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EVALUATION OF USEFULNESS OF SELF-DETERMINATE AND TRADITIONAL VARIETY OF YELLOW LUPINE TO CULTIVATION AT MIXTURE WITH SPRING TRITICALE

Summary

The studies were conducted in the years 2008-2010, at Agricultural Experimental Station in Grabów, which belongs to Institute of Soil Science and Plant Cultivation – State Research Institute (IUNG-PIB) in Puławy. The first experimental factor was yellow lupine variety: Taper (self-determinate type) and Dukat (traditional type), and the second row factor was share of components in the mixture (lupine and triticale var. Dublet): A – lupine 100% (100 plants·m^2), B – lupine 75% (75 plants·m^2) + triticale 25% (125 plants·m^2), C – lupine 50% (50 plants·m^2) + triticale 50% (250 plants·m^2), D – lupine 25% (25 plants·m^2) + triticale 75% (375 plants·m^2), E – triticale 100% (500 plants·m^2). The aim of undertaken researches was evaluation of usefulness of traditional and self-determinate varieties of yellow lupine to cultivation with spring triticale. Both yellow lupine varieties occurred useful to cultivation in mixture with triticale in regard on similar rate of growth and development, and particularly similar date of maturation. In the all years of studies were achieved similar yield of triticale cultivated in mixture with traditional and self-determinate lupine variety. Percentage share of individual varieties seeds in yield after the harvest was different than their share in sowing mixture – there was obtained considerably lower share of lupine and greater share of triticale. Therefore to obtain considerably lupine yield its share in the sowing mixture should exceed 50% of pure sowing.
***Key words**: yellow lupine, spring triticale, varieties, mixtures, yield structure*

OCENA PRZYDATNOŚCI SAMOKOŃCZACEJ I TRADYCYJNEJ ODMIANY ŁUBINU ŻÓŁTEGO DO UPRAWY W MIESZANKACH Z PSZENŻYTEM JARYM

Streszczenie

Badania prowadzono w latach 2008–2010, w Rolniczym Zakładzie Doświadczalnym w Grabowie należącym do IUNG-PIB w Puławach. Czynnikiem pierwszego rzędu były odmiany łubinu żółtego: Dukat (typ tradycyjny) i *Taper (typ samokończący), a czynnikiem drugiego rzędu udział komponentów w mieszance (łubinu i pszenżyta odm. Dublet): A – łubin 100% (100 roślin·m^{-2}); B – łubin 75% (75 roślin·m^{-2}) + pszenżyto 25% (125 roślin·m^{-2}); C – łubin 50% (50 roślin·m^{-2}) + pszenżyto 50% (250 roślin·m^{-2}); D – łubin 25% (25 roślin·m^{-2}) + pszenżyto 75% (375 roślin·m^{-2}); E – pszenżyto 100% (500 roślin·m^{-2}). Celem przeprowadzonych badań było określenie przydatności tradycyjnych i samokończących odmian łubinu żółtego do uprawy z pszenżytem jarym. Ze względu na zbliżony rytm wzrostu i rozwoju, a zwłaszcza termin dojrzewania, obydwie odmiany łubinu żółtego okazały się przydatne do uprawy w mieszance z pszenżytem. We wszystkich latach badań, uzyskano podobny plon mieszanki pszenżyta uprawianego zarówno z tradycyjną jak i samokończącą odmianą łubinu. Procentowy udział nasion poszczególnych gatunków w plonie po zbiorze był inny niż w wysiewanej mieszance – uzyskano znacznie mniejszy udział łubinu a większy pszenżyta. Dlatego, aby uzyskać znaczny plon łubinu jego udział w wysiewanej mieszance powinien przekraczać 50% siewu czystego.*
***Słowa kluczowe**: łubin wąskolistny, pszenżyto jare, odmiany, mieszanki, plonowanie, struktura plonu*

