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IMPACT OF STUBBLE INTERCROP AND ORGANIC FERTILISATION ON THE HEALTH STATUS OF SPRING BARLEY CULM BASE

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ABSTRACT

The research aimed at defining a regenerating effect of stubble intercrop fertilised with cattle slurry and wheat straw on the value of spring barley stand. A strict field experiment, set up as a randomised split-plot design, was carried out over 1996-2000 at the Mochełek Experiment Station, in the Kujawy and Pomorze Province. White

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mustard, radish, winter rape, sunflower and blue phacelia were sown as stubble intercrops. The culm disease infection was defined on barley culm base. Bipolaris sorokiniana and *Fusarium* genus fungi, *F. culmorum* especially, constituted the greatest, while *Pseudocercosporella herpotrichoides* and *Rhizoctonia* spp. much lower threat for barley. There was shown a favourable effect of fertilising on the barley culm base health status. A significantly lower infection was observed following the application of straw, especially when barley was cultivated after mustard, rape and sunflower, while following the application of slurry – only when barley followed mustard and sunflower. A favourable effect of intercrops on barley culm base health status was seen especially when combined with organic fertilisation. Sunflower and winter rape cultivated after wheat straw application enhanced the barley culm health status considerably, and slurry was favourable when sunflower, mustard and phacelia were sown as intercrops. Phytosanitary forecrop stand value for barley varied both over years and respective development phases.

Key words: fungi, spring barley, stubble intercrop, slurry, straw, fertilisation, culm base, health status

INTRODUCTION

An increasing share of cereals in the crop structure limits an adequate crop sequence in crop rotation, which leads to a deteriorated plant health status and hence a decreased yield. Improper crop sequence, especially cereals cultivated after one another, can intensify the occurrence of root and culm base diseases. Barley, like wheat, is very susceptible to culm base diseases. Its cultivation after some cereals can increase the occurrence of diseases inflicted on by *Gaeumannomyces graminis*, *Bipolaris sorokiniana, Pseudocercosporella herpotrichoides* as well as by *Fusarium* and *Rhizoctonia* fungi [3,12,13,23,27].

Attempts are being made at limiting negative effects of unfavourable crop sequence due to a high share of cereals in crop rotation by cultivating regenerating crops as stubble intercrops. Post-harvest residues or biomass of whole plants, constituting the intercrop, can also enhance the soil biological activity, which can lead to improving intercrops and after-crops health status [10]. To compensate for negative effects of frequent cereals in crop rotation, the brassica seems most applicable [9]. The presence of active substances, obtained from brassica root secretions, in soil decreases the intensity of root and culm base diseases, mainly by decreasing the plant infection with *G. graminis* and *P. herpotrichoides* [2].

In Poland the intercrop plantation area has decreased considerably. The declining interest in the cultivation of intercrops can be attributed also to generally applied cereal harvesting with combine harvesters and hence a delayed intercrops sowing and a common tendency to simplify farming methods [30].

Changes in agriculture, especially a considerable decrease in animal farming, resulted in a considerable shortage of the most valuable fertiliser, namely manure, all of which makes more and more frequent research into other methods of organic soil fertilisation justifiable, e.g. fertilisation with straw, slurry and intercrop plant biomass [35]. Application of straw in soil fertilisation becomes a necessity and allows for managing the straw surplus; straw fertilisation can make up for shortages of manure fertilisation or replace it [25]. Organic fertiliser and harvest residues can not only constitute a source of organic matter in soil and plant nutrients but can also enhance the phytosanitary conditions limiting the occurrence of plant diseases. However organic fertilisers can be infected with different microorganisms, including cereal pathogens. Cereal straw can be a very good medium for a development of numerous fungal parasites, increasing their lifespan. Similarly slurry, apart from being a valuable fertiliser, when used unconditioned can disturb the microbiological equilibrium due to a considerable content of microorganisms which are introduced together with slurry, which can inflict on

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plant diseases [24,26]. The present research hypothesis assumes that stubble intercrop, straw and slurry used as organic fertilisers enhance health status of spring barley culm base.

The research aimed at defining the effect of stubble intercrops fertilised with organic fertilisers on culm base disease infection of spring barley cultivated after winter wheat.

MATERIAL AND METHODS

The research into 'Maresi' spring barley was carried out over 1996-2000 at the Mochełek Experiment Station in the Kujawy and Pomorze Province. The experiment was set up as randomised split-plot design in 4 reps on experimental plots of 15 m^2 on lessive soil of a very good rye soil suitability complex. For four years before the experiment neither liming nor organic fertilisation was applied.

Factor I – stubble intercrops

a. 'Bolko' winter rape,
b. 'Adagio' radish,
c. 'Nakielska' white mustard,
d. 'Stala' blue phacelia,
e. 'Wielkopolski' sunflower,
f. control (no stubble intercrop).

Factor II – stubble intercrop fertilisation

a. slurry + mineral fertilisation supplementing up to 60 $kg \cdot ha^{-1}$ of P_2O_5 and 80 $kg \cdot ha^{-1}$ of K_2O,
b. straw + mineral fertilisation supplementing up to 80 $kg \cdot ha^{-1}$ of N, 60 $kg \cdot ha^{-1}$ of P_2O_5, 80 $kg \cdot ha^{-1}$ of K_2O,
c. control – mineral fertilisation only at the doses of 80 $kg \cdot ha^{-1}$ of N, 60 $kg \cdot ha^{-1}$ of P_2O_5, 80 $kg \cdot ha^{-1}$ of K_2O.

The slurry dose depended on the content of nitrogen so as to make the dose of nitrogen being introduced, having accounted for nitrogen equivalents, correspond to 80 $kg \cdot ha^{-1}$ of N. Straw, left after winter wheat harvest, was crushed and supplemented with 5 $kg \cdot ha^{-1}$ of N per t. The shortage of nutrients was compensated with pre-sowing mineral fertilisers up to 80 $kg \cdot ha^{-1}$ of N, 60 $kg \cdot ha^{-1}$ of P_2O_5 and 80 $kg \cdot ha^{-1}$ of K_2O. Mineral fertilisation only constituted the control.

Stubble intercrops were sown over August 6-12 following winter wheat harvest. Intercrops were harvested in the third decade of October, after 75-78 days of vegetation. In the first decade of November plant biomass was crushed and ploughed. 'Maresi' spring barley was sown every year in the first decade of April to obtain 320 plants per 1m^2 of post-emergence plant density. Phosphorus and potassium fertilisation was applied in autumn while nitrogen before barley sowing (60%) and over culm shooting (40%). Fertiliser doses were fixed following the Institute of Plant Cultivation, Fertilisation and Soil Science guidelines. Weeds were controlled with Puma Super 069 EW + Granstar 75 DF over barley plant tillering.

The present study investigated field and lab barley health status; the latter included isolating and marking fungi. The plant health status evaluation coincided with the emergence phase, GS 13-14 according to Zadoks et al. [36], shooting phase (GS 34-36) and milk and waxy maturity (GS 75-83). Over plant emergence plant sheath infection with fungal pathogens was identified with yellow or brown streaky and necrotic spots. Over plant shooting and milk and maturity the spots on barley culm base were divided into two groups: necrotic yellow or brown, eye spots characteristic of *Pseudocercosporella herpotrichoides* and *Rhizoctonia* spp. infection and brown, streaky and necrotic spots typical for *Bipolaris sorokiniana* and *Fusarium* spp. Each time the health status of 30 randomly sampled plants from each plot was defined and the infection was evaluated with 0-3^o scale; the infection degree was converted into infection index with the Townsend and Heuberger formula. The results were statistically verified with the Tukey test at p=95%.

The macroscopic plant health evaluation was accompanied by the analysis of fungal species identified on culm base. The material for mycological analysis was randomly sampled over the shooting and milk and waxy maturity from culms showing diseases symptoms. A single 5 mm-long disc was cut out from each of 100 culms and rinsed for 45 minutes under running water, disinfected for 5 sec in 75% C_2H_5OH solution and for 15 sec in $HgCl_2$, and then rinsed 3 times in sterile distilled water and finally put onto Petri dishes filled with PDA medium of pH 5.5.

