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Original article

Broomrape (*Phelipanche ramosa* (L.) Pomel) Control in Winter Oilseed Rape with Imazamox-Containing Herbicide Products

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Abstract

The broomrapes are root, obligate parasites without chlorophyll. They parasitize mostly the dicotyledonous plants. Phelipanche ramosa (L.) Pomel attacks a wider range of hosts among which is the winter oilseed rape (Brassica napus L.). The broomrape can reduce the yields and aggravate the quality of production. There are few effective measures to control this parasite. One of the most promising approaches is the cultivation of Clearfield® oilseed rape and the treatment of imazamox-containing herbicide products. For this purpose during the growing seasons of 2016 - 2017 and 2017 - 2018 a field pot experiment with the Clearfield® oilseed rape hybrid PT 228 CL was conducted. The soil of the field pots was artificially infested with Ph. ramosa seeds. The herbicide application was performed in two stages of the crop in the spring - BBCH 31–33 (1-3 internodes visible) and BBCH 51 („green button"). Variants of the trial were: 1. Untreated control; 2. Cleranda® (375 g/l metazachlor + 17.5 g/l imazamox) – 2.00 l/ha (BBCH 31–33); 3. Cleravo® (250 g/l quinmerac + 35 g/l imazamox) – 1.00 l/ha (BBCH 31–33); 4. Pulsar® Plus (25 g/l imazamox) – 1.00 l/ha (BBCH 31–33); 5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33); 6. Pulsar® Plus – 0.50 l/ha (BBCH 51); 7. Pulsar® Plus – 1.00 l/ha (BBCH 51); 8. Pulsar® Plus – 2.00 l/ha (BBCH 51). Average for both years of the study, the highest efficacy against the parasite after the application of Pulsar® Plus – 2.00 l/ha (BBCH 51) – 92.9% followed by Cleranda® – 2.00 l/ha (BBCH 31–33) – 91.2% was reported.

Keywords: Winter oilseed rape, broomrape, control, imazamox, efficacy.

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INTRODUCTION

Broomrapes are root obligate parasites without chlorophyll. They parasitize mostly the dicotyledonous plants that grow in the dry regions of the Middle East, Mediterranean, Eastern Europe, Western Australia and California (Parker, 2009). The parasitation of Phelipanche and Orobanche species can cause yield decrease from 5 to 100% (Joel et al., 2007; Musselman, 1980; Parker and Riches, 1993; Venkov and Bozoukov, 1994. Press and Graves, 1995; Press and Phoenix, 2005; Schneeweiss, 2007; Habimana et al., 2013, 2014; Kaya, 2014, 2015).

Phelipanche ramosa (L.) Pomel (Joel, 2009) has a wide host range among which are plants from the *Solanaceae*, *Brassicaceae* and *Fabaceae* families (Parker and Riches,1993; Entcheva and Shindrova, 1994; Buschmann et al., 2005a; Haidar et al., 2003; Bozukov et al., 2005; Joel et al., 2007; Yanev et al., 2014). In recent years the parasite expands its areal distribution and range of host plants, regardless of whether crops or weeds. One of the *Ph. ramosa* hosts are *Brassica napus* L. (Perny, 1989; Buschmann et al., 2005b; Gibot-Leclerc et al., 2006; Boulet et al., 2007; Tsialtas and Eleftherohorinos, 2011).

The development of an effective blue wrist control strategy is hampered by the following circumstances: Orobanche / Phelipanche spp. has a wide range of hosts; The parasite is directly connected to the host; The processes of infection and pathogenesis take place underground and the damage to the crop occurs before the broomrape appears above the soil; *Phelipanche* spp. forms a large number of seeds of very small size, which are easily distributed by irrigation water, wind, animals, humans, and tillage equipment (Zindahl, 1993). Seeds germinate only in the presence of a root exudate separated from the host plant (Westwood, 2013). Difficulties in the broomrape control strategies also occur from the fact that the parasite seeds contain the "preservative" substance called tricin, which, according to literature data, preserves their viability in the soil for decades (Linke and Saxena, 1989; Joel et al., 2007).

