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COMPETITION BETWEEN SPRING WHEAT AND SPRING BARLEY UNDER CONDITIONS OF DIVERSIFIED FERTILISATION PART I. INFLUENCE ON SELECTED MORPHOLOGICAL CHARACTERISTICS OF PLANTS

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A b s t r a c t. In a jar experiment, implemented according to the additive pattern on a medium soil with standard fertilization and NPK fertilization increased by 50%, the competitive influence occurring between spring wheat and spring barley was investigated. The influence was assessed on the basis of plant height, number of stems and leaves, length of heads, number of grains per head, and grain yield. The experiment was carried out in three cycles during the years 2003-2004, considering five periods determined by the development cycle of spring barley as pure crop, i.e. during the phases of seedling growth (according to Zadoks 10-13), tillering (25), stem elongation (37), inflorescence emergence (55) and ripening (87-91). It was shown that joint cultivation of both cereals had a negative influence on their morphological characteristics and grain yield. That situation was better visible in generative parts and less visible in vegetative ones. In the case of wheat, a larger reduction in the number of leaves and grains per head was recorded in the environment more abundant with NPK, while the head length in the less abundant one. In the case of the mix, the influence of soil abundance with NPK on the studied characteristics of barley was more ambivalent.

K e y w o r d s: competition, wheat, barley, phenophases, fertilisation, morphology of plants

INTRODUCTION

In mixed fields of crops various influences between competitors are recorded. As a result the assumed theoretical harvest and its structure differ significantly from the actual and are difficult to forecast, which is the basic fault of this sowing method (Sobkowicz 2001, 2003). The above problem applies to all mixed crops, including that consisting of spring wheat and spring barley. As concerns the fodder value, it is characterised by quality of grain higher than in the case of other mixes, but it is usually inferior to both components cultivated as single crop. One of the reasons for that situation is the competition, i.e. influence of negative nature that represents rivalry between components of the mix for biogenes, water, light, space, and others in the situation when the resources are insufficient to satisfy their overall needs (Keddy and Shipley 1989). Competition is a highly complex process as its development and intensity are greatly modified by biotic and abiotic environmental factors, while the consequences are difficult to predict (Connoly *et al.* 2001, Fukai and Trenbath 1993, Sobkowicz 2003). As a consequence, its development will be different under different habitat conditions and will depend on different choices and structures of components. The competition in most cases starts already at the beginning of joint vegetation and it can last, with varying intensity, until its end, often switching during the latest period to the process of complementary use of the resources (a positive phenomenon). The plants can mutually influence each other through the root systems as well as the aboveground parts, and both of those competition forms are present in tight relations, mutually interlacing, although the opinions on that issue presented in the literature often differ (Lucero *et al.* 2000, Sobkowicz 2001). Results of competitive influences can include changes in the development rhythm, numbers, fertility and morphology (Sobkowicz 2001, 2003, Yachi and Loreau 2007).

Although the subject of competition in mixed crops is frequently presented by researchers, the results obtained so far do not explain the development of that phenomenon entirely. The majority of them analyse the final effect, i.e. the yield of grain only, while the works following the competition process over the entire period of joint vegetation of crops are few (Lamb *et al.* 2006). Studies concerning competition between spring wheat and spring barley are also missing.

The presented work complements and expands the knowledge on the subject. It aims at assessment of the competitive influences between spring wheat and spring barley on morphological characteristics of both cereals during individual phases of growth and development under diversified doses of mineral NPK fertilisation.

MATERIALS AND METHODS

During the years 2003-2004, at the greenhouse laboratory of the University of Warmia and Mazury in Olsztyn, three cycles of jar experiments were carried out. The subject of the study was spring cereals: wheat (Torka cultivar) and barley (Rabel), sown in 2-component mix and as pure crop. The first experimental cycle continued from 10.04.2003 until 7.07.2003, the second covered the period of 26.02.2004-25.05.2004, and the third from 18.09.2004 until 20.12.2004. The experiment was carried out according to the additive pattern, the nature of which was that the number of plants of each species in the mix was the same as in the single crop cultivation; this pattern also allows investigating competition between species without deformation of the image by competition within species and allows following the process from the beginning of joint vegetation of plants (Keddy 1989, Semere and Froud-Williams 2001, Sobkowicz 2001).

