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THE EFFECT OF ADJUVANTS AND REDUCED RATES OF CROP PROTECTION AGENTS ON WEED INFESTATION, HEALTH AND LODGING OF SPRING BARLEY (*Hordeum sativum* L.)

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Abstract

A field experiment in the cultivation of spring barley was carried out in the period 2007-2009 at the Experimental Farm in Czesławice (central Lublin region) on grey-brown podzolic soil derived from loess (soil quality class II). The study involved 3 rates of herbicides, growth retardant and fungicides (100%, 75%, 50%) as well as different adjuvant types (oil, surface-active, mineral adjuvant). Plots without any adjuvant were the control treatment. Conventional tillage was used, while mineral fertilization was adjusted to high initial soil nutrient availability.

A hypothesis was made that the reduction of pesticide rates by 25-50%, with the simultaneous addition of adjuvants, would allow health, weed infestation and lodging of spring barley to be maintained at a level similar to that obtained under the conditions when maximum rates are applied without any adjuvant. It was also assumed that particular adjuvants could show different interactions with the tested groups of crop protection agents. It was proved that the application of full recommended rates of pesticides gave the best values of the indicators relating to weed infestation, health and lodging of spring barley. However, thanks to the addition of adjuvants to the spray solution, the application of pesticide doses reduced by 25% produced similar results. A higher reduction of pesticide rates (by 50%) had an adverse effect on the traits in question. In such case, there was noted higher weed infestation of the spring barley crop, compensation of some weed species, and increased stem-base infection by the fungal disease complex. On the other hand, less radical changes were observed in the case of spring barley lodging. The above-mentioned situation occurred in spite of the fact that the action of pesticides was aided by adjuvants. From the group of adjuvants under comparison, the oil adjuvant Atpolan 80 EC showed the best interaction with the crop protection agents under consideration.

Key words: spring barley, pesticide rates, adjuvants, weed infestation, stem-base disease index, lodging

INTRODUCTION

A trend towards a reduction in the use of crop protection agents by 25% up to 50% has been observed in many countries in recent years. This is associated with attempts to reduce the amount of biologically active substances introduced every year into crop fields in the form of pesticides (Praczyk, 2001; Woźnica, 2003). Lowering doses of crop protection agents used involves the risk of decreased grain yields or deteriorated grain quality as a result of crop lodging, increased weed infestation, or increased plant diseases caused by fungal pathogens (Pawłowska et al. 1999; Wesołowski et al. 2005). In order to prevent these consequences, it is advisable to improve the effectiveness of the performance of reduced rates of pesticides by combining them with adjuvants. These are biologically inactive substances used as aiding agents. They lower the surface tension of the spray solution, improve the uniform coverage of the leaf surface, facilitate better uptake of pesticides by the plant and their penetration into it, increase adhesion of the spray solution to the plant surface, and prevent crop protection sprays from being washed away by rain. Some adjuvants increase the weight of spray drops and thus reduce their movement by the wind or air currents (Nalewaja et al. 1996; Gaskin et al. 2000; Woźnica et al. 2003, 2004). The addition of adjuvants to the spray liquid improves the effectiveness of the treatment eliminating agricultural pests and can compensate the reduced dose of an active substance (Koziara, 2004; Kierzek and Ratajkiewicz, 2004).

Most adjuvants are products intended for use mainly with herbicides, and only few of them can be applied with other plant protection agents (Holloway et al. 2000). The application of lower doses of chemicals serves to maintain the intensity of infestation by an agricultural pest at a level at which its harmfulness does not exceed the threshold of economic harmfulness, that is, it does not pose a threat to crops and does not cause losses of economic importance (P r a c z y k , 2001; W o ź n i c a , 2003).

In the present study, a hypothesis was made that the reduction of pesticide rates by 25-50%, with the simultaneous addition of adjuvants, would allow health, weed infestation and lodging of spring barley to be maintained at a level similar to that obtained under the conditions when maximum rates are applied without any adjuvant.

The aim of the present study was to determine the effect of reduced rates of herbicides, fungicides and growth retardant as well as three adjuvant types on selected indicators for spring barley health, weed infestation, and lodging.

