CHANGES IN THE AGROPHYTOCENOSES AND CHEMICAL INDICATORS OF PEAS AND SUGAR BEET CROPS IN SHORT CROP ROTATIONS

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Over the period 1997- 2004 a series of field experiments was conducted in Dotnuva (Lithuania) on an Endocalcari-Endohypogleyic Combisol with the aim of testing the possibilities of shortening of crop rotations, choice of optimal preceding crops in relation to yield quality and weed community composition in the crops.

Crop rotations affected nitrogen and potassium contents in pea. Continuous growing of sugar beet tended to reduce sugar and dry matter contents. Shortening of rotations deteriorated sugar beet root technological properties: the contents of α amino nitrogen, potassium, noxious substances.

Key words: *crop rotation, pea, sugar beet, weed, chemical indicators*.

Field pea (*Pisum sativum* L.), a native of Southwest Asia, was among the first crops cultivated by man. Optimum growth is obtained on loams, silt loam or well texture soils with a pH 6.0 - 7.5 [2]. Field pea is used for seed, hay, pasture, silage and green manure [5]. Plant is rich in high quality protein. It is rich in phosphorus and calsium, and also a good source of vitamins, especially vitamins A and D [11]. These qualities make field pea one of the best feeds for animals and almost indispensable for efficient, economical livestock feeding [3]. Weed competition may severely reduce yield of field pea. Heavy weed infestations should be controlled by cultural or chemical measures prior to rotating into field pea, and prior to planting [9]. Weed competition is a serious limitation to field pea (*Pisum sativum* L.) production. Field pea growth habit (cultivar) did not affect number of weeds, but increasing stand density (seed rate) reduced weed numbers in all 3 years, express reduced above-ground dry matter production of broadleaf weeds [13]. The late studies have shown that the inclusion of forage legumes in a crop rotation can increase the density of annual broadleaf weeds in the succeeding crop [6,14]. Peas are often grown in a rotation with cereals and mixed with cereals [8]. Cultivation of sugar beet is dependent on many factors which reduce the crop. One of these factors is weeds [4]. An early method of reducing weed control requirements was to plant sugar beet for successive years. Modern experience indicates that monoculture is likely to exacerbate weed control problems by increasing the populations of some weeds that are difficult to control [12]. Crop diversification provides more control opportunities and disrupts life cycles of weeds that are crop mimics [1].

The work presents results of seven-year trials aimed at observing the effects of several factors (previous crop) on weed incidence and selected chemical indicators (nitrogen, phosphorus, potassium, calcium) protein, saccharose content and dry matter values in short crop rotations.

MATERIALS AND METHOD

Research on shortening of crop rotations was conducted at the Lithuanian Institute of Agriculture in Dotnuva during the period 1997-2004. The experiment was composed of 9 short crop rotations (2–4 courses) and monocrop. All in all 27 rotations-members (*table 1*).

Table 1.

Experimental design

Crop rotation No.	Course No. and plant species	Crop rotation No.	Course No. and plant species	Crop rotation No.	Course No. and plant species
I	1. Peas	II	1. Peas	III	1. Peas
	2. Winter wheat		2. Winter wheat		2. Winter wheat
	3. Sugar beet		3. Spring barely		3. Winter wheat
	4. Spring barley				
IV	1. Sugar beet	V	1. Sugar beet	VI	1. Sugar beet
	2. Spring barley		2. Peas		2. Spring barley
	3. Winter wheat		3. Winter wheat		3. Peas
VIII	1. Peas	IX	1. Sugar beet	X	1. Spring barley
	2. Winter wheat		2. Spring barley		2. Sugar beet
			3. Spring oilseed		
XI	Sugar beet				
	(mono culture)				

Net plot size for peas was 43.5 m^2, sugar beet 36 m^{-2}. The plots were replicated four times. Replication treatments were arranged randomly. According to the new classification of soils 1999 (LTDK-99), systematic units that have been coordinated with FAO-UNESCO World soil map legends, predominant soils of the experimental site are *Endocalcari-Endohypogleyic Cambisol* [7], humus content in the ploughlayer 2.28 % (according to Tyurin), pH_{KCl} 7.2 (measured potentiometrically), mobile phosphorus and mobile potassium 142 and 180 mg kg^{-1} soil, respectively (A-L method).

In the trial were grown pea crop *(Pisum sativum* L.*)* 'Profi' (1 mln. ha^{-1} germinable seed) sugar beet (*Beta vulgaris* var. *saccharifera* Alef.) 'Manhatan' (1.3 seed units ha^{-1}), winter wheat (*Triticum aestivum* L.) 'Sirvinta' (seed rate 4 million ha^{-1}), spring barley (*Hordeum vulgare* L.) 'Alsa' (3.5 million ha^{-1}) and spring oilseed rape 'Maskot' (7 kg ha^{-1}).