The following factors were assessed:

1. mineral NPK fertilisation levels:
   – standard dose for field conditions totalling 162 kg ha^{-1} of pure components, including: N – 70, P – 26, K– 66; which, converted to one jar, was: N – 0.50, P – 0.20, K – 0.45g, respectively;
   – dose increased by 50% (total of 243 kg ha^{-1}, including: N – 105, P – 39, K – 99; in g/jar: N – 0.75, P – 0.30, K – 0.675).
2. plants sowing methods:
   – mixed
   – single crop.

In the paper the standard dose will be referred to as 1 NPK, and the increased dose as 1.5 NPK.

The medium for the experiments was a medium, typical brown soil formed of dusty, low clay soil in loose dusty sand. It was characterized by the content of organic substances at from 1.22 to 1.91%, slightly acid reaction (pH in 1 M KCl 5.9-6.3), and high abundance of available forms (g kg^{-1} of soil) of phosphorus (117-136), potassium (83-123) and magnesium (14-17). As concerns agricultural suitability, it represents very good rye complex, bonitation class R IIIb. Prior to filling the jars the soil was screened and next well mixed with appropriate doses of mineral fertilisers in the form of urea, potassium phosphate, and potassium sulphate. Nitrogen was applied twice during vegetation: the first dose was applied into the soil before sowing (together with phosphorus and potassium) and the second was applied at the beginning of barley stem elongation phase.

Competitive influence between plants was investigated during 5 development stages of cereals, i.e. during seedling growth (according to Zadoks 10-13), tillering (25), stem elongation (37), inflorescence emergence (55) and ripening (87-91), conducting the measurements according to the development rhythm of spring barley cultivated as a single crop.

In total, the experiment consisted of 120 jars (two species as single crop plus in mix x two NPK doses x 5 development stages x 4 repetitions).

The analysed cereals were sown in Kick-Brauckmann jars 22 cm in diameter and 25 cm deep, at density of 19 germinating seedlings per jar, which corresponded to the density of 350 plants per 1 m^2. The seedlings were distributed in jars at equal distances from one another (according to templates), and immersed in soil at the depth of 3 cm. Loss of water was complemented daily to 50% of maximum water capacity of the soil. The laboratory was maintained at 20-22°C during the major part of vegetation period. At full seedling growth, to secure the passage through the spring exposure experience, the temperature in the laboratory was decreased to 6-8°C for the period of 10 days. When the cereal reached the appropriate development stage, all plants were removed from some jars (planned for a given stage) and next the aboveground parts were separated from the roots. The material prepared in this way was used for determination of plant height as well as the number of stems and leaves and, additionally, during the final stages of vegetation (inflorescence emergence and ripening), the length of head, number of grains per head and grain yield were measured.

The data were presented as average values for three experimental cycles. The data were statistically processed by applying the variance analysis including computation of the LSD at the probability of 0.05 by applying the Tukey test.

RESULTS

As indicated by the numbers in Table 1, the method of sowing did not diversify the height of spring wheat in the phase of seedling growth only. At the further stages of vegetation the plants cultivated in the mix with barley were significantly lower; on average for NPK doses the differences as compared to pure crop cultivation were: at tillering stage – 2.2 cm, stem elongation stage – 9.5, inflorescence emergence stage – 8.8 and ripening stage – 7.8 cm. Fertilization doses had a certain influence on the extent of the differences presented. Mixed cultivation of cereals supplied with the standard NPK dose resulted in development of longer stems at the stem elongation stage, inflorescence emergence stage and ripening stage by wheat, however, the above relation was confirmed statistically for inflorescence emergence stage only; the difference between the height of plants supplied with 1 NPK and 1.5 NPK reached in this case 8.0 cm. However, wheat supplied with the fertilisation dose increased by 50% developed significantly longer stems (by 1.0 cm) during the tillering stage only.

