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ECONOMIC INDICATORS AND EFFECTIVENESS OF CHEMICAL CONTROL OF LEAF BEETLE LARVAE AND DISEASES IN SPRING WHEAT IN PODKARPACIE VOIVODESHIP POLAND

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ABSTRACT

Background. The increase in the area of cereal cultivation in Poland is favorable for a rise in significant damage to wheat leaves arising from an increasing activity of cereal leaf beetle larvae and pathogenic fungi. The aim of the research was an assessment of the effectiveness and economic efficiency of the applied insecticides and fungicides in the control of selected agrophages in spring wheat.
Material and methods. The research on the economic efficiency of applied fungicides and insecticides in spring wheat was conducted in the years 2013-2015 in Boguchwała. The experiment was set up in a randomized block design in four replications. Spring wheat was sown on brown soil, class IIIa.
Results. On the control plots, the average leaf area infected with wheat diseases was 48.1%, while damage by leaf beetle larvae was 71.1%. The effectiveness of the applied fungicides ranged from 23.1 to 71.8%, and for insecticides it was from 77.1 to 97.5%. The value of increased yield ranged from 73 to 903 PLN·ha^{-1}. The cost coverage index ranged from 0.3 to 10.3, while the indicator of treatment profitability ranged from 0.11 to 0.62. Percentage cost index varied from 1.9 to 19.4.
Conclusion. The cost-effectiveness of chemical plant protection treatments depended mainly on the number and type of the applied plant protection treatments. Applying two treatments during the growing season caused a significant cost increase in spring wheat protection relative to the obtained yield and grain price.

Key words: chemical protection, economic indicator, leaf diseases, *Oulema* spp., *Triticum aestivum*

INTRODUCTION

Spring wheat is characterized by the high quality of its grain. In south-eastern Poland obtaining a high grain yield with good quality parameters, especially if free of mycotoxins, requires undertaking many preventive activities as cereal stands here are threatened by many agrophages (Kaniuczak and Bereś, 2011). An increasing significance is being taken on by pests, which apart from having a direct effect on decreasing the yield, also contribute to generating indirect losses connected with the higher susceptibility of damaged plants to infection by disease-causing agents (Bereś, 2014).

In the Podkarpacie Voivodeship pests occurring on cereals may cause significant losses, as in some years their number exceeds the economic threshold (Kaniuczak, 1997; 2004; Kaniuczak and Matłosz, 1999). For spring wheat in the period of spring vegetation, aphids and leaf beetles, as well as cecidomyidae, constitute the greatest threat (Bereś, 2014).

According to Korbas *et al.* (2008a) as well as Mrówczyński *et al.* (2007), under Polish conditions

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average losses in wheat yields caused by all pests are estimated to range from 0.2 to 2 Mg·ha^{-1}.

Another significant causes decreasing the yield in spring wheat is its infection with diseases caused by fungi (Kurowski, 2002). During its cultivation, spring wheat has a shorter vegetation time. For this reason, the importance of diseases in spring wheat is lower compared to that of winter wheat (Horoszkiewicz--Janka *et al.*, 2013). Preventing the potential losses is possible through the use of protection methods, including agronomic methods and chemical treatments (Korbas, 1998; Lipa, 1999; Walczak, 2010; Kaniuczak and Noworól, 2012). Controlling diseases caused by fungi enables the attainment of high wheat yields of good quality. In addition, chemical protection allows for the effective use of other elements such as fertilization (Jończyk, 1999). Studies of other authors have indicated that spring wheat responds more favourably to fertilization with an application of fungicide protection. All assessed cultivars were characterized by a significant increase in the grain yield and by an increase in the value of yield components (Kołodziejczyk and Szmigiel, 2014).

The aim of this study was to assess the effectiveness and economic efficiency of chosen fungicides in controlling diseases caused by pathogenic fungi and of insecticides in controlling leaf beetle larvae in the cultivation of spring wheat in field experiments.