RESULTS

The weather conditions differed over the research period (Table 1). The highest rainfall over barley vegetation period was noted in 1998, and the lowest – in 2000, especially April through June. The highest mean air temperature over vegetation was recorded in 1999 and in 2000, mainly in May, which could have been responsible for the highest leaf sheath infection over plant emergence in 2000.

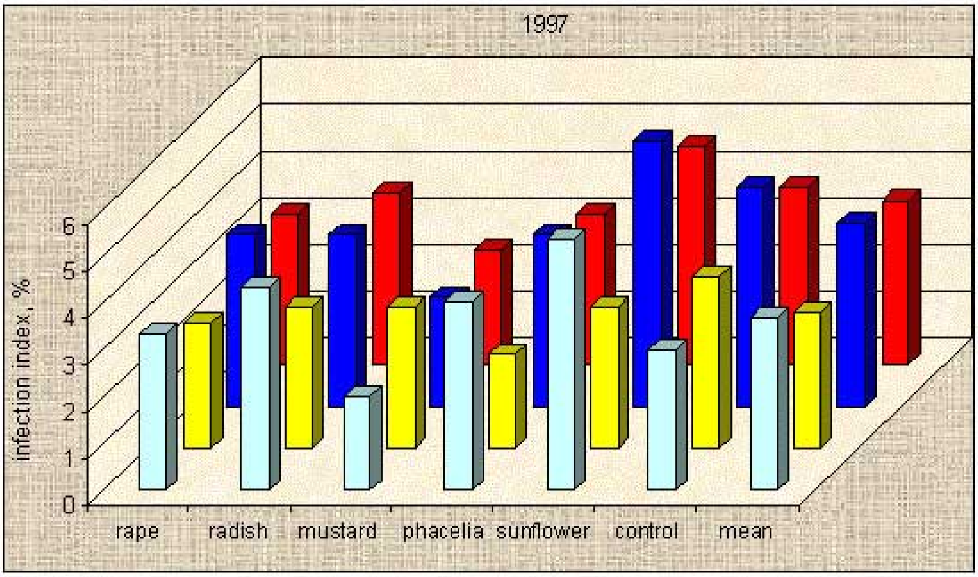
Table 1. Rainfall and mean air temperature recorded by the Mochełek Experiment Station over spring barley vegetation period

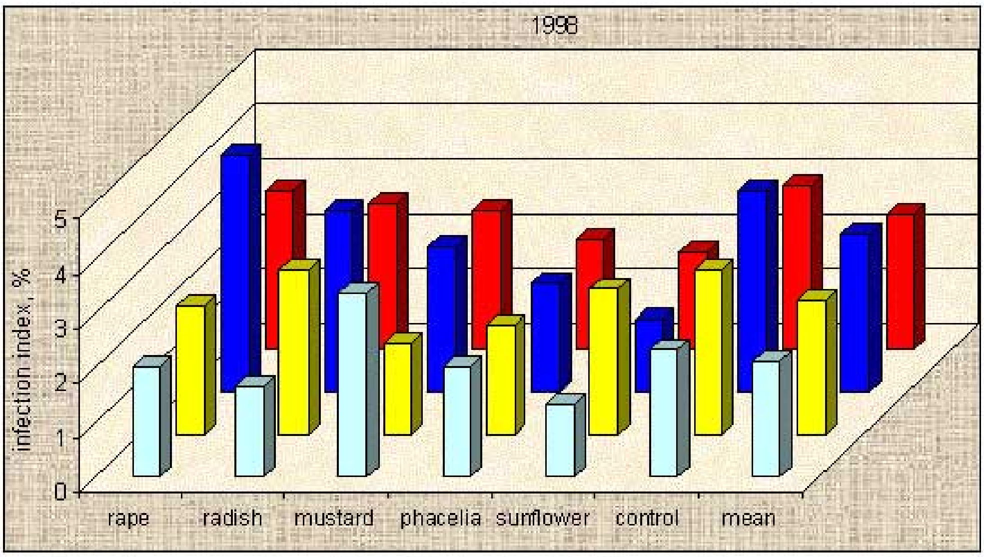
Month	Year				1949-1994 multi-year mean
	1997	1998	1999	2000	
Rainfall, mm					
March	28.4	40.1	44.3	36.1	21.3
April	20.7	21.1	62.1	14.6	27.0
May	96.5	46.4	45.5	24.6	36.8
June	36.7	94.7	58.6	19.1	55.5
July	108.5	96.0	43.9	100.9	69.4
August	15.1	65.8	53.8	58.4	47.9
Total	305.9	364.1	308.2	253.7	257.9
Mean temperature, ° C					
March	2.8	1.9	3.9	3.1	0.1
April	4.7	9.3	8.6	11.0	7.2
May	11.5	13.8	12.2	14.5	12.9
June	16.0	16.6	16.5	16.7	18.2
July	17.7	16.7	20.0	15.7	17.8
August	19.9	15.2	17.4	17.3	17.3
Mean	12.1	12.3	13.1	13.1	12.3

The 4-year research results show that stubble intercrop and organic fertilisation affected barley culm base diseases significantly, however the effect was slight and different over respective years and development phases. A significant variation was noted at the end of the vegetation period and in the years when plant infection was higher.

Over plant emergence barley plant infection was slight; the disease symptoms were seen on leaf sheath only. The results of variance analysis from the four-year period showed neither a significant effect of straw or slurry fertilisation nor of the crops cultivated as intercrops on the health status of barley (Fig. 1). A significant variation was observed in 2000, only, which recorded the highest infection index value.

Fig. 1. Effect of stubble intercrop and organic fertilisation on spring barley leaf sheath health status over 1997-2000 emergence phases





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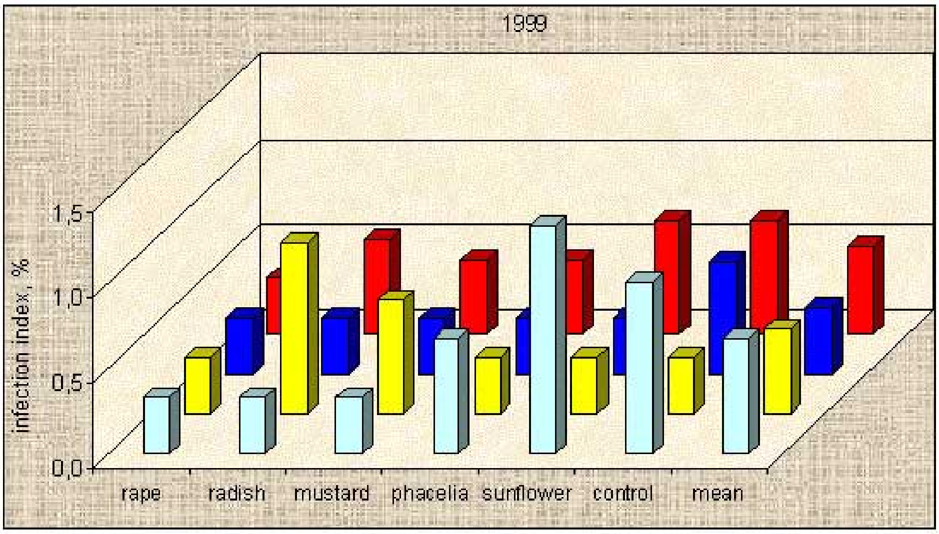
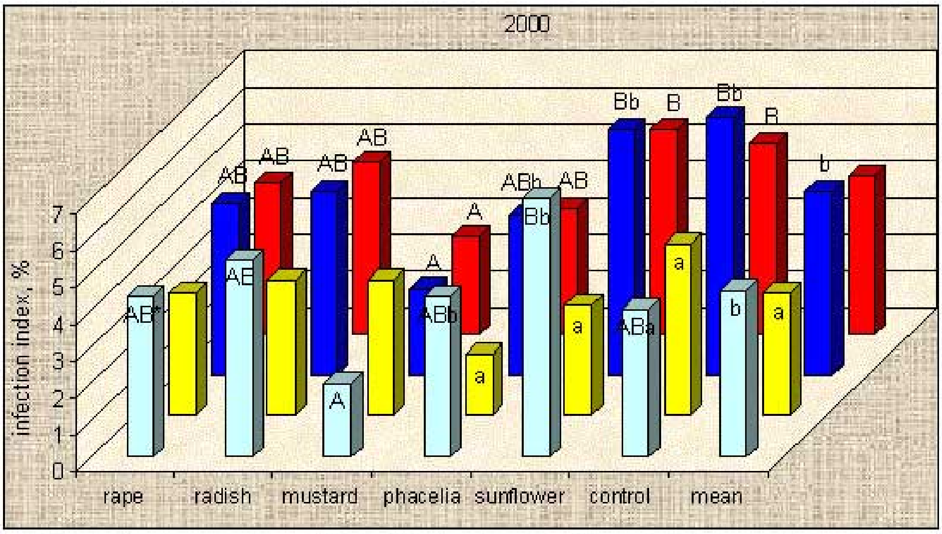
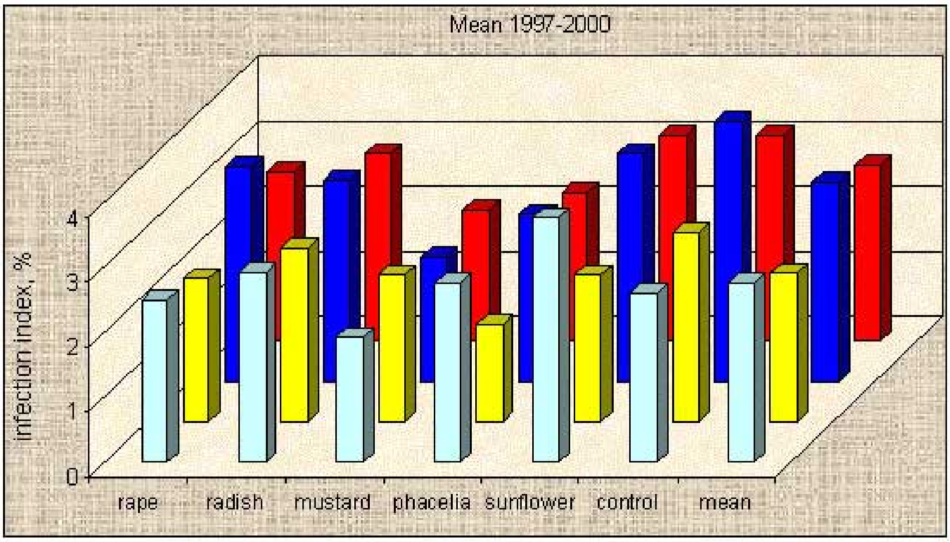


