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EFFECTS OF TILLAGE METHODS ON THE OCCURRENCE OF CULM BASE DISEASE IN SEVERAL WINTER WHEAT CULTIVARS

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ABSTRACT

The 1999-2001 study investigated the effect of simplified tillage methods on culm base diseases in eight winter wheat cultivars as cereal crop rotations with a yearly cereal cultivation intermission. The disease intensity was more affected by the weather over the growing season than by the tillage methods applied. A decreased rainfall over flowering and draught in June and July of 2000 decreased infection and revealed no differences between the traditional method and direct sowing. However in 1999 and 2000 an intensified culm base occurrence was

recorded due to traditional soil cultivation and weather conditions were most responsible for differences in the number of fungi across the tillage methods. Wheat cultivars were most infected by *Fusarium* fungi, while *F. culmorum* and *F. equiseti* were most intensive whenever traditional land cultivation was applied, unlike ploughless tillage of 1999. In 2000, however, *F. culmorum* was more numerous when direct sowing was applied. The cultivars tested differed in the degree of infection with *Fusarium culmorum*, *F. equiseti* and *F. avenaceum.*

Key words: culm bade disease, winter wheat cultivars, simplified tillage methods

INTRODUCTION

In the future the participation of cereals in the crop structure will increase, reaching 65-70% where winter wheat, triticale, barley and maize will prevail. Intensified wheat cultivation, changed agricultural practices and crop rotation, as well high nitrogen fertilisation increase the occurrence of the fungal diseases. An increased cereal share in crop rotation makes *Fusarium* and *Pseudocercosporella herpotrichoides* [14] diseases more frequent. In general cereals make a bad forecrop for winter wheat, however, currently it is possible to grow cultivars tolerant to unfavourable phytosanitary conditions of soil [4]. Harasim [7] showed that high yielding was feasible due to 2-year intermission in wheat growing in the same field.

Many literary reports stress a favourable inhibitory effect of papilionaceous plants and rape on winter wheat culm base diseases [11,12,15,19]. Researching the effect of soil tillage on culm base disease occurrence gave no clear-cut results. Schmidt and Stahl [20] reported on less intensive culm base diseases due to ploughless tillage or direct sowing. Różalski et al.[19] found a considerable effect of zero-tillage only on a decrease in *Gaeumannomyces graminis* infection, while others found no significant effect of agricultural practices applied [1,3,5]. Varied plant infection with culm base diseases can be related to a conserving effect of plough tillage which introduces crop residues deep into soil. Equilibrated temperature and moisture in the lower soil layers constitutes favourable conditions for fungi spores. Subsequent ploughing brings the pathogens up onto the surface which in cereal crops find optimum conditions for development. Ploughless tillage leaves the crop residues on the surface or in the upper soil layer where they, together with pathogenic fungi, undergo a fast decay under a variable temperature and moisture [8].

Numerous reports emphasise also a significant impact of weather conditions on the development of culm base diseases in cereal crops. High-cereal-share crop rotations showed a considerable intensity of culm base disease. Decaying crop residues the fungi feed on also affect the composition of soil saprophytes which may produce wheat phytotoxins or growth stimulators. *Fusarium avenaceum, F. culmorum, Pseudocercosporella herpotrichoides, Rhizoctonia cerealis, Gaeumannomyces graminis, Drechslera sorokiniana* are most frequent pathogens [2,23,25]. Currently it is *Fusarium* and *Gaeumannomyces graminis* which are most frequent in cereal crops and inflict on pre- and post- emergence take-all, culm base rot and ear fusariosis in all climates [17], developing on varied plant material and often producing mycotoxins which infect an average of 20-30% of crops. *Fusarium* fungi show also a high adaptability to variable environmental conditions; *F. culmorum*, especially, can develop and sporulate under poor water potential [13,24]. The reaction of wheat cultivars to simplified tillage varies and is most seen in yielding. Under stress following ploughless tillage, infection with pathogenic fungi occurring on wheat cultivars varies more considerably, unlike under optimal tillage conditions.

The aim of the present study was to define the effect of varied soil tillage methods on the intensity of infection of culm base with pathogenic fungi in seven winter wheat cultivars.