MATERIAL AND METHODS

The research was carried out in the years 2013-2015 in the cultivation of spring wheat cv. Bombona at the Podkarpacki Agricultural Advisory Center in Boguchwała (49°59' N; 21°57' E). The experiment was set up in a randomized block design in four replications. It consisted of 7 experimental plots, including the control plot, which were sown in four replications (28 plots in total). Each of the experimental plots had an area of 15 m^2. 5 preparations were used in the studies (2 fungicides; 3 insecticides).

Wheat was sown on a brown soil, class IIIa. The forecrop was winter rape. Agronomic and herbicidal treatments were carried out according to the recommendations of the Institute of Soil Science and Plant Cultivation National Research Institute and of the Institute of Plant Protection National Research Institute. The grain was sown in the first days of April at a rate of 500 grains·m^{-2}. The grain was dressed with Sarfun T 65 DS (carboxin + tiuram) at a rate of 200 g·100 kg^{-1}. The following fertilization was applied: N – 120 kg·ha^{-1}, P_2O_5 – 60 kg·ha^{-1}, K_2O – 90 kg·ha^{-1}. Over the time of the research, chemical weed control was carried out on all the experimental plots. During the research period, chemical weed control was applied on all experimental plots with the use of Lintur 70 WG (dicamba + triasulfuron) at a rate of 0.15 dm^3·ha^{-1} + Chwastox Extra 300 SL (MCPA) at a rate of 1.5 dm^3·ha^{-1}.

The intensity of diseases and pests was analyzed during wheat growth according to the method described by Lisowicz *et al.* (1993). In order to control the diseases occurring on plants, two types of treatment were used:

I – in spring – at the stage of shooting (BBCH 30–32) Alert 375 SC (flusilazole + carbendazim) was used at a rate of 1.0 dm^3·ha^{-1},

II – before flowering – at the stage of ear formation (BBCH 51–59) Artea 330 EC (propiconazole + cyproconazole) was used at a rate of 0.5 dm^3·ha^{-1}.

To control leaf beetle larvae the following insecticides were used: Karate 050 CS (lambda--cihalotrine) at a rate of 0.1 dm^3·ha^{-1}, Sumi-Alpha 050 EC (esfenvalerate) at a rate of 0.25 dm^3·ha^{-1} as well as Fastac 100 EC (alpha-cipermetrine) at a rate of 0.1 dm^3·ha^{-1}. The treatments were carried out once before flowering of the plants at the stage of ear formation (BBCH 51–59) with the use of a pressure sprayer Ap1/p, using 300 dm^3 of liquid per hectare.

The evaluation of wheat infection by pathogenic fungi and of damage caused by leaf beetle larvae was carried out by determining the percentage of infection of two upper leaves' area: flag leaf and penultimate leaf on 100 stems in each experimental combination at the milk stage (BBCH 73-77). After the plants reached full maturity, they were harvested and their grain yield and 1000 grain weight was determined. Grain moisture was determined, and the obtained yields were calculated for 14% moisture. Significance of differences was evaluated between means with Duncan's test for 5% significance level.

In an economic analysis of the profitability of chemical control of leaf beetle larvae and diseases, the following indicators were calculated:

CCI – cost coverage index (which defines relations between saved production and treatment costs),

E_1 – treatment profitability index (E_1 index – defines the amount of the increased yield (in $Mg \cdot ha^{-1}$) required to cover the costs of the protection treatments),

E_2 – percentage cost index (E_2 index gives information about the yield (%), that would be required to cover the costs of plant protection).

To calculate the above mentioned indicators, average prices of wheat grain were assumed as well as of the applied plant protection preparations and the cost of performing treatments.

RESULTS AND DISCUSSION

The conducted analyses of spring wheat plants indicated the occurrence of pests such as: aphids (Aphididae), leaf beetles (*Oulema* spp.), gout fly (*Chlorops pumilionis*), Cecidomyiidae, as well as thrips (Thysanoptera). Among the harmful entomofauna, leaf beetles had the greatest economic significance during research years.

