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REDUCTION OF CHEMICAL CONTROL IN WINTER BARLEY CULTIVAR MIXTURES

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Abstract: Monoculture of modern cereal crops are popular due to the technical and organizational reasons. They are easier in crop husbandry, quality and product use. However, in monoculture chemical protection of crops is a norm, due to the fact that they are more susceptible to diseases, pests and sometimes weed infestation. In order to keep high and stable grain yields and quality in monoculture one has to use high inputs. Experimentally and practically it has been proved that cultivar and species mixtures can constitute an alternative to cultivar growing in pure stands. It has been found that in mixtures opperate different epidemiological and ecological factors, which lead to considerable disease reduction, pest and weed control, which finally result in higher and more stable grain yields than in barley varietes grown in pure stands.
The results of two years field experiment designed to evaluate epidemiological and economical effects of winter barley cultivar mixtures are presented. The studies were carried out in two sites – Experimental Station for Variety Testing Słupia Wielka (in Wielkopolska region) and Plant Breeding Station Bąków (Opole District). This two sites were 300 km away from each other, and had different soil and meteorological conditions. In the experiment impact of different barley cultivars and their different two- and three-component mixtures were tested with reduced dosages of fungicidies on grain yield in the mixtures compared with pure stands were evaluated.

Key words: pro-ecological agriculture, cultivar mixtures, winter barley

INTRODUCTION

Appropriate mixtures of winter barley cultivar can considerably restrict the development of powdery mildew (*Blumeria graminis* f. sp. *hordei*) and to some extent other airborne diseases (Gacek et al.1996). Cultivar mixtures can provide functional diversity that limits pathogen and pest expansion, and that makes use of knowledge about interactions between hosts and their pests and pathogens to direct pathogen evolution. Indeed, one of the most powerful ways to reduce risk of resistance break-down and to still make use of defeated resistance genes is to use cereal variety and species mixtures. (Finckh et al. 1999; Finckh et al. 2000).

The results of two years field experiments designed to evaluate epidemiological and economical effects of winter barley cultivar mixtures are presented. The aim of the studies was to evaluate the possibility of reduction of powdery mildew (*Blumeria graminis* f. sp. *hordei*) and its effect on grain yield in winter barley, both through growing cultivar mixtures in combination with fungicide reduced use.

MATERIAL AND METHODS

In the growing seasons 2001/2002, two experiments with winter barley cultivar mixtures combined with different treatments with fungicides were done in two sites, namely in the Experimental Station for Variety Testing (ESVT) Słupia Wielka (Wielkopolska District) and the Plant Breeding Station (PBS) Bąków (Opole District).

During the growing season 2002/03 the studies were carried out in one place – ESVT Słupia Wielka. The experiment in PBS Bąków was completely destroyed by late frost in the spring (March). In the experiment at Słupia Wlk., because of late frost, 25% of plots were destroyed. Because of this, in the second vegetation season there were no statistical analyses.

In the experiments, four different winter barley cultivars and composed of them two- and three-component mixtures were tested on 10 m^2 plots in four replicates. The winter barley cultivars, were: Bombay, Gil, Gregor and Bażant, and the following mixtures: Bombay/Gil, Bombay/Gregor and Gil/Gregor/Bażant.

On the experimental plots different treatments with fungicides were used, namely:

– untreated plots (control)
– one treatment with 0.25 recommended dosage of fungicides
– one treatment with 0.5 recommended dosage of fungicides
– one treatment with full recommended dosage of fungicides
– two treatments with 0.25 recommended dosages of fungicides
– two treatments with 0.5 recommended dosages of fungicides
– two treatments with full recommended dosages of fungicides

The grain yield from all the experimental plots was measured and statistically evaluated. During the vegetation season powdery mildew observations were done 3–5 times using 1–9 scale (where 9 – fully resistant, 1 – fully susceptible).

