Protection possibilities of agricultural minor crops in the European Union: a case study of soybean, lupin and camelina

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Abstract

In the central part of the European Union soybean, lupin and camelina are minor agricultural crops. The paper presents analysis of plant protection products availability for those crops in Austria, Belgium, Czech Republic, Germany, Holland, Hungary, Poland and Slovakia. Data from year 2019 show that availability of products is generally insufficient. For camelina in some countries, there are no chemical products available whatsoever. For lupin and soybean, there are not always products available to control some pest groups. However, the products on the market differ significantly among the member states. The results show that in protection of soybean, lupin and camelina, no single active substance is registered for the same crop in all the analysed member states. In very numerous cases, active substance is registered in one out of eight analysed member states only.

Keywords Minor crops · Speciality crops · Soybean · Lupin · Camelina · Protection · Crop rotation · Integrated pest management · IPM

Introduction

Protection of minor crops (EU Minor Uses Coordination Facility 2019) raises problems in numerous regions of the world. This is due to the fact that minor crops, as well as major crops, are endangered by different harmful organisms (Pszczółkowska et al. 2016; Elhady et al 2018); however, because of limited production area they are not attractive enough for industry. As a consequence, chemical and biological products registered to their protection are scarce. Abundance of harmful organisms and lack of means to control them may lead even to total crop destruction and make production unprofitable. In effect, farmers may be reluctant to grow minor crops.

When discussing minor crops, the focus is most often on vegetables, fruits and herbs (EU Minor Uses Coordination Facility 2019). Indeed, they are essential for composing a balanced diet. However, the protection problems also affect the other crop groups like seed production (EU Minor Uses Coordination Facility 2019), edible flowers (Matyjaszczyk

and Śmiechowska 2019), forests (Matyjaszczyk et al 2019) and numerous arable crops.

It seems that the minor arable crops are quite important not only from the point of view of diet. They are also crucial in integrated pest management of numerous major crops. Besides contributing to biodiversity in the fields, they are very precious tool in crop rotation. Their value as such is recognised and confirmed by thousands years of agricultural practice. Some of them like legumes enrich soil microflora and fertility while some others, like mustard or alfalfa, can be used as phytosanitary crops (Mokrini et al 2019; Matyjaszczyk 2019; Tillmann et al. 2017).

The aim of the study was the analysis of protection possibilities of three minor crops: camelina (*Camelina sativa* L.), lupin (*Lupinus angustifolius* L., *Lupinus luteus* L. and *Lupinus albus* L.) and soybean (*Glycine max* (L.) Merr.) in selected European Union (EU) member states: Austria, Belgium, Czech Republic, Germany, Holland, Hungary, Poland and Slovakia.

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Methods

There is no common list of minor crops in the EU so far. All analysed crop species: camelina, lupin and soybean, are grown in Poland and are minor crops according to Polish law (Rozporządzenie 2017).

The data on plant protection products availability were collected in the spring and summer of 2019. There is database on minor uses available <http://www.eumuda.eu/>. Accessed 13 Sep 2019. Its aim is to collect the minor use needs from Member States and to manage projects, therefore, it was not possible to use it in this search.

The source of data for Poland was the register of plant protection products available on the website of Ministry of Agriculture and Rural Development (Wyszukiwarka 2019). The source of data for the other member states was responses to the query performed by the author. The query was sent in the spring and the reminder in the summer of 2019 to the responsible authorities of the member states belonging to the European Union central registration zone as defined in the Regulation 1107/2009. The data presented include 8 member states: Poland and 7 member states that responded to the query: Austria, Belgium, Czech Republic, Germany, Holland, Hungary and Slovakia.

