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FORECROP VALUE OF NON-PAPILIONACEOUS PLANTS CULTIVATED IN STUBBLE INTERCROP FOR SPRING BARLEY UNDER VARIOUS FERTILISATION CONDITIONS

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ABSTRACT

Field experiments were carried out over 1996-1999 at the Experimental Station of the Faculty of Agriculture at Mochełek in the vicinity of Bydgoszcz on a very good rye complex soil. The aim of the present research was to evaluate the forecrop value for spring barley of five species of fodder crops (white mustard, radish, winter rape, sunflower and phacelia) cultivated in stubble intercrop after winter wheat, depending on the fertilisation method (cattle slurry fertilisation, wheat straw with mineral fertilisers added and with mineral fertilisers only). The effect of stubble intercrops on spring barley fertilisation was slight and differed over years. On average over three research years the highest grain yields were obtained after sunflower and phacelia; however the yield increase, as compared with the control, was 3.3% only. Neither was there observed a significant effect of intercrop fertilisation method on barley yielding. Radish and winter rape significantly increased the content of total protein in spring barley grain, which could have been due to a commonly known potential of accumulation of considerable amounts of nitrogen in biomass of these plants to be then made available to successive crops. The content of protein in grain collected from objects fertilised with wheat straw with mineral fertilisers added was significantly higher than those in the other variants of intercrop fertilisation.

Key words: successive effect, spring barley, stubble intercrop, white mustard, winter rape, sunflower, radish, phacelia, fertilisation, slurry, straw

INTRODUCTION

Over the last dozen-and-so years Polish agriculture has been observing a tendency to limit the number of crop species grown on farms, seen as an increasing share of cereals in crop rotation. In 1980 they made up 54.0% of all the crops however since 1996 the share has remained 69.1-71.3% [18]. Such a large share of cereals poses numerous threats to these plantations in the future. These threats have been well identified and widely covered in literature. The authors observe an increasing infection of plants with fungal diseases [2,17], increased occurrence of pests [6], compensation of weeds [21] secretion of toxins by plants and production of toxins due to plant reside decomposition [4,22].

Jelinowski [9] noted that as a result of simplification of plant production, all components of crop rotation got eliminated, affecting the soil productivity and plant yields. The number of fields on which root crops were cultivated on manure and after fodder crops is too low. Under these conditions the missing crop-rotation components are substituted with intercrop plantations aiming mainly at enriching soil with organic matter, and so affecting its biotic condition. The cultivation of intercrops to be ploughed-in and the application of slurry or straw after plants collected with harvester in rotation can replace organic fertilisation, connected with the field of root crops eliminated from crop-rotation.

Out of numerous plant species which can be cultivated in stubble intercrop, the best stand is after leguminous crops. However the value of this stand depends on the cultivation success. Legumes cultivated in intercrops require an early sowing which, due to delayed ripening and prolonging harvests, is most often impossible. Production difficulties and high seed price pose an excessive risk of losses if the plantation fails, which is conditioned much by weather conditions [14]. Reports by Skinder and Sypniewski [19] show a considerable applicability of non-papilionaceous plants to be cultivated in stubble intercrop thanks to their short vegetation period, which allows for relatively high yields of green matter, also at slightly delayed sowing dates. The research hypothesis assumed that also non-papilionaceous plants grown in stubble intercrop would increase the spring barley grain and straw yields and enhance the chemical composition and grain plumpness.

The aim of the present research was to define the forecrop value for spring barley of five plant species (white mustard, radish, winter rape, phacelia and sunflower) cultivated in stubble intercrop after winter wheat, depending on the fertilisation method.

MATERIAL AND METHODS

Field experiments were carried out over 1996-2000 at the Experimental Station of the Faculty of Agriculture at Mochełek in the vicinity of Bydgoszcz. Over successive research years strict field experiments were set up with the method of split block design in four replications. The sowing plots were 15 m^2 each, while harvest plots – 12 m^2. Stubble intercrop was sown following winter wheat harvest. Field experiments were carried out on lessive soil, made from heavy loamy sand, of very good rye complex, highly rich in available phosphorus (8.8 mg P in 100g), of high potassium (16.0 mg K in 100g) and average magnesium contents (6.28 mg Mg in 100g). Soil reaction in 1M KCl was 5.84.

The first factor – stubble intercrop fertilisation method:
I – cattle slurry
II – straw + mineral fertilisation ($kg \cdot ha^{-1}$): 80 N, 60 P_2O_5, 80 K_2O,
III – mineral fertilisation ($kg \cdot ha^{-1}$): 80 N, 60 P_2O_5, 80 K_2O.