There are few effective measures to control the parasite. One of the most commonly used is chemical methods. It is based on the use of systemic herbicides that are not metabolized in the host plant but are transported to the parasite.

Compared to other crops, the information for *Ph. ramosa* control in oilseed rape is limited. Literature data show that treatment with glyphosate at doses of 0,25 to 0,75 kg/ha with herbicide-resistant oilseed rape significantly reduces parasite density (Nandula, 1998; Nandula et al., 1999).

Duroueix and Guillet (2013) recommend two times treatment with imazamox. The first in the second half of October at a dose of 25 g/ha of the active substance, and the second in February at a dose of 25 g / ha of active substance again.

This study aims to monitor the control of *Phelipanche raposa* (L.) Pomel in winter oilseed rape by using imazamox containing herbicides.

Materials and Methods

During the growing seasons of 2016 - 2017 and 2017 - 2018 a field pot experiment with the Clearfield® oilseed rape hybrid PT 228 CL was conducted. The soil of the field pots was artificially infested with Ph. ramosa seeds. The study was performed in four replications.

The soil of the field pots was artificially infested with 1g seeds of *Ph. ramosa* per pot in the autumn of 2016. In the next experimental year, artificial infestation was not performed. The herbicide application was done in two stages of the crop in the spring - BBCH 31–33 (1-3 internodes visible) and BBCH 51 („green button"). Variants of the trial were: 1. Untreated control; 2. Cleranda® (375 g/l metazachlor + 17.5 g/l imazamox) – 2.00 l/ha (BBCH 31–33); 3. Cleravo® (250 g/l quinmerac + 35 g/l imazamox) – 1.00 l/ha (BBCH 31–33); 4. Pulsar® Plus (25 g/l imazamox) – 1.00 l/ha (BBCH 31–33); 5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33); 6. Pulsar® Plus – 0.50 l/ha (BBCH 51); 7. Pulsar® Plus – 1.00 l/ha (BBCH 51); 8. Pulsar® Plus – 2.00 l/ha (BBCH 51).

At the end of the oilseed rape vegetation the following parameters were evaluated: Nuber of broomrape parasites per oilseed pant; Height of the plants (m); Seed yield per plant (g); Absolute seed mass of 1000 seeds (g) (Tonev et al., 2018); In 2018 the seed oil content (%) was determined by the Soxhlet method as described by Ivanov and Popov (1994).

Statistical analysis of collected data was performed by using Duncan's multiple range test by the software SPSS 19. Statistical differences were considered significant at $p<0.05$.

Results and Discussion

The results of our previous trial conducted in field conditions of the period 2014-2015 and 2015-2016 showed the high injurious level of the broomrape on one hand and the possibilities for effective herbicide control of the parasite on the other hand. Average for the period, the broomrape density at the untreated control was 10.22 specimens per 1 m^2. The highest herbicide effect was achieved after the spring treatments (Mitkov et al., 2017).

In the current trial, it was found that in the second year the broomrape number was higher than the first year. It was probably due to the growing of oilseed rape on the same place for second year. For effective broomrape control in oilseed rape, the plants should be sawn on the same field after 4 years minimum (Tonev et al., 2019).

In the current trial, the highest efficacy for the treatment of Pulsar® Plus – 2.00 l/ha (BBCH 51) (Variant 8) was recorded (Table 1). The broomrape number per one oilseed rape plant was the lowest – 0.25 in 2017 and 1.50 for 2018. The other treatments had a higher number of parasites per plant, but the

results were with not proved differences according to Duncan's multiple range test. All treatment data were with proved differences with the untreated control only. The plants of the untreated control had 12.54 broomrape parasites per plant average for both years of the study (Table 1). No phytotoxicity symptoms from any of the herbicide applications were observed.