The tables were elaborated based on the member states responses. They report data on active substances and not on number of registered products. Only data on the active substances listed in the EU Pesticide Database are considered (EU Pesticides Database 2019). The names of active substances follow the database. Biological active substance *Bacillus subtilis* strain QST 713 was referred to as *Bacillus amyloliquefaciens* strain QST 713 which is the current name. It is worth stressing that propaquizafop and quizalofop-P are to be merged when SANTE/10,482/2018 becomes applicable. However they are still listed as separate active substances in the paper, following the fact that while preparing the paper the EU Pesticide Database included them separately, and their names were given as separate by the member states. Sometimes the member states provided additional information in response to the query (ex. on isomeric form of active substance present in the product). If the EU Pesticide Database lists the forms as separate active substances this is reported, however if not only the active substance given by database appears in the tables. The substances not listed by EU database were not reported here as well. This includes products working by physical action and so-called biostimulants (Podleśna et al 2019; Baranowska 2019; Matyjaszczyk 2015; Böckmann et al 2015) where there are no common EU registration rules. Besides that no other editing of the source responses was made.

The desiccants were included to the group of herbicides. The active substances used to disinfection of warehouses were included to the group of “others”.

Results

The data on plant protection products availability in 8 European Union member states belonging to the central registration zone: Austria, Belgium, Czech Republic, Germany, Holland, Hungary, Poland and Slovakia, are presented in Tables 1, 2 and 3. Even the mere fleeting scanning of the tables shows that the available chemical protection means are rather limited and in a number of member states there are no chemical solutions against whole pest groups available. It is also possible to observe that different active substances are registered in the analysed member states to control some pest groups in the same crops.

Table 1 presents the search results for camelina. In 4 out of 8 analysed member states: Austria, Belgium, Hungary and Slovakia, there are no registered products for camelina protection whatsoever. In further two: Poland and Czech Republic, there are no registered insecticides. In both Belgium and Germany, two active substances are registered for the protection against insects, but the substances differ.

There are products registered for the protection of camelina against diseases in four countries: Czech Republic, Germany, Holland and Poland. In three of them one active substance is registered and a different one: in Czech Republic isofetamid, in Poland tebuconazole, in Germany a biological substance based on fungi. It is worth considering that these three member states are neighbours with no unlike climatic conditions. In Holland there are four active substances available for camelina protection against diseases and only one of them (*Coniothyrium minitans* strain CON/M/91-8) the same as registered in Germany.

In the Czech Republic, Germany, Holland and Poland, there are herbicides available for camelina protection. Significant differences in availability are, however, observed. In the Czech Republic dimethenamid-P, quinmerac and quizalofop-P-ethyl can be used that are not registered in the other three member states. In Germany fluazifop-P is used for camelina protection, while in Poland florasulam, halauxifen methyl, metsulfuron methyl and tribenuron methyl that are not registered for camelina protection in the other member states.

Availability of the active substances for lupin protection is presented in Table 2. It should be stressed that part of the active substances are registered for some lupin types only. In the analysed member states, some products for lupin protection are generally available, although in Belgium there are no products to control insects and in Hungary no products

Table 1 Active substances of plant protection products registered to the protection of camelina *Camelina sativa* (L.) Crantz

MS	Fungicides	Herbicides	Insecticides	Others
Austria	–	–	–	–
Belgium	–	–	–	–
Czech Republic	Isofetamid	Dimethenamid-P, Metazachlor, Propaquizafop, Quinmerac, Quizalofop-P-ethyl	–	Ferric phosphate
Germany	<i>Coniothyrium minitans</i> strain CON/M/91-8	Fluazifop-P, Glyphosate, Metazachlor	Lambda-Cyhalothrin, Maltodextrin	Zinc phosphide, Calcium-phosphide, Ferric phosphate, Metaldehyde
Holland	<i>Bacillus amyloliquefaciens</i> str. QST 713, Boscalid, <i>Coniothyrium minitans</i> strain CON/M/91-8, Potassium bicarbonate, Pyraclostrobin	Glyphosate, Quizalofop-P	<i>Bacillus thuringiensis</i> subsp. <i>Aizawai</i> , <i>Metarhizium anisopliae</i> var. <i>anisopliae</i> strain F52	Aluminium phosphide, Ferric phosphate
Hungary	–	–	–	–
Poland	Tebuconazole	Florasulam, Halauxifen methyl, Metsulfuron methyl, Propyzamide, Tribenuron methyl	–	Metaldehyde
Slovakia	–	–	–	–

for weed control whatsoever. There are, however, differences in availability of active substances among the member states.

