Scientific Papers. Series A. Agronomy, Vol. LXIV, No. 1, 2021
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

WEED ASSOCIATION DYNAMICS IN THE OILSEED RAPE FIELDS

Tonyo TONEV, Shteliyana KALINOVA, Mariyan YANEV, Anyo MITKOV, Nesho NESHEV

Agricultural University of Plovdiv, 12 Mendeleev Blvd., Plovdiv, Bulgaria

Corresponding author email: s_kalinova@yahoo.com

Abstract

The monitoring shows that in the oilseed rape fields of Bulgaria the dominating weed species are Sinapis arvensis L., Raphanus raphanistrum L., and on separate fields Papaver rhoeas L. The most common cereal weeds are Lolium ssp., Avena fatua L.. and wheat self-seeding. Perennial weeds are relatively limited. Species of the genus Phelipanche are most common in southern Bulgaria. The reasons for the mass distribution of these weed species are the violated crop rotations, seeding of oilseed rapes in short period of time - in 1-2 years on the same field, insufficient quality of the soil tillage, limited choice of herbicides for control of parasitic weeds, etc. The implementation of alternative cropping technologies like Clearfield®, their constant improvement, as herbicide content and selection process showed positive effect for decreasing the density and range of distribution of these weeds in the oilseed rape fields.

Key words*: oilseed rape, weed associations, dynamics, Clearfield®.*

INTRODUCTION

Over the last four decades, oilseed rape (*Brassica napus* L.) is established as one of the most important oilseed crops in the world, ranked as the second most important source of vegetable oil around the globe (Brennan and Bolland, 2007). The growing role of oilseed crops is also due to their use as a raw material for biodiesel production (Abbadi and Leckband, 2011; Vinnichek et al., 2019). Oilseed rape is also a potential source of specific proteins and industrial raw materials, biopolymers, surfactants and adhesives (Wu и Muir 2008).

In Bulgaria for 2019 the oilseed rape is grown on an area of 151,174 ha with a total production of 428,256 t (MZH, 2020). One of the factors limiting the normal growth and development of the crop is weed infestation. Weeds are the main competitors of *B. napus* in terms of vegetation factors like water, nutrients, space and light, etc. (Tonev et al., 2019). In addition, they cause indirect damage, as many weed species are hosts of diseases and pests of the crop (Kalinova et al., 2012).

Oerke (2005) points out that the largest crop losses in agriculture, around 34%, are due to the high weed infestation in crops, while the reduction in yields due to pests and diseases is lower and is approximately 16-18%. Moradi, et al. (2020) found that weed competition not only reduced grain yield but also the seed oil content by 5%. If weeds, are not controlled, can lead to a 50% loss of seed yield and reduce the quality of the production (Llewellyn et al., 2016; Konstantinović et al., 2007; Blackshaw et al., 2002; Radosevich et al., 1996). In order to obtain an optimal yield from B. napus, on time and precise weed control is necessary to be accomplished (Tonev et al., 2019; Pavlovic´ et al., 2015; Dimitrova et al., 2014a; Hamzei et al., 2010; Maataoui et al., 2003). An important element for successful weed control in oilseed rape is the establishment of the weed species and associations (Tonev, 2000). There is a dynamics in the weed species composition depending on the latitude in which the crop is grown. Studies on showed that *Lolium rigidum*, *Vulpia myuros*, *Avena fatua* are the most abundant weed species in oilseed rape in Australia (Lemerle et al., 2001).

The most distributed weeds in Hubei, China are *Alopecurus aequalis*, *Veronica persica*, *Polypogon fugax*, *Malachium aquaticum*, *Beckmannia syzigachne*, *Galium aparine*, *Poa annua* (WenDa, et al., 2008).

In Tehran province (Iran) dominant weeds in *B. napus* fields are presented by *Descurainia sophia, Cardaria draba, Rapistrum rugosum, Goldbachia laevigata, Erysimum rependum, Capsella bursa-pastoris, Lamium amplexicaule, Malva neglecta, Veronica persica, Sonchus spp., Galium tricornutum,*

Vicia villosa, Silene conoidea, Fumaria officinalis, Convolvulus arvensis, Avena ludoviciana, *Bromus tectorum, Euphorbia helioscopia,* etc. (Salimi and Sajedi, 2005).

Also in Iran, but in Golestan Province the most distributed weed species are *Phalaris minor* Retz., *Melilotus officinalis* (L.) Pall., *Rapistrum rugosum* (L.) All., *Avena sterilis* subsp. *ludoviciana*, *Veronica persica* Poir. and *Sinapis arvensis* L. (Ataie et al., 2018). In District Swat-Pakistan major weeds found in oilseed rape are *Sinapsis arvense*, *Chenopodium* spp., *Convolvulus arvensis*, *Coronopus didymus*, *Medicago denticulata*, *Fumaria indica*, *Vicia sativa*, *Poa annua*, etc (Saeed et al., 2011).

In areas of north-east Scotland in winter oilseed rape the most frequently recorded and abundant species are *Poa annua*, *Stellaria media*, *Viola arvensis*, *Hordeum vulgare* [volunteer barley], *Matricaria* spp., *Capsella bursa-pastoris* and *Fumaria officinalis*. Several mainly spring-germinating species are also recorded, e.g. *Spergula arvensis*, *Polygonum aviculare*, *Galeopsis tetrahit*, *Veronica arvensis* and *Capsella bursa-pastoris* (Gillian et al., 1992).

