

## Supplementary material

**Table S1.** Frequency of practices related to carbon sequestration according to yield

Yield T/ha		Cover cropping		Compost application		Manure application		Residue incorporation	
		yes	no	Yes	No	Yes	No	Yes	No
Less than 30	count	2	13	4	11	6	9	8	7
	%	66.7	48.1	66.7	45.8	31.6	81.8	40.0	70.0
Between 30 to 40	Count	0	11	1	10	9	2	8	3
	%	0	40.7	16.7	41.7	47.4	18.2	40.0	30.0
Between 40 to 50	Count	33.3	11.1	1	3	4	0	4	0
	%	2	13	16.7	12.5	21.1	0	20.0	0.0

Table S2. Different pesticides used in grapevine cultivation in Sebou Basin area and some toxicological information's

Active ingredients	Category	CAS RN	Trade names	Chemical families	WHO Classification	Toxicological information's		
						Enviro. Fat	Ecotoxicity	Human health
Abamectin	Insecticide	71751-41-2	ACAGRIM 18EC/GLOBAMEC	Micro-organism derived	Ib	m	h	h
Acrinathrin	Insecticide	101007-06-1	ORYTIS EW 7.5	Pyrethroid	U	m	h	m
Ametoctradin	Fungicide	865318-97-4	ORVEGO*	Triazolopyrimidine	III	m	h	m
Argile sulfurée	Fungicide	NA	MYCO-SIN	NA	NA	-	-	-
Azoxystrobin	Fungicide	131860-33-8	ORTIVA 25 SC/ ALFABET 250SC	Strobilurin	U	h	m	m
Bacillus thuringiensis var. Kurstaki ABTS-351	Insecticide	68038-71-1	DIPEL 8L	Micro-organism	III	m	m	l
Benalaxyl	Fungicide	71626-11-4	GALBEN M*	Acylamino acid	III	m	m	m
Boscalid	Fungicide	188425-85-6	COLLIS SC*	Carboxamide	U	h	m	m
Chlorpyrifos methyl	Insecticide	5598-13-0	EXOCIDE 48 EC	Organophosphate	III	m	h	h
Copper hydroxide	Fungicide	20427-59-2	BLUE SHIELD	Inorganic compound	II	l	h	m
Copper oxychloride	Fungicide	1332-40-7	COPRANTOL BLEU/ACROBAT CU*	Inorganic compound	II	m	h	m
Copper sulfate	Fungicide	7758-98-7	SERGOMIL L-60/ COPAS	Inorganic compound	II	l	m	h
Cyflufenamid	Fungicide	180409-60-3	KAISER 10SC	Amide	NA	m	h	m
Cymoxanil	Fungicide	57966-95-7	AVISO DF*/ EQUATION PRO*	Cyanoacetamide oxime	II	h	m	h
Cyprodinil	Fungicide	121552-61-2	SWITCH 62.5WG*	Anilinopyrimidine	NA	m	h	m
Deltamethrin	Insecticide	52918-63-5	DECIS FLUXX	Pyrethroid	II	h	h	h
Dicofol	Insecticide	115-32-2	DICOLTHANE WP/ ARTILA	Organochloride	II	h	h	h
Difenoconazole	Fungicide	119446-68-3	PRIORI TOP*	Conazole	II	h	h	m
Dimethomorph	Fungicide	110488-70-5	ORVEGO*	Morpholine	III	m	h	m
Essence d'orange [d-limonène]	Insecticide	8028-48-6	LIMOCIDE	Plant derived substance	NA	-	m	m
Famoxadone	Fungicide	131807-57-3	TITAH*	Dicarboximide	U	h	h	m
Fenamidone	Fungicide	161326-34-7	VERITA FLASH*	Imidazole	III	m	m	m

