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CONVENTIONAL OR INTEGRATED PROTECTION OF WINTER WHEAT AGAINST FUNGAL DISEASES AND PESTS

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Abstract: Research performed in the years 1999–2002 was carried out in Great Poland region on varieties of winter wheat Elena and Tercja. Experiments included three programmes of wheat cultivation: 1 – Conventional winter wheat protection based on recommendations for commercial fields; 2 – Integrated pest management programme where the control of diseases and insect pests was carried out on the background of thresholds of harmfulness/noxiousness, and weather forecasts; 3 – Untreated, without protection against diseases and pests. Two levels of nitrogen fertilization were applied in the experiments (120 kg N/ha and 170 kg N/ha) and the newest plant protection products were used for controlling fungal pathogens and noxious insects. The occurrence of diseases and insect pests, as well as beneficial entomofauna was determined in relation to each experimental variant, and occurring changes were analysed. Effectiveness of disease and pest control were calculated. Grain yield and its quality were determined and economical profitability for both conventional and integrated programmes calculated. It was shown that a high profitability can be obtained through the application of integrated pest management, as a result of correct choice and application of plant protection products, as well as proper choice of wheat cultivars and appropriate nitrogen fertilization.

Key words: 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 million hectares, from which winter wheat is cultivated on 1.6 million hectares.

Such an acreage as well as high average yield of winter wheat were the reason of conducted research. Early experiments on integrated pest management in this cereal were undertaken in nineteen eighties (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 and 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).

In such 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, choice of plant protection products, optimal timing, proper technique as well as determining necessity of particular treatments.

Elaboration of scientific and practical background for integrated pest management in winter wheat including the determination of its economic effect was the main aim of research carried out in 1999–2002. The effect of integrated pest management was compared with conventional programme and untreated plots.

MATERIALS AND METHODS

Experiments were carried out in Agricultural Experimental Farm of Plant Protection Institute at Winna Góra (Great Poland) in 1999–2002. Experiments were laid out using randomized block design, on plots of 16.5 sq. m. in 4 replications. Two cultivars of winter wheat (Elena and Tercja) of differentiated susceptibility to the infection by pathogenic fungi 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 N), whereas the second one (170 kg N) corresponded with optimal recommendations. Choice of a proper field was every year confirmed by the results of chemical analysis and pH of soil. Soil cultivation was conformable with agrotechnical recommendations. Experimental treatements were:

1. untreated – without protection against diseases and pests,
2. conventional protection according to the programme established for commercial fields: first treatment – spraying with a fungicide in BBCH-31 stage of first node against eyespot, second treatment from the beginning up to the end of earing stage (BBCH-49-55) against the diseases of upper leaves and ear. Treatment using insecticide against pests (cereal leaf beetles, aphids, mining insects) is in agricultural practice most frequently performed on the background of threshold of noxiousness for aphids (5 aphids on 1 ear in average);
3. integrated pest management – in this treatment pest and disease control was established on the background of detailed analysis of disease and pest risk as well as on the background of noxiousness thresholds.

In order to determine significant elements of integrated pest management in winter wheat the following works were performed:

- evaluation of effectiveness of fungal diseases control (EPPO 1999),
- entomological catchings in order to evaluate the number and composition of noxious and beneficial entomofauna (microscopic analyses) as well as dynamics of population of most frequently occurring species;

– evaluation of effectiveness (macroscopic evaluation of plant damage) and effect of applied plant protection products on the occurrence of beneficial entomofauna;
– analysis of yield obtained: quality of grain (weight of 1000 grains), average number of grains in one ear, average weight of grain per ear;
– quantitative analysis of grain: protein and gluten contents in winter wheat grain;
– evaluation of economic profitability of specific programmes of winter wheat protection. Results of mycological analyses, yield and its parameters were calculated statistically using the analysis of variance according to Student T-test on the level of significance p= 0.01.

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

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

Trade name	Active ingredient		Chemical group	Application rate per one ha
	Common name	Contents of active substance		
Alert 375 SC	flusilazol	125 g	triazoles	1.0 l
	carbendazim	250 g	benzimidazoles	
Archer 425 EC	propiconazole	125 g	triazoles	1.0 l
	fenpropimorph	300 g	morpholines	
Amistar 250 SC	azoxystrobin	250 g	strobilurin analogues	1.0 l
Karate 25 WG	lambdacyhalothrin	250 g	pyrethroides	0.25 kg
Dimilin 25 WP	diflubenzuron	25 %	benzoylurea derivatives	0.30 kg

RESULTS

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

1.1. Observations of the appearance and development of diseases and their control

At the beginning of shooting infection of leaf sheaths by pathogens was low. Infection by *Pseudocersosporella herpotrichoides* (Fron.) Deighton (eyespot) on Elena cultivar amounted on average to 7% and on Tercja cultivar to 5% of affected plants. In the stage of first node (BBCH-31) chemical treatment was performed using Alert 375 SC. This treatment of preventive character became justified as in July in untreated control per cent of infected by *Pseudocercosporella herpotrichoides* plants amounted to above 80% (Tab. 2).

Diseases appeared on the second leaf (L2) in third decade of May. The decision of second treatment was undertaken on the background of observations of second leaf infection which amounted to ca 2% of leaf surface for both varieties and two nitrogen levels. This decision was also motivated by weather forecast. Second treat-

Table 2. Occurrence and control of eyespot [*Pseudocercosporella herpotrichoides* (Fron. Deighton] in the phase of water maturity (BBCH – 71) – 3 July 2000

No.	Experiments	Total per cent of infected leaf sheaths		Effectiveness of control (%)*	
		ELENA cultivar	TERCJA cultivar	ELENA cultivar	TERCJA cultivar
	I level of N fertilization				
1.	untreated	83.0	89.0	–	–
2.	conventional programme	54.0	36.0	66.7	76.7
3.	integrated pest management	46.0	37.0	77.8	73.3
	II level of N fertilization				
1.	untreated	85.0	84.0	–	–
2.	conventional programme	48.0	40.0	75.6	66.7
3.	integrated pest management	33.0	35.0	82.9	66.7
	LSD (0.01)	12.44	17.44		

*Efficacy calculated using Abbott's formula

ment was performed at the beginning of earing stage (BBCH-49) using Archer 425 EC. After three weeks diseases appeared on flag leaf (L1). In untreated control of both varieties and two nitrogen fertilization levels the occurrence of three diseases (powdery mildew, brown rust and Septoria blotch) amounted to above 4% of affected leaf surface. The level of infection and favourable for disease development weather conditions justified the decision on further wheat protection. Third treatment was performed at the beginning of flowering (BBCH-61) using Amistar 250 SC.

