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THE EFFECT OF SOIL TILLAGE SYSTEM ON INFECTION OF STEM BASES OF WINTER WHEAT BY *FUSARIUM* SPP.

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Abstract

The health of winter wheat grown in conventional and reduced tillage systems (direct sowing, post-harvest and pre-sowing cultivator, pre-sowing cultivator), as well as after direct drilling of seed, was studied at Swojec Agricultural Experimental Station, near Wrocław, in 2003–2006. Two doses of nitrogen fertilizer were also compared, including 120 kg/ha (1N) and 180 kg/ha (2N). The winter wheat was grown after winter wheat, as part of the three-year rotation: winter oilseed rape – winter wheat – winter wheat. The higher nitrogen dose favoured infection of wheat shoots by pathogenic fungi. In 2004 and 2005, the smallest amounts of disease were observed, respectively, in: (i) reduced tillage, with no post-harvest cultivation, with cultivation reduced to the pre-planting seed-bed preparation by cultivator and (ii) traditional cultivation. In 2006 there was no significant difference between treatments in intensity of disease. Therefore the results do not allow conclusions to be made on the precise effects of tillage and fertilizer treatments on occurrence of the stem base disease of the winter wheat.

Key words: winter wheat, stem base, *Fusarium* spp., healthiness

Introduction

The soil tillage system is one of the agronomic factors affecting the health and grain yield of winter wheat. An increased interest in reduced tillage and direct drilling of seed of winter wheat has been observed recently. These practices shorten the time necessary for seed-bed preparation, making earlier sowing of wheat possible, reducing soil erosion, and decreasing the cost of production by about 30% or even 50% if shallow ploughing rather than deep ploughing is used (Miętkiewicz et al. 1989).

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A reduced tillage system includes shallow ploughing or other shallow treatment such as seed-bed preparation by cultivator, instead of deep ploughing. The cultivator scarifies the soil by moving, loosening and mixing a 5–20 cm deep layer, without the inversion achieved by ploughing. Direct drilling involves sowing the grain into untilled soil (Kordas 1999). Despite the positive aspects of the reduced tillage systems, an increased occurrence and higher intensity of diseases, particularly of stem base diseases caused by *Fusarium* species, has been observed. This develops from post-harvest residues of the previous crop, an absence of inversion by ploughing which can break the life cycle of pathogens, and an increased infestation by weeds (Bischoff 2002).

The objective of these studies was to evaluate the effects of different methods of cultivation (traditional, reduced to seed-bed preparation by cultivator, and direct drilling) and different amounts of nitrogen fertilizer on the degree of infection of winter wheat by *Fusarium* pathogens responsible for root and stem base disease.

Materials and methods

Studies were carried out at Swojec Agricultural Experimental Station, near Wrocław, in 2003–2006. Field experiments were established in 60 m^2 (15 × 4 m) plots arranged in four randomized replicate blocks, on river alluvial soil developed from sandy clay. Winter wheat cultivar 'Mewa' was grown after wheat, in the rotation: winter oilseed rape – winter wheat – winter wheat.

Four methods of soil tillage were compared, including traditional cultivation (1), cultivation reduced to after-harvest and pre-sowing seed-bed preparation by cultivator (2), cultivation reduced to pre-sowing seed-bed preparation by cultivator (3), and direct drilling with no cultivation (4), and two amounts of nitrogen fertilizer, including 120 kg/ha (1N) and 180 kg/ha (2N). A detailed description of the experiment is included in Kordas (2007).

All experimental plots were fertilized with the triple superphosphate (40 kg of P_2O_5 per 1 ha) and potassium salt (60 kg K_2O per 1 ha) before sowing. The first dose of nitrogen fertilizer, in form of 34% ammonium nitrate was applied at 50 kg N per 1 ha (1N) or 70 kg N per 1 ha (2N) after growth started in spring, at the beginning tillering. It was followed by treatment with herbicides, e.g. Izotron 500 SC and Chwastox Turbo 340 SL. The second dose of nitrogen fertilizer in form of 46% urea was applied in dose of 70 kg N per 1 ha (1N) or 110 kg N per 1 ha (2N) at the end of the tillering phase.

