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EVALUATION OF SPRING TRITICALE, FABA BEAN AND THEIR MIXTURES CULTIVATED AS FORECROPS FOR WINTER WHEAT

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Abstract. In an experiment carried out in the years 2004-2007 at the Agriculture Research Station Zawady (52°20' N; 22°30' E) owned by the Podlasie Academy in Siedlce the forecrop value was evaluated for winter wheat of post-harvest residues alone or in combination with straw, of spring wheat, faba bean and spring wheat-faba bean mixtures. Post-harvest residue and straw biomass as well as total nitrogen, phosphorus and potassium accumulations were assessed. Spring triticale produced more post-harvest residues and straw than faba bean. Spring triticale-faba bean mixtures in turn produced intermediate amounts of post-harvest residues and straw compared with the plants in question cultivated in pure stand. Spring triticale biomass was poorer in nitrogen and potassium than faba bean and spring triticale-faba bean mixtures. Winter wheat cultivation following faba bean and mixtures of spring triticale and faba bean significantly increased grain yield and total protein yield, compared with winter wheat cultivation after spring triticale. Soil quality increased as faba bean share in the mixture increased. Straw added to forecrop post-harvest residues significantly increased grain yield, number of ears per 1 m^2 and total protein content and yield.

Key words: biomass, forecrop, grain and total protein yield, mixture, yield components, winter wheat

INTRODUCTION

In recent years there has been observed a tendency to increase the share of cereals in the sowing structure of many farms, which results in continuous cropping of cereals. As a consequence, grain yield has been decreasing, the yield level depending on crop plant species and cultivars, habitat conditions and cultivation intensity [Hruszka and Sadowski 1997, Kaczmarska and Gawrońska-Kulesza 2000, Wanic and Nowicki 2000, Wanic et al. 2000]. The decrease is first of all a result of soil environment degradation which is termed „soil tiredness" [Smyk 1992, Wanic and Nowicki 2000]. Its most

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visible symptoms are e.g. excessive weed infestation, and disease and pest development [Wolny 1992, Kaczmarska and Gawrońska-Kulesza 2000, Wanic and Nowicki 2000, Wanic et al. 2000]. Researchers have long been searching for methods of preventing the above-mentioned problems. Cultivation of cereal and cereal-legume mixtures is an example of such methods [Rudnicki and Kotwica 1994, Rudnicki and Wasilewski 2000, Wanic and Nowicki 2000, Wanic et al. 2000, Kotwica 2006]. Maybe, by introducing into rotation a substitute for the so-called bio-diversity, the cultivation will at least partially prevent negative results of neglect in rotation management [Wanic and Nowicki 2000, Wanic et al. 2000]. Possibilities of limiting unfavourable changes in agro-systems resulting from the continuous cultivation of cereals may also result from incorporating plant biomass – straw and catch crop biomass – into the soil [Siuta 1998, 1999, Jaskulski and Jaskulska 2004]. An effect of plant biomass on soil properties and plant yields is many-sided and depends, among others, on the soil type, chemical composition, as well as the date and manner of incorporation [Jaskulski and Jaskulska 2004].

The objective of the study was to determine the value of post-harvest residues of spring triticale, faba bean and mixtures of the plants as well as post-harvest residues in combination with straw, the aforementioned plants preceding winter wheat cultivation.