On the other hand, in the case of barley the investigated characteristic did not change under the influence of the sowing method from seedling growth stage until ripening stage. During that last period the plants cultivated together with wheat were, on average, lower by 2.7 cm than those in single crop cultivation. This, however, was visible only in the case of cultivation with increased fertilisation; plants of single crop were higher than plants in the mix by 5.7 cm. That influence, contrary to expectations, was not recorded in the case of standard fertilisation (1 NPK), although it seemed that lower abundance of soil should boost the process of competition. It is interesting that, in the mix, barley on more abundant soil developed stems significantly shorter than on the less abundant one (by 2.9 cm). Although the partners had 50% more macroelements available than in the case of standard fertilisation, this did not result in increasing the height of barley.

Table 1. Height of plants (cm)

Development stage	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
spring wheat						
Seedling growth	23.4	22.0	24.0	23.2	23.7	22.6
Tillering	44.8	42.4	45.3	43.4	45.1	42.9
Stem elongation	58.8	50.4	60.9	50.3	59.9	50.4
Inflorescence emergence	75.0	59.9	64.4	61.9	69.7	60.9
Ripening	73.2	63.0	65.2	59.7	69.2	61.4
spring barley						
Seedling growth	24.2	26.0	22.6	23.7	23.4	24.9
Tillering	43.7	43.5	47.6	43.7	45.7	43.6
Stem elongation	53.9	56.4	55.5	54.7	54.7	55.6
Inflorescence emergence	66.3	62.4	63.4	59.4	64.9	60.9
Ripening	64.1	64.4	67.2	61.5	65.7	63.0

LSD $_{(p = 0.05)}$

spring wheat: seedling growth: sowing method – insignificant; synergy (NPK fertilisation x sowing method) – insignificant; tillering: sowing method – 0.3; synergy (NPK fertilisation x sowing method) – 1.0; stem elongation: sowing method – 2.3; synergy (NPK fertilisation x sowing method) – insignificant; inflorescence emergence: sowing method – 1.5; synergy (NPK fertilisation x sowing method) – 4.1; ripening: sowing method – 2.9; synergy (NPK fertilisation x sowing method) – 4.8.
spring barley: seedling growth: sowing method – insignificant; synergy (NPK fertilisation x sowing method) – insignificant; tillering: sowing method – insignificant.; synergy (NPK fertilisation x sowing method) – insignificant.; stem elongation: sowing method – insignificant.; synergy (NPK fertilisation x sowing method) – insignificant; inflorescence emergence: sowing method – 1.5; synergy (NPK fertilisation x sowing method) – insignificant; ripening: sowing method – 2.4; synergy (NPK fertilisation x sowing method) – 3.4.

Joint cultivation of the cereals resulted in weaker tillering process and, in the case of barley, higher than in single crop cultivation loss of plants during vegetation (Tab. 2). In this case a lower number of stems developed than in the case of single crop cultivation and the reaction to that sowing method was stronger in the case of barley than of wheat. In the case of wheat, for both fertilisation combinations, the difference between sowing methods formed during tillering was retained until the end of vegetation, and for the mix the more NPK – abundant soil limited tillering more than the less abundant one. On the other hand, in the case of barley, for standard fertilisation, mixed sowing increased the number of stems slightly (insignificantly) at the tillering as opposed to 1.5 NPK, where the number of stems was significantly lower (by 27.3%). During the stem elongation phase the first fertilisation combination recorded a significant reduction of stems (by 30%) that remained at unchanged level until the ripening phase; in the case of the soil more abundant in biogenes, the difference that formed during tillering remained unchanged until inflorescence emergence phase, and then during ripening it was increased.

