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CHEMICAL PROTECTION OF WINTER TRITICALE AGAINST DISEASES AND PESTS AND ECONOMIC EFFECTIVENESS OF RESPECTIVE TREATMENTS

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Abstract: The aim of the study carried out during 2002–2004 was to assess the effects and economic effectiveness of application of fungicides and insecticides in winter triticale crops. Its leaves were attacked by pathogenic fungi in 43.2% to 52.2% and the damage to leaf blade surfaces by cereal leaf beetle (*Oulema* spp.) ranged from 23.6% to 34.4%. The effectiveness of applied fungicides ranged from 44.7% to 90.8%, and that of insecticides was within 70.1% and 94.4%. The saved crops were evaluated for PLN 198 to 1 171 per ha. The cost coverage ratio ranged from 0.7 to 9.9 and the treatment profitability index ranged from 0.9 to 7.4. Cost index in percentage ranged from 0.8 to 8.5, with its average value of 4.2.

Key words: triticale, diseases, pests, chemical control, costs, economic index

INTRODUCTION

Many harmful pests affect grain plantations and cause serious losses in grain crops, as well as worsening of their quality. Diseases and pests may be controlled through the use of well planned protective measures including agro – technical chemical treatments (Korbas 1998). As stressed by many authors, obtaining high and reasonably stable grain yields over consecutive years is possible only in conditions of controlled fungal infections (Jaczewska-Kalicka 2003; Lipa 1999; Mierzejewska 1996). In the years with unfavourable weather for fungal growth and development, the use of fungicides can also contribute to the increase of yields by 3–19%, as was shown by Jaczewska (1993).

Profitability of plant protection treatments depends on many factors, including the magnitude of losses caused by pests and the costs of disease, pest and weed control. In Mierzejewska's opinion (1996), modern agricultural technologies have adopted chemical plant protection treatments as the essential outlay, because they protect the crops.

In Poland, triticale cultivations occupy considerable arable areas among grain crops. This grain cultivar is tolerant to pH of soil, provides high crops, contains a lot

of protein and its composition is very favourable/suitable for both people and animals (Tarkowski 1989). The infection of triticale by pathogens and damage caused by pests lead to considerable losses in grain crops, as well as to worsening of their quality.

The research on control of most important diseases and pests of different intensities, as well as current analysis of achieved economic effectiveness of performed treatments becomes a vital necessity. Although research on triticale diseases and pests was conducted in some regions of our country, it did not cover the south-eastern region of Poland (Bubniewicz 1988; Łacicowa et al. 1985; Pokacka 1991a, b; Pokacka and Jańczak 1987; Miczulski 1989; Leszczyński 1991; Zamorski and Schollenberger 1995).

The purpose of this study was to assess biological efficacy and to analyse economic effectiveness of application of fungicides and insecticides in controlling diseases and pests in triticale cultivations in field experiments.

MATERIALS AND METHODS

The research was carried out during the period of 2002–2004 on winter triticale of Woltario cultivar on experimental fields in Boguchwała. The experiments were laid out using random block method in four replications. Triticale was sown on brown soil of class IIIa, a less soil formation. Seed were dressed with Sarfun T 450 FC at 5 the dose of 250 ml per 100 kg of seeds. The following fertilization was applied: N – 90 kg/ha, P_2O_5 – 70 kg/ha and K_20 – 103 kg/ha. Huzar 0.5 WG preparation at the dose of 0.2 kg per ha was used for weed control. The intensity of disease and pest occurrence was analyzed within the entire growing period according to the method described by Lisowicz et al. (1993). The research comprised both observation and analysis of plants with respect to any disease and/or pest presence. It enabled determining a correct treatment date. In order to determine the harmfulness of diseases caused by fungi various fungicide treatments were used: I – in the spring – Alert 375 SC in plant growth stage 30–32 according to Zadoks et al. (1974) and then II – prior to flowering – in plant growth stage 51–59 – Folicur BT 225 EC, Amistar 250 EC at the dose 1.0*l* per ha and Folicur Plus 375 EC at 0.75l per ha. In 2002–2003, the insecticide Karate 025 EC was used for pest control at the dose 0.2l per ha while in 2004 it was Karate Zeon 050 CS at the dose 0.1l per ha. The treatments were carried our with the Solo Master sprayer using 300 dm^3 of the liquid per ha. The assessment of biological effectiveness of applied fungicides and insecticides was performed three weeks after the 2nd treatment by determining the percentage of injured leaf surface on two upper, flag and second leaves, by fungal pathogens and by larvae of cereal leaf beetle on 100 stems of each experimental variant. When winter triticale reached its full harvest maturity, it was harvested with parcel combine harvester. Water content of grain was determined and converted to the humidity of 15%. The significance of differences between average disease and pest damage, as well as grain crop was assessed using Duncan's test, and the least significant difference (LSD) was determined with confidence at the level of 0.05%.