MATERIAL AND METHODS

A field experiment was carried out in the years 2004-2007 at the Agriculture Research Station Zawady (52°20' N; 22°30' E) owned by the Podlasie Academy in Siedlce. It was situated on the very good rye complex soil characterised by neutral pH, and average available phosphorus, potassium and magnesium contents. The experiment was designed as a two-factor split-block arrangement of treatments in three replications. The plot area for harvest was 20 m^2. The first factor was a winter wheat forecrop which included: spring triticale cv. Kargo, faba bean cv. Titus, or mixtures of spring triticale and faba bean containing the following shares of respective components: 75 + 25%, 50 + 50% and 25 + 75%. The species share in the mixture was established relative to the number of pure stand-planted seeds, that is 400 spring triticale seeds and 70 faba bean seeds per 1 m^2. The second factor was forecrop biomass: either post-harvest residues alone or post-harvest residues + straw. Forecrop plants were grown for grain or seeds. In the treatments where only post-harvest residues were incorporated, straw was removed from the field. In contrast, in the treatments with straw, the straw was chopped during harvest and left in the field. Spring triticale straw was ploughed under with an addition of nitrogen (0.7% N relative to straw amount). Mean straw samples were taken in addition to post-harvest residues (stubble, litter, roots) sampled by the method described by Batalin [1962] from an area of 0.25 m^2 and a depth of 0.30 m. Total nitrogen (N), phosphorus (P) and potassium (K) contents were determined in the dry matter of forecrop post-harvest residues and straw by means of the Kjeldahl method, vanadium-molybdenum method and flame photometry method, respectively. Next, there were calculated the contents of the above elements accumulated in post-harvest residues and straw separately, and then in post-harvest residues and straw together.

Winter wheat cv. Sakwa was drilled in the second decade of September in an amount of 550 germinating seeds per 1 m^2. The seed was treated with Baytan Universal 19.5 WS. In the rotation, winter wheat was preceded by oats. Mineral fertilizer rates were as follows: 100 kg N·ha^{-1}, 26 kg P·ha^{-1} and 79 kg K·ha^{-1}. Phosphorus and potassium fertilizers were applied pre-plant. Nitrogen fertilizer was applied in split application – the first rate (60 kg N·ha^{-1}) in spring after plant growth had been initiated, and the second one (40 kg N·ha^{-1}) at the third internode stage of winter wheat. Apyros 75 WG + Atpolan 80 EC were applied to control weeds and Decis 2.5 EC or Fastac 100 EC were used for pest control. The rates and application dates of the chemicals were in accordance with recommendations of the Institute of Plant Protection in Poznań. Winter wheat was harvested at the ripening stage. In the study there were determined: grain yield at grain moisture of 15%, ear number per 1 m^2, number of kernels in an ear, 1000-kernel weight, and total protein content in winter wheat grain (by the Kjeldahl method, N% x 5.7). Moreover, total protein yield in winter wheat grain was calculated.

The experimental data were statistically analysed by means of variance analysis and Tukey test.

The weather conditions in spring and summer months (April – July) 2005-2007 were fairly differentiated. Total precipitation in the period from April to July 2005 was 207.6 mm (92.8% multi-year standard), while in 2006 – 109.6 mm (49% multi-year standard) and in 2007 – 209.5 mm (93.7% multi-year standard). In the spring and summer months of 2005-2007 mean monthly temperatures were higher than the multi-year average, except for May and June 2005. Mean air temperatures from April to July were as follows: in 2005 – 14.4^{o}C, in 2006 – 15.4^{o}C and in 2007 – 15.1^{o}C, compared with 13.6^{o}C for the multi-year period. The most favourable precipitation and temperature conditions for winter wheat growth were recorded in 2005, and the least favourable in 2006, which was characterized by a low amount of precipitation in May, June and July and a high air temperature in July (higher than the multi-year average by 4.7^{o}C).

RESULTS

Forecrops examined in the research produced comparable amounts of post-harvest residues and straw (Table 1).

Table 1. Dry matter yield of forecrop post-harvest residues and straw, t·ha^{-1} (mean for 2004-2006)
Tabela 1. Plon suchej masy resztek pożniwnych i słomy przedplonu, t·ha^{-1} (średnia z lat 2004--2006)

Forecrop – Przedplon	Post-harvest residues Resztki pożniwne	Straw Słoma	Post-harvest residues + straw Resztki pożniwne + słoma
Spring triticale – pszenżyto jare	3.93	4.12	8.05
Faba bean – bobik	2.40	3.27	5.67
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	3.71	3.93	7.64
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	3.35	3.76	7.11
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	2.89	3.45	6.34
Mean – Średnia	3.26	3.71	6.96
$LSD_{0.05}$ – $NIR_{0,05}$	0.24	0.28	0.47

