INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
20–0115/2020/24–2–195–200
DOI: 10.17957/IJAB/15.1423
http://www.fspublishers.org

Full Length Article

Temporal Changes of *Elytrigia repens* Density in Intensive Cereal-Based Cropping Systems

Milan Macák[1], Ivica Đalović[2*], Josef Smatana[1], Adriana Kiss Rohárikovǻ[1], Markola Saulic[3] and Mirko Kulina[4]
[1]*Department of Sustainable Agriculture and Herbology, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, Nitra, Slovak Republic*
[2]*Institute of Field and Vegetable Crops, Novi Sad, Serbia*
[3]*University of Belgrade, Faculty of Agriculture, Belgrade–Zemun, Serbia*
[4]*University of East Sarajevo, Faculty of Agriculture, Vuka Karadzića 30, Istočno Novo Sarajevo, Republic of Srpska, Bosnia and Hercegovina*
[*]For correspondence: maizescience@yahoo.com; ivica.djalovic@ifvcns.ns.ac.rs
Received 23 January 2020; Accepted 06 February 2020; Published 31 May 2020

Abstract

The common effects of cultivation practices, weed management measures and crop rotation on *Elytrigia repens* population dynamics under condition of large scale fields were studied in South-Western Slovakia during 2007–2014. The evaluated fields reflect the changes of cultivation practices associated with the growing crops in intensive crop rotation systems characterized by high proportion of cereals, changes of tillage practices (mouldboard stubble cultivation replaced by less effective disc stubble cultivation) and exclusion of cover crops and leguminous forage crops. Introduction of management practices with lack of preventive measures into six evaluated large-scale fields led to increasing proliferation of *E. repens*. Therefore, intensive herbicide application (from 2 to 5 application during 8-year rotation period) was needed to manage *E. repens* satisfactorily. *E. repens* was substantially higher in crops following two crops period of sunflower and spring barley crops, but lower in crops following winter oilseed rape.

Keywords*:* Cereals; Couch grass; Crop rotation; Perennial weed; Tillage

Introduction

Weeds are one of the major crops pests and cause serious losses in grain yield of field crops (Li *et al.* 2018). Therefore, effective weed management is integral component of crop husbandry packages (Gnanavel and Natarajan 2014; Take–tsaba *et al.* 2018). Inclusion of some crops, which usually have different weed floras, can avoid vigorous propagation of some aggressive weeds which are well adapted and competitive in specific crop types (Andreasen and Skovgaard 2009; Satrapová *et al.* 2013; Kumawat *et al.* 2017). Suitable crop rotation and use of cover crops influenced the number of weed species and their density including *Elytrigia repens* (Błażewicz–Woźniak *et al.* 2016; Harasim *et al.* 2017). The rhizomatous growth of *E. repens* L. (couch grass) causes serious problems for farmers in many crops. In Slovakia, *E. repens* belongs to the most troublesome weeds in winter wheat and spring barley (Týr and Vereš 2011). Similarly, in Finland *E. repens* was found to be the most frequent perennial weed species in organic spring cereals (Salonen *et al.* 2013). Repeated mowing, during autumn, can help reduce couch grass rhizome infestation. A low-yielding cover crop (30–60 g m^{-2} in October) may only reduce the shoot biomass produced during autumn with no effect on the rhizome biomass. The rhizome biomass reflects the accumulated biomass during the whole season and during the previous seasons as well. However, the shoot biomass adjusts quickly to the prevailing conditions (Ringselle *et al.* 2015). Physical weed control methods are less effective than the use of chemical herbicides. Therefore, weed control often requires a support from cultural and preventive measures for satisfactory weed management (Melander *et al.* 2012; Rasmussen *et al.* 2014). To control the competitive and troublesome perennial weeds, like *E. repens,* there is often a choice between physical weed control option and intensive use of non-selective herbicides. In the conventional agriculture, application of glyphosate is the most common method to control couch grass (Soukup *et al.* 2008; Aronsson *et al.* 2015). Information on influence of cultivation practices, weed management options and crops sequences on the dynamics of *E. repens* in cereal-based intensive cropping systems in agroclimatic conditions of Central European countries is lacking. Therefore, this study

To cite this paper: Macák M, I Đalović, J Smatana, AK Rohárikovǻ, M Saulic, M Kulina (2020). Temporal changes of *Elytrigia repens* density in intensive cereal-based cropping systems. *Intl J Agric Biol* 24:195–200

was conducted to evaluate the common effect of main cultivation practices, weed management measures and crops sequences on *E. repens* population changes under intensive cropping system with high share of cereals growing in large scale fields.

