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WEED MANAGEMENT INVESTIGATION OF IMIDAZOLINON TOLERANT WINTER OILSEED HYBRID

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1. INTRODUCTION, AIMS OF THE RESEARCH

In the recent years the cultivated area of oilseed rape has increased significantly. At the same time the intensity of the production technology in oilseed rape has also increased. Historically oilseed rape was an extensive culture but thanks to technology development and the decline of sugar beet area, it has become one of the most intensive field crops. This focus on oilseed rape productivity has in turn increased the importance of effective weed control in autumn.

The main weeds of winter oilseed rape come from the group T_1, T_2 (pl. *Matricaria spp.*, *Setaria media*, *Lamium amplexicaule* and *Papaver rhoeas*) as well as group T_4 weeds (pl. *Amaranthus spp.*, *Chenopodium spp.*, *Datura stramonium*). However increased the number of weeds which belongs to *Cruciferea* family (*Descurania sophia, Sinapis arvensis, Capsella-bursa pastoris*) and the monocot weeds as volunteer cereals and *Apera spica-venti*.

The herbicide tolerance based weed control technologies have been very successful in both sunflower and corn. The efficacy of weed control in these crops has increased significantly owing to this technology and it been highly successful in the control of traditionally problematic weeds. Imidazolinon tolerance based weed control technology was first introduced in winter oilseed rape in 2011 (Hungary being the first country in Europe to launch the technology).

Aims of the research:

- Identify the possible uses of imidazolinon tolerant weed control technology in oilseed rape
- Assess the performance of imidazolinon tolerant winter oilseed rape technology

Identify the possibility to use this technology within the Hungarian field crop production system.

- Recognize the benefits and the potential disadvantages of imidazolinone tolerant technology the light of an integrated and sustainable crop production.
- Evaluate the weed control spectrum of imidazolinone tolerant oilseed rape technology including the assessment of the herbicide control spectrum against a variety of different weeds species according to development status.
- Evaluation of the phytotoxicity effects on the crops. Determine the potential yield losses and understand the plant tolerance limits.
- Define the possible methods of herbicide control for volunteer imidazolinone tolerant oilseed rape in following crops.

2. MATERIALS AND METHODS

2.1. Examination of imidazolinon tolerance based winter oilseed rape weed control technology

2.1.1 Investigation to determine effective dose rate and phytotoxicity. (2009, 2010, 2011, 2012)

Trials were carried out in 2009-2010-ben in Győr, in 2011 in Ászár, in 2012 in Románd. The experiments were made in every year in small plots with 3 replications in a randomized block system.

We were sprayed Cleratop herbicide (17,5 g/l imazamox + 375 g/l metazaklór) during the dose rate studies with 1,0, 2,0 and 4,0 l/ha concentration alone and in combination with Dash HC adjuvant (1,0 + 1,0, 2,0 + 1,0 and 4,0 + 2,0 l/ha) when the weeds were 2-4 leaves growth stage. A standard application of Ikarus (240 g/l klopiralid + 80 g/l pikloram + 40 g/l aminopiralid 0,3 l/ha) was used as a comparison The protocol was same in every year.

Weed surveys were made across the trial area. The coverage of detected weeds was assessed in % coverage. We assessed the effect of herbicides against the different weed species, respectively. The weed control efficacy was visually assessed on a scale of 0 to 100 (0% = no weed control, 100% =full weed control). Evaluations of means were investigated by the Student-Newman-Keuls test at $P \leq 0.05$ as significance level. The significant differences were indicated with different letters which follow the values of weed control efficacy in the description of results. The trials were assessed at 7, 14 and 30 days after the application in the autumn. The trials were also assessed in the spring time at the beginning of oilseed rape development and beginning of flowering (this method was applied throughout the study).

The experiment plots were harvested with a Wintersteiger Delta harvest machine and all results were subjected to statistical analysis.