In the United Kingdom, the most common broadleaf weeds in oilseed rape fields are *Stellaria media*, *Matricaria* spp., and *Veronica persica*, while the volunteer cereals and *Poa annua* are the most frequently recorded grass weeds (Whitehead and Wright, 1990).

The weeds infesting oilseed rape in Germany are mainly represented by *Matricaria* spp., *Viola arvensis*, *Capsella bursa-pastoris*, *Stellaria media*, etc. The predominant winter weeds are *Poa annua* and *Apera spica-venti* (Hanzlik, et al., 2010). Hanzlik and Gerowitt (2012) report that in areas with intensive oilseed rape cultivation prevalence of *Geranium* spp., *Sisymbrium* spp. and *Anchusa arvensis* is recorded.

Goerke et al., (2008) found that most of the weed species found in winter oilseed rape in Germany are not evenly distributed. *Sisymbrium officinale*, *Descurainia sophia*, *Centaurea cyanus*, *Anchusa* spp., *Sonchus* spp., *Rumex* spp. or *Euphorbia* spp. are some of the weed species of predominantly regional importance. In contrast, statistically proven differences in weed density in the Germany were recorded for *Capsella bursa-pastoris, Chenopodium album*, *Galium aparine*, *Matricaria* spp., etc.

In the Lublin (Poland) the weeds infesting oilseed rape are *Matricaria maritima*, *Athemis arvensis*, *Centaurea cyanus*, *Agropyron repens* (Kapeluszny, 2005).

In France between the 1970s and the 2000s the most distributed weed species was *Geranium dissectum* (Fried et al., 2015).

In addition to weeds with autotrophic nutrition in oilseed rape, there are also weeds with heterotophic nutrition. Broomrapes are without chlorophyll, root, obligate parasitic plants. In Swat-Pakistan District *Orobanche* spp. parasitizes on rapeseed (Saeed et al., 2011). Kohlschmid et al., 2011 found that the oilseed rape grown in Germany is parasitized by *Phelipanche ramosa*. Gibot-Leclerc et al. (2012) report that broomrape parasite can cause approximately 80% loss of oilseed rape yield.

In order to protect the environment and human health, the efficient use of material and energy resources in the cultivation of oilseed rape for the control of weeds, non-chemical methods and biological products are applied (Marcinkevičiene et al., 2017; Velička et al., 2016; Marcinkevičiene et al., 2015.

Not all the time organic oilseed rape cultivation can easily and effectively applied. That is the main reason for controlling the weeds mainly by the chemical method. The application of herbicides in oilseed rape is one of the most important and responsible points during the vegetation (Frisen, et al, 2003; Heard, et al., 2003; Harker, et al. 2003; Senior and Dale, 2002; Tonev, 2000). The successful weed control in oilseed rape depends on the herbicide application time, i.e. from the optimal stages of the weeds and the crop. The soil or early-vegetation herbicide application is more effective in comparison to the spring treatment (Freeman and Lutman, 2004; Franek, 1994).

The choice of herbicide depends on that if that grown oilseed rape hybrid is selected to be grown by the conventional or Clearfield® technology. In dependence of the existing weed flora at the time of herbicide application a great number of herbicides for weed management in the conventional oilseed rape production technology are evaluated. Such herbicides are propisochlor, trifluralin, haloxyfop-p-methyl; metazachlor; bifenox; clomazone,

napropamide, dimethachlor; alachlor; isoxaben; halauxifen-methyl, picloram; propyzamide, aminopyralid; clopyralid; ethametsulfuron-methyl; clethodim and propaquizafop (Bardsley et al., 2018; Lourdet and Rougerie, 2016; Koleva-Valkova et al., 2016; Zotz et al., 2016; Koprivlenski et al., 2015; Dimitrova et al., 2014b; Dimitrova et al., 2014c; Werner, 2014; Duroueix et al., 2013; Lourdet, 2013; Drobny and Schlang, 2012; Stormonth et al., 2012; Bijanzadeh et al., 2010; Majchrzak and Jarosz, 2010; Majchrzak et al., 2008; Konstantinovic´, 2007; Franek and Rola, 2002a; Franek and Rola, 2002b; Franek and Rola, 2001).

At the conventional oilseed rape hybrids some of the registered selective herbicides cannot ensure effective control of the cruciferous weeds like *Sinapis arvensis*, *Raphanus raphanistrum* and *Descurainia sophia*. An alternative for solving this problem is the Clearfield® technology at oilseed rape (Pfenning et al., 2012). In this cropping system, the oilseed rape hybrids are IMI-tolerant (Imidazolinone-tolerant).

During the growing season, for the CL oilseed rape hybrids, Cleranda SC (375 g/l metazachlor + 17.5 g/l imazamox) in rate of 1.50 – 2.00 l/ha + Dash (adjuvant) is successfully applied (Schönhammer et al., 2010; Ádámszki et al., 2010).

The application of imazamox-containing herbicides also provides very good control of the blue wrist in rapeseed. Yanev et al. (2020) found that Pulsar® Plus - 2.00 l / ha (BBCH 51) showed good efficacy against *Ph. ramosa* when applied at Clearfield oilseed rape.