Most post-harvest residues remained after winter triticale and a mixture of 75% spring triticale and 25% faba bean. A decreasing share of spring triticale in a mixture with faba bean from 75 to 50% and from 50 to 25% significantly decreased post-harvest residue amount (by 0.36 and 0.46 t·ha^{-1}, respectively) and the combined amount of post-harvest residues and straw (by 0.53 and 0.77 t·ha^{-1}, respectively). Faba bean produced significantly least post-harvest residues, whereas faba bean or spring triticale in a mixture with 75% of faba bean produced least straw. The amount of faba bean post-harvest residues and of post-harvest residues with straw was lower by 1.53 and 2.38 t·ha^{-1} compared with spring triticale amount, and by 0.49-1.31 and 0.67-1.97 t·ha^{-1} compared with the amount of biomass of spring triticale-faba bean mixture.

The forecrops under comparison accumulated varying amounts of total nitrogen, phosphorus and potassium in post-harvest residues and straw (Table 2). Post-harvest residues of a mixture of spring triticale and faba bean (50 + 50% or 25 + 75%, respectively) were found to be the richest nitrogen source. The best sources of phosphorus were spring triticale and the post-harvest residues of a spring triticale-faba bean mixture in which shares of components were 75 + 25% and 50 + 50%. As for potassium, post-harvest residues of a mixture of 25% spring triticale and 75% faba bean proved to be the richest source of this element. Faba bean straw and the straw of a mixture of 25% spring triticale and 75% faba bean accumulated most nitrogen and potassium, whereas spring triticale straw and the straw of the mixture consisting of 75% spring triticale and 25% faba bean accumulated most phosphorus. Post-harvest residues incorporated with the straw in the first place enriched the soil with potassium (65-80 kg·ha^{-1}) and nitrogen (54-76 kg·ha^{-1}) and, to a lesser extent, with phosphorus (7-8 kg·ha^{-1}). Spring triticale post-harvest residues biomass and straw accumulated less nitrogen and potassium than the biomass of faba bean and spring triticale-faba bean mixtures.

Table 2. Amount of macroelements (N, P, K) in forecrop post-harvest residues and straw, kg·ha^{-1} (mean for 2004-2006)
Tabela 2. Ilość makroskładników (N, P, K) w resztkach pożniwnych i słomie przedplonu, kg·ha^{-1} (średnia z lat 2004-2006)

Forecrop – Przedplon	Post-harvest residues Resztki pożniwne			Straw Słoma			Post-harvest residues + straw – Resztki pożniwne + słoma		
	Macroelements – Makroskładniki								
	N	P	K	N	P	K	N	P	K
Spring triticale – pszenżyto jare	24.76	3.93	22.40	29.25	4.53	42.85	54.01	8.46	65.25
Faba bean – bobik	33.84	3.12	25.20	41.53	3.92	54.94	75.37	7.04	80.14
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	33.02	4.08	24.49	31.83	4.32	45.59	64.85	8.40	70.08
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	37.52	4.02	26.46	36.10	4.14	49.63	73.62	8.16	76.09
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	36.99	3.47	28.32	38.99	4.14	52.10	75.98	7.61	80.42
Mean – Średnia	33.23	3.72	25.37	35.54	4.21	49.02	68.77	7.93	74.40
$LSD_{0.05}$ – $NIR_{0,05}$	2.51	0.30	1.64	2.67	0.32	3.78	6.13	0.74	5.76

Winter wheat grain yield was significantly affected by the kind and biomass of the forecrop incorporated (Table 3). Winter wheat grown after faba bean and spring triticale-faba bean mixtures produced significantly higher grain yields (by 25.93 and

11.57-28.01%, respectively), compared with winter wheat cultivation following spring triticale. Winter wheat grain yield harvested from treatments in which mixtures of spring triticale and 50 and 75% share of faba bean had been grown was similar to the yield obtained after faba bean. The yield discussed was significantly lower compared with the grain yield of winter wheat grown after a mixture of spring triticale and 25% share of faba bean. Forecrop post-harvest residues incorporated with the straw significantly increased winter wheat grain yield (on average by 0.44 $t \cdot ha^{-1}$, that is 9.09%), compared with post-harvest residues alone. The forecrop impact on winter wheat grain yield was affected by the forecrop biomass. The highest winter wheat grain yield was obtained in the post-harvest residue treatments where the cereal followed either faba bean or mixtures of spring triticale with 50 and 75% share of faba bean. In contrast, the treatments including straw incorporation the most beneficial influence on grain yield was observed for faba bean and a mixture of 25% spring triticale and 75% faba bean.