Fludioxonil	Fungicide	131341-86-1	SWITCH 62.5WG*	Phenylpyrrole	U	h	h	m
Fluopicolide	Fungicide	239110-15-7	PROFILER*	Benzamide	U	h	m	m
Folpet	Fungicide	133-07-3	MIKAL FLASH*	Phthalimide	U	m	h	m
Fosetyl-Aluminium	Fungicide	39148-24-8	ALLUM WG/ VERITA FLASH*	Organophosphate	U	h	m	m
Glyphosate	Herbicide	1071-83-6	ROUNDUP TURBO	Organophosphate	III	m	m	m
Hexaconazole	Fungicide	79983-71-4	ORSALIS 5% SC/ HEXA5 SC	Triazole	III	h	m	h
	Pesticide	64741-89-5	SPRAY OIL 7 E/ OVIPRON 78EC	Unclassified	NA	h	na	h
Imidacloprid	Insecticide	138261-41-3	BRIGHT SC*	Neonicotinoid	II	h	h	h
Indoxacarb	Insecticide	173584-44-6	AVAUNT 150 EC	Oxadiazine	II	h	h	h
Iprodione	Fungicide	36734-19-7	IPROSS 480SC	Dicarboximide	III	m	m	h
Kresoxim-methyl	Fungicide	143390-89-0	ALLIAGE/ COLLIS SC*	Strobilurin	III	h	m	h
Lambda cyhalothrin	Insecticide	91465-08-6	KARATE 5 EC/ KARIS 10SC	Pyrethroid	II	h	h	h
Malathion	Insectide	121-75-5	MALYPHOS 50/ MALAPRON	Organophosphate	III	m	h	h
Mancozeb	Fungicide	0818-01-7	FORTUNA BLEUE 80 WP/ KEM-TAN	Carbamate	U	h	h	h
Mandipropamid	Fungicide	374726-62-2	REVUS 250	Amide	U	m	m	m
Maneb	Fungicide	12427-38-2	MOLOSS M*/ MANAGRI	Carbamate	U	m	h	h
Meptyldinocap	Fungicide	131-72-6	KARATHANE 3D	Dinitrophenol	III	m	h	h
Metalaxyl	Fungicide	57837-19-1	RIDOMIL GOLD R WG*	Anilide	II	m	m	m
Methomyl	Insecticide	16752-77-5	SALVADOR 25WP	Carbamate	Ib	h	h	h
Metiram	Fungicide	9006-42-2	AVISO DF*	Carbamate	U	m	h	m
Myclobutanil	Fungicide	88671-89-0	MIRACLE	Triazole	II	m	m	h
Oxyfluorfen	Herbicide	42874-03-3	GOAL460SC	Nitrophenol ether	U	m	h	h
Penconazole	Fungicide	66246-88-6	TOPENCO 100 EC	Triazole	III	h	m	h
Propineb	Fungicide	12071-83-9	ANTRACOL 70 WP	Carbamate	U	na	h	m
Pyraclostrobin	Fungicide	175013-18-0	PRISTINE*/ CABRIO DUO	Strobilurin	NA	h	h	h
Pyriproxyfen	Insecticide	95737-68-1	ADMIRAL 10 EC	Juvenile hormone mimic	U	m	h	m
Pythium oligandrum	Fungicide	NA	POLYVERSUM	Micro-organism	NA	-	l	l

Sulphur	Fungicide	7704-34-9	AZUMO MG/ MICROTHIOL SPECIAL	Inorganic compound	III	m	h	l
Spirotetramat	Insecticide	203313-25-1	MOVENTO 100 SC	Tetramic acid	III	m	m	h
Sulfoxaflor	Insecticide	946578-00-3	CLOSER 240 SC	Sulfoximine	II	h	h	m
Tau-fluvalinate	Insecticide	102851-06-9	MAVRIK 2F	Pyrethroid	III	m	h	h
Tebuconazole	Fungicide	107534-96-3	MATIZ 250 EW	Triazole	II	m	h	h
Tetraconazole	Fungicide	112281-77-3	EMERALD 125	Triazole	II	h	m	m
Thiophanate-methyle	Fungicide	23564-05-8	PELT 44/ PELT 70 WDG	Carbamate	U	m	h	h
Triadimenol	Fungicide	55219-65-3	MATADOR 300 EC*	Triazole	II	m	h	h
Trifloxystrobin	Fungicide	141517-21-7	FLINT 50WG	Strobilurin	U	m	h	h
Nbr of A. I.: 58			Nbr of C. F.: 31					

Ia: Extremely hazardous, Ib: Highly hazardous, II: Moderately hazardous, III: Slightly hazardous, U: Unlikely to present acute hazard in normal use, A.I.: Active ingredient, C.F.: chemical families, l: Low alert, m:

Medium alert, h: Hight alert.