The application of this fungicide effectively checked further disease development. Shortly after third treatment on untreated plots diseases stopped to develop becase of high temperature and lack of rainfall which 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 remained green for 10 days longer, as compared to untreated plots.

1.2. Occurrence of pests and beneficial entomofauna on winter wheat in 2000

Meteorological conditions favoured both early and fast development of noxious and beneficial entomofauna. Among numerous pests of economic importance most frequently larvae of cereal leaf beetles occurred. Less numerously cereal aphids occurred (3 on one ear in average). More numerous occurrence of pests was observed on the plots where higher nitrogen fertilization was applied. Pests more frequently 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, this became the background of decision on chemical control. Insecticide Karate 25 WG was 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 plants treated with Dimilin 25 WP, which is selective for beneficial insects. In entomological catchings most frequently occurred species presented in table 3.

Table 3. Number of noxious insects and benefical insects of 10 catchings since 24 April 2000 to 28 June 2000

No.	Insects	Cultivar and level of N fertilization											
		ELENA (I – N)			ELENA (II – N)			TERCJA (I – N)			TERCJA (II – N)		
		Total number of insects in specific programmes of protection											
		1	2	3	1	2	3	1	2	3	1	2	3
1.	*Thysanoptera*	200	185	209	196	196	216	244	229	257	274	241	263
2.	*Agromizidae*	210	165	185	169	168	181	158	155	154	207	174	200
3.	*Anthomyiidae*	43	42	41	50	48	45	51	46	34	49	49	55
4.	*Oscinella frit* L.	40	30	44	48	88	54	59	44	47	65	45	51
5.	*Chlorops pumilionis* Bjerk.	35	30	34	32	32	34	28	40	36	32	31	31
6.	*Aelia acuminata* L.	14	3	4	9	11	9	8	2	7	10	12	6
7.	*Notostira erratica* L.	42	31	22	37	24	34	32	30	56	30	33	41
8.	*Lema melanopa* L.	30	27	26	23	33	26	36	37	39	58	43	52
9.	*Lema cyanella* Voet.	20	14	17	22	16	22	23	27	22	33	26	33
10.	*Cephus pygmaeus* L.	11	15	11	16	13	13	17	18	13	25	14	25
11.	*Staphylinidae*	11	5	8	12	5	7	11	9	7	13	9	11
12.	*Cantharis* sp.	13	9	12	15	8	15	26	16	17	25	17	20
13.	*Ichneumonidae*	12	10	13	16	13	13	15	11	17	15	20	16
14.	*Braconidae*	16	13	18	18	12	17	21	14	13	16	10	24
15.	*Aphidiidae*	50	47	49	61	55	60	49	57	56	80	73	85
16.	*Telenomus* sp.	47	38	44	55	62	38	30	30	29	32	23	33
17.	*Syrphidae*	12	5	10	11	2	12	16	14	11	16	7	11
18.	*Coccinellidae*	14	18	14	22	16	12	11	14	20	16	20	20
19.	*Chrysopa* sp.	18	15	15	16	15	14	17	15	11	18	17	18

Programmes of protection: 1 – untreated plots; 2 – conventional programme; 3 – integrated pest management

noxious insects 1–10; benefical insects 11–19

2. Occurrence of diseases and pests and application of plant protection products in three programmes of winter wheat protection in 2001

2.1. Observations of the appearance and development of diseases and their control

Wheat protection experiments were supplemented in 2001 with an additional programme of extensive integrated pest managament (two treatments with fungicides).

At the beginning of shooting (BBCH-30) average infection of leaf sheaths by *P. herpotrichoides* amounted to: 22% on Tercja cultivar and 16% on Elena cultivar. Treatment against the development of eyespot was performed in the stage of first node (BBCH-31). Plants were sprayed in the three programmes of protection with Alert 375 SC. Treatment was significantly justified as in the middle of July symptoms of eyespot on maturing leaf sheaths were present on 100% of plants (Tab. 4). It should be noted that the intensity of infection by *P. herpotrichoides* was higher than observed in the years 2000 and 2002.

During five weeks after first treatment weather was not favourable for disease development. The decision on second treatment was undertaken on the back-

Table 4. Occurrence of eyespot (*Pseudocercosporella herpotrichoides* (Fron.) Deighton on maturing leaf sheaths – 16 July 2001

No.	Experiments	Total per cent of infected leaf sheaths		Effectiveness of control (%)*	
		ELENA cultivar	TERCJA cultivar	ELENA cultivar	TERCJA cultivar
	I level of N fertilization				
1.	conventional programme	89	77	56.6	48.6
2.	integrated pest management I	80	79	59.6	65.7
3.	integrated pest management II	88	82	47.5	52.8
4.	untreated	100	99	–	–
	II level of N fertilization				
1.	conventional programme	88	88	44.2	36.6
2.	integrated pest management I	75	73	59.3	32.9
3.	integrated pest management II	71	92	54.6	47.9
4.	untreated	89	97	–	–
	LSD (0.01)	17.37	17.87		

*Efficacy calculated using Abbott's formula

ground of observations of second leaf infection as well as on weather conditions. Shortly before second treatment on control plots average infected area of second leaf (L 2) amounted to 3.0% (Elena cultivar) and 1.6% (Tercja cultivar). This treatment was performed using Archer 425 EC in the stage of full earing (BBCH-51) (6 June 2001). Both wheat cultivars in conventional programme and integrated pest management programme I (curative treatment) were sprayed. Integrated pest management programme II (extensive) remained without further protection, because flag leaf at that time was healthy.

Dynamics of disease development during two weeks after second treatment was very fast. Intensive development of pathogens was observed on flag leaf and on second leaf (Tab. 5).

The decision on curative treatment was undertaken on the background of flag leaf infection (threshold of harmfulness 1–5% of infected leaf area). Treatments with Amistar 250 SC were performed at the beginning of flowering on 24 June 2001 in integrated pest management programme I (third treatment) and in integrated pest management programme II – extensive (second treatment).

In the stage of water maturity (BBCH-71) ten days after treatment on 4 July 2001 the infection of flag leaf and ear was also evaluated. The occurrence of glume blotch (*Septoria nodorum* Berk.) and sooty moulds (*Alternaria spp., Cladosporium spp.)* was low. Among leaf diseases the infestation by brown rust was the highest. The infestation by powdery mildew was the lowest (Tab. 6).

The occurrence of diseases on flag leaf of Elena cultivar was distinctly higher than on Tercja. High leaf infestation of Elena cultivar reveals a considerably high susceptibility of this cultivar to brown rust and Septoria leaf blotch. Stimulating effect of higher nitrogen fertilization on disease development was stated.