Slurry dose in object I was set based on its share of nitrogen. Mean contents of nutrients in slurry were as follows: 0.21% N, 0.064% P_2O_5 and 0.25% K_2O in fresh matter. The content of dry matter accounted for 4.19%. The dose of nitrogen in slurry corresponded to the dose introduced in a form of mineral fertiliser in object III factoring in fertiliser equivalent at 50% (compliant with the Puławy Institute of Plant Cultivation and Soil Science (IUNG) guidelines [13]). Slurry satisfied also phosphorus-and-potassium fertilisation requirements at the level of doses applied in object III. In 1996 only due to a low content of phosphorus, a supplementary dose of 50.8 kg $P_2O_5 \cdot ha^{-1}$ was used. Object II – straw after winter wheat threshing was crushed and supplemented with a dose of 5 kg N per tonne of straw in order to balance the loss of this nutrient by biological immobilisation.

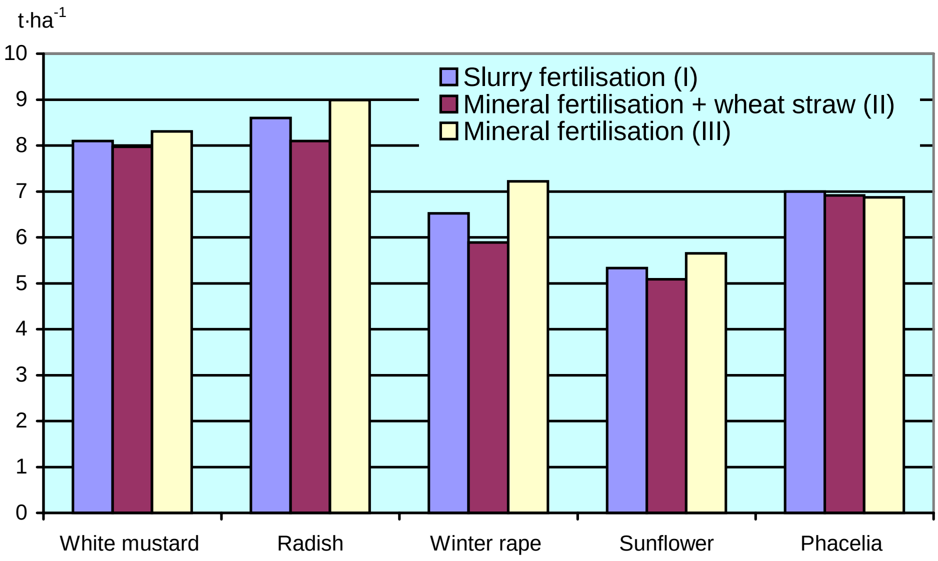
The second factor – species of crop cultivated in stubble intercrop:

1. 'Nakielska' white mustard,
2. 'Adagio' radish,

3. ‘Bolko’ winter rape,
4. ‘Wielkopolski’ sunflower,
5. ‘Stala’ phacelia,
6. Control (without intercrop).

Having sown mineral fertilisers and poured slurry disking was carried out and then plough down to about 12 cm. Prior to sowing, seedbed was prepared with cultivation aggregate (the control was also covered by the treatments). Seeds of crops cultivated in stubble intercrop were sown with plot drill, OYORD, over August 6-12. Plants were harvested after 75-78 days of development. After harvest the yield of the intercrop biomass produced was defined (Fig. 1). Overground plant parts were crushed and ploughed-in.

Fig. 1. Dry matter of stubble intercrops



‘Maresi’ spring barley was sown each year in the first decade of April. The sowing rate was established based on 1000 grain weight and functional value of the sowing material at a planned post-emergency plant density of 320 plants per 1 m^2. Phosphorus fertilisation (granulated triple superphosphate – 46% P_2O_5) and potassium fertilisation (potassium salt – 60% K_2O) was applied under pre-winter plough at the doses defined following the Puławy IUNG guidelines (based on the richness in phosphorus and potassium and agricultural soil suitability complex). Nitrogen fertilisation (ammonium nitrate – 34% N) was applied at two doses based on the Puławy IUNG six-degree scale for nitrogen fertilisation requirements estimation for very good rye complex. The first dose (60%) was applied in spring prior to barley sowing, while the second one (40%) at shooting stage. Weeds were controlled with herbicides (Puma Super 069EW + Granstar 75DF) at barley tillering.

After barley emergence the plant density was defined and prior to harvest - spike density and the number of grains per spike. Having harvested the plants, grain and straw yields were determined, samples were taken in which the contents of total protein, P, K, Ca, Mg were estimated as well as 1000 grain weight. Grain moisture was measured for each plot. Grain yields were calculated to 15% moisture.