A similar species composition of wheat pests was also indicated in the studies of other authors carried out in various regions of Poland (Jańczak *et al.*, 1990; Wałkowski *et al.*, 2000; Mrówczyński *et al.*, 2007; Kaniuczak, 2008; Roik *et al.*, 2011; Kaniuczak and Noworól, 2012).

In the analyzed period, the occurrence of pathogenic fungi was also observed. On the experimental plots, spring wheat was infected by fungal leaf diseases such as: powdery mildew (*Blumeria graminis*), wheat leaf rust (*Puccinia recondita*) and septoria leaf blotch (*Septoria tritici*). Other authors have also observed similar diseases in their studies on the territory of Poland (Korbas *et al.*, 2008b; Kuś *et al.*, 2011; Segit and Kociuba, 2014).

Under conditions favorable for the development of fungal diseases it has previously been observed that both a greater leaf area was infected with the diseases and there was a higher effectiveness of the applied fungicides (Danyte and Pecio, 2009; Kaniuczak and Noworól, 2012). Studies conducted by Pecio and Danyte (2008) on spring cereals confirmed that weather conditions during a growing season significantly vary plant infection by pathogens causing leaf diseases.

Spring 2013 was characterized by highly changeable atmospheric conditions, especially in terms of the air temperature. Extreme weather conditions occurred especially in April, when the mean air temperature in the first decade was 1.7°C, and in the third decade it increased up to 15.3°C. In 2013, despite cool periods and rainfall in spring, there occurred a visible warming in June and July. In the period of July and August, there occurred prolonged periods of moisture deficiency, which significantly accelerated plant maturation. Such weather conditions favorably affected both the development of pathogenic fungi and pest activity in the spring wheat (Table 1).

Table 1. Weather conditions in 2013-2015 in Boguchwała

Month	Decade	Mean air temperature °C			Rainfall total mm		
		2013	2014	2015	2013	2014	2015
1	2	3	4	5	6	7	8
April	I	1.7	8.5	4.3	24.4	16.2	21.4
	II	11.1	8.0	9.4	7.6	8.9	7.9
	III	15.3	13.6	12.6	1.9	9.5	1.9
	Mean/monthly total	9.4	10.0	8.7	33.9	34.6	31.2

Table 1 cont.

1	2	3	4	5	6	7	8
May	I	10.8	11.6	13.1	26.3	8.2	30.4
	II	11.1	12.8	13.4	0.5	59.8	7.8
	III	8.8	17.3	12.8	60.7	24.3	54.7
	Mean/monthly total	10.2	13.9	13.1	87.5	92.3	92.9
June	I	16.8	17.6	19.5	78.6	3.3	0.0
	II	20.0	16.1	17.9	25.3	12.5	8.0
	III	18.6	16.0	16.4	39.5	32.3	1.1
	Mean/monthly total	18.4	16.6	17.9	143.4	48.1	9.1
July	I	19.7	19.9	21.1	0.1	36.8	13.1
	II	17.5	20.2	19.9	19.1	43.4	25.7
	III	20.8	21.6	20.6	0.0	48.4	26.5
	Mean/monthly total	19.3	20.6	20.5	19.2	128.6	65.3
August	I	23.3	21.7	23.5	0.0	12.2	7.2
	II	19.5	18.4	22.8	3.0	20.5	6.1
	III	15.8	14.8	20.7	8.0	31.8	8.8
	Mean/monthly total	19.6	18.2	22.3	11.0	64.5	22.1

In 2013 the infection of leaf surface in wheat with diseases on the control plots was 54%. In that year leaf beetle larvae damaged 70.8% of leaf blade area. On the other plots the applied fungicides reduced the percentage of leaf damage by 29.6 to 71.8%, while the applied insecticides decreased leaf damage by 92.9 to 96.6%. Each of the protection combinations applied in the experiment contributed to a significant reduction in the degree of leaf blade damage compared with the control (without protection). An increase in the grain yield of wheat compared with the control varied from 0.61 to 1.39 Mg·ha^{-1} (on average an increase of 42.7%). The highest value of 1000 grain weight was noted (38.8 g) when the fungicides Alert 375 SC and Artea 330 EC had been applied together, however, the highest grain yields were obtained after application of insecticides – Karate 050 SC, Sumi-Alpha 050 EC or Fastac 100 EC without the fungicides (Table 2).