The aim of current research is to study the weed association dynamics in oilseed rape fields under the agro-ecological conditions of the Republic of Bulgaria.

MATERIALS AND METHODS

The study was performed during the period of 2010-2019 in 12 municipalities and lands of 17 settlements in Republic of Bulgaria.

Table 1. Description of the examined area with winter oilseed rape in the period of 2010 – 2019

Year/ Municipalities	Settlements	Oilseed rape hybrid	Examined area, da	Total area, da
2010/Ivanovo	Village of Shtraklevo	LG Architect	320	1640
2010/Ivanovo	Village of Shtraklevo	Ambassador	320	1360
2011/Sliven	Village of Kovachite	Imminent CL	200	650
2012/Yambol	Village of Malomir	Imminent CL	100	1050
2012/Nova Zagora	Village of Omarche	Visbi, Kodiak	500	2500
2013/Nova Zagora	Village of Omarche	PT 200 CL, Sunset CL	500	2500
2013/Bolyarovo	Village of Stephan Karadzhovo	Vectra	100	460
2014/Bolyqrovo	Village of Gorska polyana	Imminent CL	100	1050
2014/Plovdiv	Trial field of Agr. University	PT 279 CL	60	200
2014/Rodopi	Village of Krumovo	Imminent CL	200	600
2015/Silistra	Village of Ivanski	PT 228CL	90	310
2015/Silistra	Village of Neophit Rilski	PX 100 CL	130	1000
2015/Silistra	Village of Vaglen	PT 200CL	130	700
2015/Silistra	Village of Smolnitsa	PX 100 CL	160	520
2016/ Plovdiv	Village of Krumovo	PT 200CL	200	2000
2016/Stara Zagora	Village of Pastren	DK Impression CL	350	1000
2017/Plovdiv	Trial field of Agr. University	PX 111CL	50	50
2017/Svishtov	Village of Bulgarsko slivovo	PX 100 CL	100	150
2017/Ihtiman	Village of Chernyovo	Imminent CL	200	650
2018/Pazardzhik	Village of Simitovo	Imminent CL	150	900
2018/Ivanovo	Village of Krasen	Ambassador	140	1500
2019/Plovdiv	Village of Krumovo	PT 200 CL	200	2000
2019/Plovdiv	Trial field of Agr. University	PT 225	10	30
12 total	17 total		4 310 da 18.88%	22 820 da/ 100%

The criteria for choosing the pigeonholed areas were to be typical for the oilseed rape production and with optimal soil-climatic conditions. The weed infestation monitoring of the fields on which conventional oilseed rape hybrids are grown is in period of 10 years and the weed infestation monitoring of the areas with Clearfield® oilseed rapes is in period of 10 years also.

Weed mapping was performed according to "Methodology for reporting and recording the weeds in major field crops" (Dimitrova et al., 2004).

The efficacy of herbicide products with active substances imazamox + metazachlor and clopyralid + aminopyralid + picloram was recorded by the visual score scale of EWRS.

The data on table 1 shows that the weed infestation research in fields with winter oilseed rape is conducted on an area of 22 820 da. The mapping and identification of the wed species covers an area of 4 310 da, which is 1.88% of the total area.

RESULTS AND DISCUSSIONS

The weed species composition in the areas of the studied regions is very diverse (Table 2). Tatal of 22 weed species from 6 biological groups have been identified. The ephemerals are presented by three species: ivyleaf speedwell - *Veronica hederifolia* L., common henbit – *Lamium amplexicaule* L. and common fumitory – *Fumaria officinalis* L.

From the early spring weeds, widely distributed species in South Bulgaria were: wild oat – *Avena fatua* L., meadow fescue - *Festuca pratensis L. and* cleavers - *Galium aparine* L. Eight species presenting the weeds from the winter-spring group were reported (7 broadleaf and 1 grass): ryegrass - *Lolium rigidum* Gaud., wild radish - *Raphanus raphanistrum L. and* wild mustard - *Sinapis arvensis* L. These three weeds were found to in low density. This was probably due to the fact that the applied herbicide products for weed control had high efficacy when applied in nonconventional winter oilseed rape hybrids.

The most distributed weeds from the late-spring group were fat-hen - *Chenopodium album L.)* and common purslane - *Portulaca oleracea L.*

In separate regions from South Bulgaria wild hemp - *Cannabis ruderalis Janisch. and* cornflower - *Centaurea cyanus* L.

