Supplement S1: Raw and Supplementary Data

The pots were $30.0 \pm_{\Delta} 0.1\,\mathrm{cm}$ in diameter, resulting in a surface area of $7.07 \pm_{\Delta} 0.05\,10^{-6}\,\mathrm{ha}$ per pot. A dose of $8.77 \pm_{\Delta} 0.44\,\mathrm{mL}$ of spray mixture was applied to each pot, equivalent to $1\,240 \pm_{\Delta} 60\,\mathrm{L\,ha^{-1}}$. The composition of the spray mixture is detailed in Table S1.

Modalities and date of sampling are defined for each pot number in Table S2, without further reference in Tables S3 to S7.

Mefenpyr-diethyl ($\mathrm{LQ_{soil\ solution}} = 0.15\,\mu\mathrm{g\,L}$) and halauxifen-mexyl ($\mathrm{LQ_{soil\ solution}} = 0.03\,\mu\mathrm{g\,L}$) were never detected in soil solution samples (ND for all samples) and were omitted from Table S4.

Where no value of $\mathrm{K_{foc}}$ was available in the PPDB, $\mathrm{K_{foc}}$ was used in Table S5 instead. Where no value of BCF was available, it was calculated using (Fu et al., 2009):

$$\mathrm{BCF} = \begin{cases} 10^{\left(-0.2(\log_{10}\mathrm{K_{oc}})^2 + 2.74\log_{10}\mathrm{K_{oc}} - 4.72\right)} & \text{where} \quad \log_{10}\mathrm{K_{oc}} > 6 \\ 10^{(0.85\log_{10}\mathrm{K_{oc}} - 0.7)} & \text{where} \quad 0 < \log_{10}\mathrm{K_{oc}} < 6 \end{cases} \tag{S1}$$

Table S1. Spray mixture composition.

formulated product	MAD	q_{prod}	active substance	formulation	$q_{a.s.}$
Afinto	0.32	0.26	flonicamid	500	130
Aquino	2.00	1.6	fenpicoxamid	50	80
Axial	1.20	0.96	cloquintocet-mexyl	12.5	12
			pinoxaden	50	48
Bofix	4.00	3.2	clopyralid	20	64
			fluroxypyr	40	130
			MCPA	200	640
Butizyl	5.00	4.0	MCPB	400	1600
Capri	0.25	0.21	cloquintocet-mexyl	75	16
			pyroxsulam	75	16
Comet New	2.50	2.0	pyraclostrobin	200	400
Frimax	0.50	0.40	cloquintocet-mexyl	12	4.8
			fluroxypyr	280	110
			halauxifen-methyl	12.5	4.5
Mesiofis Pro	1.50	1.2	iodosulfuron-methyl-sodium	2	2.4
			mefenpyr-diethyl	30	36
			mesosulfuron-methyl	10	12
Mizona	2.00	1.6	fluxapyroxad	30	48
			pyraclostrobin	200	320
Primus	0.10	0.08	florasulam	50	4.0
Revytrex	3.00	2.4	fluxapyroxad	66.7	160
			mefentrifluconazole	66.7	160
Tebusip	3.00	2.4	tebuconazole	250	600

MAD: maximum authorised dose, in $\mathrm{L\,ha^{-1}}$ or $\mathrm{kg\,ha^{-1}}$ (data extracted from *phytoweb.be*);

$\mathbf{q_{prod}}$: quantity of the formulated product in the pray mixture, in $\mathrm{mL\,L^{-1}}$ or $\mathrm{g\,L^{-1}}$ of spray mixture;

formulation: active substance content in formulated product, in $\mathrm{g\,L^{-1}}$ or $\mathrm{g\,kg^{-1}}$;

$\mathbf{q_{a.s.}}$: quantity of the active substance in the spray mixture, in $\mathrm{mg\,L^{-1}}$.

Table S2. Experimental set-up raw data.

sampling	modality	pot	fresh soil	soil DM	soil solution	sowing	biomass	
05-01-24		1	10.03	80.2	—	—	—	
		2	9.42	79.2	—	—	—	
		3	10.24	80.3	—	—	—	
		4	10.03	80.7	—	—	—	
		5	9.25	80.3	—	—	—	
19-02-24	bare	6	10.43	79.1	20	—	—	
		7	9.80	77.7	19	—	—	
		8	9.82	77.7	38	—	—	
		9	9.77	77.9	39	—	—	
		10	9.85	77.8	0	—	—	
	thin	11	10.33	78.6	56	149.1	0.35	$\pm_{\triangle}$ 0.03
		12	10.12	77.2	32	147.0	0.32	$\pm_{\triangle}$ 0.02
		13	10.21	78.4	37	147.4	0.21	$\pm_{\triangle}$ 0.02
		14	9.75	78.4	52	151.9	0.15	$\pm_{\triangle}$ 0.01
		15	9.97	78.6	40	144.1	0.23	$\pm_{\triangle}$ 0.02
	thick	16	9.40	78.2	54	190.1	0.39	$\pm_{\triangle}$ 0.03
		17	9.14	77.4	11	205.0	0.46	$\pm_{\triangle}$ 0.03
		18	9.65	78.8	17	209.1	0.49	$\pm_{\triangle}$ 0.04
		19	9.13	77.6	15	184.9	0.41	$\pm_{\triangle}$ 0.03
		20	9.06	77.9	28	174.9	0.40	$\pm_{\triangle}$ 0.04
29-04-24	bare	21	9.67	79.2	48	—	—	
		22	9.59	79.3	17	—	—	
		23	10.07	80.9	23	—	—	
		24	9.55	79.4	52	—	—	
		25	10.06	79.9	30	—	—	
	thin	26	9.59	79.4	41	145.0	0.33	$\pm_{\triangle}$ 0.02
		27	9.33	81.1	55	144.6	0.28	$\pm_{\triangle}$ 0.02
		28	9.60	80.1	30	147.4	0.29	$\pm_{\triangle}$ 0.02
		29	9.67	80.6	0	147.9	0.40	$\pm_{\triangle}$ 0.03
		30	9.57	80.4	30	144.6	0.50	$\pm_{\triangle}$ 0.04
	thick	31	9.46	79.8	3	187.7	1.12	$\pm_{\triangle}$ 0.08
		32	9.12	79.9	16	168.3	1.12	$\pm_{\triangle}$ 0.08
		33	9.35	79.8	35	195.3	1.10	$\pm_{\triangle}$ 0.08
		34	9.50	79.5	14	196.0	1.12	$\pm_{\triangle}$ 0.08
		35	8.83	79.4	3	194.1	1.16	$\pm_{\triangle}$ 0.08

fresh soil: fresh soil mass, in kg, with a measurement error of $\pm_{\triangle} 0.02\,\mathrm{kg}$;

soil DM: soil dry matter content, in %, with a measurement error of $\pm_{\triangle} 0.1\,\%$ (except for 5 January 2024: $\pm_{\triangle} 0.4\,\%$);

soil solution: sampled soil solution volume, in mL, with a measurement error of $\pm_{\triangle} 2\,\mathrm{mL}$;

sowing: sown seed density, in $\mathrm{kg_{seed}\ ha^{-1}}$, with a measurement error of $\pm_{\triangle} 0.1\,\mathrm{kg\,ha^{-1}}$;

biomass: sampled dry matter biomass, in $\mathrm{t_{DM}\ ha^{-1}}$.

