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EFFECT OF CROP ROTATION ON YIELD AND QUALITY OF WINTER WHEAT

Research in shortening of crop rotations was conducted at the Lithuanian Institute of Agriculture in Dotnuva during the period 2001-2004. The experiment was composed of 10 short crop rotations (2-4 courses) and two monocrops.

*Conventional crop cultivation technology linked with sustainable fertilisation of agricultural crops was applied in the trial. According to averaged experimental data grain yield was significantly affected particularly by the year. During the period of 2001-2004 the number of productive stems and yield significantly decreased in the three courses, where 2/3 of the total crop area was occupied by spiked cereals (pea-wheat-barley, pea-**wheat**-wheat, pea-wheat-**wheat** and sugar beet-barley-wheat). In our trials with short rotations the lowest 1000 grain weight (48.8 g) and yield (4.8 t ha^{-1}) was registered in the crop rotation composed solely of wheat (pea-wheat-**wheat**). The year considerably affected nitrogen (N) parameter and there were significant differences among very dry 2002 and 2003 under the study. The lowest content of nitrogen was in 2002. Phosphorus (P), potassium (K) and calcium (Ca), no significant differences was identified.*

Wheat is one of the world's most important grains, with annual world production of about 600 million tons. Approximately 70 % of wheat grain is used for food production (Dendy, Dobraszczyk, 2001). The genetic effect of wheat on grain quality is commonly accepted while influences of environmental (climate, soil, temperature) condition, watering, fertilization level and timing and crop rotation (Lopez-Bellido et al., 1998; Sadowska et al., 2001) are still widely discussed. Among those factors, the crop rotation is very important which strongly affects the yield as well as the physical properties of the wheat grain. Crop rotation as a unit of diversification can reduce risk even further (Nel, Loubser, 2004). Rotation cropping is generally thought to reduce yield variability compared with monoculture practices (Helmers et al., 2001).

Studies by Vucans and Livmanis (2004) have shown that peculiarities of meteorological conditions during the experimental years caused greater fluctuations in grain quality than the fertilizer applied. Atkinson et al. (2005) showed that the weather conditions during both grain growth and grain ripening will have an important effect on specific weight. Solar radiation is necessary as the energy source for synthesis of the carbohydrate needed to fill the grain. Well-filled grain often relates closely to specific weight (Bayles, 1977) and thus a priori solar radiation would be expected to influence specific weight. In the analyses described below, two developmental periods are referred to: grain filling and grain ripening. Grain filling is the period between the development stages: anthesis and end of grain fill (maximum grain weight). The start of the grain-ripening period was defined as the day after the end of grain fill and the end as 19 days after the end of grain fill (Kettlewell, 1998). David et al. (2005) observed, that the heat temperature during grain filling limiting thousand grain weight.

The work presents results of four-year trials aimed at observing the effects of several factors (previous crop) on grain biometric indicators, yield and selected chemical indicators (nitrogen, phosphorus, potassium, calcium) gluten and sedimentation values in short crop rotations.

Materials and methods of research. Research in shortening of crop rotations was conducted at the Lithuanian Institute of Agriculture in Dotnuva during the period 2001-2004. The experiment was composed of 10 short crop rotations (2-4 courses) and two monocrops (Table 1).

The soil of the experimental site is *Endocalcari-Endohypogleyic Cambisol*, with a humus content of 2.28 % (according to Tyurin), pH_{KCl} 7.2 (measured potentiometrically), phosphorus and potassium contents 142 and 180 mg kg^{-1} soil, respectively (A-L method). The experiment involved the following crops: winter wheat (*Triticum aestivum* L.) var. 'Sirvinta', seed rate 4 million ha^{-1} germinal seeds, spring barley (*Hordeum vulgare* L.) var. 'Alsa' 3.5 million ha^{-1} germinal seeds, peas (*Pisum sativum* L.) var. 'Profi' (1 million ha^{-1}), sugar beet (*Beta vulgaris* var. *saccharifera* Alef.) var. 'Manhatan' (1.3 seed units ha^{-1}), winter oilseed rape (*Brassica napus* L. var. oleifera DC.) var. 'Kazimir' (4.5 kg ha^{-1}), and spring oilseed rape var. 'Maskot' (7 kg ha^{-1}).

Conventional crop cultivation technology linked with sustainable fertilisation of agricultural crops was applied in the trial. All by-products (chopped straw of cereals, pea vines, oilseed rape stems, and sugar beet leaves) were used as fertiliser and were spread on the soil surface. To speed up mineralization processes in the soil after harvesting, 10 kg of nitrogen per 1 tone of straw (dry matter) was applied and shortly afterwards the stubble was cultivated at the 10-12 cm depth. Two-three weeks later the soil was ploughed down at the 20-22 cm depth. In the case of delayed cereal harvesting, the plots intended for winter wheat sowing were ploughed one week after stubble cultivation. Pre-sowing tillage was similar for all crops: shallow loosening by a cultivator fitted with a light harrow at the 5-8 cm depth, repeating the operation twice.