The weather conditions were analysed based on observations made at the local observations-and-measurement station. To calculate variance analysis, AWAR software was used which was developed by Puławy IUNG. The analysis was carried out for split-block model. Significance of the differences was defined with Tukey test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Barley development over successive research years differed, which was mainly due to different weather conditions (Table 1). From sowing to the 2-3 leaf stage the differences in barley plant development over research years were relatively small and were mostly due to differences in temperature. Emergence occurred after 8-11 days after sowing (Table 2). In 1998 April mean temperature was higher than in the other years and resulted in a slightly earlier plant emergence. The barley grain yield depended more on the further development (from the beginning of tillering to the beginning of earing) in which the number of ear-bearing shoots and the number of spikelets develop and hence the number of grains per spike. There was noted here a considerable variation over successive research years. In 1998 this period was only 20 days long, while in the other years - 27 (1997) and 28 (1999) days long. The shortening of tillering and shooting was due to a rainfall deficit in the second and third decades of May and showed an unfavourable effect on the number of grains per spike and on the grain and straw yield. The grain filling was from 16 days in 1999 to 26 days in 1998 and showed a decisive effect on 1000 grain weight. Prolonging the grain filling in 1998 did increase 1000 grain weight by 16.2%, as compared with 1997 and by 13.7%, as compared with 1999. Similarly barley ripening showed some differences in successive vegetation periods. In 1997 and 1998 the total rainfall in July was considerably higher than the multi-year mean for this month, which delayed the harvest considerably, as compared with 1999. Plants cultivated in stubble intercrop as well as the fertilisation methods applied in the present research did not affect spring barley development.

Table 1. Weather conditions over spring barley cultivation on the research area

Month	Year			
	1997	1998	1999	Mean for 1949-1999
Monthly rainfall, mm				
April	20.7	21.1	62.1	27.3
May	96.5	46.4	45.5	39.9
June	36.7	94.7	58.6	55.5
July	108.5	96.0	43.9	69.5
Total April – July	262.4	258.2	210.1	192.2
Mean monthly temperature, ^{o}C				
April	4.7	9.3	8.6	7.2
May	11.5	13.8	12.2	12.6
June	16.0	16.5	16.5	16.2
July	17.7	16.7	20.0	17.8
April – July mean	12.5	14.1	14.3	13.4

Table 2. 'Maresi' spring barley development

Development stage	Sowing date		
	09.04.1997	07.04.1998	01.04.1999
	Number of days from sowing date to the beginning of		
Germination	7	5	7
Emergence	10	8	11
2-3 leaf stage	23	23	25
Tillering	31	30	36
Shooting	37	35	45
Tillering and flowering	58	50	64
Milk stage	83	82	86
Dough stage	105	99	103
Full grain ripeness	119	114	116
Vegetation period length / Harvest date	126 / 13.08.	122 / 07.08.	117 / 27.07.

In the present research the experiment factors changed neither the post-emergence plant density nor production culms (Tables 3-4). Neither did they affect the number of grains per spike (Table 5). The literature also very frequently reports no effect of non-papilionaceous intercrops on these parameters [10] or slight differences [1,8]. The 1000 grain weight recorded in the present research was, on average, 40g and by 9.3% lower as compared with 'Maresi' in Research Centre for Cultivar Testing (COBORU) experiments [23]. Barley grain plumpness measured with 1000 grain weight did not depend on the factors used in the experiment (Table 6). The results reported in literature are not consistent. Deryło [3] showed a slight increase in 1000 grain weight in cereals cultivated in stubble intercrop. Reports by Kuś and Jończyk [10] did not show a favourable effect of spring rape and white mustard intercrops on that parameter.

Table 3. Post-emergence spring barley plant density, pcs.·m^{-2}

Intercrop fertilisation variant / year	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
I	278 Aa	275 Aa	268 Aa	275 Aab	267 Ab	267 Ab	272 a
II	282 Aa	273 Aa	274 Aa	286 Aa	288 Aa	288 Aa	282 a
III	268 ABa	277 Aa	270 ABa	268 ABb	275 ABab	258 Bb	269 a
1997	294 A	289 A	293 A	291 A	292 A	289 A	291
1998	233 A	237 A	225 A	234 A	245 A	231 A	234
1999	300 A	299 A	295 A	304 A	293 A	292 A	297
Mean	276 A	275 A	271 A	276 A	277 A	271 A	274

I – intercrops fertilised with slurry supplemented with mineral fertilisation
II – intercrops fertilised with straw and mineral fertilisers
III – intercrops fertilised exclusively with mineral fertilisers
A, B, C – means marked with the same letter constitute a homogenous group across rows
a, b, c – means marked with the same letter constitute a homogenous group across columns

Table 4. Spike density prior to spring barley harvest, pcs.·m^{-2}

Intercrop fertilisation variant / year	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
I	585	617	598	629	597	602	605
II	630	627	647	575	640	615	622
III	580	614	600	605	572	591	594
1997	705	760	755	655	656	697	705
1998	525	547	534	594	588	554	557
1999	566	550	556	560	565	557	559
Mean	598	619	615	603	603	603	607

