kg and [3-^{14}C]MPP at 0.9 mg/kg in the same sandy loam soil in the dark at 10°C under aerobic conditions for 120 days. The results are shown in Table 22 and 23.

The estimated half-life for glufosinate-ammonium disappearance was 24 days; the rate of mineralization was slow with an estimated half-life of 300 days or more. MPP and subsequently MPA were major components of the residue after the longer periods of incubation. NAG and

AE F065594 (4-methylphosphinico-2-oxobutanoic acid) and possibly AE F086486 (3-methylphosphinico-3-oxopropionic acid) were identified as minor products.

The estimated half-life for MPP disappearance and mineralization were 86 days and 220 days respectively. MPA was the only product of significance accounting for 40% of the extractable residue by day 120.

Stumpf and Zumdick (1998) further investigated the nature of the minor soil product previously identified as AE F086486 and, using LC-MS-MS, identified the compound as 3-methylphosphinicoacrylic acid (AE 0015081). The structure was confirmed by synthesis.



AE 0015081
3-methyl-phosphinico
acrylic acid

Table 22. Residues resulting from incubation of 1.9 mg/kg [3,4-^{14}C]glufosinate-ammonium in a sandy loam soil in the dark at 10°C under aerobic conditions for 120 days (Stumpf *et al.*, 1995d).

Incubation, days	Residues, % of applied ^{14}C					
	Extractable residue	Glufosinate	MPA	MPP	NAG/ AE F065594	AE F086486[1]
0	94	90	<0.5	1.6	1.8	<0.5
1	93	85	<0.5	5.3	2.5	<0.5
4	91	72	1.9	12	1.8	2.3
7	86	57	3.3	20	2.2	4.0
14	87	42	5.5	32	2.6	4.9
21	87	32	7.9	38	2.5	7.1
30	86	25	9.5	43	1.8	6.8
56	79	9.9	14	45	2.5	6.7
91	69	2.0	19	41	3.1	4.1
120	69	5.4	22	36	2.7	3.9

[1]Subsequently identified as AE 0015081 (Stumpf and Zumdick, 1998).

Table 23. Aerobic degradation of [3-^{14}C]3-methylphosphinicopropionic acid (MPP) incubated at 0.9 mg/kg in a sandy loam soil in the dark at 10°C for 120 days (Stumpf *et al.*, 1995d).

Incubation, days	Residues, % of applied ^{14}C			
	Extractable residue	CO_2	MPP`	MPA
0	97	0	97	<1.0
1	95	0.1	95	<1.0
4	96	0.6	94	1.8
7	90	1.1	87	3.1
14	91	3.0	79	11.4
21	89	5.4	80	9.0
30	90	6.1	76	13.5
56	74	18	49	25
91	68	21	46	22
120	62	32	37	25

Zumdick (1995a) incubated 2.1 mg/kg [3,4-^{14}C]L-*N*-acetyl-glufosinate in a sandy loam and a loamy sand under aerobic conditions for 120 days at 20°C in the dark (Table 24). In a second experiment glufosinate-tolerant tomato leaves containing residues equivalent to 1 mg glufosinate-ammonium per kg soil were incorporated into the sandy loam and incubated under the same conditions (Table 25). Bound residues accounted for about 14-23% of the applied residue in each of the three incubations from days 28 to 120.

N-acetyl-glufosinate disappeared very quickly, with half-lives of only hours, producing initially L-glufosinate, which was then degraded further to MPP, MPA and CO_2. MPP became the major component of the residue after 1-3 days.

The tolerant-tomato residue comprised mainly glufosinate and *N*-acetyl-glufosinate. After 3 days incubation in the sandy loam soil most of the residue had been converted to MPP, which itself was degraded more slowly to MPA and ultimately to CO_2.

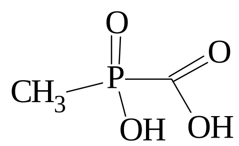
Table 24. Residues resulting from incubation of 2.1 mg/kg [3,4-^{14}C] L-*N*-acetyl-glufosinate in a sandy loam and a loamy sand under aerobic conditions for 120 days at 20°C in the dark (Zumdick 1995a).

Days	Residues, % of applied ^{14}C									
	loamy sand					sandy loam				
	NAG	CO_2	L-glufosinate	MPP	MPA	NAG	CO_2	L-glufosinate	MPP	MPA
0	70	-	20	8.4	0.4	61	-	30	4.7	0.0
0.25	14	0.3	58	13	1.2	29	0.2	58	8.1	0.7
1	15	1.1	23	35	4.7	9.2	0.9	49	22	2.2
2	6.2	3.6	23	38	5.9	4.3	2.3	41	29	3.4
3	5.1	2.8	16	42	7.4	3.1	4.9	24	37	5.9
7	4.1	11	6.3	36	9.6	1.8	1.1	38	34	8.1
14	2.8	21	5.2	27	7.6	1.0	10.5	2.6	39	19
28	1.3	39	2.2	5.2	0.8	0.4	23	1.0	28	18
62	0.5	49	1.3	1.9	0.0	0.2	56	1.0	2.1	1.2
90	0.5	52	1.1	0.7	0.0	0.4	67	1.0	0.7	0.3
120	0.3	72	0.4	0.1	0.0	0.2	66	0.4	0.5	0.1

Table 25. Residues resulting from incubation of [3,4-^{14}C]glufosinate metabolized in tolerant tomato leaves, incorporated at 1 mg glufosinate-ammonium equivalent per kg soil, in a sandy loam under aerobic conditions for 120 days at 20°C in the dark (Zumdick 1995a).

Days	Residues, % of applied ^{14}C				
	glufosinate	CO_2	NAG	MPP	MPA
0	46	-	33	4.1	0.3
0.25	47	0.0	27	4.3	0.4
1	44	0.0	30	8.9	0.6
2	27	0.1	20	27	4.1
3	5.4	0.2	2.9	52	16
7	1.4	5.3	0.4	47	25
14	0.7	5.8	0.0	40	18
28	0.6	16	0.0	31	0.6
62	0.7	48	0.0	6.7	1.2
90	0.2	49	0.0	0.8	0.0
120	0.3	43	0.0	2.4	0.0

Zumdick (1995b) incubated 1 mg/kg [3,4-^{14}C]L-*N*-acetyl-glufosinate in a sandy loam from Germany and a silt loam from Nebraska under aerobic conditions for 120 days at 20°C in the dark (Table 26). The results were consistent with other similar experiments, with the NAG rapidly forming glufosinate, which was in turn converted to MPP and MPA. An additional product (AE F130947, methylphosphinicoformic acid) was separated from the others by the HPLC systems used. Bound residues from days 14 to 90 constituted 14-22% of the applied ^{14}C.



AE F130947
methylphosphinico-formic acid

Table 26. Residues resulting from incubation of 1 mg/kg [3,4-^{14}C] L-*N*-acetyl-glufosinate in a sandy loam and a silt loam under aerobic conditions for 120 days at 20°C in the dark (Zumdick 1995b).

Days	Residues, % of applied ^{14}C											
	sandy loam						silt loam					
	NAG	CO_2	L-glufos	MPP	MPA	130947	NAG	CO_2	L-glufos	MPP	MPA	130947
0.1	91	-	9.7	0.8	0.1	<0.1	85	-	13	1.7	0.1	<0.1
0.25	16	0.2	66	7.3	0.6	0.4	26	0.3	36	11	0.3	0.3
1	7.5	0.8	48	21	1.8	2.0	11	1.7	46	23	3.2	2.8
3	4.7	7.0	26	35	5.2	4.2	3.5	6.3	26	25	11	5.9
7	3.2	16	10	32	9.1	6.3	2.4	15	11	18	21	10
14	1.9	29	4.3	20	12	7.3	0.7	36	2.6	2.8	18	8.7
21	1.2	41	6.1	12	8.8	5.3	0.3	44	2.8	1.9	15	4.5
30	0.7	48	4.2	5.8	5.3	3.9	0.3	59	1.5	0.4	4.4	1.3
59	1.3	64	1.5	1.5	0.2	0.3	<0.1	63	0.8	<0.1	<0.1	<0.1
90	0.3	68	0.6	0.3	<0.1	<0.1		65				
120		77						67				

Stumpf *et al*. (1989) subjected [3,4-^{14}C]glufosinate-ammonium in a thin layer of a microbiologically active sandy loam soil to UV irradiation (xenon arc with 290 nm cut-off filters) for 35 days in a 12 hours light-dark cycle at 25°C and identified the products. The calculated degradation half-life was 35 days, with 7.6% production of $^{14}CO_2$ in that time. Three degradation products were identified: MPP (6-21% of the applied ^{14}C), MPA (0-5%) and NAG (0-10%). Three other products were in too small amounts (0-3% and 4-9%) to be identified. Degradation was caused by microbiological processes and photolysis in the presence of humic acids.

In a rotational crop study Campbell and Bennett (1997) treated bare ground plots in North carolina, Missouri and California twice at 10-day intervals with glufosinate-ammonium at 0.39 and 0.54 kg ai/ha and planted winter wheat 75 and 90 days after the final treatment. No residues of glufosinate or MPP were detected (LOD 0.05 mg/kg) in forage, hay, grain or straw samples. No uptake of glufosinate or MPP should occur in winter wheat following a previous use of glufosinate-ammonium.

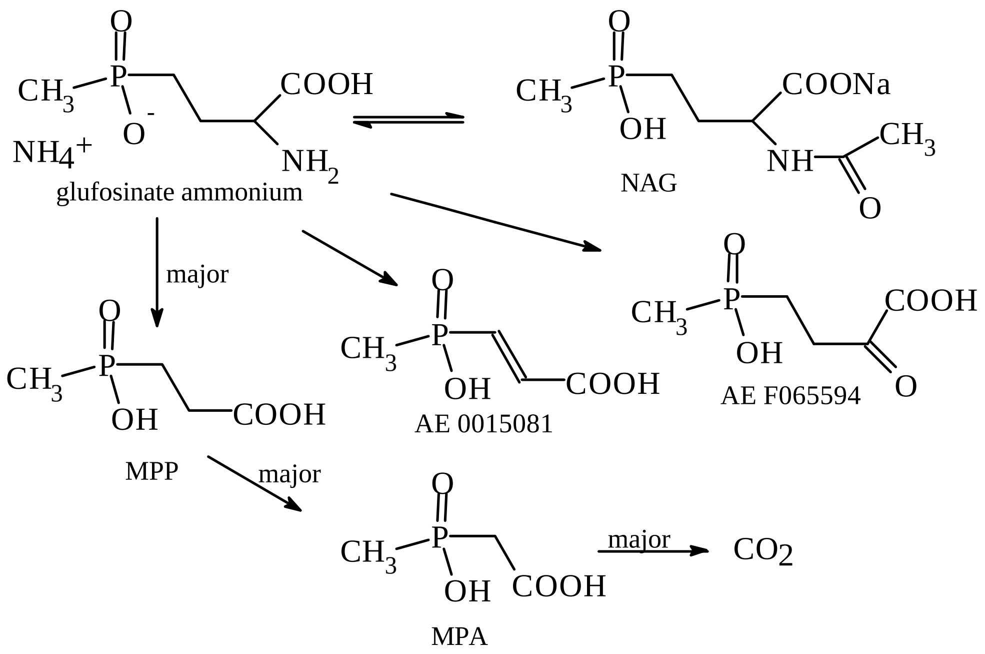
In a confined rotational crop study, Meyer *et al*. (1995) applied [3,4-^{14}C]glufosinate-ammonium to a bare sandy loam soil in a greenhouse in stainless steel tanks at 1.0 kg ai/ha and planted radishes, lettuce and wheat 28 and 119 days later. The intervals represented resowing after crop failure and immediate recropping. Residue levels are shown in Table 27. Product A was not identified, but was characterized as a relatively simple polar unconjugated compound that may be a degradation product taken up by roots. The products were similar in the root, leafy and small cereal grain crops. Levels were much lower after the longer sowing interval. Residues should be undetectable or very low in rotational crops.

Table 27. ^{14}C residues in rotational crops after application of [3,4-^{14}C]glufosinate-ammonium at 1.0 kg ai/ha to a bare sandy loam soil (Meyer *et al.*, 1995).

Commodity	Residues, mg/kg, as glufosinate free acid							
	28 days interval to sowing				119 days interval to sowing			
	total ^{14}C	MPP	MPA	Compound A	total ^{14}C	MPP	MPA	Compound A
Radish top	0.110	0.053	0.006	0.021	0.013[1]			
Radish root	0.090	0.047	0.008	0.024	0.009[1]			
Lettuce	0.079	0.020	0.006	0.013	0.013[1]			
Wheat forage	0.30	0.17	0.019	0.027	0.047[1]			
Wheat straw	0.78	0.35	0.073	0.19	0.14	0.029	0.008	0.035
Wheat grain	0.33	0.11	0.035	0.035	0.12	0.015	<0.001	0.016

[1]Residue too low for characterization.

Figure 3. Proposed aerobic soil degradation pathways of glufosinate-ammonium.



Environmental fate in water/sediment systems

Stumpf and Schink (1992) subjected [3,4-^{14}C]glufosinate-ammonium dissolved in surface water from a gravel pit to UV irradiation for 118 hours (equivalent to 33 days sunlight) at 25°C. Glufosinate suffered little degradation under these conditions, with 3-5% conversion to MPP and 0.2% mineralization. Photolytic degradation of glufosinate in surface waters is a minor degradation route.

Stumpf (1993b) incubated [3,4-^{14}C]glufosinate-ammonium at 0.1 mg/kg in aerobic systems consisting of 180 ml water and 20 g sediment at 20°C and 8°C for 361 days. The sediment was sandy with 0.4% organic carbon.

Glufosinate disappeared from the water/sediment system with half-lives of 3 and 20 days at 20°C and 8°C respectively. Mineralization occurred to the extent of only 25 and 20% at the two temperatures in the 361 days of the study. Within a few days at 20°C and after 29 days at 8°C MPP became the major component of the residue. Seven other products were observed, but five were very minor. Two others amounting to 5% and 20% of the applied dose at various times were not positively identified. At all times most of the total residue was in the aqueous phase.

In sterile (autoclaved) samples incubated for 29 and 120 days up to 50% of the residue was converted to NAG in some samples, but heat resistant bacteria may have been present.

Table 28. Residues resulting from incubation of [3,4-^{14}C]glufosinate-ammonium in a water/sediment system under aerobic conditions at 8°C and 20°C (Stumpf 1993e).

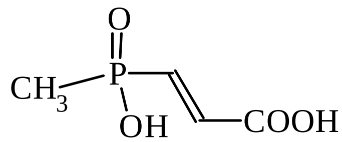
Days	Residues, % of applied ^{14}C									
	20°C					8°C				
	Glufosinate	CO_2	MPP	NAG	MPA	Glufosinate	CO_2	MPP	NAG	MPA
0	95	-	4.4	2.6	0.0	95	-	4.4	2.6	0.0
1	60	0.3	21	14	1.0	84	0.1	7.8	7.0	0.3
4	39	0.8	40	9.8	1.4	61	0.3	15	10.3	0.4
7	24	1.5	49	5.7	3.4	56	0.3	21	14	0.7
14	7.1	4.4	59	3.9	3.2	48	0.7	28	12	1.5
21	0.3	8.2	56	2.4	2.9	45	1.5	32	6.5	2.8
29	0.1	12	53	1.9	3.8	33	1.7	39	3.7	3.5
60	0.0	18	52	0.2	2.9	15	5.4	44	3.3	3.3
90	0.0	21	52	0.1	3.0	2.7	6.7	49	4.2	3.7
120	0.0	17	47	0.0	4.0	0.0	9.0	51	3.0	3.3
238	0.0	23	46	0.0	5.6	0.0	17	45	0.0	2.3
361	0.0	25	48	0.0	5.6	0.0	20	55	0.0	1.4

Stumpf (1994a) incubated [3,4-^{14}C]glufosinate-ammonium at 1 and 0.1 mg/kg in two aerobic systems consisting of 180 ml water and 20 g sediment at 20°C in the dark for 130 days (Tables 29 and 30).

The mineralization in130 days in the gravel pit sediment was 7% at the lower dose and 12% at the higher dose. The half-lives for the degradation of glufosinate itself were 11, 91 and 1.4 days for the loamy river water sediment at 1 mg/kg and the gravel-pit sediment at 1 mg/kg and 0.1 mg/kg respectively. MPP was the main product identified and it was quite persistent in both systems. In all cases most of the residue was in the water phase.

As in a previous experiment (Stumpf, 1993b) a number of minor products were detected but not identified. Two products, sometimes constituting 10-20% of the residue, were further investigated and identified as AE F086486 and possibly AE F130947 (methylphosphinicoformic acid).

In a subsequent study, Stumpf (1994b) used glufosinate labelled in different positions and a higher dose rate to produce sufficient material for positive identification as AE F130947, also identified as a soil degradation study (Zumdick, 1995b).



AE 0015081
3-methyl-phosphinico
acrylic acid

Stumpf and Zumdick (1998) corrected the identification of AE F086486 (3-methylphosphinico-3-oxopropionic acid) to AE 0015081 and confirmed AE F130947.

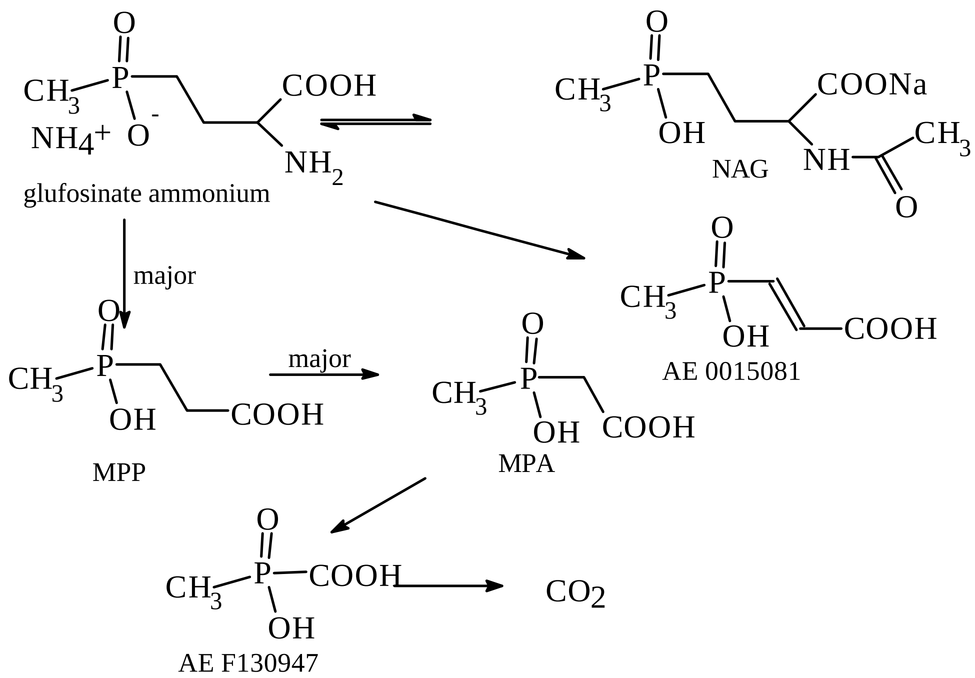
Table 29. Residues resulting from incubation of [3,4-^{14}C]glufosinate-ammonium in a gravel pit water/sediment system at 20°C in the dark for 130 days (Stumpf, 1994a).

Days	Residues, % of applied ^{14}C in whole system									
	gravel-pit sediment, 1 mg/kg					gravel-pit sediment, 0.1 mg/kg				
	Glufosinate	CO_2	MPP	NAG	MPA	Glufosinate	CO_2	MPP	NAG	MPA
0	91	-	2.0	0.7	0.0	89	-	2.9	1.7	0.0
1	86	0.0	6.8	2.0	0.4	59	0.0	23	9.9	0.9
3	74	0.0	15	4.0	0.7	21	0.2	55	7.5	3.5
7	69	0.2	19	4.1	2.4	3.8	1.0	79	1.8	4.7
14	60	0.5	25	3.7	4.1	0.1	2.8	80	0.3	5.7
21	57	0.8	27	2.5	6.2	0.0	4.4	78	0.0	4.6
30	46	1.9	28	3.3	10.0	0.0	6.8	76	0.0	4.1
50	39	2.9	31	4.3	12	0.0	8.6	76	0.0	4.2
77	36	4.3	30	2.9	14	0.0	10.6	74	0.0	4.4
91	37	5.0	30	1.4	14	0.0	12	70	0.0	5.1
130	33	7.1	30	2.1	16	0.0	12	67	0.0	6.8

Table 30. Residues resulting from incubation of [3,4-^{14}C]glufosinate-ammonium in a loamy river water sediment system at 20°C in the dark for 130 days (Stumpf, 1994a).

Days	Residues, % of applied ^{14}C				
	Glufosinate	CO_2	MPP	NAG	MPA
0	91	?	1.3	1.0	0.0
1	87	?	5.4	2.5	0.3
3	72	?	13	6.2	3.4
7	60		19	8.2	5.9
14	46		26	7.6	10.2
21	35		29	4.5	12
30	19		37	1.5	16
50	3.0		41	0.0	20
77	0.0		48	0.0	18
91	0.0		48	0.0	17
130	0.0		45	0.0	16

Figure 4. Proposed aerobic degradation pathways of glufosinate-ammonium in water/sediment systems



METHODS OF RESIDUE ANALYSIS

Analytical methods

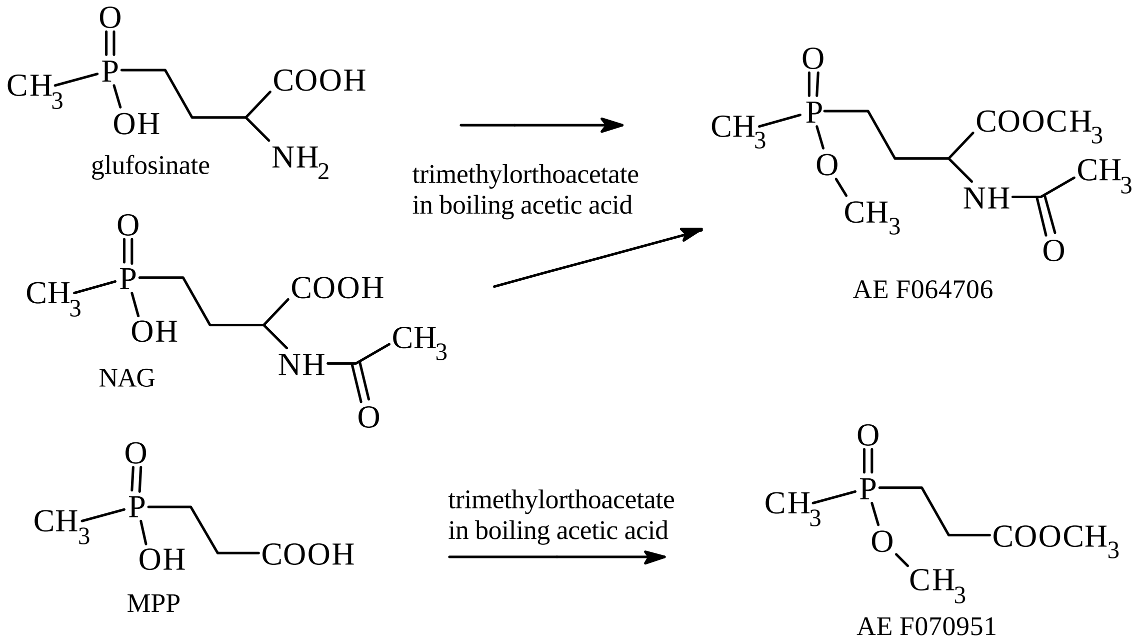
The main components of the residue in genetically modified tolerant crops are glufosinate, NAG (*N*-acetyl-L-glufosinate) and MPP (3-methyl-phosphinico-propionic acid). Analytical methods have been designed to measure the three components separately or, because glufosinate and NAG produce the same derivative in the analytical procedure, to measure glufosinate and NAG combined and MPP separately.

Holzwarth (1995) described the methods used for residue analysis of tolerant crops. Residues are extracted from the finely ground sample with water. The clear extract, after separation from solid material, is passed through an anion exchange resin and the residues are eluted with formic acid. After evaporation of the formic acid the residue is taken up in a 1:1 ethanol/water mixture which is then applied to a cation exchange column. NAG and MPP are eluted with ethanol/water and glufosinate with aqueous ammonia.

After evaporation to dryness the residues from both fractions are taken up in glacial acetic acid and methylated and acetylated with trimethyl orthoacetate in refluxing acetic acid. After solvent exchange and a final silica gel cartridge clean-up the residues are determined by GLC with flame photometric detection.

Variations on the extraction and initial clean-up are needed for samples such as maize oil. The lower limit of determination for crop samples is typically 0.05 mg/kg for each of the three analytes. For fats and milk a mixture of n-propanol and water is used for extraction instead of water.

Figure 5. Derivatization of glufosinate, NAG and MPP.



Czarnecki *et al.* (1989) used a method (HRAV-5A) similar in principle to that described above for the determination of glufosinate and MPP in apples, grapes, soya beans, maize and tree nuts. Czarnecki and Bertrand (1993) described a similar method (HRAV-24) for the determination of glufosinate, MPP and NAG in maize and its processed fractions. Sochor *et al.* (1991) measured residues of glufosinate, MPP and NAG in tomatoes, tobacco and potatoes by the same method and achieved practical LODs of 0.05-0.2 mg/kg.

Czarnecki (1995a) analysed animal commodities for glufosinate and MPP by a similar method but without the cation exchange column clean-up, achieving LODs of 0.02 mg/kg for milk, 0.05 mg/kg for eggs, meat and fat, and 0.1 mg/kg for kidneys and liver. Czarnecki (1995b) included NAG in the same method with the same LODs. NAG and glufosinate appear in the same GLC peak so the LOD is for either compound or the combined residue.

Czarnecki and Bertrand (1994) described a comprehensive procedure for the determination of glufosinate, MPP and NAG in many commodities. The method (AE-24) is essentially as described above with many variations on the extraction depending on the nature of the sample. Recoveries should lie within the range 70-120% at the practical LOD of 0.05 mg/kg for each compound, expressed as glufosinate free acid. The method was determined and used on maize grain, silage, forage, fodder, starch, grits, flour, meal and hulls, and soya bean seed, hay, hulls and meal. The same method was described by Czarnecki (1995c). Bertrand (1994) validated the method (Table 31). Most tests were at a fortification level of 0.05 mg/kg, but recoveries did not seem to depend on concentration. Median recoveries were 95%, 95% and 102% for glufosinate, MPP and NAG respectively.

Bertrand (1994) pointed out that part of the glufosinate added to glufosinate-tolerant plant material could be converted to NAG during recovery testing. When racemic glufosinate was added to transgenic soya bean seed at 0.5 mg/kg, 44-54% was recovered as glufosinate and 33-43% as NAG. When D-glufosinate was used, recoveries of glufosinate were 85-100%. In some transgenic materials it is necessary to use D-glufosinate, which is not subject to enzymic *N*-acetylation, to determine the analytical recovery of glufosinate. The method is not selective for either isomer.

Table 31. Recoveries of glufosinate, MPP and NAG from maize grain, forage, fodder, silage, flour, meal, hulls, starch, and crude oil, and soya bean seeds, hulls, meal, hay/fodder and crude oil (Bertrand, 1994).

Recovery range, %	Number of tests		
	Glufosinate	MPP	NAG
61-70		4	1
71-80	5	13	0
81-90	16	28	4
91-100	17	30	19
101-110	17	23	18
111-120	7	15	8
121-130		4	6
131-140		1	

Castro and Dacus (1994) validated analytical method AE-24 (suitable for enforcement) on commodities from transgenic maize and soya beans. D-glufosinate was used to determine recoveries from soya bean seed. An LOD of 0.05 mg/kg for each compound on each commodity was achieved (Table 32). The time needed to analyse a batch of six samples was about 18 working hours over 3 working days.

Table 32. Recoveries by analytical method AE-24 from transgenic maize and soya bean commodities (Castro and Dacus, 1994).

Commodity	Glufosinate		MPP		NAG	
	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %
Maize grain	0.05 0.25	73-98% (n=4)	0.05 0.25	73-78% (n=4)	0.10 0.50	89-107% (n=4)
Maize forage	0.50 2.5	83-89% (n=4)	0.10 0.50	76-87% (n=4)	3.0 15	101-110% (n=4)
Corn oil, refined	0.05 0.25	57-96% (n=4)	0.05 0.25	70-82% (n=4)	0.05 0.25	113-149% (n=4)
Soya bean seed	0.05 0.25 (D-glufosinate)	65-89% (n=4)	0.10 0.50	80-91% (n=4)	0.20 1.0	85-109% (n=4)

Holzwarth (1996a) determined the suitability of analytical method AE-24 for residues in glufosinate-tolerant maize shoots. Recoveries of spiked analyte over the concentration range 0.05-5 mg/kg were glufosinate 60-99% (n=6), NAG 65-85% (n=6) and MPP 53-99% (n=12). Holzwarth (1996b) also validated method AE-24 for residues in maize grain from plants susceptible to glufosinate-ammonium. Recoveries over the concentration range 0.05-5 mg/kg were: glufosinate 81-95% (n=6), NAG 68-82% (n=6) and MPP 54-94% (n=11).

Snowdon and Taylor (1995b) validated method AE-24 for glufosinate-tolerant maize, achieving LODs of 0.05 mg/kg for each analyte. Recoveries are shown in Table 33.

Table 33. Recoveries by analytical method AE-24 from transgenic maize commodities (Snowdon and Taylor, 1995b).

Commodity	Glufosinate		MPP		NAG	
	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %
Maize shoots	0.05 2.0 50	61-105 (n=7)	0.05 2.0 50	69-85 (n=14)	0.05 2.0 50	76-132 (n=7)
Cobs	0.05 0.50	64-104 (n=5)	0.05 0.50	66-89 (n=10)	0.05 0.50	80-113 (n=5)
Cob/spadix	0.05 0.50	95-131 (n=4)	0.05 0.50	74-105 (n=10)	0.05 0.50	97-122 (n=5)

Czarnecki (1995c) validated analytical method AE-24A for maize and its processed products. The method differs from AE-24 in omitting the cation-exchange column step before derivatization. Consequently, the compounds appear as a single peak and are reported as a combined residue. Recoveries were acceptable for maize grain, forage and fodder.

Niedzwiadek and Bertrand (1995b) validated analytical method AE-24A for residues in glufosinate-tolerant rape seed commodities (Table 34). The LOD was 0.05 mg/kg for each analyte in each sample.

Table 34. Recoveries by method AE-24A from transgenic rape seed commodities (Niedzwiadek and Bertrand 1995b).

Commodity	Glufosinate		MPP		NAG	
	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %	spiking levels, mg/kg	Recovery range, %
Rape shoot	0.05 0.50 10	92-114 (n=15)	0.05 0.50 10	76-115 (n=30)	0.05 0.50 10	91-119 (n=15)
Rape pod	0.05 0.50 5.0	87-108 (n=15)	0.05 0.50 5.0	71-109 (n=30)	0.05 0.50 5.0	88-120 (n=15
Rape straw	0.05 0.50	95-116 (n=10)	0.05 0.50	71-108 (n=20)	0.05 0.50	101-134 (n=10)
Rape seed	0.05 0.50	76-109 (n=10)	0.05 0.50	82-117 (n=20)	0.05 0.50	99-118 (n=10)

Idstein *et al.* (1987b) extracted glufosinate and MPP from soya beans and derivatized the compounds with trimethyl orthoacetate. After clean-up on a silica gel cartridge, the residues were measured by GLC with a flame photometric detector. Idstein *et al.* (1987a extracted glufosinate and MPP from milk by dialysis and completed the analysis in the same way. Schuld (1988) extracted the residues from hens' eggs with water, washed the aqueous extract with dichloromethane and hexane to remove lipids and then followed a similar procedure.

Sochor *et al.* (1987a) extracted rape seed with water and removed oil with dichloromethane before proceeding with the Idstein method. Sochor *et al.* (1987b) extracted the residues from fats by an initial water/dichloromethane partition before following the remainder of the procedure. Sochor *et al.* (1988) extracted animal organs with water, precipitated high MW co-extractives with acetone and continued with the Idstein method, achieving practical LODs of 0.05-0.1 mg/kg.

The method used for glufosinate in The Netherlands relies on extraction of samples with water and clean-up by dialysis and ion-exchange. The residue is measured by GLC with an FPD after derivatization with trimethyl orthoacetate. Recoveries are 70-80% and the LOD 0.05 mg/kg.

Stability of pesticide residues in stored analytical samples

Information was made available on the frozen storage stability of glufosinate and its metabolites in genetically modified maize and processed commodities, soya bean and processed commodities, dairy cow tissues and milk, eggs and chicken tissues, susceptible maize grain, and transgenic rape seed and sugar beet root.

Belcher (1995a) determined the stability of glufosinate and its metabolites in genetically modified maize commodities (hulls, grits, flour and refined maize oil) during frozen storage for 12 months (Table 35). The report did not state the storage conditions. Residues were generally stable for 12 months, but glufosinate decreased by 30% and NAG by 19% in refined maize oil.

Table 35. Recoveries of glufosinate, NAG and MPP from maize commodities spiked with 0.5 mg/kg and stored for periods up to 12 months under frozen conditions (Belcher 1995a). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	glufosinate ammonium, racemate				NAG, racemate, free acid				MPP, free acid			
	hulls	grits	flour	oil, refined	hulls	grits	flour	oil, refined	hulls	Grits	flour	oil, refined
0	88%	92%	94%	83%	80%	101%	87%	102%	82%	93%	73%	89%
3	81%	84%	71%	67%	91%	89%	82%	94%	92%	81%	86%	84%
6	76%	74%	83%	68%	90%	93%	93%	85%	87%	86%	85%	79%
12	87%	88%	103%	58%	81%	93%	108%	83%	77%	81%	75%	76%

Belcher (1996b) determined the stability of glufosinate and its metabolites in genetically modified maize grain, fodder and forage during frozen storage for 24 months (Table 36). Residues were generally stable. The report did not include the storage conditions.

Table 36. Recoveries of glufosinate, NAG and MPP from maize commodities spiked with 0.5 mg/kg and stored for periods up to 24 months under frozen conditions (Belcher 1996b). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	glufosinate ammonium, racemate			NAG, racemate, free acid			MPP, free acid		
	grain	fodder	forage	grain	fodder	forage	grain	fodder	forage
0	95%	87%	94%	99%	88%	96%	88%	91%	98%
3	89%	97%	91%	93%	89%	90%	86%	99%	97%
6	91%	91%	83%	109%	86%	100%	90%	91%	93%
12	83%	85%	76%	93%	95%	88%	94%	103%	105%
24	88%	79%	76%	101%	88%	78%	90%	89%	87%

Belcher (1995b) determined the stability of glufosinate and its metabolites in genetically modified soya bean meal, hulls and refined oil during frozen storage for 12 months (Table 37). In some samples of meal and hulls enzyme activity converted some of the added glufosinate to NAG. In these cases the sum of glufosinate and NAG was treated as the remaining residue and used for the calculation in Table 37. Residues were generally stable for the 12 months. The report did not specify the storage conditions.

Table 37. Recoveries of glufosinate, NAG and MPP from soya commodities spiked with 0.5 mg/kg and stored for periods up to 12 months under frozen conditions (Belcher 1995b). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	glufosinate ammonium, racemate			NAG, racemate, free acid			MPP, free acid		
	meal	hulls	oil, refined	meal	hulls	oil, refined	meal	hulls	oil, refined
0	68%	83%	79%	84%	91%	104%	113%	90%	87%
3	86%	86%	77%	92%	82%	86%	101%	96%	96%
6	93%	96%	78%	100%	104%	97%	90%	93%	82%
12	83%	94%	93%	78%	96%	103%	93%	95%	87%

Homogenized eggs, chicken tissue, milk and cow tissue samples were spiked with glufosinate-ammonium, NAG and MPP at 0.25 mg/kg and stored at -12°C to -27°C for 15 months (Crotts and McKinney, 1995, 1996; McKinney and Crotts, 1997). The results are shown in Table 38 and 39.All three compounds were stable for 15 months.

Table 38. Recoveries of glufosinate, NAG and MPP from homogenized eggs and chicken tissues spiked with 0.25 mg/kg and stored for periods up to 15 months under frozen conditions (Crotts and McKinney, 1995; McKinney and Crotts, 1997). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	Glufosinate ammonium, racemate			NAG, L-isomer, disodium			MPP, free acid		
	muscle	Liver	eggs	muscle	liver	eggs	muscle	liver	eggs
0	102%	106%	105%	103%	111%	102%	96%	88%	85%
1	104%	102%	109%	103%	102%	101%	89%	92%	82%
3	79%	81%	83%	76%	91%	81%	86%	87%	79%
15	102%	105%	100%	108%	108%	86%	90%	84%	87%

Table 39. Recoveries of glufosinate, NAG and MPP from milk and cow tissues spiked with 0.25 mg/kg and stored for periods up to 15 months under frozen conditions (Crotts and McKinney, 1996). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	glufosinate ammonium, racemate				NAG, L-isomer, disodium				MPP, free acid			
	kidneys	muscle	liver	whole milk	kidneys	muscle	liver	whole milk	kidneys	muscle	liver	whole milk
14	107			86	112			83	100			82
15		76	97			93	107			81	92	

Werner (1997a-d) spiked homogenized transgenic maize shoots, rape seed and sugar beet roots and susceptible maize grain with glufosinate-ammonium, NAG and MPP at 0.5 mg/kg (expressed as glufosinate free acid) and measured the stability of the residues stored deep-frozen (temperature not stated) for 24 months. Results are shown in Table. All three compounds were stable for 24 months.

Table 40. Recoveries of glufosinate, NAG and MPP from homogenized transgenic maize shoots, susceptible maize grain, transgenic rape seed and sugar beet root stored for periods up to 24 months under frozen conditions (Werner 1997a-d). Results are means of duplicate samples, uncorrected for analytical recovery.