In the protection against diseases, there is no single active substance available in all analysed member states. The following solutions are unique, i.e. limited to one member state only: difenoconazole in Austria, metconazole in Belgium, carboxin and thiram in the Czech Republic, prothioconazole and pirymethanil in Holland and thiophanate-methyl in Poland.

In the protection of lupin against weeds, there is no single active substance available in all analysed member states. The following solutions are unique: bentazone and cycloxdim in Holland, flutriafol, halauxifen methyl and propyzamide in Poland and diquat in Slovakia.

In the protection of lupin against insects, there is again no single active substance available in all the analysed member states. The following solutions are unique: maltodextrin in Germany, chloropyrifos in Hungary, thiacloprid in Poland plus all three substances registered in Holland: pirimicarb, *Bacillus thuringiensis* subsp. *Aizawai* and *Metarhizium anisopliae* var. *anisopliae* strain BIPESCO 5/F52.

In spite of being one of the most important crops at the global scale, soybean is a very minor crop in the central registration zone of European Union. Table 3 presents active substances used to soybean protection in the analysed member states.

In the protection of soybean against diseases, there is no single active substance available in all the analysed member states. The following solutions are unique for one

of eight analysed member states only: fluopyram and prothioconazole in Austria, fludioxonil in Czech Republic, pyrimethanil in Holland, copper hydroxide and copper oxychloride in Hungary, flutriafol and thiophanate-methyl in Poland and cyproconazole in Slovakia. In fact, majority of fungicide active substances listed in the table are registered for the protection of soybean in one member state only. The active substances of biological origin seem to be an exception, as they are registered in several member states.

When analysing protection possibilities of soybean against weeds again no single active substance is registered for use in all the eight member states. The following herbicidal solutions are unique: quinmerac in Germany, benfuraline and prosulfocarb in Holland, florasulam, halauxifen methyl and metobromuron in Poland, diquat and quizalofop-P-tefuryl in Slovakia.

There are no products for soybean protection against insects available in Czech Republic and Belgium and consequently no insecticidal active substance is registered for use in all eight member states. There are very few solutions to soybean protection against insects available in the remaining member states, but they differ significantly. Azadirachtin only is available in Austria, maltodextrin only in Germany, two biological substances as well as pirimicarb only in Holland, chlorpyrifos and etoxazole only in Hungary, cypermethrin and thiacloprid only in Poland and fenpyroximate only in Slovakia.

Table 2 Active substances of plant protection products registered to the protection of lupin (*Lupinus angustifolius* L., *Lupinus luteus* L. and *Lupinus albus* L.)

MS	Fungicides	Herbicides	Insecticides	Others
Austria	Azoxystrobin, Cyprodinil, Difenoconazole, Fludioxonil <i>Pythium oligandrum</i> M1, Tebuconazole	Clethodim, Clomazone, Dimethenamid-P, Fluazifop-P, Glyphosate, Pendimethalin, Prosulfocarb, S-Metolachlor, Terbutylazine	K-soap (fatty acids and unsaturated potassium salts), Lambda-Cyhalothrin	Ferric phosphate, metaldehyde
Belgium	Azoxystrobin, Metconazole	Clomazone, Pendimethalin	–	–
Czech Republic	Azoxystrobin, Carboxin, <i>Bacillus amyloliquefaciens</i> strain QST 713, Cyproconazole, Cyprodinil, Fludioxonil, Methalaxyl-M, <i>Pythium oligandrum</i> M1, Thiram	Aclonifen, Pendimethalin, Pyridate, S-Metolachlor	Cypermethrin	–
Germany	Azoxystrobin, <i>Coniothyrium minitans</i> strain CON/M/91-8, Cyprodinil, Fludioxonil, Tebuconazole,	Dimethenamid-P, Fluazifop-P, Glyphosate, Pendimethalin, Prosulfocarb, Pyridate, S-Metolachlor, Terbutylazine	Cypermethrin, K-soap(Fatty acids and unsaturated potassium salts), Lambda-Cyhalothrin, Maltodextrin	Zinc phosphide, Ferric phosphate, Metaldehyde
Holland	<i>Bacillus amyloliquefaciens</i> str. QST 713, <i>Coniothyrium minitans</i> strain CON/M/91-8, cyprodinil, fludioxonil, Metalaxyl-M, prothioconazole, tebuconazole, pyrimethanil	Bentazone, Clethodim, Clomazone, Cycloxydim, dimethenamid-P, pendimethalin, glyphosate, propaquizafop	<i>Bacillus thuringiensis</i> subsp. Aizawai, <i>Metarhizium anisopliae</i> var. anisopliae strain BIPESCO 5/F52, Pririmicarb	Aluminium phosphide, Ferric phosphate, Garlic extract
Hungary	–	S-Metholachlor	Chlorpyrifos	–
Poland	Tebuconazole, Thiophanate-methyl	Florasulam, Flutriafol, Halauxifen methyl, Propyzamide, Quizalofop-P	Cypermethrin, Thiacloprid,	–
Slovakia	Azoxystrobin, <i>Bacillus amyloliquefaciens</i> str. QST 713, Cyproconazole, Fludioxonil, <i>Pythium oligandrum</i> M1	Aclonifen, Diquat Pendimethalin, S-Metolachlor	Cypermethrin	–