I – intercrops fertilised with slurry supplemented with mineral fertilisation
II – intercrops fertilised with straw and mineral fertilisers
III – intercrops fertilised exclusively with mineral fertilisers
The first factor – ns, second factor – ns, interactions – ns; ns – non-significant differences

Table 5. Number of grains per spring barley spike

Intercrop fertilisation variant / year	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
I	19.4	18.8	20.1	19.2	19.4	19.6	19.4
II	19.4	19.3	19.3	19.4	19.5	19.5	19.4
III	19.2	19.5	18.9	18.5	19.4	19.0	19.1
1997	22.0	22.4	22.5	21.5	21.8	22.8	22.2
1998	15.4	14.7	15.0	15.3	15.7	14.8	15.2
1999	20.7	20.5	20.8	20.2	20.8	20.6	20.6
Mean	19.3	19.2	19.4	19.0	19.4	19.4	19.3

I – intercrops fertilised with slurry supplemented with mineral fertilisation
II – intercrops fertilised with straw and mineral fertilisers
III – intercrops fertilised exclusively with mineral fertilisers
The first factor – ns, second factor – ns, interactions – ns; ns – non-significant differences

Table 6. Spring barley 1000 grain weight, g

Intercrop fertilisation variant / year	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
I	40.1	39.9	39.7	40.8	40.3	40.1	40.2
II	39.7	39.3	40.2	40.2	40.5	40.0	40.0
III	40.1	39.6	39.8	39.8	40.0	39.8	39.8
1997	37.7	36.4	38.0	38.0	37.7	38.2	37.7
1998	43.8	43.3	43.3	44.1	44.3	43.6	43.7
1999	38.3	39.0	38.3	38.7	38.7	38.1	38.5
Mean	40.0	39.6	39.9	40.3	40.3	40.0	40.0

I – intercrops fertilised with slurry supplemented with mineral fertilisation
II – intercrops fertilised with straw and mineral fertilisers
III – intercrops fertilised exclusively with mineral fertilisers
The first factor – ns, second factor – ns, interactions – ns; ns – non-significant differences

Three-year mean spring barley grain yields ranged from 4.07 $t{\cdot}ha^{-1}$ in control objects to 4.21 $t{\cdot}ha^{-1}$ with ploughed-in sunflower and phacelia intercrop and from 4.08 $t{\cdot}ha^{-1}$ in mineral fertilisation objects to 4.27 $t{\cdot}ha^{-1}$ with wheat straw ploughed-in (Table 7). Statistical analysis did not reveal significant yield difference across multi-year means. In successive years of field experiments there was recorded a high yielding variation. The highest grain and straw yields were recorded in the first research year (1997), while the lowest in 1998 in which also poorer grain germination was noted, and so a lower post-emergence plant density. Weather conditions over further development were unfavourable and barley did not manage to compensate for a lower number of plants over tillering or grain setting. Similar yield decreases e.g. due to soil and air drought were recorded by Paprocki et al. [16]. High yielding variation must have been due to different weather conditions across the years which must have affected respective development stages, and so the development of structural yield components. In the first research year there was observed high rainfall over April – May and relatively low temperature which prolonged barley tillering and the production of a high number of ear-bearing shoots and higher number of grains per spike than in successive years. A low rainfall in June that year combined with moderate temperature enhanced barley flowering.

Table 7. Spring barley grain yield, t·ha^{-1}

Intercrop fertilisation variant	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
1997							
I	5.04 Aa	5.00 Aa	4.90 Aa	4.67 Aa	4.90 Aa	4.91 Aa	4.90 a
II	5.13 Aa	5.17 Aa	5.15 Aa	5.24 Aa	5.32 Aa	5.11 Aa	5.19 a
III	5.07 Aa	5.01 Aa	4.74 Aa	4.63 Aa	4.49 Aa	4.75 Aa	4.78 a
Mean	5.08 A	5.06 A	4.93 A	4.85 A	4.90 A	4.92 A	4.96
1998							
I	3.42 ABa	2.69 Ba	3.10 ABa	3.71 Aa	3.60 Aa	3.23 ABa	3.29 a
II	3.15 Aa	3.32 Aa	3.29 Aa	3.56 Aa	3.71 Aa	3.66 Aa	3.45 a
III	3.47 Aa	3.38 Aa	3.27 Aa	3.76 Aa	3.43 Aa	3.51 Aa	3.47 a
Mean	3.35 A	3.13 A	3.22 A	3.68 A	3.58 A	3.47 A	3.40
1999							
I	4.11 Aa	4.25 Aa	4.16 Aa	4.23 Aa	4.18 Aa	3.95 Aa	4.15 a
II	4.22 Aa	4.26 Aa	4.17 Aa	4.14 Aa	4.24 Aa	4.00 Aa	4.17 a
III	4.13 Aa	4.27 Aa	4.10 Aa	3.94 Aa	3.97 Aa	3.51 Ba	3.99 a
Mean	4.15 AB	4.26 A	4.14 AB	4.10 AB	4.13 AB	3.82 B	4.10
Means for 1997-1999							
I	4.19 Aa	3.98 Aa	4.06 Aa	4.20 Aa	4.23 Aab	4.03 Aa	4.12 a
II	4.17 Aa	4.25 Aa	4.21 Aa	4.32 Aa	4.42 Aa	4.26 Aa	4.27 a
III	4.22 Aa	4.22 Aa	4.04 Aa	4.11 Aa	3.97 Ab	3.92 Aa	4.08 a
Mean	4.19 A	4.15 A	4.10 A	4.21 A	4.21 A	4.07 A	4.16

