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HEALTH STATUS OF SPRING BARLEY GROWN IN MONOCROP AND IN MIXTURES WITH CEREALS OR LEGUMINOUS PLANTS

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Abstract: In 1997–1999 observations of health status of spring barley grown in two-component mixtures with cereals or pea were performed in two experiments, differing in the agricultural utility of soil. A much better health status of the studied species was found in the mixed crop than in their pure stand. Two-component mixtures were differentiated in the occurrence of leaf diseases caused by *Drechslera teres*, *Drechslera graminea*, *Puccinia graminis* and *P. hordei*, *Rhynchosporium secalis* and *Erysiphe graminis*. The healthiness of lower parts of stem and roots depended on the quality of soil and mixtures factor. A higher infection due to foot root rot complex was noted on barley cultivated on the poorer soil in homogenous stand.

Key words: spring barley, mixtures, diseases

I. INTRODUCTION

Two-component mixtures are the kind of intercropping system. In traditional agricultural systems, cultivation of mixtures within and between species helps protect crops against stresses. The most important (particularly from plant protection angel) is the possibility of better control of weeds, pests and diseases (Willey 1979; Wolfe 1985; Elmstrom et al. 1988). The weed aspect is effective control being possible where intercropping provides a more competitive community of crop plants, either in space or time, than sole cropping (Creamer et al. 1996; Cousens 1996). The pests and disease aspects are more complex. Wolfe (1990) provides that mixtures have unique effect in restraining the spread of the pathogen population. The mechanism operates in three principal ways:

- decrease in the spatial density of susceptible plants,
- barrier effect provided by resistant plants that fill the space between susceptible plants,
- resistance induced by non-pathogenic pathogen population.

Genetic diversity favours the resistance of cereal crop stands, especially to airborne, foliar pathogens, which cause spots and clusters of spores on leaves (Stolen et al. 1980; Karjalainen and Jokinen 1993). Often the major disease problem arises from soilborne pathogen such as *Pseudocercosporella herpotrichoides*, *Fusarium species*, and *Gaeumannomyces graminis* (Vilich-Meller 1992; Wenda-Piesik and Lemańczyk 1997). Vilich-Meller (1992) provided that mixed cropping of two cereal species resulted in

a reduction of stem-rot diseases and mechanism regulating susceptibility of plant species to those pathogens may result in varying number of propagules causing secondary infections.

The objective of the study was to evaluate the health status of roots and lower parts of stem as well as the leaves of spring barley in relation to the way of seeding and the site conditions.

II. MATERIALS AND METHODS

The investigations were based on two field experiments carried out in 1997–1999 at two locations differing in agricultural usefulness of soils. One of the strict experiments was at the Mochełek Experimental Station of the Bydgoszcz University of Technology and Agriculture on grey brown podsolic, light loam soil, (according to Polish useful soil taxonomy this is Good Rye Complex), while the other one was at Chrząstowo Experimental Station for Cultivar Testing, on a brown soil, silty light loam on medium heavy loam (Good Wheat Complex).

Spring barley (cultivars Maresi in Mochełek and Lot in Chrząstowo) was cultivated in pure seeding and in mixtures with following plants and density:

- barley in pure stand – 360 plants per m^2;
- barley with oats – 210 + 240 plants per m^2;
- barley with spring triticale – 160 + 250 plants per m^2;
- barley with pea – 210 + 50 plants per m^2.

The both tested cultivars of spring barley have similar susceptibility to the pathogens, such as: *Drechslera teres*, *Rhynchosporium secalis* and *Puccinia* spp. The mean degree of infestation due to those pathogens amounts in over 7.5% (9-degree scale). Cv. Lot is characterised as less affected by *Erysiphe graminis* than cv. Maresi, and the difference in degree of infestation reaches 0.2–0.4 percentage points. They are both slightly infested by *Drechslera graminea*, average in only 1% (Behnke et al. 1996).

The experiments were carried out in randomised block designed with four replications. Total area of each plots was 15 m^2 .The forecrop of studied objects was winter wheat, and the sites of experiments were selected where the incidence of "foot root rot" diseases exceeded 60% in the previous wheat crop. Seeds of barley, oats, triticale and pea were treated with Vincit 050 FS against pathogens. Apart from seed dressing no plant protection products were used during plant vegetation.

The observations of infection were performed in the phases described in table 1.

