

EVALUATION OF YIELDING OF PEA MIXTURES WITH SPRING WHEAT GROWN FOR SEED ON GOOD SOILS

Summary

Increasing the percentage of pea seeds from 40 to 80% had only a little impact on the yield of mixtures. Significantly larger yields were recorded only in 2012 with Tarchalska variety pea, when the percentage of pea amounted to 60%. Average yields of mixtures seeds with a semi-leafless variety Tarchalska and Wiato variety with bipinnate leaves were very similar. The percentage of pea seeds in the yield of mixtures (regardless of the foliage type) were much smaller than in the weight of the sown seeds. The seeds of pea of Wiato variety had a larger percentage in the mixtures yield compared to the seeds of pea variety Tarchalska. Increasing the pea percentage in the mixture resulted in an increase in the number of nodes with pods per plant and in the thousand seeds weight in both evaluated varieties, while with Tarchalska variety, it resulted in significant decrease in the weight and number of seeds per plant. Small changes in the height of pea plant as well as in the length of the fruiting part of stem, dry weight of the stem per plant and the weight of siliques were observed.

Key words: wheat, pea, mixture, organic farm, yield, plant structure

OCENA PLOWANIA MIESZANEK GROCHU Z PSZENICĄ JARĄ UPRAWIANYCH NA NASIONA NA GLEBACH DOBRZYCH

Streszczenie

Celem przeprowadzonych badań była ocena plonowania mieszanek grochu z pszenicą jarą w zależności od odmiany grochu i jego udziału w masie wysiewanych nasion, uprawianych według zasad rolnictwa ekologicznego. Doświadczenie polowe przeprowadzono w CDR Radom (gospodarstwo Chwałowice) w latach 2011-2012, w układzie losowanych podbloków (split-plot), w 4 powtórzeniach. Czynnikiem I rzędu były odmiany grochu: Wiato (liście parzystopierzaste) i Tarchalska (wąsolistna), a czynnikiem II rzędu udział grochu w mieszance: 40, 60 i 80%. Określano plon nasion mieszanki, udział komponentów w plonie, masę tysiąca nasion oraz strukturę roślin. W badaniach wykazano, że zwiększanie udziału nasion grochu przy wysiewie z 40 do 80% miało niewielki wpływ na poziom plonowania mieszanek. Istotnie różnice zanotowano tylko w 2012 roku, w którym mieszanka z 60% udziałem grochu odmiany Tarchalska plonowała istotnie wyżej niż pozostałe mieszanki. Udział nasion grochu w plonie mieszanek (niezależnie od odmiany) był znacznie niższy niż w masie wysiewanych nasion. Większy udział w plonie stanowiły nasiona grochu odmiany o tradycyjnym ulistnieniu Wiato niż wąsolistnej odmiany Tarchalska. Zwiększenie udziału grochu w mieszance powodowało wzrost liczby węzłów ze strąkami i strąków na roślinie oraz MTN u obu ocenianych odmian, a u odmiany Tarchalska powodowało również istotne zmniejszenie masy i liczby nasion na roślinie. Małym zmianom ulegała wysokość roślin grochu, długość części owocującej lodygi, sucha masa lodygi jednej rośliny oraz masa strączyn.

Słowa kluczowe: pszenica, groch, mieszanka, gospodarstwo ekologiczne, plon, struktura roślin

1. Introduction

Growing mixtures of cereals with legumes is recommended under poor habitat conditions and with the cultivation of species with lower yielding stability or with limp stems which impede mechanical harvesting. Large differences in the plant habit and type of root system between cereals and legumes affect a better use of variable soil conditions by mixtures compared with pure sowings of these species [1]. A significant competitive potential of mixtures against weeds reduces weed infestation, and the complementary use of environmental resources by components of mixtures increases the yielding [2, 3]. Moreover, an intercrop cultivation of legumes with cereals has a number of beneficial effects of structural and physiological nature, as well as promotes the competition between plants. In such stands, the development of fungal pathogens and pest gradation are significantly limited. Such mixtures, besides many advantages, show also some defects. Interspecies competition in the stand causes a significant differentiation

of the effects of their cultivation depending on environmental conditions, species composition and the percentage of components in the mixtures. However, stable yields and high forecrop value for cereals encourage to the cultivation of such mixtures as a source of fodder for monogastric animals, but also as forecrop for cereals [4]. Moreover, such mixtures may be an integral part of the sustainable system, in particular of an ecological one [5]. A growing interest in ecology and environmental protection may promote a further increase in the cultivation areas of such mixtures in the coming years.

