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CHEMICAL PROTECTION OF SPRING BARLEY AGAINST DISEASES AND PESTS AND ITS INFLUENCE ON GRAIN YIELD AND ECONOMIC INDICES

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Abstract: In the years 1999–2001 studies were conducted with the aim to evaluate biological, farm and economic effectiveness of plant protection products used in controlling fungal diseases and pests in spring barley. The following chemical compounds were tested in the experiments: Sportak Alpha 380 EC, Alert 375 SC, Amistar 250 SC, Juwel 250 SC, Karate 025 EC, Tango 500 SC. The infection of barley leaf area on non- protected plots amounted, on the average, to 52.0%, whereas the damage caused by leaf beetle larvae averaged 25.0%. The tested fungicides exhibited a high efficacy from 31.6% to 92.3%, while the effectiveness of the applied insecticide constituted, on average, 91.6%. The use of the above plant protection products contributed to the increase of barley grain yield from 3.2 dt/ha to 15.9 dt/ha. The defrayal index was, on average, 1.8 and the index of chemical treatment profitability constituted 5.3.

Key words: spring barley, diseases, pests, chemical control, economic index

INTRODUCTION

Many harmful agrophages occur on cereal crops. Every year barley plants are invaded by pests and fungal pathogens, which cause high yield losses and deterioration of grain quality. Because of that it becomes indispensable to undertake studies on the control of the most important diseases and pests occurring at a varying intensity and to assess current economic effects of applied treatments. Plant protection treatments using highly effective chemicals may result in substantial yield increase of barley seed (Jańczak et al. 1990; Kaniuczak 1997; Lisowicz 2001; Lisowicz et al. 2001; Wałkowski 1991).

The purpose of these studies was to evaluate biological as well as farm and economic effectiveness of the applied fungicides and insecticides in controlling pests and fungal diseases of spring barley in field trials.

MATERIAL AND METHODS

During 1999–2001, the studies on spring barley crops of the cv. Lot were carried out in field trials in Boguchwała. The trials were conducted by the method of random block design with three replications. Barley seeds were sown into brown loessial soil of class IIIa with a sufficient content of nutrients. Agrotechnical and weedkilling procedures were implemented according to recommendations of Institute of Soil Science and Plant Cultivation (Instytut Nawożenia i Gleboznawstwa – IUNG) and Institute of Plant Protection (Instytut Ochrony Roślin – IOR). The intensity of disease and pest occurrence was analyzed throughout the vegetation period according to the method described by Lisowicz (Lisowicz et al. 1993). The conducted observations and plant analyses for the presence of diseases and pests allowed to establish proper timing of chemical application. To control fungal diseases, fungicides were used in different combinations I – in the spring – at plant growth stage 30–32 according to Zadoks (Zadoks et al. 1974) Sportak Alpha 380 EC (a.i. prochloraz, carbendazim), Alert 375 SC (a.i. flusilazole, carbendazim) and II – before flowering – at growth stage 51–59 Amistar 250 SC (a.i. azoxystrobin), Juwel 250 SC (a.i. krezoxim-methyl, epoxyconazole), Tango 500 SC (a.i. epoxyconazole, tridemorph). Karate 025 EC (a.i. lambda-cyhalothrin) was used for pest control. The treatments were carried out by Solo 412 Master sprayer, using 300 dm^3 liquid per hectare. The biological effectiveness of the applied fungicides and insecticide was estimated three weeks after treatment II by assessing per cent of infection of two upper leaves (flag and second leaf) with fungal diseases and the damage of leaf area caused by leaf beetle larvae on 100 stems from each experimental combination. After reaching the stage of full harvest ripeness, spring barley seeds were harvested with a plot combine. Water content in grain was determined and the obtained grain yield was assessed as related to 15% humidity.

In the analysis of economic profitability of chemical treatments used to control diseases and pests the method given by Mierzejewska was applied (Mierzejewska 1985) to calculate the following indices: 1 – defrayal index, 2 – surplus index of rescued production, 3 – index of chemical treatment profitability. To calculate the above indices, the mean prices of barley grain, the applied plant protection products as well as the cost of treatment implementation were used. The cost of plant protection was enlarged by the inflation rate in the period from treatment application to the harvest.

RESULTS AND DISCUSSION

Weather conditions during these studies were variable. During 1999 and 2001, a relatively high temperature in the spring months, i.e. in April, May and June, as well as low rainfall were favourable to the occurrence and development of diseases and pests on barley plants. These factors caused that the intensity of diseases and leaf damage by pests in the those years were also relatively high. In the year 2000, meteorological conditions were unfavourable to the development of spring cereal crops. The influence of spring drought for barley plants was particularly unfavourable.

