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CONTENT OF MACROELEMENTS AND CRUDE FIBRE IN GRAIN OF SPRING BARLEY CULTIVATED IN DIFFERENT AGRONOMIC CONDITIONS*

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Abstract. The aim of this study was to determine the effect of a catch crop on the content of nutrients in grain of spring barley grown after it, intended for animal feed, using different intensities of chemical plant protection and nitrogen fertilization. Field experiments were carried out at the Research Station at Mochełek on *Alfisols*, in 2008-2011. The split-plot experimental design was used. The effect of the catch crop (field pea plowed in autumn of the year preceding the barley sowing – factor I) on N, P, K, Ca, Mg and crude fiber content in grains of barley grown with the use of different levels of chemical plant protection (low and high – factor II) was evaluated. Moreover, different rates of nitrogen fertilization were tested (0, 35, 70, 105 and 140 kg·ha^{-1} – factor III). The catch crop plowed in the autumn as a green manure significantly increased the nitrogen and phosphorus content in spring barley grain. Intensity of chemical protection of barley had no effect on the content of N, P, K, Ca, Mg and crude fiber in the grain. Increasing the rate of nitrogen in the range from 0 to 140 kg·ha^{-1} contributed to increase in concentrations of N, P and K in grain and reduction in the content of Mg. The content of P, K, Ca and crude fiber was negatively correlated with the yield of pea biomass plowed in. Ca concentration in the grain was also negatively correlated with grain yield, whereas magnesium content was positively correlated with both the yield of pea biomass plowed in and grain yield of barley. The study confirmed the importance of the catch crop used as green manure in improving the quality of spring barley grain. Research hypothesis has not been fully confirmed in the impact of this factor on the grain composition of barley grown under low nitrogen fertilization. In treatments without N fertilization the catch crop used as green manure had only an effect on the Ca content in the grain. Barley fertilized with nitrogen at 35 kg·ha^{-1} responded significantly to the catch crop used as green manure only by increasing the concentration of potassium and magnesium in the grain.

Key words: catch crop, field pea, nitrogen rate, plant protection intensity, spring barley

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INTRODUCTION

Barley in Poland is mainly used as a feed for animals. Currently 65.5% of the grains consumed in the country is allocated for this purpose [Central Statistical Office 2013]. Besides of the concentration of metabolic energy, the feed value of grains, is also determined by crude fiber and content of minerals. Barley grain is not very rich in macronutrients. Their content is lower than in seeds of leguminous plants, and also substantially smaller than the optimal concentrations of these components in feeds for pigs [Norms of feeding... 1993]. The nutritional value of barley meal is largely shaped by agronomic factors, in particular by fertilization, which can have a significant impact on the content of individual elements and their quantitative interrelations in grain [Wojtasik 2004, Majcherczak *et al*. 2006]. Both mineral and organic fertilizers not only allow a significant increase in grain and straw yield but also improve macronutrient content in the grain and/or straw of cereals [Ruza *et al*. 2011, Hejcman *et al*. 2013, Wilczewski *et al*. 2013].

The analysis of the available scientific literature suggests that the effects of fertilization on the concentration of nutrients in grain is affected by agrotechnical factors, as well as soil and weather conditions. Hejcman *et al*. [2013] found a positive effect of fertilizers, both mineral (ammonium nitrate + superphosphate + potassium chloride (91 kg N + 31 kg P + 146 kg K)) and organic (farmyard manure and poultry litter), on N, P and K, as well as the lack of impact of this factor on the concentration of Mg and Ca in barley grains. According to this study, enhancing the content of N, P and K may be associated with a significant reduction in the concentration of Mg in the grain, even in conditions of high soil abundance in this element. Studies by Liszewski [2008] and Zbroszczyk and Nowak [2009], carried out on good soil conditions, indicated no effect of nitrogen on P, K, Ca and Mg content in barley grain. In the study by Kraska [2011], using the catch crop as a green manure did not affect the content of K and Mg in the grain of spring wheat.

The aim of the study was to determine the effect of the catch crop on nutrients concentration in the grain of spring barley intended for animal feed, grown on *Alfisols*, using different intensities of chemical plant protection and nitrogen fertilization.

Research hypothesis assumed that the use of field pea grown as the catch crop and plowing the biomass as a green manure will help to improve the content of essential nutrients in the grain of spring barley grown next year. It was assumed that the impact of the catch crop on the grain composition depends on the intensity of chemical plant protection and nitrogen fertilization.