Average temperatures during the growing season varied from 7.5–18.1°C in Mochełek station and of 8.0–18.6°C in Chrząstowo. The more significant diverse was noted in rainfalls and in air moisture. In Chrząstowo higher air moisture was observed in April and May (78% and 74% respectively), whereas in Mochełek air moisture reached over 80% in June and July (Tab. 2).

For statistical purposes, degrees of infection were recalculated to indexes of infection (%) according to the Townsend-Heurberger formula. Data were analysed using ANOVA for single experiments and synthesis from three years in each site. Significant differences were calculated according to the Tukey-test.

Table 1

Occurrence of pathogens observed on spring barley

Phenophase in Zadoks scale	Agrophage (symptoms)	Evaluation means
Stem elongation 34–36	*Rhynchosporium secalis* (scald disease)	in 6-degree scale on 30 plants 0° – symptomless or slightly infections, 5°– symptoms on more than 75% area of leaf (EPPO Standards 1997)
Flag leaf just visible 37	*Erysiphe graminis* (powdery mildew)	in 6-degree scale on 30 plants 0° – symptomless, 5° – symptoms on more than 50% area of leaf (EPPO Standards 1997)
Ear emergence 55–59	*Drechslera teres, D. Graminea* (barley leaf net and stripe diseases)	in 5-degree scale on 30 plants 0° – symptomless, 4° – symptoms on more than 75% area of leaf (Łacicowa et al. 1991)
Milk development 73–75	*Puccinia* spp. (rusts)	in 6-degree scale on 30 plants 0° – symptomless, 5° – symptoms on more than 50% area of leaf (EPPO Standards 1997)
	complex of take all diseases and root rot	in 3-degree scale on 30 plants 0° – slightly infection, 2° – strong infection (Ponchet 1958)

Table 2

Weather conditions in experimental sites

Year	Month	Average temperature (°C)		Rainfall (mm)		Air moisture (%)	
		Mochełek	Chrząstowo	Mochełek	Chrząstowo	Mochełek	Chrząstowo
1997	IV	4.7	5.0	20.7	28.7	74	76
	V	11.7	12.1	96.5	80.1	78	77
	VI	15.9	15.9	36.7	85.9	76	76
	VII	17.7	17.7	108.5	110.9	78	79
1998	IV	9.3	9.2	21.1	34.0	72	82
	V	13.8	13.6	46.4	57.8	69	75
	VI	16.5	16.6	94.7	83.1	93	73
	VII	16.6	16.7	96.0	100.6	95	75
1999	IV	8.6	9.8	62.1	83.5	78	77
	V	12.1	14.0	45.5	45.6	64	70
	VI	16.5	17.7	58.6	53.6	73	72
	VII	20.0	21.5	43.9	36.8	81	75
1997–1999	IV	7.5	8.0	34.6	48.7	75	78
	V	12.5	13.2	62.8	61.2	70	74
	VI	16.3	16.7	63.3	74.2	81	74
	VII	18.1	18.6	82.8	82.8	85	76

III. RESULTS

Soilborne diseases

The quality of stand affects the plant healthiness of roots and stem base. The occurrence of disease symptoms on barley roots was higher on average by 33% at Mochełek loca-

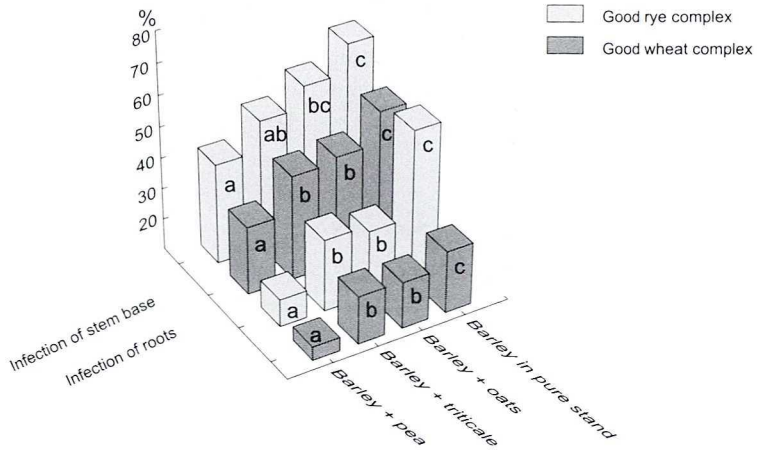

Fig. 1. Index of barley stem base and roots infection in stage of milk development
% – values of index infection, a, b, c – homogenous groups by Tukey-test

