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EFFECTS OF CROP ROTATIONS ON WEED INFESTATION IN WINTER WHEAT

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Abstract

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The effects of crop rotations, as one of the systems of the crop production in field plots, were studied on weed infestation in winter wheat crops. Winter wheat, as a second crop in the sowing structure, is usually cultivated in two cropping systems: continuous cropping and the two crop rotation. Based on these facts, the aim of the present study was to organise permanent crop rotations in the experimental agricultural farm of Radmilovac, a section of the Faculty of Agriculture in Belgrade. Crop rotations with different crops were established in 1992 and have been lasting ever since. Crop rotations, as a cropping practice, are a complex category with broad effects on the soil and crops.

This paper presents results on effects of various systems of the crop production (crop rotation and continuous cropping) on a weed community of a winter wheat crop during two years of investigations (2008/09 and 2009/10). Crop rotations, especially three and two crop rotations were more efficient in suppression of weed plants per species and weed biomass than continuous cropping and six crop rotations.

Key words: weeds, crop rotations, continuous cropping, winter wheat

Introduction

The most significant characteristic of an intensive crop production, especially of important species such as wheat, is yield stability (Dolijanovic et al., 2009). However, such a production has to be accompanied with high inputs (deep tillage, high costs of pesticides, irrigation and similar) and a proper system of cultivation. As a result, the scientific and professional community has increased interests in non-chemical methods of weed suppression (Weiner et al., 2001), organic agricultural production (Lampkin, 2003) and intercropping (Vandermeer, 1989) i.e. changes in the system of field crop cultivation.

In the situation when prices of agricultural products oscillate very much and when there is no safety, the producers very often avoid highly intensive systems. They opt for more extensive systems and force continuous cropping, which lead to a massive occurrence of weeds, one of the greatest limiting factors of the agricultural production. (Barberi et al., 1997). Weeds are particularly susceptible to mechanical and chemical, and especially phytosanitary, measures (crop rotation). The application of crop rotations can significantly increase yield, and one of more important reasons for the yield increase is the reduction of weed infestation, especially of the number of plants per perennial weed species. Two, three and four crop rotations are exceptionally important for the reduction of weed infestation of the most important field crops (maize, wheat and soya bean) (Kovacevic et al., 2008; Kovacevic et al., 2010; Dolijanovic et al., 2008).

All stated studies emphasise the reduction of the number of weed plants per species, the number of perennial weeds, and therefore the reduction of weed biomass per area unit. A situation is largely reverse, when winter wheat is cultivated in continuous cropping, especially in long-term continuous cropping. Based on the 15-year studies (1971/72 to 1986/87), Stojanovic and Cvetkovic, 1989 concluded that the longer continuous cropping was the lower wheat yields were. The reason for this was the increase in the number and the biomass of weeds per area unit. The winter wheat grain yields in 30-year continuous cropping in Iran (Bahrani et al., 2002),

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as well as, 25-year continuous cropping in India (Sharma and Subehia, 2003) were significantly reduced, not only due to continuous cropping, but also due to extremely increased weed infestation in such long-term cultivation systems.

The effect of the crop rotation on weed infestation of crops is long lasting: as effects of continuous cropping cannot be explained in a short period, equally, the effects of crop rotations, particularly multispecies crop rotations, can be explained only after long-term cultivation of a certain crop in such cultivation systems. The paper analyses weed infestation in wheat depending on crop rotation in an eighty-year period.

Material and Methods

The trial with different systems of plant cultivation was set up on leached chernozem in the experimental agricultural farm of Radmilovac, a section of the Faculty of Agriculture in Belgrade, in 1992 and has been conducted ever since.

The following cultivation systems have been observed:
- continuous cropping (winter wheat, maize and soya bean) and different crop rotations:
- two-crop rotation (winter wheat-maize)
- three-crop rotation (winter wheat-maize-soya bean)
- six-crop rotation (winter wheat-maize-soya bean-spring barley+ red clover-red clover-sunflower).

The plot size under one crop that is one rotation was 12 areas.

The common conventional cropping practices specific for each individual crop were applied in systems, continuous cropping and crop rotations.

Long-term effects of various cultivation systems on weed infestation were observed on weed samples drawn on July 3, 2009 and May 27, 2010 by the one square meter area method. The floristic composition, number of weed plants per species and fresh biomass were determined in the field and then air-dry biomass of weeds was measured.

All parameters of weed infestation were statistically processed by the method of a single factor analysis of variance (STATISTICA 8.0 for Windows), while the least significant difference (LSD) test was used for individual comparison of differences between means.

