Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2000
Volume 3
Issue 1
Series AGRONOMY

JASKULSKI D., KOTWICA K., JASKULSKA I. 2000. SOWING DENSITY- AND RAINFALL- RELATED YELLOW LUPIN YIELDING VARIABILITY IN PURE STAND AND IN MIXTURES WITH SPRING TRITICALE **Electronic Journal of Polish Agricultural Universities**, Agronomy, Volume 3, Issue 1.
Available Online http://www.ejpau.media.pl/

SOWING DENSITY- AND RAINFALL-RELATED YELLOW LUPIN YIELDING VARIABILITY IN PURE STAND AND IN MIXTURES WITH SPRING TRITICALE

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ABSTRACT

The research aimed at defining the variability in the yielding of yellow lupin cultivated in pure stand and in mixtures with spring triticale in a field experiment at a varied April-July rainfall as well as a varied sowing density of both components. The experiments were carried out over 1990-1993 at the Mochełek Experiment Station of the Bydgoszcz University of Technology and Agriculture, Faculty of Agriculture. The experiments were conducted on light soil of a good rye soil suitability complex, IVa soil quality classification. The value of the rainfall variability coefficient over April-July amounted to 37.1%. The driest period rainfall amounted to 106 mm, while the most moisten period rainfall - 260 mm. It was observed that the yellow lupin yielding variability in pure stand was considerably lower than in the mixtures with spring triticale. An increasing lupin sowing density from 25 to 50-100 seeds per 1 m^2, both in pure stand and in mixtures, showed a stabilising effect on the seed yield and plant density, however it increased the variability of seed weight per plant. A variability in yellow lupin yields, as a result of its varied sowing density, was the highest under a high (240 mm) April-July rainfall, especially when lupin was sown in a mixture with spring triticale.

Key words: yellow lupin, spring triticale, mixtures, yield variability, rainfall

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INTRODUCTION

Crop yields are determined by genetics (species, biotype, cultivar) as well as habitat conditions, including soil and climatic as well as agronomic conditions. The results of the earlier research show a significant link between the yellow lupin seed yield and its form and cultivar [1,2,5]. Similarly essential yield-determiners are soil quality [6,12] and weather conditions [5]. Depending on the soil agronomic category, yellow lupin cultivated for green mass calls for 220-250 mm rainfall over April - July [3]. Similarly there is a necessity of adequate agronomy, including adequate timing of sowing, optimum plant density, macro- and micro-element fertilisation, plant nurturing. All those practices affect both the yield and yielding stability [7,9,15,16]. The yellow lupin seed yields recorded in Poland, as compared with other leguminous species, are relatively low and changeable over years [14]. One of the agronomic practices enhancing crop yielding stability is the cultivation of the crop with mixtures. A mutual plant supplementing of different species in one stand leads to a greater yielding stability [10,13].

The present research offers a hypothesis that the source of yellow lupin yielding variability are weather conditions, especially rainfall, as well as a varied sowing density and companion planting of spring triticale in mixtures. However a direct aim of the present research was to define the variability of yellow lupin seed yielding in pure stand and in mixture with spring triticale when exposed to a varied rainfall over April-July and a varied sowing density of both species.

MATERIALS AND METHODS

The variability of yellow lupin yielding observed in the 'Topaz' cultivar was defined with the analysis of field trial results which included the cultivation of lupin in pure stand as well as in mixtures with spring triticale 'Maja'. The yellow lupin sowing density amounted to 25, 50, 75 and 100 seeds per 1 m^2, while that of triticale in mixtures - 135, 270 and 405 seeds per 1 m^2. The field experiments were conducted at the Mochełek Experiment Station of the Faculty of Agriculture, University of Technology and Agriculture, Bydgoszcz, over 1990-1993. The annual experiment was carried out on lessive soil, classified as light, of a good rye soil suitability complex, IVa soil quality classification. Both for lupin as well as for mixtures, winter rye acted as a forecrop. The sowing dates for lupin and for triticale were identical, depending on the research year, from 21st March to 19th April. The seeds of both species were sown separately, perpendicular to each other. The split-block experiment was carried out in four replications, at the plot size of 29.2 m^2. The pure stand and mixture harvests coincided in time, from August 4th, 1992, to September 15th, 1993. Each time the harvest was followed by the seed water content analysis.