Materials and Methods

Experimental site

Field investigations was conducted during 2007–2014 at the Experimental farm of the Slovak Agricultural University in Nitra (48°22' 0" N, 18°12' 0" E) in South-Western Slovakia. Altitude of fields varied from 180 to 260 m above sea level. The weather condition of decisive period of crop management is given in the Table 1.

Experimental details

The six large scale arable fields located on an experimental farm on sand loamy Haplic Luvisol were selected according the share of cereals. The average area of surveyed field was 55.7 ha with field size ranging from 24 ha to 131 ha. For direct control of *E. repens,* the total herbicides Cosmic, Glyphogan 480 SL and Kaput with 36% content of glyphosate as the isopropylamine salt were applied between two crops periods in dose of 1080 g ha^{-1}, and propoxycarbazone sodium (PKS) herbicide Attribut SG 70 in dose of 60 g ha^{-1} was also applied. Herbicide control of *E. repens* was used if the actual *E. repens* density began to reach a 5–6 shoots m^{-2}, with one exception on the field 1 in 2009, where the PKS was applied to regulate *Avena fatua* L. The spring application of glyphosate and PKS (field 4 – 2011 and field 5 – 2008) was applied in second decade of April. The summer application of glyphosate was made between two crops periods in August–September. The second glyphosate application was made on 7 November in fields 3 and 5. Application of herbicides is indicated according timing by arrow in Fig. 1. Nutrients were added according to projected yield and soil nutrient status[25]. The average yield of cereals was 4.61 t $ha^{–1}$, oilseed rape 2.55 t $ha^{–1}$, grain maize 6.90 t $ha^{–1}$ and silage maize 14.9 t $ha^{–1}$ dry matter of biomass in 2010–2014. Catch crops were not included in the crop rotation. No direct mechanical weed control in canopy of row crops was used. Immediately after harvest of cereals (winter wheat, winter rye, spring barley) and winter oilseed rape, one summer stubble disc cultivation made by disc cultivator was followed by medium deep mouldboard ploughing (0.2 m) in autumn. After harvest of sunflower and grain maize, disc harrow with rollers was followed with deep autumn mouldboard ploughing (0.26–0.28 m), except field 3 in 2009 when shallow mouldboard ploughing was used (0.15–0.18 m). When harvesting maize for silage, the disc harrowing was omitted. In spring barley – winter rape sequences, only stubble disc cultivation was applied.

Observations

There were six experimental fields, all with different rotations (Fig. 1). In each field, permanently located experimental area of 3600 m^2 (60 m × 60 m) subjected to common evaluated field management practices were surveyed, positioned at least 50 m from boundaries to avoid field edge effects following Fried *et al*. (2008). Each of the experimental treatments was replicated four time. Four 1 m^2 quadrants (1 m × 1 m) were placed in each replication according random selection methods with distance of 10 m between samples square as described by Colbach *et al.* (2000). Density of *E. repens* was recorded during spring before seed bed preparation and spring term of herbicide application (glyphosate or PKS).

Statistical analysis

Prior to statistical analysis, the data of weed density were checked for normal distribution by PP plots and Shapiro-Wilk test. Fields with different crop rotation pattern associated with common effect of crop management and year (effect of crop management and agro-climatic conditions) were taken as experimental factors. The overall two-way analysis of variance (ANOVA) and one-way ANOVA for main effects analysis of particular crop rotation sequences, separately for each field, followed by Fisher post-hoc test at $P = 0.05$ level and Bartlett's, Cochran's, and Hartley's tests for the equality of variances were made using the Statistica 10 software (StatSoft Inc., Tulsa, U.S.A.). Shoot density response was described by Microsoft Excel 2016 graphs supplemented by statistical differences.

Results

The shoots density response

Two–way ANOVA showed a significant effect of crop rotation sequences and the common effect of weed and crop management practices in year conditions (source of variation expressed as year factor) on the population dynamics of *E. repens* density (Table 2). Two–way of interaction between two sources of variation: field (different crop rotation) and year (effect of previous crop management and agroclimatic conditions) was also statistically significant and indicates substantially higher influence than single effects of both evaluated factors. Different crop sequences and crop management of growing crops significantly influenced the temporal dynamics of couch grass population density (Table 3) in all evaluated fields except field 1 with very low *E. repens* density and herbicide control of *Avena fatua* by PKS.