In these weather conditions barley plants were subjected to the infection with powdery mildew of cereals and grasses (*Erysiphe graminis* DC.), brown rust of barley (*Puccinia hordei* Otth), leaf stripe of barley (*Pyrenophora graminea* Ito et Kurib.), leaf scald [*Rhynchosporium secalis* (Oud.)Davis] and net blotch of barley [*Pyrenophora teres* (Died.)Drechs.]. In particular years, the highest percentage of barley leaf infection was caused by the fungi : *Pyrenophora teres* and *Rhynchosporium secalis*. This was reported earlier by authors conducting studies in different regions of Poland (Gawrońska-Kulesza et al. 1998; Jańczak et al. 1998; Korbas and Kubiak 1998; Weber et al. 1999). Powdery mildew occurred at a weak intensity. Other fungal diseases occurred on barley plants at a very weak or trace intensity.

Insect pests were also found on spring barley plants. They were: leaf beetles (*Qulema* spp.), aphids (*Aphididae*), thrips (*Thysanoptera*), frit fly (*Oscinella frit* L.), gout fly (*Chlorops pumilionis* Bjerk.) and *Cecidomyiidae*. In the years of these studies, leaf beetles occurred at the highest intensity, aphids and thrips - at a weak intensity, whereas other insects occurred at a very weak intensity. In some years, barley plants besides leaf beetles, may also be threatened by aphids, gout fly, frit fly and *Cecidomyiidae*, which was reported by authors conducting studies in different regions of Poland (Kaniuczak and Matłosz 1999; Gołębiowska and Boczek 1959; Ruszkowski 1950; Wałkowski 1991).

Results of chemical control of fungal diseases and pests and their influence on barley grain yield are presented in table 1.

In the year 1999, the infection of barley leaves with fungal pathogens was relatively high and amounted to, on average, 60.1%, while the damage of leaf area caused by leaf beetle larvae constituted 27.4%. The applied fungicides – Sportak Alpha 380 EC and Amistar 250 SC restricted the degree of the leaf area infection and their effectiveness constituted from 62.3% to 89.7%. The effectiveness of the applied insecticide was, on average, 90%. The increase of spring barley grain yield (on average, by 11.3%) as compared to the control ranged from 3.2 dt/ha to 11.3 dt/ha and amounted to 5.7 dt/ha after the application of the insecticide.

In the year 2000, weather conditions were less favourable to the development of fungal diseases and pests on barley crops; the leaf infection amounted to an average of 41.3%, and the damage caused by leaf beetle larvae was 12.8%. The fungicides Alert 375 SC and Juwel 250 SC applied in one and two protection dates restricted the degree of leaf damage by the occurring diseases. The effectivenss of these fungicides ranged from 31.6% (one treatment) to 75.1% (two treatments), whereas the effectiveness of the insecticide amounted to 87.5%. The grain yield increase of spring barley (on average, by 19.8%) after the application of fungicides ranged from 5.1 dt/ha to 9.3 dt/ha, but following the insecticide application of the insecticide it amounted to 3.2 dt/ha.

In 2001, barley infection with pathogenic fungi was, on average, 54.6% in the control, whereas the leaf area damage by leaf beetle larvae constituted 34.8%. The fungicides used for plant protection showed high effectiveness in controlling fungal diseases, which ranged from 64.2% to 92.3%, and the effectiveness of Karate 025 EC was 34.8%. The applied fungicides contributed to the grain yield increase