The profitability of chemical control of diseases and pets was subjected to economic analysis using the method presented by Mierzejewska (1985) and the following indices were calculated: E – cost coverage ratio, Q_1 – treatment profitability index, Q_2 – cost index in percentage. Average prices of triticale grain, applied plant protection products and treatment cost were accepted for the calculation the of above mentioned indices.

RESULTS AND DISCUSSION

Meteorological conditions in the vegetation period which most influenced the grain healthiness in 2002–2004, are presented in Figure 1.

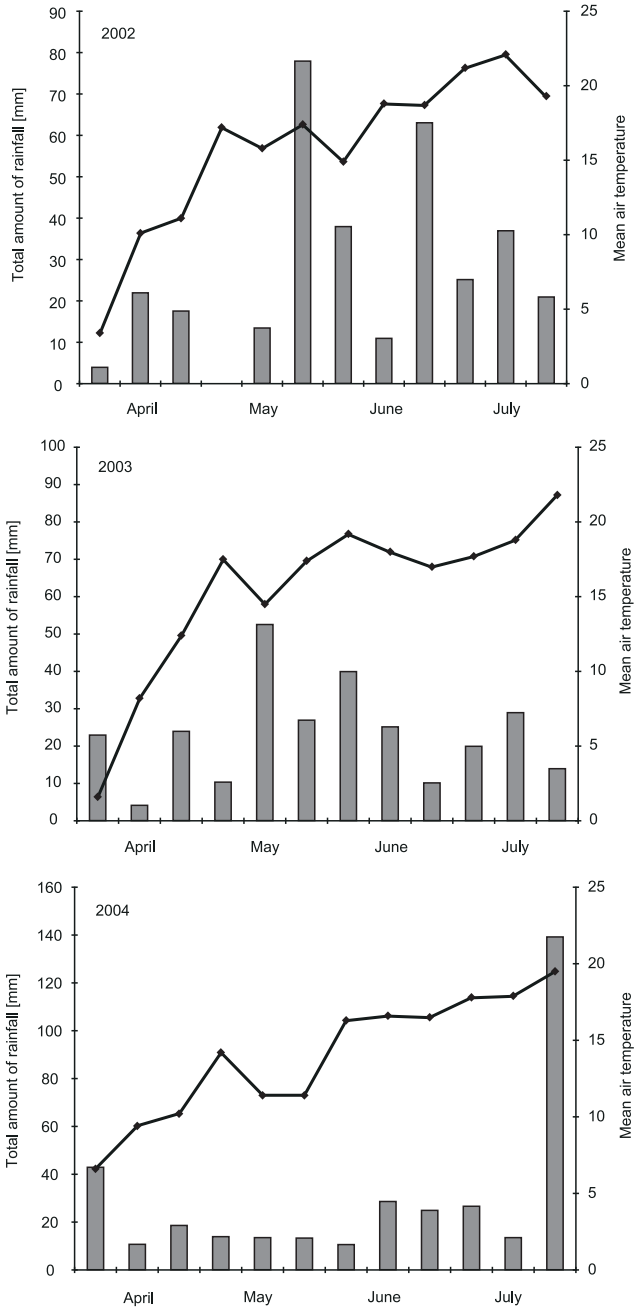

Fig 1. Mean decade air temperature and total amount of rainfall in the months: April–July 2002–2004