Table S3. Quantification raw data: soil samples.

pot	clop	cloq	fenp	flon	flor	flur	flux	hala	iodo	MCPA	MCPB
LQ	5.00	0.20	0.20	0.50	0.25	2.50	0.25	0.50	0.75	0.20	2.50
1	95.43	0.50	21.45	54.04	1.68	331.97	266.78	1.35	0.99	1164.60	706.52
2	42.97	0.68	15.95	24.42	0.99	176.72	176.74	1.13	<LQ	529.15	220.53
3	45.67	0.80	18.11	30.77	0.96	171.83	167.45	0.99	<LQ	550.55	324.99
4	45.51	0.54	21.26	24.00	0.99	195.50	200.73	1.17	<LQ	627.58	211.52
5	49.55	1.65	37.80	35.80	1.18	278.57	240.80	1.77	0.83	773.60	632.97
6	<LQ	<LQ	0.60	<LQ	<LQ	3.46	102.89	<LQ	<LQ	1.21	<LQ
7	8.91	<LQ	0.50	<LQ	<LQ	5.85	107.46	<LQ	<LQ	1.38	<LQ
8	8.90	<LQ	0.49	<LQ	<LQ	7.72	92.35	<LQ	<LQ	1.26	<LQ
9	13.27	<LQ	0.45	0.61	<LQ	10.99	92.6 8	<LQ	<LQ	1.67	<LQ
10	11.04	<LQ	0.71	0.52	<LQ	6.20	86.31	<LQ	<LQ	1.52	<LQ
11	5.57	<LQ	1.02	<LQ	<LQ	4.70	164.85	<LQ	<LQ	4.10	5.15
12	7.00	<LQ	0.38	<LQ	<LQ	4.48	79.55	<LQ	<LQ	2.05	<LQ
13	9.75	<LQ	0.56	0.59	<LQ	8.10	100.73	<LQ	<LQ	2.39	2.77
14	<LQ	<LQ	0.70	<LQ	<LQ	2.93	124.64	<LQ	<LQ	1.47	2.53
15	6.46	<LQ	0.65	<LQ	<LQ	5.05	128.03	<LQ	<LQ	1.17	<LQ
16	7.00	<LQ	0.95	<LQ	<LQ	3.27	173.38	<LQ	<LQ	1.79	4.13
17	6.36	<LQ	0.49	<LQ	<LQ	<LQ	103.06	<LQ	<LQ	1.45	<LQ
18	8.43	<LQ	0.59	<LQ	<LQ	4.22	124.27	<LQ	<LQ	1.38	<LQ
19	<LQ	<LQ	0.73	<LQ	<LQ	1.81	131.26	<LQ	<LQ	1.12	2.58
20	5.91	<LQ	0.64	<LQ	<LQ	<LQ	136.20	<LQ	<LQ	1.23	2.68
21	<LQ	<LQ	0.44	<LQ	<LQ	<LQ	167.74	<LQ	<LQ	0.94	5.19
22	<LQ	<LQ	0.82	<LQ	<LQ	<LQ	255.22	<LQ	<LQ	1.84	7.90
23	<LQ	<LQ	0.75	<LQ	<LQ	<LQ	255.00	<LQ	<LQ	1.42	7.63
24	<LQ	<LQ	1.10	<LQ	<LQ	2.64	268.82	<LQ	<LQ	1.58	9.03
25	<LQ	<LQ	0.81	<LQ	<LQ	<LQ	232.44	<LQ	<LQ	1.82	8.62
26	<LQ	<LQ	0.99	<LQ	<LQ	<LQ	278.53	<LQ	<LQ	1.66	8.16
27	<LQ	<LQ	0.83	<LQ	<LQ	3.24	263.39	<LQ	<LQ	1.81	8.35
28	<LQ	<LQ	0.95	<LQ	<LQ	<LQ	270.33	<LQ	<LQ	1.61	7.26
29	<LQ	<LQ	0.81	<LQ	<LQ	<LQ	250.55	<LQ	<LQ	1.50	8.09
30	<LQ	<LQ	1.05	<LQ	<LQ	<LQ	322.96	<LQ	<LQ	1.75	9.18
31	<LQ	<LQ	0.60	<LQ	<LQ	<LQ	152.63	<LQ	<LQ	0.92	6.05
32	<LQ	<LQ	0.46	<LQ	<LQ	<LQ	135.38	<LQ	<LQ	1.00	6.40
33	<LQ	<LQ	0.28	<LQ	<LQ	<LQ	118.44	<LQ	<LQ	0.76	5.07
34	<LQ	<LQ	0.33	<LQ	<LQ	<LQ	167.76	<LQ	<LQ	0.88	5.32
35	7.01	<LQ	0.48	1.17	<LQ	<LQ	163.65	<LQ	<LQ	1.70	5.51

clop: clopyralid; **cloq**: cloquintocet-mexyl; **fenp**: fenpicoxamid; **flon**: flonicamid; **flor**: florasulam; **flur**: fluroxypyr; **flux**; fluxapyroxad; **hala**: halauxifen-methyl; **iodo**: iodosulfuron-methyl-sodium.

Table S3 (continued). Quantification raw data: soil samples.