2.1.2 Identify the optimum application windows of imazamox + metazachlor + adjuvant combination (timing trial), Assess phytotoxicity effects on the crop (2010, 2011, 2012)

Timing trials were carried out in 2010 at Csabacsűd, Makó and Győr, in 2011 at Szarvas and Ászár and in 2012 at Románd.

Cleratop + adjuvant (Dash HC) tank mix combinations were applied to the plots at two different dose rates (reduced and normal dose rate) and at three different post emergence application timings. The growth stage of the weeds at first application time (B) were 1-2 leaves age, in a second time (C) 2-4 leaves age, in the third (D) 4-6 leaves age. Ikarus was applied as a standard in the second post emergence application time (C) (8. treatment). Butisan Star (metazachlor + quinmerak) was applied as a standard in pre emergence (A) followed by a post emergence application of (C) Galera (chlopiralid + pichloram) (9. treatment).

2.1.3 Mixibility studies (2009, 2010, 2012)

The trials were carried out at Győr in 2009 at Győr Csabacsűd and Mako in 2010 at Ászár and Szarvas in 2011, The applications were applied when the weeds had 2-4 leaves and the oilseed rape had 4-6 leaves. Cleratop herbicide was applied at 2,0 l/ha dose rate alone and in different tank mix combinations, The tank mix combination included adjuvant (Dash HC), growth regulator (Caramba Turbo – 30 g/l metconazole + 210 g/l mepiquat-chloride), graminicide (Focus Ultra – 100 g/l cikloxidim) and insecticide (Fendona – 100 g/l alfa-cipermetrin).

2.2. Selectivity trials with imidazolinon tolerant winter oilseed rape (2009, 2010, 2012)

The selectivity trials were carried out over 3 years in two different locations. At Algyő and Szepetnek in 2009 Telekgerendás and Győr in 2010 and at Örménykút in 2012. In Örménykút in two different imidazolinon tolerant oilseed rape fields were used The trials were carried out in small plots with four replications on a randomized block system.

The selectivity experiments were carried out in each case in weed free areas. The protocol contains imazamox + metazachlor combination at standard dose rate (2,0 l/ha) and double dose rate (4,0 l/ha) , alone and together with an adjuvant. In 2009 and 2010 the oilseed rape was at growth stage 2-4 leaves. In 2011 the applications were made at either 2-4 or 6-8 leaves. Metazachlor + quinmerak (Butisan Star) was applied as the standard at commercial dose rate (2,5 l/ha) and double dose rate (5 l/ha). The crop was harvested with a Wintersteiger Delta parcel harvest machine, the yield and the results were analyzed with a statistic method.

2.3. Soil preparation and post emergence weed control (2010, 2011, 2012)

The experiments were carried out in in 2010 and in 2012 at Győr, and in 2011 at Szarvas. Different methods of soil preparation were used in the trail; ploughing (rotational tillage) and disk harrow (without rotation).Cleratop + adjuvant was used as the herbicide across the trial applied at two different dose rates (reduced and normal dose rate). The herbicide was applied at two different times; (A) weeds at 1-2 leaves age (B) weeds at 2-4 leaves age. Ikarus (240 g/l klopiralid + 80 g/l pikloram + 40 g/l aminopiralid 0,3 l/ha) was applied as the second application time (B).