In the winter oilseed rape fields in Bulgaria the only presenter of the perennial weeds was creeping thistle - *Cirsium arvense (L.) Scop.*

Table 2. Weed species of the infestation of winter oilseed rape fields in areas not treated with herbicides for the period 2010 - 2019

	GRASS WEEDS	BROADLEAF WEEDS
ANNUAL		
Ephemerals		Ivyleaf speedwell - *Veronica hederifolia* L.
		Common henbit – *Lamium amplexicaule* L.
		Common fumitory – *Fumaria officinalis* L.
Winter-spring	Annual ryegrass - *Lolium rigidum* Gaud.	Corn chamomile - *Anthemis arvensis* L.
		Corn-cockle - *Agrostema githago* L.
		Wild radish - *Raphanus raphanistrum* L.
		Shepherd's purse - *Capsella bursa-pastoris* (L.) Med.
		Cornflower – *Centaurea cyanus* L.
		Common poppy - *Papaver rhoeas* L.
		Oriental knight's-spur – *Consolida orientalis* L.
Early-spring	Wild oat – *Avena fatua* L.	Muskweed - *Myagrum perfoliatum* L.
	Fescue - *Festuca pratensis L.*	Hairy vetch - *Vicia hirsuta* (L.) S.F. Gray
		Wild mustard - *Sinapis arvensis L.*
		Cleavers - *Galium aparine* L.
Late-spring		Fat-hen – *Chenopodium album* L.
		Common purslane – *Portulaca oleracea* L.
PERENNIAL		
Root-sprouted		Creeping thistle – *Cirsium arvense* (L.) Scop.
PARASITIC		Branched broomrape – *Phelipanche ramosa* (L.) Pomel
		Mutel's Broomrape – *Phelipanche mutelli* (Schultz) Pomel

Data from the ten-year mapping of the root parasites *Phelipanche ramosa* (L.) Pomel. and *Phelipanche mutelli* (Schultz) Pomel do not lead to the establishment of an exact algorithm for their distribution. Exceptions are seen from the observations in the region of Stara Zagora and Plovdiv, where due to impaired rotation of oilseed rape and its cultivation over a period of 2-3 years, as well as after precrop vegetable crops such as tomatoes, cabbage and others, infestation pressure of species from genus *Phelipanche* is observed and increased.

The analysis of the obtained data for the weed flora before treatment in the areas with oilseed rape grown by the Clearfield technology showed the following. On average for the period of the study period, the following species of weeds are reported in high-density: the winter-spring weeds are the corn chamomile, common poppy, oriental knight's-spur and ryegrass.

From the group of ephemerals only the ivy-leaved speedwell. From early-spring weeds in higher density wild oat and cleavers are found, and from late-spring weeds in some parts of the country the density of fat-hen was high. The root parasite broomrape is also found to be in high density in some areas of South Bulgaria, and especially in regions of Stara Zagora, Yambol, Plovdiv and Pazardzhik. Excellent efficacy of the herbicide products applied in the oilseed rape grown by the Clearfield technology is observed. The controlled weeds in this technology are corn chamomile, common poppy, oriental knight's-spur, cleavers and fat-hen (Figure 1).

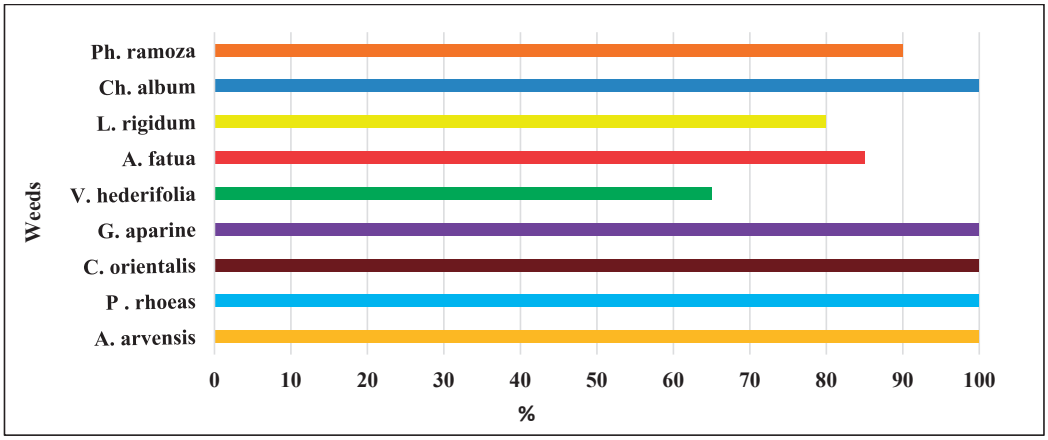

Figure 1. Efficacy of imazamox + metazachlor average for the research period

In a trial conducted by Yanev (2020) the highest herbicide efficacy against *Anthemis arvensis* L., *Papaver rhoeas* L., *Galium aparine* L., *Capsella bursa-pastoris* (L.) Medik, *Lolium temulentum* L., *Avena fatua* L. and the *Triticum aestivum* L. volunteer after the application of Cleranda SC + Dash in rates of 2.00 + 1.00 l/ha, Cleranda SC + Dash in rates of 1.40+1.00 l/ha, as well as Cleravis + Dash in rates of 2.00+1.00 l/ha was found.

It is worth noting that for obtaining high herbicide efficacy against corn chamomile, the herbicide application should be performed before 2nd – 4th leaf stage of the weed. After the growing stage rosette, the efficacy of the herbicides is severely decreased. Ivyleaf speedwell is relatively more resistant to the application of herbicides with active substance imazamox + metazachlor when compared to the above mentioned weeds, but it forms low aboveground biomass and cannot concur the oilseed rape at a higher extend. The grass weeds wild oat and ryegrass are relatively difficult to control with imazamox + metazachlor treatments. For obtaining satisfactory herbicidal effect it is necessary to apply the herbicides before tillering stage of the grass weeds. At the time when these grass weeds are in high density on the field several graminicide herbicides can be applied - cycloxidim, fluazifop-P-butyl, quizalofop-P-ethyl, etc. Very often in the practice these herbicides are used for control of winter wheat volunteers, grown as a predecessor before

oilseed rape. Against the parasite broomrape, at the Clearfield technology is relied entirely on the mode of action of the herbicide containing imazamox + metazachlor. According to Mitkov et al. (2017) the effect is high enough and the herbicide applied in the spring controls an average of 90% of the parasite (Yanev et al., 2020). Many scientific studies have shown that the broomrape that remains in the field after treatment with imazamox - containing products forms sterile seeds, which also has economic significance.