In 2002 a relatively high temperature and low precipitation were favourable for triticale disease occurrence and development. The reserves of winter moisture in soil in early spring of 2003 were good enough but as early as in the 3rd decade of April and in May precipitation shortage took place and, combined with relatively high temperatures, caused progressive spring drought. In 2004 on the other hand rainfall was in excess, especially in June and July, so that local flooding of plantations occurred. Air temperatures at that time were close to long-term average.

Prevailing weather conditions caused the development on triticale plants such diseases as septoria blotch (*Septoria* spp.), fusarium leaf blotch (*Fusarium* spp.), eyespot (*Tapesia yallundae*), rusts (*Puccinia* spp.), rhynchosporium stalds (*Rhynchosporium secalis*), and tan leaf spot (*Pyrenophora tritici-repentis*).

In individual years and treatments under study, triticale leaves were mostly attacked by *Septoria* spp., *P. tritici-repentis*, *Fusarium* spp., *Rhynchosporium secalis,* and on stem bases (*Tapesia yallundae*) *occurred,* as reported by many authors who studied those pathogens (Eyal et al. 1999; Jańczak and Turkiewicz 1992; Korbas 1998; Łacicowa et al. 1985; Pokacka 1991a, b; Zamorski and Schollenberger 1995). Such diseases as mildew and rusts occurred at low intensities. Other pathogens attacked only slightly triticale crops.

Winter triticale plants/crops were also infested by pest insects such as cereal leaf beetle (O*ulema* spp.), aphids, thrips, *Oscinella frit* L., *Chlorops pumilionis* Bjerk. as well as gall midges (*Cecidomyiidae*). In the years under study, cereal leaf beetle (*Oulema* spp.) occurred most frequently. Aphids and thrips occurred at lower intensities, while the occurrence of other insects was unfrequent. During some years, in addition to cereal leaf beetle (O*ulema* spp.), triticale crops may be threatened by aphids, *Chlorops pumilionis* Bjerk., *Oscinella frit* L., as well as gall midges (*Cecidomyiidae*), as reported by authors who carried out research in various regions of the country (Bubniewicz 1988; Leszczyński 1991; Miczulski 1989; Wałkowski 1991).

Wakuliński et al. (2000) monitored the development of *Pyrenophora tritici-repentis* in triticale and wheat cultivations during consecutive plant development stages. Dynamic development of the disease was recorded from the time of shooting. In all subsequent stages of plant development a sudden development of pathogens was observed. The respective authors reported that lowest leaves of wheat and triticale were attacked to a similar extent, whereas the infection of flag leaf, second and third leaves of triticale was twice lower.

The research by Jańczak and Turkiewicz (1992), as well as that of Łacicowa et al. (1985), showed that the infection of triticale ears and stem bases by *Fusarium* fungi is observed every year. The difference between individual growing seasons consists only of the degree of the disease intensity. The harmfulness of *Fusarium* and *Septoria* fungi for triticale consists primarily of their negative effect on the yielding level and grain quality, and that applies to both consumption grain and sowing material.

Rhynchosporium secalis scald belongs to the earliest occurring diseases of triticale. Its intensity is in close relationship with the course of the weather and, in optimum conditions, even flag leaf becomes affected. It may lead to premature withering of all leaves (Zamorski et al. 1993).

In experiments performed by Bubniewicz (1988) larvae of mining insects and cereal leaf beetle were most numerous on triticale leaves. Aphids and thrips occurred on triticale ears in somewhat lower intensity. Other authors also mention a significant role of cereal leaf beetle and aphids in triticale cultivation (Leszczyński 1991; Miczulski 1989).