1. Introduction

Legumes are characterized by greater yielding variability in years than the other crop species [16]. One of the most important factors limiting their yielding is unfavorable course of weather conditions and mainly precipitation deficit, especially occurring during the flowering period[1-4, 23, 27]. One of the methods of enlargement of this group plants yielding stability is their cultivation at mixture with cereals [26]. The low yield of legume plant obtained in the years with unfavorable course of weather conditions is, at considerable degree, compensated by cereal seed yield. In effect of species differentiation follows compensated growth and development of cultivated species, decreasing spreading of diseases and pests, as well as weeds restriction [5, 13, 24]. Mixtures of spring cereals with legumes play an important role at integrated and ecological systems of production, where attention to soil environment has special meaning [11, 15]. At the beginning a pea was cultivated at this kind of stands in regards on easier harvest of this prone to logging plant and better quality of seeds [17-18]. The other legumes species, in this especially yellow lupine, were in that time less usefulness to this kind of stands, mainly in regards on problem at matches of their rhythm of growth and development to cereal plants. Great progress achieved in the last years in the lupine breeding concerns obtaining new varieties, with changed morphological structure and greater yielding possibilities. Therefore new varieties of legumes could be useful to cultivation at mixtures with cereals [20, 25]. It can be suppose that self-determinate varieties of yellow lupine can be more useful to cultivation with triticale than traditional ones in regard for the lack of lateral shoots and a little shorter vegetation period.

The aim of conducted researches was determination of usefulness of traditional and self-determinate yellow lupine varieties to cultivation with triticale.

2. Material and methods

The researches were conducted in the 2008-2010 at Agricultural Experimental Station in Grabów, which belongs to Institute of Soli Science and Plant Cultivation – State Research Institute (IUNG-PIB) in Puławy. An experiment was established with *split-plot – split-block* method, at 4 replications on soil belongs to very good rye complex, III a class. The first row factor was yellow lupine variety: Taper (self-determinate type) and Dukat (traditional type), and the second row factor was the share of components in mixture (e.g. lupine and triticale var. Dublet): A – lupine 100 % (100 plants $\cdot m^{-2}$), B – lupine 75% (75 plants $\cdot m^{-2}$) + triticale 25% (125 plants $\cdot m^{-2}$), C – lupine 50% (50 plants $\cdot m^{-2}$) + triticale 50% (250 plants $\cdot m^{-2}$), D – lupine 25% (25 plants $\cdot m^{-2}$) + triticale 75% (375 plants $\cdot m^{-2}$) and E – triticale 100% (500 plants $\cdot m^{-2}$). Intended lupine density at pure sowing amounted 100, and triticale 500 plants $\cdot m^{-2}$. In the every year of an experiment winter wheat was cultivated as a forecrop. Seeds of yellow lupine and triticale were dressing by Sarfun T 450 FS (a.s. carbendazym, tiuram) and sowing at the same time with Amazone drill on depth 2-3 cm. Sowed seeds were characterized with high germination capacity which, as a mean for 3 years, amounted 90 and 96 %, for lupine and triticale, respectively. Nutrient resources of the soil was similar in all years of studies and was an average ($g \cdot kg\ soil^{-1}$): P_2O_5 – 0,224; K_2O – 0,461; Mg – 0,084 and concentration of total nitrogen was on the level 0,19%. In the 2008 and 2010 sowing was performed on April 10, and in the 2009 – April 9. Phosporus and potassium fertilizers were applied in spring at doses: K_2O – 70 and P_2O_5 – 50 kg/ha. Nitroger fertilization was used in the two terms: I dose before sowing – 50 kg/ha, and II in the shooting phase of triticale – 30 kg N/ha.

Detailed observations of growth and development of plants as well as incidence of diseases and pests were led in the vegetation period. After the germination and before the plant harvest the lupine and triticale density was evaluated by counting the plants number on the area 1 m^2. During the whole vegetation period measurements of lupine and triticale plants height were performed. Whereas at lupine flowering (BBCH - 60) leaf area was measured with use AM 350 device (ADC BioScientific). 10 plants from the each plot was randomly collected in the aim of evaluation of dry and fresh matter of lupine and triticale particular organs. Roots were collected from the 20 cm depth of soil.

The area of plots to harvest amounted 27 m^2. Harvest of seeds was performed at full maturity, in the first half of August, with a plot harvester "Seedmaster". Yield structure of lupine was made during the harvest by evaluation: number of pods and seeds per plant, weight of seeds per plant and thousand seeds weight and structure of triticale yield by evaluation: number of ears and grains per plant and mass of grains per plant as well as mass of grains per plant and thousand grains weight.

Results of studies, as a mean of 4 replications, were statistically elaborated with analysis of variance method, with using Tukey's half-confidence interval at significant level $\alpha = 0,05$.