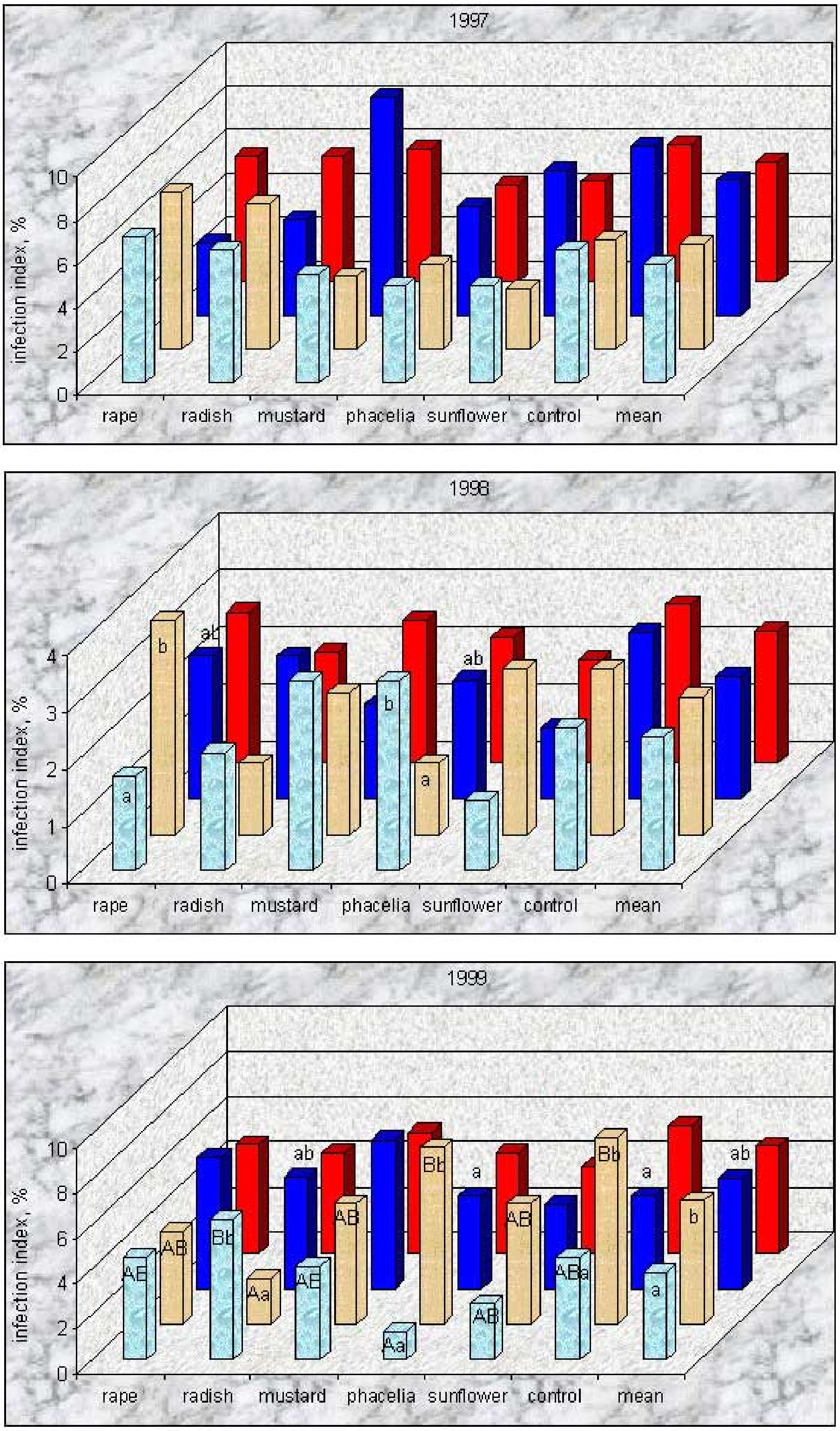


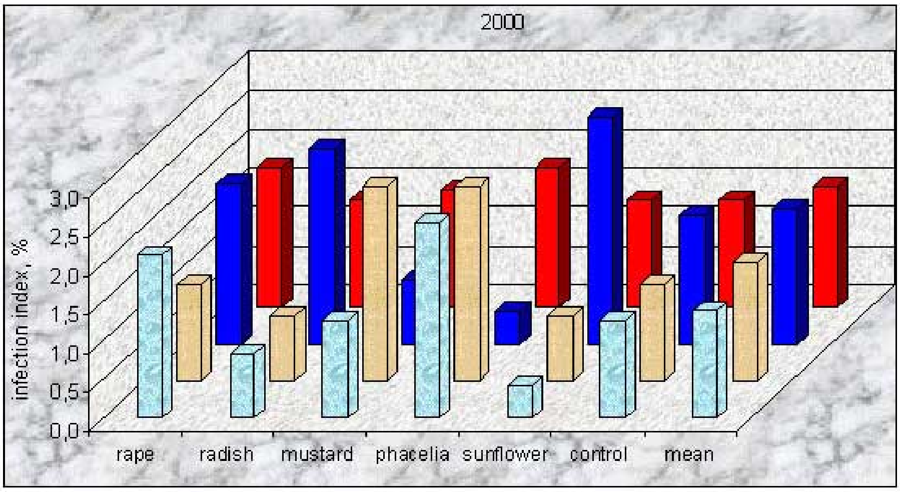


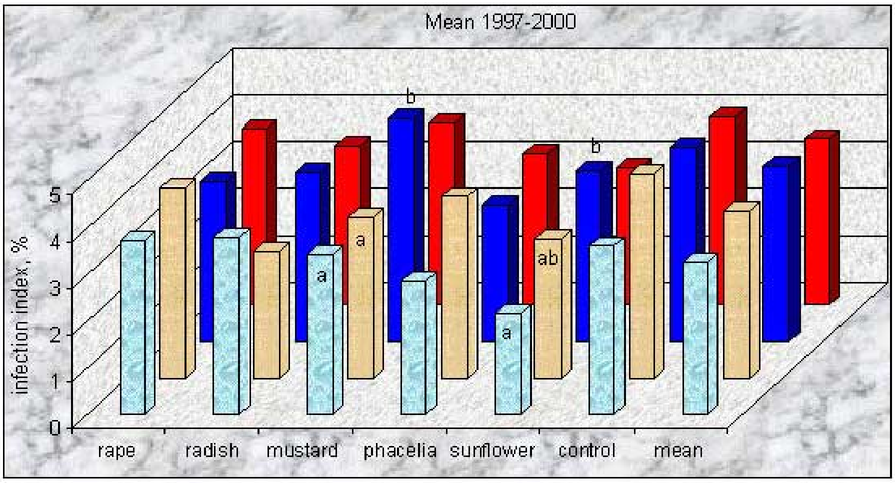
***Means followed by different letters differed significantly capital letters stand for a significantly varied effect of intercrop lower-case letters stand for a significantly varied effect of organic fertilisation**