Table 1. Influence of chemical protection of triticale on grain yield

No.	Plant protection products – growth stage		Dose/ha	% leaf infection with pathogens	% effective-ness	% leaf injuries by insect pests	% effective-ness	Yield		
	30–32	51–59						[dt/ha]	increase	
									[dt/ha]	[%]
2002										
1	Control		–	43.2	–	30.4	–	65.0	–	–
2	Alert 375 SC	–	1.0	21.6	50.0	–	–	71.1	6.1	9.3
3	–	Folicur BT 225 EC	1.0	15.2	65.0	–	–	71.3	6.3	9.6
4	Alert 375 SC	Folicur BT 225 EC	1.0 +1.0	15.4	64.4	–	–	72.0	7.0	10.7
5	–	Karate 025 EC	0.2	–	–	1.6	94.4	71.8	6.8	10.4
6	Alert 375 SC	Folicur BT 225 EC +Karate 025 EC	1.0 +1.0 +0.2	13.4	69.0	1,6	93.0	72.0	7.0	10.7
LSD (0.05)				14.7		1.2		6.0		
2003										
1	Control		–	43.4	–	34.4	–	86.3	–	–
2	Alert 375 SC	–	1.0	24.0	44.7	–	–	91.1	4.8	5.5
3	–	Amistar 250 SC	1.0	4.4	89.9	–	–	90.0	3.7	4.3
4	Alert 375 SC	Amistar 250 SC	1.0 +1.0	4.8	89.0	–	–	91.7	5.4	6.2
5	–	Karate 025 EC	0.2	–	–	9.2	73.3	90.1	3.7	4.3
6	Alert 375 SC	Amistar 250 SC +Karate 025 EC	1.0 +1.0 +0.2	4.0	90.8	10.3	70.1	91.6	5.3	6.1
LSD (0.05)				4.8		4.3		7.9		
2004										
1	Control		–	52.2	–	23.6		100.3	–	–
2	Alert 375 SC	–	1.0	27.2	47.9	–		112.4	12.1	12.0
3	–	Folicur Plus 375 EC	0.75	9.0	82.8	–		110.8	10.4	10.4
4	Alert 375 SC	Folicur Plus 375 EC	1.0 +0.75	7.0	86.6	–		112.7	12.3	12.3
5	–	Karate Zeon 050 CS	0.1	–	–	6.2	73.8	109.3	9.0	8.9
6	Alert 375 SC	Folicur Plus 375 EC +Karate Zeon 050 CS	1.0 +0.75 +0.1	6.6	88.6	6.6	72.1	122.5	22.1	22.1
LSD (0.05)				6.1		3.2		10.6		

The results of chemical control of diseases and pests and their effect on triticale grain yield are presented in Table 1.

In 2002, triticale leaves were affected by diseases at an average level of 43.2%. Applied fungicides, Alert 375 SC and Folicur BT 225 EC, limited the extent of damage to leaves and their effectiveness ranged from 50.0 to 65.0%. The effectiveness of Karate 025 EC averaged at 94.4%. In reference to control plots, triticale grain yields increased from 6.1 to 7.0 dt/ha (average 10.1%).

In 2003, triticale leaves were affected by diseases in 43.4%, while the damage to leaves by larvae of cereal leaf beetle reached 34.4%. Applied fungicides, Alert 375 SC and Amistar 250 SC, limited the extent of that damage and their effectiveness ranged from 44.7 do 89.9%. The effectiveness of Karate 025 EC was 73.3%. In reference to control plots, triticale grain yields were increased from 3.7 to 5.4 dt/ha (average 5.2 dt/ha).