Winter wheat plants were collected for laboratory examination at the milk- and dough-ripe growth stages. 10 stems were collected from 10 places located along a diagonal transect of each plot. The extent of necrotic lesions (brown foot rot) on the stem base was scored using a 0–5 scale: 0 – healthy plants, 1 – stains, stripes and blackening on 1–5% of the stem base area, 2 – 6–10%, 3 – 11–25%, 4 – 26–75%, 5 – lesions covering the entire stem base. A disease index was calculated for each replicate using the formula:

$$Wp = \Sigma (P \cdot W) / n$$

where:

$\Sigma (P \cdot W)$ – a sum of the product of the number of plants in each score category (P) and the score value (W),

n – the number of plants assessed.

Conclusions were based on analysis of variance.

10 stems collected from each plot were used for mycological analysis which aimed at finding the agents of the stem base necrosis. A piece 5 cm long was cut from each stem base and surface sterilized for 1 min in sodium hypochlorite (0.5% available chlorine). After removing both ends, each piece was cut into 5-mm-long pieces, which were placed on cereals medium (Rose Bengal Lab-Agar™ BioCrop Polska Ltd) at six pieces per Petri dish. After incubation for 7–14 days at 25°C, the plates were examined microscopically. Subcultures were made on potato dextrose agar (PDA) slants for preservation of cultures. Sporulating fungi were identified on the basis of their morphology according to the available literature (Nelson et al. 1983).

Results

In all the study years 70–100% of winter wheat stem bases showed disease symptoms (brown foot rot). The intensity of disease was greatest in 2004 (Table 1). Higher nitrogen doses favoured infection of wheat stem bases by pathogenic fungi. In 2005 and 2006, the smallest number of the damaged stems was observed, respectively, in: (i) reduced tillage, with no post-harvest cultivation, with cultivation reduced to pre-planting seed-bed preparation by cultivator (3) and (ii) traditional cultivation (1) (Table 1). In 2006 there was no significant difference in intensity of disease among treatments. Therefore the results do not allow conclusions to be made on the precise effects of tillage treatments and fertilizer applications on the occurrence of stem base diseases of the winter wheat.

Fusarium species were major agents of the disease, regardless of the cultivation system applied. Their frequency was very high and in certain treatment combinations amounted 80% of the total number of the fungal isolates. *Fusarium avenaceum* was the most often identified species.

Discussion

Most of the winter wheat stem bases showed symptoms of disease in each year of the experiment (2004–2006). Disease is likely to have resulted mostly from growing wheat after wheat. The previous crop (wheat) favours the build-up of soil- and residue-borne pathogens which in favourable conditions multiply and infect plants growing in next cropping season. Pląskowska (1997) showed that a suitable

Table 1

Disease index (0–5 scale) on stem bases of wheat infected by *Fusarium* spp. grown in four methods of cultivation and two doses of nitrogen fertilizer