The aim of this study was to evaluate the yield of mixtures of peas with spring wheat grown in organic system, depending on the pea variety and its percentage in the weight of sown seeds.

2. Material and methods

The field experiment with spring wheat-pea mixtures was carried out in the years 2011-2012, at the Center Advi-

sory Agriculture in Radom (organic farm in Chwałowice), in split-plot system, with four replication. The first factor was the variety of peas: Wiato (with bipinnate leaves) and Tarchalska (semi-leafless variety). The second factor concerned the percentage of peas in mixture with spring wheat: 40, 60 and 80%. The density of plants in pure sowing, used as the base to calculate their density in the mixtures, was as follows: peas – 80 units·m⁻², wheat – 500 units·m⁻². The area of the plot was 30,0 m². The experiment was conducted on a soil belong to a good wheat complex, class IIIa. The contents of available nutrients were (mg·kg⁻¹ soil): phosphorus 220-234, potassium 211-223 and magnesium 124-131. Soil pH, as determined in 1 N KCl, was 6,0-6,2. Seeds were sown at fifth (2011) and tenth (2012) of April. The plots were harrowed twice to control weeds in the mixtures.

Plants were harvested at full maturity stage of mixture components at the third (2011) and twenty (2012) of August. During the vegetation period, the dates of the following development stages were recorded: peas – full emergence, development of the tendrils, start and end of the flowering, full maturity and wheat – full emergence, full tillering, shooting, heading and full maturity. Before the harvest, the height to the first and to the last pod and the height of whole plant were determined for 10 plants of peas randomly chosen in each plot. The number of fruiting nodes per plant and pods per node was counted. Additionally, the number of pods and seeds per plant, as well as the weight of seeds per plant, stem dry matter of one plant and weight of dry pods were evaluated. Seed yield of the mixture, the participation of components in the yield (this was done after separating the yield collected from a whole plot) and the weight of a thousand seeds at a humidity of 14% were evaluated after the harvest. Assessing the significance of the impact of the considered factors on the features under investigation was based on the variance analysis, indicating Tukey's confidence half-intervals at a significance level of 0,05.

3. Results and discussion

Yields of mixtures are significantly affected by the percentage of pea seeds in the sown weight and weather conditions. Larger yields of mixtures were recorded in 2011 compared to 2012. Precipitation during the vegetation period also played an important role, especially heavy rainfalls in July which caused severe lodging of the mixtures' stands in the period of cereal grains filling and pea seeds, and difficulties in plant harvesting (tab. 1). In contrast, a high sensitivity of pea mixtures with spring cereals to a small amount of rain in June was observed by Książak and Magnuszewska [6]. In these conditions, pea plants were characterized by a shorter flowering period and a small number of

pods. Also, a significant acceleration of maturation of plants was observed, which did not affect a good formation of pea seeds and cereal grains. The same authors [6] reported that the obtained results indicated a high sensitivity of peas to a lower amount of rainfall during the growing season. They also confirmed that, under these conditions, cultivation of mixtures of legumes with cereals ensured a greater yielding stability and higher yields than the cultivation of these plants in pure sowings.