In 2004, triticale leaves were affected by diseases at an average level of 52.2%, while the damage to leaves by larvae of cereal leaf beetle reached 23.6%. Applied fungicides, Alert 375 SC and Folicur Plus, limited the extent of damage to leaves and their effectiveness ranged from 47.9 to 82.8%. The effectiveness of Karate Zeon 050 CS was 73.8%. In reference to control plots, triticale grain yields increased from 9.0 to 22.1 dt/ha (average 13.1%).

The results obtained by Jończyk (1999) indicate that control of diseases caused by fungi is a condition for achieving high yields of wheat and rye. In addition, chemical protection permits effective utilization of fertilizers, as well as the improvement of crop quality.

The study by Jańczak and Turkiewicz (1992) shows that the harmfulness of *Fusarium* and *Septoria* fungi, which may also occur on triticale leaves, consists of damaging the flag leaf assimilating surface. According to the mentioned authors, controlling of triticale fusarial diseases through spraying with fungicides during the vegetation period is of a relative low effectiveness.

The economic results of application of fungicides and insecticides for triticale crops are presented in Table 2.

In 2002, the productive effectiveness of treatments, achieved on individual triticale fields and expressed in the value of saved crops, ranged from PLN 305 to 350 per ha and averaged at PLN 332 per ha. The cost coverage ratio ranged within 1.0 and 4.8. The treatment profitability index was within 1.4 and 6.5, while the cost index in percentage ranged from 1.8 to 8.5.

Triticale crop protection measures in 2003 brought about the increase of value of saved crops from PLN 198 to PLN 286 per ha and averaged at PLN 244 per ha. The most favourable cost coverage ratio was recorded in the field where Karate 025 EC and Alert 375 SC were used (4.0 and 2.0, respectively). The treatment profitability index averaged at 4.4 and the cost index in percentage was 4.8.

In 2004, the productive effectiveness of treatments, achieved on individual triticale fields and expressed in the value of saved crops, ranged from PLN 477 to PLN 1171 per ha. Relatively high cost coverage ratios (average 5.1) were achieved in all fields. The treatment profitability index averaged at 3.2 and the cost index in percentage reached the average value of 2.7.

In experiments carried out by Bubniewicz (1988) in field conditions, winter triticale yields increased from 0.4 to 0.9 t/ha as a result of two disease control treatments applied. In author's own study, carried out in 2002–2003, the triticale grain yield in

Table 2. Economic effects of disease and pest control in triticale

No.	Plant protection products – growth stage		Expenses on protection/ha	Yield increase		Coefficient		
	30–32	51–59		[dt/ha]	[PLN/ha]	E	Q_1	Q_2
2002								
1	Alert 375 SC	–	143	6.1	305	2.1	2.7	3.8
2	–	Folicur BT 225 EC	157	6.3	315	2.0	2.9	4.1
3	Alert 375 SC	Folicur BT 225 EC	301	7.0	350	1.1	5.6	7.9
4	–	Karate 025 EC	70	6.8	340	4.8	1.4	1.8
5	Alert 375 SC	Folicur BT225 EC +Karate 025 EC	325	7.0	350	1.0	6.5	8.5
2003								
1	Alert 375 SC	–	123	4.8	254	2.0	2.3	2.5
2	–	Amistar 250 SC	250	3.7	198	0.8	4.7	5.2
3	Alert 375 SC	Amistar 250 SC	373	5.4	286	0.8	7.0	7.6
4	–	Karate 025 EC	50	3.7	200	4.0	0.9	1.0
5	Alert 375 SC	Amistar 250 SC +Karate 025 EC	393	5.3	283	0.7	7.4	8.0
2004								
1	Alert 375 SC	–	114	12.1	641	5.6	2.1	1.9
2	–	Folicur Plus 375 EC	150	10.4	551	3.6	2.8	2.5
3	Alert 375 SC	Folicur Plus 375 EC	264	12.3	652	2.4	4.9	4.4
4	–	Karate Zeon 050CS	48	9.0	477	9.9	0.9	0.8
5	Alert 375 SC	Folicur Plus 375 EC + Karate Zeon 050 CS	282	22.1	1171	4.1	5.3	4.3

E – cost coverage ratio , Q_1 – treatment profitability index, Q_2 – cost index in percentage

crease was similar to that achieved by that author in Winna Góra near Poznań. The results achieved 2004 (very favourable spring weather conditions for grain formation) were still higher and ranged from 9.0 to 22.1 dt/ha.