MATERIAL AND METHODS

The increased area of wheat plantation on poorer soils made it justifiable to set up the present experiment on very good rye soil suitability complex as randomised blocks in four reps. The study was carried out in the fields of the Jelcz-Laskowice Land Cultivation Techniques Department of the Institute of Cultivation, Fertilisation and Soil Science over 1999-2001. The insignificant soil variability led to an application of multiple experiments to define the variability of infection in wheat cultivated under varied soil cultivation methods after one-year cereal farming intermission. The harvest area of a single plot covered 110 m^2. The following methods of soil tillage were applied:

1. Plough tillage
    a. 15 cm deep post-harvest grubber + roller
    b. 25 cm deep ploughing + harrow
    c. pre-sowing cultivation aggregate (cultivator + string roller), herbicides if required
2. Simplified tillage
    a. 15 cm deep post-harvest grubber + roller
    b. pre-sowing rotary harrow + string roller, herbicides if required
3. Direct sowing with 'Great Plains' sowing drill, weed control with herbicides

The following herbicides were applied: Lentipur, 2.0 $dm^3 \cdot ha^{-1}$, Chwastox + Lontrel, 3.5 + 0.8 $dm^3 \cdot ha^{-1}$. The experiment covered 'Elena', 'Kobra', 'Maltanka', 'Mikon', 'Izolda' and 'Sakwa' winter wheat cultivars. 'Zorza' was tested in 1999, while 'Aleta' in 2000 and 2001. The intensity of plant infection with culm base diseases was defined over the milky- and wax-maturity with a 5-degree scale on 100 randomly sampled main culms from each plot and broken into healthy, slightly and highly infected ones which, in the opinion of several authors, are responsible for a significant yield decrease.

Slightly infected plants (1, 2 and 3 degree of infection) were identified with single more or less extensive stripes or spots which did not appear all over the culm, unlike highly infected culms (4 and 5 degree of infection) where they were observed all over the culm base, or which destroyed the culm base completely. To analyse the composition of fungi, 10 infected plants were randomly sampled from each plot; the cut-out culm bases were disinfected in a 0.5% solution of sodium hypochlorite for 1 minute. Having cut off the edge sections of the bases, six inocula were cut out and placed on PDA; 14 days later fungal colonies were isolated and identified down to the species following the guidelines available.

The weather conditions over wheat vegetation periods are presented in Figs. 1 and 2.