Table 5. Average infection of two upper leaf surface in untreated plots before third treatment on 20 June 2001 two weeks after second treatment

Diseases (Pathogens)	Elena cultivar		Tercja cultivar	
	second leaf (L2)	flag leaf (L1)	second leaf (L2)	flag leaf (L1)
I level of N fertilization				
Brown rust (*Puccinia recondita* Erikss.)	6.11	2.21	0.57	0.16
Leaf blotch (*Septoria tritici* Rob. ex Desm.) *Stagonospora nodorum* (Berk.) (Castellani et Germano)	4.53	0.68	4.18	0.46
Powdery mildew (*Erysiphe graminis* DC.)	2.10	1.00	3.31	2.21
Total	12.74%	3.89%	8.06%	2.83%
II level of N fertilization				
Brown rust (*Puccinia recondita* Erikss)	6.35	2.98	0.28	0.10
Leaf blotch (*Septoria tritici* Rob. ex Desm.) *Stagonospora nodorum* (Berk.) (Castellani et Germano)	4.86	0.82	3.16	0.48
Powdery mildew (*Erysiphe graminis* DC.)	2.68	1.43	3.76	1.95
Total	13.89%	5.23%	7.20%	2.53%

Table 6. Occurrence of diseases on flag leaf (L1) in untreated plots – 4 July 2001

Diseases (Pathogens)	Average per cent of infected flag leaf (L1) surface			
	Elena cultivar		Tercja cultivar	
	I level of N fertilization	II level of N fertilization	I level of N fertilization	II level of N fertilization
Brown rust (*Puccinia recondita* Erikss.)	21.04	30.67	7.33	9.80
Leaf blotch (*Septoria tritici* Rob.ex Desm.) *Stagonospora nodorum* (Berk.) (Castellani et Germano)	24.00	27.83	10.03	9.92
Powdery mildew (*Erysiphe graminis* DC.)	1.51	1.62	1.98	2.16
Total	46.55	60.12	19.34	21.88

2.2. Occurrence of pests and beneficial entomofauna on winter wheat in 2001

Larvae of cereal leaf beetles and aphids occurred most numerously in the stage of water maturity of wheat grain. 4 July 2001 the number of cereal leaf beetles amounted to 1.2 larvae per one blade (threshold of noxiousness 1–1.5 larvae per one blade) and 5.3 aphids per one ear (threshold of noxiousness 5 aphids per one ear). Decision was undertaken on control treatment against these pests with Karate 025 WG in integrated pest management programme I (curative) and in conventional programme. In integrated pest management programme II (extensive) threshold of noxiousness for larvae of cereal leaf beetles was exceeded in the stage of milk maturity of grain 11 July 2001. Taking into consideration numerous occurrence of beneficial entomofauna control treatment was performed using selective insecticide Dimilin 25 WP. Effectiveness of Karate 25 WG in controlling larvae of cereal leaf beetles and aphids amounted to 100%, whereas effectiveness of Dimilin 25 WP in controlling cereal leaf beetles was 95%. The latter insecticide because of its specific activity was not effective in aphid control.

Table 7. Number of noxious and benefical insects of 10 catchings since 17 May 2001 to 26 July 2001

No.	Insects	Cultivar and level of N fertilization															
		ELENA (I –N)				ELENA (II – N)				TERCJA (I – N)				TERCJA (II – N)			
		Total number of insects in specific programmes of protection															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.	*Thysanoptera*	386	362	408	373	518	370	411	522	155	513	581	622	539	538	519	546
2.	*Agromizidae*	163	178	192	176	155	138	146	114	133	109	98	121	134	95	88	115
3.	*Anthomyiidae*	29	42	23	46	25	29	43	33	24	42	41	42	20	29	32	48
4.	*Oscinella frit* L.	9	27	26	29	28	25	23	36	25	19	26	31	23	21	24	33
5.	*Chlorops pumilionis* Bjerk.	5	11	6	11	6	3	4	15	6	9	2	5	4	8	8	11
6.	*Aelia acuminata* L.	1		2		1	1	5	3	2	2			2		3	
7.	*Notostira erratica* L.	13	28	32	25	16	36	25	17	17	15	18	19	13	28	21	7
8.	*Lema melanopa* L.	4	5	4	6	6	10	8	5	5	9	6	7	7	9	7	11
9.	*Lema cyanella* Voet.	3	1	7	2	3	4	3	3	2	8	1	6	4	4	5	1
10.	*Cephus pygmaeus* L.	1		1	1	1	1	1	1	1	1	2	5	2	2		1
11.	*Staphylinidae*	2	2		2	3	2		3	3		2	1	1	1		2
12.	*Cantharis* sp.	7	10	4	7	14	10	6	8	3	10	14	3	6	7	3	6
13.	*Ichneumonidae*		2	1		2	2	1	1	1	2	2	1	1			2
14.	*Braconidae*	4	2	3	2	5	5	10	2	6	2	1	4	2	4	5	6
15.	*Aphidiidae*	19	35	26	27	23	16	29	20	23	28	31	26	32	23	49	43
16.	*Telenomus* sp.	10	9	9	25	13	13	18	10	12	12	11	4	8	4	2	6
17.	*Syrphidae*	4		2	1	1	1		3	3	2	3	3	2	2	1	1
18.	*Coccinellidae*	1	2	2	4	3	3	2	1	2	2	1	3	3	3	2	2
19.	*Chrysopa* sp.	2			3	1				2			2	3		1	3

Programmes of protection: 1 – untreated plots; 2 – conventional programme; 3 – integrated pest management I; 4 – integrated pest management II

noxious insects 1–10; benefical insects 11–19

The course of meteorological conditions caused late and moderate development of noxious and beneficial entomofauna (Tab. 7). Beneficial entomofauna was the most numerous in integrated pest management programme II, in which Dimilin 25 WG, highly selective for beneficial insects, was applied. Beneficial entomofauna was most numerously represented by the species belonging to *Aphidiidae* family.

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

3. Occurrence of diseases and pests and application of plant protection products in three programmes of winter wheat protection in 2002

3.1. Observations of the appearance and development of diseases and their control

After the start of vegetation on stem bases of both wheat cultivars mixed infection caused by *P. herpotrichoides* occurred (per cent of infected plants of Elena cultivar – 23%, and of Tercja cultivar – 9%) and by *Fusarium* species (per cent of infected plants

Table 8. Occurrence of eyespot (*Pseudocercosporella herpotrichoides* (Fron.) Deighton on maturing leaf sheaths – 10 July 2002

No.	Experiments	Total per cent of infected leaf sheaths		Effectiveness of control (%)*	
		ELENA cultivar	TERCJA cultivar	ELENA cultivar	TERCJA cultivar
	I level of N fertilization				
1.	conventional programme	53	47	61.0	65.2
2.	integrated pest management I	57	59	41.5	76.1
3.	integrated pest management II	48	54	70.7	56.5
4.	untreated	67	71	–	–
	LSD (0.01)	15.302	14.310		
	II level of N fertilization				
1.	conventional programme	55	46	69.0	77.4
2.	integrated pest management I	59	52	64.3	48.4
3.	integrated pest management II	60	47	61.9	83.9
4.	untreated	64	63	–	–
	LSD (0.01)	13.67	13.37		

*Efficacy calculated using Abbott's formula

of Elena cultivar – 10%, and of Tercja cultivar – 9%). In three programmes of protection at BBCH-31 growth stage treatment with Alert 375 SC was performed.

