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INFLUENCE OF SOIL TILLAGE AND WEED SUPPRESSION ON WINTER WHEAT YIELD

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Abstract: Modern soil tillage systems based on different tools than mouldboard plough have very often stronger weed occurrence, which can be a serious problem for achieving high yields. An obvious solution for weed suppression is a herbicide, whose improper use can deteriorate environment and lead toward serious ecological problems. In order to investigate the interaction between soil tillage and herbicide, trial was set up in Valpovo in seasons 2008/09 - 2010/11. Two soil tillage systems (CT-conventional tillage, based on mouldboard ploughing, and CH-chiselling and disk harrowing, without ploughing) and five herbicide treatments (NH-control, no herbicides; H10-recommended dose of Herbaflex (2 l ha^{-1}); H05-half dose of Herbaflex; F10-recommended dose of Fox (1.5 l ha^{-1}); and F05-half dose of Fox) were applied to winter wheat crops. Results showed similar effects of soil tillage on the winter wheat yield, whereas different herbicide dosages showed similar weed suppression and influence on winter wheat yield.

Key words: winter wheat, soil tillage, soil compaction, herbicide, yield.

Introduction

In the most of the Central and East Europe, the soil tillage for winter wheat (*Triticum aestivum* L.) is based on the conventional soil tillage where mouldboard ploughing is unavoidable soil tillage operation, followed by disk harrowing, seedbed preparation and, finally, seeding (Mihalić, 1989).

Although very effective in mechanical weed control, such soil tillage can be economically very demanding (Stipešević et al., 2007), requires abundant energy, machine and human labor (Jug et al., 2007), and it can produce certain negative effect on the soil (Jug et al., 2006). In the first place, regarding the whole soil tillage process there is a large number of passes over the soil, often in wet

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condition, when soil is susceptible to compaction, having the consequences for subsoil layers, soil structure deterioration and, generally, soil tilth and fertility destruction (Žugec et al., 2006). Therefore, alternative soil tillage methods are necessary, such as reduced soil tillage, where mouldboard plough is replaced by some other soil tillage tools which are loosening soil within crop rooting zone, but without turning it over (Birkas et al., 2008).

From the beginning of the 'Green Revolution' in the 1950s, the weed control has been more and more assigned to herbicides, which, in comparison with the soil tillage, successfully replaced mechanical weed control ways, for at least some time. However, the adaptation to herbicides and survival of weed progeny lead toward resistance to active ingredients in the herbicides (Flegar and Ostojić, 1993; Rubin, 1996), which forced a regular exchange and introduction of new active ingredients, together with the necessity of different weed control means, including soil tillage (Wrucke and Arnold, 1985).

However, there is the great complexity of interactions between soil tillage and herbicide expression, recognized by the scientific community (Buhler, 1995; Tolimir et al., 2006; Knežević et al., 2009).

Therefore, further examination of the available systems of reduced soil tillage and herbicide active ingredients for the winter wheat is the basis for future high yields through the efficient weed control.

In order to provide further contribution toward described problems, the main goal of this research was to evaluate efficiency of soil tillage and herbicide doses on winter wheat grain yield in agroecological conditions of north-eastern Croatia.

Materials and Methods

The experimental site with different side-dressing fertilization systems has been established near Valpovo, Osijek-Baranja County, Croatia. The experiment has been conducted on the luvisol soil type, with slightly acid soil reaction (pH (H_2O) = 6.2, pH (KCl) = 5.6) and moderate soil humus content (1.8%).

The experimental design was split-plot in four repetitions, with the main factor 'Soil Tillage', and the sub-factor 'Herbicide', and a basic experimental plot size of 10 m^2.

The main factor 'Soil Tillage' had two levels: CT) conventional soil tillage, based on mouldboard ploughing up to the depth of 25-30 cm, followed by disk harrowing, seedbed preparation and seeding; and RT) reduced soil tillage, where mouldboard ploughing has been replaced by chiseling at the same depth.

