Kazimierz KLIMA, Mariusz SMACZNY
Agricultural University in Kraków, Department of Agrotechnology and Agricultural Ecology
al. Mickiewicza 21, 31-120 Kraków, Poland
e-mail: rrklima@cyf-kr.edu.pl

YIELDING AND COMPETIVENESS OF OATS AND SPRING VETCH DEPENDING ON CULTIVATION SYSTEM AND SOWING METHOD

Summary

The subject of the experimental research referred to a two-factor field experiment carried on at the Experimental Station in Czyrna near Krynica over a period from 2010 to 2013. The first factor included two farming systems: conventional and organic. The second factor comprised the crops grown in pure stands (oats and spring vetch grown separately) and in mixed stands (oats mixed with spring vetch). The objective of the experiment was to determine both the yielding of oats in pure stands and of oats with spring vetch in mixed stands, and the response of those mixture components to the cultivation in mixed stands. Based on the results of the experiment, it was concluded that the yield of oats grains and seeds of crops sown in pure stands and in stands mixed with spring vetch decreased by 12% under the organic farming system. The total yield of oats grains and spring vetch seeds decreased along with the decrease in the content of oats in the mixture. The growing of oats and spring vetch in mixed stands under the conventional system of farming resulted in the better yielding of oats compared to the yield of oats under the organic farming. The mixtures of oats and spring vetch were found to better utilize the habitat conditions in their mixed stands compared to those grown separately in pure stands.
Key words: *oats, conventional system, organic system, competitiveness of mixture components*

PLONOWANIE I KONKURENCYJNOŚĆ OWSA Z WYKĄ JARĄ UPRAWIANYCH W SYSTEMIE KONWENCJONALNYM I EKOLOGICZNYM

Streszczenie

Przedmiotem badań było dwuczynnikowe doświadczenie polowe przeprowadzone w latach 2010-2013 w Stacji Doświadczalnej Czyrna k. Krynicy. Czynnikiem pierwszym były dwa systemy rolnicze: konwencjonalny i ekologiczny. Czynnikiem drugim były siewy czyste i mieszane owsa z wyką jarą. Celem badań było określenie plonowania siewów czystych i mieszanych owsa z wyką jarą oraz określenie reakcji komponentów na uprawę w mieszankach. W wyniku badań stwierdzono, że zmniejszenie plonu ziarna i nasion siewów czystych i mieszanek owsa z wyką jarą uprawianych w systemie ekologicznym wyniosło 12%. Wraz ze zmniejszaniem udziału w mieszankach owsa zmniejszał się łączny plon ziarna owsa i nasion wyki jarej. Wysiew owsa w mieszance z wyką jarą w systemie konwencjonalnym wpłynął korzystniej na plonowanie owsa niż w systemie ekologicznym. Mieszanki owsa z wyką jarą lepiej wykorzystywały warunki siedliskowe niż siewy czyste komponentów mieszanek.
***Słowa kluczowe**: owies, system konwencjonalny, system ekologiczny konkurencja komponentów mieszanek*

1. Introduction

The results of many research studies prove the usefulness of cereal mixtures and of cereals and legumes mixtures in organic farming [4]. The reason thereof is that no artificially synthesized fertilizers are allowed for use in the organic farming and, therefore, the necessary nutrients may become deficient in soil. The decrease in the yielding of cereal and cereal-legume mixtures as their response to the nutrient deficit in soil is not large since different mixture components have differentiated nutrient demands and, consequently, they better utilize all the nutrients available in soil [5]. Another reason of no decrease occurring in the yielding is that the competitiveness of mixture components within a stand is lower than that of plants grown in pure stands [13].

The first objective of the experimental research was to determine the yielding of oats grown in pure stands and the yielding of oats and spring vetch mixtures sown in mixed stands. The second objective was to determine the response of the mixture components to the cultivation in mixed stands.

2. Materials and methods

The subject of the experimental research referred to a two-factor field experiment performed at the Mountain Experimental Station owned by the Department of the Agrotechnology and Agricultural Ecology, situated in Czyrna near the town of Krynica (Beskid Niski Mountain Range, at 545 m a.s.l; geographic coordinates: N 49°25` E 20°58`). The experiment was carried out in period between 2010 and 2013. The first factor included two farming systems: conventional and organic. The second factor comprised oats and spring vetch grown separately in pure stands and three mixtures of oats and spring vetch grown in mixed stands (Tab. 1).