MATERIALS AND METHODS

The field experiment in the cultivation of spring barley (*Hordeum sativum* L.), cv. 'Justina', was carried out in the period 2007-2009 at the Czesławice Experimental Farm belonging to the University of Life Sciences in Lublin. It was set up as a split-block design with 3 replications, in 27 m^2 plots. The experiment was established on grey-brown podzolic soil derived from loess, classified as good wheat complex. Sugar beet was the forecrop for spring barley. Mineral fertilization, adjusted to high soil nutrient availability, was applied at the following rates, calculated on a per hectare basis: N – 60 kg; P_2O_5 – 50 kg; K_2O – 80 kg. The study investigated the following types of adjuvants: A – control treatment (without any adjuvant); B – surface-active adjuvant Break Thru S 240 (1.5 l×ha^{-1}); C – oil adjuvant Atpolan 80 EC (1.5 l×ha^{-1}); D – mineral adjuvant – ammonium sulphate (10% solution – 1.5 l×ha^{-1}), as well as 3 rates of herbicides, growth retardant, and fungicides (100%, 75%, and 50%). The following pesticides were applied: herbicides Chwastox Turbo 340 SL (active substance MCPA + dicamba) + Puma Uniwersal 069 EW (fenoxaprop-P-ethyl + mefenpyr-diethyl) – 2.0 + 1.0 l×ha^{-1} (100% rate), 1.5 + 0.75 l×ha^{-1} (75% rate), 1.0 + 0.5 l×ha^{-1} (50% rate) – in the spring at the tillering stage BBCH 27-28; growth retardant (Cerone 480 SL 460 SL – ethephon) 1.0 l×ha^{-1} (100% rate), 0.75 l×ha^{-1} (75% rate), 0.5 l×ha^{-1} (50% rate) – at the stem elongation stage BBCH 31-32; fungicides Tilt Plus 400 EC (propiconazole + fenpropidin) and Alert 375 SC (flusilazole + carbendazim) at identical rates – 1.0 l×ha^{-1} (100% rate), 0.75 l×ha^{-1} (75% rate), and 0.5 l×ha^{-1} (50% rate). The fungicide Alert 375 SC was applied at the stem elongation stage BBCH 31-32, whereas Tilt Plus 400 EC at the stage BBCH 35-36. The crop protection agents were applied using a field sprayer under a pressure of 0.25 MPa.

The infection of barley plants by the stem-base disease complex was determined at the tillering stage (BBCH 28) and at the milk stage (BBCH 75). 50 plants were pulled out from each plot. After washing away the soil, the plants were divided, depending on the degree of stem-base infection, into groups according to the below scale:

Level of infection	% of the infected stem base
I	1 – 10
II	11 – 25
III	26 – 50
IV	51 – 75
V	76 – 100

Subsequently, the disease index was calculated for stem-base diseases in accordance with Mc Kinney-'s formula given by Ł a c i c o w a (1969).

Assessment of weed infestation of the spring barley crop was made at the dough stage (BBCH 83–85) using the botanical gravimetric method in test plots of 1 × 0.5 m, with two replications in each plot. Lodging of spring barley was estimated several days before harvest, using a 9-point scale.

The obtained results were statistically analysed using the analysis of variance and determining the significance of differences by Tukey's test (p = 0.05).

RESULTS AND DICUSSION

Infection of the spring barley plants by the stem-base disease complex at the tillering stage was low and ranged 2-5% (Table 1). It should be clearly indicated that at this growth stage the individual treatments differed only in the application of herbicide doses with adjuvants.

At the milk stage of spring barley, the application of the recommended (100%) rates of crop protection agents resulted in the stem-base disease index at a level of 12.3%, irrespective of the adjuvant (Table 2). The reduction of pesticide rates by 1/4 and 1/2 caused an increase in the spring barley stem-base disease index by, respectively, 4.8 and 13.2 percentage points. At the same time, the statistical analysis showed significant differences in stem-base infection of spring barley both between the treatments with 100% and 75% pesticide rates and between the treatments with 75% and 50% pesticide rates, irrespective of the adjuvant.

The addition of adjuvants to the spray solution, irrespective of the pesticide rate, contributed to a significant decrease in the stem-base disease index (on average by 8.3 percentage points) relative to the control plots. The statistically proven highest stem-base infection of the barley plants by the fungal disease complex was found in the case when the pesticide rates had been reduced by 1/2 and no adjuvant had been added to the spray solution.