pot	mef.d	mef.a	meso	pino	pyra	pyro	tebu
LQ	1,00	1,25	0,50	0,20	1,00	0,25	1,00
1	<LQ	199,38	14,84	<LQ	532,09	21,13	818,24
2	<LQ	147,98	7,28	0,21	371,26	8,00	532,18
3	<LQ	121,17	7,30	0,19	293,11	10,87	477,36
4	<LQ	154,44	10,12	<LQ	413,86	10,99	643,14
5	<LQ	195,33	13,94	0,60	482,65	13,06	738,71
6	<LQ	72,80	2,76	<LQ	53,82	<LQ	285,50
7	<LQ	74,42	3,51	<LQ	42,55	0,65	280,96
8	<LQ	57,23	3,32	<LQ	48,08	0,71	236,96
9	<LQ	58,79	3,30	<LQ	42,07	1,07	244,71
10	<LQ	54,79	2,92	<LQ	52,35	0,89	252,69
11	<LQ	114,28	3,05	<LQ	98,97	0,25	444,13
12	<LQ	42,68	2,31	<LQ	34,32	0,25	178,16
13	<LQ	65,09	2,72	<LQ	60,64	0,57	262,63
14	<LQ	84,01	2,98	<LQ	70,11	<LQ	322,48
15	<LQ	77,46	3,33	<LQ	64,95	0,35	306,72
16	<LQ	139,92	3,60	<LQ	114,92	<LQ	499,47
17	<LQ	72,30	3,48	<LQ	58,23	<LQ	268,56
18	<LQ	82,09	3,04	<LQ	58,06	<LQ	360,60
19	<LQ	83,36	3,58	<LQ	68,24	<LQ	369,23
20	<LQ	85,61	3,27	<LQ	58,98	<LQ	364,14
21	<LQ	101,63	1,77	<LQ	30,05	<LQ	355,97
22	<LQ	169,24	2,51	<LQ	64,80	<LQ	557,42
23	<LQ	163,51	2,44	<LQ	61,96	<LQ	572,18
24	<LQ	179,23	3,79	<LQ	60,85	<LQ	588,86
25	<LQ	144,54	2,74	<LQ	44,87	<LQ	535,90
26	<LQ	191,77	3,29	<LQ	76,03	<LQ	657,97
27	<LQ	173,79	3,81	<LQ	68,90	<LQ	585,14
28	<LQ	184,35	3,32	<LQ	53,18	<LQ	617,68
29	<LQ	162,38	3,38	<LQ	53,48	<LQ	541,03
30	<LQ	236,07	3,67	<LQ	81,71	<LQ	730,82
31	<LQ	87,45	1,24	<LQ	31,89	<LQ	303,98
32	<LQ	89,58	1,49	<LQ	34,86	<LQ	298,62
33	<LQ	71,21	1,57	<LQ	22,50	<LQ	267,28
34	<LQ	95,99	2,24	<LQ	38,50	<LQ	360,45
35	<LQ	102,13	1,76	<LQ	31,01	<LQ	374,20

mef.d: mefenpyr-diethyl; **mef.a**: mefentrifluconazole; **meso**: mesosulfuron-methyl; **pino**: pinoxaden; **pyra**: pyraclostrobin; **pyro**: pyroxsulam; **tebu**: tebuconazole.

Table S4. Quantification raw data: soil solution samples.

pot	clop	cloq	flon	flor	flur	flux	iodo	MCPA	MCPB	mef.a	meso	pyra	pyro	tebu
LQ	1,50	0,10	0,10	0,10	0,50	0,03	0,20	0,20	0,75	0,25	0,10	0,20	0,05	0,15
6	2,88	ND	<LQ	ND	ND	4,56	ND	ND	ND	0,36	1,16	ND	<LQ	14,42
7	24,09	ND	0,20	0,23	1,35	9,01	ND	<LQ	ND	0,57	6,78	ND	0,46	32,13
8	41,03	ND	0,48	0,39	9,88	0,46	ND	0,21	ND	ND	1,91	ND	1,75	1,21
9	47,94	ND	0,67	0,40	5,29	7,49	ND	0,31	ND	0,46	3,94	ND	1,75	24,48
11	14,81	ND	0,30	0,19	3,24	3,75	ND	0,27	ND	<LQ	2,77	ND	0,34	7,28
12	17,30	ND	0,21	0,23	3,10	1,14	ND	<LQ	ND	<LQ	1,63	ND	0,32	3,20
13	22,38	ND	0,38	0,26	5,57	3,18	ND	<LQ	ND	0,28	2,08	ND	0,70	9,90
14	20,66	ND	0,54	0,23	3,55	4,74	ND	0,23	ND	<LQ	2,78	ND	0,51	9,96
15	32,91	ND	1,81	0,58	8,98	8,40	ND	4,70	ND	0,63	4,46	ND	3,07	24,70
16	38,86	ND	0,38	0,28	8,55	2,69	ND	0,49	ND	ND	3,53	ND	1,03	6,45
17	16,12	ND	<LQ	0,20	0,85	2,59	ND	ND	ND	<LQ	3,02	ND	0,19	7,65
18	44,57	ND	4,61	0,75	42,02	2,15	<LQ	5,37	3,49	ND	5,37	ND	5,83	7,39
19	21,66	ND	0,89	0,28	4,92	0,45	ND	1,14	ND	ND	3,79	ND	1,40	2,21
20	25,82	ND	0,41	0,23	2,45	5,07	ND	0,25	ND	0,35	3,24	ND	0,80	14,81
21	15,36	ND	0,85	0,21	6,94	9,29	ND	0,57	<LQ	0,50	3,16	ND	0,87	16,09
22	12,99	ND	0,14	0,19	1,53	4,48	ND	0,23	ND	0,53	1,97	0,26	0,22	9,33
23	8,65	ND	ND	ND	0,92	4,62	ND	ND	ND	0,35	2,47	ND	0,20	8,74
24	7,18	ND	0,21	ND	1,52	8,95	ND	0,22	ND	0,68	2,59	0,48	0,19	16,62
25	5,98	ND	<LQ	ND	0,65	2,01	ND	ND	ND	<LQ	1,84	ND	0,07	4,61
26	13,52	ND	0,30	0,17	2,94	8,05	ND	0,20	ND	0,29	2,89	ND	0,42	12,80
27	1,68	ND	<LQ	ND	<LQ	2,92	ND	ND	ND	<LQ	1,66	ND	0,07	4,46
28	4,55	ND	ND	ND	0,83	3,11	ND	ND	ND	<LQ	2,21	ND	0,10	5,35
30	3,63	ND	<LQ	ND	0,98	7,40	ND	<LQ	ND	0,29	1,97	ND	0,14	13,04
31	<LQ	ND	<LQ	ND	<LQ	1,83	ND	<LQ	ND	ND	0,57	ND	<LQ	6,04
32	3,63	ND	0,13	ND	1,48	4,17	ND	0,97	ND	0,37	0,97	ND	0,17	11,90
33	6,12	ND	0,26	ND	1,82	2,93	ND	0,64	ND	<LQ	1,11	ND	0,20	9,14
34	<LQ	ND	ND	ND	ND	5,49	ND	ND	ND	0,27	1,16	ND	<LQ	15,30
35	<LQ	ND	<LQ	ND	0,51	2,20	ND	0,24	ND	<LQ	1,24	ND	0,06	8,10

clop: clopyralid; **cloq**: cloquintocet-mexyl; **fenp**: fenpicoxamid; **flon**: flonicamid; **flor**: florasulam; **flur**: fluroxypyr; **flux**; fluxapyroxad; **iodo**: iodosulfuron-methyl-sodium; **mef.a**: mefentrifluconazole; **meso**: mesosulfuron-methyl; **pino**: pinoxaden; **pyra**: pyraclostrobin; **pyro**: pyroxsulam; **tebu**: tebuconazole.