Nitrogen fertilization	Soil tillage	Years			Mean
		2003/04	2004/05	2005/06	
120 kg/ha	Traditional cultivation	3.46	1.58	3.07	2.70
	Cultivation reduced to post-harvest and pre-sowing seed-bed preparation by cultivator	3.11	2.24	2.38	2.57
	Cultivation reduced to pre-sowing seed-bed preparation by cultivator	2.60	2.22	2.22	2.35
	Direct drilling with no cultivation	3.08	2.36	2.96	2.80
180 kg/ha	Traditional cultivation	3.44	1.89	2.75	2.69
	Cultivation reduced to post-harvest and pre-sowing seed-bed preparation by cultivator	3.35	2.46	2.54	2.78
	Cultivation reduced to pre-sowing seed-bed preparation by cultivator	3.18	2.61	2.92	2.90
	Direct drilling with no cultivation	3.45	2.21	2.76	2.81
$LSD_{0.05}$		n.s.	0.43	n.s.	n.s.
Means for factors and years					
Nitrogen fertilization	120 kg/ha	3.06	2.10	2.66	2.61
	180 kg/ha	3.35	2.30	2.74	2.81
$LSD_{0.05}$		n.s.	n.s.	n.s.	0.14
Soil tillage	Traditional cultivation	3.45 a	1.73	2.98	2.72
	Cultivation reduced to post-harvest and pre-sowing seed-bed preparation by cultivator	3.23 a	2.35 a	2.46	2.68
	Cultivation reduced to pre-sowing seed-bed preparation by cultivator	2.89	2.41 a	2.57	2.62
	Direct drilling with no cultivation	3.27 a	2.29 a	2.86	2.80
$LSD_{0.05}$		0.29	0.27	n.s.	n.s.
Years		3.21	2.20	2.72	2.71
$LSD_{0.05}$			0.35		–

Values in columns followed by the same letter are not significantly different.
n.s. – no significant difference.

crop rotation and the appropriate previous crop are the best way to prevent the spread of stem base diseases in wheat.

The results of the study do not allow us to determine precisely the effect of the applied tillage systems on the occurrence of stem base diseases of winter wheat, what is peaceably with resumes of other authors. According to Truszkowska et al. (1980), traditional cultivation reduces the threat of eyespot disease. Schmit et al. (1999) showed that reduced cultivation, compared with conventional cultivation and direct drilling, greatly favours the fast degradation of post-harvest residues, followed by the improved plant health. Różalski et al. (1998) reported, however, on smaller infection of stems after direct drilling. According to Weber et al. (2001), traditional cultivation, compared with reduced cultivation, allows greater preservation of post-harvest crop residues. This effect depends on transfer of the residues deep into the soil during the first ploughing and their return to the soil surface after a second ploughing. The dormant forms and resting spores are able to survive and retain their propagating abilities in the conditions of steady temperature and moisture deep in the soil. The second ploughing transfers them to the soil surface where they find optimal conditions during growth of the new crop (Heyland 1988). The non-plough system leaves the post-harvest residues on the soil surface, where the continuous changes of temperature and moisture accelerate the process of decomposition of the organic matter, including the post-harvest residues colonized by pathogenic fungi.

The degree of stem base disease resulted not only from the cultivation system applied but also from the weather during the growing season. There was most *Fusarium* disease on stems in very dry year of 2003. This finding confirms observation of Łacicowa and Pięta (1998), who reported the domination of *Fusarium* species in wheat stem tissues after a very hot and dry summer. *Fusarium avenaceum* was the species most often identified, regardless of the cultivation system applied. Its frequency was very high and amounted even to 85% of the total number of *Fusarium* isolates found. Smiley et al. (1996) reported that a temperature of 10–25°C favours growth of *F. avenaceum*, and such temperatures prevailed between April and July in 2003–2006.

Różalski et al. (1998) claimed that the health of wheat stems depends on nitrogen fertilization. Results of their studies show that greater doses of nitrogen favour the infection of stems by *Fusarium* spp. In the study reported here, nitrogen dose did not affect the amount of stem base disease in each of 2003–2006 crops, although the average amounts of stem base disease from 2004–2006 are consistent with the observation of Różalski et al. (1998).

Conclusions

1. In the presented studies, reduced tillage applied to winter wheat grown as a second wheat crop did not affect the amount of stem base disease caused by *Fusarium* spp.

2. *Fusarium avenaceum* was the main fungus associated with stem base disease of winter wheat.

Streszczenie

WPŁYW SPOSOBU UPRAWY ROLI NA ZASIEDLENIE PODSTAWY ŹDŹBŁA PSZENICY OZIMEJ PRZEZ *FUSARIUM* SPP.