Table 3. Grain yield of winter wheat, $t \cdot ha^{-1}$ (mean for 2005-2007)
Tabela 3. Plon ziarna pszenicy ozimej, $t \cdot ha^{-1}$ (średnia z lat 2005-2007)

Forecrop – Przedplon	Forecrop biomass – Masa organiczna przedplonu		
	post-harvest residues resztki pożniwne	post-harvest residues + straw – resztki pożniwne + słoma	mean – średnia
Spring triticale – pszenżyto jare	4.19	4.45	4.32
Faba bean – bobik	5.18	5.69	5.44
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	4.63	5.00	4.82
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	4.96	5.44	5.20
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	5.25	5.80	5.53
Mean – Średnia	4.84	5.28	–
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:			
forecrop – przedplonu			0.28
forecrop biomass – masy organicznej przedplonu			0.26
interaction – interakcji: forecrop x forecrop biomass – przedplon x masa organiczna przedplonu			0.32

The winter wheat ear number per m^{-2} was significantly influenced by the experimental factors (Table 4). The number of ears per m^{-2} was significantly lower in the treatments where faba bean and spring triticale-faba bean mixtures were cultivated. Among the mixtures compared, only the mixture of spring triticale and 25% faba bean significantly reduced the winter wheat ear number per m^{-2}, compared with faba bean. An addition of straw to forecrop post-harvest residues significantly increased the winter wheat ear number per m^{-2}. An interaction of the experimental factors revealed that the difference in the ear number of winter wheat planted after post-harvest residues of mixtures of spring triticale with 50 or 75% share of faba bean was within the experimental error limits. In contrast, in the treatments where post-harvest residues and straw were incorporated the winter wheat ear number significantly increased as the faba bean share in a mixture with spring triticale increased.

Table 4. Yield components of winter wheat (mean for 2005-2007)
Tabela 4. Elementy struktury plonu pszenicy ozimej (średnia z lat 2005-2007)

Forecrop Przedplon	Number of ears per m^2 Liczba kłosów na m^2			Number of kernels per ear Liczba ziaren w kłosie			Weight of 1000 kernels, g Masa 1000 ziaren		
	Forecrop biomass – Masa organiczna przedplonu*								
	1	2	mean średnia	1	2	mean średnia	1	2	mean średnia
Spring triticale – pszenżyto jare	482	498	490	26.3	26.7	26.5	32.9	33.1	33.0
Faba bean – bobik	547	576	562	27.6	28.1	27.9	34.0	34.6	34.3
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	506	530	518	26.8	27.3	27.1	33.7	34.0	33.9
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	529	558	544	27.2	27.8	27.5	34.1	34.5	34.3
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	548	582	565	27.6	28.2	27.9	34.2	34.7	34.5
Mean – Średnia	522	549	–	27.1	27.6	–	33.8	34.2	–
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:									
forecrop – przedplonu			19			1.1			1.0
forecrop biomass – masy organicznej przedplonu			16			ns – ni			ns – ni
interaction – interakcji:									
forecrop x forecrop biomass – przedplon x masa organiczna przedplonu			22			ns – ni			1.2

* 1 – post-harvest residues – resztki pożniwne, 2 – post-harvest residues + straw – resztki pożniwne + słoma
ns – ni – non-significant differences – różnica nieistotna