Table S5. Physicochemical properties of the active substances.

a.s.	CAS RN	DT_{50} soil	$\log(K_{oc})$	s	GUS	p	k_H	$\log(K_{ow})$	BCF	m
clop	1702-17-6	23	0.70	$7.9\,10^{3}$	3.02	1.4	$1.8\,10^{-11}$	−2.63	1	192.00
cloq	99607-70-2	5.0	3.99	$5.9\,10^{-1}$	0.00	$5.3\,10^{-3}$	$3.0\,10^{-3}$	5.20	621	335.80
fenp	517875-34-2	3.5	4.73	$4.1\,10^{-2}$	−0.29	$1.2\,10^{-4}$	$2.4\,10^{-3}$	4.40	18	614.64
flon	158062-67-0	3.1	0.20	$5.2\,10^{3}$	1.87	$9.4\,10^{-4}$	$4.2\,10^{-8}$	−0.24	1	229.16
flor	145701-23-1	1.9	1.34	$6.4\,10^{3}$	2.50	$1.0\,10^{-2}$	$4.4\,10^{-7}$	−1.22	1.5	359.28
flur	69377-81-7	13	1.83	$6.5\,10^{3}$	1.03	$3.8\,10^{-6}$	$1.7\,10^{-10}$	0.04	62	255.03
flux	907204-31-3	183	2.86	3.4	2.57	$2.7\,10^{-6}$	$3.0\,10^{-7}$	3.13	36	381.31
hala	943831-98-9	1.3	3.15	$1.8\,10^{3}$	1.64	$5.9\,10^{-6}$	$1.2\,10^{-6}$	3.76	217	345.16
iodo	144550-36-7	2.7	1.65	$2.5\,10^{4}$	1.19	$2.6\,10^{-6}$	$2.3\,10^{-11}$	−0.70	1	529.24
MCPA	94-74-6	12	1.87	$2.5\,10^{5}$	3.13	$4.0\,10^{-1}$	$1.5\,10^{-1}$	−0.81	1	200.62
MCPB	4-81-5	3.7	2.02	$6.0\,10^{1}$	1.12	$5.3\,10^{-2}$	$9.4\,10^{-5}$	1.33	1	228.67
mef.d	135590-91-9	18	2.80	$2.0\,10^{1}$	1.49	$6.3\,10^{-3}$	$2.6\,10^{-4}$	3.83	392	373.23
mef.a	1417782-03-6	268	3.54	$8.1\,10^{-1}$	1.06	$3.2\,10^{-3}$	$1.6\,10^{-3}$	3.40	167	397.78
meso	208465-21-8	44	1.96	$4.8\,10^{2}$	3.85	$3.5\,10^{-9}$	$3.7\,10^{-12}$	−0.48	1	503.51
pino	243973-20-8	0.5	2.54	$2.0\,10^{2}$	−0.32	$2.0\,10^{-4}$	$9.2\,10^{-7}$	3.20	1	400.51
pyra	175013-18-0	42	3.97	1.9	0.05	$2.6\,10^{-5}$	$5.3\,10^{-6}$	3.99	706	387.82
pyro	422556-08-9	3.3	1.52	$3.2\,10^{3}$	2.84	$1.0\,10^{-4}$	$6.9\,10^{-7}$	−1.01	1	434.35
tebu	107534-96-3	63	2.89	$3.6\,10^{1}$	1.86	$1.3\,10^{-3}$	$1.0\,10^{-5}$	3.70	78	307.82

a.s.: active substance; **CAS RN**: Chemical Abstracts Service Registry Number; **DT_{50} soil**: typical soil persistence (in days); **$\log(K_{oc})$**: soil sorption coefficient (in $\mathrm{mL\,g^{-1}}$); **s**: water solubility at 20 °C (in $\mathrm{mg\,L^{-1}}$); **GUS**: groundwater ubiquity score (dimensionless); **p**: vapour pressure at 20 °C (in mPa); **k_H**: Henry's law constant (in $\mathrm{Pa\,m^3\,mol^{-1}}$); **$\log(K_{ow})$**: n-octanol–water partition coefficient at pH 7 and 20 °C (dimensionless); **BCF**: biocententration factor (in $\mathrm{L\,kg^{-1}}$); **m**: relative molecular mass (dimensionless).
clop: clopyralid; **cloq**: cloquintocet-mexyl; **fenp**: fenpicoxamid; **flon**: flonicamid; **flor**: florasulam; **flur**: fluroxypyr; **flux**: fluxapyroxad; **hala**: halauxifen-methyl; **iodo**: iodosulfuron-methyl-sodium; **mef.d**: mefenpyr-diethyl; **mef.a**: mefentrifluconazole; **meso**: mesosulfuron-methyl; **pino**: pinoxaden; **pyra**: pyraclostrobin; **pyro**: pyroxsulam; **tebu**: tebuconazole.

Table S6. Property thresholds and data interpretation.

parameter	low	moderately low	moderate	moderately high	high	very high
DT_{50} soil	$\leqslant 30$		30 — 100		100 — 365	> 365
$\log(K_{oc})$	$\leqslant 15$	15 — 75	75 — 500	500 — 4000	> 4000	
s	$\leqslant 10$		10 — 1 000		1 000 — 100 000	> 100 000
GUS	$\leqslant 1.8$		1.8 — 2.8		> 2.8	
p	$\leqslant 5.0$		5.0 — 10.0		> 10.0	
k_H	$\leqslant 0.1$		0.1 — 100		> 100	
$\log(K_{ow})$	$\leqslant 2.7$		2.7 — 3		> 3	
BCF	$\leqslant 100$		100 — 5 000		> 5 000	

DT_{50} soil: typical soil persistence (in days); **$\log(K_{oc})$**: soil sorption coefficient (in $\mathrm{mL\,g^{-1}}$), inversely proportional to soil mobility; **s**: water solubility at 20 °C (in $\mathrm{mg\,L^{-1}}$); **GUS**: groundwater ubiquity score (dimensionless), proportional to leachability; **p**: vapour pressure at 20 °C (in mPa); **k_H**: Henry's law constant (in $\mathrm{Pa\,m^3\,mol^{-1}}$); **$\log(K_{ow})$**: n-octanol–water partition coefficient at pH 7 and 20 °C (dimensionless); **BCF**: biocententration factor (in $\mathrm{L\,kg^{-1}}$).

Threshold extracted from Lewis et al. (2016), see *sitem.herts.ac.uk/aeru/ppdb/en/docs/Background_and_Support.pdf*.

Supplement S2: Pesticide quantification

Soil and soil solution samples were analysed at the laboratory of the Walloon Agricultural Research Centre (CRA-W) in Gembloux, Belgium, for quantification of the 18 applied active substances. No metabolites were quantified.

