Winter Wheat Protection against Diseases and Pests in Conventional Programme of Crop Protection and in Integrated Pest Management

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Abstract

Results of researches carried out in 2000 and 2001 have demonstrated, that main factors determining yield of winter wheat are: agrotechnical measures, mainly proper choice of field, optimal nitrogen fertilization as well as choice of cultivar well adapted to local climatic conditions. Chemical protection of winter wheat affects first of all stability of yield. Regular inspections of fields with special account to present phytosanitary situation, thresholds of noxiousness and expected development of disease and pest populations should decide on the need of chemical treatments.

Keywords: winter wheat; cultivars; susceptibility; nitrogen fertilization, beneficial insects; noxious insects; insecticides; fungal diseases; fungicides; effectiveness of control

INTRODUCTION

Cereals are presently grown in Poland on above 8 millions hectares, from which winter wheat on 1.6 millions hectares. Such the acreage as well as high average yield were the reason of intensive researches on winter wheat. Very early experiments on integrated pest management in this cereal have been undertaken (POKACKA 1992).

Economic changes taking place in Poland at the beginning of the nineties caused among others considerable reduction of the use of plant protection products decreasing to 0.6 kg of active substance per one hectare (MIECZKOWSKI & PRUSZYŃSKI 2001). At the same time fertilization was also reduced, so the yield of winter wheat decreased from 32.8 dt/ha in 1990 to 25.3 dt/ha in 2000 (KRASOWICZ 2002).

New complex of conditions appeared, in which commonly applied in Poland programmes of winter wheat protection do not ensure the needs of protection, and, because of considerable reduction of number of treatments in lower degree take into account proper evaluation of the need of treatment.

In such the situation especially important became the elaboration of integrated pest management in winter wheat taking into consideration presented elements of integration consisting of: modern diagnostics, thresholds of noxiousness, optimal timing, choice of plant protection products, proper technique as well as determining in details need of separate treatments.

Elaboration of scientific and practical backgrounds for integrated pest management in winter wheat as control measures against the complex of diseases and pests together with the determination of economic effect of such the programme was main aim of researches carried out in 1999–2002. In these researches integrated pest management was compared with conventional programme and untreated plots.

MATERIALS AND METHODS

Experiments were carried out in Agricultural Experimental Station of Plant Protection Institute at Winna Góra (Great Poland) in 1999–2002. Experiments were started using the methods of randomized blocks, on the plots of 16.5 square meters in 4 replications. Two

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cultivars of winter wheat (Elena and Tercja) of differentiated susceptibility to the infection by pathogenic fungi and pests, were studied. In the experiments two levels of nitrogen fertilization were applied, from which the first one corresponded with average fertilization of winter wheat in Poland (120 kg), whereas the second one (170 kg) corresponds with optimal recommendations. Choice of proper field for the cultivars of differentiated soil requirements was every year confirmed by the results of chemical composition and pH of soil. Soil cultivation was conformable to agrotechnical recommendations for winter wheat and was the same on all experimental plots. Experimental combinations, taking into consideration researches according to uniform method on two winter wheat cultivars and on two levels of nitrogen fertilization were as follows:

1. untreated – without protection against diseases and pests;
2. conventional protection – on this plot treatments against diseases and pests were performed according to the programme performed on productive fields;
3. integrated pest management – in this combination pest and disease control was established on the background of detailed analysis of diseases and pests risk in separate vegetative season as well as on the background of thresholds of noxiousness.

In the Table 1 the list of fungicides and insecticides applied for the protection of winter wheat is presented.

Results of mycological analyzes, yield and its parameters have been calculated statistically using the analysis of variance according to the Student *t*-test on the level of significance amounting to 0.01.

In the report the results of two-year researches (2000 and 2001) are discussed. Results of experiments carried out in 2002 are still elaborated.