Fig. 1. Mean rainfall over the wheat growing season

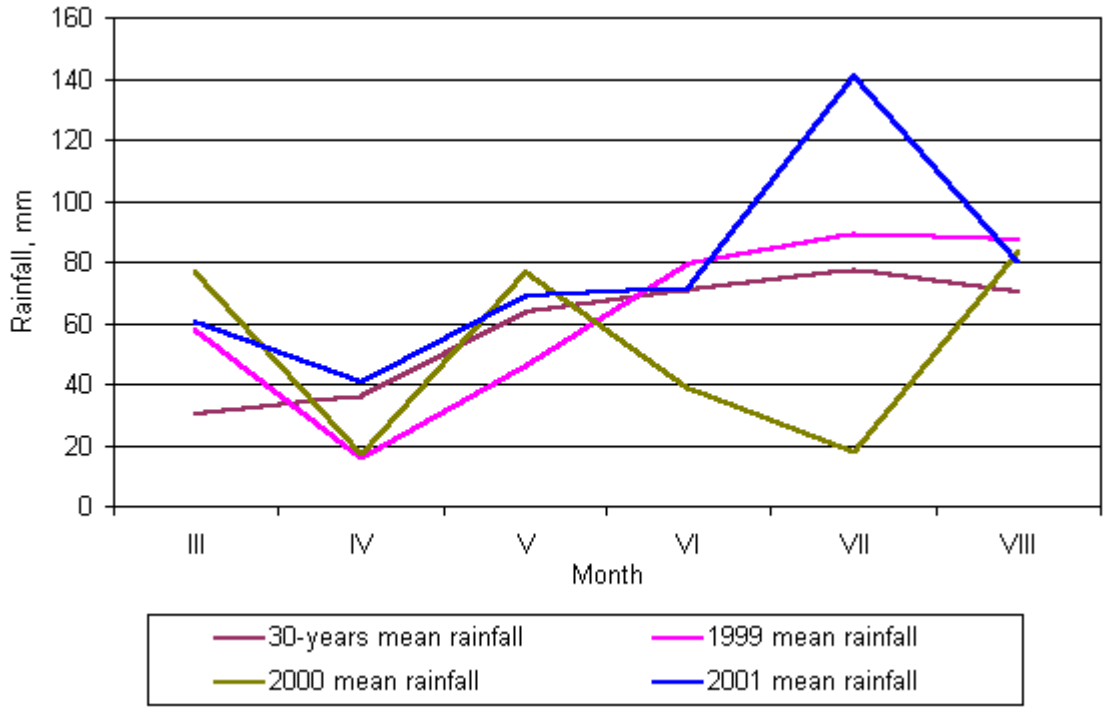
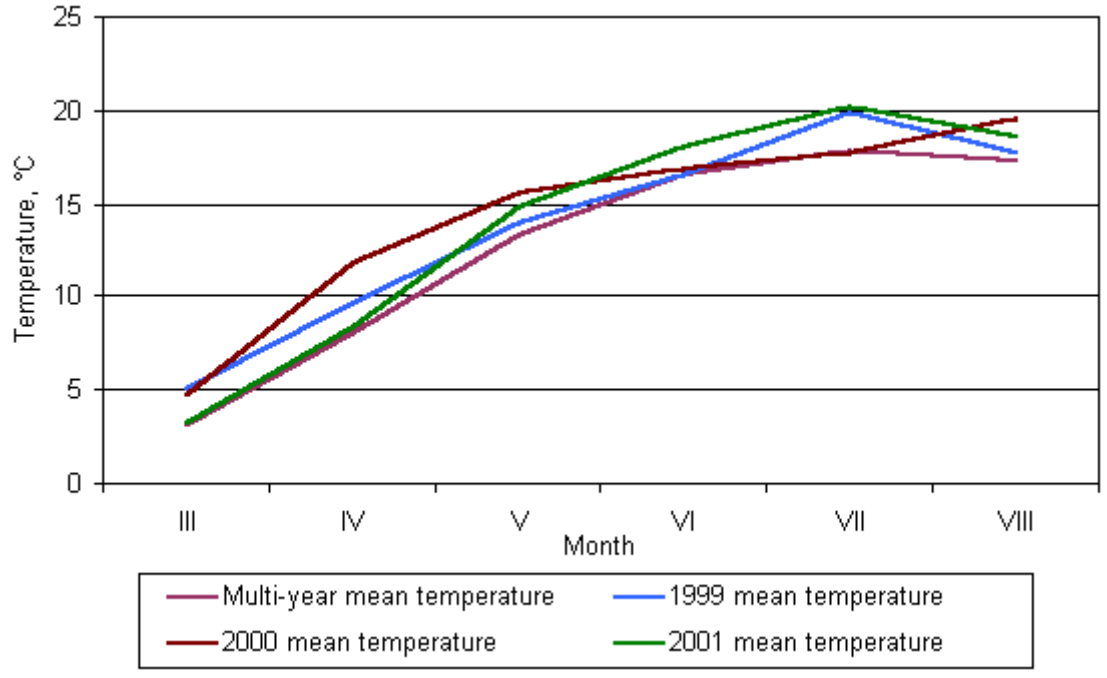