In order to compare the disease occurrence levels on different cultivars in pure stands and on their mixtures combined with different fungicide treatments the Area Under Disease Progress Curve (AUDPC) (Finckh et al. 1997) was evaluated.

The results were statistically evaluated. In the variance analysis the site effect was treated as the random effect. Tukey's test (p=0.05) was used for multiple comparing.

Combination and timing of fungicide use in testing sites (growing season 2001/02)

Chemical treatment	Słupia Wielka (site 1) (date/applied chemicals)	Bąków (site 2) (date/applied chemicals)
First treatment (beginning of shooting)	07.05.2002 (Amistar 250 SC + Tilt Plus 400 EC – 0.6 l/ha)	09.05.2002 (Amistar 250 SC + Tilt Plus 400 EC – 0.6l/ha)
Second treatment (full shooting)	14.05.2002 (Amistar 250 SC – 0.6 l/ha)	16.05.2002 (Amistar 250 SC – 0.6 l/ha)

Combination and timing of fungicide use in testing sites (growing season 2002/03)

Chemical treatment	Słupia Wielka (site 1) (date/applied chemicals)
First treatment (beginning of shooting)	12.05.2003 (Amistar 250 SC + Tilt Plus 400 EC – 0.6 l/ha)
Second treatment (full shooting)	20.05.2003 (Amistar 250 SC – 0.6 l/ha)

RESULTS AND DISCUSSION

In the vegetation periods 2001/2002 and 2002/2003, due to adverse weather conditions, generally low incidence of powdery mildew was observed. Nevertheless, there were seen some differences between cultivars and their mixtures (Tabs. 1, 2). In general, cultivar mixtures were less affected by the disease than pure stands both on plots without – and with fungicide control. In 2001/2002 cultivar Gil was the most severely infected, whereas cultivar Gregor was the least infected in both sites. In 2002/2003 cultivar Bażant was the most severely infected, whereas cultivar Gregor was the least infected.

The development of powdery mildew in different treatments was analysed on the basis of the Area Under Disease Progress Curve (AUDPC). There were no interactions beetwen chemical treatments and cultivars in pure stands or their mixtures.

Table 1. Average size of the Area Under Disease Progress Curve (AUDPC) (average from two sites) – 2001/2002

Number of sprays	Dosage of fungicide	Area Under Disease Progress Curve							Average
		Bombay	Gil	Gregor	Bażant	Bombay + Gil	Bombay + Gregor	Gil + Gregor+ Bażant	
–	untreated	104.6	238.4	75.9	98.7	117.1	82.7	92.3	115.7 a
1	0.25 dosage	86.1	127.7	44.6	69.2	77.6	66.7	61.6	76.2 bc
1	0.5 dosage	98.5	136.2	53.8	74.1	75.3	70.3	81.8	84.3 ab
1	full dosage	93.2	131.7	62.1	69.9	112.2	68.1	65.7	86.1 ab
2	0.25 dosage	84.4	117.4	41.6	53.2	76.2	51.2	59.5	69.1 bc
2	0.5 dosage	84.7	104.2	42.3	53.2	76.5	48.4	56.0	66.5 bc
2	full dosage	69.9	85.1	39.6	42.6	55.0	44.6	40.6	48.1 c

Replication of letter denotes the absence of significant differences beetwen compared averages – Tukey's test, p=0.05

Table 2. Average size of the Area Under Disease Progress Curve (AUDPC) – Słupia Wielka – 2002/2003

Number of sprays	Dosage of fungicide	Area Under Disease Progress Curve						
		Bombay	Gil	Gregor	Bażant	Bombay + Gil	Bombay + Gregor	Gil + Gregor + Bażant
–	untreated	84.2	72.5	76.0	168.3	101.6	65.2	114.4
1	0.25 dosage	78.8	57.0	48.9	129.0	57.0	76.0	93.5
1	0.5 dosage	104.8	43.4	43.4	259.6	43.4	84.2	178.1
1	full dosage	62.5	57.0	62.5	125.1	54.3	84.4	93.5
2	0.25 dosage	76.0	43.4	51.6	128.6	48.9	54.3	93.5
2	0.5 dosage	57.0	43.4	48.9	128.6	54.3	57.0	93.5
2	full dosage	47.5	43.4	51.6	118.3	53.6	57.7	94.6

Statistically, there were high significant differences (AUDPC) beetwen chemical treatments, and there were no differences beetwen cultivars in pure stands and their mixtures (Tab. 1).