Frozen soil samples were thawed and sieved to $2\,\mathrm{mm}$ to homogenise and remove plant fragments, stones and other debris. A $5\,\mathrm{g}$ subsample was extracted using the following QuEChERS method. $5\,\mathrm{mL}$ of Milli-Q water were added to the soil subsample, which was then vortexed and left to macerate for $30\,\mathrm{min}$. $10\,\mathrm{mL}$ of acidified acetonitrile ($2\,\%$ formic acid) were then added and the sample was shaken again and left to macerate for a further $30\,\mathrm{min}$. A pre-weighed bag of QuEChERS salt ($4\,\mathrm{g}\,MgSO_4$, $1\,\mathrm{g}\,NaCl$, $0.5\,\mathrm{g}$ sodium hydrogencitrate sesquihydrate, $1\,\mathrm{g}$ sodium citrate dihydrate; purchased from Agilent, USA) was added and the mixture was shaken for $1\,\mathrm{min}$ at $20\,\mathrm{Hz}$ (using a MM400 Retch mixer mill). After centrifugation at $4800\,\mathrm{rcf}$ at $4\,^\circ\mathrm{C}$ for $15\,\mathrm{min}$, the supernatant was filtered on a $0.2\,\mu\mathrm{m}$ polytetrafluoroethylene (PTFE) filter and transferred to a glass vial. A $5\,\mu\mathrm{L}$ aliquot was analysed by liquid chromatography (LC; Nexera X2™ Shimadzu, USA) coupled to a quadrupole time-of-flight mass spectrometer (QTOFMS; X500R ABSciex, Singapore).

Soil solution samples were analysed within $7\,\mathrm{d}$ of collection. $2\,\mathrm{mL}$ of acetonitrile were added to $10\,\mathrm{mL}$ of soil solution sample, shaken manually and centrifuged at $4800\,\mathrm{rcf}$. The supernatant was filtered through a $0.2\,\mu\mathrm{m}$ PTFE filter and $5\,\mu\mathrm{L}$ was analysed on the same LC-QTOFMS instrument.

The column used for LC was a Waters ACQUITY UPLC™ HSS T3 ($100\,\mathrm{mm} \times 2.1\,\mathrm{mm}$, $1.8\,\mu\mathrm{m}$ particle size), maintained at $40\,^\circ\mathrm{C}$. The mobile phase gradient (at a flow of $0.3\,\mathrm{mL\,min^{-1}}$) consisted of (A) Milli-Q water and methanol (90/10, v/v) containing $2\,\mathrm{mM}$ ammonium formate acidified with $0.1\,\%$ formic acid and (B) methanol containing $0.1\,\%$ formic acid. The gradient progressed from $100\,\%$ aqueous phase A to $100\,\%$ organic phase B in $4\,\mathrm{min}$, was held at $100\,\%$ organic phase B for $4.5\,\mathrm{min}$ then returned to $100\,\%$ phase A during $6\,\mathrm{min}$ for re-equilibration. Analyses were performed in multi reaction monitoring (MRM) mode with electrospray ionisation in positive mode (ESI+), except for MCPA et MCPB which were quantified in negative mode (ESI−).

Soil quantification was calibrated using a matrix calibration curve based on pesticide-free organic soil as reference material. For each analysis sequence, three spiked reference soils (0.2, 1 and $10\,\mu\mathrm{g\,kg^{-1}}$) were processed to verify extraction efficiency. Soil solution quantification was performed using a calibration curve prepared in Milli-Q water containing $20\,\%$ acetonitrile, after confirming no matrix effect.

Two active substances were excluded from soil solution quantification due to solubility limitations (fenpicoxamid) and non-linear responses under the conditions applied (pinoxaden). Mefenpyr-diethyl was never quantified in either soil or soil solution samples. We have no explanation for this absence.

Soil samples collected on day 0 ($n = 5$), day 45 ($n = 15$) and day 80 (random selection; $n = 3$) were thawed, sieved, QuEChERS extracted and analysed by LC-QTOFMS in duplicate one month later to assess analytical variability for fluxapyroxad, mefentrifluconazole and tebuconazole (Table S7). The average absolute difference between duplicate quantifications for these molecules was $1.7 \pm_{\mathrm{sd}} 9.2\,\%$ ($n = 23$). Due to their high concentrations, these three molecules required dilution to fit within the calibration range (0.1 to $20\,\mu\mathrm{g\,kg^{-1}}$), introducing a potential source of variability compared to undiluted compounds. In

addition, the one month interval between the first and second analyses may have contributed to the variability. For the sake of readability, this analytical variability is not repeated throughout the paper. As this assessment was not carried out for all quantified molecules, the error bars in Fig. 3 and Fig. 5 do not take this into account.

Table S7. Quantification raw data: soil samples ; Duplicated quantification for analytical variability analysis.

pot	flux	mef.a	tebu
1	255,18	192,64	752,12
2	187,21	144,67	529,58
3	170,65	137,29	508,84
4	201,93	162,88	612,37
5	232,69	182,82	676,60
6	114,86	71,98	302,11
7	107,84	71,11	284,69
8	83,66	55,53	199,90
9	97,98	61,63	255,77
10	90,82	59,46	246,56
11	155,09	108,42	394,38
12	93,42	45,53	219,62
13	107,92	66,80	260,04
14	126,21	83,96	316,39
15	111,87	60,08	278,49
16	151,67	92,11	421,23
17	121,19	71,89	301,65
18	137,92	93,33	361,15
19	137,25	78,93	347,53
20	142,55	87,21	361,14
23	253,17	165,11	601,26
28	276,38	186,24	625,86
33	134,48	69,30	270,45

flux; fluxapyroxad; **mef.a**: mefentrifluconazole; **tebu**: tebuconazole.

Supplement S3: Selection of three contrasted molecules

In order to analyse the behaviour of active substances under the different cover types, we selected a subset of compounds that serve as representative examples of the pesticides used. This selection was based on two main criteria: (1) contrasting physicochemical properties and (2) consistent detection over time in soil samples. In order to maximise the contrast between the 18 applied active substances, we chose not to use PCA clustering —which tends to produce average values from cluster centres— and instead used archetypal analysis (Cutler and Breiman, 1994[1]).

Archetypal analysis is a statistical method that synthesises multivariate observations by identifying a set of extreme points (archetypes) or their closest observed counterparts (archetypoids) that lie on the boundary of the data set. Mathematically, it is an unsupervised learning approach that identifies extreme observations that are convex combinations —linear combinations with positive coefficients that sum to one— of the data set. The analysis was performed using the `archetypes` package in *R* (http://CRAN.R-project.org/package=archetypes; Eugster and Leisch, 2009).

