ENDURE

European Network for Durable Exploitation of crop protection strategies

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PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

ENDURE: European Network for Durable Exploitation of crop protection strategies

AI: active ingredient (ingredient which is responsible for the action of a product, e.g. pesticide)

PPP: plant protection product (also pesticide in the text)

MRL: The Maximum Residue Limit (MRL) is the maximum concentration of residues in a product considered by the authorities as without sanitary hazard for the consumer and without effect on the manufacturing processes.

Summary

Fresh vegetables are an important production in Europe accounting for a share of 8.9 % of the overall output value of the European agricultural industry. Moreover, they are recognized for their nutritional value and for their beneficial impact on human health, especially in the prevention of coronary heart diseases and some cancers. Most of the vegetables which are consumed within Europe are produced in the different member states. Crop protection which objective is to ensure quality and safety of the products (with respect to minimizing pest damage symptoms and pesticide residues, for example) is thus questioned for three reasons: (i) registration of PPPs is made on a national basis and is known to be different from among the countries, (ii) producers fear exceeding MRLs which would ruin the campaign in favour of vegetable consumption, (iii) most vegetable crops are minor crops grown on a comparatively small production area and thus of low economic interest for the pesticide industry applying for the approval of new PPPs. In this project we have reported the different options that were available to growers in 7 European countries (CH, D, DK, E, F, I, NL) for 5 major vegetable crops (cabbage, onion, carrot, leek, lettuce), and analysed the differences between countries. For a given crop, the numbers of active ingredients (AI) which are registered greatly varies among the countries. For example, methods to control weeds, insects and diseases on cabbage rely on 60 active ingredients in Switzerland compared to 43, 42, 29, 28 and 9 for respectively Spain, France, Italy, The Netherlands, Germany, and Denmark. Denmark is the country with the lowest number of pesticide options. Switzerland is the country with the greatest numbers and diversity in available PPPs, but is also the country where proposed biocontrol options are most numerous. The importance of a harmonization of the availability of PPPs at the European level is discussed as well as the benefit of considering situations being ahead in offering the widest range of biocontrol methods

Teams involved: INRA, Agros, AU, JKI, SSSUP, UdL, WUR, *also contribution from Ulf Reiling (RA4.3) for complement on natural products and BCAs*

Geographical areas covered: Denmark, France, Germany, Italy, Spain, Switzerland, The Netherlands.

1. Vegetable production in Europe

European statistics on field vegetable area and production are not easy to extract from global figures grouped within 'Fruit and Vegetables' or as 'Fresh vegetables', including in this latter case field vegetables and vegetables grown under shelter (cold shelter or greenhouses). In the following section, figures are given for 'Fresh vegetables'.

1.1. The importance of fresh vegetables in Europe

According to Eurostat statistics, fresh vegetables including occupy 2% of the arable crops (EU-27, 2005) while accounting for a share of 8.9% of the overall output value (producer prices, 2006) of the agricultural industry. As a comparison, cereals account for 56% of the arable land and for 9.6% of the overall output value of the agricultural industry.
Fresh vegetables cover a wide range of crops grown in fields or under shelter

Source: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-ED-08-001/EN/KS-ED-08-001-EN.PDF

In Italy, 476 400 ha were devoted to fresh vegetable production in 2006. Spain ranks second with 397 900 ha (2005 figure), France third with 254 500 ha. These three main producers are followed by Poland (197 900 ha), Greece (116 000 ha), UK (111 800 ha), Germany (106 400 ha, 2005 figure), Hungary (91 100 ha) and The Netherlands (81 200 ha). According to UMS (Union Maraîchère Suisse) about 11 000 ha are dedicated to fresh vegetables (2006).

Source: http://agreste.agriculture.gouv.fr/IMG/File/plant_production.pdf

Thus, this is an important economic sector for Europe and within Europe as 81% of the imports by member states origin from other EU countries (*vs* 63 % for fruits). In 2007, 7 701 000 tons of vegetables where exchanged within the EU, while 1 781 000 t were exported and 1 217 000 t imported. Tomato accounted for 26% of the importation from outside the EU.

