Effect of Seed Treatment and Foliar Protection with Fungicides on Health Status of Winter Wheat

Zuzanna SAWINSKA and Irena MAŁECKA

Department of Soil and Plant Cultivation, Agricultural University of Poznan, Poznań, Poland

Abstract

Sawinska Z., Malecka I. (2007): **Effect of seed treatment and foliar protection with fungicides on health status of winter wheat**. Plant Protect. Sci., **43**: 13–18.

The experiments were conducted in 2001–2003 at the Experimental Station in Złotniki of the Agricultural University of Poznan (Poland). The impact of different fungicidal protection programs on occurrence and incidence of fungal diseases on leaf and ear as well as of diseases on stem base and roots of winter wheat was determined. Infections on stem base and roots were mostly caused by *Fusarium* spp. and *Gaeumannomyces graminis.* Seed treatment with Latitude 125 FS reduced significantly take-all of winter wheat in comparison with the standard treatment (Raxil 060 FS). However, the seed treatments lowered only slightly the incidence of brown foot rot. The applied complex chemical protection program of winter wheat reduced successfully the infection of leaves and ears by fungal diseases.

Keywords: wheat; *Gaeumannomyces; Fusarium;* seed treatments; fungicides; protection

The increase of the acreage under cereal cultivation, in particular of winter wheat, in Poland in recent years creates favourable conditions for increased infection of this crop with fungal diseases which would negatively affect both quantity and quality of yields (Parylak & Kordas 2001; Jaczewska-Kalicka 2005). One of the important elements in the cultivation of cereals is a complex approach to limiting the occurrence of pathogens on roots, stem base, leaves and ears. The first step in this complex approach is seed dressing and, later on, spraying with appropriate fungicides during plant vegetation (Lipa 1999). Seed treatment with a proper formulation affects the initial development of plants which, in turn, will influence later stages of growth and development and, finally, yield levels (Dawson & Bateman 2000; Schoeny *et al.* 2001; Krzyzińska *et al.* 2004). The most difficult problem was to find a substance effective against *Gaeumannomyces graminis* (Sacc.) v. Arx et Olivier. Seed dressing formulations containing some triazole reduce the development of *G. graminis* only slightly and remain active only for a short time (Bockus 1983; Coventry *et al.* 1989; Smiley *et al.* 1990; Kurowski & Adamiak 2001). Fortunately, new seed dressings registered recently, Latitude 125 FS and Jockey 201 FS, filled this gap (Hornby 1998; Schoeny & Lucas 1999; Dawson & Bateman 2000; Schoeny *et al.* 2001).

The realisation of a protection program of winter wheat should focus on preventing high infection with diseases in the early stages of plant development and, by doing so, delay their occurrence until they are no longer very dangerous to crops (Everts & Leath 1993; Horoszkiewicz-Janka *et al.* 2005). Dahab and O'Callaghan (1997) maintain that only complex plant protection programs restrict the incidence of various pathogens and allow the achievement of high yields.

The aim of this paper was to evaluate the effectiveness of seed dressing products and fungicides in the control of fungal diseases of winter wheat in field trials.

MATERIAL AND METHODS

Location of field trials. The experiments were carried out at the Experimental Station at Złotniki on the basis of two-factorial trials in 2001–2003. The soil of the experimental fields is classified as Albic Luvisols developed on loamy sands overlying loamy materials. The winter wheat cv. Sakwa was sown in plots of 20 m^2 at a rate of 400 seeds/m^2 with row spacing of 12 cm. Fertiliser was applied at 26 kg P, 81 kg K and 120 kg N/ha. Herbicide was applied using standard farming methods.

Layouts and treatments. The trials were laid out as fully randomised complete blocks (4 blocks × 10 treatments). The experimental design comprised two types of seed dressing and five variants of foliar protection with fungicides (Tables 1 and 2). Untreated plots without fungicide application were included as a reference. Seeds were treated with Raxil 060 FS in one treatment and Raxil 060 FS + Latitude 125 FS in two independent, successive treatments. Foliar fungicides were applied using a boom plot sprayer delivering spray solution at 300 l per 1 ha. Details of the type and rates of fungicides are shown in Table 1.

