ISSN 1392-3196
Zemdirbyste-Agriculture, vol. 95, No. 3 (2008), p. 180–185
UDK 633.1:631.582:631.17:632.51

THE INFLUENCE OF PRODUCTION TECHNOLOGY INTENSITY ON WEED INFESTATION UNDER CEREAL CROP ROTATION

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Abstract

The aim of the study was to evaluate the rate and the state of winter wheat, winter triticale and spring barley weed infestation. Grain species since year 1998 have been cultivated under cereal crop rotation and different technology intensities: economy, integrated and intensive. Technologies differ in seed rate per ha, level of mineral fertilisation and chemical plant protection against weeds, fungi, and insects. Herbicide efficacy was very good or good. Potential weed infestation significantly increased as intensity degree of production technology decreased. Weather conditions differentiation in years strongly influenced the rate of weed infestation. Differences in the state of infestation were much smaller.

Key words: weed infestation, cereal crop rotation, technology production intensity.

Introduction

Several years ago, grain species cultivation in monoculture became increasingly popular among farmers. At that time, at the Institute of Soil Science and Plant Cultivation, quite a few long-term experiments with grain species grown in monoculture or under cereal crop rotation were established. In this paper we presented results of one of them which started in 1998 and will be continued for many years more.

Materials and Methods

Investigations were conducted in the vegetative seasons 2005/2006, 2006/2007, and 2007/2008 in the Experimental Station Osiny at the Institute of Soil Science and Plant Cultivation-state institute located at Puławy, Poland. Microplot experiments (plot area 2 m^2) were placed within large area experiment in which since 1998 intensity of winter wheat, winter triticale and spring barley cultivation has been differentiated (Table 1). Every three-year cycle, after winter wheat, winter triticale was grown and the next year spring barley was planted. Certain level of technology intensity was always located on the same field part independently on grain species cultivated in certain growing season. In all experimental years, the real and the potential weed infestation was evaluated. Real weed infestation was evaluated on the field parts which were treated with herbicides (Table 2), and potential weed infestation was evaluated on the parts of field which were covered with plastic foil during spraying. Plastic foil was removed just after herbicides application. In all experimental objects, weed samples were taken from areas treated and untreated with herbicides which were located close one to another. Weeds were collected at grain heading stage from each grain species and technology intensity, in six replications from area 0.25 m^2 each one. During botanic analysis, plant number of weed species were stated and after plant drying total dry matter of all collected species was determined. Statistical analysis for weed dry matter yield was done after three-year study.

Table 1. Inputs on means of production under three production technologies (example)

Technology	Seed kg ha^{-1}	Fertilisers kg ha^{-1}			Number of protective treatments during vegetative season		
		N	P_2O_5	K_2O	herbicides	fungicides	retardants
Intensive	207	145	88	110	1–2	2–3	2
Integrated	247	100	65	80	1–2	1–2	1
Economy	285	64	27	40	1	1	-

Table 2. Herbicides applied in the experiment during the vegetative seasons 2004/2005, 2005/2006, and 2006/2007

Species	Production technology intensity	Vegetative season 2004/2005 Herbicide	Vegetative season 2005/2006, 2006/2007 Herbicide
Winter wheat	intensive	Maraton 375 SC 4.0 l ha^{-1} Puma Universal 069 EW 0.4 l ha^{-1} Starane 250 EC 0.4 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1} Apyros 75 WG 26.5 g ha^{-1}
	integrated	Maraton 375 SC 4.0 l ha^{-1}, Puma Universal 069 EW 0.4 l ha^{-1} Starane 250 EC 0.4 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1} Starane 250 EC 0.5 l ha^{-1}
	economy	Glean 75 WG 25 g ha^{-1}	Glean 75 WG 25 g ha^{-1}
Winter triticale	intensive	Maraton 375 SC 4.0 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1}
	integrated	Maraton 375 SC 4.0 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1}
	economy	Glean 75 WG 25g ha^{-1}	Glean 75 WG 25 g ha^{-1}
Spring barley	intensive	Mustang 306 SE 0.6 l ha^{-1} Chwastox Turbo 340 SL 2.0 l ha^{-1}	Mustang 306 SE 0.6 l ha^{-1}
	integrated	Mustang 306 SE 0.6 l ha^{-1} Chwastox Turbo 340 SL 2.0 l ha^{-1}	Mustang 306 SE 0.6 l ha^{-1}
	economy	Chwastox Turbo 340 SL 2.0 l ha^{-1} Chwastox Turbo 340 SL 2.0 l ha^{-1}	Aminopielik D 450 SL 3.0 l ha^{-1}