The course of weather conditions in the study years are shown at table 1. The amount and uniformity of precipitation in the particular years were differentiated. The greatest rainfall shortages occurred in April 2009, and their greatest amount was noted in June and July 2009 as well as in May and August 2010. In the 2008 total amount of precipitation in the period of April – August amounted 340 mm and was similar as in the 2009 – 336 mm and considerable lower than in 2010 – 394 mm. However their uniformity was greater than in the remaining years of researches. Thermal conditions during the analyzed years were also very similar. Only a little greater differences concerning the values of mean daily temperatures were noted in April and June 2009 and in July and August 2010.

Table. 1. Weather conditions in the vegetation period
Tab. 1. Warunki pogodowe w okresie wegetacji

Month	Decade	Precipitation (mm)			Temperature (°C)		
		2008	2009	2010	2008	2009	2010
April	I	10.7	0.0	14.8	7.5	10.2	7.9
	II	57.2	0.0	4.1	8.9	9.6	9.3
	III	3.9	0.6	1,9	10,6	12.3	10.0
		71.8[1/]	0.6	20.8	9.0[2/]	10.7	9.1
May	I	43.4	4.5	28.4	12.0	12.9	13.1
	II	33.4	12.7	70.0	13.6	13.1	13.6
	III	10.8	10.3	15.6	13.8	14.4	14.9
		87.6	27.5	114.0	13.1	13.5	13.9
June	I	0.0	53.4	11.1	18.0	14.6	18.7
	II	19.9	40.4	28.5	18.4	15.4	17.3
	III	21.2	24.1	11.1	18.6	16.3	16.8
		41.1	117.9	50.7	18.3	15.4	17.6
July	I	13.6	66.3	6.4	17.9	19.7	20.0
	II	15.5	14.1	0.0	19.2	20.2	24.4
	III	56.3	37.4	47.0	19.4	19.4	20.2
		85.4	117.8	53.4	18.8	19.8	21.5
August	I	8.4	29.1	38.1	19.7	19.3	21.3
	II	21.8	17.8	37.3	19.0	17.7	21.4
	III	24.3	25.7	79.7	17.1	17.3	20.7
		54.5	72.6	155.1	18.6	18.1	21.1

[1/] monthly sum of precipitation (mm); [2/] mean air temperaturę (°C)
Source: own work / *Źródło*: praca własna

3. Results and Discussion

In spite of similar amount of precipitation and mean daily temperature in particular years of research, occurring short-lived and intensive weather features caused great changes in the course of plant vegetation and considerably effected on obtained crop yields of yellow lupine and triticale mixture. Very intensive precipitation which caused strong encrusting of soil occurred in the second half of April 2008, while on the beginning of June was found water shortage in the soil as well as high temperatures of air. These factors caused reduction of growth and development of plants. In April and in the beginning of May 2009 occurred drought which caused retardation of lupine and triticale plants growth. Moreover, strong winds occurred in the second half of April 2009 increased soil drying up what considerably restricted also efficiency of herbicides affect. Abundant and frequent precipitation, low number of sunny days and considerably cooler weather in the June negatively affected also on growth and development of mixture components. Then in the beginning of July occurred intensive rainfall accompanied with hail what cause logging of

Table 2. Plant density after emergence and before the harvest and plant losses in the vegetation period
Tab. 2. Obsada roślin po wschodach i przed zbiorem oraz ubytki roślin w okresie wegetacji

Lupine variety	Share of components in mixture (%)	Number of plants after emergence		Number of plants before the harvest		Plant losses (%)	
		Lupine	Triticale	Lupine	Triticale	Lupine	Triticale
Taper	Lupine (100)	84.7	-	80.1	-	5.4	-
	Lupine (75) + triticale (25)	60.0	107.3	54.2	103.9	9.6	3.2
	Lupine (50) + triticale (50)	36.7	186.0	32.1	175.6	12.7	5.6
	Lupine (25) + triticale (75)	21.3	233.3	18.2	231.9	14.5	8.3
	triticale (100)	-	336.0	-	301.0	-	10.4
Dukat	Lupine (100)	88.0	-	80.4	-	8.6	-
	Lupine (75) + triticale (25)	66.0	100.7	58.2	103.7	11.8	3.3
	Lupine (50) + triticale (50)	45.3	179.3	38.3	168.2	15.4	6.2
	Lupine (25) + triticale (75)	26.7	228.0	21.8	205.7	18.5	9.8
	triticale (100)	-	366.7	-	324.3	-	12.6
Lupine (100)		86.3	-	80.2	-	7.0	-
Lupine (75) + triticale (25)		63.0	104.0	56.2	103.8	10.7	3.2
Lupine (50) + triticale (50)		41.0	182.6	35.2	171.9	14.0	5.9
Lupine (25) + triticale (75)		24.0	230.6	20.0	218.8	16.5	9.0
Triticale (100)		-	351.3	-	312.6	-	11.5
LSD I (α=0.05) for share of components		17.81	44.62	12.44	32.24	2.14	1.88
Taper		50.7	215.6	46.1	203.1	10.5	6.9
Dukat		56.5	218.7	49.7	200.5	13.6	8.0
LSD II (α=0.05) for variety		n.s.	n.s.	2.24	n.s.	1.14	0.84