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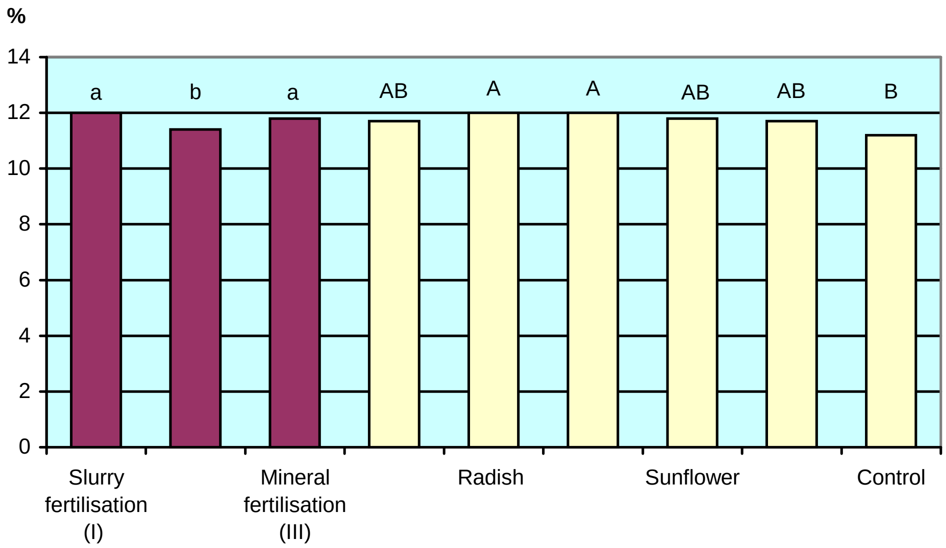
The present research shows a varied effect of the factors applied across years on decreasing negative effects of spring barley cultivation after winter wheat. In 1999 there were recorded significantly higher barley yields following radish plough-in, as compared with objects without intercrop. Over the other years no significant differences were recorded. The highest three-year spring barley grain yield means were obtained from the stand with sunflower and phacelia intercrops ploughed-in. The yields were by 3.4% higher than those from the control, without intercrop. Stubble intercrop fertilisation method did not have a considerable effect on barley yielding. Mean grain yields from objects with ploughed-in wheat straw were 4.7% higher as compared with those with mineral fertilisation of intercrops only. In the present research there was recorded no interaction between the intercrop species researched and their fertilisation methods as far as the grain yield was concerned. The results reported in literature show a great discrepancy. Numerous authors [3,5,7] indicate a potential of cereals yielding enhancement in monoculture or crop rotation of a high share of cereals. According to other authors [12,15], a favourable effect of intercrops is not always visible and sometimes even their effect on cereals yield is negative. Authors report on the effect of intercrops depending on weather (rainfall, temperature) and soil conditions.

The present research noted no effect of experimental factors on multi-year straw yield means. In the third year only the objects after radish plough-in gave a significantly higher yield than from no-intercrops objects, with sunflower and rape. In the third research year there were also recorded higher straw yields from objects with wheat straw ploughed-in, as compared with the others (data not shown).

The present research shows a varied-over-years effect of intercrops on yielding of spring barley cultivated after winter wheat. Kuś et al. [12] relate a varied effect of intercrop to disturbed soil water relations or to a prolonged organic matter decomposition of intercrop under unfavourable moisture conditions and immobilisation of nitrogen over intensive barley growth. According to authors, the effectiveness of treatments enhancing the quality of stand for barley is greater in better soils. The present research shows also that spring barley was relatively resistant to short-term cereal crop rotation. The species reacts only with a slight yield decrease. According to Deryła [1], spring barley is less sensitive to the effects of cereals concentration than winter wheat. A similar opinion is expressed by Kuś and Nawrocki [11] who report on winter cereals being more considerably infected by take-all diseases and as such they are less resistant when grown in temporary monoculture than spring cereals.