Table 1. Number of broomrape parasites per oilseed plant at the end of the vegetation

Treatments	2017	2018	Average
1. Untrated contol	8.25 a	16.83 a	12.54
2. Cleranda® – 2.00 l/ha (BBCH 31–33)	0.38 b	1.83 b	1.11
3. Cleravo® – 1.00 l/ha (BBCH 31–33)	0.75 b	3.83 b	2.29
4. Pulsar® Plus – 1.00 l/ha (BBCH 31–33)	0.88 b	4.67 b	2.78
5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33)	0.63 b	2.67 b	1.65
6. Pulsar® Plus – 0.50 l/ha (BBCH 51)	0.63 b	4.00 b	2.32
7. Pulsar® Plus – 1.00 l/ha (BBCH 51)	0.45 b	2.17 b	1.31
8. Pulsar® Plus – 2.00 l/ha (BBCH 51)	0.25 b	1.50 b	0.88

Figures with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$)

The results concerning the plant height are presented on Table 2. It was found that the plants treated with Pulsar® Plus – 2.00 l/ha in BBCH 51 (Treatment 8) were the highest – 1.50 m average for both years of the experiment. The plants were shorter in the second year.

Table 2. Heihgt of the plants (m)

Treatments	2017	2018	Average
1. Untrated contol	1.18 c	1.04 c	1.11
2. Cleranda® – 2.00 l/ha (BBCH 31–33)	1.39 b	1.24 b	1.32
3. Cleravo® – 1.00 l/ha (BBCH 31–33)	1.43 b	1.28 b	1.36
4. Pulsar® Plus – 1.00 l/ha (BBCH 31–33)	1.38 b	1.22 b	1.30
5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33)	1.43 b	1.29 b	1.36
6. Pulsar® Plus – 0.50 l/ha (BBCH 51)	1.40 b	1.25 b	1.33
7. Pulsar® Plus – 1.00 l/ha (BBCH 51)	1.37 b	1.22 b	1.30
8. Pulsar® Plus – 2.00 l/ha (BBCH 51)	1.58 a	1.41 a	1.50

Figures with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$)

The obtained results were with proved differences with the other variants in both experimental years. The hight of the treated plants varied between 1.32 to 1.36 m average for the period. The lowest plant height was found for the plants of the untreated control – 1.11 m on average for the study years.

The highest oilseed rapeseed yield was recorded after the treatment with Pulsar® Plus – 2.00 l/ha (BBCH 51) (variant 8) – 18.59 g per plant average for the period (Table 3). In comparison to the other treatments, the difference of the obtained results for the seed yield at treatment 8 was with proved differences according to Duncan's multiple range test in the different trial years. The yield from the other treated plants was higher than those of the control infested with broomrape. The untreaeted control had

the lowest yields – 8.49 g per plant. This, in turn, shows how harmful the broomrape can be. It was also found that the yield per plant was lower for the second experimental year.

Table 3. Seed yield per plant (g)

Treatments	2017	2018	Average
1. Untrated contol	10.43 f	6.55 e	8.49
2. Cleranda® – 2.00 l/ha (BBCH 31–33)	11.95 e	9.42 d	10.69
3. Cleravo® – 1.00 l/ha (BBCH 31–33)	16.41 b	12.25 b	14.33
4. Pulsar® Plus – 1.00 l/ha (BBCH 31–33)	13.88 c	10.25 c	12.06
5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33)	12.97 d	10.17 c	11.57
6. Pulsar® Plus – 0.50 l/ha (BBCH 51)	16.58 b	13.57 b	15.08
7. Pulsar® Plus – 1.00 l/ha (BBCH 51)	13.72 c	10.23 c	11.98
8. Pulsar® Plus – 2.00 l/ha (BBCH 51)	21.08 a	16.11 a	18.59

Figures with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$)

The absolute seed mass of 1000 seeds is an important quality indicator (Tonev et al., 2018). The results are presented in Table 4. The seeds with bigger values of the indicator have a higher price. This indicator is crucial for the formation of the yields (Georgiev et al., 2014).