The reduction of powdery mildew in the mixtures occurring due to epidemiological and ecological factors functionning in mixed stands (Wolfe et al. 1975) were also evaluated (Tabs. 3, 4). The biggest and most frequently occurring disease re-

Table 3. Powdery mildew reduction according to the Area Under Disease Progress Curve – 2001/2002

Number of sprays	Dosage of fungicide	Słupia Wielka			Bąków		
		Bombay + Gil	Bombay + Gregor	Gil + Gregor + Bażant	Bombay + Gil	Bombay + Gregor	Gil + Gregor + Bażant
–	untreated	33.8	4.1	35.0	18.7	7.3	11.5
1	0.25 dosage	36.1	20.4	27.2	no reduction	no reduction	10.1
1	0.5 dosage	47.9	no reduction	28.6	4.9	16.4	no reduction
1	full dosage	10.8	20.2	50.4	no reduction	no reduction	no reduction
2	0.25 dosage	5.2	26.8	13.9	30.8	no reduction	17.8
2	0.5 dosage	24.5	25.2	15.9	no reduction	18.1	10.2
2	full dosage	38.1	24.3	21.5	9.3	no reduction	33.3

Table 4. Powdery mildew reduction according to the Area Under Disease Progress Curve – 2002/2003

Number of sprays	Dosage of fungicide	Słupia Wielka		
		Bombay + Gil	Bombay + Gregor	Gil + Gregor + Bażant
–	untreated	no reduction	16.52	no reduction
1	0.25 dosage	14.57	no reduction	no reduction
1	0.5 dosage	40.23	no reduction	no reduction
1	full dosage	7.14	no reduction	no reduction
2	0.25 dosage	18.02	12.51	no reduction
2	0.5 dosage	no reduction	no reduction	no reduction
2	full dosage	no reduction	no reduction	no reduction

duction was observed in three-component mixture (Gil + Gregor + Bażant) in 2001/02. In the growing season 2002/2003 disease reduction was observed in two-component mixtures.

As far as the grain yield is concerned, sometimes yield grain was observed in the mixtures compared with pure stands (mixing effect). Futhermore yield increase was also observed between treated – and untreated plots (chemical control effects) (Tabs. 5, 6). Statistically, there were no interactions beetwen cultivars in pure stands, their mixtures and chemical treatments. There were no significant differences for cultivars in pure stands, their mixtures and for chemical treatments separately (Tab. 5).

Table 5. Yield (dt/ha) of pure cultivars and mixtures with different combinations of chemical control (average from two sites) – 2001/2002

Number of sprays	Dosage of fungicide	Cultivars/Mixtures							Average
		Bombay	Gil	Gregor	Bażant	Bombay + Gil	Bombay + Gregor	Gil + Gregor+ Bażant	
–	untreated	67.0	69.5	68.0	72.4	69.0	66.6	68.6	68.7 b
1	0.25 dosage	76.2	79.2	78.1	80.9	77.8	76.3	79.5	78.3 ab
1	0.5 dosage	76.6	77.8	77.6	81.2	75.3	80.5	79.6	78.4 ab
1	full dosage	76.2	78.7	78.0	79.9	82.7	77.0	77.0	78.5 ab
2	0.25 dosage	77.6	81.0	78.6	78.4	80.1	77.5	81.4	79.2 ab
2	0.5 dosage	77.4	81.7	84.7	81.3	83.8	81.7	82.2	81.1 a
2	full dosage	85.1	86.0	93.6	89.4	86.7	82.1	86.0	87.0 a