Fig. 2. Mean temperature over the wheat growing season

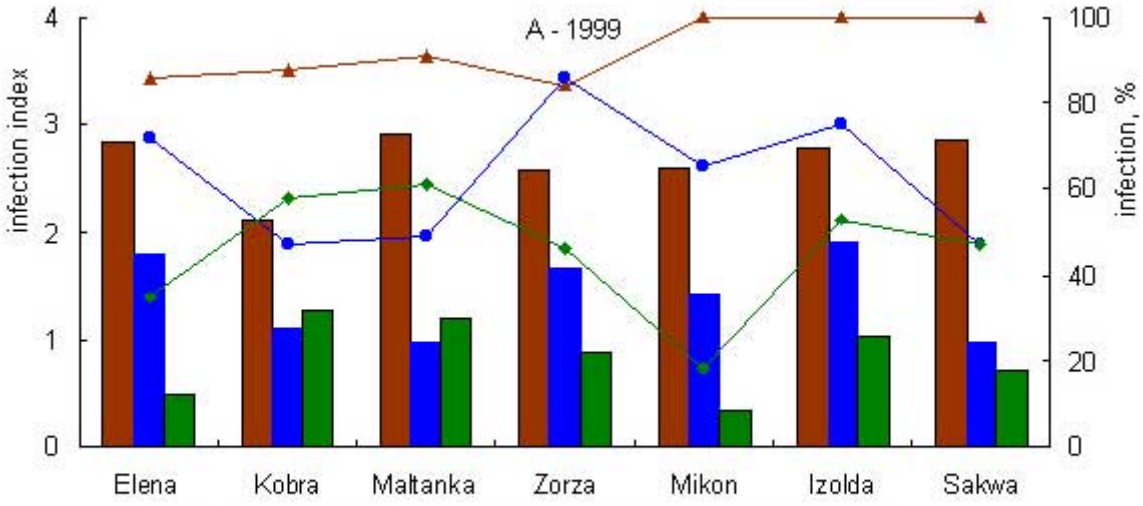


RESULTS AND DISCUSSION

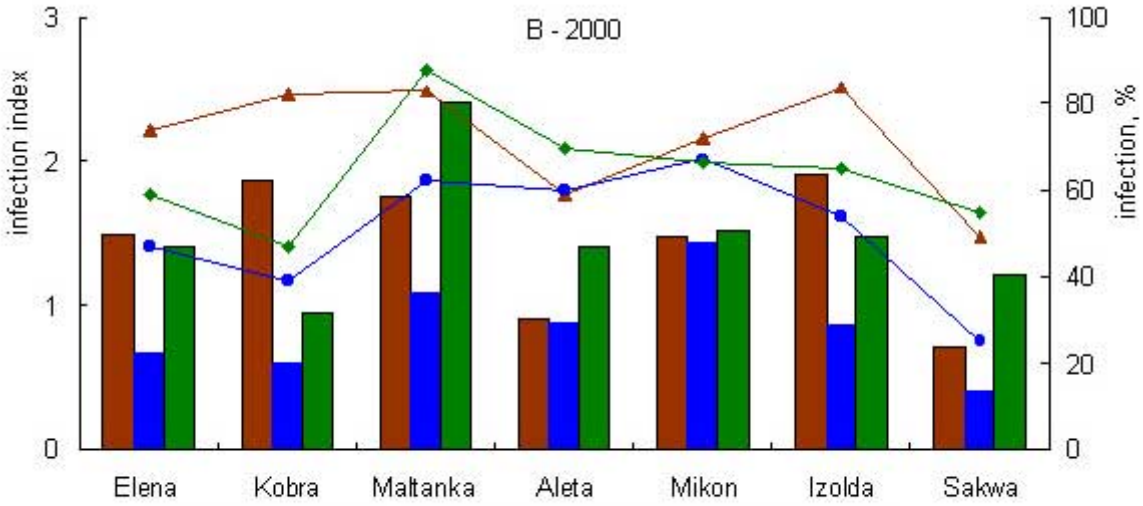
The variance analysis of the 1999-2001 revealed a significant effect of the tillage method on the wheat cultivars infection with culm base diseases. A higher percentage and infection index value were observed in traditional tillage in 1999 (Fig. 3 A), while direct sowing showed a lower intensity of culm base diseases and the values observed for ploughless tillage in 1999 scored between the two, similarly to those reported by Weber et al. [26]. Particularly high disease intensity due to plough tillage could have blurred the assumed differences due to a

lower sensitivity of some genotypes. Simplified tillage and direct sowing recorded significantly lower values for 'Sakwa'. 'Mikon' exposed to direct sowing resulted in the least, while exposed to simplified tillage – in a slightly higher infection. The highest susceptibility to the pathogens studied following ploughless tillage was found in 'Izolda' which when all the agricultural practices were given up showed also a higher infection index value and infection percentage. A high susceptibility of 'Maltanka' to culm base diseases following ploughing and direct sowing was not confirmed as a result of simplified tillage where the highest infection was observed in 'Izolda'. Differences in the degree of infection could have been due to an unequal distribution of crop residues in the upper soil layers.