Over the shooting phase the plant infection with respective pathogens differed. There was noted relatively few of eyespot and sharp eyespot, despite which 1998 and 1999 observed an inhibiting effect of both organic fertilisation and in 1999 – intercrops. Analysing the total research period, there was noted a more favourable effect of fertilisation with slurry and straw when compared with the control when barley followed mustard and sunflower (Fig. 2).

Fig. 2. Effect of stubble intercrop and organic fertilisation on spring barley culm base infection with *P. herpotrichoides* and *Rhizoctonia* spp. over 1997-2000 plant shooting

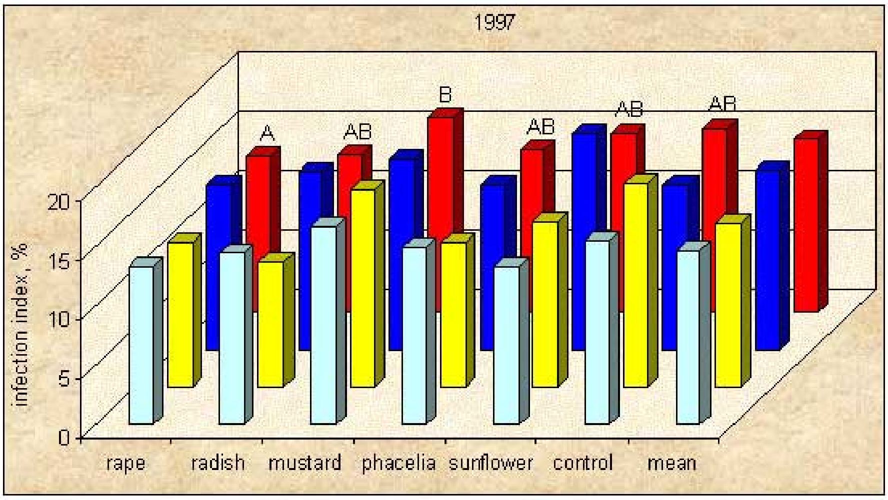






However, many more rot symptoms were recorded as inflicted on by *Bipolaris sorokiniana* and *Fusarium* spp. Their intensity varied with years. The effect of intercrops over 4-year research period was slight, while significant differences resulted from fertilisation. The lowest barley plant infection was recorded on plots fertilised with straw, while the highest – on the control. An especially favourable effect of straw and slurry was observed when barley followed rape, a much lower infection as compared against the control (Fig. 3).

Fig. 3. Effect of stubble intercrop and organic fertilisation on spring barley culm base infection with *B. sorokiniana* and *Fusarium* spp. over 1997-2000 plant shooting



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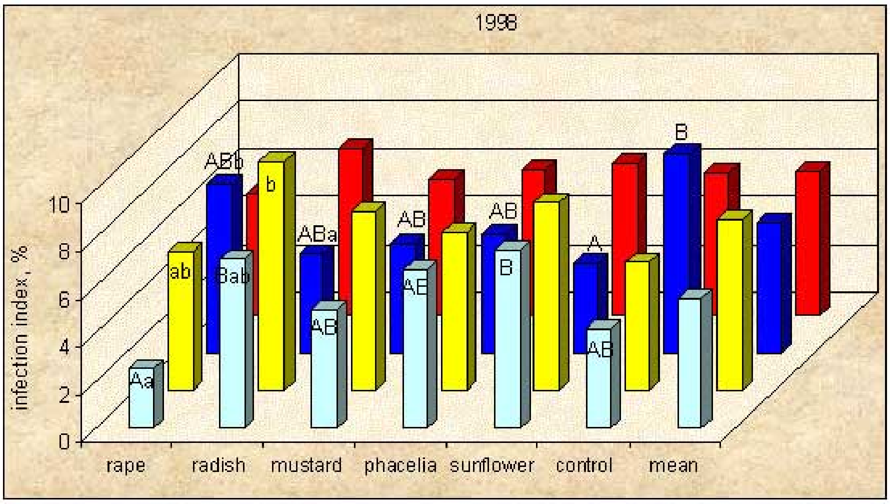
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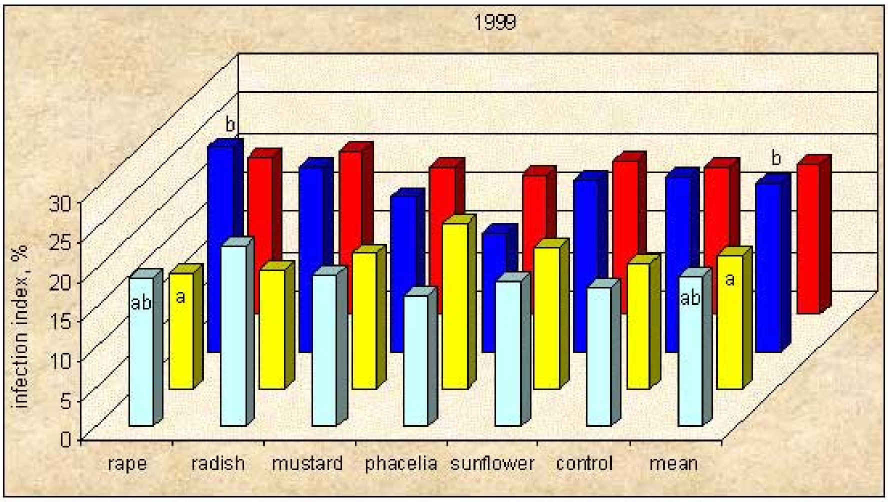
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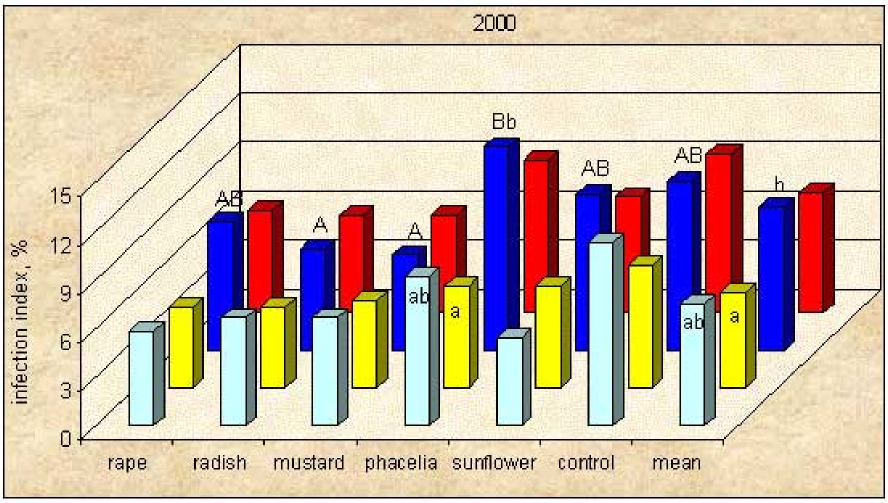
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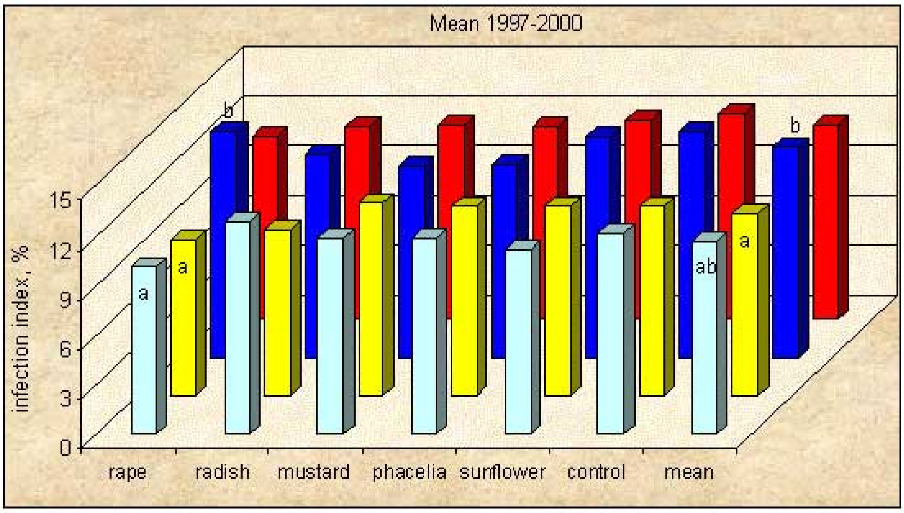