The research years varied in their weather conditions. The coefficient of variability for the rainfall of April - July amounted to 37.1%, while the mean monthly temperature ranged from 12.8 to 15.4°C. The yield variability observed over the 4-year research period, seed weight per plant and yellow lupin plant density were applied to calculate the variability coefficients. Then the legume seed yields were estimated both in pure stand and in mixtures with spring triticale at a varied sowing density of both plant species and at a varied April-July rainfall. There was applied a multiple regression which was followed by an estimated-values - based yellow lupin yielding variability analysis; accounting for a varied sowing density, in pure stand and mixed with spring triticale, at a varied rainfall from April to July.

RESULTS

Minimum and maximum yields and yield structure element values resulted from varied weather conditions as well as yellow lupin agronomy practises (Table 1). The lowest seed yields were observed in the semi-dry 1992 (106 mm rainfall over April-July). What considerably limited the yellow lupin yielding in pure stand and in mixtures in spring triticale were a low lupin density and high cereal density. Similar effect was observed for seed yield per plant.

The yellow lupin yielding stability in pure stand was linked with a sowing density (Table 2). The coefficient of yield variability for 25 seeds per 1 m^2 amounted to 33.4%. An increase in the sowing density from 50-100 seeds per 1 m^2 helped the yielding stability. The value of the coefficient of variability ranged from 16.7-21.3%. The yellow lupin yielding variability in spring triticale mixture was much higher than the respective pure stand value and it resulted from both legume and cereal sowing densities. An increase in spring triticale sowing density in mixture coincided with an increase in the yielding variability calculated for yellow lupin sown both at low and high densities. Consequently, in mixtures, the most stable yielding was observed for yellow lupin sown at 75-100 seeds per 1 m^2, at an inconsiderable (135 seeds per 1 m^2) share of spring triticale. Here the value of the seed yield variability coefficient amounted to 38-44% and it was almost twice lower than the respective value calculated for legume sown at the density of 25 seeds per 1 m^2 together with 405 cereal seeds.

A high variability in the real yields of yellow lupin cultivated in pure stand and in mixtures with spring triticale was mainly the result of variability of the seed yield per plant, and, to a lesser extent, of the harvest plant density (Table 2). The coefficient of variability of the lupin seed weight per plant in pure stand ranged from 76.0-92.6% and increased with the increase in the sowing density. A similar relationship was observed in mixtures yet the value of the coefficient of variability was slightly higher, ranging from 78.0-109.1%. A greater share of cereal in the mixture (405 seeds per 1 m^2), as compared with lower density sowing (135 seeds per 1 m^2), enhanced the stability of the seed yielding per lupin plant, irrespective of the sowing density. The variability of pre-harvest yellow lupin plant density, both in pure stand and in mixtures, was slight, especially at the sowing density of 50-100 seeds per 1 m^2. The value of the coefficient of yielding variability did not exceed 13%.

Estimated yellow lupin yields, depending on the sowing density and April-July rainfall, in pure stand and with a varied share of spring triticale are presented in Table 3. The yield of yellow lupin sown in a pure stand at the amount of 25-100 seeds per 1 m^2 increased with an increase in the sowing density and with an increase in the rainfall over the vegetation period. The increase in rainfall over April-July from 120 to 240 mm increased the yellow lupin seed yield.