Conventional crop cultivation technology linked with sustainable fertilisation of agricultural crops was applied in the trial.

Only mineral fertilisers were applied: for peas -$P_{40}K_{40}$, sugar beet - $N_{150}P_{60}K_{12}$, wheat -$N_{80}P_{40}K_{30}$, barley -$N_{70}P_{40}K_{30}$, and for spring oilseed rape -$N_{90}P_{60}K_{60}$. Phosphorus and potassium fertilisers were applied in the autumn, before ploughing, nitrogen was applied in spring.

Herbicides were used for all crops: sugar beet was sprayed with Betanal Expert (1.5 l ha^{-1}) in mixture with Goltex (1.5 kg ha^{-1}), peas with Bulet (1.5 l ha^{-1}).

Weediness (number and air-dry weight of weeds) was assessed before herbicide application at peas ripening stage (BBCH 81), in sugar beet crops - when leaves covered interrows (BBCH 39) [7]. The assessments were made using a 0.25 m^2 frame by taking weeds in four places for each replication.

Accounting data for the number and mass of weeds for evaluation of statistically significant differences were transformed according to the formula: x=x+1. The experimental data were processed by ANOVA (* - 95 %, ** - 99 % probability level) [13].

Quality assessment indicators of the primary and by production of the crop rotation peas crops – total nitrogen content (N) was determined by Kjeldahl method (LST 1523), P – by wet combustion, colorimetrical method using *Technikon* instrument, K and Ca – by flame photometry, protein content in wheat was calculated according to N_{total} content, measured by Kjeldahl method (LST 1523). All analyses were done at LIA's laboratory of chemical tests.

Sugar beet indicators were calculated according to sugar beet quality assessment methodology developed by A.V.Ustimenko-Bakumovski, A.I. Ostroushka, V.A. Makaveck, C.Winner, Carruthers & Oldfield [16].

The weather conditions were different during the experimental period (*table* 2).

Sums of precipitation and average temperatures in each month.

Table 2

Sums of precipitation and average temperatures in each month

Month	Precipitation (mm)					Temperatures (°C)				
	2001	2002	2003	2004	N	2001	2002	2003	2004	N
January	22.5	44.8	22.6	22.9	29.0	-0.7	-1.5	-5.1	-7.0	-4.9
February	29.7	49.1	15.2	32.9	25.6	-2.8	1.6	-5.8	-1.9	-4.5
March	33.6	34.4	2.7	43.0	28.1	0.2	3.2	0.8	1.5	-0.9
April	34.7	21.6	37.6	11.1	37.8	8.0	7.9	5.4	7.6	5.7
May	34.6	19.5	36.3	27.8	52.0	12.8	15.4	13.6	11.2	12.2
June	52.8	53.2	54.9	44.2	62.1	14.4	16.8	15.5	14.2	15.6
July	102.5	35.7	54.6	81.6	73.8	21.0	20.3	20.6	16.9	17.6
August	59.1	29.1	66.5	94.5	73.4	17.6	20.3	17.3	18.1	16.6
September	76.5	14.6	22.4	53.2	51.8	11.9	12.9	12.9	12.9	11.9
Sum	446	302	312.8	411.2	433.6					
Average	49.6	33.6	34.8	45.7	48.1	9.2	10.8	8.4	8.2	7.7

RESULTS AND DISCUSSIONS

During 1997-2004 periods the number of weeds depended on the shortening of crop rotations and specificity of preceding crops.

According to averaged experimental data, in pea crops at the end of rotation the number of weeds for all crop rotations increased, on average, by 27 % (*table 3*). The weed incidence had a significant increased in the crop rotation peas-wheat-barley and peas-wheat-wheat composed solely of wheat, where 2/3 of the total crop area was occupied by spiked cereals by 39.5 and 23.4 %, respectively.