To distinguish between different environmental transfer mechanisms, we selected physicochemical properties relevant to key fate processes (data extracted from the PPDB, Table S5): typical soil persistence ($\mathrm{DT50_{soil}}$, in days) and soil sorption coefficient ($\mathrm{K_{oc}}$, in $\mathrm{mL\,g^{-1}}$) for persistence and mobility in soil, respectively; water solubility at $20\,^{\circ}\mathrm{C}$ (s, in $\mathrm{mg\,L^{-1}}$) and groundwater ubiquity score (GUS, dimensionless) for transfer to soil solution and tendency to leach; vapour pressure at $20\,^{\circ}\mathrm{C}$ (p, in mPa) and Henry's law constant ($\mathrm{k_H}$, in $\mathrm{Pa\,m^3\,mol^{-1}}$) for transfer to air; n-octanol–water partition coefficient (i.e. lipophilicity) at $\mathrm{pH}\,7$ and $20\,^{\circ}\mathrm{C}$ ($\mathrm{K_{ow}}$, dimensionless), bioconcentration factor (BCF, in $\mathrm{L\,kg^{-1}}$) and relative molecular mass (m, dimensionless) for uptake in plants.

To ensure representativeness while avoiding bias towards highly persistent molecules, we prioritised compounds detected in at least $25\,\%$ of samples on day 0 and day 45, rather than selecting only those consistently quantified across all sampling dates. This approach allowed the inclusion of compounds that became undetectable in a compartment by day 80. Recognising the limitations associated with our low LQ in soil solution, we chose not to impose consistent quantification in soil solution samples as a selection criterion. The archetypal analysis algorithm was run 50 times to avoid convergence to a local minimum and the first three archetypes identified were selected: mesosulfuron-methyl, MCPA and mefentrifluconazole. These three substances exhibit low volatility (consistent with their high detection rates) but have distinct physicochemical profiles in terms of water solubility, soil persistence and molecular mass:

- Mesosulfuron-methyl (systemic post-emergence herbicide): moderate soil mobility, moderate water solubility, very low volatility and high molecular weight.
- MCPA (systemic post-emergence herbicide): high soil mobility, very high water solubility, low volatility and low molecular weight.
- Mefentrifluconazole (systemic fungicide): very low soil mobility, low water solubility, low volatility and moderate molecular weight.

[1]Cutler, A., Breiman, L.: Archetypal analysis. Technometrics, 36 (4), 338-347, https://doi.org/10.1080/00401706.1994.10485840, 1994

Supplement S4: Minimal sampling size

Minimal sampling size was evaluated for unilateral testing assuming normal distribution, using the formula:

$$n = \frac{2\left(Z_{1-\alpha} - Z_{\beta}\right)^2}{d^2} \tag{S2}$$

where n is the minimum sample size for each modality to achieve a test power of $1-\beta$ at a threshold of α, where $Z_{1-\alpha}$ and Z_{β} are the quantiles of order $1-\alpha$ and β of the standard normal distribution $\mathcal{N}(0,1)$ and where d is Cohen's d measuring the effect size of the modality (Cohen, 2013):

$$d = \frac{\mu_1 - \mu_2}{\sqrt{\frac{(n_1-1)\sigma_1^2 + (n_2-1)\sigma_2^2}{n_1+n_2-2}}} \tag{S3}$$

where μ_i are the means of the contents in the cover modality and the control, σ_i their standard deviations and n_i their sample sizes. Values of $\alpha = 0.05$ and $\beta = 0.20$ were used throughout the analysis.

We calculated the minimum sample sizes required to achieve at least $80\,\%$ statistical power under similar conditions of active substance levels, variances between independent replicates and cover development. These sample sizes are presented in Table S8 by date, cover type, compartment and active substance.

Table S8. Sample size (n) tested in our experiment (with associated statistical significativity obtained) and minimal sample size (Min. n) needed to reach a statistical power of at least $80\,\%$.

				Soil			*Soil Solution*	
		Substance	n tested	p-val.	Min. n	n tested	p-val.	Min. n
day 45	Thin cover	clopyralid	5 vs 5	·	12	5 vs 5		46
		cloquintocet-mexyl	5 vs 5		57	5 vs 5		–
		fenpicoxamid	5 vs 5		32	5 vs 5		–
		flonicamid	5 vs 5		28	5 vs 5		40
		florasulam	5 vs 5		–	5 vs 5		251
		fluroxypyr	5 vs 5		22	5 vs 5		286
		fluxapyroxad	5 vs 5		29	5 vs 5		98
		MCPA	5 vs 5	·	13	5 vs 5		35
		mefentrifluconazole	5 vs 5		26	5 vs 5		71
		mesosulfuron-methyl	5 vs 5		19	5 vs 5		85
		pyraclostrobin	5 vs 5	·	13	5 vs 5		–
		pyroxsulam	5 vs 5	$*$	6	5 vs 5		99694
		tebuconazole	5 vs 5		33	5 vs 5		29
	Thick cover	clopyralid	5 vs 5	·	9	5 vs 4		17751
		cloquintocet-mexyl	5 vs 5		39	5 vs 4		–
		fenpicoxamid	5 vs 5	·	15	5 vs 4		–
		flonicamid	5 vs 5	$**$	3	5 vs 4		31
		florasulam	5 vs 5		–	5 vs 4		75
		fluroxypyr	5 vs 5	$*$	4	5 vs 4		38
		fluxapyroxad	5 vs 5	$*$	5	5 vs 4		13
		MCPA	5 vs 5		2896	5 vs 4		22
		mefentrifluconazole	5 vs 5	$*$	7	5 vs 4	·	8
		mesosulfuron-methyl	5 vs 5		18	5 vs 4		339
		pyraclostrobin	5 vs 5	$*$	7	5 vs 4		–
		pyroxsulam	5 vs 5	$*$	3	5 vs 4		56
		tebuconazole	5 vs 5	$*$	5	5 vs 4		11

Sample size tested: $n_{\text{cover type}}$ vs n_{control}; ***p*-value:** $0.1 \geqslant \cdot > 0.05 \geqslant * > 0.01 \geqslant ** > 0.001$; **Minimum sample size:** n for both cover and control (–: ND).

Table S8 (continued). Sample size (n) tested in our experiment (with associated statistical significativity obtained) and minimal sample size needed to reach a statistical power of at least $80\,\%$.