1. Experimental design

Crop rotat. 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 4. Spring barley		3. Spring barley		3. Winter wheat
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
VII	1. Winter oilseed rape	**VIII**	1. Peas	**IX**	1. Sugar beet
	2. Winter wheat		2. Winter wheat		2. Spring barley
					3. Spring oilseed rape
X	1. Spring barley 2. Sugar beet	**XI**	Sugar beet (mono culture)	**XII**	Spring barley (mono culture)

After cereal sowing the field was rolled by ring rollers and oilseed rape field was also rolled before sowing. Only mineral fertilisers were applied: for wheat – $N_{80}P_{40}K_{30}$, barley – $N_{70}P_{40}K_{30}$, peas – $P_{40}K_{40}$, sugar beet – $N_{150}P_{60}K_{120}$, winter oilseed rape – $N_{120}P_{60}K_{90}$, 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.

At the end of plant growing season plants were pulled from two 0.25 m^2 plots per each plot and sheaves were made from which we determined the number of productive stems, plant height and productivity of ears. For chemical composition and 1000 grain weight determination, 1 kg samples were taken from each plot after grain harvesting and cleaning. Quality assessment indicators of the primary and by production of the crop rotation 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, gluten content by hand washing (LST 1522), protein content in wheat was calculated according to N_{total} content, measured by Kjeldahl method, by multiplying by coefficient 5.7 (LST 1523), sedimentation by Zeleny method (LST 1498 and LST 1512). The weather conditions were different during the experimental period (Table 2).

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 of research. During the period of 2001-2004 the biometric indicators of winter wheat depended on the shortening of crop rotations, specificity of preceding crops and on meteorological factors. Grain yield was significantly affected particularly by the seasonal weather conditions. Considerably higher grain yields of winter wheat were obtained in wet spring and summer conditions, particularly in 2003 an average of 5.57 t ha^{-1}, whereas in 2002 – 5.15, and 2001 – 5.02 t ha^{-1}. According to averaged experimental data, the number of productive stems and grain yield significantly decreased in the three course rotation, where 2/3 of the total crop area was occupied by spiked cereals (pea-wheat-barley, pea-**wheat**-wheat, pea-wheat-**wheat**, sugar beet-barley-wheat) and two course (winter rape-wheat, pea-wheat) crop rotations (Table 3).

In our trials with short rotations the lowest 1000 grain weight (48.8 g) and yield (4.8 t ha^{-1}) was registered in the crop rotation composed solely of wheat (pea-wheat-**wheat**). During the period 2001-2004 was tested winter wheat for the contents of the main macro chemical indicators (Table 4). The crop rotations that included a legume had marked effects on wheat quality () Nitrogen (N) content arranged from 2.03 % in the three-course crop rotation (sugar beet-spring barley-winter wheat) to 2.13 % in the two-course crop rotation (pea-winter wheat). The years considerably affected this parameter and there were found significant differences among very dry 2002 and wet 2003 under the study. In the trials published by Rharrabti et al. (2003), total water input during grain filling appears to negatively affect grain quality.

3. Effect of crop rotation on winter wheat ‚Širvinta' biometric indicators and grain yield (Dotnuva, 2001-2004)

Rotations [x]	Productive stems per m^{-2}	Plant height cm	Number of grains per ear	1000 grain weight g	Grain yield	
					t ha^{-1}	%
P-**W**-SB-B	435	118.1	37.5	52.4	5,8	100
P-**W**-B	390**	115.6	37.5	52.0	5.3**	91
P-**W**-W	395**	114.5*	38.5	51.8	5.3**	91
P-W-**W**	368**	108.5**	38.4	48.8**	4.8**	83
SB-B-**W**	390**	112.1**	37.5	49.0**	4.9**	84
SB-P-**W**	410	116.4	37.3	52.2	5.6	97
WR-**W**	388**	112.9**	39.1*	51.0**	5.1**	88
P-**W**	382**	114.6*	38.7	51.6	5.1**	88
LSD_{05}	26.5	2.8	1.5	0.99	0.28	
LSD_{01}	35.0	3.7	1.9	1.31	0.38	

*, ** – differences significant at the P>0.05 %, P>0.01 % level, respectively.

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

Conclusions. 1. Choice of preceding crops and shortening of rotations had a deciding effect on the formation of individual productivity elements of winter wheat.

2. The grain yield of winter wheat depended on the choice of preceding crops and shortening of rotations. The number of productive stems and grain yield of winter wheat significantly decreased in the three course rotation, where 2/3 of the total crop area was occupied by spiked cereals, and two course crop rotations.

3. Crop rotations did not affect the main chemical elements of winter wheat grain quality (nitrogen, phosphorus, potassium, calcium) and gluten and sedimentation values.

4. Effect of crop rotation on winter wheat, Širvinta' grain quality (Dotnuva, 2001-2004)

Crop rotation	% in dry matter N	P	K	Ca	Wet gluten %	Sedimentation cm³
P-**W**-SB-B	2.12	0.363	0.426	0.061	25.9	38
P-**W**-B	2.11	0.357	0.415	0.063	26.7	39
P-**W**-W	2.07	0.363	0.419	0.063	26.8	40
P-W-**W**	2.11	0.347	0.440	0.064	26.8	39
SB-B-**W**	2.03	0.363	0.434	0.070	25.1	35
SB-P-**W**	2.05	0.373	0.428	0.069	26.0	38
WR-**W**	2.12	0.365	0.421	0.081	26.2	39
P-**W**	2.13	0.368	0.414	0.079	26.6	37
LSD_{05}	0.120	0.0310	0.0330	0.0260	1.70	3.7

The lowest content of nitrogen was in 2002. In the amount of phosphorus (P), potassium (K) and calcium (Ca), no significant differences were identified.

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