Herbicide efficacy of the most often used herbicide product for broadleaf weed control containing is presented on Figure 2. The presented herbicide has no efficacy against the grass weeds. As well as for the Clearfield technology, here the herbicides that control grass weeds like cycloxidim, clerhodim, fluazifop-P-butyl, quizalofop-P-ethyl, etc. The herbicide product containing clopyralid + aminopyralid + picloram shows excellent mixing abilities with the grass herbicides cycloxidim and fluazifop-P-butyl.

At the conventional technology for control of the parasite broomrape it is relied entirely on the genetic resistance of some rapeseed hybrids. The control of the weeds at the conventional oilseed rape fields during the period of the study is conducted by soil herbicides with active substances napropamide, metazachlor, clomazone, dimethachlor, etc.

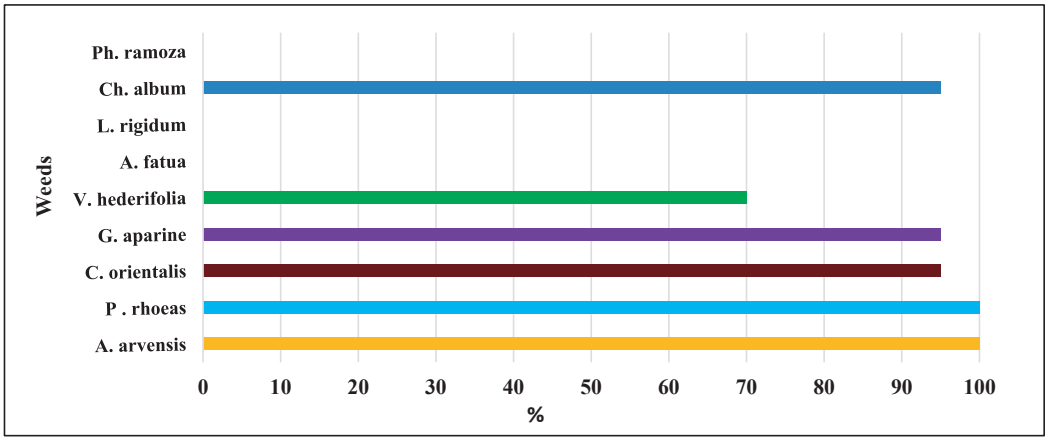

Figure 2. Efficacy of clopyralid + aminopyralid + picloram average for the research period

CONCLUSIONS

The data analyses from the research showed that in the oilseed rape fields of Bulgaria a significant dynamics of the weed species and densities that form the weed associations has occurred. The dominating weed species are wild mustard (*Sinapis arvensis* L.), wild radish (*Raphanus raphanistrum* L.) and on separate fields the wild hemp (*Cannabis ruderalis* Janisch.), common poppy (*Papaver rhoeas* L.) in high density was prevailing. Perennial weeds are relatively limited. Species of genus *Phelipanche* are most common in southern Bulgaria.

The implementation of alternative cropping technologies like Clearfield®, their constant improvement, as herbicide content and selection process showed positive effect for decreasing the density and range of distribution of these weeds in the oilseed rape fields. In Clearfield technology, the herbicides that control cereal weeds wary well are cycloxydim, cletodim, fluazifop-P-butyl, quizalofop-P-ethyl.

At the conventional technology for control of the parasite broomrape it is relied entirely on the genetic resistance of the rapeseed hybrids.

The control of the weeds at the conventional oilseed rape fields during the period of the study is conducted by soil herbicides with active substances napropamide, metazachlor, clomazone, dimethachlor.

REFERENCES

Abbadi, A., Leckband, G. (2011). Rapessed breeding for oil content, quality, and sustainability. *Eur. J. Lipid Sci. Technol*., *113*. 1198–1206.

Ádámszki, T., Kukorelli, G., Torma, M., & Reisinger, P. (2010). Experiences in weed control of imidazolinon resistant winter oilseed rape. *Magyar Gyomkutatás és Technológia*, *11*(2), 45–59.

Ataie, S., Pirdashty, H., Kazemi, H., Younesabadi, M. (2018). Mapping the distribution and flora of the weeds in canola fields of Gorgan Township by Geographic Information System (GIS). *Journal of Plant Protection (Mashhad)*, *31*(4), 605–616.

Bardsley, E., Waite, P., Sellars, J. (2018). GF-3447 - a new herbicide concept containing halauxifen-methyl for the post emergence control of broadleaf weeds in winter oilseed rape. *The Dundee Conference. Crop Production in Northern Britain 2018, Dundee, UK, 27-28 February 2018*, 139–144.