Table 2. Number of stems in 1 plant

Development stage	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
spring wheat						
Tillering	1.5	1.2	1.9	1.4	1.7	1.3
Stem elongation	1.5	1.2	1.9	1.4	1.7	1.3
Inflorescence emergence	1.4	1.1	1.8	1.2	1.6	1.2
Ripening	1.4	1.1	1.7	1.1	1.6	1.1
spring barley						
Tillering	2.0	1.9	2.2	1.6	2.1	1.8
Stem elongation	2.0	1.4	2.2	1.6	2.1	1.5
Inflorescence emergence	1.8	1.3	2.1	1.6	2.0	1.5
Ripening	1.8	1.3	2.1	1.3	2.0	1.3

LSD $_{(p = 0.05)}$
spring wheat – tillering: sowing method – 0.3; synergy (NPK fertilisation x sowing method) – 0.4. stem elongation: sowing method – 0.2; synergy (NPK fertilisation x sowing method) – 0.3; inflorescence emergence: sowing method – 0.2; synergy (NPK fertilisation x sowing method)– 0.2; ripening: sowing method – 0.4; synergy (NPK fertilisation x sowing method) – 0.3.
spring barley – tillering: sowing method – 0.2; synergy (NPK fertilisation x sowing method) – 0.3; stem elongation: sowing method – 0.3; synergy (NPK fertilisation x sowing method) – 0.5; inflorescence emergence: sowing method – 0.4; synergy (NPK fertilisation x sowing method) – 0.3; ripening: sowing method – 0.6 ; synergy (NPK fertilisation x sowing method) – insignificant.

The number of leaves, in the case of both cereals, increased systematically from the beginning of vegetation until inflorescence emergence phase (Tab. 3). During ripening, as a result of the natural drying process followed by discharge of lower leaf blades, it decreased as compared to the inflorescence emergence phase.

Table 3. Number of leaves on 1 plant of spring wheat

Development stage	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
spring wheat						
Seedling growth	2.0	2.0	2.0	2.8	2.0	2.4
Tillering	4.4	4.0	5.2	4.1	4.8	4.1
Stem elongation	6.3	5.2	6.9	5.4	6.6	5.3
Inflorescence emergence	6.5	6.4	6.5	5.8	6.5	6.1
Ripening	5.6	5.1	5.8	5.0	5.7	5.1
spring barley						
Seedling growth	2.8	2.0	2.8	2.0	2.8	2.0
Tillering	7.1	7.1	8.1	5.5	7.6	6.3
Stem elongation	7.8	7.1	11.1	7.5	9.5	7.3
Inflorescence emergence	13.9	8.3	15.6	10.9	14.8	9.6
Ripening	9.9	5.9	14.5	9.5	12.2	7.7

LSD $_{(p = 0.05)}$

spring wheat – seedling growth: sowing method – 0.2; synergy (NPK fertilisation x sowing method) – 0.3; tillering: sowing method – 0.6; synergy (NPK fertilisation x sowing method) – 0.8. stem elongation: sowing method – 0.5; synergy (NPK fertilisation x sowing method) – 1.2; inflorescence emergence: sowing method – insignificant; synergy (NPK fertilisation x sowing method) – 0.5; ripening: sowing method – 0.5; synergy (NPK fertilisation x sowing method) – 0.7.
spring barley – seedling growth: sowing method – insignificant; synergy (NPK fertilisation x sowing method) – insignificant. tillering: sowing method – 0.6; synergy (NPK fertilisation x sowing method) – 0.6; stem elongation: sowing method – 0.9; synergy (NPK fertilisation x sowing method) – 1.2; inflorescence emergence: sowing method – 2.1; synergy (NPK fertilisation x sowing method) – 2.6; ripening: sowing method – 2.0; synergy (NPK fertilisation x sowing method) – 3.1.