Fungal barley culm base pathogens isolated represented mostly *B. sorokiniana* and *Fusarium* spp. (Table 2). Over the four years *B. sorokiniana* accounted for an average of 30.2% of all the fungi isolated over the shootjing phase, however the species was most frequent in 1999 and 2000 reaching, respectively, 48.9% and 44.2%. *Fusarium* fungi constituted a total of 28.6%, with *F. culmorum* (14.4%), most frequent in 1998, and *F. equiseti* (8.1%), most frequent in 2000, being most represented. *Rhizoctonia* spp. was isolated only in 1999 accounting for 3.3% then.

Table 2. Fungi isolated from the spring barley culm base over shooting phase, %

Fungi species	Year				Mean*
	1997	1998	1999	2000	
Absidia glauca Hagen	12.9	-	-	-	3.2
Acremonium strictum W. Gams	-	8.2	-	-	2.0
Aureobasidium bolleyi (Sprague) von Arx	-	-	3.3	-	0.8
Bipolaris sorokiniana (Sacc. in Sorok.) Shoem.	12.9	14.8	48.9	44.2	30.2
Botrytis cinerea Pers.	-	-	2.2	-	0.6
Colletotrichum sp.	3.2	1.6	-	-	1.2
Epicoccum purpurascens Ehrenb. ex Schlecht.	-	-	3.3	-	0.8
Fusarium avenaceum (Fr.) Sacc.	-	4.9	2.2	6.5	3.4
Fusarium cerealis (Cooke) Sacc.	-	1.6	-	-	0.4
Fusarium culmorum (W.G. Smith) Sacc.	12.9	29.5	3.3	11.7	14.4
Fusarium equiseti Sacc.	-	-	-	32.5	8.1
Fusarium graminearum Schwabe	-	-	2.2	-	0.6
Fusarium solani (Mart.) Sacc.	-	1.6	-	5.2	1.7
Fusarium spp. total	12.9	37.7	7.8	55.8	28.6

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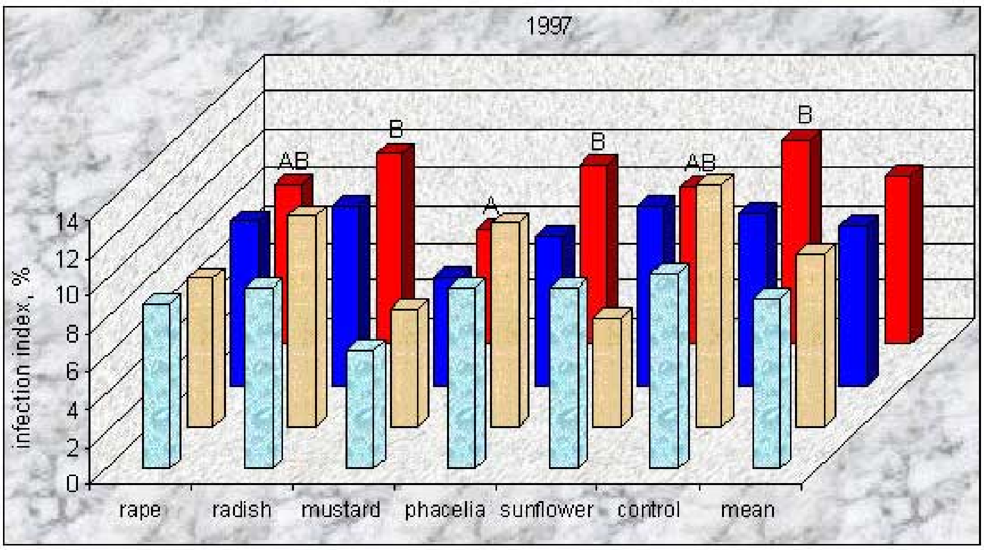
Mucor spp.	9.7	8.2	11.1	-	7.2
Penicillium spp.	25.8	11.5	7.8	-	11.3
Phoma spp.	16.1	8.2	-	-	6.1
Rhizoctonia spp.	-	-	3.3	-	0.8
Trichoderma koningii Oud.	-	-	3.3	-	0.8
Trichoderma viride Pers. ex Gray	-	-	3.3	-	0.8
Non-sporulating	6.5	9.8	5.6	-	5.5
Total number of isolates	62	61	90	77	290

***1997-2000 mean share of respective fungi isolated from culm base**

Over milk-waxy maturity the disease intensity increased considerably. Barley infection with *P. herpotrichoides* and *Rhizoctonia* spp. over 4-year period depended on both the fertilisation and on the intercrop. The highest infection was recorded on the control (without intercrop), while sunflower and phacelia as intercrops decreased barley infection significantly (Fig. 4). Rape, mustard and radish did not enhance the barley health status considerably. The most powerful effect of intercrop species was seen on the plots fertilised with straw and the control. The greatest plant infection on plots treated with straw was shown on the control, while sunflower and rape decreased the infection considerably. When no mineral fertilisation was used, the greatest disease symptoms on barley plant followed mustard, while the lowest – phacelia. Mean infection index showed that straw resulted in significantly lower values than when mineral fertilisation was applied. The most favourable effect of straw fertilisation was visible for barley following mustard and sunflower. Slurry did not enhance the barley health status significantly, however when applied after mustard, its effect was favourable while after rape and sunflower – did not change the barley health status considerably, as compared with the control.

Fig. 4. Effect of stubble intercrop and organic fertilisation on spring barley culm base infection with *P. herpotrichoides* and *Rhizoctonia* spp. over 1997-2000 milk and waxy maturity