The average number of weeds in the plots where the pesticide doses had been reduced by half was more than 5 times higher than in the case of application of 100% rates and nearly 4 times higher compared to that recorded in the case of the rate reduced by 25% (Table 3). The addition of adjuvants to the spray solution, irrespective of the pesticide rate, allowed a significant reduction in the number of weeds in the crop, respectively by 39% (Atpolan 80 EC), 34% (Break Thru S 240), and 29% (ammonium sulphate). Among the adjuvants under comparison, Atpolan 80 EC contributed to a significant decrease in the number of weeds in the crop (on average by 14%), compared to the mineral adjuvant. The significantly highest number of weeds in the spring barley crop was found when no adjuvant had been applied and the rates of crop protection agents had been reduced by 50%.

The highest air-dry weight of weeds in the spring barley crop was determined in the plots where the pesticide rates reduced by 50% had been applied, irrespective of the adjuvant (Table 4). It was nearly 13 times higher relative to the treatments with the 75% rate and more than 22 times higher compared to the 100% rate. The reduction of rates of crop protection agents by 50%, with no adjuvant, resulted in a significant increase in air-dry weight of weeds (75.4 g×m^{-2}). The addition of adjuvants to the 50% pesticide rate caused a decrease in weed weight to 25-31 g×m^{-2}. If the other pesticide rates were aided by adjuvants, the level of weed infestation of the cereal crop remained at a minimal level, in the range of 1.2-3.1 g×m^{-2}. Regardless of the spray liquid rate, the application of all three adjuvants resulted in a significant, more than twofold (Break Thru S 240, ammonium sulphate), and even threefold (Atpolan 80 EC), reduction of in-crop weed biomass compared to the control treatment.

A significant positive correlation was proved between air-dry weight of weeds and the incidence of fungal diseases damaging the stem base of spring barley at the milk stage in the treatment with the pesticide rates reduced by 1/2, irrespective of the addition of adjuvant. A significant positive correlation was also found between these traits in the case when the pesticide rates had been reduced by 25% and no adjuvant had been applied (Table 5).

The following weed species were predominant in the spring barley crops: *Viola arvensis, Stellaria media, Chenopodium album,* and *Capsella bursa-pastoris*, but greater species diversity and, at the same time, a lower total number of weeds were observed in the plots with the maximum pesticide rate. The reduction of rates of crop protection agents to 75% and 50% contributed to significantly lower species diversity relative to the 100% rate. Moreover, lowering the pesticide doses by half promoted the compensation of the dominant species in the crop, in particular the following: *Viola arvensis, Stellaria media, Capsella bursa-pastoris, Galium aparine, Galeopsis tetrahit* (Table 6).

Table 1.
Disease index for spring barley stem-base infection by the fungal disease complex (plants at the tillering stage) – mean for 2007–2009

Treatment	Pesticide rate			Mean
	100%	75%	50%	
A – Without adjuvant (control treatment)	3.6	4.2	5.0	4.3
B – Break Thru S 240 – surface-active adjuvant	3.2	3.9	4.5	3.9
C – Atpolan 80 EC – oil adjuvant	2.1	2.6	3.9	2.9
D – Ammonium sulphate – mineral adjuvant	3.5	4.2	4.4	4.0
Mean	3.1	3.7	4.4	–
LSD (0.05) for: rates = not significant; adjuvants = not significant				

Table 2.
Disease index for spring barley stem-base infection by the fungal disease complex (plants at the milk stage) – mean for 2007–2009

Treatment	Pesticide rate			Mean
	100%	75%	50%	
A – Without adjuvant (control treatment)	13.6	23.8	36.2	24.5
B – Break Thru S 240 – surface-active adjuvant	12.4	15.6	22.3	16.8
C – Atpolan 80 EC – oil adjuvant	10.2	13.1	20.8	14.7
D – Ammonium sulphate – mineral adjuvant	12.9	16.0	22.7	17.2
Mean	12.3	17.1	25.5	–
LSD (0.05) for: rates = 2.24; adjuvants = 2.04 interaction: rate × adjuvant = 8.14				

Table 3.
Number of weeds in the spring barley crop per 1 m² [pcs] – mean for 2007–2009