RESULTS

Occurrence of diseases and pests and application of plant protection products in two programmes of winter wheat protection in 2000

Observations of the appearance and development of diseases and their control. At the beginning of blade shooting infection of blades with pathogens causing eyespot was inconsiderable. No presence of *Fusarium* spp. was stated. Infection of blades with *Pseudocersosporella herpotrichoides (*Fron.) Deighton (eyespot) amounted in average: on Elena cultivar 7% and on Tercja cultivar 5% of blades. The beginning of disease development did not show that wheat would be infected by eyespot. According to the programme of winter wheat protection performed in Poland in the stage of first node (BBCH-31) on the plots of both the programmes chemical treatment has been performed using Alert 375 SC. Treatment of preventive character became justified. Lack of risk in April was verified by the course of weather in further months. In July on maturing wheat blades *Pseudocercosporella herpotrichoides* predominated. Infection of wheat blades Tercja cultivar in two levels of nitrogen fertilization amounted 28% in average; more susceptible was Elena cultivar (38%). No statistical differences in the infection of both the cultivars in differentiated levels of nitrogen fertilization were stated.

Diseases appeared on the second leaf (L2) in third decade of May. The decision on the second treatment has been undertaken on the background of observations of second leaf L2 infection, amounting in average to 2% of surface. On the decision on this treatment weather forecast also influenced. Second treatment has been performed using Archer 425 EC at the beginning of earing stage (BBCH-49). Both the wheat cultivars in both the protection programmes were sprayed. In conventional programme this date was convergent to wheat protection on productive fields.

After three weeks pathogens appeared on flag leaf, on which at the same time three diseases occurred. Infection of flag leaf amounting to above 4% of surface together with weather forecast favourable for disease development justified the decision on further wheat protection. In integrated pest management programme wheat has been treated with Amistar 250 SC. It was third treatment. Wheat was in the stage of the beginning of flowering (BBCH-61). The application of this fungicide effectively checked further disease development, but shortly also on untreated plots diseases stopped to develop.Weather forecasts did not prove correct, high temperature and lack of rainfalls caused fast yellowing and premature drying of leaves. Thanks to the effect of "green leaf" characteristic for the fungicide Amistar 250 SC, on protected plots flag leaves were green by 10 days longer.

Occurrence of pests and beneficial entomofauna on winter wheat in 2000. The course of meteorological factors favourized both early and fast development of noxious and beneficial entomofauna. Among numerous pests of economic importance the most numerously larvae of cereal leaf beetles occurred. Less numerously occurred cereal aphids (3 on one ear in average). More numerous occurrence of pests was observed on

the plots on which higher nitrogen fertilization was applied. More frequently pests occurred on Tercja cultivar. Threshold of noxiousness for cereal leaf beetles (1–1.5 larvae on one blade) was exceeded at the beginning of earing stage, what became the background of decision on chemical control. Insecticide Karate 25 WG has been applied in conventional programme, selective insecticide Dimilin 25 WP in integrated pest management programme. The control of pests was effective; beneficial entomofauna was more numerous on the plants treated with Dimilin 25 WP, which is selective for beneficial insects. In entomological catchings the most frequently occurred species presented below:

- noxious insects: *Thysanoptera*, *Agromizidae*, *Anthomyidae*, *Oscinella frit* L., *Chlorops pumilionis* Bjerk, *Aelia acuminata* L., *Notostira erratica* L., *Lema melanopa* L., *Lema cyanella* Voet., *Cephus pygmaeus* L.
- beneficial insets: *Staphylinidae*, *Cantharis* sp., *Ichneumonidae*, *Braconidae*, *Aphididae, Telenomus* sp., *Syrphidae*, *Coccinellidae*, *Chrysopa* sp.

Occurrence of diseases and pests and application of plant protection products in two programmes of winter wheat protection in 2001

Observations of appearance and development of diseases and their control. At the beginning of ear shooting average infection of blades by *Pseudocercosporella herpotrichoides* (Fron.) Deighton amounted to: 22% on Tercja cultivar and 16% on Elena cultivar. Treatment against the development of eyespot has been performed in the stage of first node (BBCH-31). Plants have been sprayed in two programmes of protection with Alert 375 SC. Treatment became significantly justified. Eyespot on maturing blades was the disease of high importance. Infestation of disease was very high and eyespot occurred on the whole blade foot.

During five weeks after the first treatment experiments were regularly inspected. Weather at this time was not favourable for disease development. The decision on the treatment has been undertaken on the background of observations of second leaf infection as well as weather conditions. Second treatment has been performed using Archer 425 EC in the stage of entire earing (BBCH-51). Both the wheat cultivars in conventional programme have been sprayed (this date was convergent with wheat protection on productive fields) as well as in integrated pest management programme.