n.s. – not significant difference

Source: own work / *Źródło*: praca własna

plants. The course of weather conditions in 2010 was more favorable for plant cultivation then in both remaining research years because there was not observed the occurring of any unfavorable weather conditions. Indeed, in the July 2010 was found lower precipitation than in the both remaining years, and daily temperature in August were slightly higher than an average values, but weather conditions in this year turned out the most favorable for lupine and triticale cultivation.

The emergence of triticale occurred after 11-13, and yellow lupine after 14-18 days after the sowing. Seeds of both species were characterized by high germination capacity (lupine – 90%, triticale – 95%) and therefore was found the great uniformity and dynamic of plant germination. Moreover, obtained plant density after emergence was very similar to that which has been theoretic intended (Table 2). Plant density before the harvest was considerable decreased in comparison with plant density observed after germination in effect of competition on water, light and nutrients which had place during vegetation.

Plant loses in particular research years were dependent on the share of components in the mixture. Increase of cereal plant share in the stand of mixture caused greater losses of lupine and triticale plants whereas increase of legume plant caused great losses of lupine and a little losses of triticale. Sowing of traditional variety of yellow lupine in the mixture caused greater losses of triticale and lupine from the stand than sowing of self-determinate variety. It probably resulted from these varieties morphological structure. Traditional variety produces great number of lateral shoots, what causes a much larger mutual shading of plants and competition for light, water and nutrients than self-determinate variety, which does not produce or produces strong reduced lateral shoots [20].

The course of weather conditions had very big effect on growth and development of both mixture components (Table 3). Lower precipitation in June 2010 effected on shortening of triticale and both lupine variety vegetation period. In the all research years was observed some days earlier flowering, pods setting and ripened of lupine cultivated in mixture in compare to lupine cultivated in pure stand. While the method of triticale sowing and plant density had not any effect on its ontogenesis.

Table 3. Length of vegetation period of lupine and triticale (days)
Tab. 3. Długość okresu wegetacji łubinu i pszenżyta (dni)

Developmental phases of plants	Number of days from sowing			
	2008	2009	2010	Mean
Lupine var. Taper in the pure sowing	118	117	109	115
Lupine var. Taper in the mixture with triticale	115	113	105	111
Lupine var. Dukat in the pure sowing	120	120	112	117
Lupine var. Dukat in the mixture with triticale	116	115	108	113
Triticale var. Dublet in the pure sowing	118	112	106	112

Source: own work / *Źródło*: praca własna

To analyze the rhythm of growth and development, and especially the term of lupine maturation, in relation to triticale, should be assumed that both lupine varieties were suitable to cultivation in the mixtures, because the difference in the maturation of mixture components amounted only a few days. Both species cultivated in the pure and mixture sowings were characterized with relatively short period of vegetation which amounted, in dependence on weather course in the years of research, from 106 to 118 days for triticale, for lupine var. Taper cultivated in pure and mixed sowing, from 109 to 118 days and from 105 to 115 days, respectively and for lupine var. Dukat from 112 to 120 days and from 108 to 116 days, respectively. Good uniformity of mixture components maturation has very big meaning in the establishing of optimal term of harvest, in the aim of avoidance of quality and quantity losses which resulted from self-shedding of seeds and increased sensitivity of generative plant organs on

negative effect of harvest machine aggregates. Change of beginning and duration length of phenological phases of plants cultivated at interspecies mixtures was observed also in the earlier studies concerning cultivation of pea with wheat [17] and yellow lupine with spring wheat [9].

The composition of sowing mixture significantly diversified the weight of vegetative and generative organs per one lupine and triticale plant. Decrease of lupine and increase of triticale share caused clear decrease of dry weight of stems, leaves, hulls, seeds and roots of an individual lupine plant (Table 4), but the reduction of particular organ mass was greater in the case of Taper than Dukat variety. While decrease of a cereal plant share caused increase of particular vegetative and generative organs weight of an individual plant of triticale (Table 5). This dependency was greater when triticale was cultivated with lupine var. Taper than Dukat. Weather conditions had great influence on the weight of an individual plant. In the 2008, when weather conditions was not favorable for the lupine cultivation the weight of an individual lupine plant was about 50% lower than in the 2009-2010, when weather course was favored the plant cultivation.