Table S3. Regression analysis of grapevine yield on number of pesticide application

Coefficient <sup>A</sup>				
Model				
	B	Std. Error	Beta	t      Sig.
(Constant)	0.140	3.392		-0.41   0.967
Nbr. Of pesticides treatments	1.029	.126	.839	8.175   0.000

A. Dependent Variable: Yield in t/ha, t : t-test. B-Unstandardized Coefficients, Beta-Standardized Coefficients.

Table S4. EIQ values of pesticides in Sebou Basin vineyards.

(Farm Worker+ Consumer+ Ecological)/3 C(DT*5) +C(DT*P) C*((S+P)/2) *SY)+L (Fish)+(Bird) +(Bee)+ (Beneficial)						
CAS Number	Common Name	Action	EIQ Value	Farm Worker	Consumer	Ecology
71751-41-2	abamectin	I	34.68	13.80	3.90	86.35
101007-06-1	acrinathrin	I	25.33	6.00	2.00	68.00
865318-97-4	ametoctradin	F	16.67	6.00	2.00	42.00
131860-33-8	azoxystrobin	F	26.92	8.10	6.05	66.62
68038-71-1	bacillus thuringiensis	I	13.33	6.90	2.45	30.63
71626-11-4	benalaxyl	F	16	9	10	29
188425-85-6	boscalid	F	26.44	12.15	21.23	45.95
5598-13-0	chlorpyrifos-methyl	I	36.71	10.35	4.15	95.62
20427-59-2	copper hydroxide	F	33.20	24.30	9.05	66.25
1317-39-1	copper oxide	<u>E, I</u>	62.00	15	11	160.00
1332-40-7	copper oxychloride	F	29.80	8.10	5.05	76.25
12527-76-3	copper sulfate	F	61.90	24.30	13.15	148.25
7758-99-8	copper sulfate pentahydrate	F	69.83	25.00	15.50	144.00
8011-63-0	copper sulfate+lime	F	67.67	108.00	19.00	76.00
180409-60-3	cyflufenamid	<u>E</u>	16.50	6	7	36.50
57966-95-7	cymoxanil	F	35.48	21.87	21.61	62.95
121552-61-2	cyprodinil	F	26.77	12.15	14.73	53.45
52918-63-5	deltamethrin	I	28.38	18.00	2.00	65.15
115-32-2	dicofol	I	29.92	10.35	4.68	74.72
119446-68-3	difenoconazole	F	22.00	8.00	10.00	48.00
110488-70-5	dimethomorph	F	14.00	6.00	7.00	29.00
131807-57-3	famoxadone	F	10.36	9.00	2.50	19.59
161326-34-7	fenamidone	F	18.29	6.90	7.35	40.63
131341-86-1	fludioxonil	F	23.87	8.10	3.05	60.45
239110-15-7	fluopicolide	F	26.00	14.00	15.00	38.00
0133-07-03	folpet	F	31.73	12.15	6.08	76.95
39148-24-8	fosetyl-aluminium	F	12.00	6.00	4.00	26.00
38641-94-0	Glyphosate-isopropylamine	H	20.75	20	7.25	35.00