tion of poorer soil quality. The infection noted on barley stem base on a good rye soil was higher by 20% than on a good wheat soil. Investigations during the years 1997–1999 revealed that stem base rot of barley was markedly affected by mixed cropping (Fig.1). This tendency was observed on the both experiments. The frequency of stem with lesions caused by pathogens complex reached values 67.7% on the rye soil and 55.3% on wheat soil in homogenous stands. On barley cultivated in mixtures the stem rot diseases were significantly suppressed. The indexes of infections in barley mixed stands were smaller by 24.9% on the rye soil and smaller by 27.2% on the wheat complex, than in the pure stands. Significant and the smallest infection was observed in inter-row cultivation of barley with pea. More distinct differences between the objects were noted according to the degree of infection on the barley roots. Under the conditions of rye soil, a significantly favourable effect of pea on the limitation of the barley roots diseases was noted about 68%. Under the conditions of wheat soil in the same object the symptoms on barley roots were limited about 52%. The cereal mixed stands with barley revealed the restriction of soilborne pathogens on it root in similar (20%) degree (Fig. 1).

Foliar diseases

Leaf diseases were caused by pathogen complex, among others by *Drechslera teres* and *D. graminea*, *Rhynchosporium secalis*, *Erysiphe graminis* and *Puccinia* spp.

The highest rate of *D. teres* and *D. graminea* infection was noted in pure-seeded barley in both of the study and amounted 59.1% and 41.9% in a rye and wheat soil, respectively (Fig. 2a). Significant and the smallest infection was observed in the mixtures with pea, but on the wheat soil the index of infection on this object did not differ from the indexes of cereal stands. The average level of the restriction of leaf net and stripe diseases due to intercropping reached 45.9%.

The severity of rust pathogens on barley, merely caused by *Puccinia graminis* and *P. hordei* reached mean values of 37.5% on the leaves in homogenous stand cultivated on wheat soil. Only in mixtures with oat or triticale disease development was significantly suppressed (33% lower). Index of infection in mixtures with pea was comparable to those in sole stand. On the poor soil there was no significant differences between objects (Fig. 2b).