Dynamics of disease development during further two weeks was very fast. Fungi occurred on flag leaf, and on second leaf their further, intensive development was observed. During two weeks total surface of infected second leaf increased by: 10% on Elena cultivar, and by 6% on Tercja cultivar.

Decision on interventional treatment has been undertaken on the background of flag leaf infection (threshold of noxiousness 1–5%). Treatments have been performed in integrated pest management programme (third treatment). Amistar 250 SC has been applied at the beginning of flowering stage (BBCH-61).

In the stage of water maturity (BBCH-71) – ten days after treatment the infection of flag leaf and ear has been evaluated. Infestation of ears by glume blotch (*Septoria nodorum* Berk.) and ear blight (*Alternaria* spp., *Cladosporium* spp.) was low. Among leaf diseases the highest was infestation by brown rust, then by leaf spot. Infestation of powdery mildew was low, but a little higher on Tercja cultivar.

Table 1. List and characteristics of fungicides and insecticides applied for the control of fungal diseases and pests (Agricultural Experimental Station of Plant Protection Institute, Winna Góra, 2000–2002)

Trade name	Active substance		Chemical group	Application rate per one ha
	common name	contents of active substance		
Alert 375 SC	usilazol	125 g	azoles	1.0 l
	carbendazim	250 g	benzimidazoles	
Archer 425 EC	propiconazole	125 g	azoles	1.0 l
	fenpropimorph	300 g	morpholines	
Amistar 250 SC	azoxystrobin	250 g	strobilurin analogues	1.0 l
Karate 25 WG	lambda-cyhalothrin	25 g	pyrethroids	0.25 kg
Dimilin 25 WP	di ubenzuron	25%	benzoylurea derivatives	0.3 kg

Table 2. Grain yield of two winter wheat cultivars in 2000

Experiments	Grain yield (t/ha)	Increase as compared to the untreated		Economic profit	
		(t/ha)	(%)	(PLZ/ha)	(USD/ha)
ELENA cultivar I level of N fertilization					
Conventional programme	6.46 bc	0.92	16.6	**175**	**42**
Integrated pest management	6.99 c	1.45	26.2	**165**	**39**
ELENA cultivar II level of N fertilization					
Conventional programme	7.28 c	1.25	20.7	**240**	**57**
Integrated pest management	7.72 c	1.69	28.0	**185**	**44**
$NIR_{(0.01)}$	0.487				
TERCJA cultivar I level of N fertilization					
Conventional programme	7.20 b	1.19	19.8	**310**	**74**
Integrated pest management	7.61 bc	1.60	26.6	**240**	**57**
TERCJA cultivar II level of N fertilization					
Conventional programme	8.02 b	1.52	23.4	**375**	89
Integrated pest management	8.44 bc	1.94	29.8	**310**	**73**
$NIR_{(0.01)}$	0.250				

Development and occurrence of diseases on flag leaf of Elena cultivar were of epiphytic character (total infection of leaf surface: 46.6% and 60.2%). High leaf infestation shows on considerably high susceptibility of Elena cultivar to brown rust (21.0% and 30.7%) and leaf spot (24.0% and 27.8%). Stimulating effect of higher nitrogen fertilization on disease development was also stated.

Occurrence of pests and beneficial entomofauna on winter wheat in 2001. The most numerously larvae of cereal leaf beetles and aphids occurred. In the stage of water maturity of wheat grain (04.07.) the numerousness of cereal leaf beetles amounted to 1.2 larvae per one blade (threshold of noxiousness amounts to 1–1.5 larvae per one blade) and 5.3 aphids per one ear (threshold of noxiousness amounts to 5 aphids per one ear). Decision has been undertaken on control treatment against these pests using insecticide Karate 25 WG. Effectiveness of Karate 25 WG in the control of larvae of cereal leaf beetles and aphids amounted to 100%.

The course of meteorological conditions caused later and moderate development of noxious and beneficial entomofauna. Beneficial entomofauna was the most numerously represented by the species belonging to *Aphidiidae* family.