79983-71-4	hexaconazole	F	52.33	60	46	51
138261-41-3	imidacloprid	I	36.71	6.90	10.35	92.88
144171-61-9	indoxacarb	I	31.19	6.90	2.45	84.22
36734-19-7	iprodione	F	24.25	16.20	9.10	47.45
143390-89-0	kresoxim-methyl	F	15.07	9.00	4.50	31.70
91465-08-06	lambda-cyhalothrin	I	44.17	20.70	3.45	108.35
121-75-5	malathion	I	23.83	9.00	4.50	58.00
8018-01-07	mancozeb	F	25.72	20.25	8.13	48.79
374726-62-2	mandipropamid	F	27.14	21.87	19.61	39.95
12427-38-2	maneb	F	21.43	21.00	10.00	33.30
131-72-6	meptyldinocap	F	20	6	2	52
57837-19-1	metalaxyl	F	13.17	6	9	24.50
70630-17-0	metalaxyl-m	F	19.07	8.10	12.15	36.95
16752-77-5	methomyl	I	22.00	6.00	11.00	49.00
88671-89-0	myclobutanil	F	24.01	8.10	12.15	51.79
42874-03-03	oxyfluorfen	H	33.82	12.00	7.00	82.45
8012-95-1	paraffinic oil	Ac, I, Adjuvant	20,17	20.00	7.50	33.00
66246-88-6	penconazole	F	23,33	12.00	13.00	45.00
12071-83-9	propineb	F	16.90	9.00	2.50	39.20
175013-18-0	pyraclostrobin	F	27.01	8.10	4.05	68.87
95737-68-1	pyriproxyfen	I, IGR	14.67	6.00	2.00	36.00
203313-25-1	spirotetramat	I	35.29	13.11	5.99	86.77
946578-00-3	sulfoxaflor	I	18.83	15.00	12.50	29.00
7704-34-9	sulfur	F	32.66	21.87	8.29	67.82
102851-06-9	tau-fluvalinate	i	23.17	12	3	54.50
107534-96-3	tebuconazole	F	40.33	20.00	31.00	70.00
112181-77-3	tetraconazole	F	29.00	12.00	21.00	29.00
23564-05-08	thiophanate-methyl	F	23.82	16.20	15.30	39.95
55219-65-3	triadimenol	F	24.82	16.20	21.30	36.95

141517-21-7	trifloxystrobin	F	29,78	12,15	10,23	66,95
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DT: Acute dermal toxicity, L: Leaching potential, S: Soil residue half life, SY: Mode of action, C: Chronic health effects, P: Plant surface health effects. IGR: insect growth regulator, AC: acaricide, I: insecticide, F: fungicide, H: herbicide



**Table S5.** List of the nineteen most used AIs in vineyard located in SRB with their biological activity, their physicochemical (Soil half-life, Koc, GUS, Kow, Kh) and toxicological properties (LC<sub>50</sub> for Bees, earthworm and Daphnia, and EC<sub>50</sub> for Algae (PPDB, 2018; NCBI, 2018), and CLP Classification according the EU Pesticides database (EU database, 2019).