Source: http://ec.europa.eu/agriculture/agrista/2008/table_en/index.htm and http://www.coleacp.org/fr/system/files/file/coleacp/ApercuEchangesHorticolesACP.pdf

1.2. Importance of the 5 chosen crops in Europe and in the Case Study participating countries

1.2.1. Cabbage

Cabbage crops cover a range of different commodities which makes it difficult giving providing statistics for this production. As far as cauliflower is concerned, the European production (EU-27) represented 2 500 000 tons in 2005. 25% were produced in Italy, 17% in Spain and 16% in France. Poland and UK accounted each for 9% of the European production, Germany for 7%, Belgium for 7%, the other countries accounting for the remaining 14%.
Other cabbages represent a production of 5 000 000 tons in Europe with Poland being the main producer (1 350 000 t), followed by Germany (710 000 t) and Romania (production fluctuating between 550 000 t and 1 000 000 t depending on the year).

Source: httphttp://agreste.agriculture.gouv.fr/IMG/pdf/chou0905note.pdf.

1.2.2. Onion

5 306 000 tons of onion were produced in 2005 (2006)[1] in EU-27, with Spain and The Netherlands being the major producers (1 174 000 and 1 085 000 t respectively), followed by Poland (653 000 t), Germany (378 000 t), UK (376 000 t), Italy (361 000 t), France (321 000 t) and Romania (312 000 t), while the other European countries contribute with less than 100 000 t with the exception of Greece (199 000 t). Denmark ranks 12 with 56 000 t. Switzerland has a production of 26 000 t.

Source: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-ED-08-001/EN/KS-ED-08-001-EN.PDF

1.2.3. Carrot

5 415 000 tons of carrots were produced in 2005 (2006) in EU-27. Poland is the major producer with 902 000 t, followed by UK and France (752 000 and 625 000 t respectively), Italy, The Netherlands, Germany and Spain with contributions of 549 000, 543 000, 518 000 and 478 000 t respectively. Denmark ranks 13 with 69 000 t. Switzerland has a production of 66 000 t.

Source: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-ED-08-001/EN/KS-ED-08-001-EN.PDF

1.2.4. Lettuce

In 2005, 2 573 000 tons of lettuce were produced in Europe, Spain accounting for 41%, Italy and France for 14 % each, Germany for 9 %, UK for 5%, Belgium for 3 %, The other countries accounted for the remaining 14 %. Switzerland has a production of 32 000 t.

Source: http://agreste.agriculture.gouv.fr/IMG/pdf/laitue0802note.pdf

1.2.5. Leek

In 2006, 800 000 tons of leek have been produced, increasing by 30 % between 1990 and 2006. In 2007, 828 000 tons were produced in the EU. France ranks first with 21% followed by Belgium (18%). Behind those two leaders, the countries contributing significantly are The Netherlands (14%), Poland (12%), Germany (11%), Spain (9%) and UK (6%). The other countries accounted for the remaining 9%.

Source: http://agreste.agriculture.gouv.fr/IMG/pdf/poireau0901note.pdf
For Switzerland, data were obtained from the Union Suisse des Paysans: http://www.sbv-usp.ch/fileadmin/user_upload/bauernverband/Aktuell/Lage/Archive_2003/2003_02_Commentaire.pdf

2. Protection methods for cabbage, onion, carrots, lettuce and leek

Field vegetables are crops that are concerned by minor uses, as far as availability of registered plant protection products is concerned. ‘Minor uses’ are crops or situations that are relatively small in area or major crops where a particular crop protection problem is

restricted to small areas or occurring only sporadically. Minor uses typically have a small number of approved PPPs that do not cover all the problems.

2.1. PPP availability for 5 major vegetable crops

2.1.1. How to read the tables

The following figures provide a summary of the different categories of PPPs that were registered in the period from mid 2008 to mid 2009 for cabbage, onion, carrot, lettuce and leek in 7 European countries: Italy, Spain, France, Germany, The Netherlands, Denmark and Switzerland.

Four pest categories were considered for which PPPs are used: weeds, insects, diseases, 'others' (e.g. nematodes, slugs, snails, mites).