Herbicide application

The herbicides application varies considerably from 2–5

Table 1: Mean air temperature (°C) and total precipitation (mm) per month at the experimental site during 2007–2014 and 1961–1990

Month /Year	2007		2008		2009		2010		2011		2012		2013		2014		Long-term period 1961–1990	
	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)	Temp (°C)	Rainfall (mm)
March	7.5	58	5.5	63	5.3	52	5.2	21	6.2	9	7.6	5	2.7	93	9.3	15	5	30
April	12.2	0	11.0	36	14.3	20	10.5	84	12	24	11.3	40	11.7	23	12.4	49	10.4	39
Aug.	21.2	79	20.5	10	20.8	26	18.9	54	21.3	62	21.7	16	20.9	70	18.9	56	19.3	61
Sept.	13.7	91	15.4	52	14.7	78	14	70	18.5	12	17.2	31	13.6	61	16.8	122	15.6	40

(The Meteorological Yearbook, 2007–2014, 1961–1990)

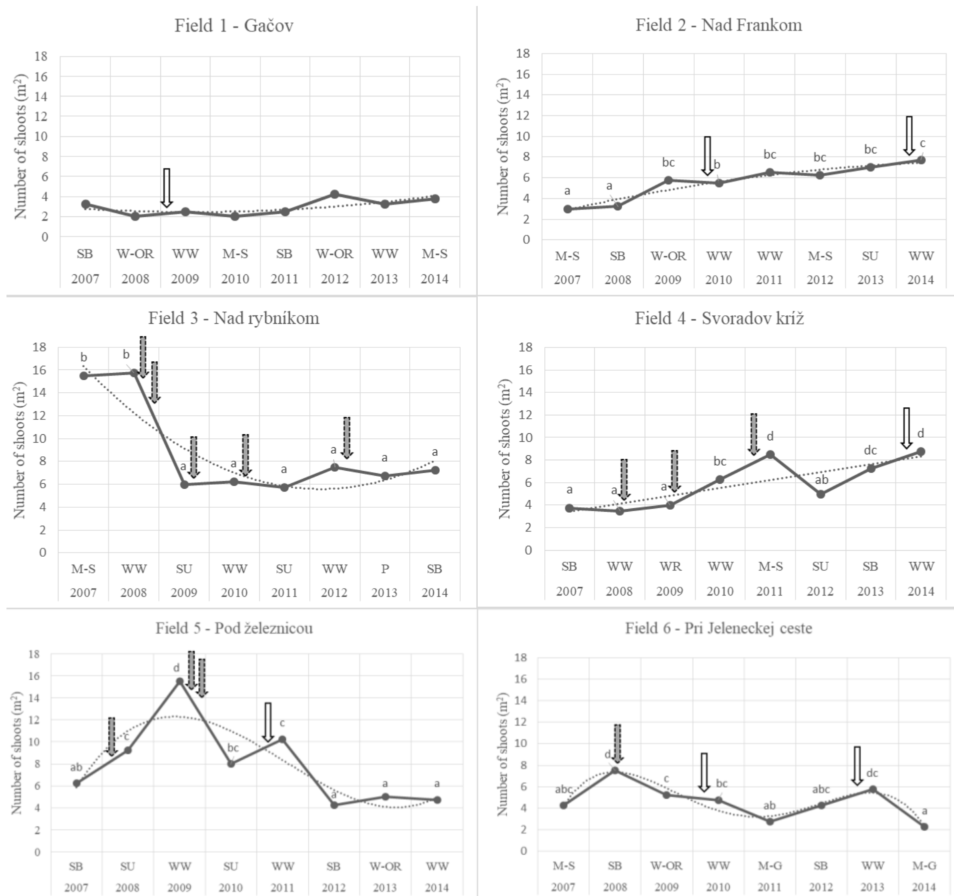

Fig. 1: Year to year changes in Elytrigia repens infestation

Shaded arrows indicate when glyphosate was applied between two crops, blank arrows indicate when propoxycarbazone sodium was top-dressed in winter wheat. Different letters indicate significant differences of *E. repens* density at $P = 0.05$ level in spring term

Field 1 without post-hoc test. M–S: silage maize, M–G: grain maize, SU: sunflower, WW: winter wheat, WR: winter rye, W–OR: winter oilseed rape, SB: spring barley, P: pumpkin grown on bare ground

over the evaluated period. PKS was applied in canopy of winter wheat and substantially reduced population density of *E. repens* with a positive effect for the next crop mainly in the fields 5 and 6 (Fig. 1). The number of herbicide applications was influenced not only by the overall effectiveness of weed management (cultural, preventive methods), but the efficacy of the herbicides with glyphosate was related to the course of the weather. The lack of precipitation in August 2008 (extra ordinary below normal) and August 2009 (very below normal) associated with a smaller leaf area of *E. repens* has reduced application efficiency and subsequent herbicide application in November (field 3 and field 5) or an application for two consecutive years (field 3 and 4) was necessary. For this reason, the frequency of herbicide applications cannot be a decisive criterion for assessing the overall effectiveness of weed control measures.