Classification according to the EC Pesticides database (EC database, 2017).												
Pesticides AI's	Biological Activity	DT <sub>50</sub>	Koc	GUS	Kow	Khf (Pa. m <sup>3</sup> /mol)	LC <sub>50</sub> g Bees (mg/bee)	LC <sub>50</sub> Worm (mg/Kg)	LC <sub>50</sub> Daphnia (mg/L)	EC <sub>50</sub> Algae (mg/L)	CLP Classification	
Sulphur	F	30	1950	-0.7 1 L	N	.	0.05	106.8×10 <sup>-3</sup>	> 2000	> 0.063	> 0.063	Health: H335, H319, H315
Copper (I) oxyde	F	0.1	1000	-1 L	N	0.4 4	.	12.1×10 <sup>-3</sup>	> 489.6	0.29	165.9	Health: H302, H314, H315, H319, H332 / Environment: H400, H410
Mancozeb	F	0.05	998	-1.4 5 L	N	2.3	6.17×10 <sup>-02</sup>	0.11	>299	0.07	0.04	Health: H317, H361d/ Environment: H400
Azoxystrobin	F	78	589	3.1 L	L	2.5	7.40×10 <sup>-09</sup>	25×10 <sup>-3</sup>	283	0.23	0.36	Health: H331/ Environment: H400, H410
Lambda cyhalotrin	I	175	2837 07	-2.0 9 L	N	5.5	2.00×10 <sup>-02</sup>	9.1×10 <sup>-4</sup>	> 500	2.3.10 <sup>-4</sup>	> 0.005	Health: H301, H312, H330 / Environment: H400, H410
Boscalid	F	484 .4	.	2.6 8 L	S	2.9 6	5.18×10 <sup>-05</sup>	> 0.16	> 500	5.33	3.75	Environment: H400, 410
Pyraclostrobin	F	41. 9	9304	0.0 5 L	N	3.9 9	5.31×10 <sup>-06</sup>	> 0,11	567	0,016	> 0,843	Health: H315, H331, H335/ Environment: H400, H410
Cymoxanil	F	1,7	.	1,4 7 L	N	0,6 7	3,30×10 <sup>-05</sup>	> 85.3×10 <sup>-3</sup>	> 1000	27	0.254	Health: H302, H317, H361fd, H373/ Environment: H400, H410
Thiophanate- methyl	F	0,5	.	0.5 L	N	1.4	1.67×10 <sup>-04</sup>	0.11	> 13.2	5.4	> 25.4	Health: H317, H332, H340/ Environment: H400, H410
Cyprodinil	F	37	.	1.0 6 L	N	4	6.60×10 <sup>-03</sup>	> 0.112	192	0.22	2.6	Health: H317 / Environment: H400, H410
Fludioxonil	F	164	1456 00	-1.3 5 L	N	4.1 2	5.40×10 <sup>-05</sup>	> 0.1	>= 1000	0.4	0.024	Health: H311, H319 / Environment: H400, H410, H412
Penconazole	F	117	.	1.2 8 L	N	3.7 2	6.60×10 <sup>-04</sup>	> 11.2×10 <sup>-3</sup>	> 331.5	6.75	4.9	Health: H302, H361d / Environment: H400, H410
Imidacloprid	I	191	.	3.6 9 L	L	0.5 7	1.7×10 <sup>-10</sup>	3.7×10 <sup>-6</sup>	10.7	85	> 10	Health: H302 / Environment: H400, H410
Maneb	F	1	2000	0.7 5 L	N	- 0.4 5	2.08×10 <sup>-05</sup>	> 89.5×10 <sup>-3</sup>	840	2.1.10 <sup>-3</sup>	0.007	Health: H317, H319; H332; H361d /Environment: H400, H410
Malathion	I	0.1 7	1800	0 L	N	2.7 5	1.00×10 <sup>-03</sup>	0.4×10 <sup>-3</sup>	306	7.10 <sup>-4</sup>	13	Health: H302, H317 / Environment: H400, H410
Ametoctradin	F	1.8	7713	0.5 5 L	N	4.4	4.13×10 <sup>-07</sup>	> 0.111	> 1000	44.10 <sup>-3</sup>	> 0.118	Health: H302
Dimethomorph	F	72. 7	.	2.2 6 L	S	2.6 8	2.5×10 <sup>-05</sup>	> 32.4×10 <sup>-3</sup>	> 500	> 20.1	29.2	Environment: H411
Abamectine	I	25	5.63 8	0.2 5 L	N	4.4	2.7×10 <sup>-03</sup>	1 × 10 <sup>-06</sup>	33	0.00	> 1.59	Environment: H400, H410

Hexaconazole F 122 1040 2.3 S 3.9 3.33×10<sup>-04</sup> > 0.1 414 > 2.9 > 0.1 Health: H302, H317 / Environment: H411

AI: Insecticide, including acaricide, I: Insecticide, F: Fungicide; H: Herbicide, DT<sub>50</sub>: Half-life in soil (day), Koc: Soil sorption coefficient, GUS: Groundwater ubiquity score, Kow: Partion coefficient, Kh: Henry's constant, LC<sub>50</sub>: Lethal concentration value, NL: Non-Leachable, L: Leachable, SL: Slightly-Leachable, “.”: Unknown.

Table S6. Pesticide ERS calculated using the PERI model for eighteen AI commonly used in SRB vineyards and GUS, Kh, Kow, algae (A), bee (B), daphnia (D) and worm (W) values used in the calculations.