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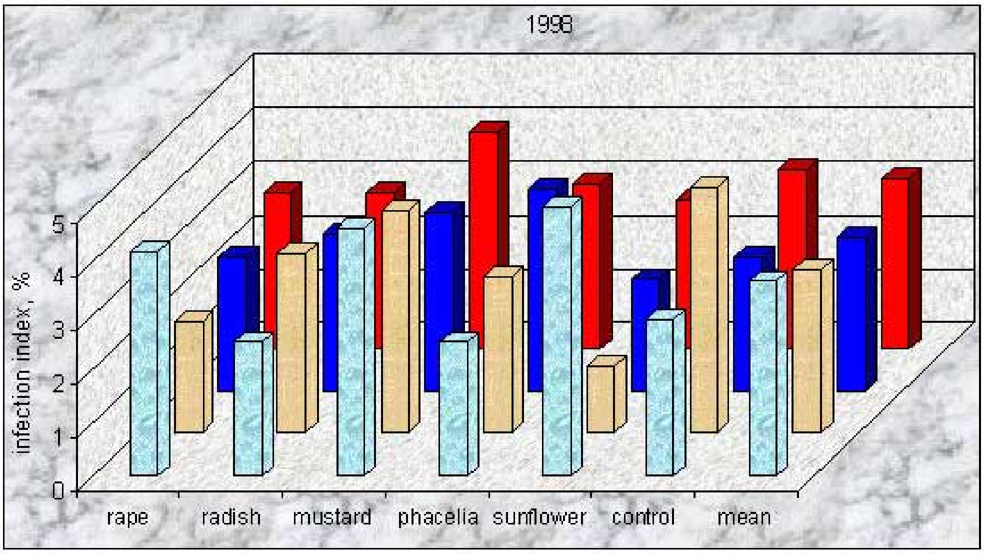
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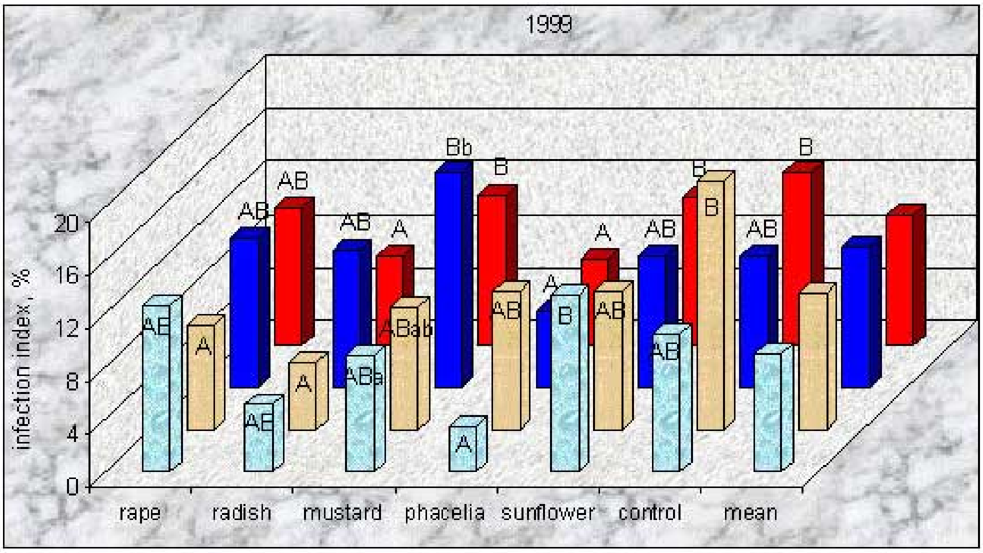
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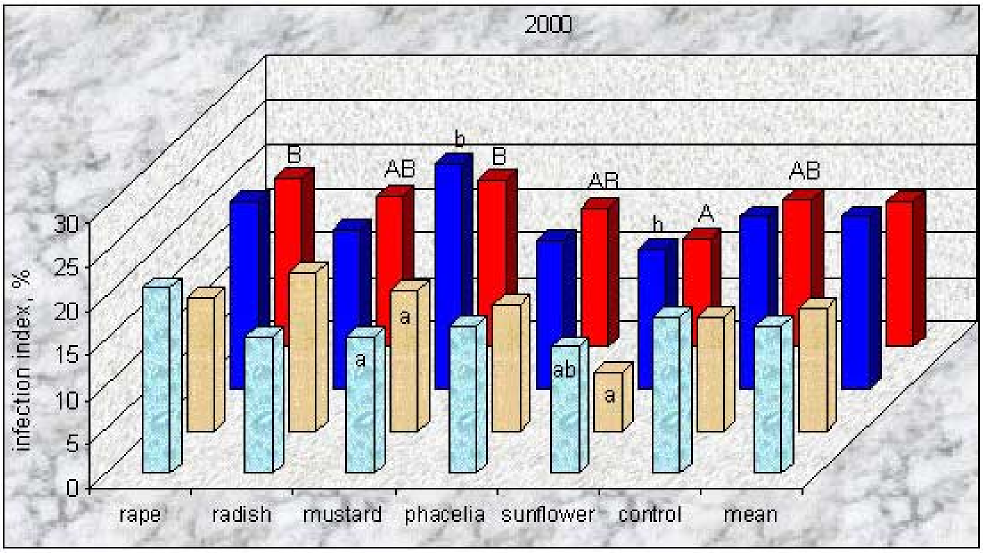
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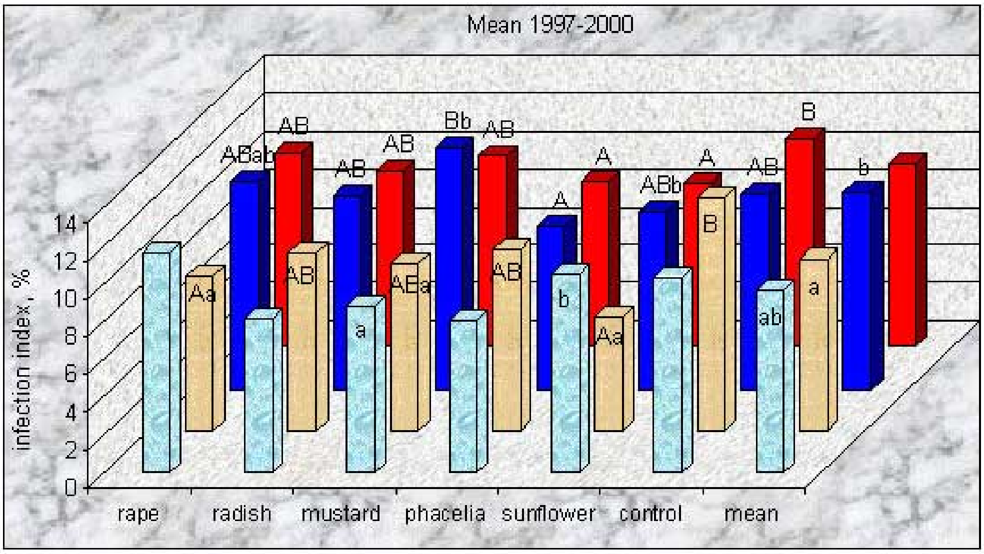
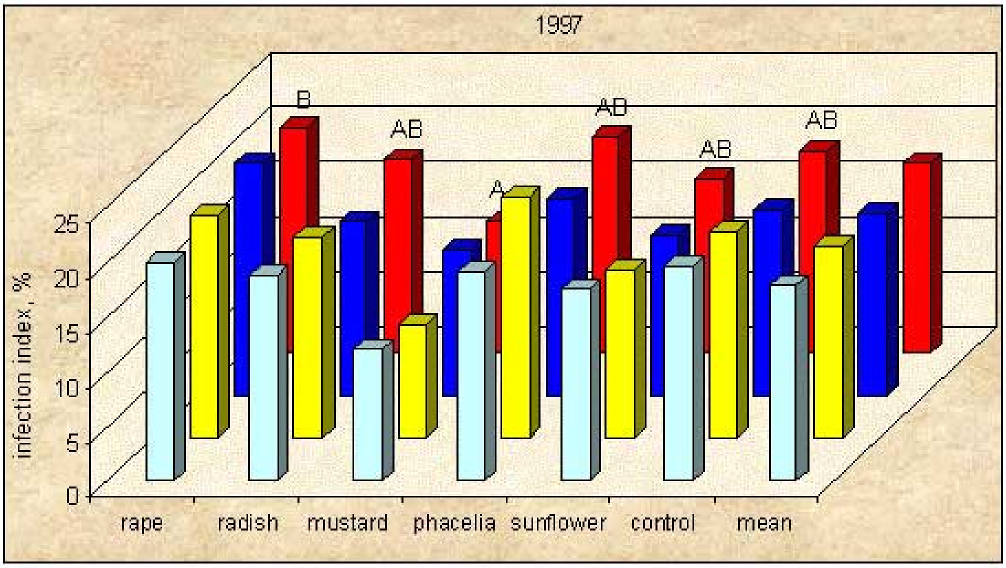


Barley infection over milk-waxy maturity with *B. sorokiniana* and *Fusarium* spp. was high and, to some extent, depended on straw and slurry fertilisation as well as intercrop species (Fig. 5). The four-year analysis revealed a crucial effect of intercrops when coinciding with slurry fertilisation. The stand value was much enhanced by sunflower, mustard or phacelia. The significant effect of organic fertilisation, even though unfavourable, on barley health status was shown only when no intercrop was applied. Plots fertilised with straw showed a similar barley infection to the control, while slurry increased the infection considerably.