W latach 2003–2006 w Rolniczym Zakładzie Doświadczalnym Swojec koło Wrocławia badano zdrowotność pszenicy ozimej uprawianej tradycyjnie, w systemie uproszczonym (kultywator pożniwnie i przedsiewnie oraz kultywator przedsiewnie) i w siewie bezpośrednim. We wszystkich wymienionych wariantach stosowano dwa poziomy nawożenia azotem: 120 i 180 kg/ha. Pszenicę uprawiano po pszenicy ozimej, w zmianowaniu (rzepak ozimy – pszenica ozima – pszenica ozima).

Większa dawka nawożenia azotem sprzyjała zakażeniu źdźbeł przez grzyby. Na podstawie przeprowadzonych badań nie można jednoznacznie ocenić wpływu zastosowanych sposobów uprawy na stopień uszkodzenia źdźbeł. W pierwszym roku trwania doświadczenia najmniej uszkodzonych źdźbeł stwierdzono w uprawie uproszczonej, bez uprawy pożniwnej, po przedsiewnym zastosowaniu kultywatora. Z kolei w następnym roku najmniej chorowała pszenica uprawiana tradycyjnie. W trzecim roku badań nie stwierdzono istotnych różnic w porażeniu roślin uprawianych różnymi systemami.

Literature

Bischoff J., 2002: Weizen ohne Pflug. Neue Landwirtschaft 8: 26–28.

Heyland K., 1988: Pflügen oder Pfluglosarbeiten aus pflanzenbäulicher Sicht. Integr. Pflanzenbau-Bodenbearbeit. 3: 61–66.

Kordas L., 1999: Energochłonność i efektywność różnych systemów uprawy roli w zmianowaniu. Folia Univ. Agric. Stetin. 195, Agric. 74: 47–52.

Kordas L., 2007: Wpływ stosowania proekologicznych systemów uprawy roli pod pszenicę ozimą na zmiany w zachwaszczeniu łanu. Progr. Plant Prot. / Post. Ochr. Rośl. 47, 4: 158–161.

Łacicowa B., Pięta D., 1998: Wpływ temperatury i opadów na udział grzybów w powodowaniu chorób podsuszkowych jęczmienia jarego (*Hordeum vulgare* L.). Acta Agrobot. 51, 1–2: 51–61.

Miętkiewicz R., Sterczewski J., Kąkol E., 1989: Wpływ uproszczonych metod przedsiewnej uprawy roli na plon i zdrowotność żyta ozimego. Fragm. Agron. 4: 79–89.

Nelson P.E., Toussoun T.A., Marasas W.F.O., 1983: *Fusarium* species. An illustrated manual for identification. The Pennsylvania State University Press, University Park.

Pląskowska E., 1997: Effect of communities of soil fungi on the growth of some pathogens which cause foot-rot complex in wheat cultivated after different forecrops. Phytopathol. Pol. 13: 109–132.

Różalski K., Blacharczyk A., Skrzypczak G., Piechota T., 1998: Choroby podsuszkowe pszenicy ozimej uprawianej po różnych przedplonach w systemie siewu bezpośredniego. Post. Ochr. Rośl. 38, 2: 555–557.

Schmit W., Doil D., Nitzsche O., 1999: Erfährungen mit pflugloser Bestellung in Sachsen. Neue Landwirtschaft 5: 2–6.

Smiley R.W., Collins H.P., Rasmussen P.E., 1996: Disease of wheat in long-term agronomic experiments at Pendleton, Oregon. Plant Dis. 80: 813–820.
Truszkowska W., Dorenda M., Kita W., Kutrzeba M., 1980: Zgorzel podstawy źdźbła pszenicy powodowana przez Fusaria w świetle doświadczeń uprawowych. Rocz. Nauk Roln. Ser. E 10, 1–2: 103–117.
Weber R., Hryńczuk B., Runowska-Hryńczuk B., Kita W., 2001: Influence of the mode of tillage on diseases of culm base in some winter wheat varieties, oats and spring wheat. J. Phytopathol. 149: 185–188.

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