The number of kernels per ear and 1000-kernel weight were significantly affected by the forecrops (Table 4). Independently of the forecrop biomass, the number of kernels per ear in winter wheat was significantly higher in the treatment where faba bean and a mixture of spring triticale and 75% of faba bean had been the previous crop, compared with the spring triticale-planted treatment. The impact of spring triticale-faba bean mixtures studied on the number of kernels per ear of winter wheat did not differ significantly from the influence of faba bean. Winter wheat grown after faba bean and mixtures of spring triticale and 50 or 75% faba bean was characterized by a higher 1000-kernel weight, compared with the wheat cultivated following spring triticale. The 1000-kernel weight of winter wheat cultivated after spring triticale-faba bean mixtures was similar to the 1000-kernel weight of winter wheat grown following faba bean. In the treatments where post-harvest residues of forecrops under comparison were incorporated, only a mixture of spring triticale with 75% faba bean significantly increased 1000-kernel weight of winter wheat, compared with spring triticale. In contrast, on plots where post-harvest residues and straw were ploughed under 1000-kernel weight of winter wheat planted after faba bean and spring triticale-faba bean mixtures in which the share of components was 50 + 50%, and 25 + 75%, respectively was significantly higher than in the case of winter wheat cultivation following spring triticale.

Total protein content in winter wheat grain was significantly affected by forecrop kinds and the amount of forecrop biomass (Table 5). The grain of winter wheat cultivated after faba bean and mixtures of spring triticale with 50 and 75% share of faba bean was characterised by a significantly higher total protein content (by 9.3, 5.3 and 7.4 $g \cdot kg^{-1}$ d.m., respectively) than the grain of winter wheat grown after spring triticale.

The total protein content in winter wheat grain planted following mixtures of spring triticale and 25 or 50% faba bean share was significantly lower (by 6.9 and 4.0 g·kg^{-1} d.m., respectively), in comparison with the grain of winter wheat cultivated after faba bean. The application of forecrop straw before winter wheat cultivation significantly increased total protein content (on average by 2.9 g·kg^{-1} d.m.). Both in treatments with post-harvest residues alone and the treatments including post-harvest residues and straw, total protein accumulation in winter wheat grain was enhanced when faba bean and a mixture of spring triticale and 75% faba bean were forecrops.

Table 5. Total protein content in winter wheat grain, g·kg^{-1} d.m. (mean for 2005-2007)
Tabela 5. Zawartość białka ogólnego w ziarnie pszenicy ozimej, g·kg^{-1} s.m. (średnia z lat 2005--2007)

Forecrop – Przedplon	Forecrop biomass – Masa organiczna przedplonu		
	post-harvest residues resztki pożniwne	post-harvest residues + straw – resztki pożniwne + słoma	mean – średnia
Spring triticale – pszenżyto jare	112.2	114.3	113.3
Faba bean – bobik	120.9	124.3	122.6
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	114.4	116.9	115.7
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	117.1	120.1	118.6
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	119.0	122.4	120.7
Mean – Średnia	116.7	119.6	–
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:			
forecrop – przedplonu			2.6
forecrop biomass – masy organicznej przedplonu			2.1
interaction – interakcji: forecrop x forecrop biomass – przedplon x masa organiczna przedplonu			3.0

Total protein yield of winter wheat grain was significantly influenced by the experimental factors (Table 6). Significantly lowest total protein yield of winter wheat grain was found in the spring triticale forecrop-based treatment. Increasing the faba bean share in the mixture with spring triticale significantly increased total protein yield in winter wheat grain. The total protein yield of winter wheat grain from the treatments where mixtures of spring triticale and a 25 or 50% faba bean share had been incorporated was significantly lower (by 106 and 49 kg·ha^{-1}, that is 16.64 and 7.69%, respectively). The total protein yield from the treatment where a mixture including 75% faba bean share had been incorporated did not differ significantly from the yield recorded for the faba bean-based treatment. Ploughing under of forecrop post-harvest residues and straw before winter wheat cultivation significantly increased grain total protein yield (on average by 63 kg·ha^{-1}, that is 11.67%), compared with post-harvest residues alone. A forecrop effect on the total protein yield of winter wheat grain was modified by the forecrop biomass. The highest total protein yield was found in the treatments where winter wheat cultivation was preceded by incorporation of post-harvest residues of faba bean as well as a mixture of spring triticale and 75% faba bean together with straw.