On control plots maturing stalks at BBCH-71 growth stage a moderate level of infection by eyespot fungus predominated, although a considerable percentage (63% to 71%) of plants were affected. The number of infected leaf sheaths of Tercja variety was in most cases and for both fertilization levels and in the three management programmes significantly lower than recorded for control plots (Tab. 8).

Foot rot caused by *Fusarium* commonly occurred on both wheat cultivars (Tab. 9). Significantly lower stem base infection in high and moderate degree was observed on plots with higher level of nitrogen fertilization, and for both cultivars.

The decision on second treatment was undertaken on the background of second leaf infection by pathogens (*Puccinia recondita* Erikss., *Septoria tritici* Rob. ex Desm., *Stagonospora nodorum* (Berk.) Castellani et Germano, *Erysiphe graminis* DC.) ranging from 4.50% to 7.18% of total infected leaf area.

On 29 May the treatment was performed with Archer 425 EC in traditional programme as well as in integrated programme I. After three weeks the infection of second leaves significantly increased, and the infection on flag leaves developed (Tab. 10). The decision on further wheat treatment was undertaken on the background of flag leaf infection. In integrated programme I it was the third treatment, and in integrated programme II the second one.

On the background of detailed analysis of effectiveness of disease control on flag leaves (Tab. 11) and ears (Tab. 12) in three programmes of protection performed 3 July 2002, it can be stated, that:

– the most effective was the control of fungal diseases in integrated programme I, in which three treatments were performed;

Table 9. Occurrence of *Fusarium* spp. in the phase of water maturity of grain (BBCH-71) – 10 July 2002

No.	Experiments	Average per cent of infected leaf sheaths			
		Degrees of infection			Total per cent of infected sheaths
		high	moderate	low	
		ELENA cultivar			
		I level of N fertilization			
1.	Conventional programme	0 a	5 a	36a	43
2.	Integrated pest management I	2 a	23 ab	20 a	51
3.	Integrated pest management II	0 a	12 a	38 a	48
4.	Untreated	10 a	49 b	26 a	79
	LSD (0.01)	11.484	26.037	28.810	
		II level of N fertilization			
1.	Conventional programme	2 a	10 a	37 b	49
2.	Integrated pest management I	1 a	17 a	32 ab	50
3.	Integrated pest management II	1 a	11 a	35 b	47
4.	Untreated	3 a	40 b	19 a	62
	LSD (0.01)	2.198	17.747	17.914	

No.	Experiments	Average per cent of infected leaf sheaths			
		Degrees of infection			Total per cent of infected sheaths
		high	moderate	low	
		TERCJA cultivar			
		I level of N fertilization			
1.	Conventional programme	3 a	10 a	32 ab	45
2.	Integrated pest management I	2 a	8 a	44 a	54
3.	Integrated pest management II	4 a	12 a	30 ab	46
4.	Untreated	12 b	52 b	21 a	85
	LSD (0.01)	10.171	25.042	21.305	
		II level of N fertilization			
1.	Conventional programme	1 a	16 a	34 b	51
2.	Integrated pest management I	0 a	12 ab	39 a	51
3.	Integrated pest management II	2 a	18 a	30 b	50
4.	Untreated	5 b	37 b	27 a	69
	LSD (0.01)	3.341	16.894	22.759	

Means in columns followed by the same letter do not differ at 1% level of significance

- limited effectiveness of Amistar 250 SC in integrated program II (2 treatments) was stated, which was caused by too late spraying, when very high infection of flag leaves already occurred;
- in existing conditions of high infection of leaves significant susceptibility of Elena cultivar to brown rust and leaf blotch, as well as of Tercja cultivar to leaf blotch and powdery mildew was observed;

Table 10. Increase of infection intensity and disease occurrence on second leaves (L2) and disease development on flag leaves (L1) in untreated plots – 18 June 2002

Diseases (Pathogens)	Average per cent of infected leaf surface			
	second	flag	second	flag
	ELENA		TERCJA	
I level of N fertilization				
Brown rust (*Puccinia recondita* Erikss.)	16.81	3.92	1.58	1.00
Leaf blotch (*Septoria tritici* Rob.ex Desm.) *Stagonospora nodorum* (Berk.) (Castellani et Germano)	8.51	3.03	17.02	5.11
Powdery mildew (*Erysiphe graminis* DC.)	2.53	1.00	5.49	2.58
Total	27.85	7.95	24.09	7.69
Increase in average by	23.35%		18.33%	
II level of N fertilization				
Brown rust (*Puccinia recondita* Erikss.)	24.38	4.94	4.38	1.08
Leaf blotch (*Septoria tritici* Rob.ex Desm.) *Stagonospora nodorum* (Berk.) (Castellani et Germano)	11.64	2.83	18.73	6.14
Powdery mildew (*Erysiphe graminis* DC.)	2.74	0.58	6.54	3.38
Total	38.76	8.35	29.65	10.60
Increase in average by	32.35%		22.47%	

– significantly higher occurrence of above mentioned diseases was stated on the plots with higher level of nitrogen fertilization.

In technological studies on grain harvested in 2002 significantly lower parameters as compared to 2000 and 2001 were obtained, which was caused by limited and irregular rainfall as well as worse conditions for wheat growth. The content of wet gluten and raw protein was rather low and fluctuated between 27 and 32% of gluten and 10.5 and 13.8% of protein. Qualitative coefficients for grain of Elena cultivar were almost the same as the minimum for bread wheat (B class) and in average amounted to: 28.2% of gluten, 7–8 mm of flowability and 11.5% of protein. The grain of Tercja cultivar was of a significantly higher quality, which can be stated on the background of 31.3% of gluten and 12.6% of protein content. The parameters of grain of this cultivar were similar as those of A class, and flowability of gluten was too high and exceeded limit value – 6 mm for this class (cited by Górniak and Rothkaehl, 1998).

Statistic analysis showed, that nitrogen fertilization and applied programmes of plant protection affected in various degree qualitative coefficients of both cultivars. No interaction between fungicide application and fertilization were stated.