Bijanzadeh, E., Ghadiri, H., Behpouri, A. (2010). Effect of trifluralin, pronamide, haloxyfop-p methyl, propaquizafop, and isoxaben on weed control and oilseed rape yield in Iran. *Crop Protection*, *29*(8), 808–812.

Blackshaw, R,, Lemerle, D., Mailer, R., Young, R. (2002). Influence of wild radish on yield and quality of canola. *Weed Science, 50*. 344–349.

Brennan, R., Bolland. D. (2007). Effect of fertiliser phosphorus and nitrogen on the concentrations of oil and protein in grain and the grain yield of canola (*Brassica napus* L.) grown in south-western Australia. *Aust. J. Exp. Agri., 47*. 984–991.

Dimitrova, M., Dimova, D., Zhalnov, I., Stoychev, D., Zorovski, P., Georgieva, T., Mitkov, A., Idirizova, E. (2014b). Influence of some herbicides on the growth and development of winter oilseed rape. Balkan Agricultural Congress, 8-11 September 2014, Edirne, Turkey, *Turkish Journal of Agricultural and Natural Science*, 1058–1062.

Dimitrova, M., Dimova, D., Zhalnov, I., Zorovski, P., Georgieva, T., Mitkov, A., Idirizova, E. (2014a). The influence of some herbicides on the structural elements of the yield of winter oilseed rape. Balkan Agricultural Congress, 8-11 September 2014, Edirne, Turkey, *Turkish Journal of Agricultural and Natural Science*, 1054–1057.

Dimitrova, M., Zhalnov, I., Stoychev, D. (2014c). Efficacy and selectivity of some herbicides on winter oilseed rape, *Agricultural Science and Technology*, *6* (3), 297–300.

Dimitrova, M., Zhalnov, I., Kalinova, Sht., Tonev, T., Baeva, G., Milanova, S., Nikolova, V., Nakova, R. (2004). Methodology for reporting and recording the weeds in major field crops. *Ministry of Agriculture, Food and Forestry and National Crop Protection Agency.* (In Bulgarian).

Drobny, H., & Schlang, N. (2012). Salsa® (ethametsulfuron-methyl 75% WG): a novel selective herbicide for oilseed rape in Europe. *Julius-Kühn-Archiv*, *2*(434), 540–543.

Duroueix, F., Hebrail, M., Lacotte, J. (2013). Weed control in winter oilseed rape: solutions for progress with postemergence. *22e Conférence du COLUMA. Journées Internationales sur la Lutte contre les Mauvaises Herbes, Dijon, France, 10-12 décembre 2013*, 249–259.

Franek, M. (1994). Spring weeding treatments in winter oilseed rape. *Ochrona Roślin*, *38*(4), 3–4.

Franek, M., Rola, H. (2001). Effects of weed control in winter oilseed rape with the herbicide Colzor Trio 405 EC in lower Silesia conditions. *Rośliny Oleiste*, *22*(1), 97–102.

Franek, M., Rola, H. (2002a). Application of herbicides to weed control in winter oilseed rape in dependence on economic condition of farm. *Rośliny Oleiste*, *23*(2), 365–372.

Franek, M., Rola, H. (2002b). Efficacy of herbicide Nimbus 283 SE to weed control in winter oilseed rape on Lower Silesia. *Rośliny Oleiste*, *23*(2), 351–356.

Freeman, S., Lutman, P. (2004). The effects of timing of control of weeds on the yield of winter oilseed rape (Brassica napus), in the context of the potential commersialization of herbicidetolerantn winter rape. *The Journal of Agricultural Science*, *142*(3), 263–272.

Fried, G., Chauvel, B., Reboud, X. (2015). Weed flora shifts and specialisation in winter oilseed rape in France. *Weed Research*, *55*(5), 514–524.

Frisen, L., Nelson, A., Van Acker, R. (2003). Fudence of contamination of pedigreed canola (Brassica narus) seedlots in western Canada with genetically engineered herbicide resistance traits. *Agronomy Journal*, *95*(5), 1342–1347.

Gibot-Leclerc, S., Pinochet, X., Sallé, G. (2006). Broomrapes (*Orobanche ramosa*) as parasite of winter oilseedrape: an extension risk under observation. OCL - Oléagineux, Corps Gras, Lipidesm *13* (2/3), 200–205.

Gillian, P., Whytock, P., Carnegie, M. (1992). The weed flora associated with winter oilseed rape in north-east Scotland. *Annales ANPP,* 249–258.

Goerke, K., Richter, U., Schulte, M., Gerowitt, B. (2008). Regional distinctions in the weed flora of winter oilseed rape in Germany. *Gesunde Pflanzen*, *60*(4), 151–158.

Hamzei, J., Nassab, A., Heidari, G., Baradaran, M., Esfandiari, E., Veisi, B. (2010). Comparison of the critical period of weed control in three winter oilseed rape (Brassica napus) cultivars. *Proceedings of 3rd Iranian Weed Science Congress, 1*. 319–322.

Hanzlik, K., Gerowitt, B. (2012). Occurrence and distribution of important weed species in German winter oilseed rape fields. *Journal of Plant Diseases and Protection*, *119*(3), 107–120.