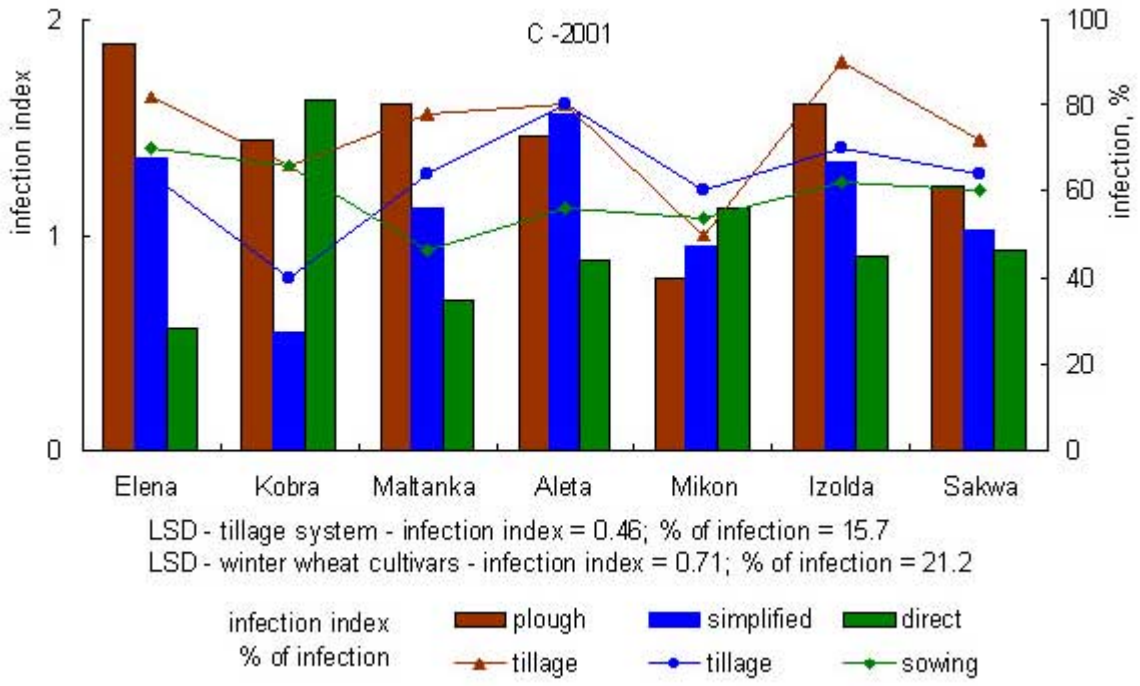
Fig. 3. Infection of winter wheat cultivars with culm base disease depending on the tillage system



LSD - tillage system - infection index = 0.49; % of infection = 17.4
LSD - winter wheat cultivars - infection index = 0.65; % of infection = 22.6



LSD - tillage system - infection index = 0.49; % of infection = 18.6
LSD - winter wheat cultivars - infection index = 0.88; % of infection = 32.8



The year 2000 recorded a high deficit of rainfall and high temperature in spring and by the end of the vegetation period; an intensifying drought inhibited the cereal development considerably. Low rainfall in April and rainless June and July decreased the infection of cereals with fungi. The infection was significantly lower following the simplified tillage (Fig. 3B). The other tillage methods brought about the differences in neither the infection index nor the percentage. 'Sakwa', similarly to the results of 1999, showed the significantly highest resistance to culm base diseases. High 'Izolda' infection index values due to ploughing and 'Maltanka' due to direct sowing confirm their highest susceptibility. Lower 'Maltanka' infection index values reported by other authors [9,10] can result from a different fungal species composition.

The weather conditions of 2001 were similar to those of the multi-year mean. July was the only one to observe considerably higher temperature and rainfall. A decreased weight of crop residues due to the temporary drought of 2000 affected considerably the wheat culm-base fungi composition. Direct sowing was noted to decrease the infection more significantly than traditional tillage (Fig. 3C), while the values of the infection index and percentage following simplified tillage scored between the two. 'Izolda' showed higher infection due to traditional and simplified tillage. 'Maltanka', particularly susceptible to culm base diseases, showed higher resistance following direct sowing, while 'Elena' - high susceptibility when exposed to ploughing and simplified tillage and higher resistance following direct sowing.

The results obtained do not offer a full understanding of the effect of soil tillage on the infection index and percentage, which could have been due to varied weather conditions and the changeable interaction between the genotype and the environment, as a result of varied agronomic practices, as well as irregular droughts over the wheat vegetation period. However, higher rainfall over the growing seasons of 1999 and 2001 coincided with a lower infection following direct sowing than traditional tillage, which confirms the conserving effect of plough tillage reported also by other authors [8,20].