Active substances	ERS	GUS score	Kh score	Kow score	Bscore	Wscore	Dscore	Ascore
Hexaconazole	5.75	4	1	5	4	2	3	5
Imidacloprid	5.325	5	1	1	5	3	2	3
Azoxystrobin	5.375	5	1	1	5	2	4	4
Cyprodinil	4.625	3	1	5	4	2	4	3
Penconazole	4.625	3	1	5	5	2	3	3
Boscalid	4.3	4	1	1	4	2	3	3
Dimethomorph	4.275	4	1	1	5	2	2	2
Abamectine	4	2	1	5	5	3	5	3
Pyraclostrobin	3.875	2	1	5	4	2	5	4
Ametoctradin	3.75	2	1	5	4	1	5	4
Cymoxanil	3.3	3	1	1	5	1	2	4
Lambda cyhalotrin	3.125	1	1	5	5	2	5	5
Fludioxonil	2.875	1	1	5	4	2	4	5
Maneb	2.425	2	1	1	5	2	5	5
Thiophanate-methyl	2.3	2	1	1	4	3	3	2
Mancozeb	1.4	1	1	1	4	2	5	5
Malathion	1.35	1	1	1	5	2	5	2
Cupper (I) oxyde	1.3	1	1	1	5	2	4	1
Sulphur	—	1	1	.	4	1	5	5

Table S7. The AIs most commonly used in Sebou bassin, the chemical products, and the correspondent final indicator of ERS

Active substance	Commercial products	final ERS
Hexaconazole	HEXA 5SC/ ORSALIS 5% SC	7.6475
Imidacloprid	BAZOOKA 200/ ADMIRE 200SL/ AKOPRID 200 SL	4.84575
	BILAD /BOREY SC/ BRIGHT SC	4.95225
Azoxystrobin	ORTIVA 25 SC/ ALFABET 250 SC/ AZUR 250SC	5.4825
	ZEBRA 320 SC	4.99875
	PRIORI TOP/ SPARTACUS DUO	6.82625
Cyprodinil	SWITCH 62,5WG	4.625
	CHORUS 50 WG	3.9775
Penconazole	TOPENCO 100 EC/ TOPAS 100EC/ BAYOUD 10 EC	4.5325
	TOKRA	5.78125
Boscalid	COLLIS SC/ HEXAGON	4.472
	PRISTINE / BELLIS WG	4.988
Dimethomorph	ORVEGO	4.14675
	ACROBAT CU	4.595625
	CABRIO DUO	3.6765
Abamectine	ACAGRIM 18EC/ GLOBAMEC/ ECHELLE 18EC / VERTIMEC	2.92
Pyraclostrobin	CABRIO DUO	3.3325
	PRISTINE / BELLIS WG	4.495
Ametoctradin	ORVEGO	3.6375
Cymoxanil	AVISO DF	3.3
	EQUATION PRO/ TITAH	3.564
	FUNGOMIL 72WP /CYMOMIL 72 WP	1.617
Lambda cyhalotrin	BILAD /BOREY SC/ BRIGHT SC	2.90625
	REEVA 5 EC/ KARATE 5 EC/ OSMOZE	2.25
Fludioxonil	SWITCH 62,5WG	2.875
Maneb	MOLOSS M/ COVAX M	2.06125
	MANEB 80/ MANAGRI	2.425
Thiophanate-methyl	PELT 44	2.3
	PELT 70 WDG/ ACTAMYL 70 WP/ THIOGRI 70	1.794
Mancozeb	MANCOXYDE	1.3958
	FUNGOMIL 72WP /CYMOMIL 72 WP	0.686
	GALBEN M	1.75
	FORTUNA BLEUE 80 WP/ MANCOTHANE 80/ KEM-TAN/ DITHANE M 45	1.162

Malathion	SMART 440 EW	1.24875
	POLATHION 50 /MALAPRON/ SIF MALATHION 50/MALYPHOS 50	1.2555
Cupper (I) oxyde	RIDOMIL GOLD R WG/ FLARE GOLD	0.884
	ACROBAT CU	1.3975