Higher decreases were recorded in the case of the mix (particularly for barley), and lower in single crop cultivation. Mixed sowing, during the initial growth period, increased the number of leaves of spring wheat significantly; in the case of single crop cultivation it developed 16.7% fewer leaf blades. However, already during the tillering stage, the situation changed to the advantage of plants from single crop sowing. Limited space available to plants resulted in mutual shading and slowing of the increase in leaves growth. This resulted in a situation where, in the case of the mix, the foliage was significantly lower than in single crop cultivation (except for the inflorescence emergence phase): during tillering by 14.6%, during stem elongation by 19.7%, and during ripening by 10.5%. That process was subject to certain modifications under the influence of fertilisation doses. Although in the case of cultivation supplemented by standard NPK dose wheat in the mixed crop developed fewer leaves from the tillering phase until the end of vegetation, the differences proved to be insignificant. On the other hand, in jars more abundant with biogenes, during the initial stage of growth a positive influence of barley on the number of leaves in wheat was recorded; their number was higher than in single crop cultivation by 40%. As of the tillering stage, the negative influence of barley on the wheat leaves development was recorded. It was the most clearly visible during tillering and stem elongation phases, reducing the number of leaves by 21.2 and 21.7%, respectively, as compared to single crop sowing; during the second part of the vegetation process the differences between the sowing methods decreased to 10.8 and 13.8%, respectively.

Significant negative influence of wheat on barley foliage development started, for standard-fertilised cultivation, at the time of stem elongation, and in the case of 1.5 NPK dose during tillering, and continued until the end of vegetation. In the two fertilisation options the process had different intensities. In the case of 1 NPK, in the mixed cultivation there were fewer leaves per plant: by 9.0% during stem elongation phase and by over 40% during the two final phases. On the other hand, in the case of soil more abundant with macro-elements, the difference of 47.2% in favour of single crop cultivation found during tillering remained at that level, with minor deviations, until the end of vegetation process.

Mixed sowing method, as compared to single crop cultivation, diversified the length of wheat and barley in a significant way during both the inflorescence emergence phase and ripening phase (Tab. 4). The magnitude of differences was modified, to a certain extent, by the fertilisation doses. In the case of spring wheat, during both measurement periods, cultivation in the mix had a stronger influence on the length of heads in the case of cultivation less abundant with biogenes than in the more abundant one. The reduction compared to single crop cultivation at inflorescence emergence phase was 32.2%, while during ripening it was 32.6%; in the environment more abundant with NPK the values were 21.6 and 18.7%, respectively.

Table 4. Head length (cm)

Development stage	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
spring wheat						
Inflorescence emergence	8.7	5.9	7.4	5.8	8.1	5.9
Ripening	9.2	6.2	8.0	6.5	8.6	6.4
spring barley						
Inflorescence emergence	8.8	4.1	5.6	3.9	7.2	4.0
Ripening	12.4	7.3	10.8	5.3	11.6	6.3

LSD $_{(p = 0.05)}$

spring wheat – inflorescence emergence: sowing method – 4.2; synergy (NPK fertilisation x sowing method) – 7.2; ripening: sowing method – 2.9; synergy (NPK fertilisation x sowing method) – 3.8.
spring barley – inflorescence emergence: sowing method – 0.8; synergy (NPK fertilisation x sowing method) – 0.6; ripening: sowing method – 0.5; synergy (NPK fertilisation x sowing method) – 0.6.

Also in the case of barley with standard fertilisation the heads in mixed cultivation were significantly shorter than in single crop cultivation: during inflorescence emergence by 53.4% and during ripening by 40.9%. On the other hand, in the environment more abundant in macro-elements the difference in favour of single crop cultivation during barley inflorescence emergence was smaller (30.4%) and not confirmed statistically, while at the end of vegetation it was significantly larger (by 50.7%). Finally, in the case of mixed sowing, despite application of mineral fertilisation higher by 50%, the heads of that cereal were significantly shorter than in the case of standard dose application (by 2.0 cm). Heads of wheat cultivated as single crop were characterised by more than 1.5 times higher number of grains than in mixed sowing (Tab. 5). In the case of the standard fertilisation dose, wheat in the mix formed 36.2% fewer grains in heads than in the case of single crop cultivation, while in the case of increased fertilisation dose the number was smaller by 41.9%. Attention should be drawn to the fact that the investigated levels of mineral fertilisation did not diversify the number of grains per head in the case of mixed sowing in any significant way.