Tables 1, 2, 3, 4, 5 and 6, including most frequent fungi only, relate the main cause of culm base diseases in the wheat cultivars tested to *Fusarium* fungi. In 1999 following traditional

tillage *Fusarium culmorum* and *F. equiseti* were most frequently isolated. A higher number of *F. culmorum* isolates identified in 'Kobra' due to 'zero' and simplified tillage must have been a result of a high susceptibility of the cultivar [26], which was also recorded by other authors who report on a high susceptibility of 'Kobra' and resistance of 'Sakwa' to fusariosis [27]. 'Mikon' showed no considerable differences in the infection with *F. equiseti* following any of the three tillage methods. The cross-cultivar variation in winter wheat resistance to fusariosis could account for different results reported by Łacicowa and Pięta [13], Sturz and Carter [21], Smijders and Perkowski [22]. The present research did not confirm the resistance of 'Aleta' to culm base diseases, which was found by Heyland [8]. The differences can also result from the genotypic variation of *Fusarium* fungi described by Quellet and Siefert [16] showed with the DNA analysis using the RAPD test. Culm bases were also highly infected by *Eppicoccum purpurascens* and *Alternaria alternata*, irrespective of the tillage method. A higher percentage of infection with *Rizoctonia solani* was also found in 'Maltanka' following both plough and traditional tillage.

Table 1. Percentage of fungal species in winter wheat cultivars depending on tillage method in 1999
Forecrop: rape after rye

Fungi	Cultivars								
	Elena			Kobra			Maltanka		
	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	20	10	23.3	13	13	12	13.3	13.3	20
Drechslera sorokiniana (Sacc.) Subram. et Jain	5	5	3.3	0	0	3.3	6.67	0	0
Epiccocum purpurascens Ehrenb. Schlecht	10	33	18.3	25	18	20	6.67	33.3	0
Fusarium culmorum W.G.Sm) Sacc	17	18	3.3	10	20	15	26.7	5	11.7
Fusarium equiseti (Corda) Sacc.	30	0	8.3	6.7	13	0	25	10	16.7
Fusarium avenaceum (Corda ex Fr.) Sacc	3.3	10	0	0	0	0	5	0	0
Rhizoctonia solani Kühn	0	3.3	3.3	6.7	3.3	0	11.7	10	1.67
Trichoderma hamatum (Bon.) Bain.	0	0	0	10	0	10	0	0	6.67
Trichoderma viridae Pers.ex S.F.Gray	0	0	0	0	5	0	0	0	0
Nigrospora oryzae (Berk.et. Br.) Petch.	5	6.7	0	0	6.7	8.3	1.67	10	0
Others	9.7	14	40.2	28.6	21	31.4	3.29	18.4	43.3

1. Plough tillage 2. Simplified tillage 3. Direct sowing

Table 2. Percentage of fungal species in winter wheat cultivars depending on tillage method in 1999
Forecrop: rape after rye

Fungi	Cultivars											
	Zorza			Mikon			Izolda			Sakwa		
	1	2	3	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	11.7	13.3	11.7	13.33	13.3	15.0	5.0	6.7	21.7	13.3	10.0	13.0
Drechslera sorokiniana (Sacc.) Subram. Et Jain	0	5.0	13.3	5.0	10.0	0	6.7	1.7	1.67	3.33	3.33	5.0
Epicoccum purpurascens Ehrenb. Schlecht	11.7	23.3	25.0	10.0	8.33	15.0	40.0	33.0	10.0	20.0	13.3	8.3
Fusarium avenaceum (Cora Fr.) Sacc.	0	0	0	0	0	0	0	0	0	11.7	0	5.0
Fusarium equiseti (Corda) Sacc.	20	11.7	8.33	8.33	6.67	5	8.3	0	0	0	13.3	5
Fusarium poae (Peck.) Wollenw.	0	5	0	0	0	0	0	0	6.67	5	5	0
Fusarium culmorum W.G.Sm) Sacc.	23.3	11.7	10	28.33	23.3	3.3	23	6.7	26.7	0	15	0
Rhizoctonia solani Kühn	5	0	0	0	0	0	0	0	0	1.67	5	10
Trichoderma koningii Oud.	0	6.67	0	0	0	0	0	0	0	0	0	0
Trichoderma hamatum (Bon.)Bain.	0	0	0	0	0	5	0	0	0	0	0	0
Trichoderma viridae Pers. Ex S.F.Gray	0	0	0	5	0	0	0	0	6.67	0	0	12
Nigrospora oryzae (Berk. Et Br.) Petch.	0	0	5	5	5	20	5	0	13.3	23.3	6.67	10
Others	28.3	23.3	26.7	25.0	33.3	36.7	12	51.9	13.3	21.7	28.4	31.7

1. Plough tillage 2. Simplified tillage 3. Direct sowing

Following the direct sowing of 2000 there was observed a higher intensity of *Fusarium culmorum* across cultivars than following the other tillage methods. *F. culmorum* was isolated more frequently from culm base of 'Maltanka' (Table 3), also highly infected in 1999. 'Sakwa', however, showed a higher resistance to *F. culmorum* (Table 4). *Fusarium*

avenaceum infected less considerably. A particularly high occurrence of *Rhizoctonia solani* was observed due to plough tillage, especially on 'Izolda' and less considerably – 'Elena'.