Fig. 5. Effect of stubble intercrop and organic fertilisation on spring barley culm base infection with B. sorokiniana and Fusarium spp. over 1997-2000 milk and waxy maturity



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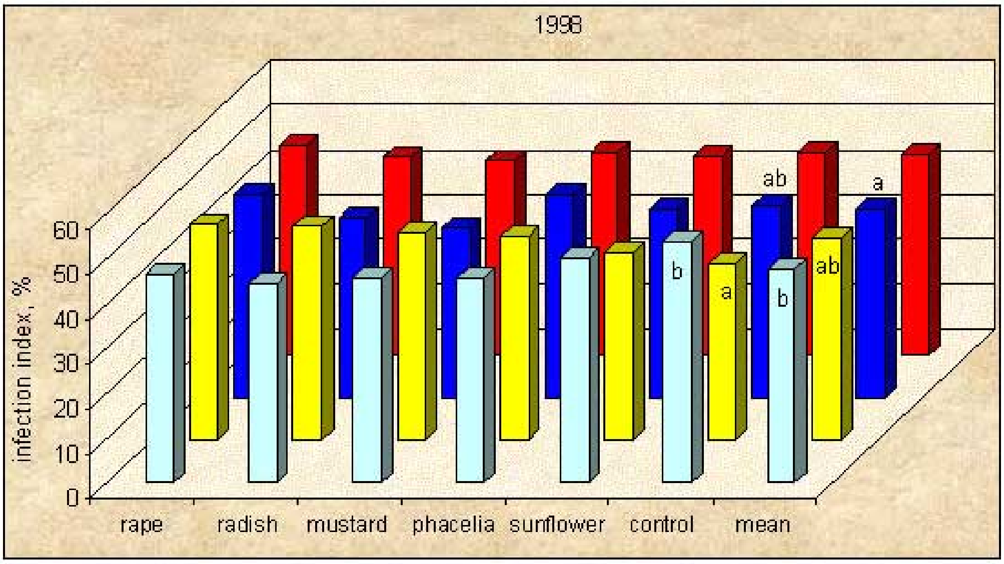
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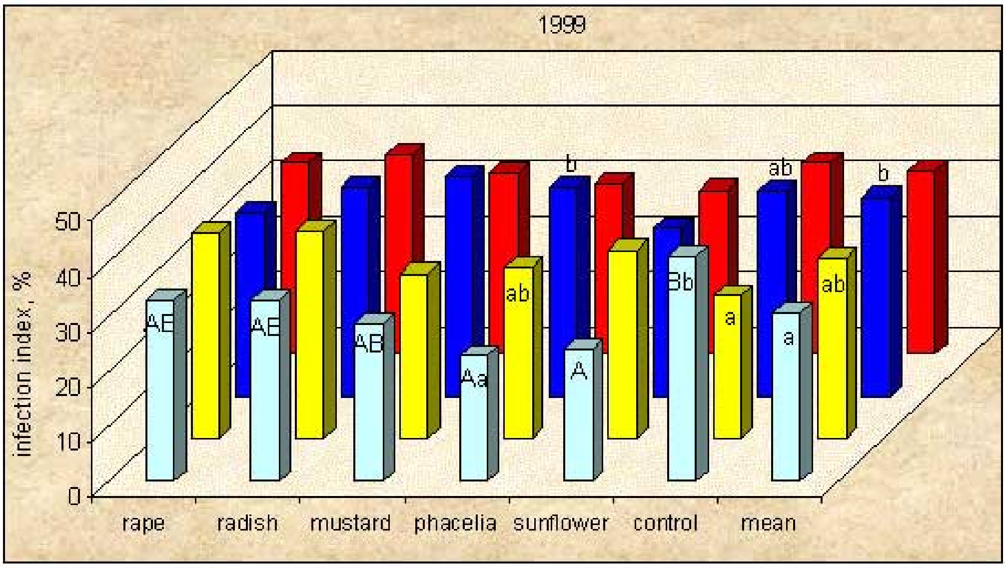
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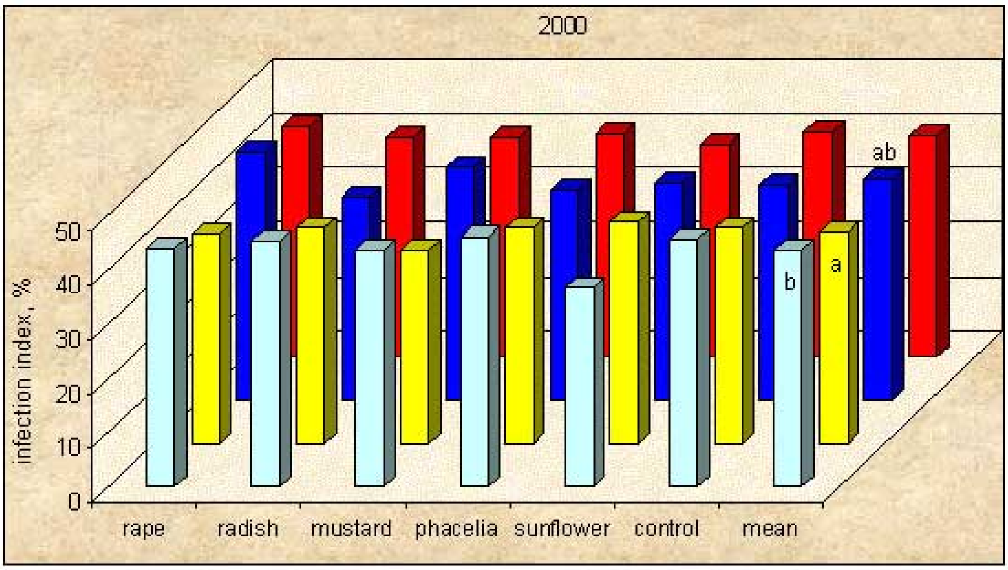
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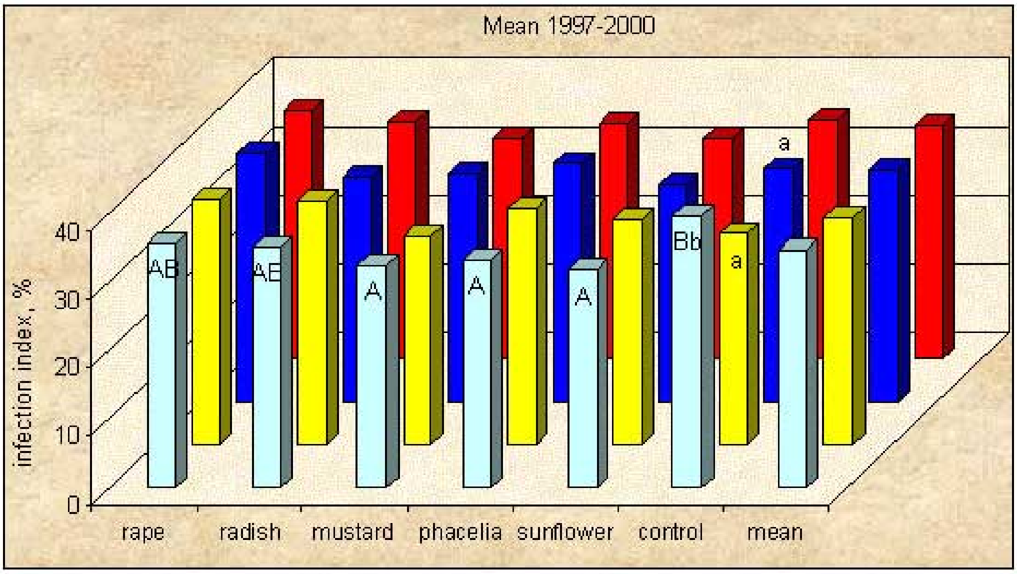

Over the milk and waxy maturity *Fusarium* spp. was most dominant of all the pathogenic fungi (63.7%) (Table 3), especially *F. culmorum* (49.1%) over 1997 and 1998. *Bipolaris sorokiniana* accounted for an average of 26.8%, most frequently in 1999 and 2000, 50.5% and 33.3%, respectively. *Rhizoctonia* fungi represented 1.5% share, only.