Figures

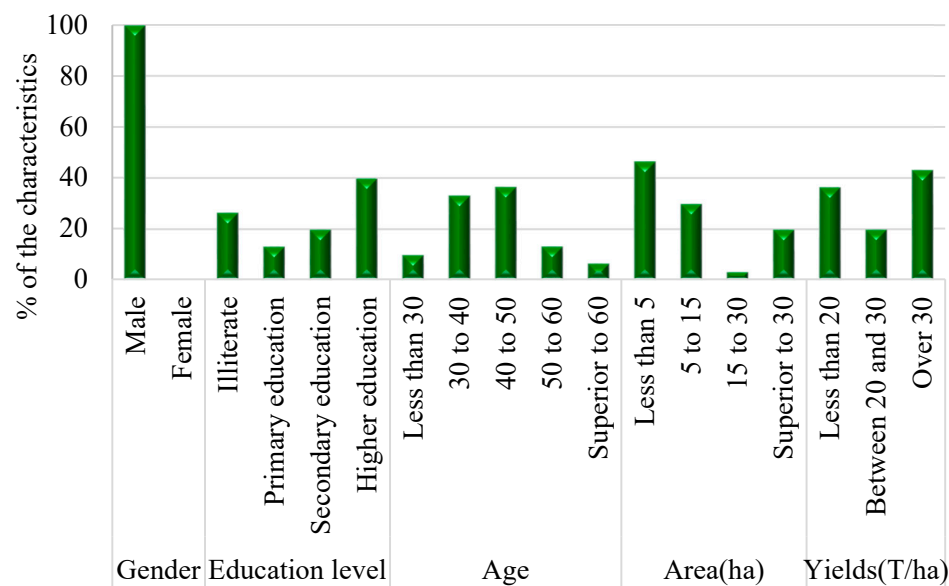


Figure S1. Characteristics of winegrowers and vineyards in region surveyed.

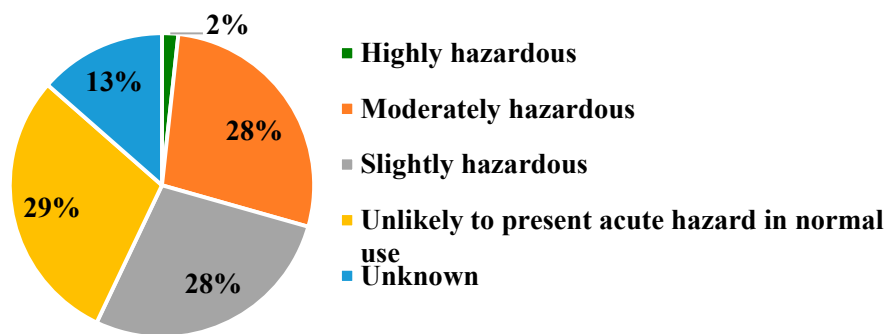


Figure S2. Distribution of chemical families listed according to the WHO classification

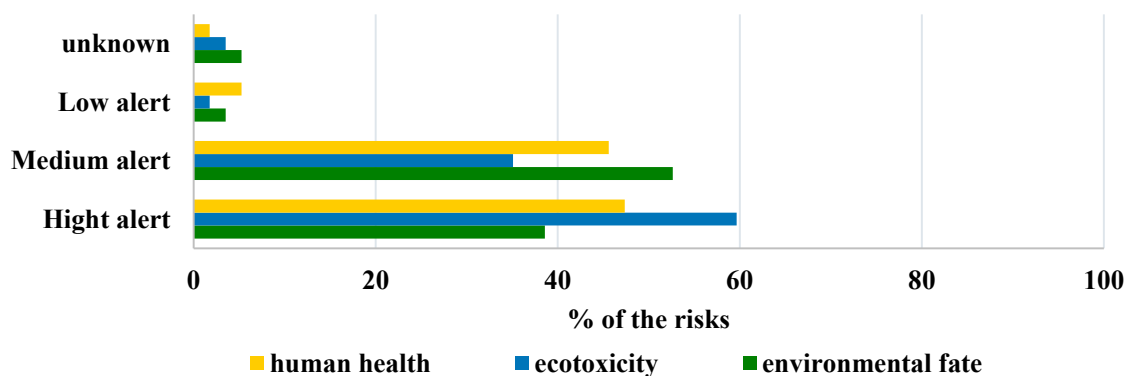


Figure S3. Risks associated with the active ingredients used in the study area according to the Pesticide Properties Database.