Table 3. Percentage of fungal species in winter wheat cultivars depending on tillage method in 2000
Forecrop: rape after rye

Fungi	Cultivars								
	Elena			Kobra			Maltanka		
	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	26.0	19.0	36.8	17.3	33.3	41.7	20.5	18.9	29.2
Drechslera sorokiniana (Sacc.) Subram. et Jain	0	0	0	2.67	1.52	2.08	0	0	0
Epiccocum purpurascens Ehrenb. Schlecht	116.4	16.67	7.89	0	0	9.38	14.10	15.09	4.49
Fusarium culmorum W.G.Sm) Sacc	0	16.67	25.00	5.33	18.18	27.08	5.13	33.96	38.20
Fusarium avenaceum (Corda Fr.) Sacc	31.5	21.4	0	2.67	0	6.25	6.41	3.77	0
Rhizoctonia solani Kühn	8.22	2.38	0	46.7	25.8	0	42.3	9.4	5.62
Arthrinium phaeospermum (Corda) M.B. Ellis	0	11.9	13.16	6.67	3.03	0	0	0	4.49
Others	17.8	11.9	16.7	18.7	18.2	13.6	11.5	18.9	18.0

1. Plough tillage 2. Simplified tillage 3. Direct sowing

Table 4. Percentage of fungal species in winter wheat cultivars depending on tillage method in 2000
Forecrop: rape after rye

Fungi	Cultivars											
	Aleta			Mikon			Izolda			Sakwa		
	1	2	3	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	7.35	25.5	30.6	22.0	31.0	37.3	12.9	21.9	25.3	4.70	12.8	35.9
Drechslera sorokiniana (Sacc.) Subram.	4.41	3.64	4.17	0	0	0	0	0	10.1	3.53	2.56	0

et Jain												
Epicoccum purpurascens Ehrenb. Schlecht	14.7	21.8	15.28	7.32	10.3	9.33	0	2.44	7.59	2.35	5.12	7.51
Fusarium avenaceum (Cora Fr.) Sacc.	5.88	1.82	0	8.54	5.17	6.67	2.35	21.95	0	15.3	10.3	2.42
Fusarium culmorum W.G.Sm) Sacc.	0	3.64	20.8	9.76	10.3	9.33	2.35	0	34.2	8.24	17.95	18.0
Rhizoctonia solani Kühn	36.76	21.8	8.33	24.4	19.0	9.33	61.2	29.3	3.80	42.4	25.6	0
Arthrinium phaeospermum (Corda) M.B. Ellis	10.29	10.9	9.72	9.76	6.9	6.67	0	0	0	5.88	12.8	23.0
Cladosporium cladosporioides Fresen.) de Vries	2.94	0	1.39	0	0	0	0	0	2.53	0	12.85	0
Others	17.67	10.9	9.72	18.3	17.2	21.3	21.2	24.4	16.5	17.7	33.3	12.4

1. Plough tillage 2. Simplified tillage 3. Direct sowing

The 2001 weather conditions were favourable to the development of fungal diseases, yet less crop residues of 2000 and a different distribution of rainfall than in 1999 brought about considerable changes in the fungal species composition; there was noted a high occurrence of *F. avenaceum*, while other species of pathogenic or antagonistic, *Trichoderma,* fungi were less frequent (Tables 5 and 6). The infection with *F. avenaceum* turned most intensive on ploughless plots, while *Rhizoctonia solani* – following traditional tillage.

The results obtained in 1999 show a higher intensity of wheat infection with *Fusarium* on ploughed plots, while in 2000 *F. culmorum* and *F. equiseti* were most frequently isolated from ploughless plots. In 2001 *F. avenaceum* was most predominant. The present research confirms a considerable relationship between wheat infection and weather conditions reported on in literature.