2.4. Examining the effect of imidazolinon tolerant oilseed rape volunteers in the following crop.

2.4.1 Control of volunteer oilseed rape in winter wheat. (2010, 2011, 2012)

The trial was conducted at Győr. Imidazolinon tolerant and conventional oilseed was planted following the sowing of winter wheat. The applied treatments: (1) Untreated (2-3) U46 M-Fluid (750 g MCPA) 1,0 and 1,5 l/ha (4-5) Esteron 60(850 g 2,4-D etil észter) 0,3-0,6 l/ha (6) Mustang (6,25 g/l floraszulam + 452 g/l 2,4 D) 0,5 l/ha (7) Starane (360 g/l fluroxipir-meptil) 0,6 l/ha (8-9) Biathlon (714 g/kg tritoszulforon) 0,05 and 0,07 kg/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 0,5 l/ha (10) Sekator (50 g/l amidoszulfuron + 12,5 g/l jodoszulfuron-metil-nátrium + 125 g/l mefenpír-dietil) 0,3 l/ha + Mero (81 % demetilt rapeoil) 1,0 l/ha (11) Sekator ((50 g/l amidoszulfuron + 12,5 g/l jodoszulfuron-metil-nátrium + 125 g/l mefenpír-dietil) 0,3 l/ha + U46 M-Fluid (750 g MCPA) 1,0 l/ha + Mero (81 % demetilt rapeoil) 1,0 l/ha (12) Biathlon (714 g/kg tritoszulforon) 0,05 kg/ha + U46 M-Fluid (750 g MCPA) 1,0 l/ha (13) Biathlon (714 g/kg tritoszulforon) 0,07 kg/ha + Starane (360 g/l fluroxipir-meptil) 0,4 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha. All treatments were applied in the spring time at the end of tillering of Winter wheat. The assessments were conducted the 7th, 14th and 30th days after treatment.

2.4.2 Control of volunteer oilseed rape in corn. (2010, 2011, 2012)

The trial was conducted at Győr in 2010 and 2012 and at Hódmezővásárhely in 2011 The imidazolinon tolerant and conventional oilseed was planted after the sowing of corn. The applied treatments were: (1) Untreated (2) Clio (336 g/l topramezon) 0,15 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha (3) Adengo (225 g/l izoxaflutol + 90 g/l tienkarbazon-metil + 150 g/l ciproszulfamid) 0,4 l/ha (4) Laudis (44 g/l tembotrion + 22 g/l izoxadifen-etil) 2,0 l/ha (5) Callisto (480 g/l mezotrion) 0,3 l/ha (6) Lumax (37,5 g/l mezotrion + 375 g/l S-metolaklór + 125 g/l terbutilazin) 4,5 l/ha (7) Callaris (70 g/l mezotrion + 330 g/l terbutilazin) 1,5 l/ha (8) Clio (336 g/l topramezon) 0,15 l/ha + Stomp Super (330 g/l pendimetalin) 3,3 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha (9) Clio (336 g/l topramezon) 0,15 l/ha + Akris (280 g/l dimetenamid-p + 250 g/l terbutilazin) 2,0 l/ha + Break Thru (25 % poliéter + 75 % trisziloxán) 0,2 l/ha (10) Stellar (50 g topramezon + 160 g dikamba) 1,0 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha (11) Cambio (320 g/l bentazon + 90 g/l dikamba) 2,5 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha (12) Callam (125 g/kg tritoszulfuron + 600 g/kg dikamba) 0,4 l/ha + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitát) 1,0 l/ha (13) Banvel (480 g/l dikamba) 0,5 l/ha (14) Esteron 2,4 D (850 g 2,4-D etil észter) 0,4 l/ha (15) Pardner (225 g/l bromoxinil) 1,5 l/ha. All treatments were applied when the corn was at 4-6 leaves stage

The assessments were conducted the 7th, 14th and 30th days after the treatment.

3. RESULTS AND DISCUSSIONS

2.1. Examination of imidazolinon tolerant weed control technology in winter oilseed rape

Occurring common weed species in the experimental area.

The weed survey showed the following weed species (16) present in the experimental area; *Papaver rhoeas* (12 places 9,73 % average cover), *Descurania sophia*, (12 places 8,11 % average cover), *Capsella-bursa pastoris* (6 places and 4,26 % average weed cover), T_4 weeds (*Chenopodium album* 12 places 6,77 %, *Datura stramonium* 4 and 4,71 %, *Amaranthus retroflexus* 2 places and 3,33 % average cover), *Matricaria inodora* (13 places 4,95 % average cover), *Lamium amplexicaula* (12 places and 2,47 % average weed cover), *Apera spica-venti* (9 places and 4,60 % average cover), *Triaticum aestivum* (6 places 3,66 % average cover).