Disease assessments. The level of infection was determined on 30 randomly removed plants per plot. Infection by stem base and root diseases was assessed at four growth stages (Zadoks *et al*. 1974): shooting (GS 31), beginning of heading (GS 51), beginning of milk maturity (GS 73) and full maturity (GS 92). This assessment included the characteristics of the spots, discoloration and necroses occurring on the bottom parts of stems and roots. For each of the diseases the percentage of plants with such symptoms, irrespective of their severity, as well as the infection index were calculated. The degree of infection with take-all was assessed on the roots of plants using the 5-grade scale based on CEB (Commission des Essais Biologiques de l'Association Nationale de Protection des Plantes) (Beale *et al*. 1998), while the severity of brown foot rot on the bases of the culm was judged according to the 3-degree scale (Windels & Wiersma 1992). Ten plants with disease symptoms were collected at random from each plot for mycological analysis. Their culm

Table 1. Characteristics of the fungicides

Trade name	Active ingredients (a.i.)	Formulation type	Rate of treatment
Seed treatments			
Latitude 125 FS	silthiofam (12.5%)	FS	200 ml/100 kg seed
Raxil 060 FS	tebuconazole (6.0%)	FS	60 ml/100 kg seed
Foliar treatments			
Sportak Alpha 380 EC	prochloraz (30.0%) + carbendazim (8.0%)	EC	1.5 l/ha
Vista 228 SE	fluquinconazole (5.4%) + prochloraz (17.4%)	SE	1.5 l/ha
Juwel 250 SC	kresoxim-methyl (12.5%) + epoxiconazole (12.5%)	SC	1.0 l/ha

Table 2. Foliar fungicide treatments

Treatment number	Fungicide application dates (growth stage)		
	treatment 1 (GS 31)	treatment 2 (GS 58–59)	treatment 3 (GS 73)
1	none	none	none
2	Sportak Alpha	none	none
3	none	Vista	none
4	Sportak Alpha	Vista	none
5	Sportak Alpha	Vista	Juwel

bases and roots were cut out and disinfected in a 0.5% solution of sodium hypochlorite for 1 min. After the adjoining parts of the bases had been cut off, six specimen of the tissue were cut out and placed on potato dextrose agar in Petri dishes. The species to which the obtained colonies of fungi belonged were determined according to available monographs. The mycological analyses were conducted at the Phytopathology Department of the Agricultural University of Poznan.

The biological effectiveness of the applied fungicides was estimated at the milk stage (GS 73–75) by determining the percentage of total leaf and ear area with disease symptoms using a graphic key for the determination of diseases developed by EPPO.

Statistical analyses. The results were subjected to statistical evaluation using the analysis of variance for factorial orthogonal experiments. The significance of differences was estimated with the Fisher-Snedecor's test at the level of significance $P = 0.05$, while significance of differences between means was assessed on the basis of the Tukey procedure. The analysis of variance of the results concerning the infection of the stem base, roots, leaves and ears was calculated after converting the values by the formula: $y = \arcsin \sqrt{x}$ ears in order to fulfil the assumptions of the analysis.

RESULTS AND DISCUSSION

The following pathogens were most frequently identified on plants of the experimental plots: *Gaeumannomyces graminis* and *Fusarium* spp. on stems and roots, *Mycosphaerella graminicola* (Fuck.) Schroet., *Pyrenophora tritici-repentis* (Died.) Drechsl., *Puccinia recondita* Rob. ex Desm. ssp. *tritici* (Erikss.) Johnson, *Blumeria graminis* DC. on leaves, and *Phaeosphaeria nodorum* (E. Muller) Hedjaroude on ears.

Effect of seed treatments on development of diseases of stem base and root. Both the percentage of plants with symptoms of take-all and the infection index were affected by seed treatment (Table 3). The severity of root diseases increased during development of plants from GS 31 to GS 92. With the standard treatment Raxil for seed dressing, the percentage of plants with infected roots ranged from 34.5% in early spring to 75.5% before harvest. In the variant treated with Raxil + Latitude, a significantly lower infection by *G. graminis* was observed at all dates of determination. During the shooting phase (GS 31) the percentage of infected plants was 11.9%, and increased to only 24.2% at the stage of full maturity. Similarly, the infection index at all dates of determination was significantly higher in the variants treated with Raxil than in those treated with Raxil + Latitude. The type of seed treatment had little effect on the infection of stems with brown foot rot (Table 3). The two preparations reduced the incidence of infection with this disease, but differences were confirmed statistically only for the last date of assessment at the stage of full maturity. At that time, both the percentage of stems with symptoms of this pathogen and infection index were significantly lower in the variant treated with Raxil + Latitude than in the one treated with Raxil alone. A similar decrease of infection by *G. graminis* following seed treatment with Latitude has been reported earlier

Table 3. The effect of seed treatments on stem base and root diseases of winter wheat at various growth stages (means of 2001–2003)