MATERIAL AND METHODS

Study site and experimental design

Field experiments were carried out in 2008-2011, at the Research Station of the Faculty of Agriculture and Biotechnology at Mochełek on the *Alfisols* produced from sandy loam. The soil was characterized by a very high content of available phosphorus and potassium (according to Egner-Riehm method), high magnesium concentration (according to Schachtschabel method) and pH slightly acidic. Strict, 3-factor, field experiments were conducted in the split-split-plot experimental design. The effect of catch crop (field pea plowed in the autumn of the year preceding the sowing of barley – factor I) on N, P, K, Ca, Mg and crude fiber content in grain of barley cultivated using different intensities of chemical protection and fertilization was examined. Two levels of chemical protection intensity of plants were compared (factor II). Low level – including seed dressing with fungicides and one application against weeds and high level - including seed dressing, one application against weeds and 2 applications against fungal pathogens. The cultivation of barley used in the following rates of nitrogen (factor III): 35 kg·ha^{-1} (used before sowing), 70 kg·ha^{-1} (40 kg before sowing and 30 kg in stage BBCH 30-32 [Lancashire et al. 1991]), 105 kg·ha^{-1} (60 kg before sowing and 45 kg in stage BBCH 31--32), 140 kg·ha^{-1} (60 kg before sowing, 50 kg in the stage BBCH 30-32 and 30 kg in phase BBCH 45-49). Also the control treatment was established where barley was not fertilized with nitrogen. Catch crop was grown after wheat harvest, and the biomass was plowed in the autumn of the year preceding the sowing of spring barley on the field.

Agrotechnology

Each year, after wheat harvest, plowing to a depth of about 15 cm was performed. Before sowing the catch crop, the soil was cultivated using a cultivator with roller. Pea 'Wiato' was sown at 150 kg·ha^{-1}, at a depth of about 5-6 cm in row spacing of 15 cm between 5-11 August. Spring barley 'Tocada' was sown in the period from 2 to 4 April, using Famarol drill in row spacing of 12 cm, to a depth of 2-4 cm. Nitrogen fertilization of spring barley was used in accordance with the experimental design. Phosphorus (26.2 kg·ha^{-1} P) and potassium (66.4 kg·ha^{-1} K) were applied in the spring, before the soil preparation was done.

In order to protect against diseases, of barley grains were primed before sowing with the preparation Kinto Duo 080 FS (triticonazole 20 g·dm^{-3} + prochloraz complex with copper 60 g·dm^{-3}). On treatments with a high level of chemical protection, plants were sprayed with the preparation Capalo 337.5 SE (fenpropimorph 200 g·dm^{-3} + epoxiconazole 62.5 g·dm^{-3} + Metrafenone 75 g·dm^{-3} in the shooting phase (BBCH 32-33) and the preparation Falcon 460 EC (spiroxamine 250 g·dm^{-3} + tebuconazole 167 g·dm^{-3} + triadimenol 43 g·dm^{-3}) at earing (BBCH 51-55). Weeds were controlled every year using Lintur 70 WG (Dicamba 65.9% + Triasulfuron 4.1%) at tillering (BBCH 21--22). Pests appearing in the canopies, mainly cereal leaf beetle (*Lema melanopus* L.) and grain aphid (*Sitobion avenae* F.), were controlled using Karate Zeon 050 CS (lambda-cyhalothrin 50 g·dm^{-3}) after they went above their harm thresholds.

In the grain samples collected after harvest from each plot, total nitrogen (Kjeldahl method), phosphorus (using vanadium – molybdenum method [Nowosielski 1974]), potassium and calcium (by flame photometry method [Nowosielski 1974]), magnesium (colorimetry of titanium yellows [Hermanowicz *et al*. 1976]) and crude fiber (modified method by Henneberg and Stohmann) were determined. These chemical analyzes were carried out in the laboratory of the Department of Agrotechnology of the University of Technology and Life Sciences in Bydgoszcz. Before performing the determination of the ingredients, ground grain samples were mineralized using the wet method.

Statistical study of the results

The results obtained were subjected to the analysis of variance. The significance of differences was determined using Tukey's half interval of confidence at the significance level P = 0.05 for the split-split-plot model. The correlation coefficient between nutrients content in the grain and catch crop biomass yield as well as grain yield of barley were calculated using Statistica for Windows.