Table 4. Dry matter (g·plant^{-1}) of vegetative and generative lupine organs cultivated at pure sowing and in mixture with triticale

Tab. 4. Sucha masa wegetatywnych i generatywnych organów łubinu uprawianego w siewie czystym i w mieszance z pszenżytem

Plant organ	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of lupine in the mixture (%)								
	100	75	50	25	100	75	50	25	
Stems	6.6	5.5	4.3	3.4	4.3	3.3	2.9	1.7	0.24
Leaves	4.1	3.4	2.2	1.7	3.1	2.4	1.6	1.2	0.43
Hulls	4.0	3.1	2.4	2.1	3.1	2.4	1.7	1.2	0.19
Seeds	4.3	3.1	2.8	3.0	3.8	3.0	2.0	1.2	0.43
Aboveground part	**19.0**	**15.1**	**11.7**	**10.2**	**14.3**	**11.1**	**8.2**	**5.3**	**2.60**
Roots	5.6	3.8	2.8	2.3	4.2	2.6	2.3	1.6	0.86
Whole plant	**24.6**	**18.9**	**14.5**	**12.5**	**18.5**	**13.7**	**10.5**	**6.9**	**3.46**

Source: own work / *Źródło*: praca własna

Table 5. Dry matter (g·plant^{-1}) of vegetative and generative organs of triticale cultivated at pure sowing and at mixture with lupine

Tab. 5. Sucha masa wegetatywnych i generatywnych organów pszenżyta uprawianego w siewie czystym i w mieszance z łubinem żółtym

Plant organ	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of triticale at mixture (%)								
	100	75	50	25	100	75	50	25	
Culm + leaves	4.0	4.5	5.2	7.6	3.5	4.7	5.6	7.9	0.64
Ears	2.3	3.5	3.6	5.2	2.4	3.0	4.0	5.3	1.16
Grain	3.6	5.0	5.5	7.8	3.9	5.0	6.1	8.0	0.95
Aboveground part	**9.9**	**13.0**	**14.3**	**20.6**	**9.8**	**12.7**	**15.7**	**21.2**	**2.26**
Roots	1.8	2.0	2.7	3.9	1.5	2.1	3.6	4.7	0.86
Whole plant	**11.7**	**15.0**	**17.0**	**24.5**	**11.3**	**14.8**	**19.3**	**25.9**	**3.66**

Source: own work / *Źródło*: praca własna

Table 6. Mass of vegetative and generative lupine organs cultivated at pure sowing and at mixture with triticale(kg·m^{-2})

Tab. 6. Masa wegetatywnych i generatywnych organów łubinu żółtego uprawianego w siewie czystym i w mieszance z pszenżytem

Plant organ	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of lupine in the mixture (%)								
	100	75	50	25	100	75	50	25	
Stems	0.56	0.30	0.16	0.06	0.38	0.20	0.11	0.03	0.14
Leaves	0.35	0.18	0.09	0.03	0.27	0.15	0.06	0.02	0.08
Hulls	0.34	0.17	0.09	0.04	0.27	0.15	0.06	0.03	0.16
Seeds	0.33	0.19	0.13	0.07	0.32	0.18	0.11	0.04	0.14
Aboveground part	**1.58**	**0.84**	**0.47**	**0.20**	**1.24**	**0.68**	**0.34**	**0.12**	**0.44**
Roots	0.48	0.22	0.11	0.05	0.36	0.16	0.09	0.03	0.21
Total yield per m^2	**2.06**	**1.06**	**0.58**	**0.25**	**1.60**	**0.84**	**0.43**	**0.15**	**0.32**

Source: own work / *Źródło*: praca własna

Table 7. Mass (kg·m^{-2}) of vegetative and generative organs of triticale cultivated at pure sowing and at mixture with blue lupine

Tab. 7. Masa wegetatywnych i generatywnych organów pszenżyta uprawianego w siewie czystym i w mieszance z łubinem żółtym