Winter wheat Tercja cultivar in II level of nitrogen fertilization was more susceptible to the larvae of cereal leaf beetles and larvae belonging to *Tenthredinidae* family. Damages caused by the larvae of insects belonging to *Agromyzidae* family were more important in the programmes with higher nitrogen fertilization on both wheat cultivars.

Effect of various programmes of protection on the yield of winter wheat Elena and Tercja cultivars. Economic effect of disease and pest control

Application of newest, very effective, but also expensive plant protection products in 2000 was moderately rentable (Table 2). Control of diseases and pests occurring numerously in 2001 gave considerable economic effects (Table 3). Third treatment on wheat in integrated pest management was justified, but application of very expensive fungicide Amistar 250 SC caused lower profit as compared to conventional programme.

Table 3. Grain yield of two winter wheat cultivars in 2001

Experiments	Grain yield (t/ha)	Increase as compared to the untreated		Economic profit	
		(t/ha)	(%)	(PLZ/ha)	(USD/ha)
ELENA cultivar I level of N fertilization					
Conventional programme	7.71 d	1.82	31.8	**762**	**181**
Integrated pest management	8.12 d	2.27	38.8	**712**	**169**
ELENA cultivar II level of N fertilization					
Conventional programme	8.63 e	2.18	33.8	**858**	**204**
Integrated pest management	9.06 e	2.61	40.5	**796**	**189**
$NIR_{(0.01)}$	0.412				
TERCJA cultivar I level of N fertilization					
Conventional programme	7.65 c	1.59	26.2	**624**	**148**
Integrated pest management	8.07 c	2.05	33.2	**580**	**138**
TERCJA cultivar II level of N fertilization					
Conventional programme	8.50 d	2.01	31.0	**756**	**180**
Integrated pest management I	8.79 d	2.30	35.4	**610**	**145**
$NIR_{(0.01)\ (0.01}$	0.253				

DISCUSSION

Experiments carried out in 200 and 2001 differred both in disease occurrence and in specific composition of pests. Weather conditions, mainly rainfalls and relative air humidity, decided on the development of pests and diseases. In 2001 infestation of diseases was very high, and development on ag leaf in the stage of water maturity of grain Elena cultivar of epiphytic character. On wheat of Tercja cultivar in 2001 larvae of cereal leaf beetle and aphids numerously occurred both on the plants and on the ears. Differentiated infestation of pathogens and pest numerousness on both the wheat cultivars resulted from their competitive development. In the conditions of high risk elements of integration in winter wheat protection against diseases and pests were of special importance. On the background of results obtained it can be stated, that the most important element of integration is proper choice of wheat cultivar evaluated on the background of local conditions. This opinion is confirmed by the results obtained on Elena cultivar. This cultivar was highly susceptible to the pathogens *Puccinia recondita* Erikss., *Septoria tritici* Rob. ex Desm. and *Septoria nodorum* Berk. Diseases caused by these pathogens are predminating in Great Poland region. Elena cultivar should not be grown in this region.

Researches showed, that nitrogen fertilization should be acknowledged as further element of integration and factor stimulating wheat yield. Additional rate of nitrogen in the stage of wheat earing caused considerable increase of grain quality.

Later rate of nitrogen resulted in better grain filling as well as better quality parameters. Results of technological grain analyzes have showed that optimal nitrogen fertilization is also a factor considerably affecting increase of glutene and total proteins contents in wheat grain. These parameters are especially favourable for Tercja cultivar, grain of which was characterized by better quality than the grain of Elena cultivar.

No effect of differentiated fungicide application on mentioned above parameters of technological quality has been stated.

As an important element in integrated pest management programme regular inspections of experiments can be acknowledged. On the background of these

inspection taking into account expected development of diseases and pests the decisions on the need of treatments were undertaken.

Choice of modern plant protection products of differentiated mode of activity, application rates and timings allowed to obtain high yield in 2000 and very high yield in 2001. Taking into consideration very high prices of plant protection products in Poland it can be stated, that economic effect of the programmes of wheat protection performed in 2000 was not fully satisfying.

Researches carried out have showed possibility of application of integrated pest management programme in winter wheat protection against the complex of diseases and pests, nevertheless it requires first of all proper education of advisory services and farmers.

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