2014 was characterized by high temperature and good humidity conditions over the whole period of growth (Table 1). Such a course of weather conditions was favorable for infection of plants by pathogenic fungi. On the control plots, infection of leaf surface by diseases was 69.6%. Over the three--year research period, the greatest damage of spring wheat leaves was observed in 2014. Locally occurring intensive rainfall did not reduce the size of the population of leaf beetles on the spring wheat. Damage caused by leaf beetle larvae led to a damage of 74.6% of the leaf blade area on the control plots (Table 3). Protection treatments against fungal diseases allowed for a reduction of infection by 38.8 to 67.6%, while the effectiveness of the applied insecticides ranged from 95 to 97.5%. An increase in grain yields in wheat on plots with protection compared with the control varied from 0.35 to 0.93 Mg·ha^{-1} (on average 27.6%). All the protection combinations applied in 2014 resulted in a significant increase in the grain yield and 1000 grain weight in wheat.

Table 2. The effects of chemical control of diseases and pests of spring wheat in 2013

No	Fungicide, insecticide Growth stage BBCH 30-32	Fungicide, insecticide Growth stage BBCH 51-59	Dose $dm^3 \cdot ha^{-1}$	Infected leaf area %	Infected leaf area Effectiveness %	Leaf blades damaged by leaf beetle larvae %	Leaf blades damaged by leaf beetle larvae Effectiveness %	1000 grain weight g	Yield $Mg \cdot ha^{-1}$	Yield Increase $Mg \cdot ha^{-1}$	Yield Increase %
1	Control		–	54.0	–	70.8	–	34.3	2.39	–	–
2	Alert 375 SC	–	1.0	38.0	29.6	–	–	35.9	3.00	0.61	25.3
3	–	Artea 330 EC	0.5	17.6	67.4	–	–	36.4	3.08	0.69	28.6
4	Alert 375 SC	Artea 330 EC	1.0 + 0.5	15.2	71.8	–	–	38.0	3.20	0.81	33.6
5	–	Karate Zeon 050 SC	0.1	–	–	2.4	96.6	35.4	3.77	1.38	57.3
6	–	Sumi-Alpha 050 EC	0.25	–	–	4.8	93.2	35.9	3.78	1.39	58.1
7	–	Fastac 100 EC	0.1	–	–	5.0	92.2	35.3	3.67	1.28	53.5
Mean			–	–	–	–	–	–	–	1.02	42.7
$LSD_{0.05}$			–	7.4	–	7.4	–	1.5	0.15	–	–

Table 3. The effects of chemical control of diseases and pests of spring wheat in 2014

No	Fungicide, insecticide Growth stage BBCH 30-32	Fungicide, insecticide Growth stage BBCH 51-59	Dose $dm^3 \cdot ha^{-1}$	Infected leaf area %	Infected leaf area Effectiveness %	Leaf blades damaged by leaf beetle larvae %	Leaf blades damaged by leaf beetle larvae Effectiveness %	1000 grain weight g	Yield $Mg \cdot ha^{-1}$	Yield Increase $Mg \cdot ha^{-1}$	Yield Increase %
1	Control		–	69.6	–	74.6	–	26.8	2.25	–	–
2	Alert 375 SC	–	1.0	42.6	38.8	–	–	28.5	2.61	0.36	15.8
3	–	Artea 330 EC	0.5	24.6	64.4	–	–	28.6	2.60	0.35	15.4
4	Alert 375 SC	Artea 330 EC	1.0 + 0.5	22.6	67.6	–	–	30.9	2.81	0.56	24.4
5	–	Karate Zeon 050 SC	0.1	–	–	1.8	97.5	26.9	3.13	0.88	38.9
6	–	Sumi-Alpha 050 EC	0.25	–	–	3.8	95.0	27.2	3.18	0.93	41.0
7	–	Fastac 100 EC	0.1	–	–	3.6	95.1	27.0	2.94	0.69	30.4
Mean			–	–	–	–	–	–	–	6.1	27.6
$LSD_{0.05}$			–	14.0	–	10.7	–	0.3	4.3	–	–