Table 4. Absolute seed mass of 1000 oilseed rape seeds (g)

Treatments	2017	2018	Average
1. Untreated control	3.01 b	2.85 b	2.93
2. Cleranda® – 2.00 l/ha (BBCH 31–33)	3.42 a	3.24 a	3.33
3. Cleravo® – 1.00 l/ha (BBCH 31–33)	3.81 a	3.35 a	3.58
4. Pulsar® Plus – 1.00 l/ha (BBCH 31–33)	3.55 a	3.21 a	3.38
5. Pulsar® Plus – 2.00 l/ha (BBCH 31–33)	3.51 a	3.25 a	3.38
6. Pulsar® Plus – 0.50 l/ha (BBCH 51)	3.50 a	3.26 a	3.38
7. Pulsar® Plus – 1.00 l/ha (BBCH 51)	3.58 a	3.21 a	3.40
8. Pulsar® Plus – 2.00 l/ha (BBCH 51)	3.68 a	3.39 a	3.54

Figures with different letters are with a proved difference according to Duncan's multiple range test ($p < 0.05$)

The lowest absolute seed mass for the untreated control was recorded (2.93 g) where the infestation was the highest. All treated variants had higher values for this indicator. The results were with proved differences according to Duncan's test. It should be mentioned that in the second year of the study, the values of this quality parameter were diminished.

The oilseed rape seed oil content is an amain quality indicator. High seed yield together with high oil content will result in high oil yield (Pospišil et al., 2014). Oil content and oil quality depend on the genetic potential of the cultivar, respectively by its expression in specific agro-ecological conditions. Parasitic weeds cause heavy damage to a lot of crops by reducing the yield and quality of the production (Dubey, 2014). This statement was confirmed in our trial. The untreated control had the highest parasitation and the seed oil content was diminished in comparison to the variants treated with herbicides

(Figure 1). The seed oil content of the control plants was 42,28%. All treated variants had higher oil content values and the results were with proved differences according to Duncan's multiple range test.

The highest seed oil content for treatments 3. Cleravo® – 1.00 l/ha (BBCH 31–33) and 8. Pulsar® Plus – 2.00 l/ha (BBCH 51) was recorded – 48.10 and 48.60% respectively.

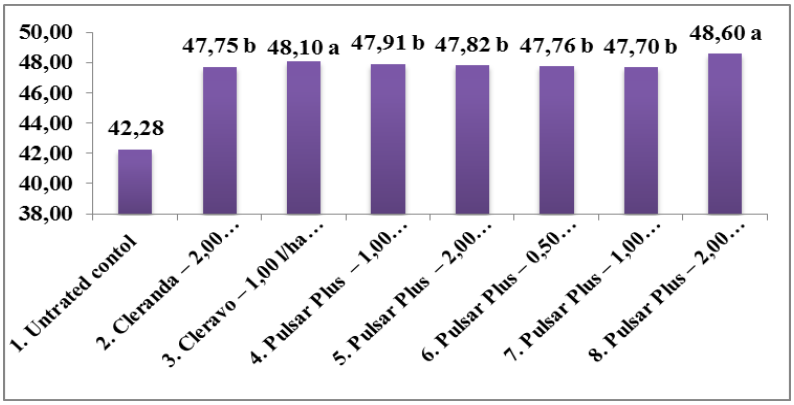

Figure 1. Seed oil content in 2018 (%).

Figures with different letters are with a proved difference according to Duncan's multiple range test ($p < 0.05$)

Conclusion

The highest biological efficacy against *Ph. ramosa* after the treatment with Pulsar® Plus – 2.00 l/ha (BBCH 51) was recorded.

During the two study years, the untreated control had the highest broomrape infestation.

All herbicide treatments in all application rates and application time were selective for the oilseed rape hybrid grown in the trial.

The highest plants, oilseed rape seed yield per plant, absolute seed mass of 1000 seeds, as well as seed oil content after the treatment with Pulsar® Plus – 2.00 l/ha (BBCH 51) were recorded. The untreated control showed had the lowest values for all studied parameters.

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Additional Declaration: Research and publication ethics principles were comply with in this study. Authors contributed equally to the study.