Hanzlik, K., Gerowitt, B., Schulte, M. (2010). What are weed species composition and species richness in oilseed rape influenced by? - Results from a weed survey on 1463 German oilseed rape fields. *Julius-Kühn-Archiv*, *428*. 328–329.

Harker, K., Clayton G., Blackshaw, R., O'Donovan, J., Stevenson, F. (2003). Seeding rate, herbicide timing and competitive hybrids contribute to integrated weed management iv canola (*Brassica narus*). *Canadian Journal of Nant. Science*, *83*(2), 433–440.

Heard, M., Hawes, C., Champion, G., Clark, S. (2003). Weeds in fields with contrasting conventional and genetically modified herbicide – tolerant crops. II. Effects on individual species. *Philosophical*

Transactions of the royal society of London Series B-Biological sciences, *358*(1439), 1833–1846.

Holt, S, Ghersa, C. (1996). Physiological aspects of competition. In: Radosevich S, Holt J, Ghersa C, editors. Weed ecology: implications for managemen. London, UK: Wiley Publications, 217–287.

Kalinova, Sht., Zhalnov, I., Dochev, G. (2012). Indirect Indication of Weed Damage as Incubators for Diseases and Pests of Cultivated Plants. *Scientific Works of the Agricultural University of Plovdiv, Bulgaria, LVI*. 291–294.

Kapeluszny, J. (2005). The medicinal, nectariferous and polleniferous weeds in oilseed rape (Brassica napus L. var. napus) in the Lublin region (Poland). *Pamietnik Pulawski (Poland)*, *134*. 113–120.

Kohlschmid, E., Müller-Stöver, D., Sauerborn, J. (2011). Spreading of the parasitic weed Phelipanche ramosa in German agriculture. *Gesunde Pflanzen*, *63*(2), 69–74.

Koleva-Valkova, L., Vasilev, A., Dimitrova, M., Stoychev, D. (2016). Determination of metazachlor rezidues in winter oilseed rape (Brassica napus var.Xanon) by HPLC. *Emirats Journal of Food and Agriculture*, *28*(11), 813–817.

Konstantinović, B., Meseldžija, M., & Konstantinović, B. (2007). Possibilities of weed control in oilseed rape. *Biljni lekar*, *35*(4), 468-475.

Konstantinovic´, B., Meseldzija, M., & Konstantinovic´, B. (2007). Possibilities of weed control in oilseed rape. *Biljni Lekar (Plant Doctor)*, *35*(4), 468–474.

Koprivlenski, V., Dimitrova, M., Zhalnov I. (2015). Economic assessment of the herbicides for weed control in oilseed rape. *Indian Journal of Research*, *4*(3), 6–8.

Lemerle, D, Blackshaw, R., Smith, A., Potter T., Marcroft, S. (2001). Comparative survey of weeds surviving in triazine-tolerant and conventional canola crops in south-eastern Australia. *Plant Protect Quart. 16*(1), 37–40.

Llewellyn, R., Ronning, D., Clarke, M., Mayfield, A., Walker, S., Ouzman, J. (2016). Impact of weeds on Australian grain production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices. Grains Research and Development Corporation; Canberra, ACT, Australia

Lourdet, Y. (2013). GF-2540: a new product for post emergence weed control in oilseed rape. *22e Conférence du COLUMA. Journées Internationales sur la Lutte contre les Mauvaises Herbes, Dijon, France, 10-12 décembre 2013*, 910-916.

Lourdet, Y., Rougerie, I. (2016). GF-3447 a new product for post emergence control of broadleaf weeds in oil seed rape. *23e Conférence du COLUMA. Journées Internationales sur la Lutte contre les Mauvaises Herbes, Dijon, France, 6-8 décembre 2016*, 700–708.

Maataoui, A., Bouhache, M., Benbella, M., Talouizte, A. (2003). Critical period of weed control in oilseed rape in two Moroccan Regions. *Communications in Agricultural and Applied Biological Sciences*, *68*(4a), 361–371.

Majchrzak, L., Jarosz, A. (2010). Efficacy of propisochlor and its tank mix for weed control in winter oilseed rape. *Progress in Plant Protection*, *50*(3), 1381–1385.

Majchrzak, L., Pudeko, J., Skrzypczak, G. (2008). Influence of mixture of bifenoks and metazachlor in weed control in winter oilseed rape. *Progress in Plant Protection*, *48*(1), 291–296.

Marcinkevičiene, A., Velička, R., Keidan, M., Butkevičiene, L. M., Kriaučiuniene, Z., Kosteckas, R., Čekanauskas, S. (2017). The impact of non-chemical weed control methods and biopreparations on winter oilseed rape preparation for over-wintering and productivity. *Zemes ukio Mokslai*, *24*(4), 119–132.

Marcinkevičiene, A., Velička, R., Mockevičiene, R., Pupaliene, R., Kriaučiuniene, Z., Butkevičiene, L. M., Kosteckas, R., Čekanauskas, S. (2015). Non-chemical weed control systems in organically grown spring oilseed rape. *Acta Fytotechnica et Zootechnica*, *18*(Special Issue), 34–36.

Mitkov A., Yanev, M., Neshev, N., Tonev, T. (2017). The broomrape (*Phelipanche* spp.): New problem in the oilseed rape fields. „Weed Science and Sustainable Rural Development", 29-31 March 2017, Orestiada, Greece, 54.