The sub-factor 'Herbicide' had five levels: NH) control, without any applied herbicide; F05) half dosage of the herbicide Fox (0.75 l ha^{-1}, active ingredients (a.i.) bromoxynil-octanoate: 218 g l^{-1}, clopyralid: 60 g l^{-1} and fluroxypyr: 180 g l^{-1}); F10) full dosage of the Fox (1.5 l ha^{-1}); H05) half dosage of the herbicide

Herbaflex (1.0 l ha^{-1}, a.i. isoproturon: 500 g l^{-1}, and beflubutamid: 85 g l^{-1}); and H10) full dosage of the Herbaflex (2.0 l ha^{-1}).

The used winter wheat cultivar 'Rapsodija' was seeded in recommended quantity (300 kg ha^{-1}). In all seasons, the previous crop was the soybean. The fertilization was uniform, 400 kg NPK 7:20:30 was applied prior to the soil tillage and 150 kg ha^{-1} of KAN (27% N) was applied to one side-dressing, at the beginning of the tillering stage.

Rest of the used crop protection was uniformly applied after tillering during the whole experiment, fungicide 'Palis C' (1.5 l ha^{-1}, a.i. klorpirilfos-etil: 500 g l^{-1} and cipermetrin: 50 g l^{-1}) and insecticide 'King' (0.25 l ha^{-1}, a.i. lambda cihalotrin, 25 g/l) were applied in all cases.

The harvests were carried out by a small-plot harvester after which the whole grain mass was weighted by portable digital scale (max. 25 kg, d = 0.5 g), and 2 subsamples had been collected from each plot for the grain moisture, hectoliter weight and 1000 grains mass laboratory determination. The winter wheat grain weight has been recalculated for 14% of grain moisture.

The soil resistance was measured by Eijkelkamp Penetrologger, with the cone base of 1 cm^2, and the cone top angle of 60 degrees. At each soil tillage basic plot, there were 10 readings each year, in spring period, up to 80 cm depth, with recording resolution of 1 cm.

The statistical analysis of variance (ANOVA) for split-split-plot analysis was performed by SAS statistic package (V 9.1, SAS Institute, Cary, NC, USA, 1999) with the 'Season' as the main factor, 'Soil Tillage' as the sub-factor and 'Herbicide' as the sub-sub-factor. The Fisher protected LSD means comparisons were performed for P = 0.05 significance levels.

Results and Discussion

The first season, 2008/09, had weather pattern more favorable for the winter wheat production at the beginning of the vegetation, with mild and moist winter, whereas spring was warm and with lower than long-period average precipitation, with very hot end, which forced early winter wheat maturity, but without drought stresses which followed after winter wheat harvest. The following season, 2009/2010, also brought favorable conditions at the beginning of the vegetation and early spring, but, a serious precipitation surplus during June 2010 (150 mm above long-term average) slowed winter wheat vegetation and caused, in general, oversaturation of the soil and decay of vegetation with shallow rooting. The third season, 2010/2011, had also favorable condition for the beginning of the winter wheat vegetation, followed with dry spring with the temperature aberrations (warm weeks followed by cold weeks in April through June). This kind of weather pattern was not limiting for the crop growth as it was limiting for the weed occurrence.

Soil tillage treatments produced different soil compaction patterns (Figure 1): Under CT treatment, there are visible two soil compaction peaks: one at 30-40 cm depth, situated beneath ploughing depth ('Plough pan'), which is almost usual observance for plough-based tillage (Mihalić, 1989), presenting a wide range of problems, among which the water percolation is the most serious one. Another compaction peak occurred at 15-20 cm depth, caused by disk harrowing. Although at shallower depth than plough pan, this disk harrowing pan can also present problems with soil water movement, together with possible limitation on winter wheat root growth (Birkas et al., 2008). The RT treatment did not express similar peaks, and compaction was significantly lower than CT at given depths (10-21 and 28-39 cm).