Weather conditions during the trail

Table 1 presents weather conditions in the experimental field during studies on weed infestation of winter wheat. Both investigation years were favourable for winter wheat. The precipitation distribution during the second year of investigation (2009/10) was particularly favourable, which suited to mass occurrence of weeds. The first year of investigation (2008/09) was characterised by two dry spells. The first dry spell occurred in autumn of 2008, inhibited winter wheat emergence, and affected entering of poorly developed plants into winter. The second dry spell was shorter (mid-April to mid-May) and affected more grain yield of wheat than very adaptable species of dominant weeds on the observed area.

Results and Discussion

Tables 2 and 3 present long-lasting effects of various crop rotations and continuous cropping on weed infestation of the winter wheat crop. The differences between the two years of investigation were small, mainly a result of different weather conditions, especially precipitation sums, and distribution during the growing season of winter wheat. Not only do crop rotations affect the reduction of weed infestation, but they also result in greater efficiency of other cropping practices in weed control, first chemical and mechanical crop cultivation measures (Kovacevic et al., 2008).

According to data presented in Tables 2 and 3, the weed community of winter wheat in all cultivation systems were composed of 13, i.e. 15 weed species in the first, i.e. the second year of investigation, respectively. *Stellaria media* (L.) Vill. and *Veronica persica* Poir. prevailed among annual weed species, while *Agropyrum repens* (L.) Beauv., *Cynodon dactylon* (L.), Pers., *Cirsium arvense* (L.) Scop. and *Convolvulus arvensis* L. were dominant perennial weed species.

The highest number of weed plants and weed plants per species, with a significant number of annual weed plants per species, was registered in winter wheat continuous cropping in both years of investigation. Perennial weed species, *Agropyrum repens* (L.) Beauv., *Cynodon dactylon* (L.) and *Convolvulus arvensis* L. prevailed and their number was higher with longer continuous cropping. Not only was a great number

Table 1
Meteorological data (temperatures and precipitation) in Belgrade during the period of investigation

Year/Months		IX	X	XI	XII	I	II	III	IV	V	VI	VII	Average/ Summ
2008/09	Temperatures °C	17.5	15.9	9.9	4.9	0.1	3.4	8.6	16.2	19.8	21.1	24	12.9
	Precipitation mm	68	18	52	77	54	84	63	6	34	153	79	688
2009/10	Temperatures oC	21	14.0	10.4	4.9	1.0	3.9	8.7	13.9	18.3	21.4	24.4	12.9
	Precipitation mm	4	101	62	122	89	111	46	41	85	180	41	882

Table 2
The effect of cultivation systems on weed floristic composition in winter wheat (2008/09)

No	Weed species	Crop rotation			
		Continuous cropping	Two crop rotation	Three crop rotation	Six crop rotation
1	*Agropyrum repens* (L.) Beauv.	3.66	-	1.33	-
2	*Avena fatua* L.	6.00	0.33	3.00	1.66
3	*Bilderdykia convolvulus* (L.) Dum.	1.00	1.33	0.33	1.00
4	*Cirsium arvense* (L.) Scop.	1.33	1.00	-	0.66
5	*Convolvulus arvensis* L.	3.33	0.66	0.66	1.33
6	*Cynodon dactylon* (L.) Pers.	2.00	1.00	0.33	2.00
7	*Galium aparine* L.	3.00	-	-	0.33
8	*Lepidium draba* L.	-	-	-	1.00
9	*Papaver rhoeas* L.	1.33	0.66	2.66	1.66
10	*Sinapis arvensis* L.	1.66	-	-	2.33
11	*Stellaria media* (L.) Vill.	4.66	2.00	1.33	3.66
12	*Stenactis annua* (L.) Ness.	1.00	1.33	-	2.00
13	*Veronica persica* Poir.	3.00	1.33	2.00	-
	Total number of weed plants per species per m^2	31.97	8.98	11.64	17.63
	LSD0.05=1.78; LSD0.01=2.16				
	Total number of weed species	12.00	9.00	8.00	11.00
	LSD0.05=1.78; LSD0.01=2.16				
	Number of annual weed plants per species	20.65	6.32	9.32	12.64
	LSD0.05=1.78; LSD0.01=2.16				
	Number of perennial weed plants per species	11.32	2.66	2.32	4.99
	LSD0.05=1.78; LSD0.01=2.16				
	Fresh biomass g m^{-2}	186.00	64.00	32.83	112.00
	LSD0.05=8.57; LSD0.01=11.76				
	Air-dry biomass g m^{-2}	35.70	20.50	16.69	30.26
	LSD0.05=8.57; LSD0.01=11.76				

of weed plants per species detected in continuous cropping, but also the greatest fresh and air-dry weed biomass was recorded. Again, perennial weed plants per species were more troublesome and they could not be easily eliminated by the application of herbicides. Several-year continuous cropping resulted in qualitative changes in the composition of anthropogenic weed community, due to the application of selective herbicides, which successfully suppressed weed species, and a vacant ground was inhabited by resistant and perennial weed species (Drazic, 1999), apart from the positive effects of crop rotation on reducing weediness (Nikolic et al., 2012).