Table 5. Percentage of fungal species in winter wheat cultivars depending on tillage method in 2001
Forecrop: rape after rye

Fungi	Cultivars								
	Elena			Kobra			Maltanka		
	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	15.5	27.8	50.8	21.8	42.5	21.7	23.7	49.3	14.9
Drechslera sorokiniana (Sacc.) Subram. Et	0	0	3.77	0	0	0	0	0	0

Jain									
Epiccocum purpurascens Ehrenb. Schlecht	6.9	11.2	0	25.5	10.9	0	0	12.0	8.5
Fusarium culmorum W.G.Sm) Sacc.	12.1	0	0	0	0	0	0	0	0
Fusarium avenaceum (Cora Fr.) Sacc.	34.5	25.9	8.20	16.3	24.6	50.0	20.3	10.67	29.8
Trichoderma hamatum (Bon.) Bain.	12.1	16.7	21.3	12.7	0	13.3	0	18.7	0
Trichoderma viridae Pers. ex S.F.Gray	0	0	4.92	0	0	15.0	20.3	0	38.3
Nigrospora oryzae (Berk. et Br.) Petch.	0	5.55	0	0	0	0	0	0	0
Rhizopus nigricans Ehrenbi	0	0	0	0	8.2	0	13.5	0	0
Rhizoctonia solani Kühn	12.1	5.55	0	23.7	0	0	11.9	9.36	0
Others	6.79	7.3	11.0	0	13.6	0	10.4	0	8.51

1. Plough tillage 2. Simplified tillage 3. Direct sowing

Table 6. Percentage of fungal species in winter wheat cultivars depending on tillage method in 2001
Forecrop: rape after rye

Fungi	Cultivars											
	Aleta			Mikon			Izolda			Sakwa		
	1	2	3	1	2	3	1	2	3	1	2	3
Alternaria alternata (Fr) Keissler	28.8	20.7	16.9	27.5	16.1	13.6	19.6	24.1	17.5	44.8	35.6	0
Drechslera sorokiniana (Sacc.) Subram. et Jain	0	3.77	0	0	0	0	0	0	0	0	0	0
Epicoccum purpurascens Ehrenb. Schlecht	13.6	0	0	11.6	19.6	5.1	34.1	7.41	0	0	5.08	6.52
Fusarium oxysporum	0	0	0	8.69	0	0	0	0	0	0	0	0

Schlecht												
Fusarium avenaceum (Cora Fr.) Sacc.	18.6	37.7	20.0	10.2	48.2	45.8	2.44	38.9	33.3	19.0	30.5	39.1
Fusarium culmorum W.G.Sm) Sacc.	0	0	0	0	0	0	0	0	0	0	0	19.5
Trichoderma hamatum (Bon.) Bain.	15.3	0	0	0	12.5	35.6	9.75	0	36.5	0	0	0
Trichoderma koningii Oud.	0	0	0	0	0	0	4.87	0	4.76	0	0	0
Trichoderma viridae Pers. Ex S.F.Gray	0	15.1	40.0	26.1	0	0	0	22.2	0	20.7	11.8	34.8
Ulocladium botrytis Preuss	0	22.6	0	0	0	0	0	0	0	0	0	0
Rhizoctonia solani Kühn	23.72	0	18.5	11.6	0	0	29.3	0	0	15.5	0	0
Others	0	0	4.61	4.34	3.58	0	0	7.4	7.93	0	16.9	0

1. Plough tillage 2. Simplified tillage 3. Direct sowing

Perkowski [18] shows that high rainfall, drizzle, especially, increased relative air humidity, mechanical damage of plants inflicted by pests remains favourable to the development of fusariosis. Other authors report on drought which coincides with a high temperature in spring decreases the occurrence of culm base diseases [24]. However, over 2000 - 2001 there was observed an increased infection with *Rhizoctonia solani* following traditional tillage.

CONCLUSIONS

1. Winter wheat infection with culm base diseases depended mostly on weather conditions.
2. 'In 1999 and in 2001 plough tillage, bringing the crop residues up onto the soil surface, increased the intensity of culm base more than direct sowing when exposed to heavier rainfall.
3. Out of all the cultivars tested 'Sakwa' showed less, while 'Izolda' more susceptible to culm base diseases.
4. Plough tillage which coincided with higher rainfall was more favourable to the development of *Rhizoctonia solani*
5. In 1999 the occurrence of *Fusarium culmorum* and *F. equiseti* was more frequent following traditional tillage methods, while in 2000 *Fusarium culmorum* was isolated more frequently following direct sowing.
6. Tillage methods did not show a decisive effect on the occurrence of *Fusarium* pathogenic fungi.
7. The wheat genotypes analysed showed a different susceptibility to the infection with *Fusarium culmorum*.

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