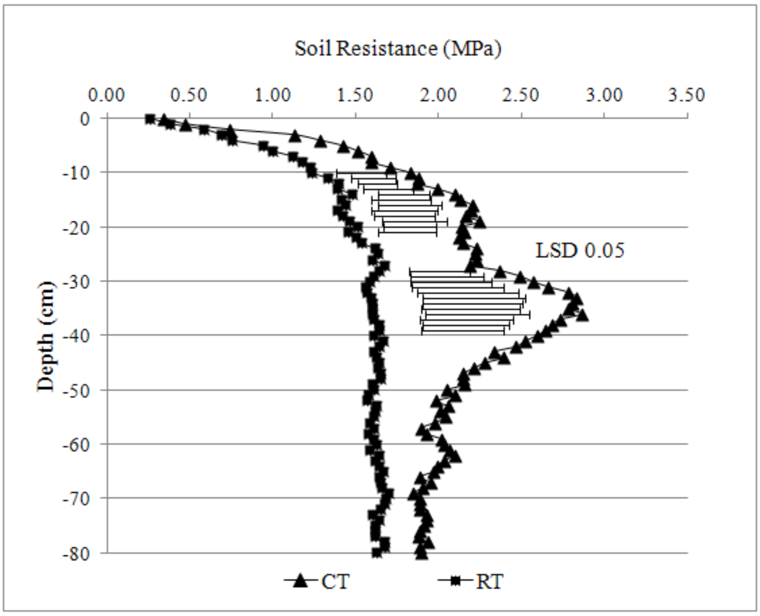

Figure 1. The soil resistance (MPa), experimental site Valpovo, Croatia, average across seasons 2008/09-2010/11 (vertical bar represents LSD at P<0.05 level differences between soil tillage treatments at given depth).

In the first season (2008/09), there was a significantly higher mass of the weed at RT in comparison with CT (Table 1), whereas there were no significant differences among herbicide treatments, although results suggest that all herbicide treatments reduced weed biomass in comparison with the herbicide control (NH), which confirms finding of Knežević et al. (2003) that half herbicide dosages can suppress weed as effectively as recommended dosages. Higher weed pressure on RT, however, significantly reduced winter wheat yield in comparison with CT (Table 2), most likely due to the competition for water in a dry spring season of 2009.

Table 1. The effects of Soil Tillage (T) and Herbicide (H) treatments on the weed biomass (g m^{-2}), experimental site Valpovo, Croatia, average for seasons and across seasons of 2008/09 through 2010/11.

Herbicide	NH	F05	F10	H05	H10	Mean T
			2008/09			
CT	37.4a	21.8a	21.5a	15.1a	19.5a	23.2A
RT	107.3a	78.8a	66.4a	56.3a	78.0a	77.2B
Mean H	72.4A	50.3A	43.9A	35.7A	48.7A	50.2
			2009/10			
CT	293.2b	305.1b	244.9b	257.2b	145.6a	249.2B
RT	196.4b	131.1a	209.0b	122.7a	86.9a	149.2A
Mean H	244.8C	218.1BC	226.9BC	190.0B	116.3A	199.2
			2010/11			
CT	14.9a	1.6a	8.1a	1.9a	0.3a	5.2A
RT	52.7a	4.2a	35.4a	26.7a	3.0a	24.4A
Mean H	33.8A	2.9A	21.8A	14.3A	1.7A	14.8
			Seasons' mean			
CT	115.2b	109.5b	91.5b	91.4b	55.1a	92.4A
RT	118.8c	71.4ab	103.6bc	68.6a	56.0a	83.6A
Mean H	90.4B	97.5BC	80.0B	55.6A	117.0C	88.0

†The means labeled with the same letter within the same T, H or H within each T average are not significantly different according to Fisher protected LSD test for significance level P<0.05.

Weather pattern of the season of 2009/10, with extremely high precipitation during the whole winter wheat growing period (including flooding and water logging in the whole area), favored even more weed occurrence, and there were approximately four times more weed biomass than in the previous season. However, a surplus of soil moisture presented problem in CT treatment, since water could not descend through disk- and plough-pans. This resulted in decreased yield in comparison with RT, where a descended water flow was not limited by an anthropogenic compaction.