Coexistence with wheat limited also the number of grains in the heads of barley. In the mixed crop cultivation the number of developed grains was lower by

46.1% than in the case of single crop cultivation; the fertilisation level applied had no modifying effect in this case. In the same way as in the case of head length, the increased NPK dose not only did not limit the negative influence of wheat on barley but, to the contrary, it increased the process. In both fertilisation options the mixed sowing of cereals resulted in a significant decrease of grain yield as compared to single crop cultivation; that decrease was slightly larger for wheat (by 60.2%) and smaller for barley (by 52.2%) (Tab. 5). The statistical analysis did not show significant synergy of the parameters investigated because, irrespective of the competition level for growth factors, similar reductions of grain yield were recorded.

Table 5. Number of grains in a head at cereal ripening stage

Cereal species	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
Spring wheat	16.3	10.4	18.6	10.8	17.5	10.6
Spring barley	25.0	13.7	21.4	11.2	23.2	12.5

LSD $_{(p = 0.05)}$

spring wheat: sowing method – 1.8; synergy (NPK fertilisation x sowing method) – 2.2.
spring barley: sowing method – 2.0; synergy (NPK fertilisation x sowing method) – 3.6.

Table 6. Cereal yield (g/jar)

Cereal species	1 NPK		1.5 NPK		Average for sowing method	
	sowing method					
	pure	mixed	pure	mixed	pure	mixed
Spring wheat	10.8	4.5	12.6	4.8	11.6	4.7
Spring barley	15.1	7.5	12.5	5.6	13.8	6.6

LSD $_{(p = 0.05)}$

spring wheat: sowing method – 1.0; synergy (NPK fertilisation x sowing method) – insignificant.
spring barley: sowing method – 2.7; synergy (NPK fertilisation x sowing method) – insignificant.

DISCUSSION

In the presented experiment the "partnership" of wheat did not diversify in any significant way the length of barley stems during almost the entire joint vegetation. This is consistent with studies by Sobkowicz (2001) who showed that barley in the mix develops stems of similar length to that in single crop sowing. Also Rudnicki *et al.* (1996), studying monoculture crops of spring cereal mixes, established that stem length of barley growing together with wheat did not differ significantly from that of barley cultivated as a single crop. Other studies by Rudnicki and Wasilewski (1993) showed, however, that barley cultivated together with wheat developed stems shorter than in single crop cultivation. In our own studies, plants of spring wheat cultivated together with barley were lower than those cultivated as a single crop during almost the entire vegetation period (except seedling growth), independent of fertilisation level. Similar results were obtained by Rudnicki and Wasilewski (1993) who showed that this cereal in single crop cultivation reached higher height (in average by 2.6 cm). In the conducted experiment barley showed more negative influence on the height of wheat plants than the other way round, although in the single crop cultivation the length of stems of the second crop was higher than that of the first one. That might be linked to the higher dynamics of barley growth as a result of which the plants obtained growth media more effectively during the initial stages of growth, as indicated by Harris and Wilson 1970, Lamb *et al.* (2006) as well as by Lambers and Poorter (1992).

In the experiment presented herein, both cereals, irrespective of fertilisation level, were characterised by a larger number of stems in single crop cultivation during almost every analysed phase. This is consistent with the data presented by Sobkowicz (2001), indicating that barley and oats reacted to joint cultivation with development of a lower number of stems. Also Majkowski *et al.* (1993), as well as Rudnicki and Wasilewski (1993), showed that barley in the mix tillered worse than in single crop cultivation, while wheat was inert in that respect. On the other hand, Idziak and Michalski (2006), Michalski (1991), as well as Rudnicki and Wasilewski (1993) did not record any influence of sowing method on the degree of spring barley tillering, while Taylor (1978) established that faster initial growth of barley favours its more extensive tillering in the mix.

In the presented studies, sowing of both cereals created more favourable conditions for development of assimilation organs during the entire vegetation period, with the exception of wheat during the seedling growth stage. Sobkowicz (2003), on the basis of foliage index as the ratio of leaves surface to soil surface occupied, showed that cereals in single crop cultivation and in mixes of two and three components are characterised by similar values of that characteristic. As a consequence, he concluded that the surface of leaf blades of the individual species in joint cultivation was lower than in the case of single crop cultivation.