Table 1. The influence of chemical protection of spring barley on grain yield

No.	Plant protection products – growth phase		Dose/ha	% leaf infection with diseases	% effective-ness	% leaf injuries by insect pests	% effective-ness	Yield		
	30–32	51–59						dt/ha	increase	
									dt/ha	%
				1999						
1.	Control		–	60.1	–	27.4	–	59.3	–	–
2.	Sportak Alpha 380 EC	–	1.5	22.6	62.3	–	–	62.5	3.2	5.4
3.	–	Amistar 250 SC	1.0	8.9	85.1	–	–	65.1	5.8	9.7
4.	Sportak Alpha 380 EC	Amistar 250 SC	1.5 + 1.0	6.1	89.7	–	–	70.6	11.3	19.0
5.	–	Karate 025 EC	0.2	–	–	2.6	90.6	66.0	5.7	9.6
6.	Sportak Aplha 380 EC	Amistar+ Karate	1.5 + 1.0 +0.2	5.7	90.5	2.9	89.5	68.3	9.0	15.1
	LSD (0.05%)			7.43		5.36		5.3		
				2000						
1.	Control		–	41.3	–	12.8	–	38.6	–	–
2.	Alert 375 SC	–	1.0	28.2	31.6	–	–	43.7	5.1	13.2
3.	–	Juwel 250 SC	1.0	11.0	73.2	–	–	47.9	9.3	24.0
4.	Alert 375 SC	Juwel 250 SC	1.0 + 1.0	10.2	75.1	–	–	47.2	8.6	22.2
5.	–	Karate 025 EC	0.2	–	–	1.6	87.5	41.8	3.2	8.2
6.	Alert 375 SC	Juwel + Karate	1.0 +1.0 + 0.2	10.1	75.6	1.8	86.0	54.5	15.9	41.2
	LSD (0.05%)			4.87		4.7		4.7		
				2001						
1.	Control			54.6	–	34.8	–	50.9	–	–
2.	Alert 375 SC	–	1.0	16.8	69.2	–	–	57.5	6.6	12.9
3.	–	Tango 500 SC	1.0	19.2	64.8	–	–	57.8	6.9	13.5
4.	Alert 375 SC	Tango 500 SC	1.0 + 1.0	7.4	86.4	–	–	58.6	7.7	15.1
5.	–	Karate 025 SC	0.2	–	–	0.4	98.8	56.6	5.7	11.2
6.	Alert 375 SC	Tango + Karate	1.0 + 1.0 +0.2	8.1	85.2	0.8	97.7	59.1	8.2	16.1
	LSD (0.05%)			12.2		1.3		5.5		

(on average by 17.3%) ranging from 6.6 dt/ha to 12.8 dt/ha ,whereas the used insecticide caused the grain yield increase by 5.7 dt/ha.

The control of spring barley disease complex during the vegetation season permitted to avoid grain yield losses, on average, for a three-year period of studies amounting to 8.0 dt/ha, i.e. by 16.4 %. These effects are higher than those obtained by Skolimowski (1980) after the application of one fungicidal treatment, and they are somewhat higher or comparable to those obtaned by Lisowicz (1989) and by Korbas and Kubiak (1998). In the opinion of many authors, a proper protection of this cereal species and a properly selected time of treatment as well as effective fungicides ensure a significant yield increase and improvement of grain quality parameters (Jańczak et al. 1998; Korbas and Kubiak 1998).

Economic effects of the fungicide application in spring barley are presented in table 2.

In 1999, the production effectiveness of treatments obtained for particular spring barley objects expressed by the value of rescued crop ranged from 144 zł/ha to 508 zł/ha. The surplus of the rescued production was relatively low and averaged 35 zł/ha. Such a low value of rescued production was determined mainly by a high price of fungicides and a low selling price of barley grain. The defrayal index constituted from 0.9 do 4.1, whereas the index of treatment profitability was the most beneficial in the case of the insecticide application for the control of leaf beetle larvae.

In barley protection in the year 2000, the increase of the rescued yield value by, on average, 421 zł/ha was obtained. The most beneficial defrayal index was obtained in the comnbination, in which Karate 025 EC was used for pest control (2.3). The index of treatment profitability was also the most beneficial after the application of the insecticide.The largest value of that index (the lowest profitability) was noted in the object with a complete plant protection (9.5).

In 2001, the value of the rescued grain yield constituted from 285 zł/ha to 410 zł/ha, on average 351 zł/ha. The most beneficial defrayal index was also obtained in the combination, in which Karate 025 EC was used for pest control. That index amounted to 4.3. In combinations, in which fungicides were applied twice to control fungal diseases, the lowest defrayal indices (1.2) indicated their low profitability. The index of treatment profitability was also the most beneficial in the case of Karate 025 EC application. The index of the highest value (the least beneficial) was obtained for the object with a complete plant protection (6.4). Also in that year of the studies, the value of these indices was determined mainly by a high price of fungicides in comparison to the selling price of barley grain.

In the three-year period of the studies, the increase of value of the rescued grain yield was obtained every year, but each year it did not allow to cover the costs of protection and to ensure profit. A relatively high index of treatment profitability indicates a diminishing beneficial relation between the costs of barley crop protection (due first of all to high prices of fungicides) and the low selling price of barley grain, which is indicated by studies carried out in the previous period (Kaniuczak 1997). Undertaking a complete protection of spring barley (two fungicidal and one insecticidal treatments), contributed to the highest grain yield increase and at the same