Treatment	Pesticide rate			Mean
	100%	75%	50%	
A – Without adjuvant (control treatment)	15.1	23.7	82.4	40.4
B – Break Thru S 240 – surface-active adjuvant	10.2	18.2	51.9	26.8
C – Atpolan 80 EC – oil adjuvant	8.8	15.8	49.6	24.7
D – Ammonium sulphate – mineral adjuvant	11.7	19.0	55.6	28.8
Mean	11.4	19.2	59.9	–
LSD (0.05) for: rates = 2.68; adjuvants = 3.06 interaction: rate × adjuvant = 9.24				

Table 4.
Air-dry weight of weeds in the spring barley crop per 1 m² [g] – mean for 2007–2009

Treatment	Pesticide rate			Mean
	100%	75%	50%	
A – Without adjuvant (control treatment)	2.4	3.9	75.4	27.2
B – Break Thru S 240 – surface-active adjuvant	1.9	2.8	28.6	11.1
C – Atpolan 80 EC – oil adjuvant	1.2	2.5	25.4	9.7
D – Ammonium sulphate – mineral adjuvant	1.8	3.1	31.3	12.1
Mean	1.8	3.1	40.2	–
LSD (0.05) for: rates = 4.31; adjuvants = 5.18 interaction: rate × adjuvant = 26.32				

Table 5.
Simple correlation coefficient (r) between air-dry weight of weeds and stem-base disease index at the milk stage – mean for 2007–2009

Treatment	Pesticide rate		
	100%	75%	50%
A – Without adjuvant (control treatment)	0.25	0.60*	0.83*
B – Break Thru S 240 – surface-active adjuvant	0.11	0.22	0.58*
C – Atpolan 80 EC – oil adjuvant	0.08	0.19	0.56*
D – Ammonium sulphate – mineral adjuvant	0.16	0.34	0.65*

*significant correlation coefficient (0.05)

Table 6.
Dominant weed species in the spring barley crop per 1 m² [pcs], irrespective of adjuvants – mean for 2007–2009

Species	Pesticide rate			Mean
	100%	75%	50%	
Chenopodium album L.	2.3	2.8	5.4	3.5
Viola arvensis Murray	2.1	3.0	11.8	5.6
Stellaria media (L.) Vill	2.0	3.9	10.3	5.4
Echinochloa crus-galli (L.) P. Beauv	0.8	1.8	2.7	1.7
Polygonum lapathifolium L.	0.7	1.1	2.3	1.4
Galinsoga parviflora Cav.	0.7	0.9	3.3	1.6
Capsella bursa-pastoris (L.) Medik	0.5	1.7	7.7	3.3
Matricaria maritima ssp. *inodora* (L.) Dostál	0.4	0.9	3.4	1.6
Galeopsis tetrahit L.	0.3	0.6	3.8	1.6
Galium aparine L.	0.2	0.5	5.1	1.9
Fallopia convolvulus (L.) Á. Löve	0.1	0.5	1.4	0.7
Lapsana communis L. S Str.	0.1	0.3	1.0	0.4
Apera spica-venti (L.) P. Beauv.	0.1	0.6	1.2	0.6
Other species	1.1	0.6	0.5	0.7
Number of species	18	15	14	–
LSD (0.05) for: rates = 1.7				

Table 7.
Spring barley lodging in a 1-9 scale – mean for 2007–2009

Treatment	Pesticide rate			Mean
	100%	75%	50%	
A – Without adjuvant (control treatment)	7.9	6.5	5.7	6.7
B – Break Thru S 240 – surface-active adjuvant	8.5	7.6	6.8	7.6
C – Atpolan 80 EC – oil adjuvant	9.0	8.2	7.7	8.3
D – Ammonium sulphate – mineral adjuvant	8.1	7.2	6.5	7.3
Mean	8.4	7.4	6.7	–
LSD (0.05) for: rates = 0.86; adjuvants = 0.81;				

[*]1 – complete lodging of the crop; 9 – no lodging

The analysis of the obtained results shows that extreme reduction (by 50%) of pesticide rates applied in spring barley crops promotes an increase in the number and weight of weeds in the crop, compensation of some weed species, and increased incidence of fungal diseases. In the opinion of some authors (Jastrzębska et al. 2001; Praczyk, 2001), the reduction of pesticide rates generally results in a decrease in cereal productivity as a result of increased occurrence of agricultural pests and adverse changes in the crop structure. In order to prevent it, pesticides should be combined with adjuvants (Woźnica, 2003). A beneficial effect of adjuvant application has been found particularly in relation to the efficacy of herbicides, but the reduction of their rates should not exceed 33% (Wesołowski et al. 2005; Kwiatkowski, 2010), which is confirmed by the results of the study under discussion.