For each pest category and country, the figures give the number of targets on which the PPPs are used. A 'target' is defined by the registration process. In most cases it is a given pest or disease (e.g. purple blotch on onion). It also can be a set of pests or diseases which can be controlled by the same pesticides (e.g. black rot and bacterial leaf spot on cabbage). There may be also different 'targets' for a given pest, leading to different PPPs registered (e.g. for controlling carrot fly either through soil treatment or through foliar application dealing in this case in 2 'targets'). For herbicides we did not define 'targets' as they are normally active against quite a wide range of weeds, although some are effective only on dicotyledons, or monocotyledons.

For each target, the numbers of AIs or mixtures of AIs which received registration in each country are counted. The numbers of AIs or mixtures of AIs, for each target, are compiled within each category of diseases, insects, weeds, and 'others' for each country, and reported in the pesticides per target (P/T) column.

The third column (CP) gives the number of commercial products, i.e. the formulations brought to the market.

The fourth column (AI) gives the number of single AIs which appear within each pest category, for each country (the same active ingredient can be registered for different targets and thus counted several times in the P/T column, a PPP can be made of different AIs). By AI we mean chemical compound as well as bio-control agents when available.

All data were collected from national database in 2008, except for Spain (collected in 2009) and may not reflect the present situation as new molecules are regularly registered and old molecules may be withdrawn from the lists. Figures for 'Nematodes, slugs, mites' might be incomplete as for some countries those are registered in a 'soil treatment' category and may not appear in the 'plant' or 'crop' category.

2.1.2. Tables

Raw data collected in the 7 countries from official database are posted on the Endure website in the Field Vegetable Case Study room (task a)

https://workspaces.inra-transfert.fr/QuickPlace/endure/PageLibraryC125729900718C03.nsf/h_F13825F8FF298505C1257570005D92E4/7CF37B4CD57A40C9C1257570005ED2B2/?OpenDocument

Cabbage	Nematodes, slugs, mites, ...				Diseases				Insects				Weeds			
	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI
Italy	4	6	38	2	20	68	602	11	12	38	143	10	-	70	10	10
Spain	1	1	n.a.	1	6	53	n.a.	16	11	116	n.a.	20	-	7	n.a.	6
France					15	38	167	14	11	59	396	20	-	8	47	8
Germany					9	16	16	10	9	20	21	13	-	5	10	5
The Netherlands	1	2	6	2	5	16	27	10	5	18	24	13	-	4	5	4
Denmark					5	10	10	4	7	19	19	5	-	0	0	0
Switzerland	2	n.a.	15	3	9	25	64	15	12	107	258	32	-	13	27	13

Onion	Nematodes, slugs, mites, ...				Diseases				Insects				Weeds			
	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI
Italy	3	4	34	4	17	61	298	17	10	37	175	11	-	18	110	18
Spain	1	1	n.a.	1	10	45	n.a.	12	5	18	n.a.	7	-	15	n.a.	15
France					11	26	101	12	3	7	34	6	-	11	45	11
Germany					9	20	20	14	6	14	18	10	-	10	20	10
The Netherlands	1	1	5	1	5	19	37	13	3	7	12	5	-	12	33	12
Denmark					2	5	5	6	2	2	2	1	-	6	6	6
Switzerland	3	n.a.	19	4	8	34	71	21	4	27	66	19	-	17	43	17

Carrot	Nematodes, slugs, mites, ...				Diseases				Insects				Weeds			
	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI
Italy	2	3	33	3	17	64	557	12	10	28	137	11	-	14	148	14
Spain	2	9	n.a.	9	9	n.a.	30	15	3	14	n.a.	9	-	4	n.a.	4
France					10	27	144	14	3	9	34	10	-	7	38	7
Germany					7	13	13	7	5	9	9	6	-	9	16	9
The Netherlands	1	2	6	2	3	8	10	8	3	5	10	5	-	8	17	8
Denmark					2	4	4	3	3	3	3	2	-	5	5	5
Switzerland	2	n.a.	15	3	4	20	64	15	6	45	134	20	-	14	41	14