Crop rotations, even a two-crop rotation, as a crop rotation with the lowest number of rotations, have a positive effect on the reduction of weed infestation (Kovacevic, 1989). Kovacevic, 2004 pointed out that the crop rotation was not just the most important measure, but also the only measure that could properly facilitate crop protection against weeds, diseases and pests. In both years of investigation, a lower number of both weed species and weed plants per species were lower in two and three crop rotation than in continuous cropping and six-crop rotation, which is in agreement with results obtained by Lampkin, 2003. Small grains with their density and good coverage interfere with many weeds, especially in two and three crop rotations in which they occupy the same ground in a shorter period. In addition, mechanical measures of soil tillage that is applied after small grains directly destroy weeds and reduces potential weed infestation by provoking their emergence in order to destroy them prior to seed dispersal. Due to a greater number of plant species entering the six-crop rotation, possibilities for weed infestation are also greater. According to our studies and studies conducted by Kovacevic et al. (2008), the six-crop rotation expressed greater efficiency in the reduction of weed infestation only in relation to winter wheat continuous cropping.

Table 3
The effect of cultivation systems on weed floristic composition in winter wheat (2009/10)

No	Weed species	Crop rotation			
		Continuous cropping	Two crop rotation	Three crop rotation	Six crop rotation
1	*Agropyrum repens* (L.) Beauv.	4.00	3.00	5.33	6.00
2	*Avena fatua* L.	0.66	-	-	-
3	*Bilderdykia convolvulus* (L.) Dum.	-	0.67	-	0.67
4	*Cirsium arvense* (L.) Scop.	4.66	-	-	2.33
5	*Convolvulus arvensis* L.	2.66	-	-	-
6	*Galium aparine* L.	1.33	-	-	1.33
7	*Papaver rhoeas* L.	0.66	1.33	0.67	0.67
8	*Polygonum aviculare* L.	1.00	-	-	-
9	*Sinapis arvensis* L.	-	-	0.67	1.00
10	*Sonchus oleraceus* L.	2.66	2.00	2.33	2.33
11	*Sorghum halepense* (L.) Pers	2.66	0.67	0.67	2.00
12	*Stellaria media* (L.) Vill.	4.00	4.67	3.33	-
13	*Veronica persica* Poir.	1.32	2.67	1.33	1.67
14	*Capsella bursa-pastoris* (L.) Med.	-	-	2.33	0.67
15	*Chenopodium album* L.	-	2.67	-	-
	Total number of weed plants per species per m^2	25.61	17.68	16.66	18.67
	LSD0.05=1.48; LSD0.01=1.96				
	Total number of weed species	11.00	8.00	8.00	10.00
	LSD0.05=1.48; LSD0.01=1.96				
	Number of annual weed plants per species	11.63	14.01	10.66	8.34
	LSD0.05=1.48; LSD0.01=1.96				
	Number of perennial weed plants per species	13.98	3.67	6.00	10.33
	LSD0.05=1.48; LSD0.01=1.96				
	Fresh biomass g m^{-2}	229.00	86.30	67.60	88.70
	LSD0.05=6.08; LSD0.01=8.16				
	Air-dry biomass g m^{-2}	73.90	26.70	20.40	26.80
	LSD0.05=6.08; LSD0.01=8.16				

Liebman and Davis (2000) have stated that by the rotation of crops with different sowing dates (summer, spring, autumn) and growth periods, contrasting competitive characteristics and dissimilar management practices, regeneration niches of different weed species could be disrupted and increases in specific weed species prevented.

The increased number of weed plants per species per area units means enhanced competition for principal factors of the growth and development, hence the crop density is lower, and without the optimum density, there are no optimum yields. Our study show that the greatest number of weed plants per species was detected in continuous cropping, then in six crop rotations and the lowest number was established in the two crop rotation (first year of investigation) that is in the three crop rotation (the second year of investigation). A statistically significant dependence between continuous cropping and crop rotations, as well as, among crop rotations, was estimated by the statistical analysis of data obtained during the first year of investigation. During the second year of investigation, the differences between two and three crop rotation, as well as, between two and six crop rotation were not statistically significant.

The increase of weed fresh biomass per area unit is mainly a result of a greater presence of perennial or annual broadleaf weeds, which are generally more competitive and suffocate main crop. In both years of investigation, the lowest values of weed fresh biomass per area unit were obtained in the three crop rotation. The differences in weed fresh biomass among cultivation systems were mainly statistically very significant, with the exception of the difference between the two crop rotation and remaining studied rotations in the second year of investigation.