3.2. Occurrence of pests and benefical entomofauna on winter wheat in 2002

The number of noxious and beneficial entomofauna was evaluated on the background of 15 catchings (Tab. 13). The most frequently thrips species (*Thysanoptera*) occurred. Also frequent occurrence of flies belonging to *Agromyzidae* and *Anthomyiidae* families was stated. No frit flies (*Oscinella frit* L.) were collected. Considerably higher pest occurrence was stated in II level of fertilization on both wheat cultivars, and they were more numerous on Tercja cultivar. Among beneficial

Table 11. Occurrence and effectiveness of disease control on flag leaves in various programmes of winter wheat protection – 3 July 2002

No.	Objects of experiments	Average per cent of			
		infected surface of leaf L1	% effectiveness	infected surface of leaf L1	% effectiveness
		Elena cultivar		Tercja cultivar	
BROWN RUST (*Puccinia recondita* Erikss.)					
I level of N fertlization					
1.	untreated	12.55 b		3.88 b	
2.	conventional programme	6.96 a	44	2.73 b	30
3.	integrated programme I	2.12 a	83	1.13 a	71
4.	integrated programme II	4.78 a	62	1.92 a	51
II level of N fertilization					
1.	untreated	18.38 b		5.17 b	
2.	conventional programme	12.20 b	34	3.89 a	25
3.	integrated programme I	7.05 a	62	2.24 a	57
4.	integrated programme II	10.07 a	45	3.00 a	42
LEAF BLOTCH [*Septoria tritici* Rob. ex Desm., *Stagonospora nodorum* (Berk.)] Castellani et Germano					
I level of N fertlization					
1.	untreated	6.14 b		11.64 b	
2.	conventional programme	4.77 b	22	5.50 a	18
3.	integrated programme I	1.99 a	67	3.01 a	74
4.	integrated programme II	2.76 a	55	4.25 a	63
II level of N fertilization					
1.	untreated	8.73 b		20.35 b	
2.	conventional programme	5.90 a	32	16.05 a	21
3.	integrated programme I	2.41 a	73	7.20 a	65
4.	integrated programme II	3.35 a	61	12.18 a	40
POWDERY MILDEW (*Erysiphe graminis* DC.)					
I level of N fertlization					
1.	untreated	2.52 b		4.38 b	
2.	conventional programme	1.09 a	57	2.96 a	32
3.	integrated programme I	0.50 a	80	1.44 a	67
4.	integrated programme II	0.97 a	62	2.12 a	51
II level of N fertilization					
1.	untreated	2.35 b		5.95 b	
2.	conventional programme	1.71 a	27	3.76 b	36
3.	integrated programme I	0.94 a	60	1.89 a	68
4.	integrated programme II	1.50 a	36	2.58 a	57

Note: – see table 9

entomofauna the most frequently species of *Aphididae* family occurred on Tercja cultivar.

The course of atmospheric conditions was not favourable for early and fast development of noxious and beneficial entomofauna. 4 July torrent rain took place

Table 12. Occurrence and effectiveness of control of ear diseases in various programmes of winter wheat protection – 3 July 2002

No.	Objects of experiments	Average per cent of			
		infected surface of leaf L1	% effectiveness	infected surface of leaf L1	% effectiveness
		Elena cultivar		Tercja cultivar	
	GLUME BLOTCH (*Stagonospora nodorum* (Berk.) Castellani et Germano)				
	I level of N fertlization				
1.	untreated	3.29 b		3.63 b	
2.	conventional programme	1.34 a	59	2.03 a	44
3.	integrated programme I	0.89 a	73	0.84 a	77
4.	integrated programme II	1.22 a	63	1.63 a	55
	LSD (0.01)	1.346			
	II level of N fertilization				
1.	untreated	2.63 b		2.72 b	
2.	conventional programme	1.06 a	60	1.94 a	29
3.	integrated programme I	0.54 a	79	0.67 a	75
4.	integrated programme II	0.81 a	69	1.62 a	40
	LSD (0.01)	1.534	2.089		
	SOOTY MOULDS (*Alternaria* spp., *Cladosporium* spp.)				
	I level of N fertlization				
1.	untreated	1.73 b		1.72 a	
2.	conventional programme	1.26 ab	27	1.47 a	15
3.	integrated programme I	0.79 ab	54	1.09 a	37
4.	integrated programme II	0.90 a	48	1.64 a	5
	LSD (0.01)	0.865	0.840		
	II level of N fertilization				
1.	untreated	1.09 a		1.44 b	
2.	conventional programme	0.92 a	16	0.74 a	49
3.	integrated programme I	0.71 a	35	0.62 a	57
4.	integrated programme II	1.00 a	8	0.99 ab	31
	LSD (0.01)	0.560		0.516	

Note: – see table 9

(49.1 mm) considerably affecting the decrease of feeding of leaf beetle larvae, aphids and other insects.

For the control of leaf beetle larvae and aphids in traditional programme and integrated program I Karate 25 WG was applied, whereas in integrated programme II Dimilin 25 WP of high selectivity for beneficial entomofauna was used. Effectiveness of Karate 25 WG in leaf beetles and aphid control amounted to 100%. Effectiveness of Dimilin 25 WP in leaf beetle control was limited, and this product was not effective in aphid control.

Results of entomological analysis of catchings performed a week after insecticide application demonstrated, that on both levels of fertilization the decrease of nox-

Table 13. Number of noxious and beneficial entomofauna collected in 15 catchings between 6 May and 17 July 2002

No.	Insects	ELENA (I – N)				ELENA (II – N)				TERCJA (I – N)				TERCJA (II – N)			
		Number of entomofauna representatives in the programmes of protection															
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.	*Thysanoptera*	177	202	188	166	289	290	203	225	298	196	327	304	411	469	394	323
2.	*Agromizidae*	133	128	108	97	140	154	150	123	152	108	90	122	138	110	103	130
3.	*Anthomyiidae*	41	31	55	53	46	54	43	44	48	60	74	73	52	68	68	78
4.	*Oscinella frit* L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.	*Chlorops pumilionis* Bjerk.	17	5	9	11	16	11	8	14	5	9	7	4	5	10	13	6
6.	*Aelia acuminata* L.	0	1	2	0	12	1	3	4	3	1	1	1	3	0	1	3
7.	*Notostira erratica* L.	21	29	32	31	30	24	32	26	26	15	27	31	23	27	14	33
8.	*Lema melanopa* L.	1	8	11	6	4	9	4	5	10	10	11	8	9	9	8	16
9.	*Lema cyanella* Voet.	2	1	1	4	2	1	0	3	3	1	5	1	2	3	1	4
10.	*Cephus pygmaeus* L.	0	1	0	0	1	0	0	0	0	0	0	0	3	0	0	0
	Total number of noxious entomofauna	392	406	406	368	549	544	443	444	545	400	542	544	649	696	602	593
11.	*Staphylinidae*	1	2	2	1	1	1	0	1	1	0	0	3	0	0	4	0
12.	*Cantharis* sp.	7	1	8	1	4	4	5	6	3	6	1	5	6	2	1	5
13.	*Ichneumonidae*	2	1	2	1	2	2	3	0	0	1	1	0	2	1	2	4
14.	*Braconidae*	6	6	4	5	3	8	1	2	4	1	3	5	3	4	5	1
15.	*Aphidiidae*	10	17	27	14	8	5	10	10	18	15	26	17	26	28	18	21
16.	*Telenomus* sp.	7	5	5	5	4	3	10	8	0	1	3	0	1	1	3	2
17.	*Syrphidae*	4	0	0	1	5	2	0	0	1	6	1	0	7	0	6	0
18.	*Coccinellidae*	0	1	0	0	4	1	2	2	3	2	5	3	2	2	4	0
19.	*Chrysopa* sp.	0	0	0	0	0	1	0	0	4	0	0	1	0	0	1	1
	Total number of beneficial entomofauna	37	33	48	28	31	27	31	29	34	32	40	34	47	38	44	34