Explanation – see table 1

Table 6. Yield (dt/ha) of pure cultivars and mixtures with different combinations of chemical control – 2002/2003

Number of sprays	Dosage of fungicide	Cultivars/Mixtures						
		Bombay	Gil	Gregor	Bażant	Bombay + Gil	Bombay + Gregor	Gil + Gregor+ Bażant
–	untreated	68.1	61.1	56.1	70.9	69.3	66.5	73.7
1	0.25 dosage	68.9	65.4	65.1	68.6	68.3	66.9	72.3
1	0.5 dosage	70.6	69.5	67.7	71.6	71.0	72.6	74.7
1	full dosage	74.6	67.2	68.4	76.9	70.7	69.4	77.2
2	0.25 dosage	69.5	61.0	61.0	79.1	76.3	65.9	78.7
2	0.5 dosage	65.8	66.7	66.7	75.4	68.9	73.8	78.9
2	full dosage	78.5	69.3	69.3	70.2	73.3	75.1	75.5

CONCLUSIONS

1. Generally speaking winter barley cultivar mixtures were less infected by powdery mildew (*Blumeria graminis* f. sp. *hordei*) than cultivars grown in pure stands.
2. Meteorological conditions in growing seasons had essential influence on experiment results.

3. In the growing season 2001/2002 the highest and most frequently occurring reduction of powdery mildew were observed in more genetically diverse three-component mixture (Gil + Gregor + Bażant).
4. In the growing season 2002/2003 the highest and most frequently occurring reduction of powdery mildew were observed in two-component mixtures.
5. The positive effect of combination of genetical disease control (cultivar mixtures) with chemical disease control (reduced doses) was found.
6. Cultivar mixtures combined with reduced fungicide treatments apart of their influence on powdery mildew reduction at the same time had a positive effect on grain yield in winter barley cultivars, and especially in their mixtures.
7. The results of the study show that the combination of cultivar mixtures with reduced use of fungicides can be regarded as a low – input and enviroment – friendly method of winter barley growing.

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POLISH SUMMARY

REDUKCJA OCHRONY CHEMICZNEJ W MIESZANINACH JĘCZMIENIA OZIMEGO

Systemy ochrony roślin uprawnych powinny obejmować wszystkie dostępne metody zwalczania, przy jednoczesnym wykorzystaniu naturalnych procesów samoregulacji zachodzących w agroekosystemach i celowym wspomaganiu tych procesów. Z dotychczasowej praktyki wynika, że im bardziej rośliny uprawne są zróżnicowane pod względem odporności genetycznej, tym mniejsze ryzyko wystąpienia epidemii. W praktyce produkcyjnej pożądany poziom różnorodności biologicznej na polach uprawnych można osiągnąć m.in. poprzez uprawę zasiewów mieszanych. Przedstawione wyniki prezentują dane z cyklu badań nad gospodarczymi i środowiskowymi efektami uprawy mieszanin odmian jęczmienia ozimego.

Badania są przeprowadzane w dwóch miejscowościach: Stacja Doświadczalna Oceny Odmian Słupia Wielka i Hodowla Roślin Smolice O/Bąków.

Oceniono zdrowotność czterech odmian jęczmienia ozimego wysianych w siewie czystym oraz mieszankach dwu- i trójskładnikowych ze sterowanym (różna ilość zabiegów i różne dawki preparatu chemicznego) zastosowaniem fungicydów.

Na podstawie wyników z sezonu wegetacyjnego 2001/2002 i 2002/2003 przeprowadzono analizę porównawczą porażenia mączniakiem prawdziwym (*Blumeria graminis* f. sp. *hordei*) oraz plonowania w zasiewach mieszanych i na odmianach czystych.

Book Review

K. O. Britton (ed.). 2004. Biological Pollution: An Emerging Global Menace. APS Press – The American Phytopathological Society, St. Paul, Minnesota (USA), 113 pp.