A method of random blocks in four repetitions was applied. The surface area of a single experimental field was 22 m^2. The two crop species were sown: glumiferous oats of Borowiak variety and determined spring vetch of Ina variety. The crops in pure and mixed stands were grown using the two above mentioned farming systems and the following crop rotation: 1) potatoes grown with the application of manure (33 $t \cdot ha^{-1}$); 2) oats in pure stand; 3) spring vetch in

pure stand and oats + spring vetch mixtures. Under the organic system, neither mineral fertilizers nor artificially synthesized pesticides were applied. In order to reduce weeds infestation, the oats field was harrowed in spring. Where the conventional system was applied, fertilizers and pesticides were applied. The dose of mineral fertilizers was calculated based on the soil fertility, fertilizing value of forecrop, and forecast crop yield. As for oats grown using a conventional farming system, 34 kg · ha^{-1} of P and 55.6 kg · ha^{-1} of K were added prior to pre-winter ploughing. A total dose of 72 kg·ha^{-1} of N was divided into the pre-sowing and top dressing dose. The grains for sowing were treated with a Vitavax 200 FS dressing preparation, its amount was 300 ml per 100 kg of grains. The weed infestation was controlled by applying 24 g of a Granstar herbicide per 1 ha at the end of the tillering phase.

As for growing spring vetch under the conventional farming system, N was added prior to sowing in the form of a starting dose of 20 kg · ha^{-1}. Prior to pre-winter ploughing, P was added in a dose of 43.6 kg · ha^{-1}, and K in a dose of 83 kg · ha^{-1}. As for growing oats and spring vetch mixtures using the conventional farming, the following was applied: N was added prior to sowing, its dose was 30 kg · ha^{-1}, 43.6 kg · ha^{-1} of P and 83 kg · ha^{-1} of K were added prior to pre-winter ploughing. For the purpose of interpreting the obtained results, a Land Equivalent Ratio (LER) [8, 9] was applied. LER is a total of relative yields of individual species grown as mixtures:

$$LER = Yij/Yi + Yji/Yj,$$

where: *Yi*- yield of *i* species grown in pure stand,
Yj- yield of *j* species grown in pure stand,
Yij- yield of *i* species and of its mixture with *j* species,
Yji- yield of *j* species and of its mixture with *i* species.

The research results were statistically elaborated using the analysis of variance method. The significance of mean differences among individual objects was tested based on the Tukey's method, at a significance level of p = 0.05.

The experimental field consisted of a brown soil made up of flysh rock waste; the soil was from a granulometric group of medium, skeletal clays and it was classified into the 12th oats-potato-mountain complex of agricultural soils and into the 5th class of soil quality class. The contents of assimilable nutrients in the soil was as follows: phosphorus: 9.4 mm · 100 g^{-1}; potassium: 24.1 mm · 100 g^{-1}; total nitrogen: 0.182%; and pH-KCl: 5.

A mean annual air temperature for a multi-year period is 6.1^{o}C; the vegetation period comprises 179 days. Considering the criteria established by Kaczorowska [2] and the monthly precipitation totals, the vegetation period in 2012 can be classified as a dry period, in 2013 as an ordinary period, in 2011 as a wet period, and in 2010 as a very wet period (Tab. 1). When based on the research results received by Klima and Pisulewska [3] as well as by Borowiecki and Księżak [1], it is possible to report that during the ongoing experiment, the most favourable precipitation distribution for the crops being grown was that of 2011.