Table 3 Active substances of plant protection products registered to the protection of soybean (*Glycine Willd.*)

MS	Fungicides	Herbicides	Insecticides	Others
Austria	Fluopyram, Prothioconazole, <i>Pythium oligandrum</i> M1	Cycloxydim, Dimethenamid-P, Fluazifop-P, Flufenacet, Imazamox, Metribuzin, Pendimethalin, Pethoxamid, Propaquizafop, Quizalofop-P, Quizalofop-P-ethyl, S-Metolachlor, Thifensulfuron-methyl	Azadirachtin, Lambda-Cyhalothrin	Ferric phosphate, Metaldehyde, Sheep fat
Belgium	<i>Bacillus amyloliquefaciens</i> strain QST 713	Clethodim, Clomazone, Dimethenamid-P, Fluazifop-P, Pendimethalin, Pethoxamid, Propyzamide, Thifensulfuron-methyl	–	Sheep fat
Czech Republic	<i>Bacillus amyloliquefaciens</i> strain QST 713, Fludioxonil, <i>Pythium oligandrum</i> M1	Bentazone, Dimethenamid-P, Fluazifop-P-butyl, Flumioxazin, Flufenacet, Glyphosate, Imazamox, Metribuzin, Pendimethalin, Pethoxamid, Quizalofop-P-ethyl	–	Ferric phosphate, Sheep fat + (substances not mentioned in EU database)
Germany	<i>Coniothyrium minitans</i> strain CON/M/91-08	Clomazone, Cycloxydim, Dimethenamid-P, Fluazifop-P, Glyphosate, Imazamox, Pendimethalin, Metribuzin, Quinmerac	Lambda-Cyhalothrin, Maltodextrin	Ferric phosphate, Metaldehyde, Zinc phosphide
Holland	<i>Bacillus amyloliquefaciens</i> strain QST 713, <i>Coniothyrium minitans</i> strain CON/M/91-8, Metalaxyl-M, Prothioconazole, Pyrimethanil, Tebuconazole	Benfluralin, Bentazone, Clomazone, Cycloxydim, Dimethenamid-P, Fluazifop-P, Glyphosate, Imazamox, Metribuzin, Pendimethalin, Propaquizafop, Prosulfocarb, Thifensulfuron-methyl	<i>Bacillus thuringiensis</i> subsp. Aizawai, deltamethrin, <i>Metarhizium anisopliae</i> str F52, pirimicarb, thiacloprid	Aluminium phosphide, Ferric phosphate, Garlic extract
Hungary	<i>Coniothyrium minitans</i> strain CON/M/91-08, Copper hydroxide, Copper oxychloride, Metalaxyl-M	Bentazone, Clethodim, Clomazone, Cycloxydim, Dimethenamid-P, Flumioxazin, Glyphosate, Imazamox, Metribuzin, Pendimethalin, Propaquizafop, Quizalofop-P-ethyl, S-Metolachlor, Thifensulfuron-methyl	Chlorpyrifos, Etoxazole	–
Poland	Flutriafol, Tebuconazole, Thiophanate-methyl	Florasulam, Halauxifen methyl, Metobromuron, Metsulfuron methyl, Propyzamide, Quizalofop-P-ethyl, S-Metolachlor, Tribenuron methyl	Cypermethrin, Thiacloprid	
Slovakia	Azoxystrobin, <i>Bacillus amyloliquefaciens</i> strain QST 713, Cyproconazole, <i>Pythium oligandrum</i> M1	Clethodim, Clomazone, Cycloxydim, Diquat, Fluazifop-P, Flufenacet, Glyphosate, Imazamox, Metribuzin, Thifensulfuron-methyl, Propaquizafop, Pendimethalin, Quizalofop-P-ethyl, Quizalofop-P-ethyl, S-Metolachlor	Fenpyroximate	Ferric phosphate, Metaldehyde, Sheep fat, Sodium 5-nitroguaiacolate, Sodium o-nitrophenolate, Sodium p-nitrophenolate