The yellow lupin seed yield in mixtures increased with an increase in the sowing density and with a decrease in the share of cereal. With a high water deficit, 120 mm rainfall over April-July and with a sufficient rainfall - 240 mm, estimated yellow lupin seed yields in mixtures, irrespective of the sowing density of both components, were lower than the yields obtained under moderate rainfall - 180 mm.

Table 1. Yellow lupin sowing density- related minimum and maximum seed yields, seed weights per plant and yellow lupin plant densities prior to harvest and some weather conditions over the 4-year research period in pure stand and mixture

Characteristic	Yellow lupin sowing density, seeds per 1 m^2	Spring triticale sowing density, seeds per 1 m^2							
		0		135		270		405	
		Value							
		min.	max.	min.	max.	min.	max.	min.	max.
Seed yield, $t \cdot ha^{-1}$	25	0.76	1.04	0.43	1.46	0.35	1.46	0.29	1.44
	50	1.18	1.78	0.70	1.90	0.63	1.89	0.53	1.79
	75	1.48	2.37	1.02	2.25	0.88	2.14	0.72	1.99
	100	1.78	2.65	1.14	2.81	0.99	2.63	0.84	2.31
Seed weight per plant, g	25	3.8	14.9	2.7	10.9	2.4	9.0	2.0	6.7
	50	3.0	13.7	2.2	10.0	2.0	8.8	1.7	6.5
	75	2.5	13.0	1.6	9.4	1.6	8.6	1.3	6.2
	100	2.1	11.5	1.1	8.2	1.1	7.0	1.0	5.4
Plant density prior to harvest, seeds per 1 m^2	25	16	22	14	20	11	20	10	19
	50	37	41	33	39	30	38	26	35
	75	54	60	50	57	47	54	42	51
	100	73	84	69	75	66	70	59	65
Rainfall over April-July, mm	min. – 106 max. – 260								
Mean monthly temperature over April-July, °C	min. – 12.8 max. – 15.4								
Seljaninov hydrothermic index	min. – 0.57 max. – 1.66								

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Table 2. Value of variability coefficients (%) of yellow lupin seed yield, seed weight per plant and plant density prior to harvest in pure stand and in mixture with spring triticale, at a varied sowing density of both components over the 4-year research period

Characteristic	Yellow lupin sowing density, seeds per 1 m^2	Spring triticale sowing density, seeds per 1 m^2			
		0	135	270	405
Seed yield	25	33.4	69.3	82.7	94.3
	50	16.7	47.3	58.4	68.9
	75	21.3	38.0	45.8	54.2
	100	18.9	44.5	50.9	55.6
Seed weight per plant	25	76.0	82.5	78.8	78.0
	50	81.9	88.5	86.9	83.7
	75	83.7	94.8	96.3	90.7
	100	92.6	109.1	108.8	102.8
Plant density prior to harvest	25	13.5	14.9	23.5	25.0
	50	4.3	6.9	9.6	12.9
	75	4.4	5.4	5.9	8.5
	100	6.8	4.1	2.6	4.3

The variability of the estimated yellow lupin yields, as a result of a varied legume sowing density, was lower in pure stand than in mixtures with spring triticale irrespective of the rainfall over April-July, even though it increased with an increase in rainfall up to 240 mm. A varied yellow lupin sowing density in mixtures enhanced the lupin yielding variability; the lower the share of cereal, the greater variability, while under a sufficient rainfall (240 mm) the stability of yellow lupin seed yields was much lower than under a lower rainfall of 120-180 mm over April - July. A sufficient rainfall must have helped to identify that a greater plant density enhanced lupin seed yield, hence an increase in yielding variability due to a varied sowing density.