As established, mixed sowing of the two cereals had a negative influence on both the length of heads and their filling with grains. Majkowski *et al.* (1993), Rudnicki & Wasilewski (1993), as well as Sobkowicz (2003), obtained different results. According to them, barley cultivated together with other cereals produced more shapely heads than in single crop cultivation. On the other hand, Idziak and Michalski (2006) recorded favourable influence of mixed cultivation on the studied characteristic.

Barley proved to be the species more resistant to competitive influence of the partner than wheat which, in joint cultivation, was characterised by larger loss of grain yield. Results of other studies indicate also that the share of barley in the yield of the mixes was generally higher than that of other species of cereals (Michalski and Waligóra 1993, Sobkowicz 2003). Rudnicki and Wasilewski (1993) reported that the most favourable conditions for cultivation of that cereal in mixes were offered by the presence of wheat because the larger the share of wheat the better the yield of barley was.

CONCLUSIONS

1. Spring barley, during the entire period of joint vegetation with wheat, had a negative influence on its height, number of stems, foliage, head length and number of grains formed. In the case of wheat cultivated in the mix, a larger reduction in the number of leaves and grains in heads was recorded in the case of cultivation on soil more abundant with biogenes, while the length of head reduction was larger on the soil that was less abundant.
2. Wheat sown with barley on soil with standard fertilisation was characterised by shorter heads during the inflorescence emergence phase, while on the soil with increased fertilisation (1.5 NPK) – during the ripening phase.
3. Cultivation of barley in the mix with wheat had no influence on barley height during the ripening period, but during that phase barley was lower in height than when cultivated as a single crop.
4. During the entire joint vegetation period the number of developed barley stems was lower than in single crop cultivation (particularly in the more NPK-abundant environment), and there were fewer leaves on the stems, particularly in the case of standard fertilisation. Additionally, in the mix, both the head length and the number of grains formed were lower than in single crop cultivation.
5. Mixed sowing, as compared to single crop cultivation, significantly, by over 50%, decreased the yield of grain of both analysed crops; that reaction was stronger in the case of wheat and slightly less pronounced in the case of barley.

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KONKURENCJA POMIĘDZY PSZENICĄ JARĄ A JĘCZMIENIEM JARYM W WARUNKACH ZRÓŻNICOWANEGO NAWOŻENIA CZ. I. WPŁYW NA WYBRANE CECHY MORFOLOGICZNE ROŚLIN

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S t r e s z c z e n i e. W doświadczeniu wazonowym, realizowanym wg schematu addytywnego na podłożu gleby średniej, nawożonej standardową i podwyższoną o 50% dawką NPK śledzono oddziaływania konkurencyjne zachodzące pomiędzy pszenicą jarą a jęczmieniem jarym. Wpływy te oceniano na podstawie wysokości roślin, liczebności źdźbeł i liści, długości kłosów, liczby ziaren w kłosach oraz plonu ziarna. Badania przeprowadzano w trzech cyklach w latach 2003-2004 z uwzględnieniem pięciu okresów wyznaczonych przez rytm rozwojowy jęczmienia jarego w siewie czystym, tj. w fazach: wschodów (wg Zadoksa 10-13), krzewienia (25), strzelania w źdźbło (37), kłoszenia (55) i dojrzewania (87-91). Wykazano, że wspólna uprawa obu zbóż wpływała ujemnie na ich cechy morfologiczne i plon ziarna. Bardziej uwidoczniło się to w częściach generatywnych, słabiej – wegetatywnych. U pszenicy większą redukcję liczby liści i ziaren w kłosach odnotowano w środowisku zasobniejszym w NPK, a długości kłosa w uboższym. W mieszance wpływ zasobności podłoża na badane cechy jęczmienia okazał się niejednoznaczny.

S ł o w a k l u c z o w e: konkurencja, pszenica, jęczmień, fenofazy, nawożenie, morfologia roślin