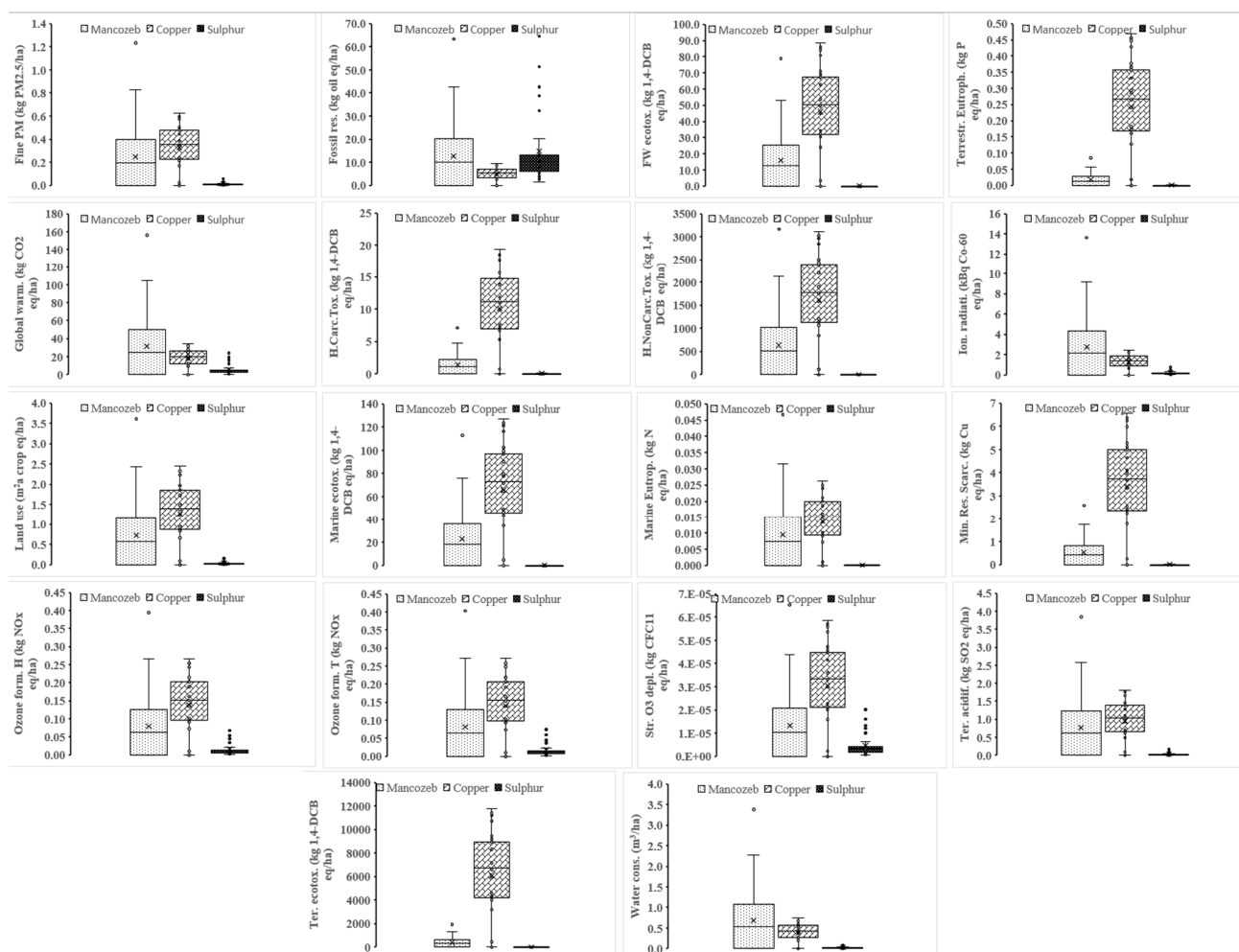


Figure S4. Comparison of the three most commonly used plant protection products