Table 3. Sowing density-related estimated yellow lupin yields ($t \cdot ha^{-1}$) and their variability (%) at a varied share of spring triticale and a varied rainfall

Spring triticale sowing density, seeds per 1 m^2	Rainfall mm	Yellow lupin sowing density, seeds per 1 m^2				Yield variability coefficient
		25	50	75	100	
0	120	1.18	1.36	1.54	1.72	12.4
	180	1.27	1.54	1.81	2.08	20.8
	240	1.36	1.72	2.08	2.44	24.5
135	120	0.74	0.95	1.17	1.38	26.1
	180	1.15	1.47	1.78	2.10	25.1
	240	0.74	1.16	1.58	2.01	39.6
270	120	0.67	0.86	1.04	1.22	24.9
	180	1.07	1.35	1.62	1.89	23.8
	240	0.66	1.02	1.38	1.74	38.7
405	120	0.62	0.77	0.91	1.05	21.5
	180	0.99	1.20	1.42	1.63	21.1
	240	0.59	0.87	1.15	1.44	36.1

DISCUSSION

Increase in yellow lupin yields as a result of an increasing rainfall over April-July from 120 to 240 mm confirms the estimates reported by Dzieżyc et. al [3] that the rainfall requirements of that species amount to 220-250 mm, while the seed yield of the legume in mixtures with spring triticale scored highest when the rainfall over a respective period amounted to 180 mm. The reason for such reaction of the legume can be defined as a competition of yellow lupin and spring triticale in order to reach more water. Under moderate rainfall (180 mm), a deep-root-system lupin could have used water supplies better than the spring triticale with its shallower fibrous root system, while a good water supply made the cereal more competitive.

Legume yielding stability, including that of yellow lupin, is low. In the 3-year research reported by Szukała et al. [12], the yellow lupin yielding index, depending on the soil suitability complex, ranged from 54 to 74%, and narrow-leafed lupin up to 67-101%. The yielding variability reported in the present research, especially the yellow lupin sown at the density of 50-100 seeds per 1 m^2, was much lower, which could have resulted from a lower diversity in the weather conditions over the research years, seen from the analysis of rainfall over respective years. The reported research rainfall over April-July ranged from 71-298.9 mm. However, the present research shows that over the driest year the rainfall amounted to106 mm in a respective year, while in the year abundant in rainfall – 260 mm. The analysis of the results obtained shows that the yellow lupin sown at a density similar to the optimal value, which, according to the earlier numerous research reports, ranges from 60-120 seeds per 1 m^2 [1,4,11,15], can show a relatively low variability in seed yielding, especially in plant density. However, at a very low sowing density, the yellow lupin yielding was more affected by habitat conditions deteriorating yielding stability, while seed weight per plant over research years varied considerably and its variability was only slightly related to the sowing density, which can signify a stronger lupin plant reaction to varied weather conditions than to the plant stand density.

Spring triticale companion crop for yellow lupin plants in mixtures, in most cases, increased the seed yield variability, seed weight per plant and plant density, which can be due a lower competition for legume and its disappearance in mixed stands, especially under less favourable habitat conditions. A lowered cereal-legume mixture yielding stability, as compared with cereal pure stand, was observed by Siuta et al. [8]. The research reported by authors showed that legume yielding was always higher than the cereal yielding variability; it was the legume component which deteriorated the mixture yielding stability.

CONCLUSIONS

1. The yielding variability of yellow lupin cultivated in pure stand was much lower than in mixture with spring triticale.
2. An increase in yellow lupin sowing density from 25 to 50-100 seeds per 1 m^2, both in pure stand and in mixtures, enhanced the stability of seed yielding and of plant density prior to harvest as well as increased the variability of seed weight per plant.
3. An increase in sowing density of spring triticale in mixtures, irrespectively of legume plant density, was accompanied by an increase in the values of variability coefficients calculated for seed yield and yellow lupin plant density.
4. The highest estimated yields of yellow lupin cultivated in pure stand were observed for the April-July rainfall of 240 mm, while in spring triticale mixtures – for the rainfall of 180 mm.
5. The yellow lupin yielding variability, as a result of a varied sowing density, was the highest when accompanied by a high (240 mm) rainfall and when cultivated in spring triticale mixtures.

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