In the "Preface" (p. IV–V) the editor associated with the USDA Forest Service emphasizes that during the last few decades biological pollutants – due to unwise human activities – create a bigger hazard than chemical pollutants. In fact, production and/or use of chemical pollutants can be reduced or prevented by quick administrative decisions. On the contrary, this is not the case with biological pollutants, being the living organisms, which grow, multiply and spread by themselves.

The book consists three parts which provide answers to three questions and topics: (1) "What is the problem?"; (2) "Weeds, diseases and other pests"; (3) "What is to be done?".

The part titled "What is the problem?" (p. 1–27) contains three chapters.

Chapter 1. "Controlling biological pollution" by K.O. Britton (p. 1–7) enlightens the role of agricultural activities in spreading unintentionally weeds and plant pests and pathogens to regions where they create serious environmental problems.

Chapter 2. "An ecological explosion in slow motion" by R.G. Westbrooks and P. White (p. 8–13) presents several examples of economic losses in agriculture, forestry or in environment due to intended or unintended introduction of 4500 plant and or animal species to the North America e.g. bird *Sturnus vulgaris* or plant *Solanum viarum*.

Chapter 3 "Exotic Pests: Past, Present, and Future" by P.N. Windle (p. 17–27) provides quantitative data on introductions of exotic species to North America in the following categories: plants and plant pathogens, terrestrial vertebrates, fishes, mollusks and insects. Economic and environmental implications of such introductions are discussed.

Part "Weeds, diseases, and other pests" (p. 28–70) contains three chapters concerning important categories of weeds, pests and plant diseases.

Chapter 4. "Exotic weeds: expensive and out of control" by R.G. Westbrooks and R.E. Epple (p. 28–35) indicates that losses due to exotic weeds exceed 20 billions of dollars in the USA. Preventive and control measures conducted by governmental agencies are reviewed e.g. biological control of weed *Euphorbia esula*.

Chapter 5. "Plant diseases on the move" by K.O. Britton et al. (p. 36–50) reviews economic impacts and control of such important plant diseases as potato blight (*Phytophtora infestans*), chestnut blight (*Cryphonectria parasitica*), pine blister rust (*Cronartium ribicola*), Dutch elm disease (*Ophiostoma ulmi*), plant viruses transmitted by *Bemisia tabaci*.

Chapter 6. "Plant parasitic nematodes which are exotic pests in agriculture and forestry" by L.D. Dwinell and P.S.. Lehman (p. 51–70) reviews such quarantine nematodes as *Globodera rostochiensis, G. pallida*, *Bursaphelenchus xylophilus*, *Heterodera glycines*, *Radopholus similis* and others. Costs and benefits of excluding nematodes has been discussed.

Part three "What is to be done?" contains four chapters.

Chapter 7 "Meeting the threat: risk assessment and quarantine" by M.H. Royer and E. Podlecki (p. 71–81) explains the procedure of "pest risk analysis" applied by the USDA in establishing of import and export regulations preventing invasion or introduction of quarantine pests.

Chapter 8. "Assessing exotic threats to forest resources" by W.E. Wallner (p. 82–95) reviews various measures preventing introduction/invasions of insects, pathogens and weeds dangerous to forests in the Northern America. Special attention was given to insects such as *Lymantria monacha*, *L. dispar* and *Anophophora glabripennis*.

Chapter 9. "Political and economic barriers to scientifically based decisions" by F.T. Campbell (p. 96–101) critically reviews the United States Government policies concerning plant quarantine.

Chapter 10. "Fighting back" by K.O. Britton (p. 102–113) discusses problems of forest quarantine and plant protection in terms of "think globally" but "act locally" what means that there must be a good legislation but also effective endorsement of available regulations in all countries participating in the trade of agricultural and forestry products.

I strongly recommend this book to all persons concerned with agricultural, forestry and environmental topics.

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