Aminopielik D 450 SL – 2,4 D + dicamba
Apyros 75 WG-sulfosulfuron
Chwastox Turbo 340 SL-MCPA + dicamba
Glean 75 WG-chlorsulfuron
Maraton 375 SC-pendimethalin + izoproturon
Mustang 306 SE-forasulam + 2,4 D
Puma Universal 069 EW-fenoxaprop-p-ethyl
Starane 250 EC-fluroksypyr

Weather conditions in 2005 and 2007 were much more favourable for plant growth and grain yielding compared to the year 2006. Very poor grain yields in 2006 were influenced by low rainfall in June and July. Total rainfall in these two months was only 45 mm while in 2005 and 2007 it was 96 and 106 mm, respectively (Table 3). At the time of weed evaluation and their harvest, weeds were big and fully developed, and on check plots they very strongly limited by water and nutrient resources in soil and negatively influenced grain yields.

Table 3. Monthly precipitation and average air temperature during 2005–2007

Year	Precipitation (mm)					Air temperature (^oC)				
	Month					Month				
	IV	V	VI	VII	VIII	IV	V	VI	VII	VIII
2005	39	13	68	28	94	8,8	13.8	16.4	20.2	17.2
2006	30	53	26	19	228	9,2	13.9	17.6	22.4	17.7
2007	14	67	58	48	59	9,2	15.8	19.1	19.3	19.2

Results and Discussion

In all three vegetative seasons much higher differentiation of weed rate infestation was stated compared to weed state differentiation of winter wheat, winter triticale and spring barley. Efficacy of applied herbicides was very good or good but potential weed infestation differed strongly between years and species. In 2005 and 2007 degree of potential weed infestation of winter wheat grown under economy production technology was a few times higher than in 2006 while spring barley was heavily infested in 2005 only and in 2007 was the less infested one (Table 4). Differentiation of the rate and the state of weed infestation on field parts which were treated with herbicides was caused by specific weed susceptibility to active ingredient of applied herbicides, and specific competitiveness of each cereal species to weeds as well as crop plant density. Very good or good activity of applied herbicides was stated. In each vegetative season potential weed infestation degree increased as inputs on grain cultivation decreased. In 2005 the smallest degree of grain species infestation with weeds was observed in winter triticale and the biggest one in spring wheat and spring barley. In 2006 herbicide efficacy also was very good but generally weed infestation degree particularly of winter wheat and spring barley fields was much smaller than in 2005 and 2007. In 2005 and 2007, more statistically significant interactions between evaluated factors appeared than in 2006. In 2007, the highest potential weed infestation of grain stand appeared in winter wheat cultivated under economy technology. It was about 500 times higher compared to spring barley (under economy technology) and over five times higher than in winter triticale (under economy technology).

The most frequently occurring dicotyledonous weeds in evaluated grain species were: *Viola arvensis* Murr., *Geranium dissectum* (L.) Jusl., *Anthemis arvensis* L., *Galium aparine* (L.), *Papaver rhoeas* (L.) and *Polygonum convolvulus* (L.). Beside of them in much smaller number occurred: *Capsella bursa-pastoris* (L.), *Veronica arvensis* (L.), *Stellaria media* (L.) and *Chenopodium album* (L.). Number of *Viola arvensis* Murr.

seedlings on the most weedy parts of field evaluated early spring exceeded 500 seedlings per 1 m^2, *Geranium dissectum* 50–60 seedlings, and number of other species was not higher than several or a few seedlings per 1 m^2. Much lower number was found of monocotyledonous species *Echinochloa crus-gali* (L.) Pal. Beauv. and *Apera spica venti* (L.) Pal. Beauv.