In the case of very sensitive weeds or those that are at very early growth stages, the addition of an adjuvant does not usually produce noticeable effects (Adamczewski and Praczyk, 1995). According to some authors, in dense crops (e.g. in cereals) the destruction of all weeds is not always necessary. It is often sufficient to reduce their occurrence by 80-90%. The remaining weed individuals will be suppressed as a result of the competitive action of the crop plant (Kudsk, 1999; Woźnica, 2003). In the opinion of Błaszkowski and Piech (2002) as well as Domaradzki et al. (2002), weeds that are not destroyed completely can contribute to a significant decrease in yield, increased weed infestation of subsequent crops, and the development of fungal diseases. As a matter of fact, this latter aspect is confirmed by the results of the present study, since a significant positive correlation was proved between air-dry weight of weeds in the spring barley crop and the development of stem-base diseases.

In the experiment under discussion, the pesticide rates reduced by 25%, but aided by the action of an adjuvant, proved to be sufficient to effectively reduce the incidence of weeds in the spring barley crop and to prevent the development of fungal diseases attacking the stem base of this cereal plant. 75% of the rate of the growth retardant also allowed lodging of spring barley to be effectively prevented. In their experiment on potato, Wachowiak and Kierzek (2003) found fungicides to have the highest efficacy when they were applied at the full recommended rate. However, a similar fungi-killing effect was observed when a half dose of fungicides was applied with the addition of an adjuvant. Piekarczyk (2005) reports that, in a field with a low level of weed infestation, rates of the herbicides Aminopielik Super 464 SL and Chisel 75 WG reduced by 25%, and even 50%, with the addition of adjuvants, were sufficient to control weed infestation of spring barley and its yield at a level similar to treatments in which rates recommended by the manufacturers of these herbicides were applied. In the opinion of Kapeluszny (2002, 2003) as well as Haliniarz and Kapeluszny (2010), half of the recommended rate of the herbicide Chwastox Trio 540 SL can efficiently protect spring cereals against annual weeds, provided that these weeds are at early growth stages and herbicide treatment is carried out at evening hours.

It was proved in the present study that the reduction by 50% of rates of the herbicides Chwastox Turbo 340 SL and Puma Uniwersal 069 EW resulted in a significant increase in the quantitative indicators of weed infestation and led to compensation of most of the dominant weed species, in particular *Viola arvensis, Stellaria media, Capsella bursa-pastoris,* and *Galium aparine*. Domaradzki et al. (2003) are of different opinion demonstrating that *Stellaria media* is very sensitive to the herbicides Starane 250 EC, Chwastox Trio 540 SL, and Granstar 75 DF, irrespective of the growth stage and herbicide rate. *Galium aparine* was also effectively destroyed at all growth stages by the full dose of the herbicide Starane 250 EC as well as by rates reduced by 25% and 50%.

The average value of the index of spring barley lodging, for the whole study period, depended significantly on the rate of crop protection agents and adjuvant type (Table 7). The application of the recommended 100% rates of pesticides (including the growth retardant) effectively protected barley against lodging, irrespective of the adjuvant type. In such case, the degree of crop lodging (in a 1-9 scale) averaged 8.4, whereas in the treatments with pesticide rates of 75% and 50% it was significantly higher, respectively by 1.0 and 1.7 points. It should be noted that the addition of adjuvants to the spray solution applied at a rate reduced by 25% guaranteed the maintenance of the degree of lodging in the spring barley crop at a level similar (or even higher – Atpolan 80 EC) to that obtained as a result of the application of 100% rates without any adjuvant. Irrespective of the pesticide rate, the oil adjuvant Atpolan 80 EC had the most beneficial effect on the reduction of spring barley lodging. Under the conditions of application of this agent, the degree of crop lodging in the spring barley crop was significantly lower both compared to the control treatment (by 1.6 points) and in relation to the treatment in which ammonium sulphate was used (by 1.0 pts). The surface-active adjuvant Break Thru S 240 also contributed to significantly lower lodging of spring barley (on average by 0.9 pts) compared to the control plots (without any adjuvant).