Cultivar and level of nitrogen fertilization

Noxious insects: 1–10
Beneficial insects: 11–19

Objects: 1. untreated
2. traditional programme
3. integrated programme I
4. integrated programme II

ious entomofauna population in integrated programme I was insignificant. In both objects of Tercja cultivar and programmes of wheat protection total pest number was higher, but number of insects was higher on higher level of fertilization. Beneficial entomofauna occurred in trace amounts in all experimental objects.

In further two catchings performed two and three weeks after insecticide application considerable decrease of noxious entomofauna population was stated as well as sporadic occurrence of beneficial species. No differences in pest numbers were stated between the programmes of wheat protection.

Yield of wheat grain and calculated economic profit are presented in tables 14, 15 and 16.

Table 14. Grain yield of two winter wheat cultivars in 2000

Experiments	Grain yield t/ha	Increase as compared to untreated objects		Economic profit PLN/ha
		t/ha	%	
ELENA cultivar				
I level of N fertilization				
untreated	5.54 a	–	100.0	
conventional programme	6.46 bc	0.92	116.6	175
integrated pest management	6.99 c	1.45	126.2	165
II level of N fertilization				
untreated	6.03 ab	–	100.0	
conventional programme	7.28 c	1.25	120.7	240
integrated pest management	7.72 c	1.69	128.0	185
LSD (0.01)	0.487			
TERCJA cultivar				
I level of N fertilization				
untreated	6.01 a	–	100.0	
conventional programme	7.20 b	1.19	119.8	310
integrated pest management	7.61 bc	1.60	126.6	240
II level of N fertilization				
untreated	6.50 a	–	100.0	
conventional programme	8.02 b	1.52	123.4	375
integrated pest management	8.44 bc	1.94	129.8	310
LSD (0.01)	0.250			

Note: – see table 9

Table 15. Grain yield of two winter wheat cultivars in 2001

Experiments	Grain yield t/ha	Increase as compared to untreated objects		Economic profit PLN/ha
		t/ha	%	
ELENA cultivar				
I level of N fertilization				
untreated	5.85 a	–	100.0	
conventional programme	7.71 d	1.82	131.8	762
integrated pest management I	8.12 d	2.27	138.8	712
integrated pest management II	7.21 c	1.36	123.2	296
II level of N fertilization				
untreated	6.45 b	–	100.0	
conventional programme	8.63 e	2.18	133.8	858
integrated pest management I	9.06 e	2.61	140.5	796
integrated pest management II	8.03 d	1.58	124.5	308
LSD (0.01)	0.412			

TERCJA cultivar				
I level of N fertilization				
untreated	6.06 a	–	100.0	
conventional programme	7.65 c	1.59	126.2	624
integrated pest management I	8.07 c	2.05	133.2	580
integrated pest management II	7.77 b	1.71	128.2	506
II level of N fertilization				
untreated	6.49 a	–	100.0	
conventional programme	8.50 d	2.01	131.0	756
integrated pest management I	8.79 d	2.30	135.4	610
integrated pest management II	8.34 c	1.85	128.5	470
LSD (0.01)	0.253			

Note: – see table 9

Table 16. Grain yield of two winter wheat cultivars in 2002

ELENA cultivar				
Experiments	Grain yield t/ha	Increase as compared to untreated objects		Economic profit PLN/ha
		t/ha	%	
I level of N fertilization				
untreated	6.33 a	–	100.0	
conventional programme	8.11 c	1.78	128.1	738
integrated pest management I	8.59 e	2.26	135.7	776
integrated pest management II	8.29 d	1.96	131.0	656
II level of N fertilization				
untreated	6.57 b	–	100.0	
conventional programme	8.34 c	1.77	127.0	612
integrated pest management I	9.12 e	2.55	138.8	830
integrated pest management II	8.50 d	1.93	129.4	518
LSD (0.01)	0.371			
TERCJA cultivar				
I level of N fertilization				
untreated	6.59 a	–	100.0	
conventional programme	8.38 c	1.79	127.2	744
integrated pest management I	8.97 d	2.38	136.1	848
integrated pest management II	8.60 d	2.01	130.5	686
II level of N fertilization				
untreated	6.80 b	–	100.0	
conventional programme	8.47 c	1.67	124.5	552
integrated pest management I	9.29 d	2.49	136.7	794
integrated pest management II	8.88 d	2.08	130.6	608
LSD (0.01)	0.383			

Note: – see table 9

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

Economic analysis was performed according to the following calculation:

	2000	2001 and 2002
Price of 1 ton of wheat	500 PLN	600 PLN
Prices of:	PLN/ha	PLN/ha
– fungicides:		
* Alert 375 SC	80	95
* Archer 425 EC	80	90
* Amistar 250 SC	180	210
– insecticides:		
* Karate 25 WG	20	25
* Dimilin 25 WP	80	95
Cost of treatment	35	40
Cost of two rates of nitrogen	100	120

In three-year cycle of research repeatability of pest and disease control was confirmed indicating generally higher yield of wheat cultivar Tercja. In the case of both cultivars the second rate of nitrogen resulted in yield increase and better filling of grain. Yield of wheat grain was the lowest in 2000, and the highest in 2002. Low wheat yield in 2000 was caused by unfavourable weather conditions, mainly the lack of rainfall in May and June, causing too early drying of upper leaves and perturbations in grain formation. The lowest economic profit resulting from wheat protection was also noted in 2000.