In the three-year period of the research, the most favorable conditions for wheat yield occurred in 2015. Throughout the growing season, there occurred high air temperatures. In terms of rainfall, 2015 was comparatively dry, however, no symptoms of moisture deficiency were observed on cereal plants in the area of research. Only in the period of April-May there occurred favorable moisture conditions, which allowed for a proper development of wheat in the stages of emergence and tillering (Table 1).

In 2015, because of the weather, a significantly lower plant infection by pathogenic fungi was observed than in the previous years. In the control plots, 20.8% of leaf area was infected by pathogenic fungi. Weather conditions in 2015, similarly as in previous years of the research, had no major impact on the damage caused by leaf beetle larvae, which at this time damaged 68% of leaf blade area on the control plots. The conducted fungicide treatments allowed to effectively reduce leaf infection by 23.1 to 42.4%. The effectiveness of insecticides used against leaf beetle larvae ranged from 77.1 to 78.7%. Compared with the control, the increase in the grain yield on plots with protection varied from 0.1 to 0.76 $Mg \cdot ha^{-1}$ (on average 4.66%). Only in some combinations did the applied fungicide and insecticide treatments result in a significant increase in the grain yield and 1000 grain weight in wheat (Table 4).

The economic effects of using insecticides and fungicides on wheat are presented in Tables 5-7 with the use of indicators.

The formation of these indicators is affected by such factors as: the applied preparation and its price, repeatability of the treatment, the sale price of the protected product, and the obtained yield (Golinowska *et al.*, 2014).

Table 4. The effects of chemical control of diseases and pests of spring wheat in 2015

No	Fungicide, insecticide Growth stage BBCH		Dose $dm^3 \cdot ha^{-1}$	Infected leaf area		Leaf blades damaged by leaf beetle larvae		1000 grain weight g	Yield		
	30-32	51-59		%	Effectiveness %	%	Effectiveness %		$Mg \cdot ha^{-1}$	Increase $Mg \cdot ha^{-1}$	Increase %
1	Control		–	20.8	–	68.0	–	41.21	6.11	–	–
2	Alert 375 SC	–	1.0	16.0	23.1	–	–	40.10	6.26	0.15	2.4
3	–	Artea 330 EC	0.5	14.6	29.8	–	–	41.58	6.22	0.10	1.7
4	Alert 375 SC	Artea 330 EC	1.0 + 0.5	12.0	42.4	–	–	41.13	6.87	0.76	12.3
5	–	Karate Zeon 050 SC	0.1	–	–	15.6	77.1	41.65	6.38	0.26	4.3
6	–	Sumi-Alpha 050 EC	0.25	–	–	15.8	77.2	40.63	6.28	0.16	2.6
7	–	Fastac 100 EC	0.1	–	–	16.1	78.7	40.55	6.24	0.12	1.9
Mean			–	–	–	–	–	–	–	0.26	2.5
$LSD_{0.05}$			–	14.0	–	10.7	–	0.3	4.3	–	–

In 2013, production efficiency of the treatments obtained on particular plots of wheat expressed as the increased yield value varied from 390 to 903 PLN·ha^{-1} (on average 661 PLN·ha^{-1}). The cost coverage index determining the ratio of the value of the saved yield to treatment costs in spring wheat was from 1.2 to 10.3 (on average 5.8). The most favorable value (10.3) was obtained on a plot where the insecticide Sumi-Alpha 050 EC was applied at the stage of ear formation in wheat (BBCH 51-59). The same preparation applied on winter wheat cultivation also had a highly favorable value (8.2) of the cost coverage index (Kaniuczak and Noworól, 2012). The lowest value in 2013 was found on the plot where fungicides Alert 375 S.C. and Artea 330 EC were used. The profitability index of treatments was determined from the number of quintals of the protected product achieved balanced against the costs of plant protection and was from 0.13 to 0.62 (on average 0.27). The most favorable values of this index occurred on plots with only insecticide protection. The percentage cost index in spring wheat varied from 3.5 to 12.8 (on average 5.9), (Table 5).

