THE INFLUENCE OF FORECROP, CULTIVATION INTENSITY AND WEATHER CONDITION ON THE YIELD OF WINTER WHEAT (*TRITICUM AESTIVUM* L.) AND YIELD COMPONENTS*

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The results of polyfactorial field trials obtained in the years 1991–2001 were analysed from the point of view of the influence of different weather conditions, forecrops (lucerne, spring barley and leguminous – lucerne + peas) and cultivation intensity (ES – ecological system according to IFOAM standards, ACS – straw incorporation + NPK and CS – farm yard manure + NPK) on the yield of winter wheat and its yield components (number of spikes per area, number of grains in spike and thousand kernel weight – TKW). The trials were situated in the water protected area at Borovce near Piešťany in the maize production zone of the Danubian Lowland (Slovak Republic) with two six-field crop rotations on the haplic chernozem. The eco-stable variety of winter wheat (Viginta) was used. The yield variability of winter wheat following lucerne and spring barley was affected by weather conditions and cultivation intensity in the years 1991, 1995–2001. The number of spikes variability was affected by weather. TKW variability was effected by weather and forecrop and finally, the number of grains in spike only by weather. Taking into consideration the grain yield, TKW and the number of grains in spike, the effect of a forecrop was modified by the weather conditions (significant interaction weather x crop). The weather conditions modified the influence of cultivation intensity on the number of spikes per square meter (significant interaction weather x cultivation intensity).The share of influence of the evaluated factors in the following sequence: the grain yield – number of spikes per square meter – TKW and the number of grains in spike represented 9.53% – 2.59% – 0.67% and 3.45% by taking into consideration the cultivation intensity; 70.16% – 96.4% – 98.32% and 91.85% when taking into consideration the weather or 0.56% – 0.64% – 0.88% and 3.72% when considering a forecrop. According to 11 years' average values, the yields of the winter wheat following leguminous forecrops depended more on weather conditions (significantly), than on cultivation intensity (insignificantly).

winter wheat; cultivation intensity, forecrops; grain yield; yield components; IFOAM

INTRODUCTION

Over the last years, the fast growing market for ecological cropping of cereals has created a favourable situation for specialised ecological arable farming systems which are mostly represented in East European countries (Slovak Republic, Czech Republic, Hungary). These systems are based on the restriction of inputs, low fix costs and extensive crop production. The using of farmyard manure (FYM) from conventional livestock or industrial compost, will possibly lead to further intensification (Baars, 1998; Olessen et al., 1998). At the same time these systems caused certain technological problems, such as nitrogen and weed management (David, 1998), which affect economic viability of system (Lampkin, 1996).

Bujnovský et al. (1998) reported, that the conventional system fertilisation (fertilisers + FYM) secured better conditions for yield formation than the ecological one. According to Von Fragstein et al. (1998) sustainable N-management has to be built up with a suitable rotation system in order to combine soil fertility building components with sufficient release of nutrients, to link nutrient provision with the integration of leguminous crops. Molnár (1999) and Kováč et al. (2003) reported, that ecological system frequently made use of fixed rotations that included a significant portion of annual and perennial leguminous whose role is to improve the nitrogen status of the soil and substitute commercial nitrogen fertilisers. It is necessary to expect the higher output of N from the soil in the ecological systems to compare with conventional one. Therefore it is necessary to compensate it by the leguminous forecrop and organic manuring (Kubicová, Földešová, 1997). According to Karabínová and Andraščík (1987) the application of fertilisers with comparison to the control (without fertilisers) had a positive influence on the number of grains in spikes (by 15.8%) and the number of grains per square meter (17.9%).

The investigation of the problems of ecological systems, the specific methodological aspects need to be considered, too. To quantify the various aspects of ecological system, the comparison methods have to be used with corresponding conventional system. The aim of this

* This work was supported by the Ministry of Agriculture of the Slovak Republic (1990–1997) and by the Ministry of Land Management of the Slovak Republic (1998–2001).

work was to investigate and to analyse the influence of forecrops, cultivation intensity and weather condition on the winter wheat yield and its yield components.