				Soil			*Soil Solution*	
		Substance	n tested	p-val.	Min. n	n tested	p-val.	Min. n
day 80	Thin cover	clopyralid	5 vs 5		–	4 vs 5		15
		fenpicoxamid	5 vs 5		20	4 vs 5		–
		flonicamid	5 vs 5		–	4 vs 5		43
		florasulam	5 vs 5		–	4 vs 5		84
		fluroxypyr	5 vs 5		296	4 vs 5		52
		fluxapyroxad	5 vs 5	·	9	4 vs 5		438
		MCPA	5 vs 5		44	4 vs 5		25
		MCPB	5 vs 5		59	4 vs 5		–
		mefentrifluconazole	5 vs 5	$*$	8	4 vs 5	$*$	7
		mesosulfuron-methyl	5 vs 5	$*$	6	4 vs 5		62
		pyraclostrobin	5 vs 5	·	12	4 vs 5		–
		pyroxsulam	5 vs 5		–	4 vs 5		53
		tebuconazole	5 vs 5	$*$	9	4 vs 5		65
	Thick cover	clopyralid	5 vs 5		–	5 vs 4	$**$	3
		fenpicoxamid	5 vs 5	$*$	4	5 vs 4		–
		flonicamid	5 vs 5		–	5 vs 4		31
		fluroxypyr	5 vs 5		–	5 vs 4		19
		fluxapyroxad	5 vs 5	$**$	2	5 vs 4	·	12
		MCPA	5 vs 5	$*$	8	5 vs 4		61
		MCPB	5 vs 5	$*$	4	5 vs 4		–
		mefentrifluconazole	5 vs 5	$**$	2	5 vs 4	$*$	6
		mesosulfuron-methyl	5 vs 5	$*$	5	5 vs 4	$**$	2
		pyraclostrobin	5 vs 5	$*$	4	5 vs 4		–
		pyroxsulam	5 vs 5		–	5 vs 4		14
		tebuconazole	5 vs 5	$**$	2	5 vs 4		118

Sample size tested: $n_{\text{cover type}}$ vs n_{control}; ***p*-value:** $0.1 \geqslant \cdot > 0.05 \geqslant * > 0.01 \geqslant ** > 0.001$; **Minimum sample size:** n for both cover and control (–: ND).

Supplement S5: Additional Figures

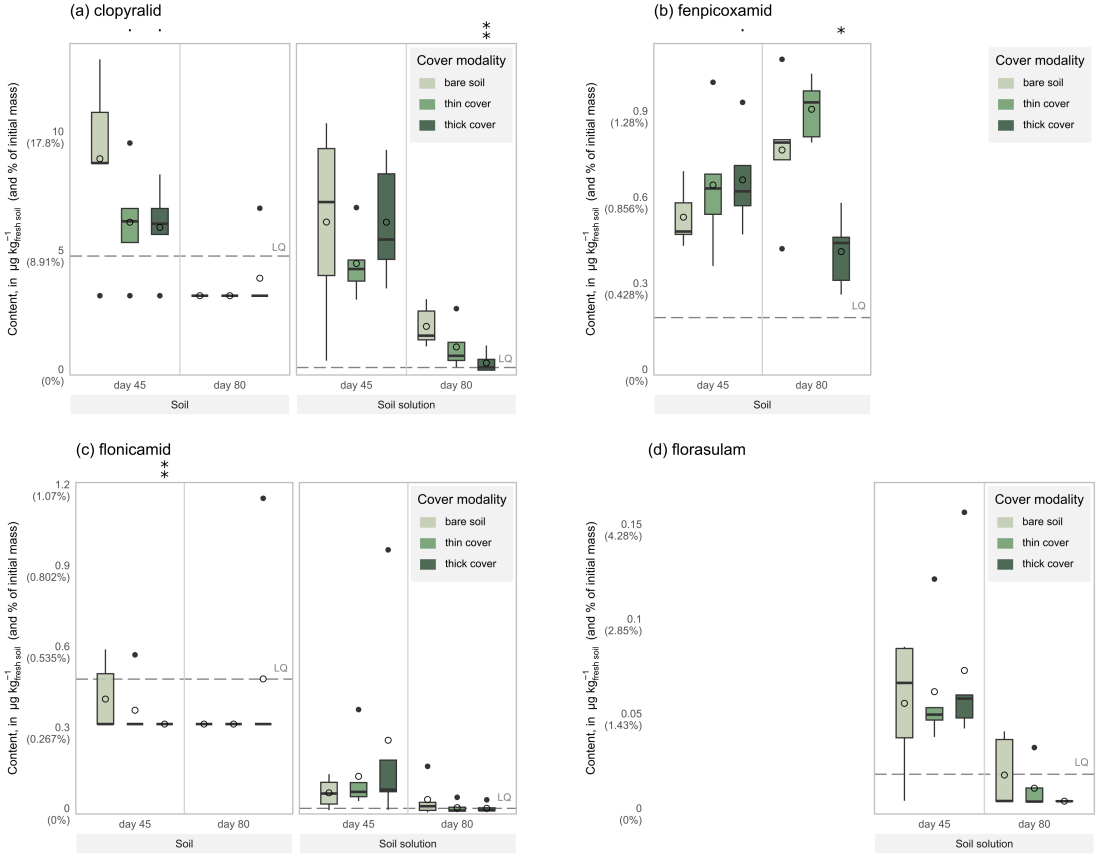

Figure S1. Active substance contents (in $\mu g\,kg^{-1}$ and in proportion of the initial applied mass on day –14) under three cover modalities (bare soil, thin cover and thick cover) in two compartments (soil and soil solution) at two dates (day 45 and day 80). Stars above the graphs depict statistically significant unilateral differences between the cover types and the control (bare soil) at each date (p-value: $0.1 \geqslant \cdot > 0.05 \geqslant * > 0.01 \geqslant ** > 0.001$).