Storage, months	glufosinate ammonium, racemate, % remaining				NAG, L-isomer, disodium, % remaining				MPP, free acid, % remaining			
	maize shoot	maize grain	rape-seed	sugar-beet	maize shoot	maize grain	rape-seed	sugar-beet	maize shoot	maize grain	rape-seed	sugar-beet
0	76	81	96	74	75	59	100	64	65	68	87	67
1		92		74		66		72		74		71
2	67		84		75		91		73		91	
3		80		67		83		67		61		63
4	75		85		60		97		51		90	
6				86	106[1]	68[1]	85[1]	79	108	78	71	80
12			103	94	100[1]	63[1]	88	96	96	73	81	77
15	87	100			68	58			57	84		
18	92	106	92	98	77	89	91	103	77	68	86	86
23			101				97				90	
23							104[1]				106	
24					91[1]	91[1]			86	88		
24	83	113		102	88	97		81	72	86		82

[1]Analyses by method AE-24A. % remaining is calculated as sum of glufosinate + NAG.

Definition of the residue

The current definition of the residue for glufosinate-ammonium is *Sum of glufosinate-ammonium and 3-[hydroxy(methyl)phosphinoyl]propionic acid, expressed as glufosinate (free acid).*

When glufosinate is used on glufosinate-tolerant crops a major part of the residue is *N*-acetyl-glufosinate (NAG). It should be included in the definition of the residue for enforcement because it is generally the main component of the residue and the same GLC derivative is produced in the analytical method from glufosinate and NAG, so unless the compounds are separated before derivatization they both appear in the GLC peak for their common derivative.

A suitable revised definition would be *Sum of glufosinate-ammonium, 3-[hydroxy(methyl)phosphinoyl]propionic acid and N-acetyl-glufosinate, expressed as glufosinate (free acid)*, but this definition could not be adopted until *N*-acetyl-glufosinate had been toxicologically evaluated.

USE PATTERN

Glufosinate-ammonium is a non-selective herbicide registered for crop uses, including desiccation, and non-crop uses. It is used to control annual and perennial grasses and broad-leaved weeds in horticultural and agricultural crops. Glufosinate acts as an inhibitor of glutamine synthetase, which leads to poisoning of the plant by ammonia. For weed control in susceptible crops it must be used either before crop emergence or as a directed spray away from foliage.

Glufosinate resistance has been imparted to several agronomic crops by insertion of a gene that enables the plant to detoxify L-glufosinate (the active isomer) by acetylation to *N*-acetyl-L-glufosinate which is not herbicidal.

The use pattern is necessarily different for conventional crops and those with glufosinate tolerance.

Table 41. Registered uses of glufosinate-ammonium. Concentrations and rates are expressed in terms of the active ingredient glufosinate-ammonium.

Crop [1]	Country	Form	Application			Number	Growth stage [2]	PHI, days
			Method	Rate, kg ai/ha	Spray conc. kg ai/hl			
Almond	USA	120 g/l SL	directed	1.7	min spray vol 187 l/ha	max total 5.1 kg/ha/yr		14
Apple	Poland [4]	150 g/l SL		0.45-0.90	0.04-0.35	2		
Apricot	Poland [4]	200 g/l SL		0.60-1.2	0.06-0.60	2		
Asparagus	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1		
Avocado	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Banana	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Banana	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Bean	Poland [4]	SL	spray HV	0.45-0.60	0.04-0.30	1	pre-emerg	
Blackberries	Netherlands	200 g/l 150 g/l	directed spray	0.75-1.0		2		-
Canola (tolerant)	Canada	150 g/l SL	foliar	0.30-0.50	min spray vol 110 l/ha	2	early bolting	[3]
Canola (tolerant)	Canada	150 g/l SL	foliar	0.60	min spray vol 110 l/ha	1	early bolting	[3]
Carambola (Starfruit)	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Carrot	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1	pre-emerg	
Carrot	Poland [4]	SL	spray HV	0.45-0.60	0.04-0.30	1	pre-emerg	
Cashew nut	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Cherry	Poland [4]	150 g/l SL		0.45-0.90	0.04-0.35	2		
Currants	Germany [4]	200 g/l SL	spray with screening	0.92	0.15-0.31	1		14
Currants	Netherlands	200 g/l 150 g/l	directed spray	0.75-1.0		2		-
Durian	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Dwarf French beans	Germany [4]	200 g/l SL	spray between rows with screening	0.92	0.23-0.31	1		14
Dwarf French beans	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14
Feijoa	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Field peas	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14
Fruit trees	Netherlands	200 g/l 150 g/l	directed under trees	0.75-1.0		2		-
Gooseberrie s	Germany [4]	200 g/l SL	spray with screening	0.92	0.15-0.31	1		14
Gooseberrie s	Poland [4]	200 g/l SL		0.60-1.2	0.06-0.60	2		
Guava	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Guava	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Hazelnut	Italy	120 g/l SL	directed	0.5-1.6	0.08-0.78	max total 2.5 kg/ha/yr		-
Horse beans	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14

Crop [1]	Country	Form	Application			Number	Growth stage [2]	PHI, days
			Method	Rate, kg ai/ha	Spray conc. kg ai/hl			
Jack fruit	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Kiwifruit	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Lamb's lettuce	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1	pre-emerg	
Leek	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1	pre-emerg	
Litchi	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Macadamia	USA	120 g/l SL	directed	1.7	min spray vol 187 l/ha	max total 5.1 kg/ha/yr		14
Maize	Germany [4]	200 g/l SL	spray	0.92	0.23-0.31	1	pre-sowing	
Maize	Germany [4]	200 g/l SL	spray, under leaf	0.92	0.23-0.31	1	stage 16-20	
Maize (tolerant)	Germany [5]	200 g/l SL	foliar	0.90	0.23-0.45	1	3-8 leaf	
Maize (tolerant)	Germany [5]	200 g/l SL	foliar	0.45	0.11-0.23	2[1]	8 leaf	
Maize (tolerant)	Canada	200 g/l SL	foliar	0.30-0.50	min spray vol 110 l/ha	2[2]	8-leaf	86 grain 20 (graze)
Maize (tolerant)	Portugal	200 g/l SL	foliar	0.40-0.80	rec spray vol 200-400 l/ha	2	2-4 leaf[3]	
Maize (tolerant)	USA	18.2%		0.20-0.36		2	60 cm	60 (corn forage) 70 (corn grain, fodder)
Maize (tolerant)	USA	200 g/l SL	foliar	0.23-0.41		2	60 cm	70 grain 70 maize fodder 60 maize forage
Mango	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Mango	Malaysia	150 g/l SL	directed	0.3-0.5	0.11	4		14
Onion	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1	pre-emerg	
Onion	Poland [4]	SL	spray HV	0.45-0.60	0.04-0.30	1	pre-emerg	
Papaya	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Parsley	Poland [4]	SL	spray HV	0.45-0.60	0.04-0.30	1	pre-emerg	
Passion fruit	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Peach	Poland [4]	200 g/l SL		0.60-1.2	0.06-0.60	2		
Pear	Poland [4]	150 g/l SL		0.45-0.90	0.04-0.35	2		
Pecan	USA	120 g/l SL	directed	1.7	min spray vol 187 l/ha	max total 5.1 kg/ha/yr		14
Pineapple	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Plum	Poland [4]	200 g/l SL		0.60-1.2	0.06-0.60	2		
Potato	Germany [4]	200 g/l SL	spray	0.55	0.14-0.18	1	stage 8-9	
Potato	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14
Potato	Netherlands	200 g/l 150 g/l	aerial parts, haulm kill	0.45-0.60		1		-
Potato	Netherlands	200 g/l 150 g/l	directed spray	0.45-1.0		1		-
Potato	Netherlands	200 g/l 150 g/l	pre-emergence	0.45-1.0		1		-

[1] Germany, split application on maize, 6 weeks interval.

[2] Maximum rate in the 2nd application is 0.40 kg ai/ha.

[3] For the second application, the maize should have no more than 8-10 leaves.

Crop [1]	Country	Form	Application			Number	Growth stage [2]	PHI, days
			Method	Rate, kg ai/ha	Spray conc. kg ai/hl			
Rambutan	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Rape seed	Poland [4]	SL	spray HV	0.38-0.50	0.04	0.25	desiccation	
Raspberries	Germany [4]	200 g/l SL	spray with screening	0.92	0.15-0.31	1		14
Raspberries	Netherlands	200 g/l 150 g/l	directed spray	0.75-1.0		2		-
Raspberries	Poland [4]	200 g/l SL		0.60-1.2	0.06-0.60	2		
Spinach	Netherlands	200 g/l 150 g/l	aerial parts, haulm kill	0.6-0.8		1		-
Soya beans (tolerant)	USA	200 g/l SL	foliar	0.23-0.41		2	bloom growth	70 seed forage[1]
Strawberries	Germany [4]	200 g/l SL	spray between rows with screening	0.73	0.18-0.24	1	stage 59	42
Strawberries	Germany [4]	200 g/l SL	spray with screening	0.73	0.12-0.24	1	after harvest	
Sugar beets	Germany [4]	200 g/l SL	spray	0.92	0.23-0.31	1	pre-sowing	
Sunflowers	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14
Tree nuts	Australia	200 g/l SL	directed	0.2-1.0	spray vol 300-1000 l/ha			-
Walnut	Italy	120 g/l SL	directed	0.5-1.6	0.08-0.78	max total 2.5 kg/ha/yr		-
Walnut	USA	120 g/l SL	directed	1.7	min spray vol 187 l/ha	max total 5.1 kg/ha/yr		14
Winter rape	Germany [4]	200 g/l SL	spraying	0.46	0.08-0.15	1	desiccation	14

[1] tolerant: tolerant to glufosinate-ammonium
[2] growth stage at final application.
[3] Do not graze the treated crop or cut for hay; sufficient data are not available to support such use.
[4] Label not provided.
[5] Label not available. Registration document 4574-00 1 Sept 1998 provided.

RESIDUES RESULTING FROM SUPERVISED TRIALS

Residue data from glufosinate-ammonium supervised residue trials on fruit, tree nuts and field crops are summarized in Tables 42-61.

Table 42	*Tropical fruits -avocado, mango, guava, carambola, papaya.* Australia, Malaysia.
Table 43	*Tree nuts – pecan, walnut, almond, hazel nuts macadamia.* USA, Italy, Australia.
Table 44	*Maize.* France, Germany, Italy, Spain.
Table 45	*Maize.* USA, Argentina.
Table 46	*Maize.* Canada.
Table 47	*Soya beans.* USA.
Table 48	*Rape seed.* France, Germany, UK.
Table 49	*Canola.* Canada.
Table 50	*Canola.* Australia.
Table 51	*Sugar beet root.* France, Germany, UK.
Table 52	*Sugar beet root.* USA.

[1] Do not feed treated green immature growing soya bean plants to livestock.

Table 53	*Maize forage and fodder.* France, Germany, Italy, Netherlands, Spain.
Table 54	*Maize forage and fodder.* USA, Argentina.
Table 55	*Maize forage and fodder.* Canada.
Table 56	*Rape seed forage and fodder.* France, Germany, UK.
Table 57	*Canola forage and fodder.* Australia.
Table 58	*Soya bean forage and fodder.* USA.
Table 59	*Sugar beet tops and leaves.* France, Germany, UK.
Table 60	*Sugar beet tops.* USA.
Table 61	*Almond hulls.* USA.

Where residues were not detected they are recorded as below the limit of determination (LOD), e.g. <0.05 mg/kg. Residue levels of glufosinate and its metabolites are generally expressed as glufosinate free acid. Residues, application rates and spray concentrations have generally been rounded to 2 significant figures or, for residues near the LOD, to 1 significant figure. Although all trials included control plots residues in control samples are recorded only when they exceeded the LOD. Residues are not corrected for recoveries. Recoveries were mainly in the range 70-120%.

Reports did not generally state whether residues in forage and fodder commodities were expressed on a fresh-weight or dry-weight basis.

Trials were fully reported as well as on summary sheets except the US trials on pecans and walnuts and the Italian trials on hazel-nuts. These trials were all reported on the detailed summary sheets used in Germany.

Glufosinate-ammonium is used as a directed spray for weed control in orchards, so that residues usually only occur in the crop through root uptake from the soil. Glufosinate-ammonium itself is not taken up, but the metabolite 3-methylphosphinicopropionic acid (MPP) can be taken up and translocated by the crop. This metabolite is not herbicidally active, so its residues may occur in the crop when glufosinate-ammonium is used as a directed spray.

In tropical fruit trials in Australia and Malaysia glufosinate-ammonium was applied to weeds around the trees as a directed spray. Plot sizes ranged from 1 tree to 1050 m^2. Intervals of 109 to 468 days of frozen sample storage elapsed before analysis. Residues are expressed on a pulp + peel basis for the avocados and mangoes in the Australian trials, but this does not influence the results which were mainly below the LOD.

Glufosinate-ammonium was used in tree nut trials in the USA with plot sizes ranging from 1 to 9 trees. The method of spraying was not clearly expressed, but was presumably a directed spray. Samples were held in frozen storage for intervals of 400 to 700 days before analysis. The method of application was also not stated for the hazel nut trials in Italy. Samples were held 240 days in frozen storage before analysis. Directed sprays were used in the macadamia trials in Australia. Samples from the year 1992 were analysed 28 days after harvest while those from 1995 were stored for almost a year.

In Canadian trials on resistant maize in 1993-95 glufosinate-ammonium was applied by ground rigs. Two different SL formulations were used, with applications at two rates and at different growth stages.

Glufosinate-ammonium was applied to resistant maize in an extensive set of trials in France from 1993 to 1996. Plot sprayers were used on plots of 11 to 79 m^2. Harvested samples were held in frozen storage for 520-670 days (1993), 310-340 days (1994), 160-230 days (1995) and 50-90 days (1996).

In a similar series of resistant maize trials in Germany from 1994 to 1996, plot sprayers were used on plots of 48-64 m^2. Frozen storage periods were 300-400 days (1994), 150 days (1995) and 30-70 days (1996).

Further European trials on resistant maize were conducted in 1994-96 in Italy, The Netherlands and Spain. Hand-carried plot sprayers were used in Italy and Spain on plots of 40-60 m^2. Information on the sprayers and plot sizes was not available for The Netherlands. Analytical samples were stored frozen for 330-340 days (1994) and 50-150 days (1995-96).

Glufosinate-ammonium was extensively tested on resistant maize in US trials in 1993-1995. In 1993 it was applied by portable and tractor-mounted plot sprayers to plots of 28-186 m^2. In 1995 ground rigs and plot sprayers were used on plots of 110-740 m^2. Harvested samples were held in frozen storage for 280-330 days (1993) and 190-280 days (1995) before analysis. Some of the higher rate treatments in trial ER-93-USA-01 (Virginia and South Dakota) suffered phytotoxicity so grain samples were limited or unavailable for analysis.

Resistant soya beans were determined with glufosinate-ammonium in trials in many States of the USA in 1994-1996. Plots of 70-95 m^2 were sprayed with CO_2 pressurised backpack or plot sprayers in 1994. In 1995 tractor-mounted ground rigs and backpack or bicycle sprayers were used on plots of 40-130 m^2 and in 1996 backpack or plot sprayers were used on 90-280 m^2 plots. Harvested samples were held in frozen storage before analysis for 200-280 days (1994), 100-300 days (1995) and 200-230 days (1996).

Glufosinate-ammonium was determined on resistant rape seed in a supervised residue trial programme in France in 1993, 1994 and 1996. Plot sprayers were used on plots of 18-72 m^2. Periods of frozen storage of samples before analysis were 570-640 days (1993), 380-550 days (1994) and 112 days (1996). In trials on resistant rape seed in Germany (1994 and 1996) and the UK (1993 and 1996) glufosinate-ammonium was applied by plot sprayers to plots of 48-100 m^2 in Germany and 20-80 m^2 in the UK. Frozen storage periods for samples were 1 year and 2 months (1994 and 1996 respectively) in Germany and 600 days and 2 months (1993 and 1995 respectively) in the UK.

Glufosinate-ammonium was applied with boom sprayers to plots of 30-42 m^2 of resistant canola in Australian trials in 1996. Harvested samples were stored for 170-240 days before analysis.

Resistant canola was treated with glufosinate-ammonium in a series of supervised residue trials in Canada in 1993 and 1994. CO_2 powered backpack, plot sprayers and tractor-mounted rigs were used on plots of 24-80 m^2. Samples were held for 170-280 days (1993) and 80 days (1994) in frozen storage before analysis. No field reports were available for trials in report A53770 (Bertrand, 1993). One canola trial (A57514, MacDonald, 1996d) was not evaluated because the data sheets were from a barley trial. It was not clear in some of the canola trials whether the residues were expressed as glufosinate free acid or as the metabolites,.

Glufosinate-ammonium was applied with plot sprayers to plots of 38-76 m^2 of resistant sugar beet in French trials in 1995 and 1996. Harvested samples were stored for 120-300 days under frozen conditions before analysis. In similar trials in the UK in 1996-97 glufosinate-ammonium was applied by plot sprayer or knapsack to 48-64 m^2 plots. Frozen samples were stored for 150-280 days before analysis.

In a US trial programme on resistant sugar beet in 1995 and 1996 glufosinate-ammonium was applied by ground rig, backpack or bicycle sprayer to plots of 17-300 m^2. Storage periods for frozen samples were 240-320 days (1995) and 130-170 days (1996).

Table 42. Glufosinate residues in tropical fruits resulting from supervised trials in Australia and Malaysia. In the Australian trials on avocados and mangoes residues are expressed on a pulp + peel basis. Residues in samples from replicate plots are shown separately. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

FRUIT, country, year	Application				PHI, days	Residues, mg/kg, as glufosinate free acid		Ref
(variety)	Form	kg ai/ha	kg ai/hl	no.		glufosinate	MPP	
AVOCADO								
Australia (Qld) 1991 (Sharwil)	SL	1.0	0.4	1	7 12 21	<0.1 (2) <0.1 (2) <0.1 (2)	<0.1 (2) <0.1 (2) <0.1 (2)	A59027 QD 27/90
Australia (Qld) 1991 (Sharwil)	SL	2.0	0.8	1	7 12 21	<0.1 (2) <0.1 (2) <0.1 (2)	<0.1 (2) <0.1 (2) <0.1 (2)	A59027 QD 27/90
Australia (Qld) 1996 (Fuerte)	SL	0.6	0.33	2	0 14 24 28	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	A59026 AU QD 26
Australia (Qld) 1996 (Fuerte)	SL	1.2	0.67	2	0 14 24 28	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	A59026 AU QD 26
Australia (Qld) 1995 (Haas)	SL	0.6	0.35 0.30	2	0 14 24 31	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	A59025 AU QD 24
Australia (Qld) 1995 (Haas)	SL	1.2	0.69 0.60	2	0 14 24 31	0.06 <0.05 <0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2) <0.05 (2)	A59025 AU QD 24
MANGO								
Australia (Qld) 1991 (Kensington Pride)	SL	1.0	0.4	1	7 14 20	<0.1 <0.1 <0.1	<0.1 <0.1 <0.1	A59030 QD 21/90
Australia (Qld) 1991 (Kensington Pride)	SL	2.0	0.8	1	7 14 20	<0.1 <0.1 <0.1	<0.1 <0.1 <0.1	A59030 QD 21/90
Australia (Qld) 1994-5 (Fascell)	SL	0.6	0.21	2	0 14 21 28	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59029 AU QD 12
Australia (Qld) 1994-5 (Fascell)	SL	1.2	0.41	2	0 14 21 28	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59029 AU QD 12
Australia (Qld) 1995 (Kensington Pride)	SL	0.6	0.2	2	0 14 21 28	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59028 AU QD 13-94
Australia (Qld) 1995 (Kensington Pride)	SL	1.2	0.4	2	0 14 21 28	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59028 AU QD 13-94
GUAVA								
Malaysia (Perat) 1995 ("with seeds")	SL	0.50	0.11	4	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57294 ER95MYS880020102

FRUIT, country, year (variety)	Application				PHI, days	Residues, mg/kg, as glufosinate free acid		Ref
	Form	kg ai/ha	kg ai/hl	no.		glufosinate	MPP	
Malaysia (Perat) 1995 ("with seeds")	SL	1.0	0.22	4	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57294 ER95MYS880020103
Malaysia (Perat) 1995 ("seedless")	SL	0.50	0.11	4	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57294 ER95MYS880020202
Malaysia (Perat) 1995 ("seedless")	SL	1.0	0.22	4	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57294 ER95MYS880020203
CARAMBOLA								
Malaysia (Selangor) 1995 (Bio)	SL	0.50	0.11	3	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57295 ER95MYS880010102
Malaysia (Selangor) 1995 (Bio)	SL	1.0	0.22	3	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57295 ER95MYS880010103
Malaysia (Perat) 1995 (Bio)	SL	0.50	0.11	3	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57295 ER95MYS880010202
Malaysia (Perat) 1995 (Bio)	SL	1.0	0.22	3	0 3 7 14 21	<0.05 <0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05 <0.05	A57295 ER95MYS880010203
PAPAYA								
Australia (Qld) 1996 (Rictor Gold)	SL	0.6	0.26	2	0 14 21 30	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59285 AU QD 25
Australia (Qld) 1996 (Rictor Gold)	SL	1.2	0.52	2	0 14 21 30	<0.05 <0.05 <0.05 <0.05	<0.05 <0.05 <0.05 <0.05	A59285 AU QD 25

Table 43. Glufosinate residues in tree nuts resulting from supervised trials in Australia, Italy and the USA. Analyses on samples from replicate plots are shown separately. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

NUT, country, year (variety)	Application				PHI, days	Residues, mg/kg, as glufosinate free acid		Ref
	Form	kg ai/ha	kg ai/hl	No.		glufosinate	MPP	
PECAN								
USA (GA) 1985 (Witchita)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A48446 16-GA-85-011
USA (GA) 1985 (Witchita)	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A48446 16-GA-85-011
USA (LA) 1985 (Cape Fear)	SL	1.7		3	21	<0.05 (3)	<0.05 (3)	A48446 16-LA-85-002
USA (LA) 1985 (Cape Fear)	SL	3.4		3	21	<0.05 (3)	<0.05 (3)	A48446 16-LA-85-002
USA (NM) 1985 (Western Schley)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A48446 07-NM-85-032
USA (NM) 1985 (Western Schley)	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A48446 07-NM-85-032
WALNUT								
USA (CA) 1984 (English)	SL	1.6 +1.2		2	14	<0.05 (3)	<0.05 (3)	A34230
USA (CA) 1984 (English)	SL	3.2 +2.4		2	14	<0.05 (3)	<0.05 (3)	A34231
USA (CA) 1984 (English)	SL	1.6 +2×1.2		3	14	<0.05 (3)	<0.05 (3)	A34232
USA (CA) 1984 (English)	SL	3.2 +2×2.4		3	14	<0.05 (3)	<0.05 (3)	A34233
USA (CA) 1985 (Serr)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A35706
USA (CA) 1985 (Serr)	SL	4.5		3	14	<0.05 (3)	<0.05 (3)	A35707
USA (CA) 1985	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A35708
USA (CA) 1985	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A35709
USA (CA) 1985 (Serr)	SL	1.7		3	11	<0.05 (3)	<0.05 (3)	A35710
USA (CA) 1985 (Serr)	SL	3.4		3	11	<0.05 (3)	<0.05 (3)	A35711
USA (CA) 1985 (Serr)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-019
USA (CA) 1985 (Serr)	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-019
USA (CA) 1985 (Serr)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-024
USA (CA) 1985 (Serr)	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-024
USA (CA) 1985 (Serr)	SL	1.7		3	11	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-038

NUT, country, year (variety)	Application				PHI, days	Residues, mg/kg, as glufosinate free acid		Ref
	Form	kg ai/ha	kg ai/hl	No.		glufosinate	MPP	
USA (CA) 1985 (Serr)	SL	3.4		3	11	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-038
ALMOND								
USA (CA) 1985 (Carmel)	SL	1.7		3	15	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-018
USA (CA) 1985 (Carmel)	SL	3.4		3	15	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-018
USA (CA) 1985 (Special)	SL	1.7		3	15	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-018
USA (CA) 1985 (Special)	SL	3.4		3	15	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-018
USA (CA) 1985 (Non-Peril)	SL	1.7		3	14	<0.05 (3)	0.07 0.07 0.07	A48446 07-CA-85-028
USA (CA) 1985 (Non-Peril)	SL	3.4		3	14	<0.05 (3)	0.14 0.22 0.17	A48446 07-CA-85-028
USA (CA) 1985 (Non-Peril)	SL	1.7		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-037
USA (CA) 1985 (Non-Peril)	SL	3.4		3	14	<0.05 (3)	<0.05 (3)	A48446 07-CA-85-037
HAZEL-NUT								
Italy 1985 (Gentile Del Piemonte)	SL	1.5	0.38	2	19	<0.05	<0.05	A35935
Italy 1985 (Nocchione)	SL	1.5	0.38	2	19	<0.05	<0.05	A35936
Italy 1985 (Gentile Del Piemonte)	SL	1.5	0.38	2	19	<0.05	<0.05	A35937
Italy 1985 (Gentile Del Piemonte)	SL	1.5	0.38	2	19	<0.05	<0.05	A35938
Italy 1985 (Gentile Del Piemonte)	SL	1.5	0.38	2	19	<0.05	<0.05	A35938
MACADAMIA NUT								
Australia 1992 (var 434)	SL	1.0	0.8	4	1 7 14 21	<0.1 (2) <0.1 (2) <0.1 (2) <0.1 (2)	<0.1 (2) <0.1 (2) <0.1 (2) <0.1 (2)	A59031 QDI/92 92/1222
Australia 1992 (var 434)	SL	2.0	1.6	4	1 7 14 21	<0.1 (2) <0.1 (2) <0.1 (2) <0.1 (2)	<0.1 (2) <0.1 (2) <0.1 (2) <0.1 (2)	A59031 QDI/92 92/1222
Australia 1995 (var 344)	SL	1.2	0.63	2	0 16 27	<0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2)	A59032 QD20-94 95/3715
Australia 1995 (var 344)	SL	2.4	1.3	2	0 16 27	<0.05 (2) <0.05 (2) <0.05 (2)	<0.05 (2) <0.05 (2) <0.05 (2)	A59032 QD20-94 95/3715

Table 44. Glufosinate residues in maize resulting from supervised trials in France, Germany, Italy and Spain. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Country, Year, Variety	Application				PHI days	Residues as glufosinate free acid, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]		glufosinate	MPP	NAG[2]	
France 1993 (LH163×LH164-×F2×T14)	SL	0.45	0.23	2 GS25	145	<0.05	<0.05		A54225 ER93ECN550 FRA000402
France 1993 (LH206×LH74-×F2×T14)	SL	0.45	0.23	2 GS24	145	<0.05	<0.05		A54225 ER93ECN550 FRA000502
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	128	<0.05	<0.05		A54225 ER93ECN550 FRA000102
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	147	<0.05	<0.05		A54225 ER93ECN550 FRA000202
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	145	<0.05	<0.05		A54225 ER93ECN550 FRA000302
France 1994 ((LH82(4)T25)sf (-2)xSH298	SL	0.45	0.23	2 GS25	123	<0.05	<0.05		A54229 ER94ECN550 FRA000202
France 1994 (F6×M1)	SL	0.45	0.23	2 GS25	119	<0.05	<0.05		A54226 ER93ECS550 FRA000102
France 1994 (LH824xT25)AF4x-B73)	SL	0.45	0.15	2 GS25	120	<0.05	<0.05		A54230 ER94ECS550 FRA000102
France 1994 (SH298(LH82(4)T25)sf(2))	SL	0.45	0.23	2 GS25	119	<0.05	<0.05		A54229 ER94ECN550 FRA000102
France 1995 (F2xLH82-T25)	SL	0.45	0.23	2 GS18	100	<0.05	<0.05		A56445 ER95ECN550 FRA000202
France 1995 (F2xLH82-T25)	SL	0.45	0.23	2 GS19	100	<0.05	<0.05		A56445 ER95ECN550 FRA000203
France 1995 (tolerant 039866)	SL	0.45	0.23	2 GS18	106	<0.05	<0.05		A56445 ER95ECN550 FRA000103
France 1995 (tolerant 039866)	SL	0.45	0.23	2 GS18	106	<0.05	<0.05		A56445 ER95ECN550 FRA000102
France 1995 (transgenic hybrid)	SL	0.53	0.27	2 GS18	116	<0.05	<0.05	<0.05	A54760 ER95ECS550 FRA000103
France 1995 (transgenic hybrid)	SL	0.53	0.27	2 GS18	116	<0.05	<0.05	<0.05	A54760 ER95ECS550 FRA000102
France 1995 (transgenic hybrid)	SL	0.45	0.23	2 GS19	119	<0.05	<0.05	<0.05	A54760 ER95ECS550 FRA000203
France 1995 (transgenic hybrid)	SL	0.45	0.23	2 GS19	119	<0.05	<0.05	<0.05	A54760 ER95ECS550 FRA000202
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	104	<0.05	<0.05		A58191 ER96ECN550 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	104	<0.05	<0.05		A58191 ER96ECN550 FRA000103

Country, Year, Variety	Application				PHI days	Residues as glufosinate free acid, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]		glufosinate	MPP	NAG[2]	
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	104	<0.05	<0.05		A58191 ER96ECN550 FRA000104
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	105	<0.05	<0.05		A58191 ER96ECN550 FRA000302
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	105	<0.05	<0.05		A58191 ER96ECN550 FRA000303
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	105	<0.05	<0.05		A58191 ER96ECN550 FRA000304
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	110	<0.05	<0.05		A58191 ER96ECN550 FRA000402
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	110	<0.05	<0.05		A58191 ER96ECN550 FRA000403
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	110	<0.05	<0.05		A58191 ER96ECN550 FRA000404
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	129	<0.05	<0.05		A58190 ER96ECS550 FRA000302
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	129	<0.05	<0.05		A58190 ER96ECS550 FRA000303
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	129	<0.05	<0.05		A58190 ER96ECS550 FRA000304
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	103	<0.05	<0.05		A58191 ER96ECN550 FRA000202
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	103	<0.05	<0.05		A58191 ER96ECN550 FRA000203
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	103	<0.05	<0.05		A58191 ER96ECN550 FRA000204
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	130	<0.05	<0.05		A58190 ER96ECS550 FRA000102
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	130	<0.05	<0.05		A58190 ER96ECS550 FRA000103
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	130	<0.05	<0.05		A58190 ER96ECS550 FRA000104
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	140	<0.05	<0.05		A58190 ER96ECS550 FRA000202
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	140	<0.05	<0.05		A58190 ER96ECS550 FRA000203
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	140	<0.05	<0.05		A58190 ER96ECS550 FRA000204
Germany 1995 (LH82^4T25sf^4F2)	SL	0.45	0.15	2 GS18	99	<0.05 (2)	<0.05 (2)		A56445 ER95ECN550 DEU010202

Country, Year, Variety	Application				PHI days	Residues as glufosinate free acid, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]		glufosinate	MPP	NAG[2]	
Germany 1995 (LH82^4T25sf^4SH-298)	SL	0.45	0.15	2 GS18	90	<0.05	<0.05		A56445 ER95ECN550 DEU050102
Germany 1995 (LH82^4T25sf^4xF2)	SL	0.45	0.15	2 GS18	113	<0.05 (2)	<0.05 (2)		A56445 ER95ECN550 DEU010102
Germany 1996 (F2 hybride - LH-82)	SL	0.60	0.20	2 GS18	126	<0.05	<0.05		A58191 ER96ECN550 DEU050102
Germany 1996 (F2 hybride - LH-82)	SL	0.80	0.27	2 GS18	126	<0.05	<0.05		A58191 ER96ECN550 DEU050103
Germany 1996 (F2 hybride - LH-82)	SL	0.45	0.15	2 GS18	126	<0.05	<0.05		A58191 ER96ECN550 DEU050104
Germany 1996 (Facet - transgen)	SL	0.60	0.20	2 GS18	125	<0.05	<0.05		A58191 ER96ECN550 DEU060102
Germany 1996 (Facet - transgen)	SL	0.80	0.27	2 GS18	125	<0.05	<0.05		A58191 ER96ECN550 DEU060103
Germany 1996 (Facet - transgen)	SL	0.45	0.15	2 GS18	125	<0.05	<0.05		A58191 ER96ECN550 DEU060104
Germany 1996 (Facet - transgen)	SL	0.60	0.20	2 GS18	122	<0.05	<0.05		A58191 ER96ECN550 DEU060202
Germany 1996 (Facet - transgen)	SL	0.80	0.27	2 GS18	122	<0.05	<0.05		A58191 ER96ECN550 DEU060203
Germany 1996 (Facet - transgen)	SL	0.45	0.15	2 GS18	122	<0.05	<0.05		A58191 ER96ECN550DEU 060204
Germany 1996 (LH82 T25 SF x F2)	SL	0.60	0.20	2 GS19	137	<0.05	<0.05		A58191 ER96ECN550 DEU010202
Germany 1996 (LH82 T25 SF x F2)	SL	0.80	0.27	2 GS19	137	<0.05	<0.05		A58191 ER96ECN550 DEU010203
Germany 1996 (LH82 T25 SF x F2)	SL	0.45	0.15	2 GS19	137	<0.05	<0.05		A58191 ER96ECN550 DEU010204
Germany 1996 (LH82 T25 SF x Fe)	SL	0.60	0.20	2 GS19	145	<0.05	<0.05		A58191 ER96ECN550 DEU010102
Germany 1996 (LH82 T25 SF x Fe)	SL	0.80	0.27	2 GS19	145	<0.05	<0.05		A58191 ER96ECN550 DEU010103
Germany 1996 (LH82 T25 SF x Fe)	SL	0.45	0.15	2 GS19	145	<0.05	<0.05		A58191 ER96ECN550 DEU010104
Italy 1994 ([B73(4)xT14]sfx - LM82)	SL	0.45	0.15	2 GS23	105	<0.05	<0.05		A54230 ER94ECS550 ITA000102
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	108	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000104
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	104	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000204

Country, Year, Variety	Application				PHI days	Residues as glufosinate free acid, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]		glufosinate	MPP	NAG[2]	
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	108	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000103
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	104	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000203
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	108	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000102
Italy 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	104	<0.05	<0.05	<0.05	A54760 ER95ECS550 ITA000202
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	100	<0.05	<0.05		A58190 ER96ECS550 ITA000105
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	124	<0.05	<0.05		A58190 ER96ECS550 ITA000205
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	100	<0.05	<0.05		A58190 ER96ECS550 ITA000103
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	100	<0.05	<0.05		A58190 ER96ECS550 ITA000104
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	124	<0.05	<0.05		A58190 ER96ECS550 ITA000203
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	124	<0.05	<0.05		A58190 ER96ECS550 ITA000204
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS19	104	<0.05	<0.05		A58190 ER96ECS550 ITA000305
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS19	104	<0.05	<0.05		A58190 ER96ECS550 ITA000303
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS19	104	<0.05	<0.05		A58190 ER96ECS550 ITA000304
Spain 1994 (LH119-6xT14/LH82)	SL	0.45	0.15	2 GS25	102	<0.05	<0.05		A54230 ER94ECS550 ESP000102
Spain 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	95	<0.05	<0.05	<0.05	A54760 ER95ECS550 ESP000103
Spain 1995 (transgenic hybrid)	SL	0.45	0.15	2 GS18	95	<0.05	<0.05	<0.05	A54760 ER95ECS550 ESP000102
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	95	<0.05	<0.05		A58190 ER96ECS550 ESP000102
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	95	<0.05	<0.05		A58190 ER96ECS550 ESP000103
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	95	<0.05	<0.05		A58190 ER96ECS550 ESP000104
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	96	<0.05	<0.05		A58190 ER96ECS550 ESP000202

Country, Year, Variety	Application				PHI days	Residues as glufosinate free acid, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]		glufosinate	MPP	NAG[2]	
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	96	<0.05	<0.05		A58190 ER96ECS550 ESP000203
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	96	<0.05	<0.05		A58190 ER96ECS550 ESP000204
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	113	<0.05	<0.05		A58190 ER96ECS550 ESP000302
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	113	<0.05	<0.05		A58190 ER96ECS550 ESP000303
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	113	<0.05	<0.05		A58190 ER96ECS550 ESP000304

[1]. GS: growth stage at final treatment

GS18 8 leaves unfolded
GS19 9 or more leaves unfolded
GS23 5[th] leaf unfolded
GS24 6[th] leaf unfolded
GS25 7[th] leaf unfolded

[2] included in glufosinate-ammonium result.