MATERIAL AND METHODS

The research project was carried out in the maize growing areas, in the polyfactorial field trial at Borovce, the Pieštany district, during the years 1991–2001. This locality is characterised by fairly good fertility of Haplic chernozem, by long-term average annual rainfall 625 mm and by average annual temperature 8.9 °C. The winter wheat was growing in the two six-field crop rotations. Biological crop rotation was represented by lucerne – lucerne – winter wheat – sugar beet + FYM – spring barley – maize + FYM. Cash crop rotation was represented by winter wheat + FYM – spring barley – peas – winter wheat – maize + FYM – spring barley).

Treatments of cultivation intensity were as follows: ecological system (ES) – farmyard manuring (40 t.ha^{-1}, two times in rotation), cultivation was carried out according to the Standards of SR for ecological agriculture and the principles of the international organisation IFOAM (International Federation of Organic Agriculture Movements).

Arable conventional system (ACS) – without livestock production, straw incorporation + NPK and chemical pest management.

Conventional system (CS) – farmyard manuring (40 t.ha^{-1} two times in rotation) + NPK and chemical pest management.

All the treatments were treated once a 6 years with ground limestone in a dose of 3 tonne per ha. Average application rate of nitrogen in the first stage was 60 kg N.ha^{-1} and in the second one 80 kg N.ha^{-1} (Table 1).

We used the eco-stable variety Viginta, at sowing rate of 450 emerge rate of grains per square meter, at row distance of 0.125 m, sowing time 1st October (with smaller fluctuation).

The experiment was divided into two stages. During the first stage of the research (the years 1991–1997) crops were rotated in 3 fields. During the second one (1998–2001) the crops were rotated in 6 fields. We followed the level of grain yield and its structure (the number of spikes per square meter, number of grains in spike and the weight of thousand grains (TKW = thousand kernel weight). The strictly statistic evaluation by the analysis of the variance without replication was used to sum up the results of the grain yield and its structure.

Table 1. Rate of nitrogen fertilisation according cultivation intensity, forecrops and research periods 1991–1997, 1998–2001 (kg.ha^{-1})

Cultivation intensity	Forecrops								
	The first research period 1991–1997								
	spring / barley phase / fertilisation dose			lucerne / phase / fertilisation dose			peas / phase / fertilisation dose		
	DC 21	DC 31	DC 43	DC 21	DC 31	DC 43	DC 21	DC 31	DC 43
ES	FYM	–	–	–	–	–	–	–	–
ACS	20 + straw	30	–	25	30	–	straw	30	–
CS	30	30	–	30	35	–	20	30	–
Cultivation intensity	The second research period 1998–2001								
	DC 21	DC 31	DC 43	DC 21	DC 31	DC 43	DC 21	DC 31	DC 43
ES	FYM	–	–	–	–	–	–	–	–
ACS	30 + straw	30	20	30	30	20	30 + straw	30	20
CS	30	30	20	30	30	20	30	30	20

EC – ecological system, ACS – arable conventional system, CS – conventional system, FYM – farm yard manure

RESULTS

The average annual temperature ranged between 8 and 10 °C (Table 2). The average annual precipitation varied from 414 mm (1991) to 650 mm (1994) with approximately 440 mm during vegetation period. During experimental periods (1991–2001) higher yield than 8 t.ha^{-1} was obtained in the years 1994 and 1996 with May rainfall 81.2 mm or 103.1 mm, respectively. Lower yield than 6 t.ha^{-1} was obtained in the years 1992, 1998 with precipitation during May from 19.1 mm to 25.4 mm.

The average number of spikes per square meter following lucerne and spring barley varied from 348 (1991) to 713 spikes per square meter (2001) within the period for 1991, 1995–2001 (Table 3). The cultivation intensity did not affect the variability of the number of spikes per square meter significantly. The differences among the years were statistically significant (Table 7). The variability of the spikes number per square meter was also affected by interaction: cultivation intensity x year.

Depending on a forecrop lucerne and spring barley the number of grains in spike after lucerne varied from 26.1 (1997) up to 36.7 (2001), after spring barley from

Table 2. Weather pattern in experimental years 1991–2001 (Borovce near Piešťany)