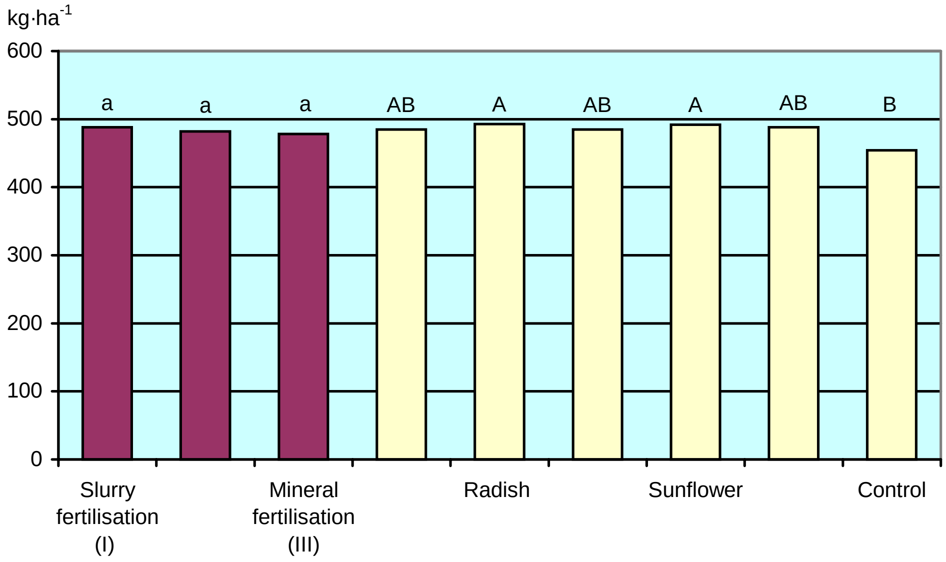
The content of total protein in grain dry-matter was 11.7% on average and depended on the factors researched (Fig. 2). Its especially high content was determined in barley cultivated after radish and winter rape after which it was significantly higher as compared with the control (without intercrops). A higher content of protein in barley grain cultivated after these intercrops could have been due to a higher content of nitrogen in their biomass. A total N content left in green forage and post-harvest residue of sunflower accounted for only 47% of the mass accumulated by radish. Additionally the availability of nitrogen from biomass of respective species for spring barley varies. Danish research showed that mineralising plant material of phacelia, fodder radish and white mustard was most often recorded in winter (as for phacelia, it started as early as in mid-November), while in winter rape as late as in spring [20]. Under our conditions which show a lower total rainfall and slightly lower temperature in winter, the mineralising rate would be slower, however one can assume that the specificity of mineralising rate for respective species would be corresponding to the present results. One can therefore assume that a considerable increase in the content of total protein in spring barley grain due to intercrop biomass must have been due to a high amount of nitrogen introduced into soil together with radish biomass. In winter rape this amount was considerably lower, however a slow mineralising was responsible for a considerable nitrogen availability at the time of nutrients accumulation in barley grain. A mean protein content in grain of barley cultivated after radish and winter rape was 12%, which shows its good nutritive value used for feed and for human consumption. However the value of such grain for brewery industry is limited.

Fig. 2. Content of total protein in spring barley grain (means followed by the same small or capital letters did not differ significantly at α = 0.05)



In the present research there was also recorded a relationship between the intercrop fertilisation methods applied and the content of protein in barley grain. The significantly lowest content of protein was determined in grain from objects in which, prior to intercrop sowing, wheat straw was ploughed- in, while significantly highest – for the variant with slurry and with mineral fertilisation. Protein yield calculated based on the grain yield and its percentage content was 8.6% higher in the stand after radish, as compared with that without intercrops (Fig. 3); the difference was significant. However there was observed no significant effect of intercrops fertilisation method on barley grain protein yield.

Fig. 3. Total protein yield from spring barley grain (means followed by the same small or capital letters did not differ significantly at α = 0.05)



The present research does not show any effect of intercrops on the content of other nutrients such as: phosphorus, magnesium and calcium in barley grain (Table 8). However the fertilisation method affected the content of potassium. The amount of this nutrient in grain collected from objects fertilised exclusively with mineral fertilisers was significantly higher than from the other objects.