Table 45. Glufosinate residues in transgenic maize resulting from supervised trials in the USA and Argentina. Analyses of replicate samples are reported individually. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Country, Year, Variety	Application				PHI	Residues, mg/kg, as glufosinate free acid[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate-ammonium	MPP	NAG	
USA (NE) 1993 (LH59 X LH51) (LH119)(4) X T14)	SL	1.8 +2.6	1.9 +2.8	2 (60 cm)	96	NQ	NQ	NQ	ER-93-USA-01-NE-02
USA (IA) 1993 (LH216) (LH119) (4) X (T14))	SL	1.5	1.6	1 (60 cm)	100	NQ	NQ	NQ	ER-93-USA-01-IA-02
USA (IA) 1993 (LH216) X (LH119) (4) × T14)	SL	0.36		1 (30 cm)	118	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IA-01
USA (IA) 1993 (LH216) X (LH119) (4) × T14)	SL	0.50		1 (30 cm)	114	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IA-01
USA (IA) 1993 (LH216) X (LH119) (4) × T14)	SL	0.50		1 (60 cm)	114	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IA-01
USA (IL) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.36	0.39	1 (30 cm)	100	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IL-01
USA (IL) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.54	1 (30 cm)	100	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IL-01
USA (IL) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.54	1 (60 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IL-01

Country, Year, Variety	Application				PHI	Residues, mg/kg, as glufosinate free acid[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate-ammonium	MPP	NAG	
USA (IL) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IL-01
USA (NE) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.36		1 (30 cm)	107	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-NE-01
USA (NE) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.48	1 (30 cm)	107	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-NE-01
USA (NE) 1993 (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.48	1 (60 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-NE-01
USA (IN) 1993 [LH119(4) X T14] X LH216)	SL	0.36	0.39	1 (30 cm)	115	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IN-01
USA (IN) 1993 [LH119(4) X T14] X LH216)	SL	0.50	0.54	1 (30 cm)	115	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IN-01
USA (IN) 1993 [LH119(4) X T14] X LH216)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	106	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-IN-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	107	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.50	0.54	1 (30 cm)	107	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	97	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	117	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.50	0.54	1 (60 cm)	117	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (LH85 X LH160) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (31 cm)	107	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-ND-01
USA (MO) 1993 (LH216) X (LH119(4) X (T14))	SL	0.36	0.39	1 (30 cm)	97	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-01
USA (MO) 1993 (LH216) X (LH119(4) X (T14))	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-01
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	119	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-01
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	129	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-01
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	106	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-01
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	116	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-01

Country, Year, Variety	Application				PHI	Residues, mg/kg, as glufosinate free acid[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate-ammonium	MPP	NAG	
USA (SD) 1993 (LH85 X LH160) (LH119)(4) X T14))	SL	0.36	0.71	1 (30 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-SD-01
USA (SD) 1993 (LH85 X LH160) (LH119)(4) X T14))	SL	0.50	0.99	1 (30 cm)	95	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-SD-01
USA (SD) 1993 (LH85 X LH160) (LH119)(4) X T14))	SL	0.36 +0.50	0.71 +0.99	2 (60 cm)	95[1]	NQ (3)	NQ (3)	0.07 (3)	ER-93-USA-01-SD-01
USA (VA) 1993 (LH216) (LH119)(4) X T14)	SL	0.36	0.71	1 (30 cm)	106[2]	NQ	NQ	NQ	ER-93-USA-01-VA-01
USA (VA) 1993 (LH216) (LH119)(4) X T14)	SL	0.50	0.99	1 (30 cm)	106[6]	NQ	NQ	NQ	ER-93-USA-01-VA-01
USA (VA) 1993 (LH216) (LH119)(4) X T14)	SL	0.36 +0.50	0.71 +0.99	2 (60 cm)	97[6]	NQ	NQ	0.07	ER-93-USA-01-VA-01
USA (MO) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (12-15 cm)	123	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (25-30 cm)	118	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (40-45 cm)	111	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (55-66 cm)	101	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (80-90 cm)	97	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-MO-02
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (12-15 cm)	127	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-02
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (25-30 cm)	120	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-02
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (40-45 cm)	114	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-02
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (55-66 cm)	96	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-02
USA (CA) 1993 (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (80-90 cm)	96	NQ (3)	NQ (3)	NQ (3)	ER-93-USA-01-CA-02
USA (FL) 1994 (LH51 X LH210) (LH119(4) X T14)	SL	0.40 +0.50	0.43 +0.54	2 (2-14 leaves)	69	NQ	NQ	[glu]	BK-94R-01-FL-01
USA (IA) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.41 +0.53	0.44 +0.57	2 (60 cm)	122	NQ	NQ	[glu]	BK-94R-01-IA-01

[1] This crop suffered some phytotoxicity and the yield of grain was limited.

[2] Each of the treatments in the Virginia trials suffered from phytotoxicity and unusual weather conditions, resulting in limited collection of samples. CLICK HERE for continue

Country, Year, Variety	Application				PHI	Residues, mg/kg, as glufosinate free acid[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate-ammonium	MPP	NAG	
USA (IL) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (60 cm)	118	NQ	NQ	glu	BK-94R-01-IL-01
USA (MN) 1994 (LH74) (LH82(3) X T14))	SL	0.38 +0.48	0.41 +0.52	2 (60 cm)	114	0.05	NQ	glu	BK-94R-01-MN-01
USA (MO) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.53	0.43 +0.57	2 (60 cm)	89	NQ	NQ	glu	BK-94R-01-MO-01
USA (NC) 1994 (LH51 X LH210) (LH119(4) X T14))	SL	0.38 +0.52	0.41 +0.56	2 (60 cm)	92	NQ	NQ	glu	BK-94R-01-NC-01
USA (NY) 1994 (LH74) (LH82(3) X T14))	SL	0.38 +0.53	0.41 +0.57	2 (60 cm)	88	0.07	NQ	glu	BK-94R-01-NY-01
USA (TX) 1994 (LH51 X LH210) (LH119(4) X T14))	SL	0.38 +0.46	0.41 +0.49	2 (60 cm)	97	NQ	NQ	glu	BK-94R-01-TX-01
USA (WA) 1994 (LH74) (LH82)3) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (60 cm)	86	NQ	NQ	glu	BK-94R-01-WA-01
USA (WI) 1994 (LH85 X LH160) (LH119(4) X T14))	SL	0.38 +0.56	0.41 +0.60	2 (60 cm)	107	NQ	NQ	glu	BK-94R-01-WI-01
USA (FL) 1994 (LH51 X LH210) (LH119(4) X T14)	SL200	0.40 +0.50	0.43 +0.54	2 (2-14 leaves)	69	NQ	NQ	glu	BK-94R-01-FL-01
USA (IA) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.41 +0.53	0.44 +0.55	2 (60 cm)	122	NQ	NQ	glu	BK-94R-01-IA-01
USA (IL) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (60 cm)	118	NQ	NQ	glu	BK-94R-01-IL-01
USA (MN) 1994 (LH74) (LH82(3) X T14))	SL	0.40 +0.51	0.43 +0.55	2 (60 cm)	114	0.07	NQ	glu	BK-94R-01-MN-01
USA (MO) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.56	0.43 +0.60	2 (60 cm)	89	0.05	NQ	glu	BK-94R-01-MO-01
USA (NC) 1994 (LH51 X LH210) (LH119(4) X T14))	SL	0.40 +0.46	0.43 +0.49	2 (60 cm)	92	NQ	NQ	glu	BK-94R-01-NC-01
USA (NY) 1994 (LH74) (LH82(3) X T14))	SL	0.40 +0.53	0.43 +0.57	2 (60 cm)	88	NQ	NQ	glu	BK-94R-01-NY-01
USA (TX) 1994 (LH51 X LH210) (LH119(4) X T14))	SL	0.40 +0.49	0.43 +0.53	2 (60 cm)	97	NQ	NQ	glu	BK-94R-01-TX-01
USA (WA) 1994 (LH74) (LH82)3) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (60 cm)	86	NQ	NQ	glu	BK-94R-01-WA-01
USA (WI) 1994 (LH85 X LH160) (LH119(4) X T14))	SL	0.38 +0.50	0.41 +0.54	2 (60 cm)	107	NQ	NQ	glu	BK-94R-01-WI-01
USA (MO) 1994 (LH59 X LH51) (LH119(4) X T14))	SL	2.0 +2.6	2.1 +2.5	2 (60 cm)	89	0.26 3.1 agf	0.06 0.75 agf	glu	BK-94R-03-MO-01

Country, Year, Variety	Application				PHI	Residues, mg/kg, as glufosinate free acid[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate-ammonium	MPP	NAG	
USA (MN) 1995 (LH202) (LH82 (4) x T25))	SL	0.39 +0.49	0.41 +0.53	2 (7-8 leaf)	100	NQ	NQ	glu	BK95R01-GGH-01
USA (KS) 1995 (B73(5)xT25) (LH51))	SL	0.39 +0.50	0.41 +0.53	2 (56-66 cm)	95	NQ	NQ	glu	BK95R01-MDA-02
USA (MI) 1995 (LH119 (9) x T14) (LH168))	SL	0.39 +0.50	0.41 +0.54	2 (61-77 cm)	111	NQ	NQ	glu	BK95R01-JRS-02
USA (MO) 1995 (B73 (5) x T25) (LH51))	SL	0.39 +0.52	0.44 +0.60	2 (60 cm)	90	NQ	NQ	glu	BK95R01-JLB-01
USA (NE) 1995 (LH119 (9) x T14) (LH51))	SL	0.39 +0.52	0.41 +0.55	2 (60 cm)	89	NQ	NQ	glu	BK95R01-MDA-01
USA (OH) 1995 (LH119 (9) x T14) (LH51))	SL	0.39 +0.52	0.43 +0.52	2 (60 cm)	117	NQ	NQ	glu	BK95R01-JRS-01
USA (TX) 1995 (LH216) (B73 (5) x T25))	SL	0.40 +0.50	0.42 +0.53	2 (53-66 cm)	84	NQ	NQ	glu	BK95R01-GLS-01
Argentina 1995)	SL	1.4	0.88	1	70	NQ	NQ		A57415 ER95ARG001 010102
Argentina 1996)	SL	1.4	0.88	1 GS17-32)	104	NQ	NQ		A57414 ER96ARG001 010102

[1] Growth stage in the US trials is recorded as the height of the plant or, in some cases, as the number of leaves.
[2] NQ - residues <LOD (0.05 mg/kg glufosinate free acid equivalents)
glu: included in glufosinate-ammonium result. agf: aspirated grain fraction from milling of the grain

Table 46. Glufosinate residues in transgenic maize resulting from supervised trials in Ontario, Canada. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Year	Application				PHI	Residues, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no[1]	days	glufosinate	MPP	NAG	
1993	SL	0.75		1 GS16	152	<0.05	<0.05	<0.05	A55207 93-IGN-C ON-1-2
1993	SL	1.5		1 GS16	152	<0.05	<0.05	<0.05	A55207 93-IGN-C ON-1-3
1993	SL	0.75		1 GS16	154	<0.05	<0.05	<0.05	A55207 93-IGN-C ON-2-2
1993	SL	1.5		1 GS16	154	<0.05	<0.05	<0.05	A55207 93-IGN-C ON-2-3
1994	SL	0.5		1 GS17-19	150	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-1-2
1994	SL	1.0		1 GS17-19	150	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-1-3

Year	Application				PHI	Residues, mg/kg			Ref
	form	kg ai/ha	kg ai/hl	no [1]	days	glufosinate	MPP	NAG	
1994	SL	0.5		1 GS17-19	136	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-2-2
1994	SL	1.0		1 GS17-19	136	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-2-3
1994	SL	0.5		1 GS17-19	136	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-3-2
1994	SL	1.0		1 GS17-19	136	<0.05	<0.05	<0.05	A55207 94-IGN-C ON-3-3
1995	SL	0.6		1 GS18-19	138	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-1-2
1995	SL	0.6		2 GS33	131	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-1-3
1995	SL	1.2		1 GS40	126	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-1-4
1995	SL	0.6		1 GS18	137	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-2-2
1995	SL	0.6		2 GS33	128	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-2-3
1995	SL	1.2		1 GS40	122	<0.05	<0.05	0.08	A55207 95-IGN-C ON-2-4
1995	SL	0.6		1 GS18-19	114	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-3-2
1995	SL	0.6		2 GS33	107	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-3-3
1995	SL	1.2		1 GS40	100	<0.05	<0.05	0.07	A55207 95-IGN-C ON-3-4
1995	SL	0.6		1 GS18	125	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-4-2
1995	SL	0.6		2 GS33	117	<0.05	<0.05	<0.05	A55207 95-IGN-C ON-4-3
1995	SL	1.2		1 GS40	111	<0.05	<0.05	0.09	A55207 95-IGN-C ON-4-4

[1]. GS: growth stage at final treatment

GS16	6 leaves unfolded
GS17	7 leaves unfolded
GS18	8 leaves unfolded
GS19	9 or more leaves unfolded
GS33	3 nodes detectable
GS40	booting

Table 47. Glufosinate residues in soya beans resulting from supervised trials in the USA. Analyses of replicate samples from the treated plots are shown separately. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Country, Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
USA (IA) 1993 (W98-7)	SL	0.5	0.51	1 trifoliate	85	<0.05 (3)	<0.05 (3)	0.06 <0.05 (2)	ER-93-USA-02-IA-01
	SL	0.5	0.51	1 full pod	65	1.2 (3)	0.44 0.44 0.39	5.0 5.4 4.9	
	SL	0.5	0.51	2 full pod	65	0.76 0.91 0.79	0.30 0.30 0.27	3.4 3.8 3.6	
USA (IL) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	85	<0.05 (3)	0.07 0.06 0.06	0.33 0.36 0.32	ER-93-USA-02-IL-01
	SL	0.5	0.53	1 full pod	65	0.96 1.0 0.90	0.51 0.61 0.57	5.0 5.4 5.1	
	SL	0.5	0.53	2 full pod	65	0.95 0.95 0.93	0.62 0.68 0.65	5.1 5.5 5.4	
USA (MO) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	85	<0.05 (3)	0.08 0.09 0.08	0.19 0.21 0.22	ER-93-USA-02-MO-01
	SL	0.5	0.53	1 full pod	65	1.4 (3)	0.89 0.61 0.79	6.7 6.7 7.2	
	SL	0.5	0.53	2 full pod	65	1.2 1.0 1.1	0.74 0.73 0.70	5.9 5.8 5.9	
USA (IN) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	85	<0.05 (3)	0.08 <0.05 (2)	0.12 0.10 0.08	ER-93-USA-02-IN-01
	SL	0.5	0.53	1 full pod	65	1.7 1.8 1.9	0.49 0.53 0.55	7.1 7.1 7.5	
	SL	0.5	0.53	2 full pod	65	1.6 1.8 1.8	0.56 0.64 0.74	5.9 6.1 7.1	
USA (IN) 1993 (W98)	SL	0.5	0.53	1 trifoliate	85	<0.05 (3)	<0.05 (3)	<0.05 (3)	ER-93-USA-02-IN-02
	SL	0.5	0.53	1 full pod	65	0.93 0.91 0.94	0.37 0.33 0.35	3.8 3.9 4.0	
	SL	0.5	0.53	1 full pod	75	0.80 0.84 0.81	0.29 0.32 0.36	3.1 3.6 3.7	
	SL	0.5	0.53	2 full pod	65	0.92 0.87 0.88	0.38 0.31 0.35	3.9 3.6 4.0	
	SL	0.5	0.53	2 full pod	75	0.69 0.70 0.68	0.30 0.36 0.33	3.4 3.5 3.4	
USA (AR) 1993 (W62)	SL	0.5	1.1	1 trifoliate	85	<0.05 (3)	<0.05 (3)	0.07 0.09 0.08	ER-93-USA-02-AR-01
	SL	0.5	1.1	1 full pod	65	0.87 0.76 0.73	0.61 0.56 0.46	6.8 5.8 4.5	
	SL	0.5	1.1	2 full pod	65	0.89 0.88 0.81	0.58 0.49 0.58	7.6 6.6 7.0	
USA (MS) 1993 (W98)	SL	0.5	1.1	1 trifoliate	85	<0.05 (3)	<0.05 (3)	0.10 0.10 0.12	ER-93-USA-02-MS-01
	SL	0.5	1.1	1 full pod	65	0.47 0.52 0.48	0.44 0.41 0.27	5.3 4.9 4.7	
	SL	0.5	1.1	2 full pod	65	0.46 0.40 0.48	0.48 0.41 0.47	5.1 5.1 5.0	
USA (VA) 1993 (W62)	SL	0.5	1.1	1 trifoliate	103	<0.05	<0.05	0.11	ER-93-USA-02-VA-01
	SL	0.5	1.1	1 full pod	65	0.10	0.10	0.69	
	SL	0.5	1.1	2 full pod	85	0.08	0.15	0.93	
USA (AR) 1994 (W62)	SL	0.39 +0.50	0.41 +0.53	2 bloom	82	0.68 0.83	0.06 0.06	glu	BK-94R-02-AR-01

Country, Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
USA (FL) 1994 (W62)	SL	0.39 +0.50	0.42 +0.54	2 bloom	93	0.58 0.62	0.09 0.09	glu	BK-94R-02-FL-01
USA (IA) 1994 (W98)	SL	0.39 +0.50	0.42 +0.54	2 bloom	86	1.1 1.1	0.14 0.10	glu	BK-94R-02-IA-01
USA (IL) 1994 (transgenic group 3)	SL	0.39 +0.50	0.42 +0.54	2 bloom	69	0.65 0.52	0.07 0.06	glu	BK-94R-02-IL-01
USA (IN) 1994 (W98)	SL	0.39 +0.50	0.42 +0.54	2 bloom	77	1.3 0.89	0.34 0.15	glu	BK-94R-02-IN-01
USA (MO) 1994 (W98)	SL	0.39 +0.50	0.42 +0.54	2 bloom	77	0.67 0.41	0.18 0.17	glu	BK-94R-02-MO-01
USA (NC) 1994 (W62)	SL	0.39 +0.50	0.42 +0.54	2 bloom	102	0.32 0.43	<0.05 (2)	glu	BK-94R-02-NC-01
USA (OH) 1994 (W98)	SL	0.39 +0.50	0.42 +0.54	2 bloom	76	0.80 0.71	0.22 0.18	glu	BK-94R-02-OH-01
USA (PA) 1994 (W98)	SL	0.39 +0.50	0.42 +0.54	2 bloom	91	0.73 0.54	0.08 0.07	glu	BK-94R-02-PA-01
USA (VA) 1994 (W62)	SL	0.39 +0.50	0.42 +0.54	2 bloom	82	1.6 1.3	0.28 0.36	glu	BK-94R-02-VA-01
USA (NC) 1994 (transgenic Group 5 W62 A5403)	SL	0.4	0.43	1 3rd node	136	<0.05 (2)	<0.05 (2)	glu	Project: BK-94R-06 Trial#: NC-01
	SL	0.4 +0.5	0.43 +0.54	2 6th node	123	<0.05 (2)	<0.05 (2)	glu	
	SL	0.4 +0.5	0.43 +0.54	2 bloom	90	0.79 0.71	0.13 0.14	glu	
	SL	0.4 +0.5	0.43 +0.54	2 full pod	77	1.1 1.1	0.23 0.27	glu	
USA (IN) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.39 +0.51	2 R2.5-R3	64	1.1 0.96	0.16 0.19	glu	BK-95R-04-DJL-01
USA (IN) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.39 +0.51	2 R2	62	1.1 0.90	0.23 0.24	glu	BK-95R-04-DJL-02
USA (MO) 1995 (MG III W62 A5504 group 5)	SL	0.39 +0.50	0.41 +0.53	2 R1	71	0.62 0.83	0.11 0.13	glu	BK-95R-04-JLB-01
USA (OH) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.40 +0.52	2 R2	86	0.32 0.18	0.07 0.06	glu	BK-95R-04-JRS-01
USA (MI) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.41 +0.53	2 R2	81	0.37 0.33	0.15 0.10	glu	BK-95R-04-JRS-02
USA (IA) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.41 +0.53	2 R2	60	0.58 0.68	0.10 0.10	glu	BK-95R-04-GGH-01
USA (WI) 1995 (MG III, W98 A3322 group 3)	SL	0.38 +0.49	0.42 +0.54	2 R2.5	82	0.65 0.93	0.10 0.18	glu	BK-95R-04-GGH-02
USA (IA) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.42 +0.53	2 R2	84	0.32 0.28	<0.05 (2)	glu	BK-95R-04-GGH-04
USA (NE) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.41 +0.53	2 R3	80	0.12 0.62	0.05 0.06	glu	BK-95R-04-MDA-01
USA (KS) 1995 (MG III, W98 A3322 group 3)	SL	0.39 +0.50	0.41 +0.52	2 R2	78	0.50 0.42	0.06 0.05	glu	BK-95R-04-MDA-02

Country, Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
USA (LO) 1995 (MG III, W62 A5504 group 5)	SL	0.40 +0.54	0.42 +0.56	2 R2	70	0.95 0.64	0.61 0.84	glu	BK-95R-04-TLS-01
USA (MS) 1995 (MG III, W62 A5504 group 5)	SL	0.39 +0.50	0.41 +0.53	2 R2	90	1.1 0.93	0.16 0.15	glu	BK-95R-04-TLS-02
USA (IA) 1993 (transgenic W98-7)	SL	2.5	2.7	1 trifoliate	95	<0.05	0.08	0.07	ER-93-USA-02-IA-02
USA (IN) 1994 (transgenic group 3 W98 A3322)	SL	2.0 +2.6	2.1 +2.7	2 bloom	77	3.4	1.1	glu	BK-94R-04-IN-01
USA (MO) 1994 (transgenic group 3 W98 A3322)	SL	2.0 +2.6	2.1 +2.7	2 bloom	77	1.5	1.8	glu	BK-94R-04-MO-01

[1]growth stage described or provided as "R" code

R1 beginning bloom

R2 full bloom

R3 beginning pod

glu: included in glufosinate-ammonium result.

Table 48. Glufosinate residues in rape seed resulting from supervised trials in France, Germany and the UK.

Country Year (variety)	Application				PHI	Residues, mg/kg, expressed as glufosinate free acid			Ref
	form	kg ai/ha	Kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
France 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	2 GS35	111	0.06	<0.05		A54228 ER93ECN553 FRA000202
France 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	2 GS35	111	<0.05	<0.05		A54228 ER93ECN553 FRA000302
France 1994 (Gs 401×90)	SL	0.60 +0.45	0.30 +0.23	2 GS33	121	0.07	<0.05		A54228 ER93ECN553 FRA000102
France 1995 (Falcon B)	SL	0.6	0.30	2 GS35	127	<0.05	<0.05		A56444 ER94ECN553 FRA000203
France 1995 (Falcon)	SL	0.67 +0.60	0.32 +0.30	2 GS39	133	<0.05	<0.05		A56444 ER94ECN553 FRA000103
France 1996 (GMO hybrid)	SL	0.60	0.30 +0.24	2 GS32	108	0.13	<0.05		A57955 ER96ECN553 FRA000103
France 1996 (GMO hybrid)	SL	0.60	0.30 +0.24	2 GS32	108	0.12	<0.05		A57955 ER96ECN553 FRA000102

Country Year (variety)	Application				PHI days	Residues, mg/kg, expressed as glufosinate free acid			Ref
	form	kg ai/ha	Kg ai/hl	No[1]		glufosinate	MPP	NAG[2]	
Germany 1995 (Falcon G-S40/90)	SL	0.60	0.20	2 GS35	106	0.06	<0.05		A56444 ER94ECN553 DEU030103
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS35	105	0.06	<0.05		A56444 ER94ECN553 DEU040103
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS35	110	0.05	<0.05		A56444 ER94ECN553 DEU040203
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS37	104	<0.05	<0.05		A56444 ER94ECN553 DEU050103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS32	94	<0.05	<0.05		A57955 ER96ECN553 DEU030102
Germany 1996 (Falcon)	SL	0.80	0.27	2 GS32	94	0.06	<0.05		A57955 ER96ECN553 DEU030103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS32	97	0.11	<0.05		A57955 ER96ECN553 DEU050102
Germany 1996 (Falcon)	SL	0.80	0.27	2 GS32	97	0.13	<0.05		A57955 ER96ECN553 DEU050103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS37	97	0.14	<0.05		A57955 ER96ECN553 DEU040102
Germany 1996 s(Falcon)	SL	0.80	0.27	2 GS37	97	0.12	<0.05		A57955 ER96ECN553 DEU040103
UK 1994	SL	0.60	0.30	1 GS21	275	<0.05	<0.05		A54227 ER93ECN552 GBR000102
UK 1994	SL	0.60	0.30	1 GS21	212	<0.05 (2)	<0.05 (2)		A54227 ER93ECN552 GBR000202
UK 1994	SL	0.60 +0.45	0.30 +0.23	2 GS35	91	<0.05	<0.05		A54228 ER93ECN553 GBR000202
UK 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	2 GS35	116	<0.05	<0.05		A54228 ER93ECN553 GBR000102
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	100	0.07	<0.05		A57955 ER96ECN553 GBR000103
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	92	0.1 [3]	<0.05 [3]		A57955 ER96ECN553 GBR000203
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	100	0.15	<0.05		A57955 ER96ECN553 GBR000102
UK 1996 (Falcon)	SL	0.80	0.40	2 GS32	100	0.07	<0.05		A57955 ER96ECN553 GBR000104
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	92	0.1 [3]	<0.05 [3]		A57955 ER96ECN553 GBR000202
UK 1996 (Falcon)	SL	0.80	0.40	2 GS32	92	0.12 [3]	<0.05 [3]		A57955 ER96ECN553 GBR000204

[1]: GS growth stage

GS21	first side shoot detectable
GS32	2 visibly extended internodes
GS33	3 visibly extended internodes
GS35	5 visibly extended internodes
GS37	7 visibly extended internodes
GS80	beginning of ripening
GS83	30% of pods ripe

[2] included in glufosinate-ammonium result.

[3]: Grain samples were harvested at GS80-83 and stored in paper bags for even drying and prepared to laboratory samples 10 days later.

Table 49. Glufosinate residues in canola resulting from supervised trials in Canada. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Location, Year, (variety)	Application				PHI	Residues, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
Canada (AB) 1992 (transgenic HCN92)	SL	0.75		1	63	<0.05	<0.05	<0.05	XEN93-09-AB-018 A53770
Canada (AB) 1992 (transgenic HCN92)	SL	0.75		1	63	<0.05	<0.05	<0.05	XEN93-09-AB019 A53770
Canada (AB) 1992 (transgenic HCN92)	SL	0.75		1	65	<0.05	<0.05	<0.05	XEN93-09-AB020 A53770
Canada (SK) 1992 (transgenic HCN92)	SL	0.75		1	65	<0.05	<0.05	0.07	XEN93-09-SK024 A53770
Canada (SK) 1992 (transgenic HCN92)	SL	0.75		1	62	<0.05	<0.05	0.14	XEN93-09-SK026 A53770
Canada (MB) 1992 (transgenic HCN92)	SL	0.75		1	65	<0.05 (2)	<0.05 (2)	<0.05 (2)	XEN93-09-MB015 A53770
Canada (MB) 1992 (transgenic HCN92)	SL	0.75		1	59	<0.05	<0.05	<0.05	XEN93-09-MB016 A53770
Canada (MB) 1992	SL	0.75		1	65	<0.05	<0.05	<0.05	XEN93-09-MB022 A53770
Canada (MB) 1992	SL	0.75		1	65	<0.05	<0.05	0.08	XEN93-09-MB028 A53770
Canada (AB) 1993 (transgenic HCN92)	SL	0.83		1 GS 3-6 leaf	95	<0.05	<0.05	<0.05	XEN93-29-AB-TC-5 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	1.5		1 GS 3-6 leaf	95	<0.05	<0.05	<0.05	XEN93-29-AB-TC-5 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 3-5 leaf	80	<0.05	<0.05	<0.05	XEN93-29-AB-TC-1 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	1.5	1.36	1	80	<0.05	<0.05	<0.05	XEN93-29-AB-TC-1 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	0.5	0.45	1	75	<0.05	<0.05	<0.05	XEN93-29-AB-TC-2 A56394

Location, Year, (variety)	Application				PHI	Residues, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
Canada (AB) 1993 (transgenic HCN92)	SL	0.75	0.68	1	75	<0.05	<0.05	<0.05	XEN93-29-AB-TC-2 A56394
Canada (AB) 1993 (transgenic)	SL	0.5	0.45	1 GS 4-5 leaf	75	<0.05	<0.05	<0.05	XEN93-29-AB-TC-3 A56394
Canada (AB) 1993 (transgenic)	SL	1.5		1 GS 4-5 leaf	75	<0.05	<0.05	<0.05	XEN93-29-AB-TC-3 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	0.5	0.45	1 GS 3-5 leaf	83	<0.05	<0.05	<0.05	XEN93-29-AB-TC-4 A56394
Canada (AB) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 3-5 leaf	83	<0.05	<0.05	<0.05	XEN93-29-AB-TC-4 A56394
Canada (MB) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 4-6 leaf	69	0.12	<0.05	<0.05	XEN93-29-MB-TC-2 A56394
Canada (MB) 1993 (transgenic HCN92)	SL	0.5	0.45	1 GS 4-5 leaf	67	<0.05	<0.05	<0.05	XEN93-29-MB-TC-3 A56394
Canada (MB) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 4-5 leaf	67	<0.05	<0.05	<0.05	XEN93-29-MB-TC-3 A56394
Canada (MB) 1993 (transgenic HCN92)	SL	0.5	0.45	1 GS 4-5 leaf	68	<0.05	<0.05	<0.05	XEN93-29-MB-TC-4 A56394
Canada (MB) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 4-5 leaf	68	<0.05	<0.05	<0.05	XEN93-29-MB-TC-4 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	1.0		1 GS 5 leaf	66	<0.05	<0.05	0.05	XEN93-29-SK-TC-1 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	2.0		1 GS 5 leaf	66	<0.05	<0.05	0.10	XEN93-29-SK-TC-1 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	0.5	0.45	1 GS 3-4 leaf	57	<0.05	<0.05	<0.05	XEN93-29-SK-TC-3 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 3-4 leaf	57	<0.05	<0.05	<0.05	XEN93-29-SK-TC-3 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	0.5	0.45	1 GS 10 leaf	69	<0.05	<0.05	<0.05	XEN93-29-SK-TC-6 A56394
Canada (SK) 1993 (transgenic HCN92)	SL	0.75	0.68	1 GS 10 leaf	69	<0.05	<0.05	<0.05	XEN93-29-SK-TC-6 A56394
Canada (MT) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 2 leaf	77	<0.05	<0.05	<0.05	A56392 Minto
Canada (MT) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 2 leaf	77	<0.05	<0.05	<0.05	A56392 Minto
Canada (MT) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 2 leaf	77	<0.05	<0.05	<0.05	A56392 Minto
Canada (MT) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 5-6 leaf	70	<0.05	<0.05	<0.05	A56392 Minto

Location, Year, (variety)	Application				PHI	Residues, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
Canada (MT) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 5-6 leaf	70	<0.05	<0.05	<0.05	A56392 Minto
Canada (MT) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 5-6 leaf	70	<0.05	<0.05	0.06	A56392 Minto
Canada (SK) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 2-3 leaf	73	<0.05	<0.05	<0.05	A56392 Indian Head
Canada (SK) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 2-3 leaf	73	<0.05	<0.05	<0.05	A56392 Indian Head
Canada (SK) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 2-3 leaf	73	<0.05	<0.05	<0.05	A56392 Indian Head
Canada (SK) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 5-7 leaf	57	<0.05	<0.05	0.17	A56392 Indian Head
Canada (SK) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 5-7 leaf	57	<0.05	<0.05	0.24	A56392 Indian Head
Canada (SK) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 5-7 leaf	57	<0.05	<0.05	0.26	A56392 Indian Head
Canada (MT) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 4-5 leaf	65	<0.05	<0.05	<0.05	A56392 Portage la Prairie
Canada (MT) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 4-5 leaf	65	<0.05	<0.05	0.07	A56392 Portage la Prairie
Canada (MT) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 4-5 leaf	65	<0.05	0.06	0.05	A56392 Portage la Prairie
Canada (AB) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 2-4 leaf	77	<0.05	<0.05	<0.05	A56392 Vauxhall
Canada (AB) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 2-4 leaf	77	<0.05	<0.05	<0.05	A56392 Vauxhall
Canada (AB) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 2-4 leaf	77	<0.05	<0.05	<0.05	A56392 Vauxhall
Canada (AB) 1994 (transgenic HCN92)	SL	0.4	0.36	1 GS 4-6 leaf	67	<0.05	<0.05	0.08	A56392 Vauxhall
Canada (AB) 1994 (transgenic HCN92)	SL	0.8	0.73	1 GS 4-6 leaf	67	<0.05	<0.05	0.17	A56392 Vauxhall
Canada (AB) 1994 (transgenic HCN92)	SL	1.2	1.1	1 GS 4-6 leaf	67	0.05	<0.05	0.24	A56392 Vauxhall

[1]GS: growth stage expressed in terms of leaf development.
[2]The expression of residues is unclear. In reports A56392 and A56394 glufosinate residues may be expressed as free acid or ammonium salt. MPP and NAG may be expressed as themselves rather than as glufosinate free acid.

Table 50. Glufosinate residues in canola resulting from supervised trials in Australia.

Location, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP[2]	NAG[2]	
Australia (NSW) 1996 (glufosinate selective line)	SL	0.6	0.72	1 GS 3-5 leaf	86	<0.05 (2)			YH 96 AH AU NW 06
Australia (NSW) 1996 (glufosinate selective line)	SL	1.2	1.4	1 GS 3-5 leaf	86	<0.05 (2)			YH 96 AH AU NW 06
Australia (WA) 1996 (var ex Canada)	SL	0.6	0.83	1 GS 1-2 leaf	124	<0.05 (2)			YH 96 AH AU WA 09
Australia (WA) 1996 (var ex Canada)	SL	1.2	1.7	1 GS 1-2 leaf	124	<0.05 (2)			YH 96 AH AU WA 09
Australia (SA) 1996 (transgenic Canadian line)	SL	0.6	0.75	1 GS 4-6 leaf	95	<0.05 (2)			YH 96 AH AU SA 17
Australia (SA) 1996 (transgenic Canadian line)	SL	1.2	1.5	1 GS 4-6 leaf	95	<0.05 (2)			YH 96 AH AU SA 17
Australia (Vic) 1997 (Canadian tolerant)	SL	0.6	0.6	1 GS 2 leaf	105	<0.05 (2)			YH 96 AH AU VN 12
Australia (Vic) 1997 (Canadian tolerant)	SL	1.2	1.2	1 GS 2 leaf	105	<0.05 (2)			YH 96 AH AU VN 12

[1]GS: growth stage expressed in terms of leaf development.
[2]included in glufosinate-ammonium result.

Table 51. Glufosinate residues in tolerant sugar beet root resulting from foliar application in supervised trials in France, Germany and the UK.

Country year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	no[1]	days	glufosinate	MPP	NAG	
France 1995 (transgenic hybrid)	SL	0.60	0.30	2 GS31	85	0.87	<0.05	[2]	A56446 ER95ECN555 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	96	0.05	<0.05	[2]	A57574 ER96ECN551 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	96 124	0.12 0.06	<0.05 <0.05	[2]	A57574 ER96ECN551 FRA000202
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	91	0.48	<0.05	[2]	A57574 ER96ECN551 FRA000302
Germany 1995 (Sä-Nr. 951 959 – 36)	SL	0.80	0.27	2 GS31	96 116	0.39 0.3	<0.05 0.05	[2] [2]	A57574 ER96ECN551 DEU010102
UK 1995 (transgenic hybrid)	SL	0.60	0.30	2 GS19	83	0.79	<0.05	[2]	A56446 ER95ECN555 GBR000102
UK 1995 (transgenic hybrid)	SL	0.60	0.60	2 GS31	94	0.32	<0.05	[2]	A56446 ER95ECN555 GBR000202

Country year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	no[1]	days	glufosinate	MPP	NAG	
UK 1996 (Roberta)	SL	0.80	0.80	2 GS31	111	0.88 0.99	0.06 <0.05	[2]	A57574 ER96ECN551 GBR000102
UK 1996 (transgenic hybrid)	SL	0.80	0.80	2 GS19	105	0.52	<0.05	[2]	A57574 ER96ECN551 GBR000202

[1]: GS growth stage

GS14	4 leaves (2nd pair unfolded)
GS15	5 leaves unfolded
GS19	9 or more leaves unfolded
GS31	beginning of crop cover formation

[2] included in glufosinate-ammonium result.

Table 52. Glufosinate residues in tolerant sugar beet root resulting from foliar application in supervised trials in the USA.