In 2014 an increase in the value of grain yield by 255 to 690 PLN·ha^{-1} (on average 464 PLN·ha^{-1}) was obtained in spring wheat. The cost coverage index was from 1.0 to 7.7 (on average 3.8). On plots protected with fungicides Artea 330 EC and Alert 375 SC + Artea 330 EC, the index was equal to 1, which meant that the use of these preparations was only on the verge of profitability. The value of the cost coverage index in the case of fungicide protection was definitely lower than on plots protected with insecticides, where each PLN spent on protection of the crop returned a four- to seven-fold increase. The profitability index of the treatments varied from 0.10 to 0.54 (on average 0.24), (Table 6). The percentage cost index reached its most favourable value (3.7) on plots where only insecticides were applied (Karate Zeon 050 SC, Sumi-Alpha 050 EC). The least favourable value (19.4) was obtained on the plot with double fungicide treatment (Alert 375 SC and Artea 330 EC), which means that costs of conducting plant protection treatments constitute 19.4% of the value of the obtained grain yield of spring wheat per hectare. Golinowska *et al.* (2014) described similar results for the chemical protection profitability of winter wheat.

The value of the saved yield in 2015 ranged from 73 to 530 PLN·ha^{-1}, on average it was 212 PLN·ha^{-1}. The cost coverage index ranged from 0.3 to 2 (on average 1.3). This index for the plot protected with fungicide Artea 330 EC was lower than 1, which means that this treatment was unprofitable. However, in studies carried out by Kaniuczak and Noworól (2012) in the years 2010-2011, when a similar experimental design was applied in winter wheat, it was indicated that all fungicide treatments were cost effective. In the research of these mentioned authors, similar fungicide preparations were applied to those applied in the present paper. The profitability index of the treatments in 2015 was from 0.12 to 0.58 (on average 0.27), and the percentage cost index varied from 1.9 to 8.5 (on average 4.0), (Table 7).

Table 5. Economic efficiency of used fungicides and insecticides in spring wheat in 2013

No.	Fungicide, insecticide Growth stage BBCH		Cost of protection PLN·ha^{-1}	Value of yield increase PLN·ha^{-1}	Coefficients		
	30-32	51-59			CCI	E_1	E_2
1	Alert 375 SC	–	154	390	2.5	0.23	7.8
2	–	Artea 330 EC	255	442	1.7	0.39	12.8
3	Alert 375 SC	Artea 330 EC	409	520	1.2	0.62	4.2
4	–	Karate Zeon 050 SC	89	890	10.0	0.13	3.6
5	–	Sumi-Alpha 050 EC	87	903	10.3	0.13	3.5
6	–	Fastac 100 EC	87	825	9.4	0.13	3.6

Table 6. Economic efficiency of used fungicides and insecticides in spring wheat in 2014

No.	Fungicide, insecticide Growth stage BBCH		Cost of protection PLN·ha^{-1}	Value of yield increase PLN·ha^{-1}	Coefficients		
	30-32	51-59			CCI	E_1	E_2
1	Alert 375 SC	–	154	262	1.7	0.2	7.8
2	–	Artea 330 EC	255	255	1.0	0.34	13.0
3	Alert 375 SC	Artea 330 EC	409	412	1.0	0.54	19.4
4	–	Karate Zeon 050 SC	89	660	7.4	0.11	3.7
5	–	Sumi-Alpha 050 EC	87	690	7.7	0.11	3.7
6	–	Fastac 100 EC	118	510	4.3	0.15	5.3

Table 7. Economic efficiency of used fungicides and insecticides in spring wheat in 2015