Crop rotation

Response of couch grass proliferation on common effect of preceding crops and management practices is describe in

Table 2: Analysis of variance of *Elytrigia repens* density at experimental site during 2007–2014

Source of variation	Sum of squares	d.f.	Mean squares	*F* – ratio	*P* – value
Field–crop rotation	743.214	5	148.643	52.224	0.000
Year	46.870	7	6.696	2.352	0.029
Replication	5.724	3	1.908	0.670	0.572
Field × Year	1154.911	35	32.997	11.593	0.000
Residual	298.859	105	2.846		

d.f. = Degree of freedom

Table 3: Analysis of variance of *Elytrigia repens* density grown in different crop rotation sequences at six experimental fields during 2007–2014

Source – Year	Sum of squares	d.f.	Mean squares	*F* – ratio	*P* – value
Field 1	18.875	7	2.696	1.457	0.236
Field 2	80.500	7	11.500	5.111	0.002
Field 3	500.469	7	71.496	15.028	0.000
Field 4	126.500	7	18.071	11.677	0.000
Field 5	397.969	7	56.853	16.154	0.000
Field 6	77.4688	7	11.067	5.481	0.001

d.f. = Degree of freedom; All experimental fields were conducted during all period of investigation 2007–2014, totally 8 years;

Fig. 1. These fields reflect the intensive crop management practices broadly employed in large scale farm in Slovakia. The share of cereals ranged from 50 % (field 1, 2, 3 and 6), over 62.5 % (field 5) up to 75 % (field 4) of which 60 % was winter wheat and the second cereals was spring barley, except field 4 where winter rye was growing in 2009. Winter rye with good supressing ability (Askegaard 2017) was grown in a sequence of 3 winter cereals which finally lead to the increase of *E. repens,* even though glyphosate was applied. Two crops period of spring barley and sunflower substantially change population dynamics of *E. repens*. Proliferation of *E. repens* significantly increased after the successive cultivation of spring barley – sunflower (field 5, 2007–2009) or sunflower – spring barley sequences (field 4, 2012–2014) respectively. Maize was grown mainly for silage, except for field 6 where maize was grown for grain in 2008 and 2014.