Lettuce	Nematodes, slugs, mites, ...				Diseases				Insects				Weeds			
	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI
Italy	3	7	38	8	15	91	591	21	10	42	202	19	-	13	74	13
Spain	1	2	n.a.	2	10	86	n.a.	35	9	93	n.a.	28	-	7	n.a.	7
France					8	19	111	15	5	23	122	14	-	4	22	4
Germany					6	16	17	13	4	13	13	10	-	4	9	4
The Netherlands	1	1	5	1	5	12	24	9	4	10	15	9	-	3	6	3
Denmark					2	3	3	3	4	7	7	7	-	0	0	0
Switzerland	2	n.a.	15	3	7	31	75	21	6	50	112	23	-	2	2	2

Leek	Nematodes, slugs, mites, ...				Diseases				Insects				Weeds			
	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI	Target	P/T	CP	AI
Italy	4	5	49	5	16	59	307	12	7	18	80	7	-	9	32	8
Spain	1	2	n.a.	2	9	36	n.a.	12	5	20	n.a.	9	-	4	n.a.	4
France					6	21	124	11	3	13	78	11	-	6	44	6
Germany					5	14	14	8	5	9	12	7	-	9	17	9
The Netherlands	1	1	5	1	4	22	28	13	5	8	15	7	-	11	18	11
Denmark					3	4	4	3	2	2	2	1	-	4	4	4
Switzerland	2	n.a.	17	3	6	11	22	7	3	28	81	19	-	14	41	14

*Target: (pest or set of pest for which a formulation is registered) * (specified conditions of use, e.g. soil, seed, plantlets, foliar applications))*
P/T: pesticides per target, e.g. active ingredients or mixtures of active ingredients that are registered for a given target
CP: commercial product (pesticide formulation offered for sale, containing one or more active ingredient)
AI: active ingredient (component of a pesticide formulation responsible for the control effect)
n.a.: non available ; for blank cells (Nematodes, slugs, mites, …) see 2.1.1. How to read the tables
Sources (2008, except Spain, 2009):
Italy, collected by Daniele Antichi, SSSUP
Spain, collected by Rosa Gabarra, UdL/IRTA, data 2009
France: http://e-phy.agriculture.gouv.fr/, collected by Philippe Lucas, INRA
Germany: collected by Arnd Verschwele, JKI
The Netherlands: collected by Huub Schepers, PRI
Denmark: collected by Klaus Paaske, AU
Switzerland: http://www.dataphyto.acw-online.ch, http://www.psa.blw.admin.ch/index_de_3_1.html; collected by S. Aviron, R. Baur, Agroscope ACW

2.2. Registered BCAs and organic farming compatible PPPs

PPPs	Country	Crops
Azadirachtin	Italy	leek, lettuce, carrot
	Spain	carrot, leek, lettuce, onion, cabbage
Bacillus subtilis	Switzerland	lettuce
Bacillus thuringiensis aizawai	Italy	lettuce, cabbage
	Spain	carrot, leek, lettuce, onion, cabbage
Bacillus thuringiensis kurstaki	Italy	leek, lettuce, cabbage
	Spain	carrot, leek, lettuce, onion, cabbage
	Switzerland	cabbage
Bacillus thuringiensis	Denmark	cabbage
	France	leek, cabbage, onion
	Germany	onion
	The Netherlands	cabbage, onion, lettuce
Beauveria bassiana	Italy	lettuce
Canola oil	Germany	leek, cabbage, carrot
Coniothyrium minitans[1]	Denmark	lettuce
	Italy	leek
	Switzerland	leek, cabbage, onion, carrot, lettuce
	The Netherlands	carrot, lettuce
Copper[2]	France	leek, cabbage, onion, carrot
	Italy	leek, lettuce, cabbage, onion, carrot
	Spain	leek, lettuce, onion, cabbage
	Switzerland	cabbage, carrot
Fatty acids (potassium salts)	Germany	cabbage, onion
	Switzerland	cabbage, carrot, lettuce
Potassium permanganate	Spain	carrot, leek
Pyrethrins	France	cabbage, carrot, lettuce
	Germany	leek, cabbage, carrot
	Italy	leek, lettuce, cabbage, onion, carrot
	Spain	carrot, leek, lettuce, onion, cabbage
	Switzerland	leek, cabbage, onion, carrot, lettuce
	The Netherlands	lettuce
Quassia extract	Switzerland	cabbage, carrot, lettuce
Rapeseed oil	Switzerland	cabbage
Rotenone	France	cabbage, lettuce
	Italy	leek, lettuce, cabbage, onion, carrot
	Switzerland	leek, cabbage, onion, carrot, lettuce
Sesame oil	Switzerland	leek, cabbage, onion, carrot, lettuce
Spinosad	Germany	Leek, cabbage, onion
	Italy	leek, onion
	Spain	lettuce
	Switzerland	leek, cabbage, onion
	The Netherlands	cabbage, onion
Streptomyces griseoviridis	The Netherlands	onion
Sulphur[3]	France	lettuce
	Italy	leek, lettuce, cabbage, onion, carrot
	Spain	carrot, lettuce,
Trichoderma harzianum	Italy	leek, lettuce, cabbage, onion
Trichoderma viride	Italy	lettuce