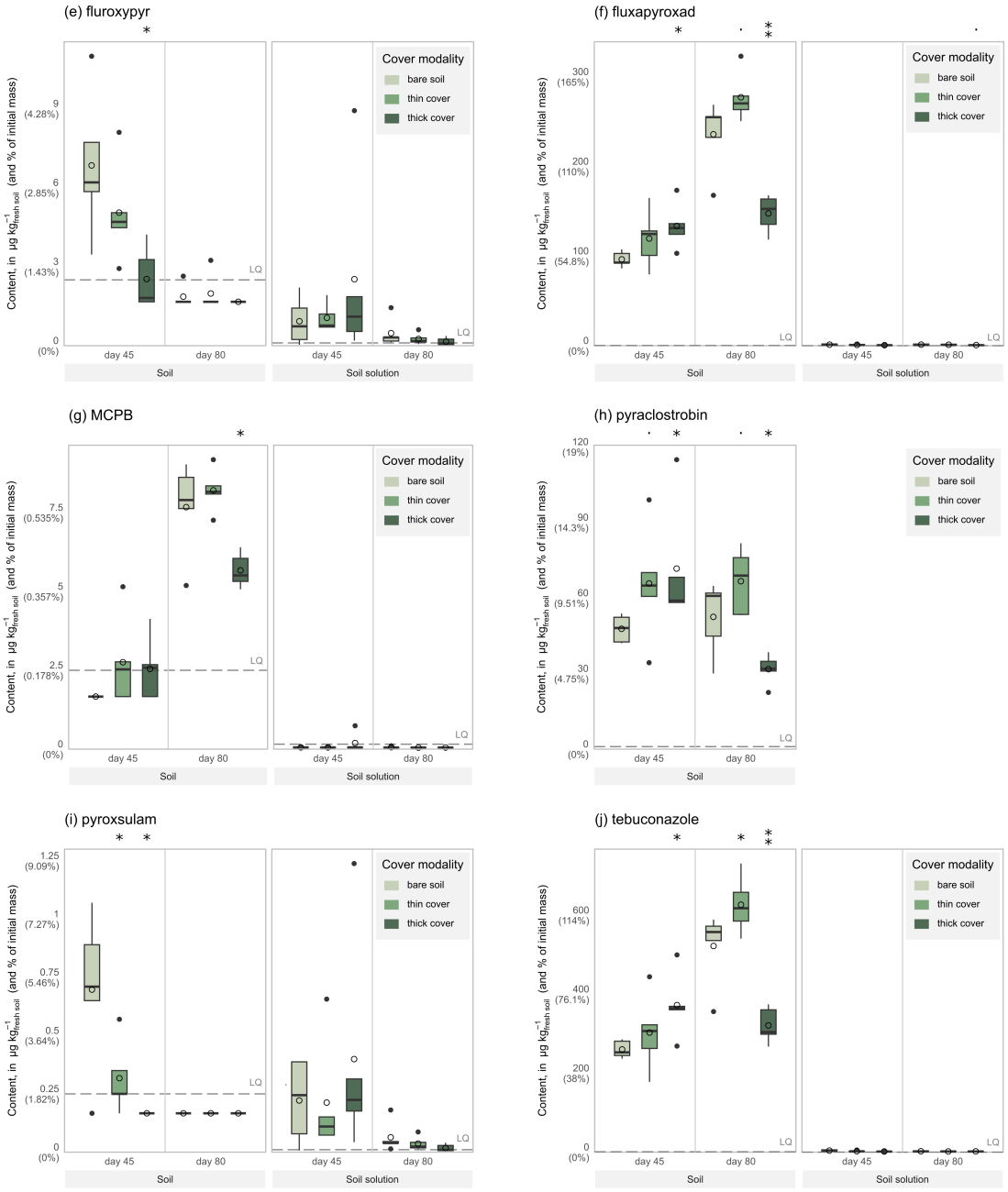

Figure S1 (continued). Active substance contents (in $\mu g\,kg^{-1}$ and in proportion of the initial applied mass on day –14) under three cover modalities (bare soil, thin cover and thick cover) in two compartments (soil and soil solution) at two dates (day 45 and day 80). Stars above the graphs depict statistically significant unilateral differences between the cover types and the control (bare soil) at each date (p-value: $0.1 \geqslant \cdot > 0.05 \geqslant * > 0.01 \geqslant ** > 0.001$).

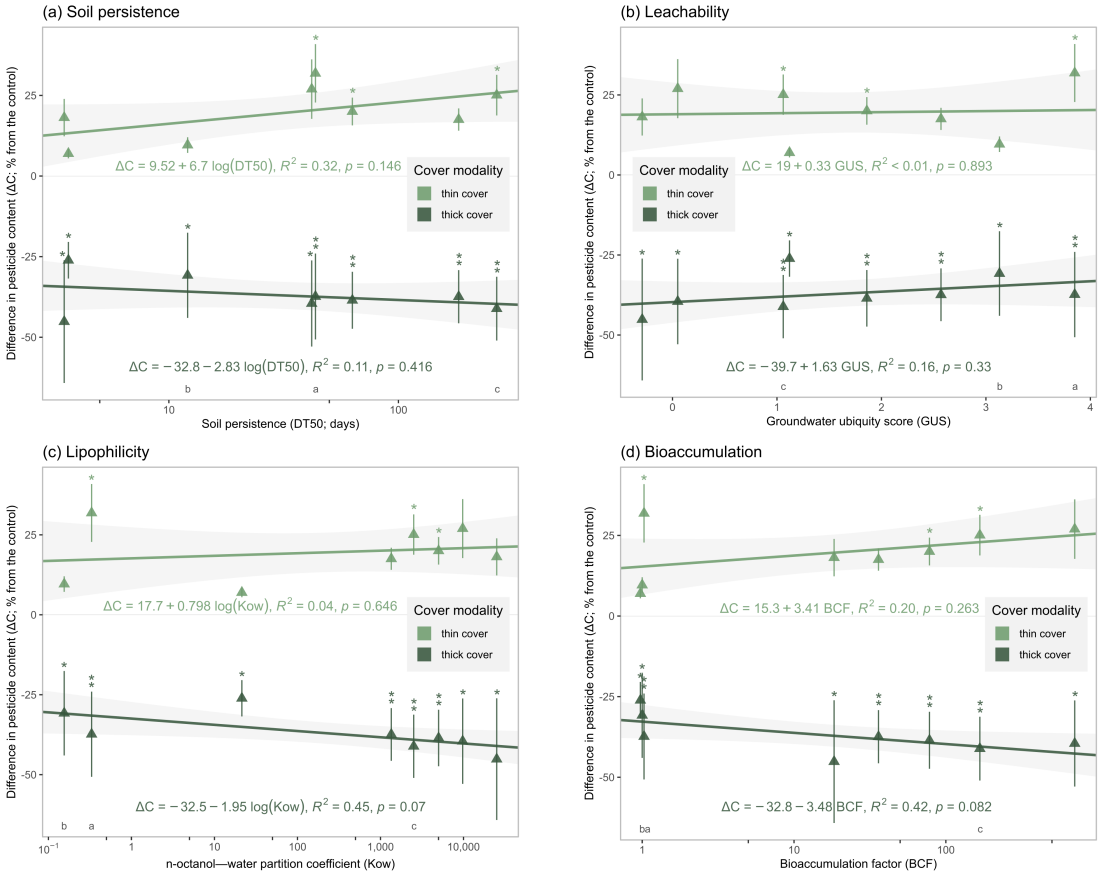

Figure S2. Differences in active substance soil contents compared to the control (bare soil) on day 80, for the eight active substance with $100\,\%$ quantification rate and for both cover types, in function of the active substance's: (a) soil persistence (as $\log(\mathrm{DT}_{50})$), (b) leachability (GUS), (c) lipophilicity (as $\log(\mathrm{K}_{\mathrm{ow}})$ and (d) bioaccumulation (BCF). The coloured lines represent linear fits for both cover types, with $90\,\%$ confidence intervals. The three contrasting molecules are tagged with a letter below them (mesosulfuron-methyl: a; MCPA: b; mefentrifluconazole: c). Stars above the error bars depict statistically significant unilateral differences between the cover type and the control at each date ($*$: $0.05 \geqslant p\text{-value} > 0.01$; $\overset{*}{*}$: $0.01 \geqslant p\text{-value} > 0.001$).