Conclusions

On analysing the data, we come to an interesting conclusion that in protection of soybean, lupin and camelina, no single active substance is registered for the same crop in all the member states: Austria, Belgium, Czech Republic, Germany, Holland, Hungary, Poland and Slovakia.

When analysing every single member state separately, there is generally rather limited number of plant protection products available to protect soybean, lupin and camelina. In 4 out of 8 member states, the chemical protection of camelina is not possible. In some countries, there are no chemical products available for protection of analysed crops against certain pest groups. In the European Union, there is no common market for plant protection products. Following the legal rules, an applicant who wishes to place a plant protection product on the market shall apply for an authorisation to each Member State where the plant protection product is intended to be placed on the market (Regulation 1107/2009). To be sold in a member state, the product must be registered in this particular member state and to bear the label in language used there.

It is worth stressing that the fact of listing certain active substances in the column of a table does not necessarily mean that protection possibilities against the pest group are available. In the column “Others” a number of substances are listed (aluminium phosphide, zinc phosphide) that are used to protect harvested crops in the storerooms, not on the field. Some other substances mentioned in this column (sodium 5-nitroguaiacolate, sodium o-nitrophenolate, sodium p-nitrophenolate) act on the crop, not against pests. In the column “herbicides” active substances like glyphosate or diquat are listed that are not selective, meaning that they destroy crop as well as weeds. Those substances may be used to clean the field before sowing (glyphosate) or for desiccation before harvest (diquat), but not to control weeds during crop vegetation. Two other herbicide active substances: propaquizafop and quizalofop-P will be merged soon (EU Pesticide Database 2009) therefore to all practical purposes they can be regarded as the same active substance.

Also listing an active substance in a column “insecticides” does not mean that products containing this active substance can be used against all possible insect pests. Similarly listing active substance as “herbicide” or “fungicide” does not mean that there are products available to control a wide range of weeds or diseases. Nowadays selective plant protection products are preferred. “Selective” means that they are efficient against narrow pest group only and are not toxic for non-target organisms. This means that even if there are active substances available to protect a minor crop against certain weeds, insects or diseases, there may be no solutions to control some others.

Besides all farmers in European Union are obliged to perform chemical treatment with due regard to the resistance prevention strategy. That means they should interchangeably use products with different modes of action. For some minor crops in some member states, this is simply not possible due to the lack of products.

However, there is another and quite optimistic conclusion of this survey that is in line with other studies on other agricultural minor and major crops (Matyjaszczyk 2017; Matyjaszczyk and Sobczak 2017). Namely there is quite a number of active substances available when considering all the analysed member states together. It is quite important as it means that some data regarding those active substances are available, their assessment by the registration authorities has been made and they were proved to be safe for humans after application on the target crop. Otherwise, the authorisation would have not been granted.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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