Table 1. Crops grown in pure and mixed stands, sowing rates, and designed plant density
Tab. 1. Siewy czyste i mieszane, ilości wysiewu oraz założona obsada

Stand with / Obiekt	Sowing Rate Ilość wysiewu [kg · ha^{-1}]	Planting density / Obsada [szt · m^{-2}] / [pcs· m^{-2}]
Glumiferous oats / Owies oplewiony	220	650
Spring vetch / Wyka jara	100	250
Glumiferous oats + spring vetch / Owies oplewiony + wyka jara /	170 30	502 75
Glumiferous oats + spring vetch / Owies oplewiony + wyka jara	150 40	443 100
Glumiferous oats + spring vetch / Owies oplewiony + wyka jara	130 50	383 125

Source: own work / Źródło: opracowanie własne

Table 2. Monthly precipitation totals (mm) and air temperatures (^{o}C)
Tab. 2. Miesięczne sumy opadów atmosferycznych (mm) oraz temperatury powietrza (^{o}C)

Years / Lata	Months / Miesiące					IV-VIII	I-XII
	IV	V	VI	VII	VIII		
	Precipitations (mm)/ Opady						
2010	65,8	234,2	226,6	131,6	144,5	802,7	1170,7
2011	106,3	72,1	44,4	278,4	85,6	586,8	732,2
2012	56,6	20,6	167,7	82,2	63,3	390,4	715,8
2013	24,7	118,0	202,4	33,1	32,9	411,1	800,4
1961-1990	62	85	105	115	98	465	848
	Temperatures (^{o}C) / Temperatura						
2010	8,5	12,0	16,6	19,7	18,5	15,3	7,50
2011	8,9	12,3	17,1	16,3	17,9	14,5	7,47
2012	8,2	13,8	16,2	18,9	17,7	14,9	7,27
2013	7,2	13,1	15,5	18,1	17,7	14,3	7,30
1961-1990	6,2	11,5	14,2	16,0	14,8	12,6	6,06

Source: own work / Źródło: opracowanie własne

3. Results and discussion

The yield of the crops grown using the organic was lower by 12% on average (Tab. 3). This was the effect of applying mineral fertilizers and pesticides that were not applied in the conventional system. In the reference literature, the results are reported, which show that the decrease in the yield of crops grown under the organic farming ranged between 17 and 31% [10, 12]. A minor difference as revealed in this experimental research could be attributed to the fact that a fore-crop applied under the two farming systems were potatoes grown on fields with manure added. Another reason thereof lay in a low yielding of spring vetch and small difference in yield of this crop grown under the two cultivation systems.

Based on the data shown in Tab. 4, it is concluded that the LER value of the spring vetch increased (from 0.36 to 0.46 in the case of conventional system and from 0.35 to 0.45 in the case of the organic farming) along with the decreasing share of oats in the mixtures with spring vetch. This fact could be attributed to a weaker competitive effect of oat plants compared to that of spring vetch plants in a stand. The result of present experimental research confirms the results received by Sobkowicz [9] in his study; he found that the decreasing content of one mixture component in one stand was offset by the dominance of the other mixture component.

Considering the competitive effects of the components contained in the oats and spring vetch mixtures (Tab. 4), it can be concluded that in the case of conventional cultivation system, the growing of oats mixed with spring vetch had a better impact on the yield of oats compared to the organic system. A higher mean value of LER confirms this conclusion: it is 0.61 for the conventional system, and 0.59 for the organic system. One of the possible reasons thereof could be that oats crop was better provided with nitrogen taken from both the mineral fertilizers (applied under the conventional system) and the spring vetch roots where rhizobia bacteria fixed nitrogen. Thanks to the rhizobia, the legumes including spring vetch enrich soils with nitrogen.

Table 3. Yield ($t \cdot ha^{-1}$) of seeds sown in pure and mixed stands under conventional and organic systems of farming
Tab. 3. Plon ($t \cdot ha^{-1}$) nasion siewów czystych i mieszanych uprawianych w systemie konwencjonalnym i ekologicznym

Object / *Obiekt*	Farming system / *System rolniczy*		On average / *Średnio*
	Conventional / *Konwencjonalny*	Organic / *Ekologiczny*	
Oats / *Owies*	3,49	3,07	3,28
Spring vetch / *Wyka jara*	0,510	0,468	0,489
170 kg·ha^{-1} of oats + 30 kg·ha^{-1} of spring vetch / *Owies 170 kg·ha^{-1} + wyka jara 30 kg·ha^{-1}*	3,265	2,815	3,040
150 kg·ha^{-1} of oats + 40 kg·ha^{-1} of spring vetch / *Owies 150 kg·ha^{-1} + wyka jara 40 kg·ha^{-1}*	2,921	2,713	2,817
130 kg·ha^{-1} of oats + 50 kg·ha^{-1} of spring vetch/ *Owies 130 kg·ha^{-1} + wyka jara 50 kg·ha^{-1}*	2,756	2,415	2,585
On average / *Średnio*	2,588	2,296	2,442
NIR $_{0,05}$ - *LSD* $_{0,05}$	0,056		0,110
NIR $_{0,05}$ - *LSD* $_{0,05}$ for synergic effect / *dla współdziałania*	0,142		