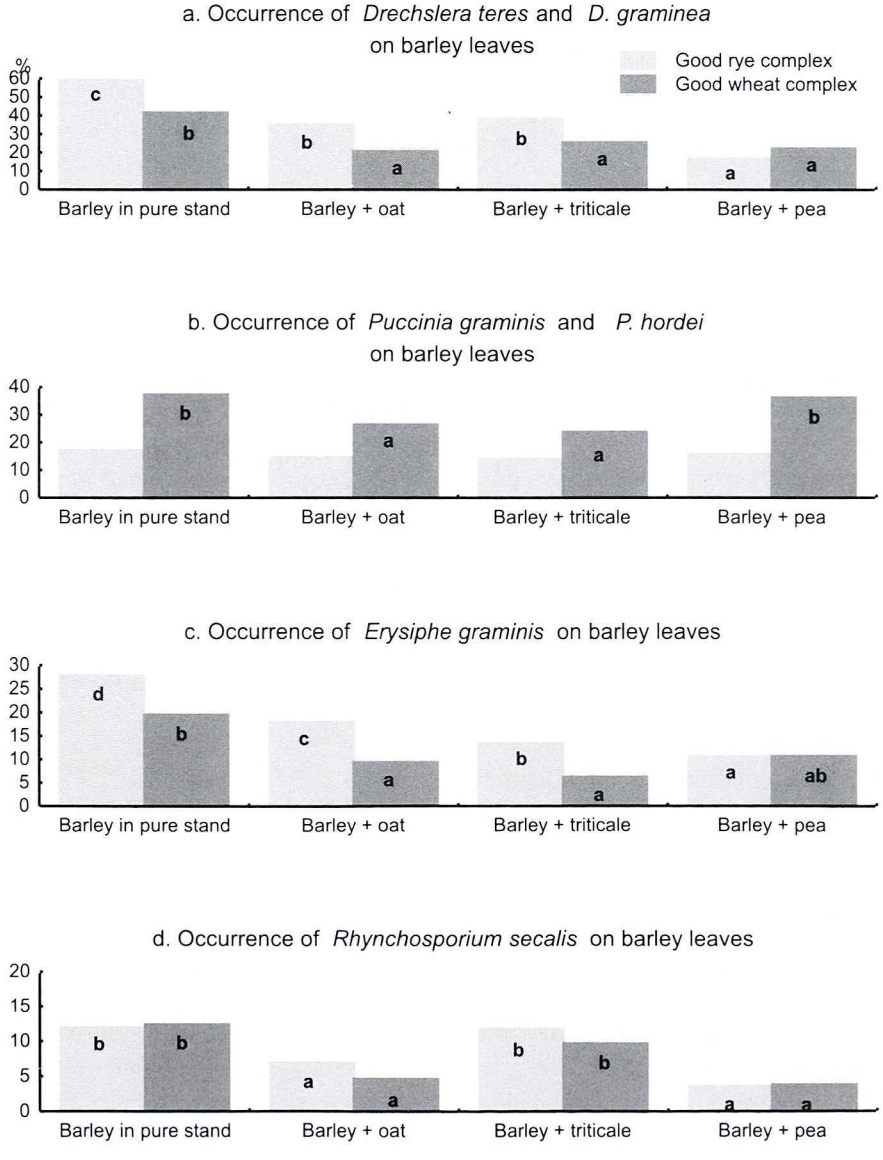

Fig. 2. Indexes of barley leaves infection
% – values of index infection, a, b, c – homogenous groups by Tukey-test

This "mixtures effect" might be responsible also for the disease development of *Erysiphe graminis* and *Rhynchosporium secalis* on barley grown in mixtures. The occurrence of scald disease was noted in studied species in slightly or moderately severity (from 3.6% to 12.5% depending on stand and objects). Only the mixed with non-host plants, such as oat and pea, restricted the development of this pathogens. The cultivation of barley with triticale had similar values of index as barley in pure stand (Fig. 2d). Mixed culture with other cereals or pea reduced powdery mildew infection on barley significantly, especially on the wheat soil. As advantage species mixtures contain genetic barriers in the form of non-host plants, therefore host-component might be less infested by powdery mildew than those cultivated in sole crop. In this study the infection due to *E. graminis* on barley leaves was restricted in average 10 percentage points (Fig. 2c).

IV. DISCUSSION AND CONCLUSION

The quality of stand affects the plants in a complex way, i.e. yield-promoting and yield-protecting. The yield-protecting role of soil is mainly because of pathogen limiting factors (Adamiak and Adamiak 1994; Wenda-Piesik and Lemańczyk 1997). In the experiment carried out on a good soil a much better health status of spring barley was noted than on a poor soil. Dilution of cultivation of spring cereals because of mixed seeding with other species is favourable for their healthiness (Gacek et al. 1997; Kurowski et al. 1998; Wenda-Piesik and Rudnicki 2000). The meaning of iner-row cultivation of multi-species mixtures in limiting the presence of fungal diseases seems to be particularly important for poor soils. The healthiness of barley roots and the base of stems in mixtures with pea appeared to be much better than in the mixtures consist of cereals and in the sole stand. Vilich-Meller (1992) has also described the variation in infestation of stem rot diseases on barley between cereals mixed compositions.

The incidences of plants with fungal lesions caused by *E. graminis*, *D. graminea* and *D. teres* were less with the less air moisture conditions in Chrząstowo during June and July. The higher rainfall and air moisture, presumably, are responsible for the foliar diseases development, just the same quality of soil is responsible for the roots and stems base infection. The mixtures with host and non-host plants may restrict spread of some foliar diseases. In presented experiments the significant restriction of foliar diseases, reached the rate of 45.9%, was obtained in the case of *Drechslera teres* and *D. graminea*. Two-years development of *D. graminea* and the lack of secondary leaf infection exclude the opportunity of stripe symptoms restriction by intercropping such as mixture. In the cases of *Erysiphe graminis* and *Rhynchosporium secalis* average decrease of their severity was lower by 35% in the mixed than in the pure stands. This finding is in agreement with the conclusions of Karjalainen and Jokinen (1993). Barley plants cultivated with cereals only on wheat soil were less infested by *Puccinia graminis* and *P. hordei* than those cultivated in sole stand or in the mixtures with pea. The occurrence of rust on the rye soil did not confirm differing between objects.