It has to be pointed out that only one herbicide treatment in CT treatment was efficient against weed: only H10 significantly reduced weed biomass, at the half value of the biomass presented on NH plots. Herbicides were more effective only in RT treatment, where only F10 showed no statistical effects on weed biomass. There were no statistical evidences that herbicide treatments influenced winter wheat yield in this season, mostly due to the unlimited water supply for both winter wheat and weed. Even more, the highest yield was recorded in NH treatment, which suggests that in given environmental conditions a depressive effect of herbicides on winter wheat prevailed over benefits from suppressed weed competition. Tottman et al. (1982) and Lingan et al. (2009) suggested that is probably cultivars' response, whereas Heath et al. (1985) proposed higher temperatures as possible environmental circumstance which can produce more crop suppression effects than benefits from the herbicide application.

Table 2. The effects of Soil Tillage (T) and Herbicide (H) treatments on the winter wheat grain yield (kg ha^{-1}), experimental site Valpovo, Croatia, average for seasons and across seasons of 2008/09 through 2010/11.

Herbicide	NH	F05	F10	H05	H10	Mean T
			2008/09			
CT	6090a†	6000a	6180a	6050a	6290a	6122B
RT	3980a	4590a	3330a	4070a	3550a	3904A
Mean H	5035A	5295A	4755A	5060A	4920A	5013
			2009/10			
CT	5845a	5798a	6011a	5881a	5780a	5863A
RT	7344a	6117a	6257a	6877a	6587a	6636A
Mean H	6595A	5957A	6134A	6379A	6183A	6249
			2010/11			
CT	8590b	7270a	7082a	7004a	7103a	7410A
RT	8424b	7311a	7322a	8486b	7675ab	7844A
Mean H	8507B	7290A	7202A	7745AB	7389A	7627
			Seasons' mean			
CT	6842a	6356a	6424a	6312a	6391a	6465A
RT	6583b	6006ab	5636a	6478b	5937ab	6128A
Mean H	6712B	6181AB	6030A	6395AB	6164A	6297

†The means labeled with the same letter within the same T, H or H within each T average are not significantly different according to Fisher protected LSD test for significance level P<0.05.

The results of the last season (2010/11) showed no differences between CT and RT in spite of the lack of precipitation at the beginning and unusual temperature regime. Weed biomass occurrence was affected by weather more than well established winter wheat, and very low weed infestation was recorded generally, not only in this experiment. Herbicide treatments effectively suppressed weed in comparison with NH treatment in both soil tillage treatments. Also, as in previous season, herbicide application affected winter wheat yield, especially in CT treatment. In RT treatment, lower winter wheat yields were recorded with the application of F05 and F10 treatments only.

Overall, on average, there were no differences in winter wheat yield between soil tillage systems, although in very wet and very dry seasons, RT treatment happened to be a slightly better than CT. For similar weather extremes, with wet or dry season, herbicide treatment can somewhat decrease winter wheat yield, especially full recommended doses in comparison with half doses of both herbicides.

Conclusion

According to the presented results of the research of different soil tillage and herbicide treatments for winter wheat at Valpovo experimental site during the seasons of 2008/09-2010/11, the following conclusions can be stated: reduced soil tillage based on chiseling, can successfully replace mouldboard ploughing, without yield decrease, and with beneficial soil condition, without plough-pan formation; reduced dosage of both applied herbicides can control weed occurrence at the same level as recommended full dosage; for given agroenvironmental condition, reduced herbicide dosages can produce lower impact on winter wheat development, thus contributing to higher yield.

References

Birkas, M., Jolankai, M., Kisić, I., Stipešević, B. (2008): Soil tillage needs a radical change for sustainability. Agriculturae Conspectus Scientificus 7(33):131-136.

Buhler, D.D. (1995): Influence of tillage systems on weed population dynamics and management in corn and soybean production in the central USA. Crop Science 35:1247-1257.

Flegar, Z., Ostojić, Z. (1993): Rezistentnost korova na herbicide. Phytomed. Herbol. 21:83-91.

Heath, M.C., McKercher, R.B., Ashford, R. (1985): Influence of high soil temperature, ammonium ion, and rapeseed residue on trifluralin phytotoxicity to wheat. Canadian Journal of Plant Science 65(1):151-161.