Plant organ	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of triticale at mixture (%)								
	100	75	50	25	100	75	50	25	
Culm + leaves	1.33	1.01	0.87	0.68	1.16	1.12	1.00	0.70	0.27
Ears	0.74	0.75	0.57	0.44	0.80	0.63	0.67	0.41	n.s.
Grain	1.12	1.05	0.83	0.62	1.27	1.04	0.95	0.54	0.18
Aboveground part	**3.19**	**2.81**	**2.27**	**1.74**	**3.23**	**2.79**	**2.62**	**1.65**	**0.44**
Roots	0.59	0.44	0.43	0.35	0.50	0.45	0.61	0.36	n.s.
Total yield per m^2	**3.78**	**3.25**	**2.70**	**2.09**	**3.73**	**3.24**	**3.23**	**2.01**	**0.72**

n.s. – not significant difference

Source: own work / *Źródło*: praca własna

Table 8. Yield of lupine seed, triticale grain and their mixture (t·ha^{-1})

Tab. 8. Plon nasion łubinu i ziarna pszenżyta oraz ich mieszanek (t·ha^{-1})

Description	Lupine variety										LSD α=0.05
	Dukat					Taper					
	Share of lupine in the sowing mixture (%)										
	100	75	50	25	0	100	75	50	25	0	
2008											
Seed of lupine	0.74	1.00	0.51	0.26	-	1.53	1.53	0.69	0.26	-	0.26
Grain of triticale	-	2.58	3.45	3.98	4.53	-	2.07	3.29	3.84	4.08	0.74
Mixture	0.74	3.58	3.94	4.24	4.53	1.53	3.60	3.98	4.10	4.08	0.86
2009											
Seed of lupine	0.95	0.84	0.97	0.55	-	1.11	0.72	0.35	0.29	-	0.28
Grain of triticale	-	0.80	1.84	2.60	3.55	-	1.26	2.55	2.91	3.85	0.75
Mixture	0.95	1.64	2.81	3.15	3.55	1.11	1.98	2.90	3.20	3.85	0.94
2010											
Seed of lupine	2.16	1.10	0.84	0.26	-	2.11	1.24	0.52	0.22	-	0,61
Grain of triticale	-	3.35	4.30	4.80	5.70	-	3.57	4.97	5.27	5.82	1.16
Mixture	2.16	4.45	5.14	5.06	5.70	2.11	4.81	5.49	5.49	5.82	0.42
2008–2010											
Seed of lupine	1.37	0.98	0.77	0.36	-	1.58	1.16	0.52	0.26	-	0.17
Grain of triticale	-	2.24	3.20	3.79	4.60	-	2.30	3.60	3.89	4.58	0.48
Mixture	1.37	3.22	3.96	4.15	4.60	1.58	3.46	4.12	4.26	4.58	0.76

Source: own work / *Źródło*: praca własna

The biggest dry matter yield of vegetative and generative lupine organs was obtained from stands in which lupine had the biggest share at mixture of sowing seeds (Table 6). While the biggest dry matter yield of triticale organs was obtained when triticale seeds had the greatest share at sowing seeds mixture (Table 7). Ducat - a traditional variety of yellow lupine produced greater yield of vegetative and generative organs than self-determined variety Taper. Stem dry matter of lupine was increasing up to full maturity phase, while leaves mass in the maturation period was decreasing in effect of their wilting and falling. It is suppose in general, that production of excessively large mass of vegetative organs could cause seed yield decrease [7]. In the presented studies was not found of such dependency, because the new lupine varieties produce much less mass of vegetative organs than the older ones [21, 22].

The decrease of triticale share in the mixture stand caused the decrease of dry matter yield of this species. Course of weather conditions at particular research years considerably more modified the dry matter yield of lupine than triticale, what confirms greater sensitivity of legumes than cereals to unfavorable weather conditions and, resulted from this, great yielding variability in years.

On a special attention deserves a fact, that during the all research years lupine roots had a considerable share in the total yield of a mixture roots dry matter what indicates on great ecological meaning of this type of stands. A traditional lupine variety Dukat produced greater root mass than self-determined variety Taper. It can be discrete as a certain correctness, because a similar dependency was found at research concerning of white lupine [19].

The course of weather conditions in the research years had significant influence on lupine seeds and triticale grain yield as well as on a mixture yield. The greatest yield of a mixture and yield of its components cultivated in the pure stands were obtained in the 2010, and the lowest in 2008 (Table 8).