Location, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
USA (CA) 1995 (Liberty Link)	SL	0.21 +0.20 +0.20	0.21 +0.20 +0.20	3 8-leaf	139	<0.05 (2)	0.14 (2)		BK-95R-06 CA-016 (Regimen B)
USA (CA) 1995 (Liberty Link)	SL	0.43 +0.40 +0.40	0.43 +0.39 +0.40	3 6-leaf	139	<0.05 (2)	0.30 0.32		BK-95R-06 CA-016 (Regimen C)
USA (CA) 1995 (Liberty Link)	SL	0.61	0.59	1 6-leaf	139	<0.05 0.05	0.27 0.31		BK-95R-06 CA-016 (Regimen D)
USA (MN) 1995 (Liberty Link)	SL	0.19 +0.20 +0.20	0.21	3 8-leaf	95	<0.05 (2)	<0.05 (2)		BK-95R-06 KBT-01 (Regimen B)
USA (MN) 1995 (Liberty Link)	SL	0.40 +0.41 +0.41	0.43	3 8-leaf	95	0.09 (2)	<0.05 (2)		BK-95R-06 KBT-01 (Regimen C)
USA (MN) 1995 (Liberty Link)	SL	0.61 +0.62	0.64	2 8-leaf	95	0.12 0.10	<0.05 (2)		BK-95R-06 KBT-01 (Regimen D)
USA (ID) 1995 (Liberty Link)	SL	0.21 +0.20 +0.21	0.21	3 8-leaf	41	0.06 <0.05 <0.05)	<0.05 (3)		BK-95R-06 TWM-01 Regimen B)
USA (ID) 1995 (Liberty Link)	SL	0.41 +0.43 +0.40	0.42	3 8-leaf	41	0.16 0.15	<0.05 (2)		BK-95R-06 TWM-01 Regimen C)
USA (ID) 1995 (Liberty Link)	SL	0.63 +0.61	0.64	2 8-leaf	41	0.21	0.06		BK-95R-06 TWM-01 Regimen D)
USA (ND) 1995 (Liberty Link)	SL	0.21 +0.21 +0.22	0.21 +0.22 +0.21	3 11-12-leaf	103	0.08 0.06 0.08	<0.05 (3)		BK-95R-06 PGM-01 (Regimen B)
USA (ND) 1995 (Liberty Link)	SL	0.43 +0.43 +0.46	0.43	3 11-12-leaf	104	0.14 (2)	<0.05 (2)		BK-95R-06 PGM-01 (Regimen C)
USA (ND) 1995 (Liberty Link)	SL	0.86 +0.64	0.85 +0.63	2 11-12-leaf	104	0.15 0.12	<0.05 (2)		BK-95R-06 PGM-01 (Regimen D)
USA (MI) 1996 (Liberty Link)	SL	0.60	0.61 +0.63	2 8-leaf	109	0.12 0.13	0.05 0.06		BK-96R-01 R05-02 (Regimen B)

Location, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
USA (MI) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.64 +0.40 +0.66	3 10-leaf	106	0.24 0.21	0.05 <0.05		BK-96R-01 R05-02 (Regimen C)
USA (OH) 1996 (Liberty Link)	SL	0.60	0.63 +0.67	2 8-leaf	83	0.27 0.12	<0.05 (2)		BK-96R-01 R05-03 (Regimen B)
USA (OH) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.66	3 10-leaf	77	0.56 0.78	<0.05 (2)		BK-96R-01 R05-03 (Regimen C)
USA (ND) 1996 (Liberty Link)	SL	0.60	0.63	2 7.5-8.5-leaf	67	0.17 0.16	<0.05 (2)		BK-96R-01 R05-04 (Regimen B)
USA (ND) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.41 +0.63	3 9.5-11-leaf	62	0.54 0.70	<0.05 (2)		BK-96R-01 R05-04 (Regimen C)
USA (NE) 1996 (Liberty Link)	SL	0.60	0.63	2 8-leaf	115	<0.05 (2)	<0.05 (2)		BK-96R-01 R07-01 Regimen B)
USA (NE) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.66	3 10-leaf	108	0.07 0.05	<0.05 (2)		BK-96R-01 R07-01 Regimen C)
USA (ND) 1996 (Liberty Link)	SL	0.60	0.63	2 8-leaf	73	0.12 0.14	<0.05 (2)		BK-96R-01 R07-02 (Regimen B)
USA (ND) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.41 +0.63	3 10-leaf	66	0.28 0.33	0.07 0.11		BK-96R-01 R07-02 (Regimen C)
USA (CO) 1996 (Liberty Link)	SL	0.60	0.59	2 8-leaf	80	<0.05 (2)	<0.05 (2)		BK-96R-01 R08-01 (Regimen B)
USA (CO) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.40 +0.58	3 10-leaf	68	0.53 0.55	<0.05 (2)		BK-96R-01 R08-01 (Regimen C)
USA (CO) 1996 (Liberty Link)	SL	0.60	0.61 +0.59	2 8-leaf	86	0.11 (2)	<0.05 (2)		BK-96R-01 R09-01 (Regimen B)
USA (CO) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.64 +0.41 +0.61	3 10-leaf	81	0.27 0.30	<0.05 (2)		BK-96R-01 R09-01 (Regimen C)
USA (CA) 1996 (Liberty Link)	SL	0.60	0.65 +0.62	2 8-leaf	132	0.06 0.08	0.07 0.06		BK-96R-01 R10-01 (Regimen B)
USA (CA) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.42 +0.63	3 10-leaf	122	0.37 0.36	0.06 0.07		BK-96R-01 R10-01 (Regimen C)
USA (ID) 1996 (Liberty Link)	SL	0.60	0.62	2 8-10-leaf	128	0.07 0.06	<0.05 (2)		BK-96R-01 R11-01 (Regimen B)
USA (ID) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.63	3 10-leaf	121	0.19 0.22	<0.05 (2)		BK-96R-01 R11-01 (Regimen C)
USA (CA) 1996 (Liberty Link)	SL	2.8 +3.0 +3.0	3.0 +3.2 +3.2	3 8-leaf	136	0.23	0.93		BK-96-R05

[1]: growth stage is described in terms of number of leaves.
[2] included in glufosinate-ammonium result.

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Table 53. Glufosinate residues in maize forage and fodder resulting from supervised trials in France, Germany, Italy, The Netherlands and Spain.

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
France 1993 (LH163×LH164-×F2×T14)	SL	0.45	0.23	2 GS25	0 39 119 119	20 shoot 0.10 shoot <0.05 shoot <0.05 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	13 shoot 0.44 shoot 0.06 shoot [glu]	A54225 ER93ECN550 FRA000402
France 1993 (LH206×LH74-×F2×T14)	SL	0.45	0.23	2 GS24	0 43 119 119	6.2 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.15 shoot <0.05 shoot <0.05 shoot <0.05 cob	8.6 shoot <0.05 shoot <0.05 shoot [glu]	A54225 ER93ECN550 FRA000502
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	0 48 84 84	27 shoot 1.2 shoot <0.05 shoot <0.05 cob	0.11 shoot <0.05 shoot <0.05 shoot <0.05 cob	19 shoot 0.76 shoot <0.05 shoot [glu]	A54225 ER93ECN550 FRA000102
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	0 51 92 92	24 shoot 0.24 shoot <0.05 shoot <0.05 cob	0.47 shoot 0.06 shoot 0.12 shoot 0.23 cob	7.0 shoot <0.05 shoot <0.05 shoot [glu]	A54225 ER93ECN550 FRA000202
France 1993 (MLC 2101/T14)	SL	0.45	0.23	2 GS24	0 39 106 106	26 shoot 0.09 shoot <0.05 shoot <0.05 cob	0.22 shoot <0.05 shoot <0.05 shoot <0.05 cob	17 shoot <0.05 shoot 0.05 shoot [glu]	A54225 ER93ECN550 FRA000302
France 1994 ((LH82(4)T25)sf (-2)xSH298	SL	0.45	0.23	2 GS25	0 35 90 90	24 shoot 0.1 shoot 0.07 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A54229 ER94ECN550 FRA000202
France 1994 (F6×M1)	SL	0.45	0.23	2 GS25	0 35 77 77	9.9 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.13 shoot <0.05 shoot <0.05 shoot <0.05 cob	6.5 shoot 0.11 shoot <0.05 shoot [glu]	A54226 ER93ECS550 FRA000102
France 1994 (LH824xT25)AF4x-B73)	SL	0.45	0.15	2 GS25	0 67 67	43 shoot <0.05 shoot <0.05 cob	0.27 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu]	A54230 ER94ECS550 FRA000102
France 1994 (SH298(LH82(4)T25)sf(2))	SL	0.45	0.23	2 GS25	0 27 69 69	24 shoot 0.12 shoot 0.36 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A54229 ER94ECN550 FRA000102
France 1995 (F2xLH82-T25)	SL	0.45	0.23	2 GS18	0 44 72 72	25 shoot 0.51 shoot 0.47 shoot <0.05 cob	0.26 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A56445 ER95ECN550 FRA000202
France 1995 (F2xLH82-T25)	SL	0.45	0.23	2 GS19	0 44 72 72	25 shoot 0.83 shoot 0.82 shoot <0.05 cob	0.29 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A56445 ER95ECN550 FRA000203
France 1995 (tolerant 039866)	SL	0.45	0.23	2 GS18	0 55 73 73	20 shoot 0.12 shoot 0.12 shoot <0.05 cob	0.2 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A56445 ER95ECN550 FRA000103
France 1995 (tolerant 039866)	SL	0.45	0.23	2 GS18	0 55 73 73	15 shoot 0.1 shoot 0.1 shoot <0.05 cob	0.15 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A56445 ER95ECN550 FRA000102

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
France 1995 (Transgenic hybrid)	SL	0.53	0.27	2 GS18	0 49 65 65	7.9 shoot 0.43 shoot 0.16 shoot <0.05 cob	0.08 shoot 0.06 shoot 0.06 shoot <0.05 cob	4.2 shoot 0.28 shoot 0.37 shoot <0.05 cob	A54760 ER95ECS550 FRA000103
France 1995 (Transgenic hybrid)	SL	0.53	0.27	2 GS18	0 49 65 65	8.3 shoot 0.14 shoot <0.05 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	4.2 shoot 0.54 shoot 0.21 shoot <0.05 cob	A54760 ER95ECS550 FRA000102
France 1995 (Transgenic hybrid)	SL	0.45	0.23	2 GS19	0 49 60 60	8.9 shoot <0.05 shoot 0.05 shoot <0.05 cob	0.13 shoot 0.05 shoot 0.07 shoot <0.05 cob	5.1 shoot 0.24 shoot 0.37 shoot <0.05 cob	A54760 ER95ECS550 FRA000203
France 1995 (Transgenic hybrid)	SL	0.45	0.23	2 GS19	0 49 60 60	14 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.14 shoot <0.05 shoot <0.05 shoot <0.05 cob	6.5 shoot 0.13 shoot 0.14 shoot <0.05 cob	A54760 ER95ECS550 FRA000202
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	0 56 75 75	9.1 shoot 0.14 shoot 0.19 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	0 56 75 75	18 shoot 0.28 shoot 0.65 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000103
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	0 56 75 75	16 shoot 0.4 shoot 0.31 shoot <0.05 cob	0.1 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000104
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	0 57 76 76	26 shoot 0.24 shoot 0.57 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000302
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	0 57 76 76	24 shoot 0.48 shoot 0.54 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000303
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	0 57 76 76	14 shoot 0.2 shoot 0.23 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000304
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	0 62 76 76	16 shoot 0.13 shoot 0.22 shoot <0.05 cob	0.07 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000402
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	0 62 76 76	25 shoot 0.2 shoot 0.27 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000403
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	0 62 76 76	20 shoot <0.05 shoot 0.15 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58191 ER96ECN550 FRA000404
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS18	0 46 75 75	16 shoot 0.31 shoot 0.37 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58190 ER96ECS550 FRA000302
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS18	0 46 75 75	19 shoot 0.33 shoot 0.64 shoot <0.05 cob	0.06 shoot <0.05 shoot <0.05 shoot <0.05 cob	[glu] [glu] [glu] [glu]	A58190 ER96ECS550 FRA000303

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS18	0 46 75 75	34 shoot 0.44 shoot 0.47 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000304
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	0 56 76 76	18 shoot 0.27 shoot 0.75 shoot <0.05 cob	0.07 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 FRA000202
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 56 76 76	23 shoot 0.44 shoot 0.46 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 FRA000203
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	0 56 76 76	22 shoot 0.17 shoot 0.38 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 FRA000204
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	0 64 91 91	31 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.14 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000102
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	0 64 91 91	36 shoot 0.06 shoot 0.08 shoot <0.05 cob	0.2 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000103
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 64 91 91	50 shoot 0.12 shoot 0.13 shoot <0.05 cob	0.24 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000104
France 1996 (transgenic hybrid)	SL	0.45	0.18	2 GS19	0 57 86 86	6.5 shoot 0.25 shoot 0.31 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000202
France 1996 (transgenic hybrid)	SL	0.60	0.24	2 GS19	0 57 86 86	8.9 shoot 0.27 shoot 0.3 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000203
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 57 86 86	7.2 shoot 0.11 shoot 0.2 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 FRA000204
Germany 1994	SL	0.45	0.15	2 GS24	0 37 55 55 76	23 shoot 0.74 shoot 0.67 shoot <0.05 cob <0.05 cob	0.65 shoot <0.05 shoot <0.05 shoot <0.05 cob <0.05 cob	glu glu glu glu glu	A54229 ER94ECN550 DEU040202
Germany 1994 (F2xLH82-4)T25sf(2)	SL	0.45	0.15	2 GS23	0 55 87 87	39 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.53 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A54229 ER94ECN550 DEU050102
Germany 1994 (LH82(4)T25st2xS-H298)	SL	0.45	0.15	2 GS25	0 31 51 84 84	29 shoot 0.78 shoot 0.19 shoot 0.26 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu glu	A54229 ER94ECN550 DEU030102
Germany 1995 (LH82^4T25sf^4F2)	SL	0.45	0.15	2 GS18	0 38 78 78	30 shoot 1.5 shoot 0.79 shoot 0.09 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A56445 ER95ECN550 DEU010202

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
Germany 1995 (LH82^4T25sf^4SH -298)	SL	0.45	0.15	2 GS18	0 59 77 77	18 shoot <0.05 shoot 0.05 shoot <0.05 cob	0.1 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A56445 ER95ECN550 DEU050102
Germany 1995 (LH82^4T25sf^4xF 2)	SL	0.45	0.15	2 GS18	0 48 90 90	26 shoot 0.34 shoot 0.23 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A56445 ER95ECN550 DEU010102
Germany 1996 (F2 hybride - LH-82)	SL	0.60	0.20	2 GS18	0 55 103 103	20 shoot 0.12 shoot 0.12 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU050102
Germany 1996 (F2 hybride - LH-82)	SL	0.80	0.27	2 GS18	0 55 103 103	39 shoot 0.16 shoot 0.28 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU050103
Germany 1996 (F2 hybride - LH-82)	SL	0.45	0.15	2 GS18	0 55 103 103	23 shoot 0.14 shoot 0.15 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU050104
Germany 1996 (Facet - transgen)	SL	0.60	0.20	2 GS18	0 40 69 69	24 shoot 0.15 shoot 0.17 shoot <0.05 cob	0.07 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU060102
Germany 1996 (Facet - transgen)	SL	0.80	0.27	2 GS18	0 40 69 69	40 shoot 0.18 shoot 0.52 shoot <0.05 cob	0.1 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU060103
Germany 1996 (Facet - transgen)	SL	0.45	0.15	2 GS18	0 40 69 69	31 shoot 0.08 shoot 0.15 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU060104
Germany 1996 (Facet - transgen)	SL	0.60	0.20	2 GS18	0 38 70 70	32 shoot 0.23 shoot 0.4 shoot <0.05 cob	0.1 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU060202
Germany 1996 (Facet - transgen)	SL	0.80	0.27	2 GS18	0 38 70 70	51 shoot 0.55 shoot 0.21 shoot <0.05 cob	0.16 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU060203
Germany 1996 (Facet - transgen)	SL	0.45	0.15	2 GS18	0 38 70 70	23 shoot 0.29 shoot 0.9 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550D EU060204
Germany 1996 (LH82 T25 SF x F2)	SL	0.60	0.20	2 GS19	0 48 106 106	34 shoot 0.12 shoot 0.09 shoot <0.05 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010202
Germany 1996 (LH82 T25 SF x F2)	SL	0.80	0.27	2 GS19	0 48 106 106	45 shoot 0.16 shoot 0.13 shoot <0.05 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010203
Germany 1996 (LH82 T25 SF x F2)	SL	0.45	0.15	2 GS19	0 48 106 106	27 shoot 0.08 shoot 0.06 shoot <0.05 cob	0.12 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010204
Germany 1996 (LH82 T25 SF x Fe)	SL	0.60	0.20	2 GS19	0 50 113 113	28 shoot 0.1 shoot 0.06 shoot <0.05 cob	0.13 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010102

Country,	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
Year, (variety)	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
Germany 1996 (LH82 T25 SF x Fe)	SL	0.80	0.27	2 GS19	0 50 113 113	27 shoot 0.21 shoot 0.15 shoot <0.05 cob	0.14 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010103
Germany 1996 (LH82 T25 SF x Fe)	SL	0.45	0.15	2 GS19	0 50 113 113	21 shoot 0.07 shoot 0.05 shoot <0.05 cob	0.11 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58191 ER96ECN550 DEU010104
Italy 1994 ([B73(4)xT14]sfx - LM82)	SL	0.45	0.15	2 GS23	0 40 67 67	42 shoot 0.75 shoot 0.68 shoot <0.05 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A54230 ER94ECS550 ITA000102
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 45 77 77	10 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	4.3 shoot 0.22 shoot 0.16 shoot <0.05 cob	A54760 ER95ECS550 ITA000104
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 48 78 78	16 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.12 shoot <0.05 shoot <0.05 shoot <0.05 cob	4.8 shoot 0.14 shoot 0.1 shoot <0.05 cob	A54760 ER95ECS550 ITA000204
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 45 77 77	7.8 shoot <0.05 shoot 0.07 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	4.1 shoot 0.21 shoot 0.45 shoot <0.05 cob	A54760 ER95ECS550 ITA000103
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 48 78 78	19 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.13 shoot <0.05 shoot <0.05 shoot <0.05 cob	5.2 shoot 0.08 shoot 0.15 shoot <0.05 cob	A54760 ER95ECS550 ITA000203
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 45 77 77	11 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.11 shoot <0.05 shoot <0.05 shoot <0.05 cob	3.4 shoot 0.11 shoot 0.12 shoot <0.05 cob	A54760 ER95ECS550 ITA000102
Italy 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 48 78 78	15 shoot <0.05 shoot <0.05 shoot <0.05 cob	0.17 shoot <0.05 shoot <0.05 shoot <0.05 cob	3.7 shoot 0.06 shoot 0.12 shoot <0.05 cob	A54760 ER95ECS550 ITA000202
Italy 1996 (Transgenic hybrid)	SL	0.80	0.27	2 GS18	0 38 64 64	46 shoot 0.76 shoot 1.0 shoot <0.05 cob	0.12 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000105
Italy 1996 (Transgenic hybrid)	SL	0.80	0.27	2 GS18	0 39 67 67	20 shoot 0.35 shoot 0.46 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000205
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	0 38 64 64	25 shoot 0.3 shoot 0.57 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000103
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	0 38 64 64	37 shoot 0.47 shoot 1.1 shoot <0.05 cob	0.11 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000104
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	0 39 67 67	15 shoot 0.21 shoot 0.3 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000203
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	0 39 67 67	22 shoot 0.36 shoot 0.71 shoot <0.05 cob	0.1 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000204

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
Italy 1996 (Transgenic hybrid)	SL	0.80	0.27	2 GS19	0 38 54 54	21 shoot 0.18 shoot 0.79 shoot <0.05 cob	0.05 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000305
Italy 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS19	0 38 54 54	19 shoot 0.58 shoot 0.56 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000303
Italy 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS19	0 38 54 54	20 shoot 0.43 shoot 0.7 shoot <0.05 cob	0.09 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ITA000304
Netherlands 1995 (Hudson)	SL	0.9	0.45-0.23	1 (6 leaf)	71 71	0.41 shoot <0.05 cob	<0.05 shoot <0.05 cob	glu glu	6 HMA 52-509
Netherlands 1995 (Scarlet)	SL	0.9	0.45-0.23	1 (5 leaf)	85 85	0.81 shoot <0.05 cob	0.05 shoot <0.05 cob	glu glu	6 HMA 52-510
Netherlands 1995 (Scarlet)	SL	0.9	0.45-0.23	1 (9 leaf)	72 72	1.7 shoot 0.06 cob	0.24 shoot 0.07 cob	glu glu	6 HMA 52-264
Spain 1994 (LH119-6xT14/LH82)	SL	0.45	0.15	2 GS25	0 40 70 70	27 shoot 0.14 shoot 0.05 shoot <0.05 cob	0.28 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A54230 ER94ECS550 ESP000102
Spain 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 46 57 57	24 shoot <0.05 shoot 0.07 shoot <0.05 cob	0.46 shoot <0.05 shoot <0.05 shoot <0.05 cob	4.2 shoot 0.08 shoot 0.25 shoot <0.05 cob	A54760 ER95ECS550 ESP000103
Spain 1995 (Transgenic hybrid)	SL	0.45	0.15	2 GS18	0 46 57 57	25 shoot 0.05 shoot 0.08 shoot <0.05 cob	0.39 shoot <0.05 shoot <0.05 shoot <0.05 cob	2.9 shoot 0.15 shoot 0.21 shoot <0.05 cob	A54760 ER95ECS550 ESP000102
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	0 36 54 54	14 shoot 0.25 shoot 0.28 shoot <0.05 cob	0.06 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000102
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	0 36 54 54	22 shoot 0.62 shoot 0.31 shoot <0.05 cob	0.07 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000103
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	0 36 54 54	19 shoot 0.9 shoot 0.54 shoot <0.05 cob	0.07 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000104
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	0 35 55 55	12 shoot 0.66 shoot 0.54 shoot <0.05 cob	0.06 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000202
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	0 35 55 55	17 shoot 1.2 shoot 0.72 shoot <0.05 cob	0.06 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000203
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	0 35 55 55	24 shoot 0.88 shoot 0.48 shoot <0.05 cob	0.08 shoot <0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000204
Spain 1996 (transgenic hybrid)	SL	0.45	0.15	2 GS18	0 46 59 59	25 shoot 0.33 shoot 0.47 shoot <0.05 cob	0.18 shoot 0.08 shoot 0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000302

Country, Year, (variety)	Application				PHI	Residues, as glufosinate free acid, mg/kg[2]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG	
Spain 1996 (transgenic hybrid)	SL	0.60	0.20	2 GS18	0 46 59 59	36 shoot 0.66 shoot 0.59 shoot <0.05 cob	0.25 shoot 0.05 shoot <0.05 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000303
Spain 1996 (transgenic hybrid)	SL	0.80	0.27	2 GS18	0 46 59 59	28 shoot 0.8 shoot 1.0 shoot <0.05 cob	0.23 shoot 0.05 shoot 0.07 shoot <0.05 cob	glu glu glu glu	A58190 ER96ECS550 ESP000304

[1]. GS: growth stage at final treatment

GS18 8 leaves unfolded
GS19 9 or more leaves unfolded
GS23 5^{th} leaf unfolded
GS24 6^{th} leaf unfolded
GS25 7^{th} leaf unfolded

[2] shoot: stems + leaves.

glu: included in glufosinate-ammonium result.

Table 54. Glufosinate residues in maize forage and fodder resulting from supervised trials in the USA and Argentina. Analyses on replicate samples are reported individually. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels.

Location, Year, (variety)	Application				PHI	Commodity[2]	Residues, mg/kg, as glufosinate free acid[3]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days		glufosinate-ammonium	MPP	NAG	
USA (IA) 1993 (transgenic (LH216) X (LH119) (4) × T14)	SL	0.36		1 (30 cm)	30 60 118	Forage silage fodder	0.05 0.08 0.09 NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.36 0.49 0.45 0.18 0.19 0.17 0.15 0.19 0.19	ER-93-USA-01-IA-01
USA (IA) 1993 (transgenic (LH216) X (LH119) (4) × T14)	SL	0.50		1 (30 cm)	30 60 118	forage silage fodder	0.07 0.08 0.18 NQ (3) NQ (2) 0.05	NQ (3) NQ (3) NQ (3)	0.36 0.49 0.45 0.14 0.12 0.16 0.20 (3)	ER-93-USA-01-IA-01
USA (IA) 1993 (transgenic (LH216) X (LH119) (4) × T14)	SL	0.50		1 (60 cm)	30 62 114	forage silage fodder	0.12 0.12 0.07 0.12 0.13 0.08 0.13 0.15 0.12	NQ (3) NQ (3) NQ 0.05 NQ	0.80 0.75 0.51 0.71 0.94 0.47 0.81 0.64 0.48	ER-93-USA-01-IA-01
USA (IL) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.36	0.39	1 (30 cm)	30 60 100	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.10 0.06 NQ NQ (3) NQ (3)	ER-93-USA-01-IL-01
USA (IL) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.54	1 (30 cm)	30 60 100	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.06 0.18 0.06 NQ (3) NQ (3)	ER-93-USA-01-IL-01
USA (IL) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.54	1 (60 cm)	30 61 95	forage silage fodder	NQ 0.06 0.08 NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.19 0.48 0.47 0.20 0.17 0.17 0.21 0.16 0.25	ER-93-USA-01-IL-01
USA (IL) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	30 6195	forage silage fodder	0.13 0.14 0.13 0.07 0.09 0.07 NQ (3)	NQ (3) NQ (3) NQ (3)	0.64 0.76 0.51 0.47 0.69 0.51 0.13 0.12 0.15	ER-93-USA-01-IL-01
USA (NE) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.36		1 (30 cm)	30 72 107	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	ER-93-USA-01-NE-01
USA (NE) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.48	1 (30 cm)	30 72 107	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.09 0.05 0.14 NQ (3) NQ (3)	ER-93-USA-01-NE-01

Location, Year, (variety)	Application				PHI		Residues, mg/kg, as glufosinate free acid[3]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Commodity[2]	glufosinate-ammonium	MPP	NAG	
USA (NE) 1993 (transgenic (LH 59x LH51)(LH119) (4) X T14)	SL	0.50	0.48	1 (60 cm)	30 60 95	forage silage fodder	0.16 0.20 0.15 0.05 0.05 0.06 0.16 0.08 0.14	NQ (3) NQ (3) 0.11 0.09 0.09	1.4 1.3 1.2 0.36 0.48 0.46 0.68 0.58 0.57	ER-93-USA-01-NE-01
USA (IN) 1993 (transgenic [LH119(4) X T14] X LH216)	SL	0.36	0.39	1 (30 cm)	30 69 115	forage silage fodder	NQ 0.07 0.05 NQ (2) 0.06 0.11 NQ 0.05	NQ (3) NQ (3) 0.06 NQ (2)	0.34 0.46 0.40 0.18 0.18 0.30 0.25 0.12 0.12	ER-93-USA-01-IN-01
USA (IN) 1993 (transgenic [LH119(4) X T14] X LH216)	SL	0.50	0.54	1 (30 cm)	30 69 115	forage silage fodder	0.06 0.05 0.05 NQ 0.09 NQ 0.05 NQ 0.05	NQ (3) NQ (3) NQ (2) 0.06	0.42 0.40 0.46 0.22 0.14 0.20 0.13 0.11 0.15	ER-93-USA-01-IN-01
USA (IN) 1993 (transgenic [LH119(4) X T14] X LH216)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	30 60 106	forage silage fodder	0.26 0.25 0.23 0.22 0.18 0.21 0.32 0.31 0.45	0.06 NQ (2) 0.09 NQ (2) 0.18 0.13 0.16	1.6 1.5 1.4 1.4 1.3 1.5 1.2 1.4 1.7	ER-93-USA-01-IN-01
USA (ND) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	30 80 107	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.19 0.20 0.23 0.06 NQ NQ NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14)	SL	0.50	0.54	1 (30 cm)	30 80 107	forage silage fodder	0.07 0.06 NQ NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.35 0.29 0.24 NQ 0.05 NQ NQ (3)	ER-93-USA-01-ND-01
USA (ND) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	30 72 97	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.29 0.22 0.20 0.12 0.12 0.10 0.07 0.11 0.08	ER-93-USA-01-ND-01
USA (MO) 1993 (transgenic(LH216) X (LH119(4) X (T14))	SL	0.36	0.39	1 (30 cm)	30 64 97	forage silage fodder	0.07 NQ NQ NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.22 0.16 0.14 0.06 NQ NQ NQ (3)	ER-93-USA-01-MO-01
USA (MO) 1993 (transgenic(LH216) X (LH119(4) X (T14))	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	30 60 95	forage silage fodder	0.35 0.20 0.17 0.26 0.11 0.08 0.10 0.10 0.12	NQ (3) NQ (3) NQ (3)	0.96 1.1 0.96 1.5 0.89 0.70 0.46 0.52 0.60	ER-93-USA-01-MO-01
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X T14)	SL	0.36	0.39	1 (30 cm)	30 73 119	forage silage fodder	NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.13 0.11 0.08 NQ (3) NQ (3)	ER-93-USA-01-CA-01
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X T14)	SL	0.36 +0.50	0.39 +0.54	2 (60 cm)	30 71 106	forage silage fodder	0.12 0.13 NQ (3) 0.09 0.10 0.09	0.08 0.11 NQ (3) 0.13 0.10 0.10	0.52 0.54 0.10 0.26 0.16 0.55 0.60 0.59	ER-93-USA-01-CA-01
USA (SD) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14))	SL	0.36	0.71	1 (30 cm)	30 71 95	forage silage fodder	0.12 NQ NQ NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3)	0.14 0.15 0.13 NQ (3) 0.07 0.08 0.08	ER-93-USA-01-SD-01
USA (SD) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14))	SL	0.50	0.99	1 (30 cm)	30 71 95	forage silage fodder	0.05 0.07 0.06 NQ (3) NQ NQ 0.05	NQ (3) NQ (3) NQ (3)	0.21 0.44 0.25 0.09 0.09 0.10 0.20 0.14 0.22	ER-93-USA-01-SD-01
USA (SD) 1993 (transgenic (LH85 X LH160) (LH119)(4) X T14))	SL	0.36 +0.50	0.71 +0.99	2 (60 cm)	30 60 95	forage silage fodder	0.29 0.23 0.19 0.08 0.07 NQ 0.20 0.09 0.20	NQ (3) NQ (3) 0.06 NQ 0.07	0.89 1.4 1.2 0.09 0.09 0.10 1.7 0.79 1.6	ER-93-USA-01-SD-01
USA (VA) 1993 (transgenic (LH216) (LH119)(4) X T14)	SL	0.36	0.71	1 (30 cm)	33 60	forage silage	0.05 NQ 0.06 NQ (3)	NQ (3) NQ (3)	0.41 0.22 0.33 0.15 0.11 0.08	ER-93-USA-01-VA-01
USA (VA) 1993 (transgenic (LH216) (LH119)(4) X T14)	SL	0.50	0.99	1 (30 cm)	33 60 106	forage silage fodder	0.07 NQ NQ NQ NQ 0.06 NQ NQ	NQ (3) NQ (3) 0.11 0.07	0.46 0.29 0.35 0.30 0.12 0.24 0.10 0.07	ER-93-USA-01-VA-01
USA (VA) 1993 (transgenic (LH216) (LH119)(4) X T14)	SL	0.36 +0.50	0.71 +0.99	2 (60 cm)	30 61 97	forage silage fodder	0.31 0.36 0.44 0.49 0.64 0.44 0.27 0.33	NQ (3) 0.17 0.34 0.20 0.41 0.43	1.9 2.4 3.1 2.4 2.5 2.1 0.97 0.93	ER-93-USA-01-VA-01
USA (MN) 1993 ((LH85 X LH160) (LH119)(4) X T14)	SL	0.52	1.1	1 (76 cm)	30 66	forage silage	0.34 0.27 0.25 0.20 0.20 0.28	NQ (3) NQ (3)	1.5 1.5 1.2 1.3 0.99 1.4	ER-93-USA-01-MN-01

Location, Year, (variety)	Application				PHI	Commodity[2]	Residues, mg/kg, as glufosinate free acid[3]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days		glufosinate-ammonium	MPP	NAG	
USA (MO) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (12 cm)	20 30 40 60 123	forage forage forage silage fodder	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	0.09 0.12 0.11 NQ (3) NQ (3) NQ (3) NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (28 cm)	20 30 40 60 118	forage forage forage silage fodder	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	0.19 0.14 0.06 0.06 0.19 NQ NQ (3) NQ (3) NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (46 cm)	20 30 40 60 111	forage forage forage silage fodder	0.09 0.08 0.07 0.06 0.05 NQ NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	0.68 0.55 0.46 0.29 0.23 0.16 0.06 0.12 0.11 0.13 NQ NQ NQ (3)	ER-93-USA-01-MO-02
USA (MO) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (61 cm)	20 30 40 60 101	forage forage forage silage fodder	0.41 0.40 0.40 0.27 0.37 0.35 0.50 0.22 0.44 0.14 0.14 0.14 0.23 0.20 0.18	NQ (3) 0.05 NQ NQ NQ (3) 0.31 0.45 0.34 0.05 NQ NQ	2.7 3.3 1.9 1.6 2.0 2.0 2.5 1.2 2.2 1.0 0.63 0.74 0.91 0.71 0.79	ER-93-USA-01-MO-02
USA (MO) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (86 cm)	20 30 40 61 97	forage forage forage silage fodder	0.17 0.11 0.14 0.11 0.14 0.06 0.11 0.11 0.08 NQ 0.05 NQ 0.13 0.06 0.08	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	0.77 0.67 0.82 0.74 0.90 0.52 0.73 0.87 0.57 0.31 0.45 0.34 0.31 0.27 0.30	ER-93-USA-01-MO-02
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (13-15 cm)	20 30 40 60 127	forage forage forage silage fodder	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	NQ (3) NQ (3) NQ (3) NQ (3) NQ (3)	ER-93-USA-01-CA-02
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (25-33 cm)	20 30 40 60 120	forage forage forage silage fodder	0.25 0.20 0.24 0.06 NQ 0.05 NQ (3) NQ (3) NQ (3)	0.12 0.14 0.11 NQ 0.05 NQ NQ (3) NQ (3) NQ (3)	1.3 0.87 1.2 0.25 0.23 0.35 0.11 0.14 0.13 NQ (3) 0.07 NQ 0.06	ER-93-USA-01-CA-02
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (33-51 cm)	20 30 40 60 114	forage forage forage silage fodder	0.24 0.29 0.18 0.09 0.16 0.13 NQ 0.09 0.08 NQ (3) NQ (3)	0.08 0.08 0.06 NQ NQ 0.05 NQ (3) NQ (3) NQ NQ 0.07	1.2 1.4 1.3 0.48 0.62 0.61 0.31 0.43 0.34 0.09 0.06 0.08 0.17 0.08 0.14	ER-93-USA-01-CA-02
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 (41-81 cm)	20 30 40 60 96	forage forage forage silage fodder	0.46 0.42 0.51 0.44 0.31 0.33 0.16 0.16 0.18 NQ 0.09 0.17 0.25 0.26 0.09	0.11 0.10 0.09 0.11 0.10 0.08 0.07 0.07 0.08 0.06 NQ 0.07 0.13 0.10 0.09	1.8 1.6 1.4 1.5 1.4 1.6 0.77 0.65 0.86 0.21 0.30 0.55 1.4 0.88 0.60	ER-93-USA-01-CA-02
USA (CA) 1993 (transgenic (LH59 X LH51) (LH119)(4) X (T14))	SL	0.50	0.53	1 66-117 cm)	20 30 40 60 96	forage forage forage silage fodder	0.29 0.36 0.34 0.21 0.34 0.19 0.11 0.14 0.22 0.08 0.09 NQ 0.18 0.18 0.23	0.06 0.07 0.06 0.07 0.06 0.05 NQ (3) NQ (3) 0.07 0.06 0.07	0.88 0.96 0.95 0.84 0.89 0.54 0.60 0.49 0.67 0.33 0.59 0.20 2.4 1.5 1.5	ER-93-USA-01-CA-02
USA (FL) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14)	SL	0.40 +0.50	0.43 +0.54	2 (2-14 leaves)	29 60 69	forage silage fodder	2.1 0.70 1.0	NQ NQ 0.21	glu glu glu	BK-94R-01-FL-01
USA (IA) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.41 +0.53	0.44 +0.57	2 (61 cm)	31 60 100 122	forage silage forage fodder	0.66 0.36 0.18 0.25	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-IA-01
USA (IL) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (61 cm)	31 60 76 118	forage silage forage fodder	0.26 0.11 0.12 0.12	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-IL-01
USA (MN) 1994 (transgenic (LH74) (LH82(3) X T14))	SL	0.38 +0.48	0.41 +0.52	2 (61 cm)	31 60 93 114	forage silage forage fodder	1.1 1.1 0.91 0.99	NQ NQ NQ 0.14	glu glu glu glu	BK-94R-01-MN-01

Location, Year, (variety)	Application				PHI		Residues, mg/kg, as glufosinate free acid[3]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Commodity[2]	glufosinate-ammonium	MPP	NAG	
USA (MO) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.53	0.43 +0.57	2 (61 cm)	30 60 69 89	forage silage forage fodder	1.6 1.2 0.70 1.5	NQ NQ 0.08 0.26	glu glu glu glu	BK-94R-01-MO-01
USA (NC) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14))	SL	0.38 +0.52	0.41 +0.56	2 (61 cm)	30 58 69 92	forage silage forage fodder	0.21 0.10 0.09 0.07	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-NC-01
USA (NY) 1994 (transgenic (LH74) (LH82(3) X T14))	SL	0.38 +0.53	0.41 +0.57	2 (61 cm)	30 69 77 88	forage silage forage fodder	4.0 2.1 2.9 5.3	NQ NQ NQ 0.1	glu glu glu glu	BK-94R-01-NY-01
USA (TX) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14))	SL	0.38 +0.46	0.41 +0.49	2 (61 cm)	30 60 74 97	forage silage forage fodder	0.44 0.32 0.27 0.26	NQ NQ NQ 0.07	glu glu glu glu	BK-94R-01-TX-01
USA (WA) 1994 (transgenic (LH74) (LH82)3) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (61 cm)	30 60 76 86	forage silage forage fodder	0.77 0.24 0.47 0.56	0.09 NQ 0.07 0.12	glu glu glu glu	BK-94R-01-WA-01
USA (WI) 1994 (transgenic (LH85 X LH160) (LH119(4) X T14))	SL	0.38 +0.56	0.41 +0.60	2 (61 cm)	30 60 92 107	forage silage forage fodder	0.61 0.36 0.33 0.43	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-WI-01
USA (FL) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14)	SL200	0.40 +0.50	0.43 +0.54	2 (2-14 leaves)	29 60 69	forage silage fodder	1.8 0.84 1.2	NQ NQ 0.29	glu glu glu	BK-94R-01-FL-01
USA (IA) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.41 +0.51	0.44 +0.55	2 (61 cm)	31 60 100 122	forage silage forage fodder	0.53 0.40 0.17 0.22	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-IA-01
USA (IL) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (61 cm)	31 60 76 118	forage silage forage fodder	0.32 0.15 0.11 0.11	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-IL-01
USA (MN) 1994 (transgenic (LH74) (LH82(3) X T14))	SL	0.40 +0.51	0.43 +0.55	2 (61 cm)	31 60 93 114	forage silage forage fodder	2.4 1.7 1.4 2.6	NQ NQ NQ 0.23	glu glu glu glu	BK-94R-01-MN-01
USA (MO) 1994 (transgenic (LH59 X LH51) (LH119(4) X T14))	SL	0.40 +0.56	0.43 +0.60	2 (61 cm)	30 60 69 89	forage silage forage fodder	1.5 1.2 0.86 1.2	NQ NQ 0.08 0.22	glu glu glu glu	BK-94R-01-MO-01
USA (NC) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14))	SL	0.40 +0.46	0.43 +0.49	2 (61 cm)	30 58 69 92	forage silage forage fodder	0.19 0.13 0.09 0.08	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-NC-01
USA (NY) 1994 (transgenic (LH74) (LH82(3) X T14))	SL	0.40 +0.53	0.43 +0.57	2 (61 cm)	30 60 77 88	forage silage forage fodder	1.2 0.74 0.35 1.5	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-NY-01
USA (TX) 1994 (transgenic (LH51 X LH210) (LH119(4) X T14))	SL	0.40 +0.49	0.43 +0.53	2 (61 cm)	30 60 74 97	forage silage forage fodder	0.52 0.30 0.31 0.25	NQ NQ NQ 0.07	glu glu glu glu	BK-94R-01-TX-01
USA (WA) 1994 (transgenic (LH74) (LH82)3) X T14))	SL	0.40 +0.50	0.43 +0.54	2 (61 cm)	30 60 76 86	forage silage forage fodder	0.70 0.24 0.37 0.43	0.09 0.10 0.11 0.15	glu glu glu glu	BK-94R-01-WA-01
USA (WI) 1994 (transgenic (LH85 X LH160) (LH119(4) X T14))	SL	0.38 +0.50	0.41 +0.54	2 (61 cm)	30 60 92 107	forage silage forage fodder	0.49 0.19 0.28 0.50	NQ NQ NQ NQ	glu glu glu glu	BK-94R-01-WI-01

Location, Year, (variety)	Application				PHI	Commodity[2]	Residues, mg/kg, as glufosinate free acid[3]			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days		glufosinate-ammonium	MPP	NAG	
USA (MN) 1995 (transgenic (LH202) (LH82 (4) x T25))	SL	0.39 +0.49	0.41 +0.53	2 (7-8 leaf)	30 60 100	forage forage fodder	2.4 1.5 1.2	0.06 0.08 0.10	glu glu glu	BK95R01-GGH-01
USA (KS) 1995 (transgenic (B73(5)xT25) (LH51))	SL	0.39 +0.50	0.41 +0.53	2 (56-66 cm)	32 62 77 95	forage forage forage fodder	1.3 0.97 <u>1.1</u> <u>1.2</u>	NQ NQ <u>0.09</u> <u>0.14</u>	glu glu glu glu	BK95R01-MDA-02
USA (MI) 1995 (transgenic (LH119 (9) x T14) (LH168))	SL	0.39 +0.50	0.41 +0.54	2 (61-77 cm)	30 61 98 111	forage forage forage fodder	0.73 <u>0.46</u> 0.42 <u>0.50</u>	0.08 <u>0.07</u> 0.11 <u>0.15</u>	glu glu glu glu	BK95R01-JRS-02
USA (MO) 1995 (transgenic (B73 (5) x T25) (LH51))	SL	0.39 +0.52	0.44 +0.60	2 (61 cm)	10 20 29 40 60 81 90	forage forage forage forage forage forage fodder	4.1 1.5 1.0 0.82 <u>0.49</u> 0.17 <u>0.51</u>	0.07 0.05 NQ NQ <u>0.05</u> 0.05 <u>0.18</u>	glu glu glu glu glu glu glu	BK95R01-JLB-01
USA (NE) 1995 (transgenic (LH119 (9) x T14) (LH51))	SL	0.39 +0.52	0.41 +0.55	2 (61 cm)	20 60 80 89	forage forage forage fodder	0.41 <u>0.33</u> 0.30 <u>0.53</u>	NQ NQ NQ NQ	glu glu glu glu	BK95R01-MDA-01
USA (OH) 1995 (transgenic (LH119 (9) x T14) (LH51))	SL	0.39 +0.52	0.43 +0.52	2 (61 cm)	31 60 88 117	forage forage forage fodder	1.9 <u>1.6</u> 0.63 <u>1.1</u>	NQ <u>0.07</u> 0.17 <u>0.22</u>	glu glu glu glu	BK95R01-JRS-01
USA (TX) 1995 (transgenic (LH216) (B73 (5) x T25))	SL	0.40 +0.50	0.42 +0.53	2 (53-66 cm)	10 20 30 40 61 71 84	forage forage forage forage forage forage fodder	3.2 1.6 0.88 0.85 0.72 <u>0.83</u> <u>1.6</u>	0.07 NQ NQ NQ NQ <u>0.07</u> <u>0.14</u>	glu glu glu glu glu glu glu	BK95R01-GLS-01
Argentina 1996 (transgenic)	SL	1.4	0.88	1 GS17-32)	1 34 54 54	shoot shoot shoot cob	54 0.50 1.9 0.08	0.34 NQ NQ NQ		A57414 ER96ARG001010102

[1]. growth stage at final treatment is given as the height of the plant.
[2] commodity descriptions:

forage	immature whole plant
silage	mature whole plant collected prior to the dent stage
fodder	mature plant without ears, collected at grain harvest

[3] NQ - residues <LOD (0.05 mg/kg glufosinate free acid equivalents)
glu: included in glufosinate-ammonium result.