In traditional programme of wheat protection with Elena and Tercja cultivars on two levels of nitrogen fertilization the higher economic profit was obtained in 2000 as compared to integrated programme. Such effect resulted from the price of Amistar 250 SC applied for third treatment. Sudden and unexpected change of moisture conditions causing yellowing and drying of leaves as well as reduction of disease development shortly after treatment could suggest, that this treatment was unjustified.

Comparing the effectiveness of three programmes of protection in 2001 and 2002 it can be stated, that the highest economic profit was obtained in integrated programme I. On Elena cultivar it was comparable in both years, and on two levels of nitrogen fertilization. Effectiveness of integrated programme I on Tercja cultivar was higher in 2002 (mainly in I level of fertilization). The cost of second application rate of Norway salpetre was high (120 PLN/ha), this caused the decrease of profitability.

In 2001 traditional protection gave better economic effects as compared to integrated programme II (extensive). Such results were affected by epidemic development of diseases, and their earlier control was justified. In 2002 economic profit of these programmes was similar and comparable.

DISCUSSION

Field experiments carried out in 1999–2002 differed in particular seasons taking into consideration both the appearance of fungal diseases and pests, and differentiated agrophage occurrence. Weather conditions, mainly timing of rainfall, considerably affected the development of diseases and pests, as well as the occurrence of entomofauna. Significant effect of lack or excess of soil moisture was stated in the case of eyespot disease.

Distinct example of the effect of lack of moisture on stimulation of pathogen development were the results of experiments carried out in 2000. Occurring in early spring low stem infection by *P. herpotrichoides* as well as lack of stem infection by *Fusarium spp.* in the end of April suggested, that both wheat cultivars were not threatened by these pathogens. It was observed in July, that maturating stems were strongly infected by *P. herpotrichoides*. The lack of water in the soil negatively influenced healthiness.

A factor favouring the development of pathogenic fungi on stem bases was also poor health status of plants due to the lack of moisture in the soil in June and in first decade of July 2001. Intensive mixed infection caused by the fungi *P. herpotrichoides* and *Fusarium spp.* occurred. These pathogens in both seasons occurred on both wheat cultivars, but more intensively on Elena cultivar.

The results obtained show, that undertaking the decision on treatment against stem base diseases, which first of all should be taken under consideration, are thresholds of harmfulness for these diseases, and this can be considerably changed by unfavourable weather conditions during the vegetation season. It was concluded, that a proper place for wheat growing and a proper agricultural treatments were the factors of secondary importance. Summarizing the mentioned above statements, we can suggest, that one of elements of integrated protection of winter wheat is chemical treatment against stem base diseases. At the time of spraying this treatment may be of prophylactic character, because its justification cannot be predicted in the phase of first node.

The lack of rainfall in May and June can also affect the programme of wheat protection against diseases. Such situation took place in the first year of research. Despite existing threat of flag leaf healthiness and weather forecasts favourable for the occurrence of diseases, the usefulness and profitability of third treatment were controversial. Disturbances in water balance after wheat earing caused the decrease of leaf turgor and their rapid drying, as well as the decrease of disease development on the leaves and ears.

Timing of rainfall during vegetation season was a factor affecting also the occurrence of entomofauna. The results of entomological analyses have demonstrated, that in conditions of rainfall deficit in 2000 the number of beneficial entomofauna was higher as compared to its number in 2001 season characterized by abundant rainfall. The proportions of development and number of noxious entomofauna in those years was opposite.

In 2001 a very intensive appearance of diseases was observed on flag leaves of Elena cultivar in the phase of water maturity of grain. In 2001 on Tercja cultivar very high number of leaf beetle larvae, and very high number of aphids on ears were observed. Differentiated intensity of infection by pathogen and pest occurrence on wheat resulted from their competitive development.

In 2002 vegetation season high intensity of stem base diseases and fast development of leaf pathogens were observed. The most frequently collected representatives of noxious entomofauna were thrips (*Thysanoptera*), and flies belonging to *Agromyzidae* and *Anthomyiidae* families. The occurrence of beneficial entomofauna between 6 May and 17 July 2002 was not numerous in any objects.

Predominating disease in all the years of research was brown rust (*Puccinia recondita* Erikss). Also the intensity of leaf blotch (*Septoria tritici* Rob. Ex Desm, *Septoria nodorum* Berk.) was high in the years 2001 and 2002. In conditions of intensive development of pathogenic fungi on leaves a significantly high susceptibility of Elena cultivar to brown rust and Septoria leaf blotch was stated. Tercja cultivar was also characterized by high susceptibility to leaf blotch as well as to powdery mildew (*Erysiphe graminis* DC). Nevertheless the intensity of latter disease in all the experiments was low. Tercja cultivar was characterized by higher susceptibility to the presence and feeding of leaf beetle larvae on wheat leaves on both levels of nitrogen fertilization. Such dependence resulted from generally better healthiness of Tercja cultivar.

The mentioned above results of research allow to state, that in the programme of winter wheat protection the cultivar is a very importat element of integration. The choice of wheat cultivar should be performed on the background of available information.

Winter wheat belongs to cereals of high yield potential. The most important factors affecting grain yield are: application terms of nitrogen fertilization and plant protection programme. High level of fertilization, and first of all late application rate were of a high importance not only for grain yield, but also for the architecture of field. The application of additional nitrogen rate "on the ear" in general caused the increase of size and better filling of grain, and also the improvement of its technological properties. The effect of nitrogen was similar in the case of both cultivars, but Elena cultivar reacted more intensively than Tercja cultivar. In the case of Elena cultivar late nitrogen fertilization caused mainly the increase of wet gluten content, and in lower degree content of raw protein.

Statistical analysis confirmed the opinions presented in the literature (Klupczyński 1993; Klupczyński and Ralcewicz 1998; Klockiewicz-Kamińska 2001), that the cultivar and fertilization significantly improved qualitative properies of grain (content of raw protein, wet gluten and flowability of gluten). Application of fungicides in some degree negatively influenced technological properties of grain. Both in the case of Elena cultivar, and Tercja cultivar, the best grain quality was obtained from untreated objects where only seed treatment and herbicides were applied. The application of fungicides irrespective of number of treatments and timing, caused the decrease of gluten and protein content. The only positive effect was, that after the application of fungicides, flowability of gluten was somewhat better, but these changes were not proved statistically. In the case of Tercja cultivar the reaction to the application of fungicides was more differentiated than in the case of Elena cultivar.

In integrated programme of wheat protection very important elements were systematic surveys of experiments. On the background of their results as well as expected development of agrophages the decision on the need of chemical treatments were undertaken.

Surveys of fixed points with labelled winter wheat plants allowed to determine the level of risk, in the cases when threshold of noxiousness for leaf beetle larvae and aphids was exceeded. Among numerously collected noxious entomofauna only leaf beetle larvae and *Agromyzidae* flies were really noxious in field conditions.