Table 3. Fungi isolated from spring barley culm base over milk and waxy maturity, %

Fungi species	Year				Mean
	1997	1998	1999	2000	
Alternaria alternata (Fries.) Keiss.	-	-	14.6	-	3.6
Aspergillus niger van Tieghen	-	1.2	1.9	-	0.8
Aureobasidium bolleyi (Sprague) von Arx	-	-	3.9	-	1.0
Bipolaris sorokiniana (Sacc. in Sorok.) Shoem.	10.5	12.8	50.5	33.3	26.8
Colletotrichum sp.	5.3	-	-	-	1.3
Epicoccum purpurascens Ehrenb. ex Schlecht	-	-	1.0	-	0.2
Fusarium avenaceum (Fr.) Sacc.	1.3	-	2.9	-	1.1
Fusarium cerealis (Cooke) Sacc.	1.3	5.8	-	-	1.8
Fusarium culmorum (W.G. Smith) Sacc.	76.3	73.3	15.5	31.3	49.1
Fusarium equiseti Sacc.	3.9	-	5.8	28.1	9.5
Fusarium solani (Mart.) Sacc.	1.3	4.7	-	-	1.5
Fusarium oxysporum Schlecht.	-	-	-	3.1	0.8
Fusarium spp.: total	84.2	83.7	24.3	62.5	63.7
Gliocladium catenulatum Gilman et Abbott	-	-	-	1.0	0.3

Mucor spp.	-	2.3	-	-	0.6
Rhizoctonia spp.	-	-	2.9	3.1	1.5
Trichoderma koningii Oud.	-	-	1.0	-	0.2
Total number of isolates	76	86	103	96	361

DISCUSSION

Out of all the fungi isolated from barley culm base *B. sorokiniana* and *Fusarium* spp. dominated, which was also found by Czajka et al. [6], Windels and Wiersma [34] as well as Łacicowa and Pięta [16]. Seeds for sowing infected with B. sorokiniana constitute a major source of infection [15]. According to Knudsen at al. [11] as much as 76% of seeds could be infected with the pathogen. *Bipolaris sorokiniana* is extremely important and can result in no emergence and can limit germinability to 25% or deteriorate seedling health status [15]. *Bipolaris sorokiniana* is considered one of the main barley disease agents [11,16,17,33,34], mostly responsible for barley culm base diseases; it can also infect other organs, including roots, leaves and ears. A common occurrence of this pathogen on all the barley plant organs is reported by Łacicowa [15,16], Łacicowa and Pięta [17], Łukanowski et al. [19], Truszkowska et al. [31], Tyryshkin and Voronkowa [33].

Similarly *Fusarium* was isolated from the culm base, especially *F. culmorum*, *F. equiseti, F. avenaceum, F. cerealis, F. graminearum, F. solani* and *F. oxysporum*, mostly responsible for spring barley fusariosis attacking the root system and culms, leaves and ears [20,22,17]. Out of all the *Fusarium, F. avenaceum* and *F. culmorum* are most important due to their saprophytic specificity, while a wide range of hosts makes it difficult to limit them with crop rotation [4] and so a short-term intercrop cultivation can show no greater effect on their composition. Soil, just like seeds, is the main source of *Fusarium* spp. infection. In the present research over the milky-waxy maturity there was noted an increase in the *Fusarium* fungi, which must have been due to a very high susceptibility of ageing tissue at the end of the vegetation period [18].

The mycological analysis revealed few isolates of *Rhizoctonia* spp. which are considered of considerable threat for spring barley, however they are less dangerous than *B. sorokiniana* and *Fusarium* spp. [1,17,31]. Additionally *Rhizoctonia* spp., as polyphagous, are not host-specific, show a changing virulence and a high tolerance towards environmental conditions [18,28].

Cook [5] reports on the farming system to be affecting both the plant pathogen population and on antagonistic microorganisms in the rhizosphere. Soil being the natural habitat for microorganisms has their specific balanced composition; the balance depends on many factors, including organic fertilisation and the crop itself. Crops can stimulate a development of pathogens activating their spores and, at the same time, limiting the occurrence of species beneficial for soil. The intercrop cultivation period could have been too short for the soil microorganisms to change considerably, which, as a result, could have made the present effect of stubble intercrops on barley culm base inconsiderable and different over years and over observation periods. A significant variation was noted especially at the end of the vegetation period and over years which coincided with a higher infection.

Despite disease symptoms characteristic for the infection with *Pseudocercosporella herpotrichoides*, the fungus was not isolated from the disease-affected ears, which could have been due to the isolating method applied enhancing the growth of *B. sorokiniana* and *Fusarium* fungi which were most frequent. Similarly, the culm infection index values were higher that those of *P. herpotrichoides* and *Rhizoctonia* spp. and the isolation methods do not always reveal *P. herpotrichoides* or they show many fewer isolates than the molecular methods [32].

The strongest infection of spring barley with *P. herpotrichoides* and *Rhizoctonia* spp. and with *B. sorokiniana* and *Fusarium* spp. was observed when no intercrop was applied and differed over years and over observation periods. A significant impact of the intercrop on limiting the culm base infection with *P. herpotrichoides* and *Fusarium* spp. and *Rhizoctonia cerealis* was also observed by Deryło [7]. A positive effect of intercrops is seen especially whenever the share of cereals in the crop sequence is high. Brassica shows most valuable in enhancing the phytosanitary conditions as the substances they produce decrease e.g. the intensity of infection with *P. herpotrichoides* [2,9], which, however, was not always confirmed by the present research, most probably due to a relatively low infection of barley with that pathogen.

The present research showed a favourable effect of organic fertilisation on the health status, which limited the infection of barley culm base significantly. Straw showed most favourable. A favourable effect of organic fertilisation is also reported by Martyniuk [21] stating that an adequate cereal mineral and organic fertilisation decreases or limits the disease. The plants which are adequately supplied with nutrients tiller better, produce more new roots and their tissues are more resistant to pathogens. According to Dutkiewicz and Maciejewska [8], organic fertilisation, especially with manure, increases the content of organic substances in soil which can maintain favourable water relations, enhances the development of fungi antagonistic to pathogenic fungi as well as increases the content of humus which, in turn, affects the quantitative and qualitative composition of microorganisms, biological balance and the natural resistance of soil to infection with pathogens. Organic fertilisation can prevent from unfavourable changes in the composition of soil microorganisms.

Abundant green matter obtained from intercrop ploughing can, however, lead to intercrop decaying and can deteriorate the next sowing [29]. The plants which act as barley intercrop, especially their roots, are also attacked by fungi, mainly *Fusarium* spp. as well as *Rhizoctonia* spp. Lemańczyk et al. [14] in their earlier paper on barley intercrop health status reported on a relatively low and similar infection of fodder crop roots. Slurry fertilisation increased the infection of radish and rape roots with a group of pathogens; hence its less considerable effect on barley health status. However, a low infection of intercrops and a relatively low share of pathogenic fungi isolated from stubble intercrops can show their considerable potential in easing the negative effects of frequent cereal occurrence in the crop rotation.

CONCLUSIONS

1. A favourable effect of stubble intercrops was shown as regenerating the post-cereal stand. Cultivating intercrops after winter wheat, to some extent, enhanced the phytosanitary status of stand for spring barley.

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2. A favourable effect of intercrops on the health status of barley culm base was seen especially when the intercrop coincided with the organic fertilisation. When straw was applied, barley culm health status was considerably enhanced by the cultivation of sunflower and rape, while slurry – by sunflower, mustard and phacelia.
3. Straw fertilisation showed much more favourable than slurry fertilisation. An especially favourable effect of straw, when compared against the control, was observed when barley was cultivated after mustard, rape and sunflower. The application of slurry can sometimes even lead to a deteriorated barley health status. A favourable effect of slurry was recorded only when barley followed mustard and sunflower.
4. A considerable effect of stubble intercrops and straw and slurry fertilisation on barley health status was noted especially over the milk and waxy maturity which coincided with the highest disease intensity. Over the shooting phase there was observed a significant effect of organic fertilisation only, while over emergence – no significant variation at all.
5. The greatest threat for the spring barley culm base was posed by *Bipolaris sorokiniana* and *Fusarium* fungi. There was noted a much higher value of the index of infection with these pathogens as compared with *Pseudocercosporella herpotrichoides* and *Rhizoctonia* spp.
6. The culms showing disease symptoms showed the greatest occurrence of *B. sorokiniana* and *Fusarium* fungi, mainly *F. culmorum* and *F. equiseti*, and over the shooting phase – also *F. avenaceum*. *Fusarium* fungi were much more frequently isolated from infected culms over the milk and waxy maturity than over the shooting phase.

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