[1] Registered in France in 2009 as soil treatment
[2] Might be copper hydroxide, copper oxychloride, calcium copper sulphate, cuprous oxide, copper sulphate, copper sulphate tri-basic
[3] Might be colloidal sulphur, micronized sulphur, wettable sulphur, ground sulphur, sublimed sulphur

2.3. Comparison between protection methods depending on the crop

As all 5 crops belong to the most important vegetables grown in Europe, there are still quite a significant number of AIs and PPPs registered for use.

More herbicides are registered for onion than for other crops and more insecticides for cabbage and lettuce than for carrot, onion and leek. Onion and lettuce are the crops with the highest number of registered fungicides.

Among the reported PPPs, there is quite a low number of BCAs or methods compatible with organic farming, with the exception of copper and sulphur based formulations reported in all countries. Nevertheless, they belong to a diversity of groups depending on their origin: botanicals like plant oils, microbials like species and subspecies of Bacillus, or 'natural other' like the fermentation product spinosad (not shown in the figures of this report, see details in raw data files on the Endure platform).

2.4. Comparison of crop protection methods among the countries

For a given crop, the number of AIs registered is very different from one country to the other. For example, methods to control weeds, insects and diseases on cabbage rely on 60 active ingredients in Switzerland, as compared to 43, 42, 29, 28 and 9 for Spain, France, Italy, The Netherlands, Germany, and Denmark, respectively. On this crop, where Italy, Spain and France are the main producers, 68 pesticides, based on 11 AIs are registered for 20 diseases in Italy, 53 in Spain (16 AI, 6 targets), and 38 in France (14 AI, 15 targets).

Spain and The Netherlands which are the main producers of onion (more than 1 000 000 t) have 35 and 31 AIs registered for use against weeds, diseases, insects and other pests which is far less than Switzerland with 65. According to data from the Union Suisse des Paysans, onion represents 6.5 % of the 320 000 t of vegetables produced in Switzerland in 2008 (Annual report of Centrale Suisse de la culture maraîchère, www.szg.ch).

Denmark is the country with the lowest number of pesticide options, the maximum of active ingredient for this country being 7 for controlling insects on lettuce while the number in other countries ranges from 9 (The Netherlands) to 28 (Spain) for the same use.

Switzerland and Italy have quite a high number of registered products (P/T) whereas targets addressed are more numerous in the case of Italy compared to Switzerland. Even in cases where both countries identify the same number of targets (e.g. 12 for insects on cabbage), the number of AIs on which growers can base their control is 3-fold more diverse for Switzerland (32) than for Italy (10). In Switzerland, the re-evaluation of pesticides, that has greatly reduced the number of available active ingredients in many EU Member States in the last decade, has only started recently. Therefore, many products with old actives are still approved, although no longer available on the market.

France and Italy are characterized by a high number of commercial products compared to the number of targets addressed or pesticides registered per target.