Pathogen	Growth stage	Percentage of affected stems		Infection index	
		Raxil	Raxil + Latitude	Raxil	Raxil + Latitude
Gaeumannomyces graminis	GS 31	34.5^{b}	11.9^{a}	7.4^{b}	0.6^{a}
	GS 51	46.9^{b}	16.3^{a}	15.8^{b}	1.5^{a}
	GS 73	56.5^{b}	19.4^{a}	22.1^{b}	2.3^{a}
	GS 92	75.5^{b}	24.2^{a}	56.4^{b}	4.0^{a}
Fusarium spp.	GS 51	22.9^{a}	21.3^{a}	42.7^{a}	40.4^{a}
	GS 73	41.7^{a}	42.0^{a}	95.9^{a}	90.9^{a}
	GS 92	52.9^{b}	48.6^{a}	125.5^{b}	110.5^{a}

[a,b]followed by the same letter are not significantly different at the level of significance $P = 0.05$

by Parylak and Kordas (2002) and Parylak (2004). Weber (2002) had also confirmed high effectiveness of Latitude seed treatment against *G. graminis* both on a production scale on farms and in strict field experiments. Beale *et al.* (1998) claim that the effectiveness of the Latitude 125 FS seed treatment depends, to a large extent, on the degree of infection of plants with *G. graminis*.

In the mycological analyses of instead of "invashing plant pasta" can be "the omfected stem base amd rots of winter wheat" more fungal isolates were obtained from plots treated with Raxil (44 isolates), than from plots with Raxil + Latitude (24 isolates) (Table 4). The dominant pathogenic fungi were *G. graminis* and *Fusarium* spp., of which *G. graminis* was isolated more frequently from plants treated with Raxil (34.2%) than from plants treated with Raxil + Latitude (16.7%).

Effect of seed dressing and fungicide treatments on development of brown foot rot. The analysis of variance revealed an interaction of the two experimental factors in the infection of winter wheat by *Fusarium* spp. (Table 5). It indicated a different effect of the variant with the foliar fungicidal protection within the applied seed dressing. In the variants sprayed only with Sportak Alpha, in those that were sprayed first with Sportak Alpha and then with Vista, and in the third set with an additional application of Juwel, a similar percentage of stems with symptoms of brown foot rot and a similar infection index were observed in the variants with either of the seed treatments Raxil and Raxil + Latitude. On the other hand, in both the variant without foliar fungicidal protection and the variant where Vista alone was used, seed treatment with Raxil + Latitude resulted in a lower

Table 4. Fungi isolated from infected stem base and roots of winter wheat (means of 2001–2003)

	Raxil		Raxil + Latitude	
	number of isolates	(%)	number of isolates	(%)
Acremonium charticola (Lindau) W. Gams	2	4.5	2	8.3
Acremonium strictum W. Gams	2	4.5	2	8.3
Alternaria alternaria (Fr.) Keissler	2	4.5	2	8.3
Fusarium avenaceum (Corda ex Fr.) Sacc.	4	9.1	2	8.3
Fusarium culmorum (W.G. Smith) Sacc.	4	9.1	2	8.3
Fusarium equiseti (Corda) Sacc.	3	6.8	2	8.3
Fusarium oxysporum Schlecht.	4	9.1	2	8.3
Gaeumannomyces graminis (Sacc.) Arx et Olivier	15	34.2	4	16.7
Microdochium nivale (Fr.) Samuels et Hallett	4	9.1	3	12.6
Rhizoctonia solani Kühn	4	9.1	3	12.6
Total	44	100	24	100

Table 5. Infection by brown foot rot at stage GS 92 of winter wheat depending on seed treatment and foliar protection (means of 2001–2003)

Foliar treatment	Percentage of affected stems		Infection index	
	Raxil	Raxil + Latitude	Raxil	Raxil + Latitude
Untreated	65.8^{Bc}	58.3^{Ac}	172.8^{Bc}	141.8^{Ac}
Sportak	48.5^{Aa}	45.0^{Aa}	105.0^{Aa}	96.3^{Aa}
Vista	58.6^{Bb}	51.1^{Ab}	138.5^{Bb}	106.8^{Ab}
Sportak + Vista	46.0^{Aa}	45.3^{Aa}	110.8^{Aa}	105.2^{Aab}
Sportak + Vista + Juwel	45.5^{Aa}	43.5^{Aa}	100.2^{Aa}	100.9^{Aa}

^{a,b,c,A,B}column followed by the same lowercase letter do not differ. Means within a row followed by the same uppercase letter do not differ at the level of significance $P = 0.05$