The study by Pokacka and Jańczak showed that diseases caused by *Tapesia yallundae* and *Septoria* spp. may cause serious triticale grain losses reaching 15%. They concluded that the control of triticale diseases during growing period may bring about similar economic results as in case of chemical protection of winter wheat.

Over the period of this study, the increase in the value of saved triticale grain yields has been achieved, but not each year the protection costs were covered to ensure the profit. A relatively high treatment profitability index indicates a less favourable relationship between protection costs (high fungicide prices) and selling price of triticale grain. It is confirmed by earlier studies carried out with other cereals by some authors (Jaczewska-Kalicka 2000, 2003; Juszczak and Krasiński 1998; Kaniuczak 1997, 2000).

Many authors share the opinion that a proper grain crop protection, suitably selected treatment date, as well as effective fungicides and insecticides, ensure a considerable increase in grain yield and improved technological parameters of grain (Jańczak 1992; Pokacka and Jańczak 1987; Kurowski and Hruszka 2004).

CONCLUSIONS

1. In south-eastern Poland, in cultures of winter triticale many harmful agrophages occur which cause considerable losses in grain yield, and worsen its quality. In conditions favouring the development of fungal pathogens (especially causing septoria and fusarium diseases) leaf infection and also damage by Oulema larvae is relatively high.
2. In the farms that cultivate cereals chemical treatment for plant protection is necessary because this prevents losses of grain yield. The use of selected fungicides and insecticides for disease and pest control resulted in, in case of all experimental treatments the increase of grain yield. Saved grain yield amounted to 4.3 to 22.1%.
3. Profitability of plant protection depends upon numerous factors, and among those upon the magnitude of losses caused by agrophages, and also upon the magnitude of disease and pest control costs. Considering the relation between current grain prices and prices of fungicides and insecticides chemical treatment of triticale was almost always economically profitable, and this confirmed by calculated economical indices.

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POLISH SUMMARY

CHEMICZNA OCHRONA PSZENŻYTA OZIMEGO PRZED CHOROBAMI I SZKODNIKAMI 0RAZ OCENA EKONOMICZNEJ EFEKTYWNOŚCI WYKONANYCH ZABIEGÓW

W latach 2002–2004 wykonano badania, których celem było określenie skuteczności biologicznej niektórych fungicydów i insektycydów, a także ocena efektywności gospodarczej i ekonomicznej zwalczania chorób powodowanych przez grzyby i szkodniki. W badaniach na pszenżycie ozimym, odmiana Woltario, zastosowano wybrane środki ochrony roślin: Alert 375 SC, Amistar 250 SC, Folicur BT 225 EC, Folicur Plus 375 EC, Karate 025 EC oraz Karate Zeon 050 CS.

Porażenie powierzchni liści przez patogeny w latach badań wynosiło średnio 46,2%, a przez larwy skrzypionek 29,4%. Zastosowane fungicydy wykazały skuteczność biologiczną wynoszącą od 44,7% do 90,8%, średnio 72,4%. Skuteczność zastosowanych insektycydów wyniosła średnio 82,0%. Przyrost plonu ziarna pszenżyta wahał się od 3,7 do 22,1 dt/ha (średnio 9,5%).

Plon uratowany wyniósł średnio 424 PLN/ha. Wskaźnik pokrycia kosztów wahał się od 0,7 do 9,9, a wskaźnik opłacalności zabiegów od 0,9 do 7,4, średnio 3,8. Procentowy wskaźnik kosztów wyniósł średnio 4,2.