Conclusion

According to studies on effects of different cultivation systems (crop rotation and continuous cropping) on the weed community in winter wheat conducted on leached chernozem in the experimental agricultural farm of Radmilovac during the two-year period, the following can be concluded:

The weed community in winter wheat crops was composed of 13, i.e. 15 weed species in the first, i.e. second year of investigation, respectively, with dominancy of terophytes. The annual species *Stellaria media* (L.) Vill., *Veronica persica* Poir. and *Sonchus oleraceus,* and the perennial species *Agropyrum repens* (L.) Beauv., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L.and *Sorghum halepense* (L.) Pers. prevailed in the weed community in winter wheat crops.

Obtained results indicate that the highest number of weed plants, weed plants per species, fresh and air-dry biomass was recorded in winter wheat continuous cropping. The statistically lowest values of the number of weed plants per species and fresh biomass, as the most important parameters of weed infestation, were recorded in the two and the three crop rotation in relation to both, winter wheat continuous cropping and the six crop rotation in both years of investigation. Crop rotations, especially two and three crop rotations, were more efficient in the reduction of weed infestation than the six crop rotation and especially continuous cropping.

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References

Bahrani, M. J., M. Kheradnam, Y. Emam, H. Ghadiri and M. T. Assad, 2002. Effects of tillage methods on wheat yield and yield components in continuous cropping. *Exp. Agr.,* **38**: 389-395.

Barberi, P., N. Silvestri and F. Bonari, 1997. Weed communities of winter wheat as influenced by input level and rotation. *Weed Res.*, **37**: 301-313.

Dolijanovic, Z., D. Kovacevic, S. Oljaca and N. Momirovic, 2008. The grain yield of winter wheat in different growing systems. *Agricultural Engineering*, **XXXIII** (2): 89-94 (Sr).

Dolijanovic, Z., D. Kovacevic, S. Oljaca and N. Momirovic, 2009. Growing winter wheat in continuous cropping and two-crop rotation. *Agricultural Engineering*, **XXXIV** (2): 143–148 (Sr).

Drazic, D., 1999. The importance of crop rotation on weed control. In: Crop rotation in field crops (Molnar, I. Editor), *Institute of Field and Vegetable Crops*. Novi Sad, pp. 167-190 (Sr).

Kovacevic, D., 1989. The effect of different presowing tillage methods and care measure on soil physical properties and grain yields of maize in different crop rotation. PhD thesis. Faculty of Agriculture. University of Belgrade, Zemun, pp. 1-202 (Sr).

Kovacevic, D., 2004. Organic Farming-The concept toward environmental protection. A periodical of Scientific Research on Field and Vegetable Crops. *Institute of Field and Vegetable Crops*, Novi Sad, **40**: 353-371 (Sr).

Kovacevic, D., Z. Dolijanovic, S. Oljaca and Z. Jovanovic, 2008. The effect of crop rotation on weed control. *Acta Biologica Iugoslavica (Serija G), Acta Herbologica*, **17** (2): 45-53 (Sr).

Kovacevic, D., Z. Dolijanovic, S. Oljaca, Z. Jovanovic, D. Milosev and V. Milic, 2010. Effects of crop rotation on weed floristic composition in winter wheat. *Journal of Scientific Agricultural Research*, **71** (1): 17-25 (Sr).

Lampkin, N., 2003. Organic farming. In: The Agricultural Notebook. (Soffe, R.J., Editor), *Blackwell Science*, Oxford, pp. 288-303.

Liebman, M. and S. A. Davis, 2000. Integration of soil, crop and weed management in low-external-input farming systems. *Weed Res.,* **40**: 27-47.

Nikolic, L., D. Milosev, S. Seremesic, I. Djalovic and V. Vuga-Janjatov, 2012. Diversity of weed flora in wheat depending on crop rotation and fertilisation. *Bulg. J. Agric. Sci.,* **18**: 608-615.

Sharma, S. P. and S. K. Subehia, 2003. Effects of twenty-five years of fertilizer use on maize and wheat yields and quality of an acidic soil in the western Himalayas. *Exp. Agr.,* **39**: 55-64.

Stojanovic, M. and R. Cvetkovic, 1989. The results of studying the impact of long-term growing of wheat in monoculture on yield. Improving the production of wheat and other small grains, Kragujevac, Proceedings, pp. 209-222 (Sr).

Vandermeer, J. H., 1989. The Ecology of Intercropping. *Cambridge University Press*, Cambridge: pp. 1-231.

Weiner, J., H. W. Griepentrog and L. Kristensen, 2001. Suppression of weeds by spring wheat Triticum aestivum increases with crop density and spatial uniformity. *J. of Appl. Ecol.,* **38**: 784 -790.

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