In all the years of research threshold of noxiousnes for leaf beetle larvae and aphids was most often similar, this allowed in two seasons (2000 and 2002) to control these pests at the same time in all programmes of winter wheat protection.

Karate 25 WG was characterized by very high effectiveness in controlling leaf beetle larvae and aphids. The application of Dimilin 25 WP in integrated programme was related to its specificity and selectivity for beneficial entomofauna. This insecticide was not effective in aphid control, but thanks to its selectivity, mainly for *Aphidiidae,* stimulated their development.

The application of modern generation of plant protection products of various mechanisms of action, application rates and proper timing, allowed to obtain high grain yield. Taking into consideration the fact, that prices of plant protection products in Poland are relatively high, economic aspect of performed programmes of wheat protection was in some cases unsatisfactory. As the example relatively lower economic profit obtained in 2000 in integrated programme can be indicated. Third treatment using very expensive Amistar 250 SC was not effective in conditions of sudden drying of leaves. It should be stressed, that fungicides applied in the experiments were the most expensive ones. In agricultural practice assuming that wheat will need full three-time protection, it can be suggested to choose a proper fungicide, taking into account its activity, effectiveness and the cost of application per hectare.

The performed research has demonstrated, that the application of integratred wheat protection against complex of agrophages is entirely possible. The implementation of integrated protection of winter wheat enables the effective use of plant protection products to decrease costs of production. This would also be conformable with the requirements of European Union (Górniak and Rothkaehl 1998).

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POLISH SUMMARY

KONWENCJONALNA A ZINTEGROWANA OCHRONA PSZENICY OZIMEJ PRZED CHOROBAMI GRZYBOWYMI I SZKODNIKAMI

Wykonane w latach 1999–2002 badania oraz uzyskane wyniki pozwalają na następujące podsumowanie:

– Podstawowymi czynnikami decydującymi o wysokości plonowania pszenicy ozimej są: optymalne nawożenie azotowe, dobór odmiany pszenicy ustalony w oparciu o znajomość warunków lokalnych oraz agrotechnika uwzględniająca odpowiedni wybór stanowiska.
– O potrzebie wykonania zabiegów ochronnych powinny decydować stałe lustracje plantacji z uwzględnieniem aktualnej sytuacji fitosanitarnej, progów ekonomicznej szkodliwości oraz spodziewanego rozwoju populacji agrofagów.
– Wprowadzenie niskotoksycznego środka owadobójczego pozwoliło na stałą obecność entomofauny pożytecznej na badanych poletkach.
– Zastosowany dobór środków ochrony roślin, dawki i terminy stosowania pozwoliły na uzyskanie wysokich plonów o bardzo dobrej jakości.
– Wykonane badania wykazały pełną możliwość stosowania integrowanego programu ochrony pszenicy ozimej przed zespołem agrofagów w warunkach polskich.

Book Reviews

Chen, Z.X., Chen, S.Y., Dickson, D.W. (eds.). 2004. Nematology – Advances and Perspectives. Volume I: Nematode Morphology, Physiology, and Ecology. Tsinghua University Press and CABI Publishing, Beijing and Wallingford, 636 pp., ISBN 0 85199 645 0.

Nematodes are one of the most abundant group in the animal kingdom, and four of five multicellular animals on the earth are nematodes. During the 20th century our knowledge of nematodes have developed in an unparalleled manner.

The development of nematology was largely attributed to the discovery of the importance of nematodes in agricultural ecosystems and their impact on society. But our knowledge of nematodes was developed not only on the reason of directly effect on agriculture and society. One of the most exciting and important new fields of nematology includes recent advances made in the use of *Caenorhabditis elegans* as model organism for basic biological studies. Research on the marine nematodes suggest that the secret of the natural history of our planet may lie in the nematodes dwelling deep in oceans.

The objective of this book is to summarize advances in nematology that have been made during 20th century and to provide perspectives for the development of nematology in the next century.

The book contains 12 chapters. The titles are the following: 1 – "A Century of Plant Nematology" by Kenneth R. Barker; 2 – "Perspectives on Nematology for the 21st Century" by John M. Webster; 3 – "Development Biology of Nematodes – What We Learn from *Caenorhabditis elegans*" by Marie-Anne Félix; 4 – "Nematode Morphology, Sensory Structure and Function" by James G. Baldwin and Rolland N. Perry; 5 – "Nematode Esophageal Glands and Plant Parasitism" by Richard S. Hussey and Eric L. Davies; 6 – "Surface Adhesion to Nematodes and its Consequence" by Allan F. Bird; 7 – "Nematode Behaviour and Migrations through Soil and Host Tissue' by A. Forest Robinson; 8 – "Background for Nematode Ecology in the 21st Century" by Gregor W. Yates and Brian Boag; 9 – "Marine Nematode Biodiversity" by P. John D. Lambshead; 10 – "Population Dynamics" by Robert McSorley and Larry W. Duncan; 11 – "Entomophilic Nematode Models for Studying Biodiversity and Cospeciation" by Robin M. Giblin-Davis, Kerrie A. Davis, Gary S. Taylor, and W. Kelley Thomas; 12 – "Cultivation of Nematodes" by Paul De Ley and Mannuel Mundo-Ocampo. The last part of the book is Index.

The information in each chapter is concisely presented and is up to date. In my opinion, the book is a good source of knowledge for all people interested more detailed in nematodes, and especially it will be an excellent source of inspiration for nematologists.

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Ferraz L.C., Brown D. 2002. An Introduction to Nematodes: Plant Nematology. Pensoft Publishers, Sofia–Moscow, 236 pp., ISBN 9546421553.

It is estimated that plant parasitic nematodes cause an annual global crop yield loss of about 10%. Therefore knowledge of these animals, and methods of their control, is important for plant protection.

The book is presented in the style of a short university course, as 11 lectures, which the authors suggest, can be adapted as appropriate to local circumstances by the individual Lecturer. The titles of the Lectures are: 1. Plant nematodes in modern agriculture; 2. Ectoparasitic nematodes of economic importance; 3. Endoparasitic nematodes of major economic importance: Root-knot and cyst nematodes; 4. Further endo- and semi-endoparasitic nematodes of economic importance; 5. Nematode parasites of aerial parts of plants; 6. Morphology and structure; 7. Reproduction; 8. Bio-ecology; 9. Parasitism of plants; 10. Control; 11. Taxonomy and classification. Two last parts of the book are Appendix and Index.

Obviously, the authors have had to make difficult decisions as to contents of their book. It was a subjective thing, but after reading the book the readers have a lot of new knowledge of nematodes. Therefore, in my opinion, the book is a good source of knowledge for all people interested in agricultural nematology, especially for students.

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