Moreover, the difference between triticale yield obtained from the pure and mixture stands cultivated in the unfavorable weather conditions was greater than in the case of their cultivation in the more favorable conditions. Gałęzewski [6], led researches concerning the cultivation of yellow lupine with oat and showed that in the dry years mixtures yielded lower than pure cereal stands, but under wet conditions it is inversely. The weather course modified also the share of individual components in the yield mix-

ture. In the years which are less favorable to plant cultivation the lupine share in the mixture was lower in compare to the years in which weather conditions favored cultivation of lupine and triticale. Mixed stands yielded better than lupine pure stand, however self-determined yellow lupine variety Taper cultivated with triticale a little higher yielded in all years than mixture with lupine variety Dukat. Moreover, triticale much more restricted the Taper variety yielding than Dukat variety of lupine. Kotecki et al. [8] led the field experiments with yellow lupine and triticale at unfavorable weather conditions. They also obtained the highest seed yields from the object where triticale was cultivated in pure stand, and the lowest - from lupine pure stand. Decreasing of seed yield caused by unfavorable weather course in 2008 in relation to 2010, when weather conditions favored plant cultivation, amounted for lupine cultivated at pure stand and in the mixture with triticale 46,8 and 23,9%, respectively. From the other studies [12, 14, 19] indicate that unfavorable conditions occurring during legumes cultivation could cause considerable greater yield reductions from these found at mentioned experiments. Obtained results show explicitly that mixture of lupine with triticale is less sensitivity on drought than lupine cultivated in the pure stand. Our results are confirmed also by studies of Kotwica and Rudnicki [10], in which mixtures of lupine with cereals yielded quite stably because ratio of their yielding variability was much smaller (7,3-11,6%) than lupines (9,9-33,6%).

On an attention deserves a fact that percentage share of particular species seeds at sowing mixture did not find the reflection at the percentage their share in yield after harvest (Table 9). In the case of sowing of mixture with composition: lupine - 75 and triticale - 25 % of pure sowing, was obtained a mixture with composition 35% of lupine seeds and 63% grain of triticale. Whereas, by sowing of a mixture with composition: 50% of lupine pure sowing and 50% of triticale pure sowing was obtained a mixture with composition: 17 and 83% of lupine and triticale, respectively. Therefore, the share of triticale decided in the greater degree than lupine about a total yield of a mixture.

The composition of sowing mixture modified also the features of lupine (Table 10) and triticale (Table 11) yield structure. Decreasing of lupine and increasing of triticale share caused the reduction of lupine pods per plant, number of seeds per pod and weight of thousand seeds of lupine. While, the increasing of triticale share in the mixture effected on the decrease of: shoots number per plant, number of grains per plant, number of grain per ear and thousand grain weight.

Triticale growing in the mixture with lupine produced more shoots, ears and grains per plant than cultivated at pure stand. Obtained results have found a confirmation in the Kotecki et al. [8] studies, in which was showed that triticale plants origin from mixed stands produces greater number of grains and weight of grains per ear than plants cultivated in the pure stands. However, the response of particular cereal species on mixed sowing with lupine is not the same. As an example are the papers of Gałęzewski [5, 6] and Rudnicki [26], who have shown, that oats cultivated with yellow lupine produced less tillers and fine-looking panicles as well as lower yield of grains from a panicle than cultivated in the pure stand.

Table 9. Composition of lupine with triticale mixture (%)
Tab. 9. Skład mieszanki łubinu i pszenżyta (%)

Description	Lupine variety										LSD α=0.05
	Dukat					Taper					
	The share of lupine in the sowing mixture (%)										
	100	75	50	25	0	100	75	50	25	0	
2008											
Seeds of lupine	100	24.8	16.3	5.1	-	100	25.8	9,4	4,1	-	8.24
Grain of triticale	-	75.2	83.7	94.9	100	-	74.2	90.6	95.9	100	4.72
2009											
Seeds of lupine	100	27.8	12.9	6.1	-	100	40.4	17.4	6.4	-	10.43
Grain of triticale	-	72.2	87.1	93.9	100	-	59.6	82.6	93.6	100	12.51
2010											
Seeds of lupine	100	51.0	34.6	17.6	-	100	36.3	12.1	9.4	-	14.63
Grain of triticale	-	49.0	65.4	82.4	100	-	63.7	87.9	90.6	100	11.41
2008–2010											
Seeds of lupine	100	34.5	21.3	9.6	-	100	34.2	13.0	6.6	-	10.44
Grain of triticale	-	65.5	78.7	90.4	100	-	65.8	87.0	93.4	100	8.32