Table 3

Weed composition in crop rotations, units m^{-2}

Crop	Weed species							Total amount units m^{-2}	Air dry weight g m^{-2}
Rotations[x]	*Che nopo dium album*	*Capsel lla bursa pasto ris*	*Fallo- pia con vol vulus*	*Tripleu- rosper- mum perfora tum*	*Cir- sium arven se*	*Elytrigi a re- pens*	Other		
P-W-SB-B	0.8[1] / 4.3[2]	1.4 / 0.4	0.1 / 1.5	2.3 / 2.0	0.4 / 0.2	2.6 / 1.5	7.0 / 6.6	14.6 / 16.5	17.5 / 13.0
P-W-B	1.8 / 4.6	1.5 / 2.0	2.1 / 2.4	2.8 / 2.4	0.4 / 0.3	3.2 / 10.3	8.3 / 11.2	20.1 / 33.2*	25.5 / 23.6
P-W-W	1.1 / 1.0	1.1 / 1.5	2.2 / 3.7	2.6 / 2.7	0.2 / 0.2	11.4 / 15.8	11.5 / 14.4	30.1* / 39.3*	31.8 / 26.8
SB-**P**-W	1.4 / 4.1	0.8 / 1.6	2.0 / 2.8	3.1 / 2.7	0.7 / 1.0	1.9 / 2.5	7.3 / 12.7	17.2 / 27.4	32.1 / 19.9
SB-B-**P**	2.1 / 4.2	0.9 / 1.2	1.3 / 2.2	2.2 / 1.9	0.9 / 1.3	3.2 / 4.8	4.9 / 5.1	15.5 / 20.7	23.0 / 17.2
P-W	3.6 / 3.7	1.1 / 1.4	2.6 / 2.7	1.4 / 1.0	0.9 / 1.2	14.2 / 20.8	8.0 / 9.0	31.8* / 39.8*	23.6 / 27.2
P-W-**SB**-B	0.1 / 0.7	0.5 / 0.0	0.1 / 0.6	1.0 / 0.1	0.7 / 0.1	0.3 / 0.3	1.8 / 2.0	4.5 / 3.8	4.3 / 3.0
SB-B-W	0.3 / 0.5	0.1 / 0.1	0.3 / 0.3	0.3 / 0.1	0.2 / 0.2	0.4 / 0.6	1.6 / 1.8	3.2 / 3.6	3.3 / 2.3
SB-P-W	0.6 / 0.6	0.1 / 0.1	0.3 / 0.5	0.4 / 0.1	0.3 / 0.2	0.6 / 2.2	3.0 / 1.8	5.3 / 5.5	4.1 / 4.6
SB-B-P	0.3 / 1.3	0.1 / 0.0	0.4 / 0.3	0.4 / 0.1	0.8 / 1.2	0.3 / 1.8	1.2 / 1.0	3.5 / 5.7	3.1 / 4.0
SB-B-SR	1.2 / 1.8	0.3 / 0.2	0.2 / 0.2	0.1 / 0.1	0.0 / 0.4	0.0 / 11.2	2.3 / 2.3	4.1 / 16.2*	5.9 / 11.9*
B-**CB**	0.5 / 0.5	0.5 / 0.4	0.1 / 0.2	0.6 / 0.1	0.3 / 0.6	0.2 / 0.4	1.2 / 1.3	3.4 / 3.5	4.6 / 4.9
SB	0.1 / 0.8	0.8 / 0.1	0.3 / 0.4	0.5 / 0.1	0.6 / 3.5	0.5 / 9.8	1.4 / 1.0	4.2 / 15.7*	3.2 / 19.2*

[1]- Weed incidence at the beginning of rotations, [2]- the weed incidence at the end of rotations; *, ** - differences significant at the 5 %, 1 % level, respectively.

[x] – Rotations are indicated using the first letters of crops: W – wheat, B – barley, P – pea, SB – sugar beet, , SR – spring rape.

At the end of rotations a similar weed infestation level was identified for the two-course crop rotation (peas-wheat), in which the number of weeds and air-dry weight increased by 20.1 and 13.2 %, respectively.

The following species the weeds prevailed in pea stand: *Chenopodium album* L., *Fallopia convolvulus* (L.) Löve, *Tripleurospermum perforatum* Merat M. Lainz,. *Elytrigia repens* (L.) Nevski, less abundant were *Cirsium arvense* (L.) Scop.

Averaged over seven years data show that in sugar beet crops at the end of rotation the number and air-dry weight of weeds for all crop rotations increased on average, by 47.7 and 42.9 % respectively. The lowest weed infestation level among crop rotations at the end of rotation was recorded in the four course crop rotation peas-wheat-sugar beet-barley, where the number and air-dry weight decreased by 15.6 % and 30.2 %. The highest weeds infestation level among crop rotations was recorded in three course crop rotation sugar beet-barley-spring rape, where the number and the air-dry mass of weeds significant increased by 74.7 and 50.4 %.

At the beginning of the trials (1997-2000) a low weed incidence was identified in sugar beet crop – 4.2 weeds m^{-2}, weed air-dry mass was as low as 3.2 g m^{-2}. However, in 2001 when sugar beet was sown in the soil which had been under barley monocrop for four years in succession the weed infestation level increased, in 2004 to 15.7 weeds m^{-2}, and air-dry mass to 19.2 g m^{-2}.