RESULTS

Catch crop caused an increase in the concentration of N and P in the grain of spring barley cultivated after it (Table 1). No significant effect of this factor on the concentration of K, Ca, Mg and crude fiber was observed. The level of chemical plant protection did not affect the concentration of N, P, K, Ca, Mg and crude fiber in grains of barley (Table 2). Nitrogen fertilization was the strongest factor influencing the nutrient content in barley grain (Table 3). The content of N in grain increased significantly influenced by any increase of nitrogen in the range from 0 to 140 $kg \cdot ha^{-1}$N. The content of P increased after increasing the dose of nitrogen from 0 to 35 $kg \cdot ha^{-1}$, from 35 to 70 $kg \cdot ha^{-1}$ and from 70 to 140 $kg \cdot ha^{-1}$. The concentration of K in grain also was the highest after the application of 140 $kg \cdot ha^{-1}$, significantly lower in treatments were 35, 70 and 105 $kg \cdot ha^{-1}$ N was used, and the smallest in grain of barley not fertilized with this component. Nitrogen fertilization did not affect significantly the content of Ca and crude fiber, whereas it caused a decrease in the concentration of Mg in the grain.

Table 1. Content of nutrients in spring barley grains depending on the plowed-in biomass of field pea grown as a catch crop, % (means for 2009-2011)
Tabela 1. Zawartość składników pokarmowych w ziarnie jęczmienia jarego w zależności od przyoranej biomasy grochu uprawianego w międzyplonie ścierniskowym, % (średnie z lat 2009-2011)

Nutrient – Składnik	Catch crop Międzyplon	Control Kontrola	Mean – Średnia	$LSD_{0.05}$ – $NIR_{0.05}$
Nitrogen – Azot (N)	1.74	1.61	1.68	0.086
Phosphorus – Fosfor (P)	0.382	0.368	0.374	0.006
Potassium – Potas (K)	0.520	0.500	0.510	ns – ni
Calcium – Wapń (Ca)	0.367	0.348	0.357	ns – ni
Magnesium – Magnez (Mg)	0.182	0.176	0.179	ns – ni
Crude fibre – Włókno surowe	5.01	4.74	4.88	ns – ni

ns – non-significant differences – ni – różnice nieistotne

Table 2. Content of nutrients in spring barley grains depending on intensity of chemical plant protection, % (means for 2009-2011)
Tabela 2. Zawartość składników pokarmowych w ziarnie jęczmienia jarego w zależności od poziomu intensywności ochrony chemicznej roślin, % (średnie z lat 2009-2011)

Nutrient Składnik	The level of plant protection intensity Poziom intensywności ochrony roślin			$LSD_{0.05}$ $NIR_{0.05}$
	low – niski	high – wysoki	mean – średnia	
Nitrogen – Azot (N)	1.68	1.67	1.68	ns – ni
Phosphorus – Fosfor (P)	0.375	0.374	0.374	ns – ni
Potassium – Potas (K)	0.513	0.506	0.510	ns – ni
Calcium – Wapń (Ca)	0.365	0.349	0.357	ns – ni
Magnesium – Magnez (Mg)	0.180	0.178	0.179	ns – ni
Crude fibre – Włókno surowe	4.88	4.88	4.88	ns – ni

ns – non-significant differences – ni – różnice nieistotne

Table 3. Content of nutrients in spring barley grains depending on nitrogen fertilization, % (means for 2009-2011)
Tabela 3. Zawartość składników pokarmowych w ziarnie jęczmienia jarego w zależności od nawożenia azotem, % (średnie z lat 2009-2011)

Nutrient – Składnik	Rate of nitrogen – Dawka azotu, kg·ha^{-1}					$LSD_{0.05}$ $NIR_{0.05}$
	0	35	70	105	140	
Nitrogen – Azot (N)	1.48	1.54	1.70	1.80	1.89	0.041
Phosphorus – Fosfor (P)	0.361	0.370	0.378	0.381	0.384	0.004
Potassium – Potas (K)	0.484	0.508	0.512	0.515	0.532	0.012
Calcium – Wapń (Ca)	0.361	0.365	0.349	0.334	0.377	ns – ni
Magnesium – Magnez (Mg)	0.186	0.181	0.180	0.174	0.174	0.004
Crude fibre – Włókno surowe	4.81	4.78	4.98	4.82	5.00	ns – ni