Table 6. The level of infection by leaf and ear diseases on winter wheat after foliar spray with fungicides, in percentage of total leaf area (means of 2001–2003)

Foliar treatment	Leaf below flag-leaf				Ear
	Blumeria graminis	*Pyrenophora tritici-repentis*	*Mycosphaerella graminicola*	*Puccinia recondita* ssp. *tritici*	*Phaeosphaeria nodorum*
Untreated	11.5^{C}	5.3^{C}	15.3^{C}	3.2^{C}	2.0^{C}
Sportak	4.2^{B}	2.6^{B}	8.7^{B}	1.7^{B}	1.0^{B}
Vista	3.7^{B}	2.9^{B}	10.3^{B}	1.5^{B}	1.0^{B}
Sportak + Vista	2.6^{A}	2.2^{A}	5.8^{A}	1.1^{A}	0.8^{A}
Sportak + Vista + Juwel	2.2^{A}	1.8^{A}	5.3^{A}	0.9^{A}	0.6^{A}

^{A,B,C}followed by the same letter are not significantly different at the level of significance $P = 0.05$

level of infection with brown root rot and in a lower infection index than treatment with Raxil alone. Moreover, spraying with fungicides may be ineffective for technical reasons if carried out at later stages of vegetation. Results indicating the effectiveness of some chemical agents in the control of some diseases of the stem base are published more and more frequently (Czajka *et al.* 2000; Różalski *et al.* 1997). The principles of good plant protection practice require that we should apply fungicides from different chemical groups in successive years. This does not allow the existing populations of the fungus to develop resistance to the active biological substances present in the most frequently applied chemical groups.

Effect of fungicide treatments on development of leaf and ear diseases. The incidence of diseases on leaves and ears of winter wheat ranged from trace amounts to over 15%. On the leaf below the flag-leaf we found a higher incidence of *M. graminicola* and *B. graminis* and a lower one of *P. tritici-repentis* and *P. recondita* ssp. *tritici* (Table 6). With intensified protection by foliar fungicides the infection of leaves and ears by the above pathogens was significantly reduced in comparison to the untreated control variant. Plots treated twice with Sportak Alpha (at GS 31) and Vista (at GS 58–59) or three times with the additional application of the Juwel (at GS 73) showed significantly less affected leaf and ear area than plots treated only once with Sportak Alpha (at GS 31) or Vista (at GS 58-59). In order to maintain the winter wheat crop in good health condition, it is necessary to protect it during the entire vegetation period as this maintains a larger green area of leaves which, in turn, maintains their photosynthetic activity and thus influences the yield of the crop. Numerous scientific publications mention fungicide application at the early stage of development in spring and during the early heading stage as classical elements of the control of diseases in winter cereals (Dahab & O'Callaghan 1997; Czajka *et al.* 2000; Dawson & Bateman 2000; Kurowski & Adamiak 2001). According to Dahab and O'Callaghan (1997), high yields can only be guaranteed by complex protection programs because only then is it possible to limit the occurrence of various pathogens. This principle was also confirmed by the results of the present study.

In conclusion, our experiments show that: (1) the occurrence of take-all disease of winter wheat was reduced by seed treatment with the mixture Raxil 060 FS + Latitude 125 FS; (2) the applied complex chemical protection program on winter wheat reduced successfully the infection of the stem base by *Fusarium* spp. and of leaves and ears by fungal diseases.

Acknowledgements. The authors thank Prof. S.C. Zbigniew Weber (Department of Phytopathology, University of Agriculture of Poznan, Poland) for the mycological analyses and valuable suggestions.

References

Beale R., Phillion D., Headrick J., O'Reilly P., Cox J. (1998): MON65500: A unique fungicide for the control of take-all in wheat. In: Brighton Crop Protection Conference – Pest & Diseases, No. 2: 343–350.

Bockus W. (1983): Effects of fall infection by *Gaeumannomyces graminis* var. *tritici* and seed treatment on severity of take-all in winter wheat. Phytopathology, **73**: 540–543.

Coventry D., Brooke H., Kollmorgen J., Ballinger D. (1989): Increases in wheat yield on limed soil after reduction of take-all by fungicide application and crop rotation. Australian Journal of Experimental Agriculture, **29**: 85-89.

Czajka W., Rogalski L., Kurowski T., Majchrzak B., Czajka M., Bruderek A. (2000): Zdrowotność pszenicy ozimej w zależności od sposobu chemicznej ochrony. Progress in Plant Protection/Postępy w Ochronie Roślin, **40**: 684–687.