Table 55. Glufosinate residues in transgenic maize forage and fodder resulting from supervised trials in Ontario, Canada.

Year	Application				PHI	Residues, mg/kg,			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
1993	SL	0.75		1 GS16	106 152 152	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	A55207 93-IGN-C ON-1-2
1993	SL	1.5		1 GS16	106 152 152	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	A55207 93-IGN-C ON-1-3
1993	SL	0.75		1 GS16	107 154 154	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	A55207 93-IGN-C ON-2-2
1993	SL	1.5		1 GS16	107 154 154	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	<0.05 shoot <0.05 shoot <0.05 cob	A55207 93-IGN-C ON-2-3
1994	SL	0.5		1 GS17-19	99 137	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 94-IGN-C ON-1-2
1994	SL	1.0		1 GS17-19	99 137	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 94-IGN-C ON-1-3
1994	SL	0.5		1 GS17-19	93 114	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.34 shoot <0.05 cob	A55207 94-IGN-C ON-2-2
1994	SL	1.0		1 GS17-19	93 114	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.20 shoot <0.05 cob	A55207 94-IGN-C ON-2-3
1994	SL	0.5		1 GS17-19	93 114	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.32 shoot <0.05 cob	A55207 94-IGN-C ON-3-2
1994	SL	1.0		1 GS17-19	93 114	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.15 shoot <0.05 cob	A55207 94-IGN-C ON-3-3
1995	SL	0.6		1 GS18-19	68 104	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 95-IGN-C ON-1-2
1995	SL	0.6		2 GS33	61 97	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.28 shoot <0.05 cob	A55207 95-IGN-C ON-1-3
1995	SL	1.2		1 GS40	56 92	0.12 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.86 shoot <0.05 cob	A55207 95-IGN-C ON-1-4
1995	SL	0.6		1 GS18	71 105	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.11 shoot <0.05 cob	A55207 95-IGN-C ON-2-2
1995	SL	0.6		2 GS33	62 96	0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.33 shoot <0.05 cob	A55207 95-IGN-C ON-2-3
1995	SL	1.2		1 GS40	56 90	0.50 shoot <0.05 cob	<0.05 shoot <0.05 cob	3.8 shoot <0.05 cob	A55207 95-IGN-C ON-2-4
1995	SL	0.6		1 GS18-19	56 103	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 95-IGN-C ON-3-2
1995	SL	0.6		2 GS33	64 96	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 95-IGN-C ON-3-3
1995	SL	1.2		1 GS40	57 89	0.43 shoot <0.05 cob	<0.05 shoot <0.05 cob	3.7 shoot 0.05 cob	A55207 95-IGN-C ON-3-4

Year	Application				PHI	Residues, mg/kg,			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG	
1995	SL	0.6		1 GS18	70 104	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	A55207 95-IGN-C ON-4-2
1995	SL	0.6		2 GS33	63 96	<0.05 shoot <0.05 cob	<0.05 shoot <0.05 cob	0.09 shoot <0.05 cob	A55207 95-IGN-C ON-4-3
1995	SL	1.2		1 GS40	57 90	0.40 shoot <0.05 cob	<0.05 shoot <0.05 cob	2.7 shoot 0.10 cob	A55207 95-IGN-C ON-4-4

[1] GS: growth stage at final treatment

GS16 6 leaves unfolded
GS17 7 leaves unfolded
GS18 8 leaves unfolded
GS19 9 or more leaves unfolded
GS33 3 nodes detectable
GS40 booting

Table 56. Glufosinate residues in rape seed forage and fodder resulting from supervised trials in France, Germany, and the UK.

Country Year (variety)	Application				PHI days	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	Kg ai/hl	No[1]		glufosinate	MPP	NAG[2]	
France 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	1 at GS23 2 at GS35	0 116 0 10 73 73 111	65 shoot 0.06 shoot 20 shoot 7.0 shoot 0.89 shoot 0.06 pod 1.6 straw	0.49 shoot <0.05 shoot 0.16 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A54228 ER93ECN553 FRA000202
France 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	1 at GS23 2 at GS35	0 116 0 10 73 73 111	58 shoot 0.05 shoot 24 shoot 7.2 shoot 0.82 shoot 0.1 pod 1.3 straw	0.17 shoot 0.05 shoot 0.19 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A54228 ER93ECN553 FRA000302
France 1994 (Gs 401×90)	SL	0.60 +0.45	0.30 +0.23	1 at GS21 2 at GS33	0 73 0 38 99 99 121	6.5 shoot 0.12 shoot 45 shoot 0.16 shoot 0.11 shoot 0.24 pod 0.69 straw	0.05 shoot <0.05 shoot 0.34 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.13 straw		A54228 ER93ECN553 FRA000102
France 1995 (Falcon B)	SL	0.6	0.30	2 GS35	0 16 69 69 127	7.9 shoot 2.5 shoot 0.39 shoot 0.12 pod 0.75 straw	0.08 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A56444 ER94ECN553 FRA000203
France 1995 (Falcon)	SL	0.67 +0.60	0.32 +0.30	2 GS39	0 28 78 78 133	19 shoot 2.5 shoot 1.0 shoot 0.15 pod 1.2 straw	0.07 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.11 straw		A56444 ER94ECN553 FRA000103

Country Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	Kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
France 1996 (GMO hybrid)	SL	0.60	0.30 +0.24	2 GS32	0 17 58 58 108	25 shoot 6.0 shoot 1.8 shoot 0.57 pod 5.5 straw	0.3 shoot 0.08 shoot <0.05 shoot <0.05 pod 0.22 straw		A57955 ER96ECN553 FRA000103
France 1996 (GMO hybrid)	SL	0.60	0.30 +0.24	2 GS32	0 17 58 58 108	13 shoot 2.9 shoot 0.93 shoot 0.4 pod 3.5 straw	0.11 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.15 straw		A57955 ER96ECN553 FRA000102
Germany 1995 (Falcon G-S40/90)	SL	0.60	0.20	2 GS35	0 7 53 53 106	14 shoot 9.3 shoot 1.6 shoot 0.32 pod 1.0 straw	0.28 shoot 0.05 shoot <0.05 shoot <0.05 pod 0.11 straw		A56444 ER94ECN553 DEU030103
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS35	0 20 55 55 105	14 shoot 2.7 shoot 2.4 shoot 0.38 pod 2.7 straw	0.15 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.18 straw		A56444 ER94ECN553 DEU040103
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS35	0 12 47 47 110	12 shoot 4.0 shoot 1.6 shoot 0.52 pod 2.3 straw	0.14 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.12 straw		A56444 ER94ECN553 DEU040203
Germany 1995 (Falcon)	SL	0.60	0.20	2 GS37	0 21 61 61 104	19 shoot 1.0 shoot 0.15 shoot 0.1 pod 0.17 straw	0.08 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A56444 ER94ECN553 DEU050103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS32	0 6 51 51 94	21 shoot 4.5 shoot 1.1 shoot 0.23 pod 1.7 straw	0.32 shoot <0.05 shoot <0.05 shoot <0.05 pod 0.08 straw		A57955 ER96ECN553 DEU030102
Germany 1996 (Falcon)	SL	0.80	0.27	2 GS32	0 6 51 51 94	28 shoot 5.8 shoot 1.1 shoot 0.22 pod 4.3 straw	0.43 shoot 0.07 shoot <0.05 shoot <0.05 pod 0.19 straw		A57955 ER96ECN553 DEU030103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS32	0 12 54 54 97	20 shoot 4.5 shoot 0.43 shoot 0.13 pod 1.8 straw	0.19 shoot 0.08 shoot <0.05 shoot <0.05 pod 0.09 straw		A57955 ER96ECN553 DEU050102
Germany 1996 (Falcon)	SL	0.80	0.27	2 GS32	0 12 54 54 97	26 shoot 4.7 shoot 1.1 shoot 0.35 pod 2.3 straw	0.28 shoot 0.06 shoot <0.05 shoot <0.05 pod 0.08 straw		A57955 ER96ECN553 DEU050103
Germany 1996 (Falcon)	SL	0.60	0.20	2 GS37	0 7 47 47 97	16 shoot 5.2 shoot 1.1 shoot 0.19 pod 3.0 straw	0.2 shoot 0.07 shoot <0.05 shoot <0.05 pod 0.14 straw		A57955 ER96ECN553 DEU040102
Germany 1996 (Falcon)	SL	0.80	0.27	2 GS37	0 7 47 47 97	18 shoot 6.7 shoot 1.7 shoot 0.51 pod 3.2 straw	0.2 shoot 0.07 shoot <0.05 shoot <0.05 pod 0.17 straw		A57955 ER96ECN553 DEU040103

Country Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	Kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
UK 1994	SL	0.60	0.30	1 at GS21	0 159 184 224 224 275	37 shoot <0.05 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw	0.49 shoot <0.05 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A54227 ER93ECN552 GBR000102
UK 1994	SL	0.60	0.30	1 at GS21	0 132 192 192 212	57 46 shoot 0.11 shoot <0.05 shoot <0.05 (2) pod <0.05 straw	0.67 0.60 shoot <0.05 shoot <0.05 shoot <0.05 (2) pod <0.05 straw		A54227 ER93ECN552 GBR000202
UK 1994	SL	0.60 +0.45	0.30 +0.23	1 at GS21 2 at GS35	0 121 0 11 71 71 91	52 shoot <0.05 shoot 16 shoot 2.2 shoot 0.18 shoot 0.07 pod 0.5 straw	0.62 shoot <0.05 shoot 0.08 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A54228 ER93ECN553 GBR000202
UK 1994 (Falcon)	SL	0.60 +0.45	0.30 +0.23	1 at GS21 2 at GS35	0 159 0 25 65 65 116	13 shoot 0.13 shoot 0.11 shoot 1.2 shoot 0.31 shoot 0.09 pod 0.47 straw	0.42 shoot <0.05 shoot <0.05 shoot <0.05 shoot <0.05 shoot <0.05 pod <0.05 straw		A54228 ER93ECN553 GBR000102
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	0 10 61 61 100	16 shoot 4.8 shoot 1.3 shoot 0.17 pod 1.3 straw	0.31 shoot 0.07 shoot <0.05 shoot <0.05 pod 0.06 straw		A57955 ER96ECN553 GBR000103
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	0 9 58 58 92	26 shoot 6.7 shoot 1.8 shoot 0.31 pod 3.7 straw [3]	0.17 shoot 0.11 shoot <0.05 shoot <0.05 pod 0.11 straw [3]		A57955 ER96ECN553 GBR000203
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	0 10 61 61 100	14 shoot 4.7 shoot 1.2 shoot 0.20 pod 1.5 straw	0.28 shoot 0.07 shoot <0.05 shoot <0.05 pod <0.05 straw		A57955 ER96ECN553 GBR000102
UK 1996 (Falcon)	SL	0.80	0.40	2 GS32	0 10 61 61 100	20 shoot 6.9 shoot 1.2 shoot 0.19 pod 1.4 straw	0.45 shoot 0.09 shoot <0.05 shoot <0.05 pod 0.05 straw		A57955 ER96ECN553 GBR000104
UK 1996 (Falcon)	SL	0.60	0.30	2 GS32	0 9 58 58 92	22 shoot 5.2 shoot 1.5 shoot 0.22 pod 3.3 straw [3]	0.08 shoot 0.09 shoot <0.05 shoot <0.05 pod 0.09 straw [3]		A57955 ER96ECN553 GBR000202
UK 1996 (Falcon)	SL	0.80	0.40	2 GS32	0 9 58 58 92	30 shoot 7.7 shoot 1.9 shoot 0.34 pod 4.5 straw [3]	0.09 shoot 0.1 shoot <0.05 shoot <0.05 pod 0.12 straw [3]		A57955 ER96ECN553 GBR000204

[1]: GS growth stage

GS21	first side shoot detectable
GS32	2 visibly extended internodes
GS33	3 visibly extended internodes
GS35	5 visibly extended internodes
GS37	7 visibly extended internodes
GS80	beginning of ripening
GS83	30% of pods ripe

[2] included in glufosinate-ammonium result.

[3]: Straw samples were harvested at GS80-83 and stored in paper bags for even drying and prepared to laboratory samples 10 days later.

Table 57. Glufosinate residues in canola forage and fodder resulting from supervised trials in Australia.

Location, Year (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP[2]	NAG[2]	
Australia (NSW) 1996 (glufosinate selective line)	SL	0.6	0.72	1 GS 3-5 leaf	86	<0.1 straw			YH 96 AH AU NW 06
Australia (NSW) 1996 (glufosinate selective line)	SL	1.2	1.4	1 GS 3-5 leaf	86	0.12 straw			YH 96 AH AU NW 06
Australia (WA) 1996 (var ex Canada)	SL	0.6	0.83	1 GS 1-2 leaf	29 56 124	1.0 2.4 forage dw <0.05 forage dw <0.1 (2) straw			YH 96 AH AU WA 09
Australia (WA) 1996 (var ex Canada)	SL	1.2	1.7	1 GS 1-2 leaf	29 56 124	2.5 2.3 forage dw <0.05 forage dw <0.1 (2) straw			YH 96 AH AU WA 09
Australia (SA) 1996 (transgenic Canadian line)	SL	0.6	0.75	1 GS 4-6 leaf	42 95	0.8 0.6 forage dw 0.13 0.12 straw			YH 96 AH AU SA 17
Australia (SA) 1996 (transgenic Canadian line)	SL	1.2	1.5	1 GS 4-6 leaf	42 95	2.0 1.6 forage dw 0.14 0.12 straw			YH 96 AH AU SA 17
Australia (Vic) 1997 (Canadian tolerant)	SL	0.6	0.6	1 GS 2 leaf	42 105	<0.05 (2) forage <0.1 (2) straw			YH 96 AH AU VN 12
Australia (Vic) 1997 (Canadian tolerant)	SL	1.2	1.2	1 GS 2 leaf	42 105	<0.05 (2) forage <0.1 (2) straw			YH 96 AH AU VN 12

[1]: GS growth stage expressed in terms of leaf development

[2] included in glufosinate-ammonium result.

Table 58. Glufosinate residues in soya bean forage and fodder resulting from supervised trials in the USA.

Location, Year, (variety)	Application				PHI		Residues, mg/kg, expressed as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days		glufosinate	MPP	NAG	
USA (IA) 1993 (W98-7)	SL	0.5	0.51	1 trifoliate	87	hay	0.22	0.25 0.23	0.72 0.56	ER-93-USA-02-IA-01
	SL	0.5	0.51	1 full pod	65	hay	2.8	1.3	6.7	
	SL	0.5	0.51	2 full pod	65	hay	2.1	1.1	5.1	
USA (IL) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	85	hay	0.15	0.32	0.88	ER-93-USA-02-IL-01
	SL	0.5	0.53	1 full pod	65	hay	1.3	1.3	5.8	
	SL	0.5	0.53	2 full pod	65	hay	1.8	2.2	8.1	
USA (MO) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	87	hay	0.09	0.22	0.32	ER-93-USA-02-MO-01
	SL	0.5	0.53	1 full pod	65	hay	1.8	1.4	6.9	
	SL	0.5	0.53	2 full pod	65	hay	2.0	1.6	7.4	
USA (IN) 1993 (W98-7)	SL	0.5	0.53	1 trifoliate	87	hay	0.16	0.41	0.47	ER-93-USA-02-IN-01
	SL	0.5	0.53	1 full pod	65	hay	2.5	2.5	5.6	
	SL	0.5	0.53	2 full pod	65	hay	3.2	3.0	7.3	
USA (IN) 1993 (W98)	SL	0.5	0.53	1 trifoliate	87	hay	0.06 0.05 0.06	0.16 0.17 0.18	0.15 0.14 0.16	ER-93-USA-02-IN-02
	SL	0.5	0.53	1 full pod	65	hay	1.5 1.6 2.7	1.3 1.2 1.6	4.6 3.9 7.1	
	SL	0.5	0.53	2 full pod	65	hay	2.3 3.6 1.9	1.9 2.5 1.8	6.8 9.7 5.8	
USA (AR) 1993 (W62)	SL	0.5	1.1	1 trifoliate	112	hay	<0.05	<0.05	0.12	ER-93-USA-02-AR-01
	SL	0.5	1.1	1 full pod	65	hay	1.1	0.93	5.0	
	SL	0.5	1.1	2 full pod	65	hay	1.4	1.2	6.3	
USA (MS) 1993 (W98)	SL	0.5	1.1	1 trifoliate	86	hay	0.10	0.08	0.29	ER-93-USA-02-MS-01
	SL	0.5	1.1	1 full pod	65	hay	0.58	0.58	4.7	
	SL	0.5	1.1	2 full pod	65	hay	0.80	0.63	4.6	
USA (VA) 1993 (W62)	SL	0.5	1.1	1 trifoliate	103	hay	0.43	0.31	1.3	ER-93-USA-02-VA-01
	SL	0.5	1.1	1 full pod	64	hay	0.31	0.24	1.2	
	SL	0.5	1.1	2 full pod	64	hay	0.31	0.33	1.5	
USA (NC) 1994 (transgenic Group 5 W62 A5403)	SL	0.4	0.43	1 3rd node	21 42 136	forage forage hay	0.20 <0.05 <0.05	<0.05 <0.05 <0.05	glu glu glu	Project: BK-94R-06 Trial#: NC-01
	SL	0.4 +0.5	0.43 +0.54	2 6th node	21 123	forage hay	0.36 0.33 <0.05 (2)	0.29 0.34 <0.05 0.09	glu glu	
	SL	0.4 +0.5	0.43 +0.54	2 bloom	21 90	forage hay	2.9 3.2 0.61 0.49	0.27 0.36 0.31 0.29	glu glu	

Location, Year, (variety)	Application				PHI		Residues, mg/kg, expressed as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days		glufosinate	MPP	NAG	
	SL	0.4 +0.5	0.43 +0.54	2 full pod	11 77	forage hay	2.6 (2) 1.2 1.0 0.86	0.31 0.32 0.65 0.58 0.51	glu glu	

[1] growth stage described
glu: included in glufosinate-ammonium result.

Table 59. Glufosinate residues in tolerant sugar beet tops and leaves resulting from foliar application in supervised trials in France, Germany and the UK.

Country, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	glufosinate	MPP	NAG[2]	
France 1995 (transgenic hybrid)	SL	0.60	0.30	2 GS31	0 12 16 23 85	10 plant 4.1 plant 4.1 plant 2.8 plant 1.1 leaves	0.1 plant <0.05 plant <0.05 plant <0.05 plant <0.05 leaves		A56446 ER95ECN555 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 13 20 55 96	31 plant 3.3 plant 1.6 plant 0.34 plant <0.05 leaves	0.18 plant <0.05 plant <0.05 plant <0.05 plant <0.05 leaves		A57574 ER96ECN551 FRA000102
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 13 20 54 96	26 plant 2.4 plant 1.8 plant 0.68 plant <0.05 leaves	0.11 plant <0.05 plant <0.05 plant <0.05 plant <0.05 leaves		A57574 ER96ECN551 FRA000202
France 1996 (transgenic hybrid)	SL	0.80	0.32	2 GS19	0 11 16 51 91	20 plant 4.0 plant 3.6 plant 1.6 plant 0.44 leaves	0.14 plant 0.07 plant <0.05 plant <0.05 plant <0.05 leaves		A57574 ER96ECN551 FRA000302
Germany 1995 (Sä-Nr. 951 959 -36)	SL	0.80	0.27	2 GS31	0 23 39 58 96	24 plant 4.0 plant 1.9 plant 1.2 plant 0.53 leaves	0.09 plant <0.05 plant <0.05 plant 0.05 plant 0.06 leaves		A57574 ER96ECN551 DEU010102
UK 1995 (transgenic hybrid)	SL	0.60	0.30	2 GS19	0 4 12 27 83	9.3 plant 6.9 plant 4.7 plant 2.7 plant 1.3 leaves	<0.05 plant 0.05 plant <0.05 plant <0.05 plant <0.05 leaves		A56446 ER95ECN555 GBR000102
UK 1995 (transgenic hybrid)	SL	0.60	0.60	2 GS31	0 8 21 38 94	6.5 plant 1.9 plant 1.8 plant 1.1 plant 0.65 leaves	<0.05 plant <0.05 plant <0.05 plant <0.05 plant <0.05 leaves		A56446 ER95ECN555 GBR000202
UK 1996 (Roberta)	SL	0.80	0.80	2 GS31	0 14 43 71 111	11 plant 6.1 plant 2.4 plant 2.2 plant 1.4 leaves	0.08 plant 0.07 plant 0.06 plant 0.06 plant 0.07 leaves		A57574 ER96ECN551 GBR000102
UK 1996 (transgenic hybrid)	SL	0.80	0.80	2 GS19	0 14 40 64 105	12 plant 5.2 plant 2.0 plant 1.3 plant 0.83 leaves	0.15 plant 0.09 plant 0.05 plant 0.05 plant <0.05 leaves		A57574 ER96ECN551 GBR000202

[1]: GS growth stage

GS14	4 leaves (2[nd] pair unfolded)
GS15	5 leaves unfolded
GS19	9 or more leaves unfolded
GS31	beginning of crop cover formation

[2] included in glufosinate-ammonium result.

Table 60. Glufosinate residues in tolerant sugar beet tops resulting from foliar application in supervised trials in the USA.

Location, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG[2]	
USA (CA) 1995 (Liberty Link)	SL	0.21 +0.20 +0.20	0.21 +0.20 +0.20	3 8-leaf	10 15 30 60 139	0.19 0.23 0.31 0.29 0.23 0.28 0.13 0.12 <0.05 (3)	<0.05 (2) 0.14 0.17 0.53 0.54 0.37 0.33 0.08 0.06 0.12		BK-95R-06 CA-016 (Regimen B)
USA (CA) 1995 (Liberty Link)	SL	0.43 +0.40 +0.40	0.43 +0.39 +0.40	3 6-leaf	10 15 30 60 139	0.39 0.46 1.04 1.1 1.2 0.63 0.76 0.39 0.32 <0.05 (2)	<0.05 (2) 0.51 0.37 0.48 1.2 1.1 0.88 0.78 0.21 0.25		BK-95R-06 CA-016 (Regimen C)
USA (CA) 1995 (Liberty Link)	SL	0.61	0.59	1 6-leaf	10 15 30 60 139	3.0 3.5 2.5 2.8 2.0 1.2 1.4 0.48 0.60 0.45 0.05 0.08 <0.05	0.25 0.22 0.58 0.44 0.42 1.2 1.3 0.82 0.70 0.81 0.29 0.22 0.21		BK-95R-06 CA-016 (Regimen D)
USA (MN) 1995 (Liberty Link)	SL	0.19 +0.20 +0.20	0.21	3 8-leaf	95	<0.05 (2)	<0.05 (2)		BK-95R-06 KBT-01 (Regimen B)
USA (MN) 1995 (Liberty Link)	SL	0.40 +0.41 +0.41	0.43	3 8-leaf	95	<0.05 (2)	<0.05 (2)		BK-95R-06 KBT-01 (Regimen C)
USA (MN) 1995 (Liberty Link)	SL	0.61 +0.62	0.64	2 8-leaf	95	0.10 0.09	<0.05 (2)		BK-95R-06 KBT-01 (Regimen D)
USA (ID) 1995 (Liberty Link)	SL	0.21 +0.20 +0.21	0.21	3 8-leaf	49	0.08 0.09	<0.05 (2)		BK-95R-06 TWM-01 Regimen B)
USA (ID) 1995 (Liberty Link)	SL	0.41 +0.43 +0.40	0.42	3 8-leaf	49	0.22 0.23	<0.05 (2)		BK-95R-06 TWM-01 Regimen C)
USA (ID) 1995 (Liberty Link)	SL	0.63 +0.61	0.64	2 8-leaf	49	0.31	0.05		BK-95R-06 TWM-01 Regimen D)
USA (ND) 1995 (Liberty Link)	SL	0.21 +0.21 +0.22	0.21 +0.22 +0.21	3 11-12-leaf	103	0.05 0.09 0.05	<0.05 (3)		BK-95R-06 PGM-01 (Regimen B)
USA (ND) 1995 (Liberty Link)	SL	0.43 +0.43 +0.46	0.43	3 11-12-leaf	104	0.11 0.07 0.11	<0.05 (3)		BK-95R-06 PGM-01 (Regimen C)
USA (ND) 1995 (Liberty Link)	SL	0.86 +0.64	0.85 +0.63	2 11-12-leaf	104	0.07 0.08	<0.05 (2)		BK-95R-06 PGM-01 (Regimen D)
USA (MI) 1996 (Liberty Link)	SL	0.60	0.61 +0.63	2 8-leaf	109	0.14 0.16	0.05 <0.05		BK-96R-01 R05-02 (Regimen B)
USA (MI) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.64 +0.40 +0.66	3 10-leaf	106	0.30 (2)	<0.05 (2)		BK-96R-01 R05-02 (Regimen C)

Location, Year, (variety)	Application				PHI	Residues, mg/kg, as glufosinate free acid			Ref
	form	kg ai/ha	kg ai/hl	No[1]	days	Glufosinate	MPP	NAG[2]	
USA (OH) 1996 (Liberty Link)	SL	0.60	0.63 +0.67	2 8-leaf	83	0.16 (2)	<0.05 (2)		BK-96R-01 R05-03 (Regimen B)
USA (OH) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.66	3 10-leaf	77	0.46 (2)	<0.05 (2)		BK-96R-01 R05-03 (Regimen C)
USA (ND) 1996 (Liberty Link)	SL	0.60	0.63	2 7.5-8.5-leaf	67	0.25 0.24	<0.05 (2)		BK-96R-01 R05-04 (Regimen B)
USA (ND) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.41 +0.63	3 9.5-11-leaf	62	0.65 0.53	<0.05 (2)		BK-96R-01 R05-04 (Regimen C)
USA (NE) 1996 (Liberty Link)	SL	0.60	0.63	2 8-leaf	115	<0.05 (2)	<0.05 (2)		BK-96R-01 R07-01 Regimen B)
USA (NE) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.66	3 10-leaf	108	<0.05 (2)	<0.05 (2)		BK-96R-01 R07-01 Regimen C)
USA (ND) 1996 (Liberty Link)	SL	0.60	0.63	2 8-leaf	73	0.13 0.16	<0.05 (2)		BK-96R-01 R07-02 (Regimen B)
USA (ND) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.41 +0.63	3 10-leaf	66	0.23 0.24	0.06 0.08		BK-96R-01 R07-02 (Regimen C)
USA (CO) 1996 (Liberty Link)	SL	0.60	0.59	2 8-leaf	80	<0.05 (2)	<0.05 (2)		BK-96R-01 R08-01 (Regimen B)
USA (CO) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.63 +0.40 +0.58	3 10-leaf	68	0.38 (2)	<0.05 (2)		BK-96R-01 R08-01 (Regimen C)
USA (CO) 1996 (Liberty Link)	SL	0.60	0.61 +0.59	2 8-leaf	86	0.06 (2)	<0.05 (2)		BK-96R-01 R09-01 (Regimen B)
USA (CO) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.64 +0.41 +0.61	3 10-leaf	81	0.22 0.24	<0.05 (2)		BK-96R-01 R09-01 (Regimen C)
USA (CA) 1996 (Liberty Link)	SL	0.60	0.65 +0.62	2 8-leaf	132	<0.05 0.07	<0.05 (2)		BK-96R-01 R10-01 (Regimen B)
USA (CA) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.42 +0.63	3 10-leaf	122	0.19 0.26	0.06 0.08		BK-96R-01 R10-01 (Regimen C)
USA (ID) 1996 (Liberty Link)	SL	0.60	0.62	2 8-10-leaf	128	0.10 0.07	<0.05 (2)		BK-96R-01 R11-01 (Regimen B)
USA (ID) 1996 (Liberty Link)	SL	0.60 +0.39 +0.60	0.61 +0.41 +0.63	3 10-leaf	121	0.32 0.30	0.06 0.05		BK-96R-01 R11-01 (Regimen C)

[1] growth stage is described in terms of number of leaves.
[2] included in glufosinate-ammonium result.

Table 61. Glufosinate residues in almond hulls resulting from supervised trials in California, USA, 1985 Analyses of samples from replicate plots are shown separately. Double-underlined residues are from treatments according to GAP and were used to estimate maximum residue levels. CLICK HERE

(Variety)	Application				PHI, days	Residues, mg/kg, as glufosinate free acid		Ref
	Form	kg ai/ha	kg ai/hl	no.		glufosinate	MPP	
(Carmel)	SL	1.7		3	15	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-018
(Carmel)	SL	3.4		3	15	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-018
(Special)	SL	1.7		3	15	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-018
(Special)	SL	3.4		3	15	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-018
(Non-Peril)	SL	1.7		3	14	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-037
(Non-Peril)	SL	3.4		3	14	<0.5 (3)	<0.5 (3)	A48446 07-CA-85-037

Farm animal feeding studies

Studies on cows and laying hens were reported.

Groups of 3 lactating Holstein dairy cows (each weighing 430-610 kg) were dosed with glufosinate-ammonium + NAG (15+85) in gelatin capsules at total nominal levels equivalent to 9.1, 27 and 91 ppm glufosinate free acid in the diet for 28 consecutive days (Czarnecki and Brady, 1995b). Doses were administered after the morning milking in four separate capsules, one containing glufosinate-ammonium and three containing NAG. Milk was collected twice each day and pooled for analysis. On day 29 the animals from each group were slaughtered. The cows consumed a nominal 21 kg (average 16.8-25.4 kg) feed each per day.

The dosing mixture (glufosinate-ammonium 15 parts + NAG 85 parts) was chosen to represent the typical terminal residue composition in glufosinate-resistant crops that might be fed to animals.

Residues were not detected in milk from the lowest dosing level, detected in a few samples from the middle level, and consistently detected the highest dose group where a plateau was reached on day 3. Two milk samples from the same cow (on days 16 and 18) had unusually high residues, which corresponded with a period of low feed consumption (a constant dose representing a higher feed concentration) and low milk production. Residues in the tissues were below the LODs at the lower doses. At the highest dose they were detected in the kidneys and liver, but not in muscle or fat.

Table 62. Residues in the tissues of lactating dairy cows dosed with glufosinate-ammonium + NAG (15+85) in gelatin capsules at levels equivalent to 9.1, 27 and 91 ppm glufosinate free acid in the diet for 28 consecutive days (Czarnecki and Brady, 1995b).

Tissue	Residues, mg/kg, expressed as glufosinate free acid					
	9.1 ppm		27 ppm		91 ppm	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP	Glufosinate + NAG	MPP
Muscle	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)
Fat, perirenal	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)	<0.05 (3)
Liver	<0.1 (3)	<0.1 (3)	<0.1 (3)	<0.1 (3)	<0.1 (3)	0.28 0.29 0.25
Kidneys	<0.1 (3)	<0.1 (3)	<0.1 (3)	<0.1 (3)	0.10 0.14 0.15	<0.1 (2) 0.13

Table 63. Residues in the milk of lactating dairy cows dosed with glufosinate-ammonium + NAG (15+85) in gelatin capsules at levels equivalent to 9.1, 27 and 91 ppm glufosinate free acid in the diet for 28 consecutive days (Czarnecki and Brady, 1995b).

Day	Residues, mg/kg, expressed as glufosinate free acid					
	9.1 ppm		27 ppm		91 ppm	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP	glufosinate + NAG	MPP
1	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)
3	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	0.05 0.04 0.05	<0.02 (3)
5	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	0.05 0.04 0.03	<0.02 (3)
7	<0.02 (3)	<0.02 (3)	0.02 <0.02 (2)	<0.02 (3)	0.04 0.05 0.02	<0.02 (3)
9	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	0.03 0.03 0.03	<0.02 (3)
11	<0.02 (3)	<0.02 (3)	0.02 <0.02 (2)	<0.02 (3)	0.04 0.03 0.03	<0.02 (3)
14	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	0.03 0.03 0.03	<0.02 (3)
16	<0.02 (3)	<0.02 (3)	<0.02 (2) 0.02	<0.02 (3)	0.05 0.23 0.03	<0.02 0.03 <0.02
18	<0.02 (3)	<0.02 (3)	<0.02 (3)	<0.02 (3)	0.04 0.14 0.03	<0.02 0.03 <0.02
21	<0.02 (3)	<0.02 (3)	0.03 <0.02 (2)	<0.02 (3)	0.05 0.05 0.04	<0.02 (3)
23	<0.02 (3)	<0.02 (3)	0.02 <0.02 0.03	<0.02 (3)	0.064 0.03 0.02	<0.02 (3)
25	<0.02 (3)	<0.02 (3)	0.02 <0.02 (2)	<0.02 (3)	0.072 0.02 0.03	<0.02 (3)
28	<0.02 (3)	<0.02 (3)	0.02 <0.02 (2)	<0.02 (3)	0.05 0.04 0.03	<0.02 (3)

Groups of 20 white leghorn laying hens (each bird weighing 1.4-1.5 kg) were dosed with glufosinate-ammonium + NAG L-isomer, 15+85 in gelatin capsules at nominal levels equivalent to 0.36, 1.1 and 3.6 ppm glufosinate free acid in the diet for 28 days (Czarnecki and Brady, 1995a; Helsten, 1995; Crotts and McKinney, 1995). On day 29 twelve hens from each group were slaughtered. The remaining hens from each group were placed on a residue-free diet and killed on days 35 and 42. Eggs were collected daily.

The dosing levels were chosen on the assumption of feed consumption of 180 g/bird/day, but the birds consumed 133-160 g feed each per day. The actual dosing levels would be about 20% higher than intended.

No residues of glufosinate + NAG or MPP were found above the LOD in any of the tissues or eggs (Table 64).

Table 64. Residues in the tissues and eggs of hens dosed with glufosinate + NAG, (15+85) at levels equivalent to 0.36, 1.1 and 3.6 ppm in the feed for 28 days (Czarnecki and Brady, 1995a).