Discussion

The population dynamics of *E. repens* influenced by the common effect of crop rotation sequences, weed and crop management practices in particular year conditions is demonstrated separately for all evaluated fields (Fig. 1). According to the Bond and Grundy (2001) classification, preventive measures (crop rotation, primary tillage) cultural methods (crop competition) and direct control methods (stubble cultivation and herbicides application) were taken into consideration. The purpose of this study was to depict the factors influencing *E. repens* population changes over time especially those important for out-breaks of *E. repens* infestation. Effect of soil tillage adopted, in respective crops, is an important part of weed management strategy. For managing the troublesome perennial weeds, like *E. repens*, in the northern and southern temperate zones, the growers need to make a choice between autumn tillage and intensive use of non-selective herbicides. The control of *E. repens* relies on intensive tillage, often in the form of repeated post-harvest stubble cultivation (Rasmussen *et al.* 2014). In Slovakia, *E. repens* was traditionally controlled by cereals stubble cultivation by shallow mouldboard ploughing with skim-coulter, with the best results of perennial weed control, because the rhizomes plough into a deeper layer were not capable of further reproduction (Mikulka 2014). Unfortunately, mainly for economic reasons, stubble cultivation by shallow mouldboard ploughing has been replaced by disc stubble cultivation which tends to decrease the *E. repens* control. Rhizomes of *E. repens* are mainly located within the plough layer of 0–0.2 m soil depth (Melander *et al.* 2013). Disc-based stubble cultivators only partly uproot below-ground propagules; with the fragmentation of rhizomes and insufficient exhaustion of the fragments promoted *E. repens* infestation (Legere 1999). On the other side intensive mouldboard ploughing gives a significant control of perennial weeds and effectiveness increases with ploughing depth (Legere 1999). Mouldboard ploughing was the most frequent basic soil tillage methods applied in our study fields except spring barley – winter oilseed rape sequences when stubble disc cultivation was used, only. Stubble disc cultivation followed by mouldboard ploughing in autumn was broadly adopted in all evaluated fields which contributed to more efficient weed management. According to a recent study of Brandsæter *et al*. (2017) which compared stubble disc-harrowing cultivation period followed by mouldboard ploughing, for *E. repens* control, the important factor was whether stubble cultivation was carried out or not. When assessing the suppressing ability of cereals and winter oilseed rape, the benefit of stubble cultivation followed by moldboard ploughing should be considered. Herbicide application to control *E. repens* started from second year of experiment when the previously applied preventive and cultural measures were insufficiently effective. When evaluating couch grass proliferation, we must stress the importance of preceding crops and their management (Rasmussen *et al.* 2014). The competitive ability of crops has to be associated with soil cultivation and adopted weed management practices of growing crops (Yadav *et al.* 2017). Diverse crop rotations, with inclusion of allelopathic crops in rotation, are key element for weed control in low-input organic production systems (Mandi *et al.* 2017). Weed infestation level could be lowered if maize is grown with increased stand density (Simić *et al.* 2012). Maize and winter wheat are crops with weak competitive ability against perennial weeds but catch crops prevent spread of perennial weeds (Askegaard 2017). *E. repens* is a cumbersome weed in Europe and cannot be managed solely by crop diversification and nitrogen-fixating perennial crops. It is a perennial grass weed which causes yield losses in temperate areas. Once established in a field it spreads quickly through underground rhizomes. It is controlled either with glyphosate, or repeated stubble cultivations to fragment and starve the rhizomes. Tillage only helps if it completely and deeply burrows the rhizomes and is not repeated again, creating a danger of bringing up rhizomes to the surface before they die. Disk tools are useless, as they cut and spread the rhizomes and do not incorporate completely. Glyphosate works, depending on the application conditions. Another practice, which works and avoids reinfestation, is dense soil mulch cover to starve the plants; couch grass only starts growing again, if it gets light to feed the rhizomes; kept in complete shade it can be controlled; important is the permanent soil cover. This is explained later, but should be made clearer, since a permanent soil cover can only be maintained without tillage; any tillage, even reduced tillage, interrupts the permanent soil cover and gives the grass a chance to regrow. In case of poorly developed cover crops they did not affect *E. repens* (Melander *et al.* 2013). Crop sequences of surveyed fields generally do not create a sufficiently long intercrop period often associated with inappropriate rainfall distribution during the summer months. For these reasons, catch crops were not grown on any single fields of observed period. The absence of catch crops in crop rotation reduced the competitive ability of the growing sequences. The winter oilseed rape was included 5 times into 4 crop rotations (field 1, 2, 5 and 6) and significantly maintained the population density of couch grass for following crop without herbicide application. The higher proportion of winter oilseed rape and limitation of sunflower in intensive cereal crop rotation pattern can be considered as one of the appropriate cultural measures for *E. repens* control.

Conclusion

Conservation agriculture, (including minimum soil disturbance, permanent soil cover and diversified crop rotation) should be promoted to reduce the weed infestation and herbicide application for sustainability of agricultural ecosystem. Inclusion of crops with strong allelopathic crops, like winter oilseed rape, may further reduce the infestation of *E. repens.*

Acknowledgements

Financial support from The Ministry of Education, Science, Research and Sport of the Slovak Republic, project VEGA 1/0544/13 and Ministry of Education, Science and Technological Development of the Republic of Serbia through project "*Improvement of maize and sorghum production under stress conditions*" (TR 31073) is highly acknowledged.

References

Andreasen C, M Skovgaard (2009). Crop and soil factors of importance for the distribution of plant species on arable fields in Denmark. *Agric Ecosyst Environ* 133:61–67

Aronsson H, B Ringselle, L Andersson, G Bergkvist (2015). Combining mechanical control of couch grass (*Elymus repens* L.) with reduced tillage in early autumn and cover crops to decrease nitrogen and phosphorus leaching. *Nutr Cycl Agroecosyst* 102:383–396

Askegaard M (2017). Crop rotation and its ability to suppress perennial weeds. Issuing Organisation(s): SEGES P/S. OK-Net Arable Practice abstract no. 038. Available at http://orgprints.org/31053/

Błażewicz–Woźniak M, E Patkowska, M Konopiński, D Wach (2016). Effect of cover crops and ploughless tillage on weed infestation of field after winter before pre-sowing tillage. *Rom Agric Res* 33:187–194