Spain has the highest number of active ingredients registered on cabbage (72 = 7 on weeds, 28 on insects, 35 on diseases, 2 on slugs and snails). For the other countries, the highest

figures are on cabbage (60) for Switzerland, on lettuce (53) for Italy, on cabbage (42) for France, on onion (34) for Germany, on leek (31) for The Netherlands, on onion (13) for Denmark.

A few biocontrol methods against insects are reported based on the use of *Bacillus thuringiensis* (every country, except Denmark) or against diseases (*Trichoderma* sp., *Coniothyrium minitans*, except in France[2], Denmark and Germany). *Beauveria bassiana* is registered against aphids in Italy.

Natural products like copper or sulphur are found in every country as well as pyrethrins, rotenone, spinosad

In Germany, soap is registered for controlling thrips and canola oil for controlling white flies. Azadyractin (extract from neem oil) is registered for the control of nematodes in Italy or for the control of thrips or onion moth on onion. In The Netherlands, *Streptomyces griseoviridis* is registered for controlling damping-off of onion.

Switzerland offers the largest range of BCAs and natural products with sesame oil, Spinosad, Pyrethrins, Rotenone, rapeseed oil, Quassia extract, Soap (potassium salt of fatty acids), *Coniothyrium minitans*, *Bacillus thuringiensis*, *Bacillus subtilis*.

3. Discussion

There are quite large differences between countries in pesticide availability for the 5 selected vegetable crops. There might be several reasons for that: damages caused by pests and diseases are different from one country to the others, differences in the strategy of pesticide companies for registration of PPPs, in the position of the authorities in charge of registration of PPPs, in national consumer pressure, or in surfaces dedicated to these crops and thus economic importance. It is difficult conclude on the specific or combined influence of these factors, based on the information collected in the framework of this case study.

Anyway, this is making growers considering they are facing unfair competition. This feeling is reinforced by the fact that most of the EU vegetable production is exchanged within the EU market, vegetable production being thus a global domestic market where production from different origin may be displayed on the same stall.

Although there is still a number of pesticides registered for use on these five vegetable crops (at least in some countries) which are amongst the most important in Europe (besides tomatoes) some uses are not covered or will soon face withdrawal of active ingredients (e.g. flies on cabbage and carrots and nematodes).

The numbers of registered biocontrol methods (or organic agriculture compatible methods) is low although some countries more in advance than others in the offer to growers of such PPPs.

Conclusion

Field vegetables represent an important part of the European agriculture with a share of 8.9% of the overall output value of the European agricultural industry. Vegetables are recognized for their nutritional value and for their impact on human health. Consumers are encouraged to eat at least 5 portions of a variety of fruits or vegetables a day. To meet the expectations of consumers and the society, it is important that the production of vegetables meets high standards with respect to sustainability and safety. The well-directed use of PPPs is a key factor both, with respect to an environmentally sound production and with respect to the avoidance of unwanted chemical residues on the products harvested. Although the system of MRLs established in Europe provides limits for the production of safe vegetables, the objective of producing food with as low residue levels as possible remains of crucial importance in the perception of the consumers.

As vegetables produced in Europe are broadly exchanged within Europe, it is important that the harmonization of the registration and marketing of pesticide occur between countries, although there might be room for specificities as some pests may be important in one country and secondary in another one. Nevertheless, it has to be noticed that the link between number of pesticide registered and quantity of applied pesticide is not a rule when looking at the Swiss situation. This means that reducing the number of registered pesticide is not the only way for reducing the use of pesticide.

A common effort between European countries to develop common and new methods of control for vegetable crops appears to be necessary. Considering that the pesticide industry is not expected to produce many new products in the years ahead, the investment for research must be on alternative methods and integrated pest management. Having such objective should also be a way to respond to the need for healthy products as mentioned above.

This study also reveals the differences between countries, differences in chemical methods, as well as in biological methods of control. Vegetable crops would thus be a good candidate for future projects on IPM in Europe.

[1] The figure given in the crop production database of Eurostat might be incomplete for a country a given year.
[2] Registered against sclerotinia in 2009.