Table 2. Economic effect of disease and pest control in spring barley

No.	Plant protection products – growth phase		Dose/ha	Expenses on protection/ha	Yield increase		Coefficient	
	30–32	51–59			dt/ha	zł/ha	expense defrayal	of profitability
				1999				
1.	Sportak Alpha 380 EC	–	1.5	149	3.2	144	0.9	3.3
2.	–	Amistar 250 SC	1.0	292	5.8	261	0.9	6.4
3.	Sportak Alpha 380 EC	Amistar 250 SC	1.5 + 1.0	442	11.3	508	1.1	9.8
4.	–	Karate 025 EC	0.2	61	5.7	256	4.1	1.3
5.	Sportak Alpha 380 EC	Amistar 250 SC + Karate 025 EC	1.5 + 1.0 +0.2	457	9.0	405	0.9	10.1
				2000				
1.	Alert 375 SC	–	1.0	147	5.1	255	1.7	2.9
2.	–	Juwel 250 SC	1.0	314	9.3	465	1.4	6.2
3.	Alert 375 SC	Juwel 250 SC	1.0 + 1.0	461	8.6	430	0.9	9.2
4.	–	Karate 025 EC	0.2	67	3.2	160	2.3	1.3
5.	Alert 375 SC	Juwel 250 SC + Karate 025 EC	1.0 +1.0 + 0.2	478	15.9	795	1.7	9.5
				2001				
1.	Alert 375 SC	–	1.0	137	6.6	330	2.4	2.7
2.	–	Tango 500 SC	1.0	168	6.9	345	2.0	3.3
3.	Alert 375 SC	Tango 500 SC	1.0 + 1.0	306	7.7	385	1.2	6.1
4.	–	Karate 025 EC	0.2	66	5.7	285	4.3	1.3
5.	Alert 375 SC	Tango 500 SC + Karate 025 EC	1.0 + 1.0 +0.2	324	8.2	410	1.2	6.4

time aided to obtain the highest indices of treatment profitability. In order to cover the cost of protection of 1 ha barley crop, on average, 8.7 dt of grain should be obtained for that purpose.

CONCLUSIONS

1. A relatively high biological effectiveness was obtained in controlling fungal diseases, which amounted to 74.0%, whereas the effectiveness of pest control constituted, on average, 92.3%.
2. The applied plant protection treatments permitted to obtain grain yield increase by, on average, 7.4 t/ha, i.e. by 15.7% (one fungicidal treatment – 6.1 t/ha, two fungicidal treatments – 9.2 dt/ha, one insecticidal treatment – 4.8 dt/ha, two fungicidal and one insecticidal treatment – 11.0 dt/ha).
3. A high price of fungicides influenced the increase of plant protection costs and determined low defrayal indices (on average, 1.8).
4. More beneficial indices of treatment profitability were obtained after the application of insecticide (1.3), but less beneficial indices were obtained after fungicide application (5.5).
5. At the existing relation between the prices of plant protection products and selling prices of spring barley grain, chemical protection of spring barley against diseases and insect pests proved to be unprofitable, especially in the case of fungicides.

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POLISH SUMMARY

CHEMICZNA OCHRONA JĘCZMIENIA JAREGO PRZED CHOROBAMI I SZKODNIKAMI, JEJ WPŁYW NA PLON ZIARNA I WSKAŹNIKI EKONOMICZNE

W latach 1999–2001 wykonano badania, których celem było określenie skuteczności biologicznej niektórych fungicydów i insektycydu, a także ocena efektywności gospodarczej i ekonomicznej zwalczania chorób grzybowych i szkodników. W badaniach na jęczmieniu jarym, odmiana Lot, zastosowano wybrane środki ochrony roślin: Alert 375 SC, Amistar 250 SC, Juwel 250 SC, Karate 025 EC, Sportak Alpha 380 EC, Tango 500 SC.

Porażenie powierzchni liści jęczmienia na poletkach kontrolnych przez choroby grzybowe wynosiło od 41,3% do 60,1%, a uszkodzenie liści przez larwy skrzypionek od 12,8% do 34,8%. Uzyskano stosunkowo wysoką skuteczność biologiczną zwalczania chorób grzybowych wynoszącą średnio 74,0%, a skuteczność zwalczania szkodników 92,3%. Zastosowane środki ochrony roślin pozwoliły na uzyskanie wzrostu plonu ziarna jęczmienia, średnio o 7,4 dt/ha, tj. o 15,7%. Wysoka cena fungicydów wpłynęła na podwyższenie nakładów na ochronę jęczmienia i uzyskanie niskich wskaźników pokrycia kosztów (średnio 1,8). Korzystniejsze wskaźniki opłacalności zabiegów otrzymano dla insektycydu (1,3), a mniej korzystne dla fungicydów (średnio 5,5).