REFERENCES

Boulet, C., D. Pineault, H. Benharrat, D. Bozec, P. Delavault and P. Simier (2007). Oilseed rape weeds and branched broomrape (Orobanche ramosa L.). 20ème Conférence du COLUMA. Journées Internationales sur la Lutte contre les Mauvaises Herbes, Dijon, France, 11-12 décembre, 2007 Paris: Association Nationale pour la Protection des Plantes (ANPP). pp. 326-345.

Bozukov, H., P. Nikolov, E. Tomeva, S. Kalinova, N. Getov, S. Novodrianiva and I. Georgiev (2005). Observation and enter into a card index the infection of broomrape (Orobanche spp.) on tobacco in

Macedonian and Djebel regions. Proc. I-st Congress of plant protection, Ohrid, Macedonia. pp. 247-252.

Buschmann, H., G. Gonsior and J. Sauerborn (2005a). Pathogenicity of branched broomrape (Orobanche ramosa) populations on tobacco cultivars. Plant Pathol., 54, 650–656.

Buschmann, H., S. Kömle, G. Gonsior and J. Sauerborn (2005b). Susceptibility of oilseed rape (Brassica napus ssp. napus) to branched broomrape (Orobanche ramosa L.). Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz 112 (1) Stuttgart: Verlag Eugen Ulmer GmbH. pp. 65-70.

Dubey, N. (2014). Weed Management for Parasitic Weeds. In: Recent Advances in Weed Management.

Duroueix, F. and T. Guillet (2013). Chemical control of broomrape (Phelipanche ramosa) in winter rape. 22e Conférence du COLUMA. Journées Internationales sur la Lutte contre les Mauvaises Herbes, Dijon, France, 10-12 décembre 2013 Alfortville: Association Française de Protection des Plantes (AFPP). pp. 269-277.

Entcheva, V. and P. Shindrova (1994). Broomrape (Orobanche cumana Wallr.) – a problem of sunflower production in Bulgaria. In: Proc. 3rd Int. Workshop on Orobanche and related Striga Research, Amsterdam, The Netherlands. pp. 619-622.

Georgiev G., V. Encheva, N. Nenova, P. Peevska, Y. Encheva, D. Valkova, G. Georgiev and E. Penchev (2014). Characterization of the yield components of sunflower lines under the conditions of North-East Bulgaria. Scientific Works, 3 (1), 121-131.

Gibot-Leclerc, S., X. Pinochet and G. Sallé (2006). Broomrapes (Orobanche ramosa) as parasite of winter oilseedrape: an extension risk under observation. OCL - Oléagineux, Corps Gras, Lipides 13 (2/3) Montrouge: John Libbey Eurotext, pp. 200-205.

Habimana, S., K. Murthy, V. Hatti and A. Nduwumuremyi (2013). Management of Orobanche in field crops. A review. Sci. J. Crop Sci., 2(11), 144-158.

Habimana, S., A. Nduwumuremyi and R. Chinama (2014). Management of Orobanche in field crops - a review. J. Soil Sci. Plant Nutr., 14 (1) Temuco: Chilean Society of Soil Science, 43-62.

Haidar, M., W. Bibi and M. Sidahmed (2003). Response of branched broomrape (Orobanche ramosa) growth and development to various soil amendments in potato. Crop Prot., 22, 291–294.

Ivanov, K. and N. Popov (1994). A Guidebook for Exercises on Biochemistry of the Plants. Publisher ”Zemizdat”, Sofia, 88 pages. (In Bulgarian).

Joel, D. (2009). The new nomenclature of Orobanche and Phelipanche. Weed Res., 49, 1–6.

Joel, D., J. Hershenhorn, H. Eizenberg, R. Aly, G. Ejeta, P. J. Rich, J. K. Ransom, J. Sauerborn and D. Rubiales (2007). Biology and management of weedy root parasites. Hort. Rev., 33, 267-349.

Kaya, Y. (2014). Current situation of sunflower broomrape around the world. Proc. 3rd International Symposium on Broomrape (Orobanche spp.) in Sunflower. 3-6 June, Cordoba, Spain., 2014. pp. 9-18.