Commodity	Residues expressed as glufosinate free acid, mg/kg					
	0.36 ppm		1.1 ppm		3.6 ppm	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP	glufosinate + NAG	MPP
Skin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Muscle	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Liver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fat	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Eggs[1]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[1]Eggs from days 1, 3, 5, 7, 9, 11, 14, 16, 18, 21, 23, 25 and 28 were analysed.

FATE OF RESIDUES IN STORAGE AND PROCESSING

The effects of commercial processing on residues in sugar beet, maize, soya bean seed and canola seed were reported.

Zietz and Simpson (1997) processed tolerant sugar beet roots (80-100 kg in each trial) from three glufosinate-ammonium residue trials in France, Germany and the UK (Hees and Werner, 1997d) and measured the residues in the processed fractions. The crops were each treated twice with glufosinate-ammonium at 0.80 kg ai/ha with the final treatment at GS19 (9 or more leaves unfolded) or GS31 (beginning of crop cover formation) and harvest 111-124 days later. The process (Figure 6) simulated a commercial operation.

The results are shown in Table 65.

Residues generally tended to remain in the juice and ultimately to appear in the molasses. Residues were not detected (<0.05 mg/kg) in the raw sugar.

Processing factors were calculated only for the glufosinate + NAG residues because the MPP residues in the sugar beet were too low to be useful. Processing factors for raw sugar could not be determined because residues were not found in the sugar in any of the trials. The processing factors for molasses were 5.0, 11.5 and 3.8 (mean 6.8) showing that glufosinate residues in the roots become concentrated in the molasses after removal of water.

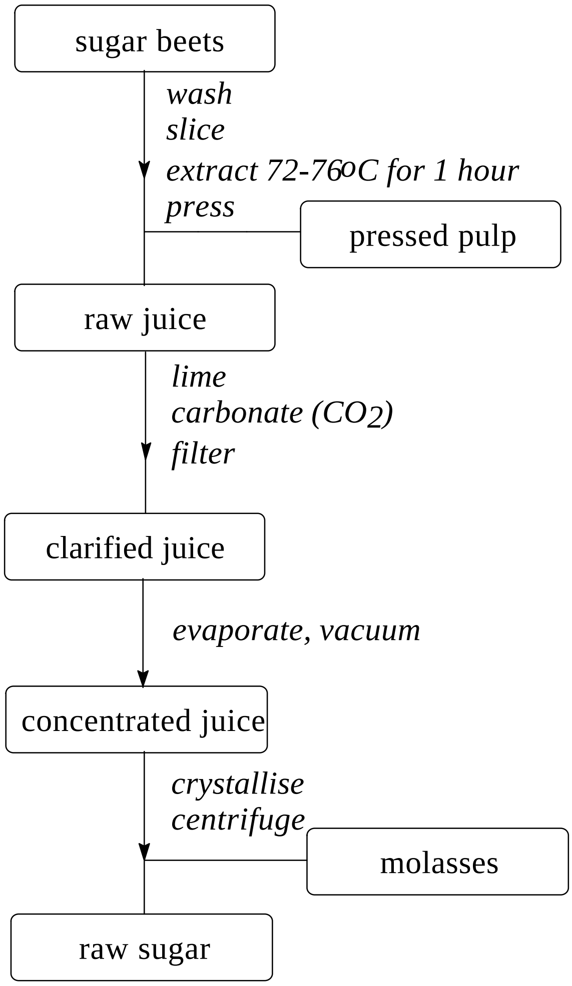


Figure 6. Sugar beet processing.

Table 65. Glufosinate residues in sugar beet roots and processing fractions arising from glufosinate-ammonium treatment of transgenic sugar beet in trials in Germany (DEU010102), France (FRA000202) and the UK (GBR000102) (Hees and Werner 1997d, Zietz and Simpson 1997).

Commodity	Residues, mg/kg as glufosinate free acid					
	DEU010102		FRA000202		GBR000102	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP	glufosinate + NAG	MPP
Root	0.3	0.05	0.06	<0.05	0.99	<0.05
Pressed pulp	<0.05	<0.05	<0.05	<0.05	0.13	<0.05
Raw juice	0.25	<0.05	0.11	<0.05	0.77	0.05
Clarified juice	0.19	<0.05	0.09	<0.05	0.82	0.05
Concentrated juice	0.72	0.14	0.55	0.05	2.5	0.17

Commodity	Residues, mg/kg as glufosinate free acid					
	DEU010102		FRA000202		GBR000102	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP	glufosinate + NAG	MPP
Raw sugar	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molasses	1.5	0.23	0.69	0.06	3.8	<0.05

Brady and Bertrand (1997) treated transgenic sugar beet, variety T-4A, with glufosinate-ammonium three times at 3.0 kg ai/ha, about 5 times the label rate and harvested the crop 136 days after the final treatment at the eighth leaf stage. The laboratory processing of 141 kg sugar beet roots was designed to simulate a commercial process (Englar, 1997) and was similar to that in Figure 6. The results are shown in Table 66.

In this trial, in contrast to the Zietz and Simpson trial, MPP was the main component of the residue. The total residue was used to calculate processing factors of 0 (<0.08) for refined sugar, and 6.4 for molasses.

Table 66. Glufosinate residues in sugar beet root and processing fractions arising from glufosinate-ammonium treatment of transgenic sugar beet in trials in the USA at 3.0 kg ai/ha and harvest 136 days after the last of three treatments (Brady and Bertrand, 1997).

Commodity	Residues, mg/kg as glufosinate free acid	
	glufosinate + NAG	MPP
Root	0.27 0.24	1.0 0.96
Dried pulp	0.14 0.15	0.56 0.63
Refined sugar	<0.05 (2)	<0.05 (2)
Molasses	1.7 1.4	6.5 6.1

Czarnecki (1996) showed that the residues in grain dust were about 10 times as high as in the grain from glufosinate-ammonium-treated tolerant maize. The grain dust contained 0.62 mg/kg of MPP and 3.0 mg/kg glufosinate + NAG from grain containing MPP and glufosinate + NAG at 0.062 and 0.31 mg/kg respectively, all expressed as glufosinate free acid. Residue levels increased as particle size decreased, with levels in the <425 µm fraction 2.5-3 times those in the >2450 µm fraction.

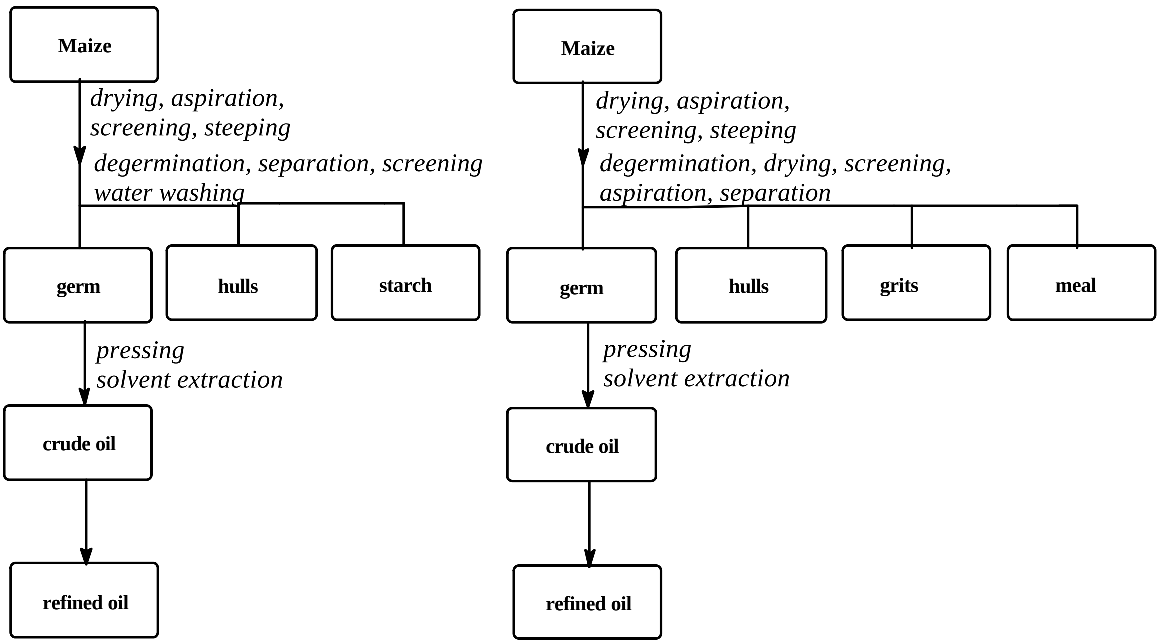
To provide samples for a processing study in the USA Brady *et al.* (1994) treated glufosinate-tolerant maize (60 cm stage) with glufosinate-ammonium at 0.50 kg ai/ha (3 times the proposed label rate) in a trial in Iowa. In a second trial in Nebraska glufosinate-ammonium was applied at 0.36 kg ai/ha to 30 cm maize with a second treatment at 0.50 kg ai/ha at the 60 cm growth stage. The maize was treated by wet and dry milling processes (Figure 7). The results are shown in Table 67.

The residues were all below the LOD (0.05 mg/kg) in the Iowa trial. NAG was present at the LOD in the meal, flour and grits and at 0.1 mg/kg in the hulls in the Nebraska trial. The best estimates for processing factors are corn meal, corn flour and grits 1, hulls 2.

Table 67. Residues in maize and processed fractions resulting from dry and wet milling of glufosinate-tolerant maize treated at excessive rates with glufosinate-ammonium (Brady *et al.* 1994).

Commodity	Iowa trial			Nebraska trial		
	Residues, mg/kg as glufosinate					
	Glufosinate	MPP	NAG	Glufosinate	MPP	NAG
Maize	<0.05	<0.05	<0.05	<0.05	<0.05	0.054
Corn meal (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	0.051
Corn flour (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	0.053
Corn hulls (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	0.10
Corn grits (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Corn crude oil (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Corn refined oil (dry milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Corn hulls (wet milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Corn starch (wet milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Corn crude oil (wet milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Corn refined oil (wet milled)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Figure 7. Wet and dry milling of maize (Brady *et al.,* 1994).



Maize, wet milling

Maize, dry milling

Trial	soya bean seeds		grain dust	
	glufosinate + NAG	MPP	glufosinate + NAG	MPP
IN-01	3.4 mg/kg	1.1 mg/kg	31mg/kg	8.7 mg/kg
MO-01	1.5 mg/kg	1.8 mg/kg	4.3mg/kg	4.7 mg/kg

Brady (1995e) processed seed from transgenic soya bean crops treated at excessive rates with glufosinate-ammonium and measured the residues, expressed as glufosinate free acid, in the aspirated grain fractions (grain dust). In the two trials 32 kg of soya bean seed produced 78 and 228 g of grain dust. Residues in the grain dust were 8.6 and 2.8 times the levels in the grain in the two trials.

Czarnecki *et al.* (1994a) treated a transgenic soya bean crop in the USA (Iowa) with glufosinate-ammonium at 2.6 kg ai/ha (5 times the normal rate) at the six-trifoliate growth stage and harvested the soya beans for processing 96 days later. After processing 31 kg of the soya beans (Figure 8) the hulls contained the highest residues with lower levels in the meal. Residues of

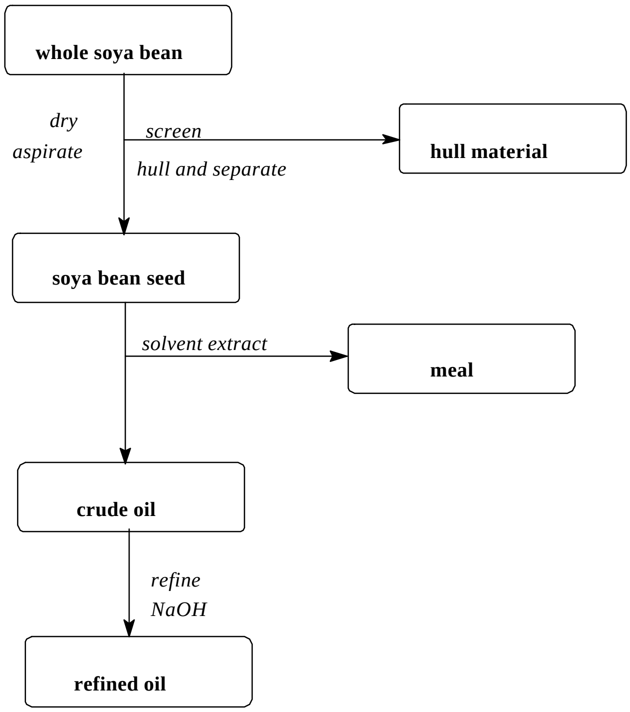


Figure 8. Simulated commercial processing of soya beans

glufosinate, NAG and MPP were not detected (<0.05 mg/kg) in the refined or crude oil. The results are shown in Table 68.

The calculated processing factors for residues in the meal and crude or refined oil are 1.3 and 0 (<0.3) respectively.

Table 68. Residues of glufosinate, NAG and MPP in seeds and processed commodities from glufosinate-treated transgenic soya beans (Czarnecki *et al.*, 1994a).

Commodity	Residues as glufosinate free acid, mg/kg		
	glufosinate	NAG	MPP
Seeds	<0.05	0.07	0.08
Hulls	0.07	0.27	0.30
Meal	<0.05	0.08	0.12
Refined oil	<0.05	<0.05	<0.05
Crude oil	<0.05	<0.05	<0.05

MacDonald (1996a) treated a transgenic canola crop in Canada (Saskatchewan) with single applications of glufosinate-ammonium at 0.75, 1.5 and 3.8 kg ai/ha (up to 4 times the normal rate) at the 4-6 leaf growth stage and harvested the seed (3.5-5 kg) for processing 70 days later.

Processing was on a small scale but was intended to simulate commercial practice. The canola seed was dried and cleaned and, after conditioning, crude oil was produced first by pressing and then by hexane extraction of the cake. The cake was toasted. The crude oil was refined, bleached and deodorised. The results are shown in Table 69.

Glufosinate itself was not detected in the seed or any processed fraction. The main residue was NAG. No residues were detected in the oils. The residues of NAG remain with the meal and change little during toasting. The calculated processing factor for untoasted meal is 3.1 (2.7, 3.1, 3.7) and for toasted meal 3.7 (3.1, 3.3, 4.8).

Table 69. Residues in seed and processed fractions from transgenic canola treated with glufosinate at three rates and harvested 70 days later in Canada (MacDonald 1996a).

Commodity	Residues, mg/kg as glufosinate free acid								
	0.75 kh ai/ha			1.5 kg ai/ha			3.8 kg ai/ha		
	glufosinate	MPP	NAG	Glufosinate	MPP	NAG	glufosinate	MPP	NAG
Seed	<0.05	<0.05	0.063	<0.05	<0.05	0.060	<0.05	<0.05	0.21
Meal, untoasted	<0.05	<0.05	0.17	<0.05	<0.05	0.22	<0.05	0.11	0.64
Meal, toasted	<0.05	<0.05	0.21	<0.05	0.05	0.29	<0.05	0.11	0.64
Oil, crude	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil, refined	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil, bleached	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oil, deodorized	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Soapstock	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.083

Residues in the edible portion of food commodities

The only information was the from processing studies on soya bean, canola and sugar beet.

The processing factors for the residues in soya bean meal and crude or refined oil were 1.3 and 0 (<0.3) respectively. Residues were not detected (<0.05 mg/kg) in the crude or refined oil.

The processing factor for residues in untoasted canola meal was 3.1 and for toasted meal 3.7. Residues were not detected (<0.05 mg/kg) in the crude, refined, bleached or deodorized oil.

The processing factors for raw sugar and molasses in one trial were 0 (<0.35) and 6.8 respectively. In another trial the processing factors for refined sugar and molasses were 0 (<0.08) and 6.4 respectively. No residues were detected (<0.05 mg/kg) in the raw or refined sugar.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

No information.

NATIONAL MAXIMUM RESIDUE LIMITS

The Meeting was informed of the following national MRLs.

Country	MRL, mg/kg	Commodity
Argentina 1/	0.05	corn grain, corn forage, corn fodder
	2/	top fruits, stone fruits, citrus, grapes
Australia 3/	15	mixed pasture (legume/grasses)
	5	edible offal (mammalian)
	0.2	assorted tropical and sub-tropical fruits – inedible peel
	0.1	berries and other small fruits, citrus fruits, meat (mammalian), tree nuts, pome fruits
	0.05	milks, stone fruits
Austria 4/	0.1	all crops
Belgium 5/	2	potatoes

Country	MRL, mg/kg	Commodity
	0.05	all other crops
Brazil 6/	0.05	lettuce, cotton, banana, citrus, potatoes, coffee, apple, maize, peach, Savoy-cabbage, soya beans, wheat, grape, bean
Canada 7/	6	lentils
	3	rape seed (canola)
	1	liver and kidneys of cattle, goats, hogs, poultry and sheep
	0.5	dry white beans
	0.4	potatoes
	0.2	corn
Colombia	8/	cotton, banana, soya bean, papaya, citrus, grape, strawberry, passion-flower, African palm, potatoes, coffee
Denmark		9/
Finland		9/
France 10/	0.5	citrus, small berries, bananas, cherries, stone fruits, pome fruits, hazel nuts, tree nuts, olives, carrots, chicory, cabbage, spinach, beans, lettuce, lamb's lettuce, sweet maize, onions, potatoes
Germany 11/	3	pulses, sunflower seeds with hulls
	1	potatoes, rape seed
	0.5	currants, kiwifruit
	0.2	bananas, citrus
	0.1	other food of plant origin
Greece		9/
Ireland		9/
Italy	0.1	citrus, small berries and small fruits, stone fruits, pome fruits, tree nuts, hazel nuts, kiwis, onion, cabbage, lettuce, beans, carrots, kohlrabi, radish, asparagus, potatoes, soya beans
Japan	0.5	potato, rice, tea
	0.3	mandarin, other citrus, large fruits, small fruits, oil seeds, nuts
	0.2	wheat, other cereals, vegetables, beans (immature + pods), leafy vegetables, rhizomes, bulb vegetables, mushrooms
	0.1	soya bean
Luxemburg 5/	0.2	potatoes
	0.05	fruits and vegetables
Netherlands 12/	0.5	potatoes
	0.05	fruit, vegetables
	0-0.05 13/	other food commodities
Norway		9/
Poland	3	legume vegetables
	0.2	fruits, vegetables (except legume vegetables)
Portugal 14/	3	barley
	1	wheat
	0.5	potatoes
	0.1	citrus, berries, brassicae
	0.1 15/	tea, hop
	0.05 15/	pome fruits, stone fruits, other fruits, roots and tubercles, bulbs, fruits and vegetables, hard shelled fruits, leaf vegetables and fresh spice plants, fresh leguminosae, stalks, fungi, leguminosae (dried) grains, oil seeds, other cereals
Spain 16/	0.05	fruits, vegetables, potatoes, cereals
	0.01 17/	legumes, oily seeds, tea and other infusions, dried hops, spices, tobacco, sugar beet, sugarcane, forages and hays, dried products (raisins, plums, etc)
South Africa 18/	2	soya beans
	0.2	canola, maize
Sweden		9/
Switzerland	0.5	potatoes
	0.05	fruits and vegetables
UK 19/	5.0	barley
	3.0	peas

Country	MRL, mg/kg	Commodity
	1.0	potatoes, wheat, linseed, field beans
	0.5	rape seed
USA	25	aspirated grain fractions (grain dust) 20/
	6	corn stover 20/
	5	soya bean hulls 20/
	4	corn forage 20/
	2	soya beans 20/
	0.5	almond hulls 21/
	0.3	banana (0.2 in pulp) 22/
	0.2	corn grain 20/
	0.1	meat by-products such as kidneys and liver of cattle, goats, hogs, horses, poultry and sheep 21/
	0.1	tree nuts 21/
	0.05 21/	apples, cattle fat, cattle meat, eggs, goats fat, goats meat, grapes, hogs fat, hogs meat, horses fat, horses meat, poultry fat, poultry meat, sheep fat, sheep meat
	0.02	milk 21/

1/ Definition of the residue: glufosinate-ammonium, expressed as glufosinate free acid

2/ For these crops Argentina follows MRLs established in Brazil or Germany.

3/ Definition of the residue: sum of glufosinate-ammonium and 3-[hydroxy(methyl)phosphinoyl]propionic acid, calculated as glufosinate (free acid).

4/ Definition of the residue: DL-homoalanin-4-yl-(methyl)phosphinic acid: in total calculated as glufosinate

5/ Definition of the residue: DL-homoalanin-4-yl-(methyl)phosphinic acid and 3-methylphosphinicopropionic acid calculated as glufosinate free acid.

6/ Definition of the residue: glufosinate-ammonium, expressed as glufosinate free acid

7/ Definition of the residue: 4-(hydroxy-(methyl)-phosphinoyl)-DL-homoalaninate ammonium salt, including the metabolite 3-methyl-phosphinicopropionic acid.

8/ Definition of the residue: the authorities accept the MRLs established by Codex and EPA

9/ No MRLs have been established by Denmark, Finland, Greece, Ireland, Norway or Sweden. Codex MRLs or those established in other EU countries are accepted

10/ Definition of the residue: 4-(hydroxy(methyl)phosphinoyl)-D,L-homoalanine

11/ Definition of the residue: DL-homoalanin-4-yl-(methyl)phosphinic acid and 3-methylphosphinicopropionic acid calculated as glufosinate

12/ Definition of the residue: glufosinate-ammonium, expressed as glufosinate.

13/ Range of 0 - 0.05 mg/kg because the LOD is 0.05 mg/kg

14/ Definition of the residue: glufosinate-ammonium and its metabolites 2-acetamido-4-methylphosphinico-butanoic acid and 3-methylphosphinicopropionic acid, expressed as glufosinate

15/ At the limit of determination

16/ Definition of the residue: glufosinate and its ammonium salt, expressed as glufosinate;

17/ 0.01 mg/kg is based on an earlier lower limit of quantification but will be adjusted to 0.05 mg/kg in near future for harmonisation purposes

18/ Definition of the residue: Glufosinate-ammonium and its metabolites 2-acetamido-4-methylphosphinico-butanoic acid and 3-methylphosphinicopropionic acid, expressed a glufosinate free acid equivalents. MRLs are temporary until 1999 and will be re-evaluated in the light of JMPR evaluation and Codex Alimentarius standards.

19/ Definition of the residue: DL-homoalanin-4-yl-(methyl)phosphinic acid and 3-methylphosphinicopropionic acid calculated as glufosinate free acid.

20/ Definition of the residue: glufosinate-ammonium and its metabolites 2-acetamido-4-methylphosphinico-butanoic acid and 3-methylphosphinicopropionic acid. Time-limited tolerance expiring 13 July 1999.

21/ Definition of the residue: glufosinate and its metabolite 3-methylphosphinico-propionic acid. Time-limited tolerance expiring 13 July 1999.

22/ Definition of the residue: combined residues of glufosinate ammonium and 3-methylphosphinicopropionic acid expressed as glufosinate equivalents. Time-limited tolerance expiring 18 Jan 2000.

APPRAISAL

Glufosinate-ammonium was first evaluated for residues and toxicology by the 1991 JMPR and subsequently for residues in 1994. Glufosinate-tolerant crops have now been developed with new GAP and different residue patterns, requiring new MRLs.

The Meeting received information on metabolism and environmental fate, registered uses and supervised residue trials on tropical fruits, tree nuts and various genetically-modified field crops. Feeding and processing studies were also reported.

Studies on the metabolism of glufosinate-ammonium in genetically modified rape seed (canola), sugar beet, maize, soya beans and tomatoes showed that the tolerant crops rapidly converted the active glufosinate isomer (L-glufosinate) to *N*-acetyl-glufosinate (NAG). The main components of the residue in tolerant plants are the L-isomer of NAG and D-isomer of glufosinate.

The Meeting received information on animal metabolism studies on rats, lactating goats and laying hens.

When rats were dosed orally with L-[3,4-^{14}C]NAG some de-acetylation to glufosinate occurred and some glufosinate was bioavailable, but unchanged NAG was the main component (85-89%) of the TRR in the faecal extracts. Almost all of the administered ^{14}C was excreted in the faeces within 4 days.

When rats were dosed orally with [3,4-^{14}C]glufosinate-ammonium, 75-89% of the ^{14}C was excreted in the faeces and 8-11% in the urine within 48 hours. The main components in the faecal extracts were glufosinate (77% of administered ^{14}C), NAG (7.5%), 4-methylphosphinico-2-hydroxybutanoic acid or MHB (4.3%) and 3-methylphosphinicopropionic acid or MPP (1.3%). The main components in the urine were glufosinate (4.3%) and MPP (0.8%).

Very small amounts of the administered ^{14}C were found in the tissues (<0.1%) and milk (<0.02%) of a lactating goat dosed orally for 4 days with [3,4-^{14}C]glufosinate. Levels of ^{14}C reached a plateau in the milk by day 2. Levels of ^{14}C were higher in the kidneys and liver than in other tissues. Glufosinate and MPP constituted about 50% and 30% respectively of the residue in both kidneys and liver. Glufosinate accounted for 50% of the ^{14}C in the milk. When a lactating goat was dosed orally with L-[3,4-^{14}C]NAG the disposition of ^{14}C in the tissues and milk was similar to that after dosing with glufosinate. Glufosinate was the main residue in the kidneys, liver and milk with NAG and MPP forming a substantial part of the residue in the kidneys and liver.

Less than 0.02% of the administered ^{14}C was present in the edible tissues when laying hens were dosed orally for 14 days with [3,4-^{14}C]glufosinate-ammonium. MPP and glufosinate were the main residues identified in the liver and eggs respectively. After dosing orally for 14 days with L-[3,4-^{14}C]NAG less than 0.1% of the administered dose was present in the edible tissues and blood. NAG was the main residue identified in liver and egg yolks while glufosinate was the main residue in egg whites.

The Meeting received information on metabolism studies in rape seed, canola, sugar beet, maize, soya beans and tomatoes.

Genetically modified rape plants rapidly acetylated glufosinate. Cut rape plants were placed in a nutrient solution containing [3,4-^{14}C]glufosinate-ammonium for 6 days, by which time 57% of the ^{14}C in the plants was associated with NAG and 36% with glufosinate.

In glufosinate-tolerant canola plant tissues sampled 1 hour after treatment with [^{14}C]glufosinate, 73% and 18% of the ^{14}C was present as glufosinate and NAG respectively, demonstrating very rapid acetylation of glufosinate. After 21 days 60%, 21% and 7% of the ^{14}C corresponded to NAG, glufosinate and MPP respectively.

When glufosinate-tolerant sugar beet plants were sprayed with [3,4-^{14}C]glufosinate-ammonium the racemic isomer composition in the surface residue was unchanged, but in the absorbed residue L-glufosinate was metabolised to L-NAG.

Glufosinate was generally a minor component of the residue in treated tolerant maize. NAG was the main residue in the forage, silage and fodder, while MPP was the major component in grain, cobs and husks. The GLC enforcement analytical method for glufosinate, MPP and NAG was in reasonable agreement with a radiolabel method for the residues in the forage.

NAG was the main residue in the forage, straw, pods and beans of treated tolerant soya bean plants. MPP levels exceeded glufosinate levels in the pods and beans. The GLC enforcement method and an HPLC radiolabel method were in reasonable agreement in analyses of forage, straw, pods and beans at the higher residue levels, but at low levels the result from the enforcement method was less than from the ^{14}C measurement.

The translocation of [^{14}C]glufosinate-ammonium from treated leaves to shoots, other leaves and roots was approximately 4 times as fast in glufosinate-resistant tomato plants as in susceptible tomatoes. Most of the surface residue was glufosinate itself, but this was very rapidly converted to NAG once absorbed into the leaves. NAG constituted essentially all the residue in the ripe fruit harvested 60 or 74 days after the plants were treated.

The Meeting received information on the degradation and dissipation of glufosinate-ammonium in soil, residues in rotational crops and fate in water-sediment systems.

Glufosinate disappeared with a half-life of about 3-6 days during aerobic incubation with a sandy loam soil. MPP, the major product, reached its maximum after about 14 days incubation. MPA, 2-methylphosphinicoacetic acid, became the main residue after long intervals. Glufosinate suffered 62% and 31% mineralization during 120 days incubation with and without incorporation of plant material into the soil respectively.

In a dissipation study glufosinate-ammonium, applied 3 times to bare ground, dissipated quickly with calculated half-lives of 15, 7.2 and 2.7 days, the increased rates probably being related to increased soil moisture and temperature. The estimated half-lives for MPP after its residues peaked were 38, 14 and 16 days, and for MPA 25, 19 and 7 days. No residues were detected below a 45-60 cm depth section, but glufosinate and MPP reached a depth of 30-45 cm on several occasions during the study. Glufosinate and its degradation products have some mobility in soil but their rapid dissipation ensures that travel down the soil profile is limited.

When L-[3,4-^{14}C]NAG was incubated in a sandy loam soil it was very rapidly converted to L-glufosinate, which was then itself broken down and mineralized. The comparable rate of mineralization and production of unextractable residues suggests that the degradation pathway for NAG is through glufosinate. Further experiments showed that the half-life of NAG was only hours.

No important degradation products other than CO_2 were identified when [2-^{14}C]MPA was incubated in a sandy loam under aerobic conditions. Estimated decline and mineralization half-lives were 24 and 74 days respectively. Degradation in a loamy sand was much slower. When MPP was incubated under aerobic conditions in a sandy loam, MPA was the only significant product after 120 days.

After 3 days incubation of a sandy loam soil with tolerant tomato leaves containing residues, mainly of glufosinate and NAG, most of the residue had been converted to MPP, which itself was degraded more slowly to MPA and ultimately to CO_2.

Residues of degradation products of glufosinate should be undetectable or at very low levels in rotational crops. When radishes, lettuce and wheat were sown in a confined rotational crop study 28 days after glufosinate treatment of bare ground (to simulate re-sowing a failed crop) residues of MPP and MPA were present at low levels in the crops, demonstrating possible uptake of these compounds. The pattern of residues was similar in the three crops. When sowing was 119 days after treatment (to simulate a following crop) residues were not detectable in lettuce or radishes but MPP and MPA were detected by ^{14}C methods at very low levels in the wheat grain and straw.

The photolytic breakdown of glufosinate in natural waters was very slow.

MPP became the major component of the residue within a few days when [3,4-^{14}C]glufosinate-ammonium was incubated in a water-sediment system at 20°C. Glufosinate itself disappeared with a half-life of 3 days, but only 25% mineralization occurred during the 361 days of the study. In other experiments the rates of degradation were shown to be affected by the source of the water and the residue level of glufosinate (with faster disappearance at lower levels). In all cases most of the residue was in the water phase.

Methods of residue analysis

The main components of the residue in genetically modified tolerant crops are glufosinate, NAG and MPP. Analytical methods have been designed to measure the three components separately or, because glufosinate and NAG produce the same derivative in the analytical procedure, to measure glufosinate and NAG combined and MPP separately. Residues are extracted from the finely ground sample with water, and the extract is cleaned up on an anion exchange resin column. After solvent exchange, NAG and MPP are separated from glufosinate on a cation exchange column. The residues are taken up in glacial acetic acid and methylated, and glufosinate acetylated, with trimethyl orthoacetate in refluxing acetic acid. After solvent exchange and final clean-up on a silica gel cartridge the derivatized residues are determined by GLC with flame-photometric detection.

Modifications of the extraction and initial clean-up are needed for samples such as maize oil, fats and milk. A variation of the method dispenses with the cation exchange separation and determines glufosinate and NAG as a combined GLC peak because both compounds produce the same analytical derivative. The LOD for crop samples is typically 0.05 mg/kg for each analyte. Analytical recoveries have been extensively tested and found satisfactory on many substrates.

Analysts should be aware that transgenic glufosinate-tolerant soya beans plants can convert L-glufosinate to NAG very rapidly, giving apparently low analytical recoveries in spiked samples.

Glufosinate, NAG and MPP were shown to be stable during frozen storage for intervals of 12, 15 or 24 months in the following substrates: genetically modified maize and soya beans and their processed commodities, cow and chicken tissues, milk, eggs, susceptible maize grain, and transgenic rape seed and sugar beet roots. The 1994 JMPR reported that residues of glufosinate and MPP (described as Hoe 061517) in apples, oranges, kiwifruit, maize, soya beans and almonds were stable during frozen storage.

Some samples from the supervised trials were stored for 2 years, but the storage stability studies have demonstrated that the residues were still stable.

Definition of the residue

The current definition includes glufosinate and MPP and is based on the residues occurring in conventional crops. When glufosinate is used on glufosinate-tolerant crops NAG is produced. It should be included in the residue definition for enforcement because NAG is generally the main component of the residue and because the same derivative is produced in the analytical method from glufosinate itself and NAG, and in the simplified method both appear in the GLC peak from their common derivative. The revised residue definition is also suitable for commodities from conventional crops because if NAG is absent it will not contribute to the analytical result and if present at low levels it is necessarily included in the analytical result.

A suitable revised residue definition would be *Sum of glufosinate-ammonium, 3-(hydroxy(methyl)phosphinoyl)propionic acid and N-acetyl-glufosinate expressed as glufosinate (free acid),* but the Meeting could not consider the adoption of this definition until the toxicological evaluation of NAG had been completed.

The residue reported in the supervised trials consists of three components, but is often reported with the glufosinate and NAG residue combined. The metabolism studies show that residues of the main component constitute 65-75% of the combined residue when all three components are at measurable levels. It follows that if all three components are below the LOD a reasonable assumption is that the combined residue is also below or close to the LOD. When one component is above and the others are below the LOD, the combined residue is assumed to be equal to the residue of the main component.

The method of calculating the total residue for various situations is illustrated by the following example.

Glufosinate	MPP	NAG	Total
<0.05	<0.05	<0.05	<0.05
<0.05	<0.05	0.06	0.06
0.05	<0.05	0.09	0.14

Information was made available on uses of glufosinate around fruit trees and nut trees. Limited information was provided on GAP for use of glufosinate on transgenic crops.

Glufosinate-ammonium is registered for use in Australia as a directed spray for weed control around avocados, bananas, feijoa, guava, kiwifruit, litchis, mangoes, papaya, passion fruit, pineapples and rambutans at 0.20-1.0 kg ai/ha. Malaysia has similar registered uses for glufosinate-ammonium as a directed herbicide spray around bananas, carambola, durians, guava, jack fruit and mangoes at 0.3-0.5 kg ai/ha. Residues in the fruit would generally not be expected from this type of use. Glufosinate itself is not taken up by roots but MPP, the main degradation product in soil, can be absorbed by the roots and translocated through the crop.

Supervised trials

Supervised trials were reported on tropical fruits, nut trees, maize, soya beans, rape, canola and sugar beet.

Residues were not detected in avocados in 3 Australian trials where glufosinate was used at 1.0, 1.2 and 2.0 kg ai/ha. In one trial at 1.2 kg ai/ha, glufosinate was detected at 0.06 mg/kg (presumably direct contamination during application) in 1 sample on day 0, but in no other samples. Residues were not detected in the fruit from 3 Australian trials on mangoes where the application rates were 1.0, 1.2 and 2.0 kg ai/ha or 1 trial on papayas at 1.2 kg ai/ha.

Residues were not detected in the fruit from Malaysian trials on carambola and guavas (2 trials at 0.5 kg ai/ha and 2 at 1 kg ai/ha on each fruit).

The Meeting agreed to consider these fruits together as “tropical fruits with inedible peel” but noted that a CXL of 0.2 mg/kg had already been established for banana, which would have to be excluded from the group. The residues in rank order from the 16 trials were <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, <0.05, 0.06, <0.1, <0.1, <0.1 and <0.1 mg/kg.

In view of the type of use and generally unquantifiable residues at 3-5 sampling intervals in all of the trials the Meeting estimated a maximum residue level of 0.05* mg/kg and an STMR of 0.05 mg/kg for glufosinate in Assorted tropical and sub-tropical fruits – inedible peel (except banana).

The US registered use for glufosinate around almond, pecan and walnut trees permits a directed application at 1.7 kg ai/ha, with no more than 5.1 kg ai/ha total per year, and a 14-day PHI. MPP residues were 0.07 mg/kg in almonds from a US trial at the label rate and up to 0.22 mg/kg in a trial at twice the label rate. MPP is the main degradation product in soil, so its presence demonstrates the possibility of root uptake rather than contamination of foliage by spray. Residues were not detected in almonds from 3 other trials at the label rate or 3 trials at the double rate. The trials were in California in 1985.

Residues were not detected (<0.05 mg/kg) in nuts from 3 trials on pecans (USA, 1985) with glufosinate applied at 1.7 kg ai/ha and 3 at twice that rate. In 2 trials nuts were harvested 21 days after application rather than 14 days, but the use pattern is sufficiently close to GAP. Residues were not detected (<0.05 mg/kg) in nuts from 6 walnut trials at 1.7 kg ai/ha, 5 trials 3.4 kg/ha or 3 at other rates higher than GAP in the USA in 1985.

The Australian registration for glufosinate-ammonium permits 0.2-1.0 kg ai/ha as a directed spray around nut trees. Residues were not detected (<0.1, <0.05 mg/kg) in macadamia nuts in Australian trials from 1992 and 1995 at the label rate (2 trials) and double rate (2 trials).

Italian registration permits a directed application of 0.5-1.6 kg ai/ha (maximum 2.5 kg ai/ha per year) for weed control around hazelnuts. Residues were not detected (<0.05 mg/kg) in nuts from 5 hazelnut trials in Italy in 1985 according to GAP.

The Meeting considered the 4 almond, 6 pecan, 14 walnut, 4 macadamia and 5 hazelnut trials as a group. The residues in the 33 trials were <0.05 (30), 0.07 and <0.1 (2) mg/kg. The Meeting estimated a maximum residue level of 0.1 mg/kg and an STMR level of 0.05 mg/kg for glufosinate in tree nuts.