Table 6. Total protein yield of winter wheat grain, kg·ha^{-1} (mean for 2005-2007)
Tabela 6. Plon białka ogólnego ziarna pszenicy ozimej, kg·ha^{-1} (średnia z lat 2005-2007)

Forecrop – Przedplon	Forecrop biomass – Masa organiczna przedplonu		
	post-harvest residues resztki pożniwne	post-harvest residues + straw – resztki pożniwne + słoma	mean – średnia
Spring triticale – pszenżyto jare	448	485	467
Faba bean – bobik	598	676	637
Spring triticale 75% + faba bean 25% Pszenżyto jare 75% + bobik 25%	504	557	531
Spring triticale 50% + faba bean 50% Pszenżyto jare 50% + bobik 50%	553	622	588
Spring triticale 25% + faba bean 75% Pszenżyto jare 25% + bobik 75%	595	677	636
Mean – Średnia	540	603	–
$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:			
forecrop – przedplonu			41
forecrop biomass – masy organicznej przedplonu			32
interaction – interakcji:			
forecrop x forecrop biomass – przedplon x masa organiczna przedplonu			48

DISCUSSION

The value of a crop plant is to a large extent determined by the quantity and quality of its post-harvest residues [Szmigiel 1986, Skrzyczyński et al. 1992, Malicki 1997, Szempliński 1997]. Post-harvest residues constitute a permanent organic matter source in the soil. Due to complex biochemical processes they are converted into humus – a basic fertility factor in the soil which conditions its physical, chemical and biological properties [Malicki 1997, Wanic et al. 2004]. In the experiment carried out the least of post-harvest residues were supplied by faba bean, whereas most post-harvest residues were supplied by spring triticale as well as a mixture of spring triticale and 25% share of faba bean. The spring triticale post-harvest residue amount did not differ significantly from the post-harvest residue amount of spring cereals determined by many authors [Batalin 1962, Paprocki and Zieliński 1966, Římovský 1987, Wanic et al. 2004]. Also, the amount of faba bean post-harvest residue dry matter was within the range of quantities recorded in other studies [Paprocki and Zieliński 1966, Skrzyczyński et al. 1992, Chrzanowska-Drożdż 1996, Jasińska et al. 1996, 1997]. In the experiment by Parocki and Zieliński [1966] faba bean post-harvest residue amount was higher compared with oats. In contrast, post-harvest residue yield produced by mixtures of faba bean and oats was lower compared with faba bean or oats cultivated in pure stand. The post-harvest residue amount varies and depends mainly on the plant species and cultivars, soil, climatic as well as agrotechnological conditions [Batalin 1962, Beringer 1984, Szmigiel 1986, Římovský 1987, Skrzyczyński et al. 1992, Jasińska et al. 1996, 1997, Malicki 1997, Wanic et al. 2004]. The post-harvest residue amount of crop plants can be increased by incorporating their straw [Chrzanowska-Drożdż 1996, Jasińska et al. 1996, 1997, Siuta 1999, Kotecki et al. 2001]. Under the conditions of the experiment discussed the post-harvest residues and straw introduced into the soil over twice as much organic matter as post-harvest residues.

The total amount of nutrients in crop plant biomass is the product of its amount and the content of individual nutrients [Paprocki and Zieliński 1966, Malicki 1997, Wanic et al. 2004]. In the present study the post-harvest residues and straw of faba bean and mixtures of spring triticale with 50 and 75% share of faba bean were richer in nitrogen and potassium than spring triticale post-harvest residues and straw. Most phosphorus was introduced into soil with post-harvest residues and straw of spring triticale and the mixture of spring triticale and faba bean sown in respective proportions of 75 + 25%. The post-harvest residues of forecrops under comparison, including the straw, accumulated twice as much nitrogen and phosphorus, and thrice as much potassium as the post-harvest residues without straw. While evaluating post-harvest residues and straw value, special attention is ascribed to the nitrogen content and the carbon-to-nitrogen ratio (C : N). These characteristics influence e.g. the rate of organic matter decomposition. Compared with papilionaceous plants, cereal post-harvest residues and straw are characterized by a wider C : N ratio. Low nitrogen organic matter (wide C : N ratio) undergoes decomposition more slowly [Szmigiel 1986, Římovský 1987, Skrzyczyński et al. 1992, Kaczmarska and Gawrońska-Kulesza 2000, Wanic et al. 2004].