Kaya, Y. (2015). Herbicide resistance breeding in sunflower, current situation and future directions. Journal of ASM. Life Sciences, 2(326), 101-106.

Linke, K. and M. Saxena (1989). Study on viability and longevity of Orobanche seed under laboratory conditions. In: Progress in Orobanche research (Eds. Wegmann K., Musselman L.J.), Eberhard-Karls Universitat, Tubingen, FRG. pp. 110-114.

Mitkov, A., M. Yanev, N. Neshev and T. Tonev (2017). The broomrape (Phelipanche ssp.): New problem in the Bulgarian Oilseed Rape Fields. Book of abstracts of the Conference: ‘‘Weed Science & Sustainable Rural Development”. March 29, 30 & 31, Democritus University of Thrace, Orestiada, Greece.

Musselman, L. (1980). The biology of Striga, Orobanche and other root-parastitic weeds. Annu. Rev. Phytopathol., 18, 463–489.

Nandula, V. (1998). Selective control of Egyptian broomrape (Orobanche aegyptiaca Pers.) by glyphosate and its amino acid status in relation to selected hosts. PhD Thesis.

Nandula, V., C. Foy and D. Orcutt (1999). Glyphosate for Orobanche aegyptiaca control in Vicia sativa and Brassica napus. Weed Sci., 47 (5), 486-491.

Parker, C. and C. Riches (1993). Parasitic Weeds of the World: Biology and Control. CAB International, Wallingford.

Parker, C. (2009). Observations on the current status of Orobanche and Striga problems worldwide. Pest Manag. Sci. 65, 453–459.

Perny, A. (1989). Branched broomrape, a new weed of rape. Bulletin CETIOM (103). pp. 17

Pospišil, M., M. Brčić, A. Pospišil and J. Butorac (2014). Yield and yield components of investigated rapeseed hybrids and cultivars. Poljoprivreda, 20, 3-9.

Press, M. and J. Graves (1995). Parasitic Plants. Chapman and Hall, London.

Press, M., and G. Phoenix (2005). Impacts of parasitic plants on natural communities. New Phytol., 166, 737–751.

Schneeweiss, G. (2007). Correlated evolution of life history and host range in the non photosynthetic parasitic flowering plants Orobanche and Phelipanche (Orobanchaceae). J. Evol. Biol., 20, 471–478.

Tonev, T., M. Dimitrova, Sht. Kalinova, I. Zhalnov, Il. Zheliyazkov, A. Vassilev, M. Tityanov, A. Mitkov and M. Yanev (2019). Herbology. Publisher “Videneov and Son”. (Textbook in Bulgarian).

Tonev, T., M. Tityanov, A. Mitkov, M. Yanev and N. Neshev (2018). A Guidebook for Exercises on General Agriculture and Herbology. Publisher: “Biblioteka Zemedelsko Obrazovanie”. Pages: 71-72.

Tsialtas, J. and I. Eleftherohorinos (2011). First Report of Branched Broomrape (Orobanche ramosa) on Oilseed Rape (Brassica napus), Wild Mustard (Sinapis arvensis), and Wild Vetch (Vicia spp.) in Northern Greece. Plant Dis., 95 (10), 1322.

Venkov, V. and H. Bozoukov (1994). Influence of different species of Orobanche on cultivated sunflower and tobacco. Biology and management of Orobanche. Proc. 3-rd International Workshop on Orobanche and Striga Research, Amsterdam, The Netherlands, RTI. pp. 349-350

Westwood, J. (2013). The physiology of the established parasite-host association. In Parasitic Orobanchaceae. Berlin: Springer. pp. 87–114.

Yanev M., H. Bozukov and S. Kalinova (2014.) Distribution of Orobanche ramosa L. and Orobanche mutelii Sch. in the main tobacco producing regions of Bulgaria. Plant Sci., LI (1), 114-117.

Zindahl, R. (1993). Fundamentals of weed science. Academic Press Inc., New York. pp. 499.