V. REFERENCES

1. Adamiak E., Adamiak J. 1994. Reakcja owsa na udział zbóż w płodozmianie i na monokulturę. Zesz. Nauk. ATR 187 – Rolnictwo (35): 53–60.
2. Behnke M., Kaczyński L., Lewandowska B., Zych J. 1996. Zboża jare – synteza wyników doświadczeń odmianowych 1996. COBORU, z. 1090: 23–47.
3. Cousens R.D. 1996. Comparative growth of wheat, barley, and annual ryegrass (*Lolium rigidum*) in monoculture and mixture. Aust. J. Agric. Res., 47 (3): 449–464.
4. Creamer N.G., Bennett M.A., Stinner B.R., Cardina J., Regnier E.E. 1996. Mechanism of weed suppression in cover crop-based production systems. HortScience 31 (3): 410–413.
5. Elmstrom K.M., Andow D.A., Barclay W.W. 1988. Flea beetle movement in a broccoli monoculture and diculture. Environ. Entomol., 17, 2: 299–305.
6. Standards OEPP/EPPO. 1997. Guidelines for the efficacy evaluation of plant protection products, vol. 2: 30–113. Fungicides and bactericides. EPPO
7. Gacek E., Czembor H., Nadziak J. 1997. Zastosowanie mieszanin odmian do poprawy zdrowotności oraz wysokości plonowania pszenicy ozimej. Biul. IHAR 201: 81–93.
8. Karjalainen R., Jokinen K. 1993. Influence of barley scald disease on yield and competition in barley-oat mixtures. J. Agron. Crop Sci., 171: 314–320.
9. Kurowski T.P., Nowicki J., Wanic M. 1998. Choroby jęczmienia jarego i owsa w siewie czystym i mieszanym. Fragm. Agronom., XV 4 (60): 25–35.
10. Łacicowa B., Kiecana I., Pięta D. 1991. Health status of spring barley in crop rotations of different share of cereals with regard to chemical protection. Phytopath. Pol., 1 (XII): 50–53.
11. Ponchet J. 1958. La prevision des epidemies du pietin-verse *Cercosporella herpot*. Fron. Phytiatr. Phytopharm., 7, 133 pp.
12. Stolen O., Hermansen J.E., Lohde J. 1980. Varietal mixtures of barley and their ability to reduce powdery mildew and yellow rust diseases. Kgl. Vet. Og. Landbohojsk. Arsskr: 109–116.
13. Vilich-Meller V. 1992. *Pseudocercosporella herpotrichoides*, *Fusarium* spp. and *Rhizoctonia cerealis* stem rot in pure stands and interspecific mixtures of cereals, Crop Prot., 11: 45–50.
14. Wenda-Piesik A., Lemańczyk G. 1997. Health status of lower stem and roots of spring barley and oat cultivated in pure stand and in mixture with leguminous plants. J. Appl. Genet., 38B: 87–96.
15. Wenda-Piesik A., Rudnicki F. 2000 Występowanie niektórych agrofagów pszenżyta jarego uprawianego w siewie czystym i w mieszankach. Fol. Univ. Agric. Stetin., 206 Agricultura (82): 303–311.
16. Willey R.W. 1979. Intercropping – Its importance and research needs. Part 1. Competition and yield advantages. Commonwealth Bureau of Pastures and Field Crops. Field Crop Abstracts 32 (1): 1–10.
17. Wolfe M.S. 1985. The current status and prospects of multiline cultivars and variety mixtures for disease resistance, Ann. Rev. Phytopatol., 23: 251–273.
18. Wolfe M.S. 1990. Intra-crop diversification: disease, yield and quality. Crop Protection in Organic and Low Input Agriculture. BCPC Monogr., 45: 105–114.

VI. POLISH SUMMARY

STAN ZDROWOTNY JĘCZMIENIA JAREGO UPRAWIANEGO W SIEWIE CZYSTYM I W MIESZANKACH Z ROŚLINAMI ZBOŻOWYMI LUB STRĄCZKOWYMI

W latach 1997–1999 prowadzono obserwacje stanu zdrowotnego jęczmienia jarego uprawianego w dwuskładnikowych mieszankach ze zbożami lub z grochem siewnym.

Znacznie lepszy stan zdrowotny u badanego gatunku stwierdzono w uprawach mieszanych niż w siewie czystym. Dwuskładnikowe mieszanki istotnie różniły się między sobą występowaniem objawów powodowanych przez: *Drechslera teres*, *Drechslera graminea*, *Puccinia graminis* i *P. hordei*, *Rhynchosporium secalis* i *Erysiphe graminis*. Zdrowotność podstawy źdźbła i korzeni jęczmienia jarego zależała zarówno od jakości stanowiska, jak i uprawy w mieszankach. Wyższe porażenie przez kompleks patogenów zgorzelowych stwierdzano na słabszej glebie w siewach jednogatunkowych.