Table 4. The influence of the production technology intensity on field weed infestation of three grain species grown under cereal crop rotation

Species I factor	Production technology intensity – II factor					
	intensive		integrated		low input	
	Weed dry matter g m^{-2}					
	weeded out	control	weeded out	control	weeded out	control
year 2005						
Winter wheat	0.21	26.93	0.62	54.87	20.48	102.38
Winter triticale	0.77	3.23	0.44	6.90	1.05	27.06
Spring barley	2.50	91.90	4.86	86.26	8.11	99.47
Weeded out LSDα = 0.05 I x II = 3.30; II x I = 3.28 Control LSDα = 0.05 I x II = 33.08; II x I = 29.44						
year 2006						
Winter wheat	0.26	13.82	1.27	11.82	0.91	27.36
Winter triticale	0.32	5.24	0.45	15.19	1.79	18.72
Spring barley	2.78	5.52	1.97	9.10	16.86	29.11
Weeded out LSDα = 0.05 I x II = 5.91; II x I = 5.45 Control LSDα = 0.05 I x II = 16.72; II x I = 18.95						
year 2007						
Winter wheat	0.01	22.80	4.89	35.58	8.10	128.98
Winter triticale	0.03	22.43	0.14	25.42	1.42	24.65
Spring barley	0.00	0.04	0.00	0.21	0.00	0.25
Weeded out LSDα = 0.05 I x II = 2.01; II x I = 2.01 Control LSDα = 0.05 I x II = 15.16; II x I = 15.80						

Results obtained during a three-year study show that the most weed-infested grain species was winter wheat and the less infested were winter triticale and spring barley. Degree of weed infestation increased as inputs on means of production decreased. Much more difficult is logic generalization of weed state differentiation because of unequal and rather big differences in years. Definitely, percentage of grasses in the total matter of all species in each evaluated grain species stand in three years' period was many times smaller than broadleaf weed species.

Confrontation of results presented above shows that generally they are in pretty good agreement with this one presented in agricultural literature. According to Parylak and Tandziagolska (2003) specialization in agriculture mainly means simplification of cropping system and reduction of soil cultivation. Grain species cultivation in monoculture leads to decreasing of productivity. Very big importance of soil cultivation systems in regulation of weed infestation was pointed out by Małecka et al. (2006). In their study number of weed species per $1m^2$ under ploughing cultivation was 12–14, integrated cultivation 9–13, and under direct sowing 5–8, it means very many times less compared to authors above presented results in particular from year 2007. Very interesting effects were published by Parylak D. and Oliwa T. (1997). Their scientific work proved that changes in weed infestation of grain species grown in monoculture for 20–23 years under luck of chemical weed control and direct drilling of continuous triticale decreased in weed number and dry matter yield of weeds compared to continuous tillage system. Complete cut out of soil cultivation after harvest period and its replacement with Reglone application resulted in total weed number reduction by 37% and shallow (to 12 cm) ploughing or applying harrowing only influenced the increase of weed number. According to Blecharczyk et al. (2007) long term fertilisation and cropping system effects weed biodiversity in winter wheat. Continuous cropping of this species led to the increase of above ground fresh weight and decrease of weed density compared to crop rotation system. Fertilisation was changing also the composition of weed population. In Borówczak et al. (2006) experiment under medium and high-input technologies weed number under high input technology was 5.5 times lower, whereas their weight was 1.1 and 14.3 times lower respectively, which stays with pretty close agreement with presented above results. Application of nitrogen fertilisers increased the number and weight of weeds under low input technology only. These results stay pretty close to the results presented by authors of this paper, however in our experiment weed dry matter was many times higher. Also, Kwiatkowski (2006) in his experiment proved that four-year spring barley monoculture resulted in weed dry matter increase compared to crop rotation, and weed plant number was six times higher than under crop rotation system. Miklaszewska and Adamczewski (2004) indicate quite different aspect of field infestation with weed plants. Namely, European Union is going to support the biodiversity on land which is under agricultural use. Different weed species should grow on cultivated fields however in limited number (not dangerous to cultivated species).

Conclusions

The degree of potential weed infestation evaluated during 2005–2007 in winter wheat, winter triticale and spring barley cultivated under cereal crop rotation since year 1998 significantly increased as inputs on industrial products decreased, was the biggest under economy technology, and differed strongly between years depending on the weather conditions. The dominating weed species in each experimental object were: *Viola arvensis* and *Geranium pusillum* irrespective of the crop species and intensity degree of applied production technology. Herbicide efficacy was very good or good in particular under intensive and integrated technologies. Herbicide efficacy was better when more effective (usually more expensive) herbicides were applied.

Received 2008-07-15
Accepted 2008-08-20

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