Summarising the averaged data we can assert that sugar beet crop remained the cleanest, during the period 1997-2004 the average number of weeds at the beginning of rotations amounted to 4.0 units m^{-2}, and weed air-dry mass was as low as 4.1 g m^{-2}. At the end of rotations weed infestation level in all crop rotations with sugar beet remained moderate – 7.7 weeds m^{-2}, weed air-dry mass was as low as 7.1 g m^{-2}, whereas pea crops in all crop rotations were the most heavily weed infested, irrespective of the preceding crop: according to averaged data the number of weeds there varied within the range 14.6-39.8 units m^{-2}, and air-dry mass varied within 13.0-32.1 g m^{-2} range. Shortening of rotations when a preceding crop of sugar beet was spring oilseed rape was not conducive to weed control.

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During the period 2001-2004 was tested peas for the contents of the main macro chemical indicators (*table 4*). Peas chemical indicators in short crop rotations depended on the choice of the preceding crop and shortening of rotation.

Nitrogen (N) content arranged from 3.49 % (significant differences compared with the control four-course crop rotation) in the two-course crop rotation (sugar beet- wheat) to 3.74 % in the three-course crop rotation (sugar beet-barley- peas).

Peas protein content depending on the interval of its return to the same place - three, two or one year, consistently declined – 23.1, 23.0 and 21.8 % (significant protein content reduction), respectively.

Table 4

Effect of crop rotation on peas 'Profi' seed quality

Crop rotation	% in dry matter				Protein %
	N	P	K	Ca	
P-W-SB-B	3.70	0.547	1.08	0.203	23.1
P-W-B	3.63	0.540	1.12*	0.221	22.7
P-W-W	3.63	0.538	1.12*	0.206	22.7
SB-**P**-W	3.71	0.560	1.12*	0.223*	23.2
SB- B-**P**	3.74	0.555	1.13*	0.201	23.4
P-W	3.49**	0.534	1.12*	0.211	21.8**
LSD_{05}	0.116	0.03	0.022	0.02	0.70

*, ** - differences significant at the 5 %, 1 % level, respectively.

According to averaged experimental data, potassium (K) content for all crop rotations increased, compared with the control four-course crop rotation.

In the amount of phosphorus (P), no significant differences were identified.

During the period 2001-2004 was tested sugar beet for the contents of the main macro chemical indicators (*table 5*). Natrium (Na) content arranged from 0,0078 % (significant reduction) in the three-course crop rotation (sugar beet-peas-wheat) to 0,0093 % in the sugar beet monocrop.

Table 5

Effect of crop rotation on sugar beet 'Manhatan' root quality

Crop rotation	% in dry matter				Dry matter %
	Na	K	Saccharose content (%)	N-amino mg 100 g^{-1}	
P-W-**SB**-B	0.0089	0.166	17.6	26.1	22.9
SB- B- W	0.0088	0.159	17.6	24.9	22.8
SB-P-W	0.0078*	0.166	17.7	21.4	23.2
SB- B-P	0.0090	0.165	17.5	27.6	22.8
SB- B-SR	0.0085	0.181	17.4	26.3	23.0
B-S**B**	0.0092	0.168	17.2	26.3	22.7
SB	0.0093	0.191**	16.3**	31.7	21.5**
LSD_{05}	0.001	0.017	0.78	5.57	0.85

*, ** - differences significant at the 5 %, 1 % level, respectively

Averaged data from the 2001-2004 period show that when sugar beet was grown in the four-course, three-course and two-course crop rotations, the saccharose content of sugar beet roots consistently declined – 17.6, 17.6 to 17.2 t ha^{-1}, respectively. When sugar beet was grown in monocrop for four years, saccharose content of sugar beet roots was the lowest – 17.2 t ha^{-1} (significant reduction). According to literature [10], the saccharose content in crop rotation amounted to an average of 15.7 % and was 0.7 % higher than obtained in a 26-31 - year monoculture.

Continuous growing of sugar beet tended to reduce saccharose and dry matter contents. Shortening of rotations deteriorated sugar beet root technological properties: the contents of α amino nitrogen, potassium, noxious substances.

Averaged experimental data from the 2001-2004 period indicate that when sugar beet was continuously grown, significantly lower values of saccharose content, dry matter and potassium were found compared with those found in the four-course crop rotation.

CONCLUSIONS

1. The weed incidence in pea crops had a significant increased in the crop rotation peas-wheat-barley and peas-wheat-wheat, by 39.5 and 23.4 %, respectively.

2. The highest weeds infestation level among crop rotations with sugar beet was recorded in three course crop rotation sugar beet-barley-spring rape, where the number and the air-dry mass of weeds increased by 74.7 and 50.4 %, respectively.

3. Crop rotations affected nitrogen and potassium contents in pea.

4. Continuous growing of sugar beet tended to reduce saccharose and dry matter contents. Shortening of rotations deteriorated sugar beet root technological properties: the contents of α amino nitrogen, potassium and noxious substances.

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