Similarly to the studies by many workers [Harasimowicz-Hermann 1997, Hruszka and Sadowski 1997, Szempliński 1997, Siuta et al. 1998, Rudnicki and Wasilewski 2000, Blecharczyk et al. 2006], the forecrop kind influenced the level of winter wheat yields under the conditions of the experiment discussed. The grain yield of winter wheat following faba bean and the mixtures of spring triticale and faba bean was significantly higher than the yield of winter wheat following spring triticale. A beneficial impact of leguminous plants selected for cultivation as winter wheat forecrops has been extensively discussed in literature [Dzienia and Romek 1993, Badaruddin and Meyer 1994, Chrzanowska-Drożdż 1996, Maidl et al. 1996, Harasimowicz-Hermann 1997, Hruszka and Sadowski 1997, Szempliński 1997, Siuta et al. 1998, Blecharczyk et al. 2000, 2006]. An increase in yields harvested following leguminous plants does not necessarily result from an amount of nitrogen supplied by the plants. It is also a result of limiting an occurrence of diseases and weeds, improving soil structure and improving availability of remaining macroelements [Paprocki and Zieliński 1966, Blecharczyk et al. 2006]. According to Rudnicki and Wasilewski [2000], some cereal-legume mixtures may constitute a rotation element which can reduce negative impacts of continuous cereal cultivation. The quality of soil at sites where cereal-legume mixtures have been grown depends on the choice of components (cereal and legumes), their proportion in the stand, cultivar characteristics, level of yields and soil conditions [Kotwica and Rudnicki 1994, Rudnicki and Kotwica 1994, Harasimowicz-Hermann 1997, Siuta i in. 1998, Wanic and Nowicki 2000, Kotwica 2006]. In the experiment discussed, spring triticale-faba bean mixtures proved to be a good forecrop for winter wheat. Winter wheat grain yield harvested from the plots on which a mixture of spring triticale and faba bean (25% share) had been cultivated, was on average higher by 0.5 $t \cdot ha^{-1}$ than the yield from the plots where spring triticale was the previous crop. Also, the research results by other authors have shown an increase in the cereal grain yield when the cereals followed cereal-legume mixtures, compared with cereals cultivated in pure stand [Paprocki and Zieliński 1966, Kotwica and Rudnicki 1994, Rudnicki and Kotwica 1994, Harasimowicz-Hermann 1997, Siuta et al. 1998, Kotwica 2006]. In the present experiment, increasing the faba bean share in a mixture with spring triticale significantly increased the grain yield of winter wheat cultivated following these mixtures. The higher a proportion of leguminous plants component in the mixture sown, the higher the value of cereal-legume mixtures cultivated as forecrops for cereals [Kotwica and Rudnicki 1994, Rudnicki and Kotwica 1994, Siuta et al. 1998, Kotwica 2006]. A higher nitrogen content and lower C : N ratio resulting from it in the biomass incorporated makes it possible to more quickly supply the following plant with nitrogen and other nutrients [Szmigiel 1986, Římovský 1987, Skrzyczyński et al. 1992, Kaczmarska and Gawrońska-Kulesza 2000]. An impact of mixtures of spring triticale with 50 and 75% share of faba bean on winter wheat grain yield was similar to an impact of faba bean. Similar findings have been reported by Rudnicki and Kotwica [1994]. Compared to winter wheat following spring triticale, an increase in the yield of winter wheat grown after faba bean and mixtures of spring triticale and faba bean resulted mainly from an increased number of ears per m^2 and heavier kernels. Similar findings were reported by Chrzanowska-Drożdż [1996], Hruszka and Sadowski [1997], and Blecharczyk et al. [2000, 2006]. Winter wheat grain from locations where faba bean and spring triticale-faba bean mixtures including 50 and 75% faba bean preceded winter wheat cultivation contained more protein than the grain from locations where spring triticale was a forecrop. It indicates that in these locations winter wheat was supplied with more nitrogen, which is mentioned by other authors [Dzienia and Romek 1993, Chrzanowska-Drożdż 1996, Szempliński 1997, Blecharczyk et al. 2000], too. Higher total protein yield of winter wheat grain from plots on which faba bean and faba bean-spring triticale mixtures were forecrops, compared to spring triticale, was influenced by both the grain yield and the total protein content in the grain [Dzienia and Romek 1993, Chrzanowska-Drożdż 1996].