No.	Fungicide, insecticide Growth stage BBCH		Cost of protection PLN·ha^{-1}	Value of yield increase PLN·ha^{-1}	Coefficients		
	30-32	51-59			CCI	E_1	E_2
1	Alert 375 SC	–	154	168	1.0	0.22	3.5
2	–	Artea 330 EC	255	73	0.3	0.36	5.8
3	Alert 375 SC	Artea 330 EC	409	530	1.3	0.58	8.5
4	–	Karate Zeon 050 SC	89	185	2.0	0.12	1.9
5	–	Sumi-Alpha 050 EC	87	182	2.0	0.12	1.9
6	–	Fastac 100 EC	118	135	1.3	0.23	2.5

Throughout the whole period of the research, the annual cost of fungicide protection varied from 154 to 409 PLN·ha^{-1}, while for insecticide protection it was from 87 to 118 PLN·ha^{-1}. According to Juszczak and Krasiński (1998), Falger *et al.* (2009) the costs of plant protection depend on the intensity of occurrence of agrophages, on the selection of plant protection products, and on the number of treatments carried out on plantations and as such they may also often be higher than the losses caused by agrophages. In the period of our research, an increase was obtained in the yield value of the wheat grain, however, not on every studied plot was it sufficient to cover the costs of protection and to be profitable. In terms of the value of the cost coverage index in the three-year research period, all insecticide treatments on the studied plots were profitable. However, similar studies conducted in the same area by Kaniuczak (2013) indicated that in 2011-2012 up to 42.8% of insecticide treatments were unprofitable. The high profitability index on plots protected chemically indicates the less and less beneficial relationship between costs of protection and the selling price of wheat grain. Similar relationships have also been found in the studies of various authors in other regions of Poland (Juszczak and Krasiński, 1998; Kaniuczak, 2000; Jaczewska-Kalicka, 2009; Kaniuczak and Noworól, 2012; Kaniuczak, 2013).

CONCLUSIONS

1. Spring wheat stands in south-east Poland were exposed to damage caused by many agrophages, but leaf beetles had the greatest economic significance during the research years.
2. Under meteorological conditions favorable for the development of pathogens, the applied fungicide preparations Alert 375 SC and Artea 330 EC indicated a high effectiveness in controlling diseases caused by pathogenic fungi.
3. Conducting two fungicide treatments Alert 375 SC and Artea 330 EC in the growing season caused a significant increase in protection costs of spring wheat that was not always compensated for with the obtained yields and grain price.
4. The value of increased production as a result of applying protection treatments, depending on their number and type, ranged from 73 to 903 PLN·ha^{-1}.
5. Profitability of chemical treatments of plant protection expressed with the assessed indicators varied according to particular combinations and research years. Among the 6 experimental combinations only Artea 330 EC had, in 2015, a cost coverage index lower than 1, which indicates the unprofitability of the treatment.

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WSKAŹNIKI EKONOMICZNE I SKUTECZNOŚĆ CHEMICZNEGO ZWALCZANIA LARW SKRZYPIONEK I CHORÓB W PSZENICY JAREJ NA PODKARPACIU

Streszczenie

Badania nad efektywnością ekonomiczną zastosowanych fungicydów oraz insektycydów w pszenicy jarej wykonano w latach 2013–2015 w Boguchwale. Średnie porażenie powierzchni liści przez choroby pszenicy wyniosło 48,1%, a uszkodzenie przez larwy skrzypionek – 71,1%. Skuteczność zastosowanych środków grzybobójczych wyniosła od 23,1 do 71,8%, a insektycydów od 77,1 do 97,5%. Nadwyżka produkcji wahała się od 73 do 903 PLN·ha^{-1}. Wskaźnik pokrycia kosztów wyniósł od 0,3 do 10,3. a wskaźnik opłacalności zabiegów wyniósł od 0,11 do 0,62. Procentowy wskaźnik kosztów wahał się od 1,9 do 19,4.

Słowa kluczowe: choroby liści, ochrona chemiczna, pszenica jara, skrzypionki, wskaźnik ekonomiczny