ns – non-significant differences – ni – różnice nieistotne

It has been found the interaction between the dose of nitrogen and catch crop in the formation of K content in grain (Table 4). In spring barley fertilized with nitrogen at rates of 35 and 70 kg·ha^{-1}, catch crop contributed to a significant increase in K content in the grain, while in other treatments there were no effects on biomass plowed on this feature. In addition, in treatments with the catch crop, increasing the nitrogen dose from 35 to 140 kg·ha^{-1} did not significantly affect the concentration of K in the grain, while in the control the content of this element in grain increased up to 140 kg·ha^{-1}, after which it was significantly higher than in barley fertilized with nitrogen in an amount of 70 kg·ha^{-1} or less.

Table 4. Interaction of nitrogen fertilization with the catch crop for the content of potassium in spring barley grains
Tabela 4. Współdziałanie nawożenia azotem z międzyplonem ścierniskowym dla zawartości potasu w ziarnie jęczmienia jarego

Catch crop – Międzyplon (I)	Rate of nitrogen – Dawka azotu, kg·ha^{-1} (III)				
	0	35	70	105	140
Field pea – Groch siewny	0.495	0.522	0.526	0.518	0.535
Control (without catch crop) Kontrola (bez międzyplonu)	0.474	0.492	0.496	0.511	0.528
$LSD_{0.05}$ – $NIR_{0.05}$ for interaction – dla interakcji: I/III – 0.024; III/I – 0.018					

Effect of catch crop on the content of Ca in grain was also dependent on the level of nitrogen (Table 5). Barley not fertilized with this component had a significantly higher concentration of Ca in grain cultivated after the catch crop than in the control, while on treatments where nitrogen fertilization was used the catch crop had no effect on this feature.

Table 5. Interaction of nitrogen fertilization with the catch crop for the content of calcium in spring barley grains
Tabela 5. Współdziałanie nawożenia azotem z międzyplonem ścierniskowym dla zawartości wapnia w ziarnie jęczmienia jarego

Catch crop – Międzyplon (I)	Rate of nitrogen – Dawka azotu, kg·ha^{-1} (III)				
	0	35	70	105	140
Field pea – Groch siewny	0.406	0.373	0.348	0.338	0.370
Control (without catch crop) Kontrola (bez międzyplonu)	0.316	0.357	0,350	0.332	0.383
$LSD_{0.05}$ – $NIR_{0.05}$ for interaction – dla interakcji: I/III – 0.063; III/I – ns – ni					

ns – non-significant differences – ni – różnice nieistotne

There was also the interaction between the rate of nitrogen and catch crop for the Mg content in grain (Table 6). In spring barley fertilized with nitrogen at rates of 70 and 105 kg·ha^{-1} and not fertilized with this component the catch crop did not affect the concentration of Mg in grain, while on the treatment where 35 and 140 kg·ha^{-1} was used, the catch crop increased the content of this component in grain.

Table 6. Interaction of nitrogen fertilization with the catch crop for the content of magnesium in spring barley grains
Tabela 6. Współdziałanie nawożenia azotem z międzyplonem ścierniskowym dla zawartości magnezu w ziarnie jęczmienia jarego

Catch crop – Międzyplon (I)	Rate of nitrogen – Dawka azotu, kg·ha^{-1} (III)				
	0	35	70	105	140
Field pea – Groch siewny	0.189	0.188	0.178	0.172	0.180
Control (without catch crop) Kontrola (bez międzyplonu)	0.183	0.174	0.182	0.174	0.168
$LSD_{0.05}$ for interaction – $NIR_{0.05}$ dla interakcji: I/III – 0.007; III/I – 0.006					

The study showed no interaction between the intensity of protection and other factors in changing the content of the components shown in grain. There was also no interaction of nitrogen fertilization and the catch crop in relation to the concentration of N, P and crude fiber in grain.

The contents of P, K, Ca and crude fiber were inversely correlated with the yield of pea biomass plowed in (Table 7). Concentration of Ca in grain was also negatively correlated with grain yield, while the content of Mg was positively correlated with both the yield of pea biomass plowed in and the yield of barley grain.