Average yields of mixture seeds with a semi-leafless variety of Tarchalska and Wiato with bipinnate leaves were very similar (tab. 2), while the percentage of peas in the weight of sown seeds with the two evaluated varieties had a significant effect on the mixture yield only in 2012. Significantly higher mixture yields were recorded with Tarchalska variety at 60% share of pea. According to Siuta [7], under the conditions of organic farming, the yields of mixtures of pea with wheat or barley, regardless of their composition, were similar to the yields of both species yield in pure sowings. According to this author, an increase of the percentage of legumes caused a decrease in the yield of mixtures. However, Książak [8] and Staniak et al. [9], under the conditions of lower rainfall in June, observed that the increase in the percentage of pea seeds in the weight of sown mixtures, regardless of variety, resulted in a decreased in their yields, while under the conditions of significant rainfall, there was an increase in yields. In the same investigation [8], the author state that the yield level of the mixtures of barley with Set and Terno varieties of peas was very similar, while it was larger for the mixtures with a semi-leafless variety of pea Ramrod. Also, Rudnicki [10] indicates that pea variety highly determines the yielding of mixtures with cereals. Other authors [11, 12, 13] obtained the largest seed yields of mixtures when the pea seeds accounted for 30 to 50% share in the sowing. Książak [14] in investigation concerning mixtures of pea with wheat grown in conventional system, he did not record an impact of increasing the percentage of peas in the sowing seeds on the yield.

The percentage of pea seeds in the mixtures yield was much smaller than in the weight of sown seeds (tab. 2). Increasing the percentage of pea seeds, regardless of the type of foliage resulted in an increase of its seeds in the yield. Książak [15] recorded a much lower percentage of pea seeds in the mixtures yield than the percentage of its seeds in the sowing weight under the conditions of limited rainfall. The seeds of Wiato variety of peas with bipinnate leaves had a larger percentage in the mixtures yield compared to mixtures with semi-leafless variety of Tarchalska (tab. 2). The obtained yield of pea seeds increased together with an increase of its percentage in the sowing, and Wiato variety yielded better than Tarchalska variety (tab. 3).

Table 1. Course of weather conditions during the vegetation periods

Tab. 1. Przebieg warunków pogodowych w okresie wegetacji

Specification	Year	Month						Sum (III-VIII)
		III	IV	V	VI	VII	VIII	
Rainfalls (mm)	2011	19,8	40,1	89,4	55,6	372,4	91,2	668,5
	2012	30,0	53,6	52,8	50,5	136,1	71,6	394,6
Rainfalls from multi-years (mm)		30,0	39,0	57,0	71,0	84,0	75,0	356,0
Temperature (°C)	2011	3,5	10,6	14,3	18,5	17,8	18,9	
	2012	5,0	9,6	15,2	17,7	21,0	19,1	
Mean temperature from multi-years (°C)*		1,6	7,7	13,4	16,7	18,3	17,3	12,5

*Average from years 1871-2000

Table 2. Yield of mixture seeds of pea spring wheat and percentage of peas seeds in mixtures
 Tab. 2. Plon nasion mieszanki i udział grochu w plonie mieszanki

Pea percentage (%)	Yield of mixture seeds of pea spring wheat (t·ha ⁻¹)				Percentage of peas seeds (%)			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	3,44	3,00	3,02	2,84	30,2	18,0	21,0	18,0
60	3,73	3,26	3,14	3,20	42,9	27,6	29,0	22,0
80	3,33	3,29	3,04	3,03	50,4	38,3	35,0	34,0
Mean	3,50	3,18	3,07	3,02	41,2	28,0	28,3	24,7
LSD $\alpha = 0,05$ for cultivar for pea percentage	n.s.		n.s.					
	n.s.		0,210					

Source: Own work / Źródło: opracowanie własne

Table 3. Yield of pea seeds (t·ha⁻¹)
 Tab. 3. Plon nasion grochu (t·ha⁻¹)

Pea percentage (%)	2011		2012	
	variety of peas			
	Wiato	Tarchalska	Wiato	Tarchalska
40	1,04	0,54	0,65	0,51
60	1,60	0,90	0,91	0,71
80	1,68	1,26	1,07	1,03
średnio	1,44	0,90	0,88	0,75
LSD $\alpha = 0,05$ for cultivar for pea percentage	0,029		0,091	
	0,129		0,068	