Glufosinate-ammonium is registered in Canada for use on transgenic maize at 0.30-0.50 kg ai/ha with final application at the 8-10 leaf stage. In Canadian trials in 1994-5 no residues (<0.05 mg/kg) were detected in 7 trials at 0.5 or 0.6 kg ai/ha or 3 trials at 1.0 kg/ha applied at growth stage GS 17-19 (7-9 leaves), or in 4 trials at 0.6 kg ai/ha at a later growth stage (GS 33, 3 nodes detectable).

Glufosinate-ammonium is registered in Portugal for use on transgenic maize at 0.40-0.80 kg ai/ha with the final application when the plant has no more than 8-10 leaves. In 7 Italian trials and 3 Spanish trials in 1996 according to Portuguese GAP no residues (<0.05 mg/kg) were detected in the harvested maize.

The German registration for glufosinate-ammonium on tolerant maize allows a single application of 0.9 kg ai/ha during the 3-8 leaf growth stage or 2 applications 6 weeks apart at 0.45 kg ai/ha with the final application at the 8-leaf stage. Residues were below the LOD (0.05 mg/kg) in 13 trials in Germany where the trial conditions (2 applications of 0.45-0.60 kg ai/ha, the second at GS 18 or GS 19, i.e. 8 or 9 leaves) were considered to comply with the registered use, 22 trials in France in accord with German GAP, and in 5 trials in Germany and 7 in France where glufosinate-ammonium was used at excessive rates (2 applications of 0.80 kg ai/ha).

Glufosinate-ammonium is registered for use in the USA on tolerant maize with 2 applications at 0.23-0.41 kg ai/ha, the second at a plant height of 60 cm with harvest 70 days later. Supervised trials on maize in the USA at rates of 0.40-0.50 kg ai/ha (1 or 2 applications) at the nominated growth stage were accepted as equivalent to the maximum GAP. The PHI (70 days) was considered secondary to the growth stage in deciding the timing of the applications. In many cases the grain was harvested 90-120 days after the final treatment. The residues (glufosinate + NAG + MPP expressed as glufosinate) in the 35 trials according to GAP were <0.05 (29), 0.05 (2) and 0.07 (4) mg/kg.

In summary, the residues of glufosinate + NAG + MPP expressed as glufosinate in tolerant maize were Canada <0.05 (14) mg/kg, Italy <0.05 (7) mg/kg, Spain <0.05 (3) mg/kg, Germany <0.05 (18) mg/kg, France <0.05 (29) mg/kg, the USA <0.05 (29), 0.05 (2) and 0.07 (4) mg/kg. The residues in rank order were <0.05 (100), 0.05 (2) and 0.07 (4) mg/kg.

The Meeting estimated a maximum residue level of 0.1 mg/kg for glufosinate in maize and noted that this was equivalent to the existing CXL. The major residue in the glufosinate-tolerant crop is NAG, which is not included in the current residue definition. NAG was included in the reported residues where the derivatization GLC procedure without an ion-exchange separation step was used, and was below the LOD when determined separately.

Glufosinate is registered for use on transgenic glufosinate-tolerant <u>canola</u> in Canada with 1 application at 0.60 kg ai/ha or 2 applications of 0.30-0.50 kg ai/ha, the final application at the early bolting growth stage. The label carries the instruction not to graze the treated crop or cut for hay. The Meeting was informed that the 10 leaves stage is very close to bolting. Only two supervised trials in Canada met the condition of final treatment at the 10-leaf stage, each with 1 application of 0.5 or 0.75 kg ai/ha. Residues were not detected (<0.05 mg/kg) in either of the trials, but 2 trials were insufficient to support a recommendation.

Glufosinate-ammonium is registered for use in the USA on tolerant soya beans with 2 applications at 0.23-0.41 kg ai/ha, the second application at bloom with harvest 70 days later. Supervised trials on soya beans in the USA with 2 applications of 0.40-0.50 kg ai/ha at the nominated growth stage were accepted as equivalent to the maximum GAP. The PHI (70 days) was considered as secondary to the growth stage in deciding the timing of the applications. In the trials the grain was harvested 62-102 days after the final treatment. The residues of glufosinate + NAG + MPP expressed as glufosinate in the 20 trials according to GAP in rank order (median underlined) were 0.32, 0.39, 0.43, 0.52, 0.56, 0.71, 0.72, 0.78, 0.81, <u>0.85</u>, <u>0.89</u>, 0.92, 0.96, 1.02, 1.24, 1.26, 1.33, 1.56, 1.64 and 1.88 mg/kg.

The Meeting estimated a maximum residue level of 2 mg/kg for soya beans but could not recommend it as suitable for use as an MRL until the toxicological evaluation of NAG had been completed.

Residues in almond hulls from 3 trials on almonds at the label rate and 3 at twice that rate (see above) were all <0.5 mg/kg. Unfortunately, residues in the hulls were not determined in the 2 trials where MPP was detected in the almonds. However, the Meeting estimated a maximum residue level of 0.5 mg/kg for almond hulls, which is recommended for use as an MRL.

The registered use of glufosinate-ammonium on tolerant maize in the USA (see above) specifies pre-harvest intervals of 60 and 70 days for maize forage and fodder respectively. The supervised trials on maize in the USA described above, which complied with GAP, showed residues of glufosinate + NAG + MPP expressed as glufosinate in the forage or silage harvested 60-92 days after treatment (the residue is reasonably persistent) in rank order, median underlined, of 0.09, 0.12, 0.12, 0.13, 0.17, 0.2, 0.26, 0.28, 0.3, 0.32, 0.33, 0.33, 0.36, 0.4, 0.48, 0.53, 0.53, 0.54, 0.54, 0.68, 0.74, 0.78, 0.78, 0.79, 0.9, 1.07, 1.1, 1.19, 1.2, 1.45, 1.67, 1.7, 1.71, 1.76, 2.9 and 3.48 mg/kg.

The residues of glufosinate + NAG + MPP expressed as glufosinate in maize fodder harvested 84-122 days after treatment were 0.07, 0.08, 0.11, 0.12, 0.15, 0.22, 0.25, 0.25, 0.32, 0.33, 0.43, 0.5, 0.53, 0.58, 0.65, 0.68, 0.69, 0.72, 0.8, 0.94, 0.95, 1.13, 1.19, 1.32, 1.42, 1.5, 1.69, 1.74, 1.76, 1.78, 1.96, 2.31, 2.65, 2.83 and 5.4 mg/kg.

The Meeting estimated maximum residue levels of 5 mg/kg in maize forage and 10 mg/kg in maize fodder but could not recommend them as suitable for use as MRLs until the toxicological evaluation of NAG had been completed.

Feeding studies on lactating dairy cows and laying hens were reported.

Lactating dairy cows were dosed with glufosinate-ammonium + NAG (15 + 85% to simulate the typical terminal residue) at rates equivalent to 9, 27 and 91 ppm glufosinate free acid equivalents in the diet for 28 days. Residues were not detected in the milk at the 9 ppm feeding level, but reached a plateau on day 3 at the 91 ppm level. Residues (glufosinate, NAG and MPP) in the tissues were below the LODs at the lower feeding levels; at 91 ppm they were detected in the kidneys and liver, but not in muscle or fat. MPP was the major residue in the liver.

Laying hens were dosed with glufosinate-ammonium + NAG (15 + 85) at levels equivalent to 0.36, 1.1 and 3.6 ppm glufosinate free acid equivalents in the diet for 28 days. Residues (glufosinate, NAG and MPP) were not detected in the tissues or eggs.

Studies on the fate of residues during the commercial food processing of sugar beet, maize, soya beans and canola were reported.

When tolerant sugar beet were treated with glufosinate-ammonium and processed, residues of glufosinate, NAG and MPP tended to remain in the juice and ultimately appear in the molasses. Residues were not detected (<0.05 mg/kg) in the raw sugar. The processing factors for glufosinate + NAG for raw sugar in 3 trials were nominally 0 (<0.17), 0 (<0.83) and 0 (<0.05) on the basis of the residues in the roots. The mean processing factor for molasses was 6.8, showing that glufosinate residues are concentrated in the molasses on evaporation of the water. In another study on sugar beet with fivefold application rates MPP was the main residue component and again no residues were detected in the raw sugar. The calculated processing factors were 0 (<0.08) for refined sugar and 6.4 for molasses.

In 2 processing trials (wet and dry milling) of glufosinate-tolerant maize treated with excessive rates of glufosinate-ammonium, only NAG was quantifiable in the grain from only one trial. In this trial no residues (<0.05 mg/kg) were detected in crude or refined oil from either process or in the starch and hulls from the wet milling process. The estimated processing factors were meal 1, grits 1, and hulls 2, all from dry milling.

Residues of glufosinate, NAG and MPP were not detected (<0.05 mg/kg) in refined or crude oil in a processing study with a transgenic soya bean crop treated with glufosinate-ammonium at a fivefold rate. The calculated factors for processing seed to meal and seed to crude or refined oil are 1.3 and 0 (<0.3) respectively.

Glufosinate itself was not detected in the seed or any processed fraction of a transgenic canola crop treated at a fourfold rate with glufosinate-ammonium. The main residue was NAG. The calculated processing factor for untoasted meal was 3.1 and for toasted meal 3.7. No residues (<0.05 mg/kg) were detected in the oils.

Information was made available to the Meeting on national MRLs. Governments have adopted a variety of residue definitions.

RECOMMENDATIONS

On the basis of data from supervised trials the Meeting estimated the maximum residue levels and STMRs listed below. The maximum residue levels are recommended for use as MRLs.

Definition of the residue for compliance with MRLs and for the estimation dietary intake: sum of glufosinate-ammonium and 3-[hydroxy(methyl)phosphinoyl]propionic acid calculated as glufosinate (free acid)

Commodity		Recommended MRL, mg/kg		STMR
CCN	Name	New	Previous	
FI 0030	Assorted tropical and sub-tropical fruits - inedible peel[1]	0.05*	-	0.05
FI 0341	Kiwifruit	W[2]	0.05*	
TN 0085	Tree nuts	0.1	-	0.05
AM 0660	Almond hulls	0.5	-	

[1]Except Banana
[2]Replaced by recommendation for group MRL
*At or about the limit of determination.

DIETARY RISK ASSESSMENT

Estimated STMRs for glufosinate-ammonium on tropical fruit and tree nuts have been added to the previous list of MRLs (21) for other commodities. The estimated dietary intakes of glufosinate-ammonium expressed as glufosinate for the 5 GEMS/Food regional diets were in the range of 3 to 10% of the ADI. The Meeting concluded that the intake of residues of glufosinate-ammonium resulting from its uses that have been considered by the JMPR is unlikely to present a public health concern.

REFERENCES

Allan, J.G. 1995. Glufosinate-ammonium (3,4-^{14}C)-Hoe 039866. Aerobic metabolism in German sandy loam soil SLV by direct application of glufosinate-ammonium and by incorporation of bushbean leaves containing residues of glufosinate. Hoechst Schering AgrEvo GmbH, Germany. Study CB93/027. Report A55393. Unpublished.

Allan, J.G. 1996. ^{14}C-labelled Glufosinate-ammonium (Hoe 039866) - metabolism in genetically modified sugar beets (*Beta vulgaris ssp vulgaris var altissima*) after two applications of ^{14}C-glufosinate-ammonium at a rate of 600 g a.i./ha each. Hoechst Schering AgrEvo GmbH, Germany. Study CM95/035. ReportA58109. Unpublished.

Ampofo, S. 1995. Metabolism of [^{14}C]-glufosinate in laying hens: in-life and total [^{14}C] residue determination. Study U012A/A525R. Project HWI 6187-155. Hazleton Wisconsin, USA. AgrEvo 509BK. Part of A54159. Unpublished.

Anderson, C. 1997. Residues of glufosinate-ammonium in transgenic Canola. AUSA17 Struan Research Centre, SA, Australia. Report A59283. Unpublished.

Asshauer, J. 1986a. Report on Plant Protection Residue Trial. Juglans regia. Hoechst Analytical Laboratory, Germany. USA84H03606. A34230. Unpublished.

Asshauer, J. 1986b. Report on Plant Protection Residue Trial. Juglans regia. Hoechst Analytical Laboratory, Germany. USA84H03607. A34231. Unpublished.

Asshauer, J. 1986c. Report on Plant Protection Residue Trial. Juglans regia. Hoechst Analytical Laboratory, Germany. USA84H03609. A34232. Unpublished.

Asshauer, J. 1986d. Report on Plant Protection Residue Trial. Juglans regia. Hoechst Analytical Laboratory, Germany. USA84H03610. A34233. Unpublished.

Asshauer, J. and Krebs, B. 1987a Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H00719. A35706. Unpublished.

Asshauer, J. and Krebs, B. 1987b. Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H07719. A35707. Unpublished.

Asshauer, J. and Krebs, B. 1987c. Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H00724. A35708. Unpublished.

Asshauer, J. and Krebs, B. 1987d. Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H07724. A35709. Unpublished.

Asshauer, J. and Krebs, B. 1987e. Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H00738. A35710. Unpublished.

Asshauer, J. and Krebs, B. 1987f. Report on Plant Protection Residue Trial. Hoe 039866, Juglans regia. Handelslab.Koerl/Specht, Germany. USA85H07738. A35711. Unpublished.

Belcher, T.I. 1995a. Frozen storage stability (amendment 2). Magnitude of the residue in transgenetic field corn RAC and corresponding processed commodities following application of Ignite herbicide. Project 93-0006. Study ER-93-USA-01. AgrEvo, USA. Project 93230. Analyt. Bio-Chem. Laboratories, Pan-Ag Division, USA. Project XEN94-13. Xenos Laboratories Inc., Canada. Report A55306. Unpublished.

Belcher, T.I. 1995b. Frozen storage stability amendment 2 to laboratory study phase report. Magnitude of the residue in transgenetic soya bean processed commodities following application of Ignite herbicide. Project 93-0007. Study ER-93-USA-02. AgrEvo, USA. Study 93231. Analytical Bio-Chem.Laboratories, Pan-Ag Division, USA. Project XEN94-14. Xenos Laboratories Inc., Canada. Report A55305. Unpublished.

Belcher, T.I. 1996a. Soil dissipation of glufosinate applied to soil in grapes in the San Joaquin Valley of California. Minnesota Valley Testing Labs, Inc., USA. AgrEvo USA Company, AgrEvo Pikeville. ABC.Laboratories, USA. MVTL project 11-9402. AgrEvo Project 93-0031. ABC study 93331. Report A55823. Unpublished.

Belcher, T.I. 1996b. Frozen storage stability amendment to laboratory study phase report. Magnitude of the residue of Ignite herbicide in transgenetic field corn following application of Ignite herbicide (2nd Amendment). Project 93-0006. Study ER-93-USA-01. AgrEvo, USA. Study 93224. Analytical Bio-Chem. Laboratories, Pan-Ag Division, USA. Project XEN93-32. Xenos Laboratories Inc., Canada. Report A55807. Unpublished.

Bertrand, N. 1993. Determination of the magnitude of Hoe 039866 residues and those of its metabolites Hoe 085355 and Hoe 061517 in transgenic canola samples. Xenos Lab.Inc., Canada. Project XEN93-09. Report A53770. Unpublished.

Bertrand, N. 1994. Method validation - determination of residue levels of glufosinate-ammonium and metabolites in various field corn and soya bean matrices. Final report. Xenos Lab.Inc., Canada. Project 93-0027. XEN93-19A. Report A53623. Unpublished.

Bertrand, N. 1996. Residue of glufosinate-ammonium in or on transgenic corn following applications of Liberty® herbicide. AgrEvo Canada Inc. Xenos Laboratories Inc. 93-IGN-01. XEN94-32. A55207. Unpublished.

Biffin, D. 1995a. Determination of the residue potential in avocado after treatment of the orchard floor for weed control with Basta. Hoechst Schering AgrEvo Pty. Ltd., Australia. AUQD24/94. YH94AA. A59025. Unpublished.

Biffin, D. 1995b. Determination of the residue potential in fruit after treatment of the orchard floor for weed control with Basta. Hoechst Schering AgrEvo Pty. Ltd., Australia. AUQD12/94. YH94AA. A59029. Unpublished.

Biffin, D. 1995c. Determination of the residue potential in macadamia after treatment of the orchard floor for weed control with Basta. Hoechst Schering AgrEvo Pty. Ltd., Australia. AUQD20/94. YH94AA. A59032. Unpublished.

Biffin, D. 1995d. Determination of the residue potential in mango after treatment of the orchard floor for weed control with Basta. Hoechst Schering AgrEvo Pty. Ltd., Australia. AUQD13/94. YH94AA. A59028. Unpublished.

Biffin, D. 1996a. Determination of the residue potential in avocado after treatment of the orchard floor for weed control with Basta. Hoechst Schering AgrEvo Pty. Ltd., Australia. AUQD26/96. YH94AA. A59026. Unpublished.

Biffin, D. 1996b. Determination of the residue potential in pawpaw after treatment of the orchard floor for weed control with Basta. AUQD25 J&B Corby, Glenwood, Australia. A59285. Unpublished.

Brady, S.S. 1995a. Magnitude of the residue of glufosinate-ammonium in or on transgenic field corn following two applications of Ignite® herbicide. ABC Laboratories, Pan-Ag Division, USA. Project BK-94R-01. Report A54160. UnpublishedBrady, S.S. 1995b. Magnitude of the residue of glufosinate-ammonium in or on transgenic field corn processed commodities following two applications of Ignite® herbicide. Xenos Laboratories Inc., Canada. Stewart Agricultural Research Services, Inc. USA. Texas A & M University, USA. Project BK-94R-03. Report A54284. Unpublished.

Brady, S.S. 1995c. Magnitude of glufosinate-ammonium residues in or on soya bean hay and seed resulting from application of Ignite® once at third node or twice at three growth stage combinations, USA, 1994. AgrEvo, USA. Project BK-94R-06. Report A54108. Unpublished.

Brady, S.S. 1995d. Magnitude of the residue of glufosinate-ammonium in or on transgenic soya beans following two applications of Ignite® herbicide. AgrEvo, USA. Project BK-94R-02. Report A54156. Unpublished.

Brady, S.S. 1995e. Magnitude of the residue of glufosinate-ammonium in or on transgenic soya bean processed commodities following two applications of Ignite® herbicide. AgrEvo, USA. Project BK-94R-04. Report A54283. Unpublished.

Brady, S.S. 1996. Magnitude of glufosinate-ammonium residues in or on transgenic soya beans resulting from application of Liberty™ herbicide once at third node and once at bloom, USA, 1995. AgrEvo, USA. Project U012B/R143. Study BK-95R-04. Report A55780. Unpublished.

Brady, S.S. 1997a. Magnitude of glufosinate-ammonium residues in or on transgenic field corn resulting from two applications of LIBERTY(™) herbicide, USA, 1995. Project BK95R01 AgrEvo, USA. Report A57728. Unpublished.

Brady, S.S. 1997b. Magnitude of glufosinate-ammonium residues in or on transgenic sugar beets resulting from multiple applications of Liberty™ herbicide at three rates, USA, 1995. AgrEvo, USA. Project R141/U012. Report BK-95R-06. Report A55839. Unpublished.

Brady, S.S., Belcher, T.I. and Bertrand, N. 1994. Magnitude of the residue in transgenetic field corn rac and corresponding processed commodities following application of Ignite herbicide. Study 93230. Pan-Agricultural Labs., USA. Project HRAV93-0006. Trial ER-93-USA-01. Report A53690. Unpublished.

Brady, S.S. and Bertrand, N. 1997. Magnitude of glufosinate-ammonium residues in or on transgenic sugar beet roots and processed commodities resulting from multiple applications of Liberty® herbicide USA, 1996. AgrEvo, USA. Study BK-96R-05. Report A57723. Unpublished.

Bremmer, J.N. and Leist, K.-H. 1997. Disodium-N-acetyl-L-glufosinate; AE F099730 - Hazard evaluation of L-glufosinate produced intestinally from N-acetyl-L-glufosinate. Hoechst Schering AgrEvo GmbH, Safety Evaluation Frankfurt. TOX97/014. A58659. Unpublished.

Bremmer, J.N. and Leist, K.-H. 1998. Disodium-N-acetyl-L-glufosinate (AE F099730, substance technical) – Toxicity and metabolism studies summary and evaluation. Hoechst Schering AgrEvo, Frankfurt. TOX98/027. A67420. Unpublished.

Burnett, T.J. 1994. ^{14}C-Glufosinate ammonium: nature of the residue in field corn. Study 93260. Pan-Agric.Lab., USA. Project 93-0025. Report A53536. Unpublished.

Campbell, J.K. and Bennett, R.M. 1997. Glufosinate-ammonium residues in winter wheat grown in glufosinate-ammonium treated soil. AgrEvo USA. Project BK95R009. Report A57840 (brief 40 page report.) Unpublished.

Castro, L.E. and Dacus, S.C. 1994. Independent laboratory confirmation of the analytical method AE-24 (Draft)-Revision 4A for glufosinate-ammonium residues in or on crops, USA, 1994. AgrEvo USA Co.Pikeville, USA. EPA MRID 43524601. Study BK-94R-05. Report A53696. Unpublished.

Clarke, M. 1997. Evaluation of glufosinate-ammonium residues in glufosinate tolerant Brassica napus. AUWA09 Badgingarra Research Station, Western Australia. Report A59282. Unpublished.

Cross, S. 1997. Determination of Liberty (glufosinate-ammonium) residues in Liberty tolerant canola. Trial AU VN 12 VIDA Plant Breeding Centre, Horsham, Australia. Report A59284. Unpublished.

Crotts, D.G and McKinney, F.R. 1995. Magnitude of glufosinate-ammonium residues in the tissues and eggs of chickens dosed with glufosinate-ammonium and Hoe 099730 at 1, 3 and 10 times the estimated maximum daily intake, for 28 consecutive days, USA, 1994. Analytical Laboratories, USA. AgrEvo, USA. Project 94-0053 EN-CAS. Study BK-94R-08. Report A54485. Unpublished.

Crotts, D.G. and McKinney, F.R. 1996. Magnitude of glufosinate-ammonium residues in the tissues and milk of dairy cows dosed with glufosinate-ammonium and Hoe 099730 at 1, 3 and 10 times the estimated maximum daily intake, for 28 consecutive days, USA, 1994. Analytical Laboratories USA. AgrEvo, USA. Project 94-0052 EN-CAS. Study BK-94R-09. Report A55843. Unpublished.

Czarnecki, J.J. 1995a. Gas chromatographic determination of HOE-039866 (ammonium-DL-homoalanin-4-yl-(methyl)-phosphinate) and its metabolite HOE-061517 (3-methylphosphinico-propionic acid) as residues in livestock and poultry tissues, milk, and eggs. AgrEvo USA Co., USA. Analytical method BK/01/95. Report A54161. Unpublished.

Czarnecki, J.J. 1995b. Gas chromatographic determination of Hoe-039866 (ammonium-DL-homoalanin-4yl(methyl)-phosphinate) and its metabolites, Hoe-061517 (3-methylphospinico-propionic acid) and Hoe-099730 (disodium L-2-acetamido-4-methylphosphinico- butyrate), as residues in livestock and poultry tissues. AgrEvo USA. Amalytical method BK/03/95. Report A53974. Unpublished.

Czarnecki, J.J. 1995c. Gas chromatographic determination of Hoe 039866 (glufosinate-ammonium) and its metabolites as residues in glufosinate-resistant corn and soya bean RAC and processed commodities. AgrEvo USA. Analytical method BK/05/95. Report A56922. Unpublished.

Czarnecki, J.J. 1995d. Magnitude of the residue of glufosinate-ammonium in or on transgenetic field corn following two applications of Ignite® Herbicide. Study 94354, ABC/Pan-Ag, USA. Study BK-94R-01, AgrEvo, USA. Report A54160. Unpublished.

Czarnecki, J.J. 1996. Magnitude of the residue of glufosinate-ammonium in or on transgenic field corn processed commodities following two applications of Ignite® herbicide. Xenos Laboratories Inc, Canada. Texas A & M University USA, Food Protein Research and Development Center, USA. AgrEvo USA Company. BK-94R-03. A55793. Unpublished.

Czarnecki, J.J. and Bertrand, N. 1993. Gas chromatographic determination of HOE-039866 (glufosinate-ammonium) and its metabolites as residues in corn grain and corn processed fractions. Analytical method HRAV-5A (draft). Hoechst Roussel, USA. Xenos Lab.Inc., Canada. Report A52270. Unpublished.

Czarnecki, J.J. and Bertrand, N. 1994. Gas chromatographic determination of Hoe-039866 (Glufosinate-ammonium) and its metabolites as residues in tolerant corn and soya bean RAC and processed commodities. AgrEvo USA, USA. Xenos Lab.Inc., Canada. Analytical method AE-24. Report A54051. Unpublished.

Czarnecki, J.J. and Brady, S.S. 1995a. Magnitude of glufosinate-ammonium residues in the tissues and eggs of chickens dosed with glufosinate-ammonium and Hoe 099730 at 1,3 and 10 times the estimated maximum daily intake, for 28 consecutive days, USA, 1994. Bio-Life Associates, USA. Project BK-94R-08 EN-CAS. Report A54485. Unpublished.

Czarnecki, J.J. and Brady, S.S. 1995b. Magnitude of glufosinate-ammonium residues in the tissues and milk of dairy cows dosed with glufosinate-ammonium and Hoe 099730 at 1, 3, and 10 times the estimated maximum daily intake, for 28 consecutive days, USA, 1994. Bio-Life Associates, Ltd., USA. Study BK-94R-09. Report A54503. Unpublished.

Czarnecki, J.J., Belcher, T.I., Norby, N.A. and Bertrand, N. 1994. Magnitude of the residue of Ignite herbicide in transgenetic field corn following application of Ignite herbicide. Pan-Agric.Lab., USA. Study 93224. Project HRAV93-0006. ER-93-USA-01. Report A53691. Unpublished.

Czarnecki, J.J., Rickard, D.A. and Bertrand N. 1994a. Magnitude of the residue in transgenetic soya bean processed commodities following application of Ignite Herbicide. Pan-Agric.Lab., USA. Study 93231. Project HRAV93-0007. Study ER-93-USA-02. Report A53606. Unpublished.

Czarnecki, J.J., Rickard, D.A. and Bertrand, N. 1994b. Magnitude of the residue in transgenetic soya beans following application of Ignite herbicide. Pan-Agric.Lab., USA. Study 93225. Project HRAV93-0007. Study ER-93-USA-02. Report A53624. Unpublished.

Czarnecki, J.J., Sochor, H., Kwiatkoski, D. and Barry, E. 1989. Gas chromatographic determination of Hoe-039866 (ammonium- -DL-homoalanin-4-yl(methyl)-phosphinate) and its metabolite Hoe-061517 (3-methylphosphinico-propionic acid) as residues in apples, grapes, soya beans, corn, and tree nuts. Hoechst Roussel, USA. Analytical method HRAV-5A. Report AL9/89-0. A40790. Unpublished.

Dorn, E. and Krebs, B. 1987a. Report on Plant Protection Residue Trial, HOE 039866, Corylus avellana. Hoechst Analytical Laboratory, Germany. ITA85H00601. A35935. Unpublished.

Dorn, E. and Krebs, B. 1987b. Report on Plant Protection Residue Trial, HOE 039866, Corylus avellana. Hoechst Analytical Laboratory, Germany. ITA85H00602. A35936. Unpublished.

Dorn, E. and Krebs, B. 1987c. Report on Plant Protection Residue Trial, HOE 039866, Corylus avellana. Hoechst Analytical Laboratory, Germany. ITA85H00603. A35937. Unpublished.

Dorn, E. and Krebs, B. 1987d. Report on Plant Protection Residue Trial, HOE 039866, Corylus avellana. Hoechst Analytical Laboratory, Germany. ITA85H00604. A35938. Unpublished.

Dorn, E. and Krebs, B. 1987e. Report on Plant Protection Residue Trial, HOE 039866, Corylus avellana. Hoechst Analytical Laboratory, Germany. ITA85H00605. A35939. Unpublished.

Dunmall, T. 1991a. Basta residue trial in avocados. Hoechst Australia Ltd. AUQD27/90. QD27/90. A59027. Unpublished.

Dunmall, T. 1991b. Basta residue trial in mangoes. Hoechst Australia Ltd. AUQD21/90. QD21/90. A59030. Unpublished.

Dunmall, T. 1992. Basta residue trial in macadamias. Hoechst Australia Ltd. AUQD1/92. QD1/92. A59031. Unpublished.

Eichelmann. 1987. Analytical report. Analysis of HOE-061517 and HOE-039866 in almonds. Study 07-CA-85-028. Hoechst Analytical Laboratory, Germany. Unpublished.

Englar, W.J. 1997. Processing commodity phase report. Magnitude of glufosinate-ammonium residues in or on transgenic sugar beet roots and processed commodities resulting from multiple applications of Liberty® herbicide USA, 1996. Wm. J. Englar & Associates. Inc., USA. Study BK-96R-05. Report A57723. Unpublished.

sugar beets. Hoechst Schering AgrEvo Germany. Study ER95ECN555. Report A56446. Unpublished.

Greenhalgh, R. and Bertrand, N. 1997. Magnitude of glufosinate-ammonium residues in or on transgenic sugar beet raw agricultural commodities resulting from multiple applications of Liberty™ herbicide at two rates, USA, 1996. AgrEvo, USA. Xenos Laboratories Inc., Canada. Project R142/U012C. Report BK-96R-01. Report A57730. Unpublished.

Hees, M. and Holzwarth, U. 1996. Glufosinate-ammonium; SL (liquid water soluble concentrate) 200, 150 and 120 g/l; codes: Hoe 039866 00 SL18 A523, Hoe 039866 00 SL14 A116 and Hoe 039866 00 SL11 A502 - Determination of residues of Hoe 039866 and its metabolites to establish a maximum residue level following 2 applications in tolerant Maize (Southern Europe). Hoechst Schering AgrEvo, Germany. Study ER95ECS550. Report A54760. Unpublished.

Hees, M. and Werner, H.-J. 1997a. Glufosinate-ammonium; SL (water soluble concentrate) 200 and 120 g/l; code: AE F039866 00 SL18 A524 and AE F039866 00 SL11 A502 - Determination of residues to establish an maximum residue level (MRL) and to determine the decline of glufosinate and its relevant metabolites following 2 applications in tolerant maize. European Union (Southern Zone) 1996. Hoechst Schering AgrEvo, Germany. Study ER96ECS550. Report A58190. Unpublished.

Hees, M. and Werner, H.-J. 1997b. Glufosinate-ammonium; SL (water soluble concentrate) 200 g/l; code: AE F039866 00 SL18 A524 - Determination of residues to establish an maximum residue level (MRL) and to determine the decline of glufosinate and its relevant metabolites following 2 applications in tolerant maize. Northern Europe, 1996. Hoechst Schering AgrEvo, Germany. Study ER96ECN550. Report A58191. Unpublished.

Hees, M. and Werner, H.-J. 1997c. Glufosinate-ammonium; SL (water soluble concentrate) 200 and 150 g/l, code: AE F039866 00 SL18 A524 and AE F039866 00 SL14 A116 - Determination of residues to establish a maximum residue level (MRL) and to determine the decline of glufosinate and its relevant metabolites following 2 applications in oil seed rape, European Union (Northern zone) 1995/96. Hoechst Schering AgrEvo, Germany. Study ER96ECN553. Report A57955. Unpublished.

Hees, M., and Werner, H.-J. 1997d. Glufosinate-ammonium; SL (water soluble concentrate) 200 g/l code: AE F039866 00 SL18 A524 - Determination of residues to establish an maximum residue level (MRL) and to determine the decline of glufosinate and its relevant metabolites following 2 applications in tolerant sugar beet. Northern Europe, 1996. Hoechst Schering AgrEvo Germany. Study. ER96ECN551. A57574. Unpublished.

Hees, M., Holzwarth, U. and Werner, H.-J. 1996a. Glufosinate-ammonium; water soluble concentrate 200 g/l; code: Hoe 039866 00 SL18 A523. Determination of residues of Hoe 039866 and its relevant metabolites to establish a maximum residue level following two applications of Hoe 039866 00 SL18 A523 in tolerant

Hees, M., Holzwarth, U. and Werner, H.-J. 1996b. Glufosinate-ammonium; SL (liquid water soluble concentrate) 200 and 150 g/l; codes: Hoe 039866 00 SL18 A523 and Hoe 039866 00 SL14 A116 - Determination of residues of Hoe 039866 and its metabolites to establish a maximum residue level following 2 applications in tolerant maize (Europe North). Hoechst Schering AgrEvo, Germany. Study ER95ECN550. Report A56445. Unpublished.

Hees, M., Holzwarth, U. and Werner, H.-J. 1996c. Glufosinate-ammonium; SL (liquid water soluble concentrate) 200 g/l; code: Hoe 039866 00 SL18 A524. Determination of residues of Hoe 039866 and its relevant metabolites to establish a maximum residue level following two applications of Hoe 039866 00 SL18 A524 in tolerant oilseed rape (Northern Europe). Hoechst Schering, Germany. Study ER94ECN553. Report A56444. Unpublished.

Helsten, B.R. 1995. Magnitude of glufosinate technical and HOE-099730 residues in the tissues and eggs of chickens dosed with glufosinate technical and HOE-099730 at 1,3, and 10 times the estimated maximum daily intake for 28 consecutive days, USA, 1994, in-life phase. Project BLAL # 149-002-09. Bio-Life® Associates, Ltd, USA. AgrEvo project BK-94R-08. EN-CAS 94-0053. Report A54485. Unpublished.

Holzwarth, U. 1995. Glufosinate-ammonium. Code: Hoe 039866. Summary and evaluation of the analytical methodology for determination of glufosinate-ammonium and relevant metabolites in various tolerant crop matrices, in food of animal origin and in air. AgrEvo, Germany. Report OE95/036. ReportA54249. Unpublished.

Holzwarth, U. 1996a. Glufosinate-ammonium, disodium L-2-acetamido-4-methylphosphinato- butyrate and 3-methyl-phosphinicopropionic acid Code: Hoe 039866, Hoe 099730 and Hoe 061517. Validation of the analytical method AE-24 in maize shoot. Hoechst Schering AgrEvo Germany. Project CR94/016. Report A56405. Unpublished.

Holzwarth, U. 1996b. Glufosinate-ammonium, disodium L-2-acetamido-4-methylphosphinato-butyrate and 3-methyl-phosphinicopropionic acid Code: Hoe 039866, Hoe 099730 and Hoe 061517. Validation of the analytical method AE-24 in maize grain. Hoechst Schering AgrEvo Germany. Project CR94/006. Report A56406. Unpublished.

Holzwarth, U. 1996c. Glufosinate-ammonium; soluble concentrate 200 g/l; code: Hoe 039866 00 SL18 - Residues of glufosinate-ammonium in tolerant maize, Netherlands. Hoechst Schering AgrEvo, Germany. Field trials 6HMA52-509, 6HMA52-510, 6HMA52-264. Study CR96/003. Report A56615. Unpublished.

Holzwarth, U. 1997a. Glufosinate-ammonium, AE F039866. Summary and evaluation of the residue behaviour of AE F039866 after treatment of tolerant sugar beets. Hoechst Schering AgrEvo GmbH, Residues and User Safety Frankfurt. OE97/066. A59802. Unpublished.

Holzwarth, U. 1997b. Glufosinate-ammonium, AE F039866. Summary and evaluation of the residue behaviour of AE F039866 after treatment of tolerant soya bean. Hoechst Schering AgrEvo GmbH, Residues and User Safety Frankfurt. OE97/087. A59803. Unpublished.

Holzwarth, U. 1997c. Glufosinate-ammonium, AE F039866. Summary and evaluation of the residue behaviour in mango, avocado, carambola and guava. Hoechst Schering AgrEvo GmbH, Residues and Consumer Safety, Frankfurt. OE97/062. A59805. Unpublished.

Horton, W.E. and Kuhner, M.E. 1988. Determination of glufosinate-ammonium (HOE-039866) and its metabolite (HOE-061517) residues in pecan, walnut, and almond nutmeat samples and almond hull samples. Dr. Specht and Partner Chem Lab. Gmbh. Hoechst AG, Germany. A48446. Includes 16-GA-85-011, 16-LA-85-002, 07-NM-85-032, 07-CA-85-019, 07-CA-85-024, 07-CA-85-038, 07-CA-85-018, 07-CA-85-028, 07-CA-85-037. Unpublished.

Huang, M.N. and Smith, S.M. 1995a. Metabolism of [^{14}C]-glufosinate in a lactating goat. AgrEvo USA Co.Pikeville, Hazleton Lab., USA, U012A/A524R. A54158. Unpublished.

Huang, M.N. and Smith, S.M. 1995b. Metabolism of [^{14}C]-N-acetyl glufosinate in a lactating goat. AgrEvo USA Co.Pikeville, PTRL East Inc., USA. Project 502BK. Study U012A/A524. Report A54155. Unpublished.

Huang, M.N. and Smith, S.M. 1995c. Metabolism of (^{14}C)-Glufosinate in laying hens. AgrEvo USA Co.Pikeville, USA, Hazleton Lab., USA. Project 509BK. Study U012A/A525R. Report A54159. Unpublished.

Huang, M.N. and Smith, S.M. 1995d. Metabolism of (^{14}C)-N-acetyl glufosinate in laying hens. AgrEvo USA Co.Pikeville, USA. PTRL East Inc., USA. Project 503BK. Study U012A/A525. Report A54157. Unpublished.

Hulme, R. and Rouch, M. 1997. The residues of glufosinate ammonium in canola. Trial AU NW 06 Agricultural Research Institute, NSW, Australia. Report A59311. Unpublished.

Idstein, H. and Klapper, S. 1987. Hoe 039866. Storage stability study in biological materials. (B)123/87. Study CR037/86. Hoechst Germany. Report A36196. Unpublished.

Idstein, H. and Klapper, S. 1988. Hoe 039866. Supplement to storage stability study in biological materials, (B)123/87, extending results in storage periods 18 and 24 months. (B)123/87 Hoechst Germany. Study CR037/86. Report A39283. Unpublished.

Idstein, H., Pleines, J. and Junker, H. 1987a. Hoe 039866 and Hoe 061517 in milk residue determination by gas chromatography after dialysis. Report AL2/87 Hoechst Analytical Laboratory, Germany. A35957. Unpublished.