Table 7. Linear correlation coefficients between concentration of nutrients in grains and dry matter yield of catch crop biomass, plowed in the autumn as well as barley grain yield – Mochełek, 2009-2011 (n = 60)

Tabela 7. Współczynniki korelacji prostej pomiędzy zawartością składników w ziarnie a plonem suchej biomasy międzyplonu i plonem ziarna jęczmienia – Mochełek, 2009-2011(n = 60)

Variable – Zmienna	Nutrient – Składnik					Crude fibre Włókno surowe
	N	P	K	Ca	Mg	
Yield of the biomass plowed in Plon przyoranej biomasy	-0,22	-0,35*	-0,27*	-0,88*	0,41*	-0,39*
Grain yield – Plon ziarna	-0,04	-0,14	-0,05	-0,86*	0,31*	-0,21

* coefficients significant for P = 0.05 – współczynniki istotne przy P = 0,05

DISCUSSION

Increasing the nitrogen content in the grain under the influence of plowed in pea biomass rich in nitrogen was in accordance with the author's expectations and confirmed the results of some previous studies on the subject [Deryło 1994, Skinder and Wilczewski 2004, Wroblewitz *et al*. 2013]. However, the effect of catch crop on protein and nitrogen content in cereal grains is not always favorable. In the study by Narkiewicz-Jodko *et al*. [2008] there was a positive effect of a mixture of legume catch crops with oat on protein content in wheat grain, while white mustard catch crop had a negative effect on this feature. The study by Wilczewski and Skinder [2011] found a positive effect of catch crop with non-legume plants on the nitrogen content in wheat straw, whereas no influence on the content of this component in the grain was obtained.

Different influence of catch crops on the nitrogen content in cereal grains may be due to the impact of factors determining the intensity of biomass decomposition and availability of components in the soil during grain formation. The most important of these may include the weather conditions in the period from the end of the growing season of catch crops until the seed formation of successive crops [Thorup-Kristensen and Dresbøll 2010], the physical properties of the soil [van Veen and Kuikman 1990, Hassink 1992] and the properties of the biomass (quantity, chemical composition) and the date of its introduction into the soil [Thorup-Kristensen 1994, Thorup-Kristensen and Dresbøll 2010]. In my study field pea rich in nitrogen was grown as the catch crop. The total mass of plowed in biomass was relatively high. In the subsequent years of the study, it was 26.8, 19.2 and 14.4 $t \cdot ha^{-1}$ [Wilczewski 2014]. Mass of nitrogen brought to the soil with the catch crop biomass was on average 78.9 $kg \cdot ha^{-1}$ per year and contributed to a significant enrichment of barley in this component. Lack of correlation between nitrogen content and the amount of biomass plowed in, despite the large variation of that amount in each year, may result from a strong, positive effect of the catch crops on grain yield [Wilczewski 2014]. This was probably also the reason for the negative correlation of the content of most nutrients in the grain with the yield of biomass plowed in as green manure. The elements were "diluted" in the enlarged grain mass produced due to the catch crops.

No effect of the catch crop on the concentration of potassium in barley grain grown without nitrogen fertilization also could be due to the strong impact of this factor on barley grain yield in this treatment [Wilczewski 2014].

Wojtasik [2004] has shown a positive effect of the NPK rate on the content of P, K, Ca, Mg and Na in the grain of spring barley. In the study by Wacławowicz *et al*. [2005] no effect of organic fertilization on the content of P and K in the yield of wheat occured, while intensification of nitrogen fertilization led to increasing concentration of these macroelements in the grain of spring wheat. The results of the present study also showed an increase in the content of P and K in barley grain with the increasing rate of nitrogen. The observed effects of fertilization on the concentration of these compounds is consistent with the extensive evidence presented in the available literature, which states a positive influence of the N rate on P and/or K content in cereal grains [Wacławowicz *et al*. 2005, Biel *et al*. 2010, Wilczewski *et al*. 2013]. It may result from a positive effect of nitrogen on the development of plant root system, allowing increased mineral uptake from the soil. The present study did not include measurements of the extent and weight of barley roots. The study by Stypczyńska and Dziamski [2008], concerning ordinary millet, found a highly significant increase in root mass due to increasing rates of N from 40 to 80 $kg \cdot ha^{-1}$. Good supply of barley in P and K may also result from very high levels of these nutrients in the soil on which the present study was conducted.