Source: own work / Źródło: opracowanie własne

Table 4. *Yielding ($t \cdot ha^{-1}$) of pure components of oats and spring vetch mixtures sown and grown in pure stands, and values of LER (Land Equivalent Ratio) depending on farming system*
Tab. 4. Plonowanie ($t \cdot ha^{-1}$) siewów czystych komponentów mieszanek owsa z wyką jarą oraz wartości współczynnika ekwiwalentu terenowego LER w zależności od systemu rolniczego

Composition of mixture / Skład mieszanki	Grain / seed yield Plon ziarna / nasion ($t \cdot ha^{-1}$)			LER - Land Equivalent Ratio Współczynnik ekwiwalentu terenowego					
	Farming systems			Farming systems				On average	In total
	conventional	organic	on average	conventional		organic			
				On average	In total	On average	In total		
Oats / Owies	3,49	3,07	3,28						
Spring vetch Wyka jara	0,510	0,468	0,489						
Oats 170 kg · ha^{-1} Owies	3,08	2,65	2,86	0,88	1,24	0,87	1,22	0,88	1,23
+ Spring veth. 30 kg · ha^{-1} + wyka jara	0,185	0,165	0,175	0,36		0,35		0,35	
Oats 150 kg · ha^{-1} / Owies	2,70	2,31	2,50	0,77	1,20	0,75	1,18	0,76	1,19
+ spring vetch 40 kg · ha^{-1} / Wyka jara	0,221	0,205	0,213	0,43		0,43		0,43	
Oats 130 kg · ha^{-1} / Owies	2,52	2,20	2,36	0,72	1,18	0,71	1,16	0,71	1,16
+ sping vetch 50 kg · ha^{-1} / wyka jara	0,236	0,215	0,225	0,46		0,45		0,45	
On average / Średnio	1,617	1,410	1,513	0,61	1,21	0,59	1,18	0,60	1,19

Source: own work / Źródło: opracowanie własne

According to the studies by Onkovich and Pate [6], and by Vance [14], the average amounts of N_2 fixed by legumes could be as high as 147 kg/ha, whereas those fixed by beans: 65 kg N/ha, and by lucerne: 180 kg N/ha. The results of the research by Yanbo et al. [15] proved that during the vegetation period, nitrogen fixed by the rhizobia, which inhabit the rhisosphere of horse beans, is transferred into the root system of wheat. The presented research results evidence how important are the legumes in the organic farming.

Considering the cumulative averages of LER values, the conclusion is that along with the decreasing share of oats in the oats and spring vetch mixture, the cumulative value of LER also decreased from 1.23 to 1.16. It was a result of low yield of spring vetch seeds; those yield values were 7-times lower, on average, than the mean oats grain yield. Thus, the effect of decreasing the share of oats in the mixture was that the value of LER decreased.

Even so, the cumulative average of LER value was bigger than 1 in all the mixtures. It means that the oats and spring vetch mixtures better utilize habitat conditions than the pure components of mixtures sown separately. This statement coincides with the results of the studies performed by Rudnicki and Wasilewski [7] as well as by Taylor [11].

4. Conclusions

1. The decrease both in the yields of grains and seeds grown in pure stands and in the yields of oats and spring vetch mixtures, all of them grown under the organic farming system, was 12% compared to the corresponding yields obtained under the conventional system.

2. Along with the decreasing share of oats in the mixtures, the total yield of oats grains and spring vetch seeds decreased. The reason thereof was that the yield of spring vetch seeds was 7-times lower than the yield of oats grains.

3. The cultivation of oats in the form of mixture of oats and spring vetch under the conventional farming system had a more beneficial effect on the oats yield compared to the oats yield obtained under the organic system.

4. The oats and spring vetch mixtures utilized the habitat conditions better than the pure mixture components sown and grown separately.

5. References

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