Idstein, H., Pleines, J. and Junker, H. 1987b. Hoe 039866 and Hoe 061517 in soya beans. Residue determination by gas chromatography after extraction with water. Report AL9/87 Hoechst Analytical Laboratory, Germany. A35794. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995a. Glufosinate-ammonium SL 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 and metabolites to establish a maximum residue level following two applications in tolerant maize. Hoechst Schering AgrEvo, Germany. Study ER93ECN550. Report A54225. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995b. Glufosinate-ammonium. SL (liquid water soluble concentrate) 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 00 SL14 A113 for establishing a maximum residue level following 2 applications in tolerant maize. Hoechst Schering AgrEvo, Germany. Study ER93ECS550. Report A54226. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995c. Glufosinate-ammonium Liquid water soluble concentrate 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 and its relevant metabolites to establish a maximum residue level following two applications of Hoe 039866 00 SL14 A113 in tolerant maize. Hoechst Schering AgrEvo, Germany. Study ER94ECN550. Report A54229. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995d. Glufosinate-ammonium SL14 liquid water soluble concentrate 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 and Hoe 099730 to establish a maximum residue level following two applications of Hoe 039866 00 SL14 A113 in tolerant maize. Hoechst Schering AgrEvo, Germany. Study ER94ECS550. Report A54230. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995e. Glufosinate-ammonium Liquid water soluble concentrate 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 00 SL14 A113 and its relevant metabolites to establish a maximum residue level following 1 application of Hoe 039866 00 SL14 A113 in tolerant rape (Final report). Hoechst Schering AgrEvo, Germany. Study ER93ECN552. Report A54227. Unpublished.

Kalter, G.J. and Holzwarth, U. 1995f. Glufosinate-ammonium Liquid water soluble concentrate 150 g/l. Code: Hoe 039866 00 SL14 A113. Determination of residues of Hoe 039866 00 SL14 A113 and its relevant metabolites to establish a maximum residue level following 2 applications of Hoe 039866 00 SL14 A113 in tolerant rape. Study ER93ECN553. Report A54228. Hoechst Schering AgrEvo GmbH, Germany. Unpublished.

Kellner, H.-M., Stumpf, K. and Braun, R. 1993. Hoe 099730-^{14}C Pharmacokinetics in rats following single oral and intravenous administration of 3 mg/kg body. Hoechst RCL, Germany, 01-L42-0670-93. A49978. Unpublished.

Köcher, H. and Becker, H. 1991. Uptake and translocation of radioactive material after foliar application of ^{14}C-labelled Hoe 039866 to glufosinate-resistant and wild type tomatoes. Hoechst AG, Germany. Kö/ru5/1991. A56812. Unpublished.

Krautter, G.R. 1995a. Metabolism of [^{14}C]-N-acetyl glufosinate in a lactating goat: in-life and total [^{14}C] residue determination. Study U012A/A524. PTRL report 1613. AgrEvo Research Center, USA. Part of A54155. Unpublished.

Krautter, G.R. 1995b. Metabolism of [^{14}C]-N-acetyl glufosinate in a laying hens: in-life and total [^{14}C] residue determination. Study U012A/A525. PTRL report 1637. AgrEvo Research Center, USA. Part of A54157. Unpublished.

Lauck-Birkel, S. 1995a. Hoe 099730-^{14}C Metabolism in male and female rats following a single oral administration of test substance at a dose level of 1000 mg/kg body weight. AgrEvo Germany. CM93/070. A54333. Unpublished.

Lauck-Birkel, S. 1995b. Hoe 039866-^{14}C, glufosinate-ammonium Metabolism in male and female rats following single oral administration of test substance at a dose level of 500 mg/kg body weight. AgrEvo Germany. CM93/071. A54334. Unpublished.

Lauck-Birkel, S. 1996. Hoe 039866-^{14}C (glufosinate-ammonium) Metabolism in male rats following single oral administration of test substance at a dose level of 2 mg/kg body weight. Hoechst Schering AgrEvo Germany. CM95/013. A54336. Unpublished.

MacDonald, R. 1996a. Determination of Hoe 039866 residue and its metabolites Hoe 085355 and Hoe 061517 in processed fractions of transgenic canola seed treated with glufosinate-ammonium. ID number 93PT-01 Xenos Laboratories Inc. AgrEvo Canada Inc. AgrEvo USA. Report A56386. Unpublished.

MacDonald, R. 1996b. Determination of Hoe 039866 residue and its metabolites Hoe 085355 and Hoe 061517 in glufosinate tolerant canola (Brassica Napus) generated from 1994 field trials. AgrEvo Canada Inc. ID number 94HCN-01. Xenos Laboratories Inc. AgrEvo USA. Report A56392. Unpublished.

MacDonald, R. 1996c. Determination of Hoe 039866 residue and its metabolites Hoe 061517 and Hoe 085355 in glufosinate tolerant canola (Brassica Napus) generated from 1993 field trials. AgrEvo Canada Inc. ID number 93-TRANS-C. Xenos Laboratories Inc. AgrEvo USA. Report A56394. Unpublished.

MacDonald, R. 1996d. Determination of Hoe 039866 residue and its metabolites Hoe 099730 and Hoe 061517 in harvested glufosinate tolerant canola seed following treatment with Harvest herbicide. AgrEvo Canada Inc. Ref ACI96-35 Xenos Laboratories Inc., Canada. Study 94PGS-01. Report A57514. Unpublished.

Mai, C.L. 1996a. Determination of residues of glufosinate-ammonium and metabolite in macadamias. Analchem report 95/3715. AgrEvo trial QD20-94. Analchem Bioassay, Australia. Unpublished.

Mai, C.L. 1996b. Determination of residues of glufosinate-ammonium and metabolite in avocadoes. Analchem report 96/2449. AgrEvo trial QD24-95. Analchem Bioassay, Australia. A59025. Unpublished.

Mai, C.L. 1996c. Determination of residues of glufosinate-ammonium and metabolite in avocadoes. Analchem report 96/3456. AgrEvo trial QD26-94. Analchem Bioassay, Australia. A59026. Unpublished.

Mai, C.L. 1996d. Determination of residues of glufosinate-ammonium and metabolite in pawpaws. Analchem report 96/4588. AgrEvo trial QD25-94. Analchem Bioassay, Australia. A59285. Unpublished.

Mai, C.L. 1996e. Determination of residues of glufosinate-ammonium and metabolite in mangoes. Analchem report 95/0752. AgrEvo trial QD13-94. Analchem Bioassay, Australia. A59028. Unpublished.

Mai, C.L. 1996f. Determination of residues of glufosinate-ammonium and metabolite in mangoes. Analchem report 95/3714. AgrEvo trial QD12-94. Analchem Bioassay, Australia. A59029. Unpublished.

McKinney, F.R. and Crotts, D.G. 1997. Magnitude of glufosinate-ammonium residues in the tissues and eggs of chickens dosed with glufosinate-ammonium and Hoe 099730 at 1, 3 and 10 times the estimated maximum daily intake, for 28 consecutive days, USA, 1994 (1st amendment). Analytical Laboratories, USA. AgrEvo, USA. Project 94-0053 EN-CAS. Study BK-94R-08. Report A57701. Unpublished.

Meyer, B.N., Tull, P.J. and Rupprecht, J.K. 1995. Uptake of ^{14}C-glufosinate-ammonium residues in soil by rotational crops under confined conditions. AgrEvo USA. Project 506BK. Study A600/U012B. Report A54272. Unpublished.

Niedzwiadek, B. and Bertrand, N. 1995a Analytical phase report. Residue of Hoe 039866 (glufosinate-ammonium) and its metabolites, Hoe 099730 and Hoe 061517 in tolerant rape. Project XEN95-07A. Xenos Laboratories, Inc., Canada. Study ER93ECN552. Report A54227. Unpublished.

Niedzwiadek, B. and Bertrand, N. 1995b. Method validation - determination of residues of Hoe 039866 (glufosinate-ammonium) and its metabolites, Hoe 099730 and Hoe 061517 in tolerant rape with method AE-24A. Xenos Laboratories Inc, Canada. Project XEN95-07. Report A55259. Unpublished.

Niedzwiadek, B. and Bertrand, N. 1996. Residues of HOE 039866 (glufosinate-ammonium) and its metabolites HOE 099730 and HOE 061517 in tolerant maize. Project XEN95-14A. Study ER95ECS550. Hoechst-AgrEvo, Germany. Xenos Laboratories, Canada. Report A54760. Unpublished.

Rickard, D.A. 1994. Magnitude of the residue in transgenetic soya beans following application of Ignite herbicide. Trials ER-93-USA-02-IA-01, ER-93-USA-02-IL-01, ER-93-USA-02-MO-01, ER-93-USA-02-IN-01, ER-93-USA-02-IN-02, ER-93-USA-02-AR-01, ER-93-USA-02-MS-01 and ER-93-USA-02-VA-01. Project 93-007. Pan-Agricultural Labs, Inc., USA. Report A53624.

Rupprecht, J.K. and Smith, S.S. 1994. Metabolism of [^{14}C]-glufosinate ammonium in soya beans, treated under normal field conditions. Study 500BK. AgrEvo USA, USA. Report A53607. GLUFOSINATE/171-4A[1]6. Unpublished.

Rupprecht, J.K., Dacus, S.C., Daniel, L.E., Singer, S.S., Stumpf, K.A. and Smith, S.M. 1996b. Metabolism of (^{14}C)-glufosinate-ammonium in transgenic soya beans, treated under normal field conditions. Hoechst Schering AgrEvo GmbH. AgrEvo USA Company, AgrEvo Pikeville. American Chemical Society National Meeting 1996. Report A55809. (Publication of A53607).

Schuld, G. 1988. Hoe 039866 and Hoe 061517. Residue determination by gas chromatography after extraction with water and removal of fats and oils from the extract; determined in hens' eggs. Report AL32/88-0. Hoechst Analytical Laboratory, Germany. A39229. Unpublished.

Shields, R. 1991a. Determination of residues of glufosinate-ammonium (BASTA®) in avocadoes. Job 91/0737. Trial QD27/91. Analchem Consultants Pty Ltd, Australia. A59027. Unpublished.

Shields, R. 1991b. Determination of residues of glufosinate-ammonium (BASTA®) in mangoes. Job 91/0258. Trial QD21/90. Analchem Consultants Pty Ltd, Australia. A59030. Unpublished.

Shields, R. 1992. Determination of residues of glufosinate-ammonium (BASTA®) in macadamia nuts. Job 92/1222. Trial QDI/92. Analchem Consultants Pty Ltd, Australia. Unpublished.

Shields, R. and Mai, C.L. 1997a. Determination of residues of glufosinate-ammonium and metabolites in canola. Report 96/4146, 96/5596, 97/1065. Analchem Bioassay, Australia. Trial AU WA 09. Report A59282. Unpublished.

Shields, R. and Mai, C.L. 1997b. Determination of residues of glufosinate-ammonium and metabolites in canola. Report 97/0612. Analchem Bioassay, Australia. Trial AU SA 17/97. Report A59283. Unpublished.

Shields, R. and Mai, C.L. 1997c. Determination of residues of glufosinate-ammonium and metabolites in canola. Report 97/0844. Analchem Bioassay, Australia. Trial AU NW 06. Report A59311. Unpublished.

Shields, R. and Mai, C.L. 1997d. Determination of residues of glufosinate-ammonium and metabolites in canola. Report 97/1796, 97/2871. Analchem Bioassay, Australia. Trial AU VN 12. Report A59284. Unpublished.

Snowdon, P.J. and Taylor, N.W. 1995a. Glufosinate SL 150 g/l. Code: HOE 039866 00 SL14 A113. Determination of residues of HOE 039866 and metabolites to establish a maximum residue level following two applications in tolerant maize. Report RESID/95/29. AgrEvo UK. Study ER94ECN550. Report A54229. Unpublished.

Snowdon, P.J. and Taylor, N.W. 1995b. Glufosinate-ammonium analytical grade active ingredient Code: Hoe 039866. Validation of analytical method; tolerant maize; active ingredient and metabolites; gas chromatography. AgrEvo, UK. Study 204/07/001. Report RESID/95/31. A55211. Unpublished.

Sochor, H. and Schuld. 1990. Hoe 039866 and Hoe 061517. Storage stability in citrus fruits and almonds. Project CR 099/87. Report A43485. Hoechst, Germany. Unpublished.

Sochor, H. and Sonder, K.H. 1996a. Report on Plant Protection Residue Trial (AE F039866, Averrhoa carambola). Dr. Specht and Partner Chem Lab. Gmbh, Germany. ER95MYS880/BBA. A57295. Unpublished.

Sochor, H. and Sonder, K.H. 1996b. Report on Plant Protection Residue Trial (AE F039866, Psidium guajava). Dr. Specht and Partner Chem Lab. Gmbh, Germany. ER95MYS880/BBA. A57294. Unpublished.

Sochor, H. and Sonder, K.H. 1996c. Report on Plant Protection Residue Trial (AE F039866, Zea mays ssp). AgrEvo Argentina. Report ER96ARG001010102. A57414. Unpublished.

Sochor, H. and Sonder, K.H. 1996d. Report on Plant Protection Residue Trial (AE F039866, Zea mays ssp). AgrEvo Argentina. Report ER95ARG001010102. A57415. Unpublished.

Sochor, H., Klapper, S. and Junker, H. 1987a. Hoe 039866 and Hoe 061517. Determination of residues by gas chromatography after extraction with water and de-fatting of the extract, determined in rape seed. Report AL37/87 Hoechst Analytical Laboratory, Germany. A44130. Unpublished.

Sochor, H., Mainzer, M. and Junker, H. 1987b. Hoe 039866 and Hoe 061517 in fat and oils residue determination by gas chromatography after extraction with water and the removal of fats and oils from the extract. Report AL40/87 Hoechst Analytical Laboratory, Germany. A38447. Unpublished.

Sochor, H., Mainzer, M. and Junker, H. 1988. Hoe 039866 and Hoe 061517. Gas chromatographic determination of residues in animal organs, determined in blood, bovine kidney, diaphragm, raw muscle, boiled muscle, broth from boiled muscle, and bovine liver. Report AL35/88-0. Hoechst Analytical Laboratory, Germany. A39949. Unpublished.

Sochor, H., Uhl, A. and Junker, H. 1991. Hoe 039866, Hoe 098412 and Hoe 061517 in tomato, tobacco and potato. Determination of residues by gas chromatography following extraction with water. Report AL019/89-1 Hoechst Germany. A46786. Unpublished.

Specht, W. 1987a. Analytical report. Analysis of HOE 61517 and HOE 39866 in pecans. Study 16-GA-85-011. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987b. Analytical report. Analysis of HOE 61517 and HOE 39866 in pecans. Study 16-LA-85-002. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987c. Analytical report. Analysis of HOE 61517 and HOE 39866 in pecans. Study 07-NM-85-032. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987d. Analytical report. Analysis of HOE 61517 and HOE 39866 in walnuts. Study 07-CA-85-019. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987e. Analytical report. Analysis of HOE 61517 and HOE 39866 in walnuts. Study 07-CA-85-024. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987f. Analytical report. Analysis of HOE 61517 and HOE 39866 in walnuts. Study 07-CA-85-038. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987g. Analytical report. Analysis of HOE 61517 and HOE 39866 in almonds. Study 07-CA-85-018. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987h. Analytical report. Analysis of HOE 61517 and HOE 39866 in almond hulls. Study 07-CA-85-018. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987i. Analytical report. Analysis of HOE 61517 and HOE 39866 in almonds. Study 07-CA-85-037. Specht and Winkelmann, Germany. Unpublished.

Specht, W. 1987j. Analytical report. Analysis of HOE 61517 and HOE 39866 in almond hulls. Study 07-CA-85-037. Specht and Winkelmann, Germany. Unpublished.

Stumpf, K. 1993a. Hoe 099730-^{14}C. Aerobic metabolism in soil. Hoechst AG, Germany. Report OE93/033. Project VV-99730. Report A50427. Unpublished.

Stumpf, K. 1993b. Hoe 039866-^{14}C. Aerobic aquatic metabolism of glufosinate-ammonium in a sandy water sediment system at two temperatures. Hoechst AG, Germany. Project CB91/091. Report A51762. Unpublished.

Stumpf, K. 1994a. Code: Hoe 039866. Aerobic aquatic metabolism of ^{14}C-labelled glufosinate-ammonium in two water sediment systems at different application rates. AgrEvo, Germany. Project CB90/109. Report A53136. Unpublished.

Stumpf, K. 1994b. Code: Hoe 039866 Aerobic aquatic metabolism of ^{14}C-labelled glufosinate-ammonium in two water sediment systems at different application rates Identification of unknown metabolites. AgrEvo, Germany. Project CB90/109. Report A53137. Unpublished.

Stumpf, K. and Zumdick, A. 1998. Code No: AE F039866. Glufosinate-ammonium. Degradation in soil and water sediment systems. Final identification of a previously characterised metabolite. Hoechst Schering AgrEvo, Germany. Report PSR98/024. C000151. Unpublished.

Stumpf, K., Schmidt, E., Schink, C., Kuenzler, K. and Dambach, P. 1995a. Code: Hoe 039866 00 SL18 F401 Metabolism and residue determination of ^{14}C-labelled glufosinate-ammonium in genetically modified tomato (*Lycopersicon lycopersicum*). AgrEvo, Germany DEU. Project CM90/043. Report A53473. Unpublished.

Stumpf, K., Schink, C. and Schmidt, E. 1995b. Code: Hoe 039866 00 SL18 D401 Metabolism in genetically modified and wild-type rape seed (Brassica napus). Model study using cut rape plants in a nutritive solution of ^{14}C-labelled glufosinate-ammonium. AgrEvo Germany. Report CM90/042. Project CM90/042. A53474. Unpublished.

Stumpf, K., Schink, C. and Schmidt, E. 1995c. Code: Hoe 064619. Degradation of the metabolite of Hoe 039866 in two soils at an application rate of 0.5 mg/kg. AgrEvo Germany. Project CB91/061. Report A55062. Unpublished.

Stumpf, K., Schink, C. and Schmidt, E. 1995d. Code: Hoe 039866 and Hoe 061517. Degradation and metabolism of the ^{14}C-labelled substances in a sandy loam at 10°C under aerobic conditions. Hoechst Germany. Study CB093/88. Report CB88/093. A55104. Unpublished.

Stumpf, K., Schink, C. and Schmidt, E. 1989. Hoe 039866-^{14}C (glufosinate-ammonium) Photodegradation on non-sterile soil. Hoechst, Germany. Project CB89/121. Report A41452. Unpublished.

Stumpf, K. and Schink, C. 1992. Hoe 039866-14C. Photodegradation in surface water. Hoechst, Germany. Project CB91/089. Report A48381. Unpublished.

Thalacker, F.W. 1994. ^{14}C-Glufosinate-ammonium: Nature of the residue in transgenic canola (rape seed). Hazleton Wisconsin, USA. Project HWI6408-100. ReportA53141. Unpublished.

Tshabalala, M. A. 1993. ^{14}C-Glufosinate-ammonium: nature of the residue in transgenic canola (rape seed). Hazleton Wisconsin., USA. Project HWI6408-100. Report A51529. Unpublished.

Werner, H.-J. 1997a. Glufosinate-ammonium; code: AE F039866; code: AE F061517; code: AE F099730. Stability in maize shoot during a deep freeze storage up to 24 months. Hoechst Schering AgrEvo Germany. Study CR94/009. Report A58845. Unpublished.

Werner, H.-J. 1997b. Glufosinate-ammonium; code: AE F039866; code: AE F061517; code: AE F099730 - Stability in maize grain during a deep freeze storage up to 24 months. Hoechst Schering AgrEvo Germany. Study CR94/014. Report 59403. Unpublished.

Werner, H.-J. 1997c. Glufosinate-ammonium; code: AE F039866; code: AE F061517; code: AE F099730 - Stability in rape seed during a deep freeze storage up to 23 months. Hoechst Schering AgrEvo Germany. Study CR94/010. Report A59116. Unpublished.

Werner, H.-J. 1997d. Glufosinate-ammonium; code: AE F039866; code: AE F061517; code: AE F099730 - Stability in sugar beet root during a deep freeze storage up to 24 months. Hoechst Schering AgrEvo Germany. Study. CR95/023. Report A59404. Unpublished.

Zietz, E. and Simpson, W. 1997. Glufosinate-ammonium SL (liquid water-soluble concentrate), 200 g/l, code: HOE 039866 00 SL18 A524. Determination of ai and relevant metabolites to establish a maximum residue level following 2 applications in tolerant sugar beets (northern Europe, 1996). processing portion. Project IF 96/24716-00, Institut Fresenius, Germany. Study ER 96 ECN 551. Unpublished.

Zumdick, A. 1995a. Hoe 099730-^{14}C, Aerobic metabolism in soil LS 2.2, SLV (2.1 mg/kg) including residues in glufosinate tolerant tomato leaves mixed with soil SLV. AgrEvo, Germany. Project CB93/016. Report A54356. Unpublished.

Zumdick, A. 1995b. Aerobic soil metabolism of (3,4-^{14}C) Hoe 099730 (N-acetyl-L-glufosinate) in a German standard soil sandy loam (LUFA, SL 2.3) and a silt loam from Nebraska (SLNE) at an application rate of 1 mg/kg. Hoechst Schering AgrEvo, Germany. Study CB94/008. Report A54528. Unpublished.

Cross-index of report numbers, study numbers and references

Reports and studies are listed in alphanumerical order, and each is linked to a reference.

(B)123/87 Idstein and Klapper 1987
(B)123/87 Idstein and Klapper 1988
01-L42-0670-93 Kellner Stumpf and Braun 1993
07-CA-85-018 Horton and Kuhner 1988
07-CA-85-018 Specht 1987g
07-CA-85-018 Specht 1987h
07-CA-85-019 Horton and Kuhner 1988
07-CA-85-019 Specht 1987d
07-CA-85-024 Horton and Kuhner 1988
07-CA-85-024 Specht 1987e
07-CA-85-028 Eichelmann. 1987
07-CA-85-028 Horton and Kuhner 1988
07-CA-85-037 Horton and Kuhner 1988
07-CA-85-037 Specht 1987i
07-CA-85-037 Specht 1987j
07-CA-85-038 Horton and Kuhner 1988
07-CA-85-038 Specht 1987f
07-NM-85-032 Horton and Kuhner 1988
07-NM-85-032 Specht 1987c
11-9402 Belcher 1996a
16-GA-85-011 Horton and Kuhner 1988
16-GA-85-011 Specht 1987a
16-LA-85-002 Horton and Kuhner 1988
16-LA-85-002 Specht 1987b
204/07/001 Snowdon and Taylor 1995b
43524601 Castro and Dacus 1994
500BK Rupprecht and Smith 1994
502BK Huang and Smith 1995b
503BK Huang and Smith 1995d
506BK Meyer, Tull and Rupprecht 1995
509BK Huang and Smith 1995c
6HMA52-264 Holzwarth 1996c
6HMA52-509 Holzwarth 1996c
6HMA52-510 Holzwarth 1996c
84H03606 Asshauer 1986a
84H03607 Asshauer 1986b
84H03609 Asshauer 1986c
84H03610 Asshauer 1986d
85H00719 Asshauer and Krebs 1987a
85H00724 Asshauer and Krebs 1987c
85H00738 Asshauer and Krebs 1987e
85H07719 Asshauer and Krebs 1987b
85H07724 Asshauer and Krebs 1987d
85H07738 Asshauer and Krebs 1987f
91/0258 Shields 1991b
91/0737 Shields 1991a
92/1222 Shields 1992
93-0006 Belcher 1996b
93-0007 Belcher 1995b
93-0025 Burnett 1994
93-0027 Bertrand 1994
93-0031 Belcher 1996a
93-007 Rickard 1994
93224 Belcher 1996b
93224 Czarnecki, Belcher, Norby and Bertrand 1994
93225 Czarnecki, Rickard and Bertrand 1994b
93230 Brady, Belcher, and Bertrand 1994
93230 Belcher 1995a
93231 Belcher 1995b
93231 Czarnecki, Rickard and Bertrand 1994a
93331 Belcher 1996a
93-IGN-01 Bertrand 1996
93PT-01 MacDonald 1996a
93-TRANS-C MacDonald 1996c
94-0052 EN-CAS Crotts and McKinney 1996
94-0053 EN-CAS Crotts and McKinney 1995
94-0053 EN-CAS McKinney and Crotts 1997
94354 Czarnecki 1995d
94HCN-01 MacDonald 1996b
94PGS-01 MacDonald 1996d
95/0752 Mai 1996e
95/3714 Mai 1996f
95/3715 Mai 1996a
96/2449 Mai 1996b
96/3456 Mai 1996c
96/4146 Shields and Mai 1997a
96/4588 Mai 1996d
96/5596 Shields and Mai 1997a
97/0612 Shields and Mai 1997b
97/0844 Shields and Mai 1997c
97/1065 Shields and Mai 1997a
97/1796 Shields and Mai 1997d
97/2871 Shields and Mai 1997d
A34230 Asshauer 1986a
A34231 Asshauer 1986b
A34232 Asshauer 1986c
A34233 Asshauer 1986d
A35706 Asshauer and Krebs 1987a

A35707 Asshauer and Krebs 1987b
A35708 Asshauer and Krebs 1987c
A35709 Asshauer and Krebs 1987d
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A35936 Dorn and Krebs 1987b
A35937 Dorn and Krebs 1987c
A35938 Dorn and Krebs 1987d
A35939 Dorn and Krebs 1987e
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A36196 Idstein and Klapper 1987
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A39229 Schuld 1988
A39283 Idstein and Klapper 1988
A39949 Sochor, Mainzer and Junker 1988
A40790 Czarnecki, Sochor, Kwiatkoski and Barry 1989
A41452 Stumpf, Schink and Schmidt 1989
A43485 Sochor and Schuld 1990
A44130 Sochor, Klapper and Junker 1987a
A46786 Sochor, Uhl and Junker 1991
A48381 Stumpf and Schink 1992
A48446 Horton and Kuhner 1988
A49978 Kellner Stumpf and Braun 1993
A50427 Stumpf 1993a
A51529 Tshabalala A. 1993
A51762 Stumpf 1993b
A52270 Czarnecki and Bertrand 1993
A53136 Stumpf 1994a
A53137 Stumpf 1994b
A53141 Thalacker 1994
A53473 Stumpf, Schmidt, Schink, Kuenzler and Dambach 1995a
A53474 Stumpf, Schink and Schmidt 1995b
A53536 Burnett 1994
A53606 Czarnecki, Rickard and Bertrand 1994a
A53607 Rupprecht and Smith 1994
A53607 Rupprecht, Dacus, Daniel, Singer, Stumpf and Smith 1996b
A53623 Bertrand 1994
A53624 Czarnecki, Rickard and Bertrand 1994b
A53624. Rickard 1994
A53690 Brady, Belcher, and Bertrand 1994
A53691 Czarnecki, Belcher, Norby and Bertrand 1994
A53696 Castro and Dacus 1994
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A53974 Czarnecki 1995b
A54051 Czarnecki and Bertrand 1994
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A54284 Brady 1995b
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A54334 Lauck-Birkel 1995b
A54336 Lauck-Birkel 1996
A54356 Zumdick 1995a
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A54485 Czarnecki and Brady 1995a
A54485 Helsten 1995
A54503 Czarnecki and Brady 1995b
A54528 Zumdick 1995b
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A54760 Niedzwiadek and Bertrand 1996
A55062 Stumpf, Schink and Schmidt 1995c
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A55211 Snowdon and Taylor 1995b
A55259 Niedzwiadek and Bertrand 1995b
A55305 Belcher 1995b
A55306 Belcher 1995a
A55393 Allan 1995
A55780 Brady 1996
A55793 Czarnecki 1996
A55807 Belcher 1996b
A55809 Rupprecht, Dacus, Daniel, Singer, Stumpf and Smith 1996b
A55823 Belcher 1996a
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A56392 MacDonald 1996b
A56394 MacDonald 1996c
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A56445 Hees, Holzwarth and Werner 1996b
A56446 Hees, Holzwarth and Werner 1996a
A56615 Holzwarth 1996c
A56812 Köcher and Becker 1991
A56922 Czarnecki 1995c
A57294 Sochor and SonderH. 1996b
A57295 Sochor and SonderH. 1996a
A57414 Sochor and SonderH. 1996c
A57415 Sochor and Sonder 1996d
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A59030 Shields 1991b
A59031 Dunmall, T. 1992
A59032 Biffin 1995c
A59116 Werner 1997c
A59282 Clarke 1997
A59282 Shields and Mai 1997a
A59283 Anderson 1997
A59283 Shields and Mai 1997b
A59284 Cross 1997
A59284 Shields and Mai 1997d
A59285 Biffin 1996b
A59285 Mai 1996d
A59311 Hulme and Rouch 1997
A59311 Shields and Mai 1997c
A59403 Werner 1997b
A59404 Werner 1997d
A59802 Holzwarth 1997a
A59803 Holzwarth 1997b
A59805 Holzwarth 1997c
A600/U012B Meyer, Tull and Rupprecht 1995
A67420 Bremmer and Leist 1998
ACI96-35 MacDonald 1996d
AE-24 Czarnecki and Bertrand 1994
AL019/89-1 Sochor, Uhl and Junker 1991
AL2/87 Idstein, Pleines and Junker 1987a
AL32/88-0 Schuld 1988
AL35/88-0 Sochor, Mainzer and Junker 1988
AL37/87 Sochor, Klapper and Junker 1987a
AL40/87 Sochor, Mainzer and Junker 1987b
AL9/87 Idstein, Pleines and Junker 1987b
AL9/89-0 Czarnecki, Sochor, Kwiatkoski and Barry 1989
AU NW 06 Hulme and Rouch 1997
AU NW 06 Shields and Mai 1997c
AU SA 17/97 Shields and Mai 1997b
AU VN 12 Cross 1997
AU VN 12 Shields and Mai 1997d
AU WA 09 Shields and Mai 1997a
AUQD1/92 Dunmall, T. 1992
AUQD12/94 Biffin 1995b
AUQD13/94 Biffin 1995d
AUQD20/94 Biffin 1995c
AUQD21/90 Dunmall, T. 1991b
AUQD24/94 Biffin 1995a
AUQD25 Biffin 1996b
AUQD26/96 Biffin 1996a
AUQD27/90 Dunmall, T. 1991a
AUWA09 Clarke 1997
BK/01/95 Czarnecki 1995a
BK/03/95 Czarnecki 1995b
BK/05/95 Czarnecki 1995c
BK-94R-01 Brady 1995a
BK-94R-01 Czarnecki 1995d
BK-94R-02 Brady 1995d
BK-94R-03 Brady 1995b
BK-94R-03 Czarnecki 1996
BK-94R-04 Brady 1995e
BK-94R-05 Castro and Dacus 1994
BK-94R-06 Brady 1995c
BK-94R-08 Crotts and McKinney 1995
BK-94R-08 EN-CAS Czarnecki and Brady 1995a
BK-94R-08 Helsten 1995
BK-94R-08 McKinney and Crotts 1997
BK-94R-09 Crotts and McKinney 1996
BK-94R-09 Czarnecki and Brady 1995b
BK95R009 Campbell and Bennett 1997
BK95R01 Brady 1997a
BK-95R-04 Brady 1996
BK-95R-06 Brady 1997b
BK-96R-01 Greenhalgh and Bertrand 1997
BK-96R-05 Brady and Bertrand 1997
BK-96R-05 Englar 1997
C000151 Stumpf and Zumdick 1998
CB093/88 Stumpf, Schink, and Schmidt 1995d
CB88/093 Stumpf, Schink, and Schmidt 1995d
CB89/121 Stumpf, Schink and Schmidt 1989
CB90/109 Stumpf 1994a
CB90/109 Stumpf 1994b
CB91/061 Stumpf, Schink and Schmidt 1995c
CB91/089 Stumpf and Schink 1992
CB91/091 Stumpf 1993b
CB93/016 Zumdick 1995a
CB93/027 Allan 1995
CB94/008 Zumdick 1995b
CM90/042 Stumpf, Schink and Schmidt 1995b
CM90/042 Stumpf, Schink and Schmidt 1995b
CM90/043 Stumpf, Schmidt, Schink, Kuenzler and Dambach 1995a
CM93/070 Lauck-Birkel 1995a
CM93/071 Lauck-Birkel 1995b
CM95/013 Lauck-Birkel 1996
CM95/035 Allan 1996
CR 099/87 Sochor and Schuld 1990
CR037/86 Idstein and Klapper 1987
CR037/86 Idstein and Klapper 1988
CR94/006 Holzwarth 1996b
CR94/009 Werner 1997a
CR94/010 Werner 1997c
CR94/014 Werner 1997b
CR94/016 Holzwarth 1996a
CR95/023 Werner 1997d
CR96/003 Holzwarth 1996c
EN-CAS 94-0053 Helsten 1995
ER 96 ECN 551 Zietz and Simpson 1997
ER-93—01 Belcher 1996b
ER-93—02 Belcher 1995b
ER93ECN550 Kalter and Holzwarth 1995a
ER93ECN552 Kalter and Holzwarth 1995e
ER93ECN552 Niedzwiadek and Bertrand 1995a
ER93ECN553 Kalter and Holzwarth 1995f
ER93ECS550 Kalter and Holzwarth 1995b
ER-93-USA-01 Czarnecki, Belcher, Norby and Bertrand 1994
ER-93-USA-01 Brady, Belcher, and Bertrand 1994
ER-93-USA-02 Czarnecki, Rickard and Bertrand 1994a
ER-93-USA-02 Czarnecki, Rickard and Bertrand 1994b
ER-93-USA-02-AR-01 Rickard 1994
ER-93-USA-02-IA-01 Rickard 1994
ER-93-USA-02-IL-01 Rickard 1994
ER-93-USA-02-IN-01 Rickard 1994
ER-93-USA-02-IN-02 Rickard 1994
ER-93-USA-02-MO-01 Rickard 1994
ER-93-USA-02-MS-01 Rickard 1994
ER-93-USA-02-VA-01 Rickard 1994
ER94ECN550 Kalter and Holzwarth 1995c

ER94ECN550 Snowdon and Taylor 1995a
ER94ECN553 Hees, Holzwarth and Werner 1996c
ER94ECS550 Kalter and Holzwarth 1995d
ER95ARG001010102 Sochor and Sonder 1996d
ER95ECN550 Hees, Holzwarth and Werner 1996b
ER95ECN555 Hees, Holzwarth and Werner 1996a
ER95ECS550 Hees and Holzwarth 1996
ER95ECS550 Niedzwiadek and Bertrand 1996
ER95MYS880/BBA Sochor and SonderH. 1996a
ER95MYS880/BBA Sochor and SonderH. 1996b
ER96ARG001010102 Sochor and SonderH. 1996c
ER96ECN550 Hees and Werner 1997b
ER96ECN551 Hees, and Werner 1997d
ER96ECN553 Hees and Werner 1997c
ER96ECS550 Hees and Werner 1997a
HRAV-5A Czarnecki and Bertrand 1993
HRAV-5A Czarnecki, Sochor, Kwiatkoski and Barry 1989
HRAV93-0006 Czarnecki, Belcher, Norby and Bertrand 1994
HRAV93-0006 Brady, Belcher, and Bertrand 1994
HRAV93-0007 Czarnecki, Rickard and Bertrand 1994a
HRAV93-0007 Czarnecki, Rickard and Bertrand 1994b
HWI 6187-155 Ampofo 1995
HWI6408-100 Thalacker 1994
HWI6408-100 Tshabalala A. 1993
IF 96/24716-00 Zietz and Simpson 1997
ITA85H00601 Dorn and Krebs 1987a
ITA85H00602 Dorn and Krebs 1987b
ITA85H00603 Dorn and Krebs 1987c
ITA85H00604 Dorn and Krebs 1987d
ITA85H00605 Dorn and Krebs 1987e
Kö/ru5/1991 Köcher and Becker 1991
OE93/033 Stumpf 1993a
OE95/036 Holzwarth 1995
OE97/062 Holzwarth 1997c
OE97/066 Holzwarth 1997a
OE97/087 Holzwarth 1997b
PSR98/024 Stumpf and Zumdick 1998
PTRL 1613 Krautter 1995a
PTRL 1637 Krautter 1995b
QD1/92 Dunmall, T. 1992
QD12-94 Mai 1996f
QD13-94 Mai 1996e
QD20-94 Mai 1996a
QD21/90 Dunmall, T. 1991b
QD21/90 Shields 1991b
QD24-95 Mai 1996b
QD25-94 Mai 1996d
QD26-94 Mai 1996c
QD27/90 Dunmall, T. 1991a
QD27/91 Shields 1991a
QDI/92 Shields 1992
R141/U012 Brady 1997b
R142/U012C Greenhalgh and Bertrand 1997
RESID/95/29 Snowdon and Taylor 1995a
RESID/95/31 Snowdon and Taylor 1995b
TOX97/014 Bremmer and Leist 1997
TOX98/027 Bremmer and Leist 1998
U012A/A524 Huang and Smith 1995b
U012A/A524 Krautter 1995a
U012A/A524R Huang and Smith 1995a
U012A/A525 Huang and Smith 1995d
U012A/A525 Krautter 1995b
U012A/A525R Ampofo 1995
U012A/A525R Huang and Smith 1995c
U012B/R143 Brady 1996
VV-99730 Stumpf 1993a
XEN93-09 Bertrand 1993
XEN93-19A Bertrand 1994
XEN93-32 Belcher 1996b
XEN94-13 Belcher 1995a
XEN94-14 Belcher 1995b
XEN94-32 Bertrand 1996
XEN95-07 Niedzwiadek and Bertrand 1995b
XEN95-07A Niedzwiadek and Bertrand 1995a
XEN95-14A Niedzwiadek and Bertrand 1996
YH94AA Biffin 1995a
YH94AA Biffin 1995b
YH94AA Biffin 1995c
YH94AA Biffin 1995d
YH94AA Biffin 1996a