3.1.1 Investigation of determination the effective dose rate and phytotoxicity test. (2009, 2010, 2011, 2012)

The imidazolinon tolerant oilseed rape showed no sign phytotoxicity or any crop damage symptoms follow the application of imazamox alone or in combination The results indicate that cruciferious weeds; *Descurania sophia*, *Sinapis arvensis* and *Capsella-bursa pastoris* are highly sensitive to Cleratop (1,0 l/ha - 17,5 g imazamox és 375 g metazachlor) solo applications. Dash HC adjuvant was found to enhance the activity of Cleratop against the full range of weeds tested. The efficacy of Cleratop combined with the adjuvant gave performance better than the double dose rate of Cleratop without adjuvant. The best performing herbicide combination across the range of weeds tested was 2,0 l/ha Cleratop in combination with 1,0 liter/ha Dash HC A higher dose rate was found not be necessary and resulted in no additional weed control benefits.

3.1.2 Recognize the right application windows of imazamox + metazaklór combination together with adjuvant (timing trial), phytotoxicity studies (2010, 2011, 2012)

The trials showed the optimal application time of Cleratop + Dash HC combinations is 2-4 leaves in weeds and 4-6 leaves in Oilseed rape This recommendation is partly due to the fact that the traditionally difficult weeds; *Papaver rhoeas* and *Matricaria* *inodora* can be effectively controlled up to 4 leaves In addition at 6-8 leaves the oilseed rape canopy spreads sideways covering many of the target weeds. Spraying after 4-6 leaves in Oilseed rape result in many weed not being covered by the herbicide and therefore not controlled.

Cleratop + Dash HC combinations are very effective against *Cruciferea* weeds from the cotyledon stage to six leaves. 100 % efficacy was observed against *Apera spica-venti* independent of growth stage. The combinations of Cleratop + Dash HC gave good efficacy against volunteer *Triticum aestivum* in the early growth stage. By comparison most of the current standards were generally ineffective against these weeds species (exception was Butisan Star 3,0 l/ha + Galera 0,3 l/ha against *Apera spica-venti*).

3.1.3 *Mixibility studies (2009, 2010, 2012)*

Between the tank mix combinations the strongest growth regulator effect was observed when a growth regulator (Caramba Turbo) + adjuvant (Dash HC) was used together. No other phytotoxicity effects were observed.

3.2. *Selectivity trials with imidazolinon tolerant winter oilseed rape (2009, 2010, 2012)*

Cleratop and Cleratop + Dash HC tank combination showed perfect selectivity in the imidazolinone tolerant oilseed rape hybrids. The yield measurement results confirm selectivity observations.

3.3. Context of soil preparation and post emergence weed control (2010, 2011, 2012)

The results showed that the quality of seedbed preparation indirectly affected the efficacy of post emergence herbicide application. This was independent on the type of tillage system used. When the soil preparation creates a fine, consistent seedbed the emergence of rape and weeds will be more uniform, and the timing and effect of the post emergence application will be more effective and safer. Poor seedbed preparation results in a long period of weed emergence and the optimum application timing becomes difficult can be seen from the

3.4 Examining the effect of cropping imidazolinon tolerant oilseed rape in a following crop as volunteer (Volunteer trials)

3.4.1 Weed control of volunteer oilseed rape from winter wheat. (2010, 2011, 2012)
Based on the results, it was seen that the imidazolinone tolerant volunteer oilseed rape can be controlled successfully in cereal crops with hormone containing herbicides. Differences were found between the efficacy of the available hormone based herbicides; The active MCPA gave 95-98 % efficacy, the active 2,4 D gave 88-93 %, and dicamba showed between 73-80 % performance. The biggest differences were observed between the performances of sulfonylurea based herbcides. Tritosulfuron (Biathlon) gave much better efficacy (85 %) against the imidazolinone tolerant volunteer oilseed rape than the combination of amidoszulfuron + jodoszulfuron-metil-nátrium + mefenpir-dietil (Sekator,) which gave only 60 % efficacy