The concentration of Mg in the soil was high, but the content of this component in grain significantly decreased with increasing rates of nitrogen. This could be due to the well-known phenomenon of ion antagonism. With high nitrogen and potassium content in the soil uptaking of magnesium may be inhibited. According to Slamka *et al*. [2011], the effect of nitrogen fertilization on the uptake and concentration of Mg in barley is dependent on the availability of water for plants. Under optimum soil moisture this effect is negative, while under the drought conditions the concentration of magnesium in plants may increase with higher rates of N. In my study, barley was well supplied with rain water in two out of the three years of the study [Wilczewski 2014]. Thus, lowering the Mg content in the grain with increasing doses of nitrogen found in the present study is consistent with the thesis by Slamka *et al*. [2011].

CONCLUSIONS

1. The content of N and P in barley grain significantly increased under green manure from the catch crop while the impact of this factor on the concentration of K, Ca and Mg in grain depended mainly on the nitrogen rate.
2. There was a positive impact of nitrogen rate on the contents of N, P and K in spring barley grain and a negative impact of this factor on Mg content in the grain.
3. The concentration of macroelements and crude fiber in the grain of barley was not related to the intensity level of chemical plant protection.

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ZAWARTOŚĆ MAKROSKŁADNIKÓW I WŁÓKNA SUROWEGO W ZIARNIE JĘCZMIENIA JAREGO UPRAWIANEGO W ZRÓŻNICOWANYCH WARUNKACH AGROTECHNICZNYCH

Streszczenie. Celem badań było określenie wpływu międzyplonu ścierniskowego na zawartość składników pokarmowych w ziarnie uprawianego po nim jęczmienia jarego w warunkach różnej intensywności ochrony chemicznej i nawożenia azotem. Badania polowe wykonano w Stacji Badawczej UTP w Mochełku na glebie płowej właściwej, w latach 2008-2011, w układzie losowanych podbloków. Oceniano wpływ międzyplonu ścierniskowego (grochu siewnego przyorywanego jesienią w roku poprzedzającym siew jęczmienia – czynnik I) na zawartość N, P, K, Ca, Mg i włókna surowego w ziarnie jęczmienia jarego uprawianego z zastosowaniem różnego poziomu ochrony chemicznej roślin (niski oraz wysoki – czynnik II) oraz zróżnicowanego nawożenia azotem (0; 35; 70; 105 i 140 kg·ha^{-1} – czynnik III). Zawartość składników w ziarnie oznaczono w laboratorium chemicznym Katedry Agrotechnologii UTP w Bydgoszczy. Międzyplon ścierniskowy, przyorany jesienią jako zielony nawóz, istotnie zwiększał zawartość azotu i fosforu w ziarnie jęczmienia jarego. Intensywność ochrony chemicznej jęczmienia nie wpływała na zawartość N, P, K, Ca, Mg i włókna surowego w ziarnie. Zwiększanie dawki azotu w zakresie od 0 do 140 kg·ha^{-1} sprzyjało zwiększaniu koncentracji N, P i K w ziarnie jęczmienia oraz zmniejszaniu zawartości Mg. Zawartość P, K, Ca i włókna surowego była ujemnie skorelowana z plonem przyoranej biomasy grochu siewnego.

Koncentracja Ca w ziarnie była ponadto negatywnie skorelowana z plonem ziarna, natomiast zwartość magnezu była dodatnio skorelowana zarówno z plonem przyoranej biomasy grochu, jak również z plonem ziarna jęczmienia. Badania potwierdziły istotne znaczenie międzyplonu ścierniskowego, wykorzystanego jako zielony nawóz, dla kształtowania jakości plonu ziarna jęczmienia jarego. Hipoteza badawcza nie została w pełni potwierdzona w zakresie wpływu tego czynnika na jakość ziarna jęczmienia uprawianego w warunkach niskiego nawożenia azotem. W obiektach, w których nie stosowano azotu, międzyplon ścierniskowy wykorzystany jako zielony nawóz wpłynął istotnie jedynie na zawartość Ca w ziarnie, natomiast jęczmień nawożony azotem w dawce 35 $kg \cdot ha^{-1}$ N reagował istotnie na zielony nawóz z międzyplonu ścierniskowego tylko poprzez zwiększenie koncentracji potasu i magnezu w ziarnie.

Słowa kluczowe: dawka azotu, groch siewny, intensywność ochrony roślin, jęczmień jary, międzyplon ścierniskowy

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