Dahab M., O'Callaghan J. (1997): A simulation modelling approach to the management of spray treatments of fungal attacks on wheat. Journal of Agricultural Engineering Research, **66**: 287–293.

Dawson W., Bateman G. (2000): Sensitivity of fungi from cereal roots to fluquinconazole and their suppressiveness towards take-all on plants with or without fluquinconazole seed treatment in a controlled environment. Plant Pathology, **49**: 477–486.

Everts K., Leath S. (1993): Effect of triadimenol seed treatment and timing of foliar fungicide applications on onset and extent of powdery mildew and leaf rust epidemics. Phytopathology, **83**: 557–562.

Hornby D. (1998): Interactions between cereal husbandry and take-all: background for newer methods of controlling the disease. In: Brighton Crop Protection Conference – Pests & Diseases, No. 1: 67–76.

Horoszkiewicz-Janka J., Nieróbca A., Czembor H. J., Sikora H. (2005): Porażenie pszenicy ozimej przez grzyby chorobotwórcze w zależności od zastosowanej strategii ochrony. Progress in Plant Protection/Postępy w Ochronie Roślin, **45**: 708–710.

Jaczewska-Kalicka A. (2005): Straty plonu ziarna pszenicy ozimej powodowane przez choroby grzybowe. Progress in Plant Protection/Postępy w Ochronie Roślin, **45**: 722–724.

Krzyzińska B., Mączyńska A., Sikora H. (2004): Zwalczanie chorób grzybowych liści za pomocą zapraw nasiennych w uprawie jęczmienia jarego. Progress in Plant Protection/Postępy w Ochronie Roślin, **44**: 877–880.

Kurowski T., Adamiak E. (2001): Możliwość ograniczenia szkodliwego oddziaływania monokultury na zdrowotność i plonowanie pszenicy ozimej przez stosowanie fungicydów. Progress in Plant Protection/Postępy w Ochronie Roślin, **41**: 755–757.

Lipa J. (1999): Nowoczesna ochrona zbóż. Pamiętnik Puławski, **114**: 241–257.

Parylak D. (2004): Possibilities of root and stem base diseases limitation in continuous wheat under conventional tillage and no-tillage system. Journal of Plant Protection Research, **44**: 141–146.

Parylak D., Kordas L. (2001): Wpływ czynników agrotechnicznych na porażenie pszenicy ozimej przez zgorzel podstawy źdźbła (*Gaeumannomyces graminis*). Progress in Plant Protection/Postępy w Ochronie Roślin, **41**: 762–765.

Parylak D., Kordas L. (2002): Efektywność zaprawy nasiennej Latitude 125 FS w ochronie pszenicy ozimej uprawianej po sobie. Progress in Plant Protection/Postępy w Ochronie Roślin, **42**: 844–846.

Różalski K., Pudełko J., Pełczyński W. (1997): Wpływ wybranych czynników agrotechnicznych na występowanie chorób w pszenicy ozimej. Progress in Plant Protection/Postępy w Ochronie Roślin, **37**: 203–205.

Schoeny A., Lucas P. (1999): Modeling of take-all epidemics to evaluate the efficacy of new seed-treatment fungicide on wheat. Phytopathology, **89**: 954–961.

Schoeny A., Jeuffroy M., Lucas P. (2001): Influence of take-all epidemics on winter wheat yield formation and yield loss. Phytopathology, **91**: 694–701.

Smiley R., Wilkins D., Klepper E. (1990): Impact of fungicide seed treatment on rhizoctonia root rot, take-all, eyespot and growth of winter wheat. Plant Disease, **74**: 782–787.

Weber Z. (2002): Wpływ przedplonu i chemicznego zaprawiania ziarna na występowanie zgorzeli podstawy źdźbła pszenicy ozimej (*Gaeumannomyces graminis* var. *tritici*). Acta Agrobotany, **55**(1): 359–365.

Windels C., Wiersma J. (1992): Incidence of *Bipolaris* and *Fusarium* on subcrown internodes of spring barley and wheat grown in continuous conservation tillage. Phytopathology, **882**: 699–705.

Zadoks J., Chang T., Konzak C. (1974): A decimal code for the growth stages of cereals. Weed Research, **14**: 415–421.

Received for publication November 27, 2006
Accepted after corrections March 19, 2007

Corresponding author:

Dr. hab. Irena Małecka, Department of Soil and Plant Cultivation, Agricultural University of Poznań, Mazowiecka 45/46, 60-623 Poznań, Poland
Tel.: + 48 61 848 74 15, fax: + 48 61 848 73 98, e-mail: malecka@au.poznan.pl