3.4.2 Weed control of volunteer oilseed rape in corn. (2010, 2011, 2012)
imidazolinone tolerant volunteer oilseed rape can be effectively controlled in corn with the triketon containing family of products; (example: Calaris, (70 g/l mezotrion + 330 g/l terbutilazin) Lumax (37,5 g/l mezotrion + 375 g/l S-metolaklór + 125 g/l terbutilazin), Clio (336 g/l topramezon) + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitat), Clio (336 g/l topramezon) + Stomp (330 g/l pendimetalin) + Dash HC (185 g/l metiloleát + 185 g/l metilpalmitat), Stellar (50 g topramezon + 160 g dikamba), and Clio (336 g/l topramezon) + Akris (280 g/l dimetenamid-p + 250 g/l terbutilazin) + Break Thru (25 % poliéter + 75 % trisziloxán) and with the hormone active ingredient (Stellar (50 g topramezon + 160 g dikamba), and Esteron (850 g 2,4-D etil-ester).

4. NEW SCIENTIFIC FINDINGS

1. The experiments confirm that in the intensive oilseed production system (using hybrid, double grain spacing, low seed rate) the early control of competition from autumn weeds (T_1, T_2 and T_4 weeds) plays a key role in crop performance Based on the weed survey it was seen that in addition to standard T_1 and T_2 weeds the number of T_4 species have increased as well . The reason for this increase could be due to the usually warm autumns seen in recent years The T_4 weeds can cause significant damage indirectly in oilseed rape crops. This occurs when a large number of weeds emerge during autumn, if no herbicide treatments are applied the T_4 weeds present serious competition to the developing rape plants. In this case the oilseed rape seedlings under competition for light and nutrients become lanky which can lead to frost damage during the Winter.

2. The adjuvant (Dash HC) was found to be essential for the successful weed control in the imidazolinone tolerant technology. The most effective dose rates in the tankmix were 2,0 l/ha Cleratop + 1,0 l/ha Dash HC. At this rate the full spectrum of weeds were effectively controlled in the imidazolinone-tolerant winter oilseed rape hybrids.

3. The application of the Cleratop + Dash HC (2,0 + 1,0 l/ha) treatment was successful up to the 2-4 leaved stage of the weeds. Based on the trials it can be concluded that in addition to the *Cruciferea* species(*Sinapis arvensis, Descurainia sophia, Capsella-bursa pastoris*) the more developedT_4 weeds *(Chenopodium hybridum, Datura stramonium, Stellaria media)* and monocot species (*Apera spica-venti)* are also sensitive to the imidazolinon contain

combination. The effectiveness of the later applications (after 2-4 leaves) is reduced as the larger, more developed rape canopy often shades the weeds and protect them from the applied herbicide. One significant benefit is that the imazamox active provided a good herbicidal effect and control against the *Cruciferae* weed species. This species has been impossible to control using the standard herbicides in conventional oilseed rape varieties due shares genetics with the crop.

4. It can be stated that *Apera spica-venti* and the volunteer *Triticum aestivum* can be successfully controlled with the combination of Cleratop + Dash HC (2,0 + 1,0 l/ha) in the imidazolinone tolerant winter oilseed with no need for a further graminicide application

5. From the selectivity trials, it can be concluded that the imidazolinone tolerant winter oilseed rape hybrid perfectly tolerated the double dose rate of Cleratop (4.0 l/ha) + Dash HC (2.0 l/ha) and that no crop damage was observed with this rate at the different e application timings (BBCH 10-18).