Moradi, K., Mohammadvand, E., Asghari, J. (2020). The Efficacy of some Herbicides and Cultivation on Weed Control and Rapeseed (*Brassica napus* L.) Yield. *Journal of Plant Protection*, *34*(2), 243–258.

MZH (2020). Agrostatistics, yields from field crops - harvest 2019. *Ministry of Agriculture, Food and Forestry* (In Bulgarian). https://www.mzh.government.bg/media/filer_public/2020/06/30/ra375publicationcrops2019.pdf

Oerke, E. (2005). Crop losses to pests. *The Journal of Agricultural Science, 144*(01), 31–43. https://doi.org/10.1017/S00218596050057

Pavlovic, D., Mitrovic, P., Marisavljevic, D., Marjanovic-Jeromela, A., Anelkovic, A. (2015). The effect of weeds on the yield and quality parameters of rapeseed. Sixth International Scientific Agricultural Symposium "Agrosym 2015", Jahorina, Bosnia and Herzegovina, October 15-18, 2015. Book of Proceedings Lukavica: University of East Sarajevo, 914–918.

Pfenning, M., Kehler, R., Bremer, H. (2012). New perspectives for weed control in winter oilseed rape due to the introduction of the Clearfield® system. *Julius-Kühn-Archiv*, *2*(434), 435–442.

Saeed, M., Marwat, K.B., Bakhtiar, Gul. (2011). Occurrence of different weeds in canola: a survey of farmers in District Swat-Pakistan. *Pakistan Journal of Weed Science Research*, *17*(1), 25–31.

Salimi, H., Sajedi, S. (2005). Identification of dominant weeds in canola fields and determination of their densities in Tehran province. *Applied Entomology and Phytopathology, 72*(2), 73–84.

Schönhammer, A., Pfenning, M., Chenevier, S. (2010). Innovative possibilities of weed control in oilseed rape with Clearfield. *Julius-Kühn-Archiv. 428*. 329-330.

Senior, I., Dale P. (2002). Herbicide – tolerance crops in agriculture oilseed rape as a case study. *Plant Breeding*, *121*(2), 97–107.

Stormonth, D., Moss, S., Guichard, A. (2012). Clethodim: evaluation in field experiments for grass-weed control in oilseed rape. *Aspects of Applied Biology* (117), 47–51.

Tityanov, M., Tonev, T., Mitkov, A. (2009). Advances in chemical weed control in rape. *Third International Symposium "Ecological approaches towards the production of safety food"*, 237–244.

Tonev, T. (2000). *Color atlas of 100 economically most important weeds in Bulgaria*. Publisher: Bibliotheka Zemedelsko Obrazovanie. (In Bulgarian)

Tonev, T., Dimitrova, M., Kalinova, Sht., Zhalnov, I., Zhelyazkov, I., Vasilev, A., Tityanov, M., Mitkov, A., Yanev, M. (2019). *Herbology*, Publisher: Vidinov & son, ISBN: 978-954-8319- 75-1. (In Bulgarian)

Tonev, T. (2000). *A guidebook for integrated weed management and proficiency of agriculture*. Publisher: Bibliotheka Zemedelsko Obrazovanie. (In Bulgarian)

Velička, R., Marcinkevičiene, A., Pupaliene, R., Butkevičiene, L., Kosteckas, R., Čekanauskas, S., Kriaučiuniene, Z. (2016). Winter oilseed rape and weed competition in organic farming using non-chemical weed control. *Zemdirbyste-Agriculture*, *103*(1), 11–20.

Vinnichek, L., Pogorelova, E., Dergunov, A. (2019). Oilseed market: Global trends. *IOP Conf. Ser. Earth Environ. Sci.*, 274, 0112030.

WenDa, Z., ShouHui, W., ChaoXian Z. (2008). Species composition and characterization of weed community in oilseed rape fields in Hubei Province. *Chinese Journal of Oil Crop Sciences*, *30*(1), 100–105.

Werner, B. (2014). Possibilities for a specific post-emergence weed control in winter oilseed rape. *Julius-Kühn-Archiv, 443*. 662–670.

Whitehead, R., Wright, H.C. (1990). The incidence of weeds in winter oilseed rape in Great Britain. *Aspects of Applied Biology*, *23*. 211–218.

Wu, J., Muir, A. (2008). Comparative structural, emulsifying, and biological properties of 2 major canola proteins, cruciferin and napin. *J Food Sci,. 73*. 210–216. doi:10.1111/j.1750-3841.2008.00675.x

Yanev M., Mitkov, A., Neshev, N., Tonev, T. (2020). Broomrape (*Phelipanche ramosa* (L.) Pomel) Control in Winter Oilseed Rape with Imazamox-Containing Herbicide Products. *International Journal of Innovative Approaches in Agricultural Research*, *4* (2), 251–258.

Yanev, M. (2020). Weed Control in Oilseed Rape (Brassica napus L.). *Scientific Papers. Series A. Agronomy*, *LXIII*(1), 622–631.

Zotz, A., Bernhard, U., Koops, A., Gaujac, X. (2016). Milestone - a selective herbicide for the control of important grasses and broadleaved weeds in winter oilseed rape. *Julius-Kühn-Archiv, 452*. 355–358.