The degree of spring barley lodging found in the experiment in question was similar to the average level (6.7-7.4 pts) recorded by other authors (Noworolnik et al. 2002; Kwiatkowski, 2009). Nowak and Zbroszczyk (2005) claim that the level of chemical protection does not have a significant impact on the degree of spring barley lodging. Lodging of spring barley occurs mainly on good wheat complex soils and the degree of crop lodging increases with increasing soil nutrient availability (Noworolnik, 1999). In the present study, however, higher crop lodging of spring barley was noted in the case of the application of pesticide rates reduced by 50% compared to the maximum dose, which is reflected in the studies of Leszczyńska and Grabiński (2003) as well as Miziniak (2004).

Holloway et al. (2000) and Gaskin et al. (2000) report that the efficacy of foliar-applied pesticides is determined by an exceptionally rich set of factors. They are associated not only with different properties of chemicals and pathogens controlled, but also with variable weather conditions and technical parameters of spray treatment. An adverse pattern of one or more of these factors generally reduces spray liquid retention or absorption of the active substance of a pesticide into plant cells. In effect, the efficacy of pesticides is frequently reduced and is not very stable, in particular when they are applied within any limits of rates (Kierzek and Ratajkiewicz, 2004).

CONCLUSIONS

1. Lowering rates of crop protection plants by 25%, thanks to the application of adjuvants, did not have a significant effect on the increase in the disease index for spring barley stem-base infection by the fungal disease complex and did not also cause any visible changes in weed infestation and crop lodging.
2. The reduction of pesticide rates by 50% resulted in a clear deterioration in health of spring barley at the milk stage, contributed to an increase in the number of weeds in the crop and their dry weight as well as to compensation of the dominant weed species and to crop lodging. The addition of adjuvants did not help mitigate these tendencies.
3. The type of adjuvant played an important role in affecting some of the traits in question. Atpolan 80 EC proved to be the most beneficial adjuvant; its application resulted in the highest reduction of the number of weeds in the spring barley crop and the lowest crop lodging.

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Wpływ adiuwantów oraz zredukowanych dawek środków ochrony roślin na zachwaszczenie, zdrowotność i wyleganie jęczmienia jarego

Streszczenie

Doświadczenie polowe z uprawą jęczmienia jarego przeprowadzono w latach 2007-2009 w Gospodarstwie Doświadczalnym Czesławice (środkowa Lubelszczyzna) na glebie płowej wytworzonej z lessu (II klasa bonitacyjna). W badaniach uwzględniono 3 dawki herbicydów, antywylegacza i fungicydów (100%, 75%, 50%) oraz rodzaj adiuwanta (olejowy, powierzchniowo-czynny, mineralny). Obiekt kontrolny stanowiły poletka bez adiuwanta. Uprawę roli prowadzono w sposób typowy, zaś nawożenie mineralne dostosowano do wysokiej wyjściowej zasobności gleby w składniki mineralne.

Przyjęto hipotezę, że obniżenie dawek pestycydów o 25-50% z jednoczesnym dodatkiem adiuwantów pozwoli na zapewnienie poziomu zdrowotności, zachwaszczenia oraz wylegania roślin jęczmienia jarego w podobnej skali, jaką uzyskuje się w warunkach stosowania dawek maksymalnych, bez adiuwanta. Założono również, że poszczególne adiuwanty mogą wykazywać zróżnicowane współdziałanie z badanymi grupami środków ochrony roślin.

Dowiedziono, iż najkorzystniejsze wskaźniki zachwaszczenia, zdrowotności i wylegania jęczmienia jarego gwarantowała aplikacja pełnych zalecanych dawek pestycydów. Jednakże, dzięki dodatkowi adiuwantów do cieczy użytkowej, podobne rezultaty przynosiło stosowanie dawek pestycydów zredukowanych o 25%. Większa redukcja dawek pestycydów (o 50%) wpływała na niekorzystne zmiany badanych cech wynikowych. Notowano wówczas większe zachwaszczenie łanu jęczmienia jarego, kompensację niektórych gatunków chwastów oraz zwiększone porażenie podstawy źdźbła przez kompleks chorób grzybowych. Mniej radykalne zmiany zaobserwowano natomiast w przypadku wylegania roślin jęczmienia jarego. Wspomniana sytuacja występowała pomimo wspomagania działania pestycydów przez adiuwanty. Z grona porównywanych adiuwantów, najlepsze współdziałanie ze środkami ochrony roślin wykazywał preparat olejowy Atpolan 80 EC.