Source: own work / *Źródło*: praca własna

Table 10. Features of lupine yield structure cultivated at pure sowing and at mixture with triticale
Tab. 10. Struktura plonu łubinu uprawianego w siewie czystym i w mieszance z pszenżytem

Description	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of lupine in the mixture (%)								
	100	75	50	25	100	75	50	25	
Number of pods per plant	8.5	7.4	6.2	5.2	7.5	5.4	5	4.7	0.74
Number of seeds per plant	63.8	58.9	40.9	31.5	56.4	39.9	35.7	31.4	4.24
Number of seeds per pod	7.5	8.0	6.6	6.1	7.5	7.4	7.1	6.7	n.s.
Weight of thousand seeds (g)	126	122	119	112	128	125,3	123	120	n.s.

n.s. – not significant difference

Source: own work / *Źródło*: praca własna

Table 11. Features of yield structure of triticale cultivated at pure sowing and at mixture with lupine
Tab. 11. Struktura plonu pszenżyta uprawianego w siewie czystym I w mieszance z łubinem żółtym

Description	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of triticale in the mixture (%)								
	100	75	50	25	100	75	50	25	
Number of shoots with ears per plant	1.2	1.5	1.8	2.6	1.3	1.7	2.2	2.7	0.31
Number of grains per plant	103	126	159	282	109	155	198	259	37.6
Number of grains per ear	86	84	87	108	84	90	90	96	2.34
Weight of thousand seeds (g)	34.0	37.5	40.2	42.6	37.4	40.7	43.7	45.9	1.77

Source: own work / *Źródło*: praca własna

Table 12. Morphological features of lupine plants
Tab. 12. Cechy morfologiczne roslin łubinu

Description	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of lupine in the mixture (%)								
	100	75	50	25	100	75	50	25	
Height of plants (cm)	63.4	66.3	64.2	65.8	57.7	64.3	66.3	67.1	n.s.
Number of lateral shoots	7.7	5.2	4.8	3.5	1.7	1.1	0.0	0.0	1.16
Area of leaves (cm^2)	31.5	18.5	14.6	11.4	24.7	14.1	10.3	8.4	2.63

n.s. – not significant difference

Source: own work / *Źródło*: praca własna

Table 13. Morphological features of triticale plants
Tab. 13. Cechy morfologiczne roślin pszenżyta

Description	Lupine variety								LSD α=0.05
	Dukat				Taper				
	Share of triticale in the mixture (%)								
	100	75	50	25	100	75	50	25	
Height of plants (cm)	109	102	97	96	113	107	106	103	n.s.
Number of lateral shoots	2.0	2.2	2.4	2.4	1.8	2.0	3.4	3.4	0.86
Area of leaves (cm^2)	72.4	86.3	88.1	89.9	68.7	74.5	81.2	84.3	n.s.

n.s. – not significant difference

Source: own work / *Źródło*: praca własna

The sowing method affected also on values of morphological features of lupine (Table 12) and triticale (Table 13). Together with increase of triticale and decrease of lupine share in the mixture the height of plants was increasing, while number of lupine lateral stems and number of shoots at triticale as well as leaf area of the both species was decreasing. Moreover, in conditions of increased triticale density in the mixture the yellow lupine variety Taper did not produced lateral stems.

4. Conclusions

1. The course of weather conditions had effect on the length of lupine and triticale vegetation period and on the yield and share of components in the total yield of mixture.
2. In regard of similar rhythm of growth and development, and especially term of maturation, both varieties of yellow lupine are useful to cultivation in the mixture with triticale. In the all years of research there was obtained similar yield of triticale mixture with both the traditional and self-determined lupine variety.
3. The composition of sowing mixture significantly differentiated weight of organs of both mixture components. The greatest mass of vegetative and generative organs was produced by lupine plants cultivated in the pure stand, and triticale – in the mixture with the greatest share of lupine.
4. The percentage share of particular species seeds in the yield after the harvest is various than in the sowing mixture – in general lower of lupine and greater of triticale. Therefore, to achieving the considerable yield of lupine its share in the sowing mixture should exceed 50 % of pure sowing.
5. The composition of sowing mixture modified also features of lupine and triticale yield structure. Decreasing of lupine and increasing of triticale share in the mixture causes reduction of pods number per plant, number of seeds per pod and thousand seeds weight of lupine. While in relation to triticale share increase was found the decrease of: number of shoots per plant, grain per plant, grain per ear and thousand grain weight.

5. References

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