Table 8. Content of basic macroelements in spring barley grain, % of d. m. (means for 1997-1999)

Intercrop fertilisation variant	Intercrop						
	White mustard	Radish	Winter rape	Sunflower	Phacelia	Control without intercrop	Mean
Phosphorus							
I	0.393	0.425	0.401	0.408	0.395	0.394	0.403
II	0.395	0.402	0.399	0.413	0.394	0.384	0.398
III	0.392	0.402	0.398	0.410	0.420	0.389	0.402
Mean	0.393	0.409	0.399	0.410	0.403	0.389	0.401
Potassium							
I	0.389 Ab	0.403 Aa	0.407 Aa	0.421 Aa	0.415 Ab	0.411 Aa	0.408 b
II	0.408 Aab	0.409 Aa	0.409 Aa	0.427 Aa	0.460 Aab	0.433 Aa	0.424 b
III	0.451 Aa	0.433 Aa	0.424 Aa	0.469 Aa	0.476 Aa	0.450 Aa	0.450 a
Mean	0.416 A	0.415 A	0.413 A	0.439 A	0.450 A	0.431 A	0.427
Magnesium							
I	0.193	0.197	0.190	0.180	0.190	0.197	0.191
II	0.167	0.180	0.193	0.190	0.190	0.183	0.184
III	0.180	0.200	0.187	0.183	0.193	0.190	0.189
Mean	0.180	0.192	0.190	0.184	0.191	0.190	0.188
Calcium							
I	0.029	0.038	0.034	0.039	0.030	0.029	0.033
II	0.029	0.036	0.028	0.027	0.027	0.020	0.028
III	0.029	0.032	0.027	0.033	0.028	0.038	0.031
Mean	0.029	0.035	0.030	0.033	0.028	0.029	0.031

I – intercrops fertilised with slurry supplemented with mineral fertilisation
II – intercrops fertilised with straw and mineral fertilisers
III – intercrops fertilised exclusively with mineral fertilisers
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The results presented show a limited potential of enhancing the stand for spring barley by cultivating stubble intercrop from non-papilionaceous plants. Despite a considerable amount of biomass ploughed-in, the yield-enhancing effect was inconsiderable. The present research confirms the results obtained by Paprocki et al. [16] who state that most probably spring barley as a cereal of poorly-developed root system and a short vegetation period does not make a good use of nutrients accumulated in large post-harvest residue. The yield-enhancing effect of nutrients introduced into soil could be visible in case of their shortage in soil. However spring barley was fertilised compliant with its requirements and so nutrients introduced into soil together with intercrop mass showed a favourable effect on the grain quality expressed as the total protein content. For that reason especially *Brassicaceae* plants, rich in nitrogen and potassium, considerably enhanced the protein content in grain and grain yield in spring barley.

CONCLUSIONS

1. The present research did not confirm the hypothesis in the part concerning a spring barley yielding-enhancement potential. Neither the crop species cultivated in stubble intercrop nor any of their fertilisation methods applied significantly increased the value of structural yielding components or grain and straw yields of spring barley cultivated after those intercrops.
2. There was observed a favourable effect of some plant species cultivated in stubble intercrop on the grain quality of spring barley which, grown after radish and winter rape, contained significantly more total protein as compared with the control, without intercrops. An average increase in barley grain protein yield due to the cultivation of stubble intercrops ranged from 6.94 to 8.71%.
3. Spring barley cultivated after stubble intercrops fertilised with slurry or with minerals contained significantly more protein than after intercrops cultivated in the stand with wheat straw ploughed-in.
4. An increased content of total protein in grain of barley sown after radish and winter rape intercrops shows a potential of these intercrops in enhancing the nutritive value of grain for human consumption and animal feed and a limited use in brewery.