Year/Month	1990–1991	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	LTA
	Average temperature (°C)											
VIII.	20.13	19.29	23.39	18.73	19.91	19.29	19.25	21.49	20.1	18.85	20.58	18.6
IX.	12.32	16.14	14.43	13.85	15.46	13.49	11.83	14.96	15.27	18.65	13.63	14.8
X.	9.12	7.81	7.93	10.44	7.63	11.25	10.18	7.56	10.81	9.85	11.95	9.5
XI.	4.50	4.0	3.4	0.86	5.08	2.03	7.08	5.24	1.56	2.63	6.98	4.2
XII.	–1.8	–3.4	–1.0	0.41	0.37	–0.74	–2.93	1.77	–2.66	–1.85	0.27	–1.8
I.	–1.09	–0.9	–1.73	1.65	–3.02	–2.94	–3.11	1.43	–1.21	–3.59	–1.25	–2.0
II.	–4.27	1.5	–3.66	–0.09	3.46	–4.1	–3.11	3.63	–0.45	1.49	0.43	–2.0
III.	5.87	4.17	1.88	5.72	2.95	1.57	4.3	3.53	6.36	3.98	4.73	4.3
IV.	8.13	8.97	9.75	8.86	9.66	10.46	6.36	12.02	11.78	12.81	7.,72	9.5
V.	10.76	14.85	17..5	13.73	14.19	15.9	15.45	15.24	15.58	15.79	15.43	14.7
VI.	16.6	18.48	17.03	17.2	17.62	18.65	18.23	19.48	18.43	18.13	15.38	17.5
VII.	20.23	20.39	17.22	22.52	23.43	18.31	19.04	20.68	21.23	16.88	19.21	19.5
Average	8.38	9.29	8.81	9.49	9.73	8.60	8.55	10.59	9.70	9.59	8.9	8.9
Year/Month	Sum of precipitation (mm)											LTA
VIII.	12.4	12.4	10.7	54.2	85.7	53.8	65.3	8.1	22.1	36.3	20.8	63
IX.	73.4	21.2	39.3	34.8	95.1	79.8	73.1	130.0	167.4	36.6	42.9	51
X.	53.7	11.6	65.6	78.0	88.9	2.9	36.6	12.1	140.0	20.1	26.9	53
XI.	63.1	101.4	33.4	35.4	23.9	20.3	13.0	90.8	25.4	39.2	82.4	59
XII.	42.0	64.7	66.7	57.5	51.6	29.4	12.2	27.5	20.8	46.8	55.2	47
I.	5.20	11.1	30.4	47.5	47.4	41.0	20.7	12.1	12.4	34.0	13.2	40
II.	10.5	17.6	18.8	9.3	31.0	21.2	27.6	0.7	36.4	29.5	19.1	35
III.	16.4	73.9	10.2	14.4	51.6	17.7	12.9	14.3	20.4	79.0	67.0	39
IV.	16.7	17.7	14.9	93.0	45.9	61.9	24.6	35.0	48.3	9.7	31.8	45
V.	66.1	25.4	26.6	81.2	59.7	103.1	36.2	19.1	27.4	35.9	30.1	60
VI.	51.4	103.4	53.2	31.4	91.4	50.1	42.5	46.1	118.4	39.1	43.0	67
VII.	36.5	51.4	62.6	28.1	8.4	26.4	133.3	38.5	87.0	69.1	118.5	66
Total	447.4	511.8	432.4	564.8	680.6	507.6	498	434.3	726	475.3	550.9	625

LTA = long term average

26.4 (1997) up to 40.4 (2000), respectively (Table 4). The variability of the number of grains in the spike was significantly affected by the years and by interaction years x forecrop (Table 7).

The average TKW depending on forecrops amounted 43.8 g following lucerne and 44.6 g after spring barley (Table 5). When we compared the TKW following lucerne and spring barley we found out that the variability of TKW was significantly affected by weather conditions (within years), forecrop and by the interaction of weather x forecrop (Table 7).

The agronomic and economic aim of the wheat growing is the stability and the quality of production. The average yield of wheat after lucerne was 6.85 t ha-1 and following spring barley 6.98 $t.ha^{-1}$ (Table 6). From the point of view of the cultivation intensity (in a sequence EC, ACS, CS), the yield of winter wheat following lucerne represented 6.97–6.54 and 7.05 $t.ha^{-1}$ and 7.07–6.61 and 7.25 $t.ha^{-1}$ following barley. The substitution of the manuring with FYM by crop residues (ACS) in the crop rotation decreased the wheat yields in both crop rotations (insignificantly). The comparison of two forecrops lucerne and spring barley showed, that the variability of grain yield was significantly affected by the weather conditions, the cultivation intensity, and by the interaction of weather x forecrop (Table 7). Hardly any influence of cultivation intensity after leguminous forecrops on TKW have been noted (Table 8). The yields of the winter wheat and number of spikes per square meter following leguminous forecrops depended more on weather condition (significantly) than on cultivation intensity (insignificantly) (Table 9). The significant relation between grain yield and sum of January–May rainfall; TKW and sum of January–May rainfall have been noted (Table 10). The influence share of experimental factors in a sequence the grain yield, number of spikes per square meter, TKV and the number of grains in spike represented 9.53% – 2.59% – 0.67% and 3.45% taking into consideration the cultivation intensity; 70.16% – 96.4% – 98.32% and 91.85% taking into consideration the weather conditions or 0.56% – 0.64% – 0.88% and 3.72% when considering a forecrop (Table 7).