The research carried out revealed that straw addition to forecrop post-harvest residues increased winter wheat grain yield, number of ears per m^2, and total protein content and yield in the grain. Similar straw effects in cereal cultivation have been reported in the papers by Kuduk [1979], Gorzelny [1986], and Siuta [1999]. Biological processes of decomposition of straw incorporated may cause various changes in soil physicochemical properties, and influence the yields of following plants [Gorzelny 1986, Kotecki et al. 2001].

CONCLUSIONS

1. Spring triticale produced more post-harvest residues and straw than faba bean. Mixtures of spring triticale and faba bean, in turn, produced intermediate amounts of post-harvest residues and straw compared with their components cultivated in pure stand.

2. Nitrogen and potassium amounts in spring triticale post-harvest residues and in the post-harvest residues in combination with straw were lower, and phosphorus amount was higher than in the post-residues of either faba bean or mixtures of spring triticale and faba bean.

3. A significantly higher winter wheat yield obtained after the cultivation of faba bean or spring triticale-faba bean mixtures resulted mainly from a higher number of ears per m^2 and increased 1000-thousand kernel weight.

4. Winter wheat grain yield, yield components and grain total protein yield and content increased following an increased faba bean share in mixtures with spring

triticale. Thus, the quality of soil was improved as a result of increasing a leguminous plant share in a mixture.

5. Incorporation of post-harvest residues of the forecrops under comparison together with their straw, preceding winter wheat cultivation, significantly increased grain yield, number of ears per m^2, and total protein content and yield, compared with post-harvest residues.

6. If grain and total protein yields are assumed as evaluation criteria, faba bean and a mixture of spring triticale with 75% share of faba bean seem to have been the best winter wheat forecrops, under the conditions of the experiment discussed.

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OCENA WARTOŚCI PRZEDPLONOWEJ PSZENŻYTA JAREGO, BOBIKU I ICH MIESZANEK DLA PSZENICY OZIMEJ

Streszczenie. W doświadczeniu zrealizowanym w latach 2004-2007 w Rolniczej Stacji Doświadczalnej Zawady (52°20’ N; 22°30’ E), należącej do Akademii Podlaskiej w Siedlcach, badano wartość przedplonową dla pszenicy ozimej resztek pożniwnych oraz resztek pożniwnych łącznie ze słomą następujących roślin: pszenżyta jarego, bobiku i mieszanek pszenżyta jarego z bobikiem. Określono masę resztek pożniwnych i słomy, nagromadzenie azotu ogółem, fosforu i potasu. Pszenżyto jare wytworzyło więcej resztek pożniwnych i słomy niż bobik. Mieszanki pszenżyta jarego z bobikiem pozostawiły pośrednią masę resztek pożniwnych i słomy między ich komponentami w czystym siewie. Masa organiczna pszenżyta jarego była mniej zasobna w azot i potas niż masa bobiku i mieszanek pszenżyta jarego z bobikiem. Uprawa pszenicy ozimej w stanowisku po bobiku i mieszankach pszenżyta jarego z bobikiem istotnie zwiększała plon ziarna i plon białka ogólnego w porównaniu z uprawą w stanowisku po pszenżycie jarym. Jakość stanowiska poprawiała się wraz ze wzrostem udziału bobiku w mieszance. Dodatek słomy do resztek pożniwnych przedplonu powodował istotny wzrost plonu ziarna, liczby kłosów na 1 m^2 oraz zawartości i plonu białka ogólnego.

Słowa kluczowe: elementy struktury plonu, masa organiczna, mieszanka, plon ziarna i białka ogólnego, przedplon, pszenica ozima

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