REFERENCES

1. Deryło S., 1990. Badania nad regenerującą rolą poplonów ścierniskowych w płodozmianach o różnym udziale zbóż [Research into regenerating role of stubble aftercrops in crop rotation with a high share of cereals]. AR Lublin, Rozpr. Nauk. 127 [in Polish].
2. Deryło S., 1991. Wpływ międzyplonów ścierniskowych w zróżnicowanych płodozmianach na zdrowotność pszenicy ozimej i jęczmienia jarego [Effect of stubble intercrop in different crop rotations on the healthiness of winter wheat and spring barley]. V sem. płodozmianowe: Synteza i perspektywa nauki o płodozmianach, ART Olsztyn – VŠZ Brno, 35-44 [in Polish].
3. Deryło S., 1994. Wpływ międzyplonów ścierniskowych na kształtowanie się struktury i jakości plonu pszenicy ozimej i jęczmienia jarego w płodozmianach zbożowych [Effect of stubble intercrops on the development of winter wheat and spring barley yield structure and quality in cereal crop rotation]. Zesz. Nauk. ATR Bydgoszcz, Rolnictwo 35, 103-111 [in Polish].
4. Deur I., 1997. Fitotoksyczność słomy i resztek pożniwnych pszenicy ozimej uprawianej w monokulturze [Phytototoxicity of winter wheat straw and post-harvest residue in monoculture]. Zesz. Probl. Post. Nauk Roln. 452, 59-70 [in Polish].
5. Dworakowski T., 1998. Działanie międzyplonu ścierniskowego w ogniwie zmianowania zboża ozime – zboża jare [Effect of stubble intercrop in crop rotation link: winter and spring cereals]. Fragm. Agronom. 3, 90-99 [in Polish].
6. Głąba B., 1986. Występowanie nicieni szkodników zbóż w województwie gdańskim [Occurrence of cereal pests eelworms in the Gdańsk Province]. Wyd. IUNG Puławy, R (210) [in Polish].
7. Jaskulski D., Kotwica K., Tomalak S., 1998. Przydatność łubinu żółtego do uprawy w międzyplonie ścierniskowym w warunkach rachunku energetycznego i ekonomicznego [Applicability of yellow lupin to cultivation in stubble intercrop under energy and economic calculus conditions]. Mat. ogólnopolskiego sem. nauk. Łubin w rolnictwie ekologicznym, Przysiek, 87-90 [in Polish].
8. Jaskulski D., Tomalak S., Rudnicki F., 2000. Regeneracja stanowiska po pszenicy ozimej dla jęczmienia jarego przez rośliny międzyplonu ścierniskowego [Regeneration of post-winter-wheat stand for spring barley by stubble intercrop]. Zesz. Probl. Post. Nauk Roln. 470, 49-57 [in Polish].
9. Jelinowski S., 1990. Rola poplonów w warunkach uproszczonej struktury produkcji roślinnej [Role of after-crops under simplified plant production structure]. Mat. sem. nauk. Międzyplony we współczesnym rolnictwie, AR Szczecin, 121-122 [in Polish].
10. Kuś J., Jończyk K., 2000. Regenerująca rola międzyplonów w zbożowych członach zmianowania [Regenerating role of intercrops in cereal crop rotation links]. Zesz. Probl. Post. Nauk Roln. 470, 59-65 [in Polish].
11. Kuś J., Nawrocki S., 1980. Ocena zmianowań o zwiększonym udziale zbóż. I. Plonowanie pszenicy ozimej i jęczmienia jarego [Evaluation of crop rotation with an increased cereals share. I. Winter wheat and spring barley yielding]. Pam. Puł. 72, 35-47 [in Polish].
12. Kuś J., Siuta A., Mróz A., Kamińska M., 1993. Możliwość kompensacji ujemnego wpływu stanowiska na plonowanie jęczmienia jarego [A possibility of compensating a negative effect of stand on spring barley yelding]. Pam. Puł. 103, 133-144 [in Polish].

13. Maćkowiak Cz., 1994. Zalecenia nawozowe. Cz. IV. Zasady stosowania gnojowicy [Fertilisation guidelines. Part 4. Slurry application rules]. Wyd. IUNG Puławy [in Polish].
14. Malicki L., Michałowski Cz., 1994. Problem międzyplonów w świetle doświadczeń [Intercrops in experiments]. Post. Nauk Roln. 4, 3-18 [in Polish].
15. Møller-Hansen E., Djurhuus J., 1997. Yield and N uptake as affected by soil tillage and catch crop. Soil & Tillage Research 42, 241-252.
16. Paprocki S., Zieliński A., Fordoński G., 1979. Wsiewki i poplony ścierniskowe jako rośliny przedzielające jęczmień jary uprawiany po sobie [Companion crops and stubble intercrop as plants separating spring barley cultivated after each other]. Zesz. Probl. Post. Nauk Roln. 218, 251-256 [in Polish].
17. Parylak D., Kita W., 2000. Porażenie podstawy źdźbła pszenżyta jarego uprawianego po sobie i po mieszankach z jego udziałem [Stem base infection of spring triticale cultivated after each other and after its mixtures]. Zesz. Probl. Post. Nauk Roln. 470, 119-126 [in Polish].
18. Rocznik Statystyczny GUS 1997, 1999, 2000 [in Polish].
19. Skinder Z., Sypniewski J., 1999. Międzyplony [W:] Szczegółowa uprawa roślin [Intercrops [In:] Plant cultivation]. Red. Z. Jasińska, A. Kotecki, AR Wrocław [in Polish].
20. Thorup-Kristensen K., 1994. The effect of nitrogen catch crop species on the nitrogen nutrition of succeeding crops. Fertilizer Research 37, 227-234.
21. Urbanowski S., Harasimowicz-Hermann G., 1982. Zachwaszczenie niektórych roślin zbożowych w zmianowaniach i monokulturze [Weed infestation of some cereals in crop rotation and in monoculture]. Zesz. Nauk. ATR Bydgoszcz, Rolnictwo 14, 90-101 [in Polish].
22. Wójcik-Wojtkowiak D., 1997. Procesy biochemiczno-fizjologiczne w roślinach a zmęczenie gleb [Biochemical-and-physiological processes in plants and soil sickness]. Zesz. Probl. Post. Nauk Roln. 452, 23-36 [in Polish].
23. Zych J., Najewski A., 2001. Jęczmień [W:] Lista opisowa odmian [Barley [In:] Descriptive list of cultivars]. COBORU Słupia Wielka [in Polish].

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