Source: Own work / Źródło: opracowanie własne

In the experiment, more important morphological characteristics which determine yielding of pea, and thus its percentage in the mixtures yield were assessed. Together with increasing the pea percentage in the mixture with wheat, there were changes in the structure of plants. The number of nodes with pods and pods per plant in both varieties increased under the influence of increasing the percentage of pea in the mixture (tab. 4 and 5). The number of nodes and the number of pods per node is considered by Świącicki [16] as a basic indicator of yielding potential of pea seeds. Increasing the percentage of pea in the weight of the sown seeds of pea variety of Tarchalska resulted in a

significant reduction in the seeds weight per plant, while the recorded differences were significantly smaller in the case of pea variety of Wiato. A higher weight of seeds per plant was characterized by Wiato variety compared to Tarchalska variety (tab. 6). Pea generated the most of seeds per plant in the mixtures with its smallest percentage in the stand. A higher share of peas in a mixture limited the number of seeds per pod and per node (tab. 7). The smallest thousand seeds weight was recorded for pea in the mixtures with its smallest share (40%), regardless of the type of foliage, (tab. 5), while the evaluated varieties grown in the mixtures were characterized by a similar seeds size.

Table 4. Number of nodes with fruiting pods and number of pods per nodes (units)

Tab. 4. Liczba węzłów ze strąkami i strąków na węzle (szt.)

Pea percentage (%)	Number of nodes with pods				Number of pods per nodes			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	2,30	2,35	3,0	3,58	1,82	1,76	1,58	1,61
60	2,34	2,36	3,38	3,19	1,84	1,73	1,63	1,67
80	2,50	2,53	3,45	2,98	1,81	1,67	1,58	1,57

Source: Own work / Źródło: opracowanie własne

Table 5. Number of pods per plant and thousand seeds weight of pea

Tab. 5. Liczba strąków na roślinie i MTN grochu

Pea percentage (%)	Number of pods per plant (units)				Thousand seeds weight (g)			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	4,18	4,15	4,70	5,75	200	194	186	187
60	4,31	4,09	5,45	5,36	205	210	184	181
80	4,52	4,23	5,48	4,63	226	225	190	176
LSD $\alpha = 0,05$ for cultivar for pea percentage	0,025		0,021		n.s.		n.s.	
	0,019		0,017		9,289		8,632	

Source: Own work / Źródło: opracowanie własne

Table 6. Number and weight of seeds on a pea plant
 Tab. 6. Liczba i masa nasion na roślinie grochu

Pea percentage (%)	Number of seeds (units)				Weight of seeds (g)			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	18,0	19,6	22,53	29,8	3,57	3,66	4,13	5,59
60	16,8	17,4	25,18	24,36	3,50	3,51	4,58	4,46
80	17,0	15,7	24,68	20,53	3,55	3,42	4,71	3,63
LSD $\alpha = 0,05$ for cultivar for pea percentage					n.s. 0,013		n.s. 0,389	

Source: Own work / Źródło: opracowanie własne

Table 7. Number of seeds in pod and number of seeds on node (units)
 Tab. 7. Liczba nasion w strąku i liczba nasion na węźle (szt.)

Pea percentage (%)	Number of seeds in pod				Number of seeds on node			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	4,31	4,72	4,70	4,56	7,83	8,34	7,39	7,38
60	3,90	4,26	4,56	4,45	7,18	7,37	7,43	7,48
80	3,76	3,71	4,57	4,45	6,80	6,21	7,16	6,95

Source: Own work / Źródło: opracowanie własne

A differentiated reaction of pea varieties grown in the mixture with barley was also observed by Zielinski et al. [17]. In his study, increasing the percentage of Fioletowa variety in the stand from 20 to 40% caused an increase in the number of pods and seeds per plant, while such a tendency was not observed for Mazurska variety. Other authors [13, 18] found the decrease in the number of pods, seeds and weight of seeds per pea plant, under the influence of an increase in cereal component. Small changes were recorded in the height of pea plants as well as in the length of the fruiting part, the dry weight of the stem per plant and the weight of siliques (tab. 8-10). However, Książak [19]

observed an increase in the dry weight of stem per plant in the mixtures with a higher percentage of pea compared with the mixtures with its lower percentage. A large dependency of the yield of pea seeds on the length of the stem strongly modified by environmental conditions was indicated by the test results of other authors [1, 11, 16].