Jug, D., Stipešević, B., Žugec, I., Knežević, M., Šeput, M. (2006): Effects of conventional and alternating tillage systems in winter wheat-soybean crop rotation. Proceedings of the 17th Triennial Conference of the International Soil Tillage Research Organisation (ISTRO), August 28th – September 3rd, Kiel, Germany, pp. 477-482.

Jug, D., Stipešević, B., Žugec, I., Jug, I., Stošić, M. (2007): Economic evaluation of winter wheat production in different soil tillage systems. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Horticulture 64(1/2):485-489.

Knežević, M., Đurkić, M., Knežević, I., Antonić, O., Jelaska, S. (2003): Effects of tillage and reduced herbicide doses on weed biomass production in winter and spring cereals. Plant Soil Environ. 49:414-421.

Knežević, M., Baličević, R., Ranogajac, L. (2009): Influence of soil tillage and low herbicide doses on weed dry weight and cereal crop yields. Weed Science Society of Bosnia and Hezegovina, Sarajevo, Bosnia-Hercegovina, Herbologia 10(1):79-88.

Lingan, K., Jisheng, S., Bo, F., Shengdong, L., Fahong, W., Ken, S. (2009): Differential responses of two types of winter wheat (*Triticum aestivum* L.) to autumn-and spring-applied mesosulfuron-methyl. Crop Protection 28(5):387-392.

Mihalić, V. (1989): Opća proizvodnja bilja. Školska knjiga, Zagreb.

Rubin, B. (1996): Herbicide-resistant weeds-the inevitable phenomenon: mechanisms, distributions and significance. Z.Pfl.-Krankh. Pfl.-Schutz, Soderheft 16:17-32.

Stipešević, B., Jug, D., Stošić, M., Žugec, I., Jug, I. (2007): Economic analysis of winter barley production for different soil tillage and nitrogen fertilization systems. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Horticulture 64(1/2):538-542.

Tolimir, M., Vesković, M., Komljenović, I., Đalović, I., Stipešević, B. (2006): Influences of soil tillage and fertilization on maize yield and weed infestation. Cereal Research Communications 34(1/1):323-326.

Tottman, D.R., Lupton, F.G.H, Oliver, R.H., Preston, S.R. (1982): Tolerance of several wild oat herbicides by a range of winter wheat varieties. Ann. Appl. Biol. 100:265-373.

Wrucke, M.A., Arnold, W.E. (1985): Weed species distribution as ifluenced by tillage and herbicides. Weed Science 33:853-856.

Žugec, I., Stipešević, B., Jug, D., Jug, I., Josipović, M., Tolimir, M. (2006): Tillage and nitrogen effects on winter wheat yield and selected soil physical properties on hypogley of eastern Croatia. Cereal Research Communications 34(1/1):355-358.

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UTICAJ OBRADE ZEMLJIŠTA I SUZBIJANJA KOROVA NA ROD OZIME PŠENICE

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R e z i m e

Moderni sistemi obrade zemljišta, koji se temelje na oruđima različitim od pluga, vrlo često imaju jače zakorovljenje, što može biti ozbiljan problem za postizanje visokih prinosa. Očito rešenje za suzbijanje korova su herbicidi, čije nepravilno korišćenje može pogoršati okolinu i dovesti do ozbiljnih ekoloških problema. Da bismo istražili interakciju između obrade zemljišta i herbicida, postavljen je ogled u Valpovu u sezonama od 2008/09. do 2010/11. Dva sistema obrade zemljišta (CT-konvencionalna obrada zemljišta, temeljena na oranju, i CH-podrivanje s tanjiranjem, bez oranja) i pet tretmana herbicida (NH-kontrola, bez herbicida, H10-preporučena doza Herbaflex-a (2 l ha^{-1}), H05-pola doze Herbaflex-a, F10-preporučena doza Fox-a (1,5 l ha^{-1}) i F05-pola doze Fox-a) primenjeni su na ozimoj pšenici. Rezultati sugerišu slične efekte obrade zemljišta na prinos ozime pšenice, dok različite doze herbicida pokazuju slični nivo suzbijanja korova i uticaja na prinos ozime pšenice.

Ključne reči: ozima pšenica, obrada zemljišta, zbijanje zemljišta, herbicidi, prinos.

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