Bond W, AC Grundy (2001). Non-chemical weed management in organic farming systems. *Weed Res* 41:383–405

Brandsæter LO, K Mangerud, M Helgheim, (2017). Berge, Control of perennial weeds in spring cereals through stubble cultivation and mouldboard ploughing during autumn or spring. *Crop Prot* 98:16–23

Colbach N, F Dessaint, F Forcella (2000). Evaluating field-scale sampling methods for the estimation of mean plant densities of weeds. *Weed Res* 40:411–430

Fried G, LR Norton, X Reboud (2008). Environmental and management factors determining weed species composition and diversity in France. *Agric Ecosyst Environ* 128:68–76

Gnanavel I, SK Natarajan (2014). Eco-friendly weed control options for sustainable agriculture – a review. *Agric Rev* 35:172–183

Harasim E, D Gawęda, M Gocół (2017). Weed infestation of soybean (*Glycine max* (L.) Merr.) crop grown under no-tillage and using mulch from various cover crops and its management, including reduced herbicides rates. *Rom Agric Res* 34:1–11

Kumawat P, MK Kaushik, VK Meena, BS Chouhan, RK Menna, R Kumar (2017). Effect of weed management and fertility levels on productivity of clusterbean [*Cyamopsis tetragonoloba* (L.)Taub]. *Legume Res* 40:884–889

Legere A (1999). Relative influence of crop rotation, tillage and weed management on weed associations in spring barley cropping systems. *Weed Sci* 47:112–122

Li Z, D Li, S Zhou, L Bai (2018). The weeds control of a novel bioorganic fertilizer and its effects on agronomic traits of rice. *Intl J Agric Biol* 20:507–512

Mandi SK, MH Reja, MK Kundu, S Maji, R Nath, S Das, A Sarker (2017). Agronomic management of lentil under relay cropping system. *Ind J Agric Res* 51:536–542

Melander B, M Nørremark, EF Kristensen (2013). Combining mechanical rhizome removal and cover crops for *Elytrigia repens* control in organic barley systems. *Weed Res* 53:461–469

Melander B, N Holst, IA Rasmussen, PK Hansen (2012). Direct control of perennial weeds between crops – Implication for organic farming. *Crop Prot* 40:36–42

Mikulka J (2014). Biology and control of couch grass (*Elytrigia repens*) in sugar beet. *Listy Cukrovar Řepařs* 130:64–68

Rasmussen IA, B Melander, M Askegaard, K Kristensen, JE Olesen (2014). *Elytrigia repens* population dynamics under different management schemes in organic cropping systems on coarse sand. *Eur J Agron* 58:18–27

Ringselle B, G Bergkvist, H Aronsson, L Andersson (2015). Under-sown cover crops and post-harvest mowing as measures to control *Elymus repens*. *Weed Res* 55:309–319

Salonen J, T Hyvönen, J Kaseva, H Jalli (2013). Impact of changed cropping practices on weed occurrence in spring cereals in Finland – a comparison of surveys in 1997–1999 and 2007–2009. *Weed Res* 53:110–120

Satrapová J, T Hyvönen, V Venclová, J Soukup (2013). Growth and reproductive characteristics of C4 weeds under climatic conditions of the Czech Republic. *Plant Soil Environ* 59:309–315

Simić M, Ž Dolijanović, R Maletić, L Stefanović, M Filipović (2012). Weed suppression and crop productivity by different arrangement patterns of maize. *Plant Soil Environ* 58:148–153

Soukup J, M Jursík, K Nováková, M Laksarová, J Holec (2008). Differences in sensitivity to glyphosate among weed species – implication for weed control in HT maize. *J Plant Dis Prot* 21:51–56

Take–tsaba IA, ASB Juraimi, MRB Yusop, RB Othman, A Singh (2018). Weed competitiveness of some aerobic rice genotypes. *Intl J Agric Biol* 20:583–593

Týr Š, T Vereš (2011). Top 10 of the most dangerous weed species in the winter wheat canopies during the last decade in the Slovak Republic. *Res J Agric Sci* 43:99–102

Yadav MR, CM Parihar, SL Jat, AK Singh, R Kumar, K Yadav, MD Parihar, G Makarana, ML Jat (2017). Impact of legume intensified crop rotations and tillage practices on maize productivity *vis-à-vis* C and N dynamics of a sandy loam soil in north-western Indo-Gangetic Plains of India. *Legume Res* 40:1028–1037