In the experiments, the mixtures composition was also slightly affected by the height of wheat and the thousand seeds weight (tab. 11), while the wheat grown in mixtures with a higher percentage of peas produced a larger number and weight of seeds per plant (tab. 12).

Table 8. Dry matter of stem of one plant and dry matter of siliques (g)
 Tab. 8. Sucha masa łodygi jednej rośliny oraz sucha masa strączy (g)

Pea percentage (%)	Dry matter of stem				Dry matter of siliques			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	2,01	2,26	3,09	4,02	0,62	0,64	0,85	1,14
60	2,17	2,34	3,31	3,27	0,65	0,63	1,07	0,97
80	2,64	2,30	3,26	2,79	0,68	0,72	1,01	0,77

Source: Own work / Źródło: opracowanie własne

Table 9. Height to the first and last pod and length of the fruiting part of stem (cm) (2011)
 Tab. 9. Wysokość do pierwszego i ostatniego strąka oraz długość części owocującej rośliny grochu (2011) (cm)

Pea percentage (%)	Variety of pea					
	Tarchalska			Wiato		
	height to:		length of fruiting part of stem	height to:		length of fruiting part of stem
	first pod	last pod		first pod	last pod	
40	54	65	4	52	58	4
60	53	59	4	55	62	5
80	55	63	6	52	59	5

Source: Own work / Źródło: opracowanie własne

Table 10. Height to the first and last pod and length of fruiting part of stem (cm) (2012)

Tab. 10. Wysokość do pierwszego strąka, wierzchołka rośliny oraz długość części owocującej rośliny grochu (2012) (cm)

Pea percentage (%)	Variety of pea					
	Wiato			Tarchalska		
	height to:		length of fruiting part of pea	height to:		length of fruiting part of pea
	first pod	last pod		first pod	last pod	
40	61,1	73,0	7,7	62,4	77,2	9,3
60	58,7	72,2	9,2	61,4	73,5	7,9
80	58,8	75,6	11,4	58,9	72,8	8,4

Source: Own work / Źródło: opracowanie własne

Table 11. Height of the wheat plant and thousand seeds weight

Tab. 11. Wysokość roślin pszenicy i masa tysiąca ziaren

Pea percentage (%)	Height to plants (cm)				Weight of 1000 seeds (g)			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	88,0	85,0	90,0	88,4	35,0	34,0	33,6	29,7
60	84,0	90,0	87,9	86,8	32,0	34,0	32,9	33,0
80	87,0	85,0	88,9	88,4	33,0	33,0	32,6	33,6

Source: Own work / Źródło: opracowanie własne

Table 12. Number and weight of grains on wheat plant

Tab. 12. Masa i liczba ziaren na roślinie pszenicy

Pea percentage (%)	Number of grain (units)				Weight of grain (g)			
	2011		2012		2011		2012	
	variety of pea							
	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska	Wiato	Tarchalska
40	48	48	74,8	66,5	1,37	1,66	2,51	1,85
60	55	65	81,8	71,4	1,47	1,75	2,67	2,38
80	60	69	83,9	101,1	1,93	1,79	2,42	3,43

Source: Own work / Źródło: opracowanie własne

4. Summary

1. Increasing the percentage of pea seeds from 40 to 80% had only a little impact on the yield of mixtures. Significantly larger yields were recorded only in 2012 with Tarchalska variety peas, when the percentage of peas amounted to 60%. Average yields of mixtures seeds with a semi-leafless variety Tarchalska and Wiato variety with bipinnate leaves were very similar.

2. The percentage pea seeds in the yield of mixtures (regardless of the foliage type) were much smaller than in the weight of the sown seeds. The seeds of peas of Wiato variety had a larger percentage in the mixtures yield compared to the seeds of peas variety Tarchalska.

3. Increasing the pea percentage in the mixture resulted in an increase in the number of nodes with pods per plant and in the thousand seeds weight in both evaluated varieties, while with Tarchalska variety, it resulted in significant decrease in the weight and number of seeds per plant. Small changes in the height of pea plant as well as in the length of the fruiting part of stem, dry weight of the stem per plant and the weight of siliques were observed.

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