6. The soil preparation has an indirect affect on the efficacy of the post-emergence herbicide in the winter oilseed rape. A well prepared, fine seedbed will allow the than the oilseed rape plants and weeds to emerge at a similar time and grow uniformly. This allows the herbicide to be applied the optimum time resulting in more effective weed control. The oilseed rape canopy can then grow to cover the soil more successfully after the weed control limiting further weed growth when the soil preparation is less uniform; a rough seedbed or one containing a lot of crop residue can result in heterogeneous emergence of the oilseed rape and weed plants. With weeds at different

growth stages the timing of the herbicide application will not be ideal, missing the sensitive growth stage in some of the weeds.

7. It was demonstrated that it is possible to successfully control the imidazolinone tolerant volunteer oilseed rape in both cereals and in corn crops. In wheat the active MCPA was observed to give the best efficacy followed by 2,4 D-containing products. In the sulfonylurea active group the best efficacy was achieved with tritosulfuron but this did not achieve total control of the volunteers. In corn triketone or hormone containing herbicides (2,4 D) showed acceptable efficacy against the imidazolinone tolerant volunteers of oilseed rape.

5. LIST OF PUBLICATIONS

Rewiewed papers published in scientific journal

Ádámszki, T. - Torma, M. (2015): Imidazolinon tolerancián alapuló gyomirtási technológia hatékonyság vizsgálata őszi káposztarepcében. Magyar Gyomkutatás és Technológia.

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Ádámszki, T. – Torma, M. (2014): Tankkombinációs lehetőségek imidazolinon toleráns repcében. Georgikon for agriculture volume 19.(1.):151-157.

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Ádámszki, T. (2011): Biztonságos és sikeres növényvédelem extrém években is. Növényvédelmi Tippek 2011/1: 14-15. BASF Kiadvány

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Ádámszki, T. - Torma, M. - Kukorelli, G. - Reisinger, P. (2011): Experiences in weed control of imidazolinon resistant winter oilseed rape. 3rd International Symposium on Weeds, Sarajevo, May 20- 21.

Kukorelli, G. - Reisinger, P. - Torma, M. - Ádámszki, T. (2011): Experiments with the control of common ragweed in imidazolinone-resistant and tribenuron-methyl-resistant sunflower. 3rd International Symposium on Weeds Sarajevo, May 20- 21.

Kukorelli, G. – Reisinger, P. – Ádámszki, T. (2010): Herbicid rezisztens napraforgó fajták árvakeléseinek érzékenysége különböző ALS gátló herbicidekkel szemben. MTA 56. Növényvédelmi Tudományos Napok. Budapest

Kukorelli, G. – Reisinger, P. – Ádámszki, T. (2010): Egyszikű gyomnövények elleni hatékony védekezés cikloxidim rezisztens (CR) kukoricában. MTA 56. Növényvédelmi Tudományos Napok. Budapest

Poster presentations in scientific conferences:

Kukorelli, G - Nagy, S. - Reisinger, P. – Ádámszki, T. (2010): Susceptibility of volunteers of some herbicide-resistant sunflower hybrid against different ALS-inhibitors. European Weed Research Society, 15th Symposium Kaposvár

Kukorelli, G - Reisinger, P. – Ádámszki, T. (2010)**:** Effective control against perennial and annual monocotyledon weed species in cycloxydiem-resistant maize. European Weed Research Society, 15th Symposium Kaposvár

Abstract published in a scientific conferescens:

Kukorelli, G - Nagy, S. - Reisinger, P. – Ádámszki, T. (2010): Susceptibility of volunteers of some herbicide-resistant sunflower hybrid against different ALS-inhibitors. European Weed Research Society, 15th Symposium Proceedings, Kaposvár

Kukorelli, G - Reisinger, P. – Ádámszki, T. (2010)**:** Effective control against perennial and annual monocotyledon weed species in cycloxydiem-resistant maize. European Weed Research Society, 15th Symposium Proceedings, Kaposvár