Table 3. The number of winter wheat spikes per square meter after Lucerne and spring barley forecrops and different cultivation intensity in the years 1991, 1995–2001

Cultivation intensity (A)	Forecrop/Number of spikes per area								Average	%
	Lucerne/years (B)									
	1991	1995	1996	1997	1998	1999	2000	2001		
ES	374	648	630	684	453	315	642	725	558	100,0
ACS	252	742	616	651	451	421	552	655	542	97.1
CS	439	588	629	539	376	516	612	799	569	102.0
$\bar{x}$	355	659	625	624	426	437	602	726	557	
Cultivation intensity (P < 0.05, P < 0.01) NS (insignificant)										
LSD for the years (P < 0.05 – 233, P < 0.01 – 292)										
	Spring barley/years									
ES	353	604	614	608	531	300	533	721	533	100.0
ACS	262	537	594	672	493	391	539	561	506	94.9
CS	413	613	571	645	500	407	624	819	574	107.7
$\bar{x}$	342	584	593	641	508	386	565	700	537	
LSD for cultivation intensity (P < 0.05, P < 0.01) NS										
LSD for the years (P < 0.05 – 164, P < 0.01 – 206)										
	Average of lucerne and spring barley									
ES	363	626	622	646	492	307	587	723	545	100.0
ACS	257	639	605	661	472	406	545	608	524	96.1
CS	426	600	600	592	438	491	618	809	571	104.8
$\bar{x}$	348	622	609	633	467	401	583	713	541	
LSD for the years (P < 0.05 – 103, P < 0.01 – 129)										
LSD for interaction A x B (P < 0.05 – 223, P < 0.01 – 273)										

Table 4. The number of winter wheat grains in a spike after lucerne and spring barley forecrops and different cultivation intensity in the years 1991, 1995–2001

Cultivation intensity (A)	Forecrop/Number of grains in spikes								Average	%
	Lucerne									
	1991	1995	1996	1997	1998	1999	2000	2001		
ES	33.3	30.7	28.7	32.1	33.3	33.9	37.2	37.3	33.3	100.0
ACS	33.1	28.9	36.3	21.6	35.5	28.5	34.3	34.8	31.6	94.9
CS	35.5	29.6	34.2	24.6	37.7	29.3	36.9	38.0	33.2	99.7
$\bar{x}$	33.9	29.6	33.0	26.1	36.5	30.5	36.1	36.7	32.7	
LSD for the years (P < 0.05 – 8.34, P < 0.01 – 10.46)										
	Spring barley									
ES	32.3	28.0	28.9	36.7	33.8	40.7	40.7	38.6	34.9	100.0
ACS	30.6	31.0	32.4	27.0	32.3	38.0	38.7	36.5	33.3	95.4
CS	33.1	27.0	35.7	25.7	32.5	40.1	41.8	39.3	34.4	98.6
$\bar{x}$	32.0	28.6	35.6	26.4	32.8	39.6	40.4	38.1	34.2	
LSD for the years (P < 0.05 – 4.69, P < 0.01 – 5.89)										
	Average of lucerne and spring barley									
ES	32.8	29.3	33.8	29.4	33.5	37.3	38.9	37.9	34.1	100.0
ACS	31.8	29.8	34.3	24.3	33.9	33.2	36.5	35.6	32.4	95.0
CS	34.3	28.3	34.9	25.1	35.1	34.7	39.3	38.6	33.8	99.1
$\bar{x}$	32.9	29.1	34.3	26.2	34.1	35.0	38.2	37.4	33.4	
LSD for the years (P < 0.05 – 5.48, P < 0.01 – 6.87)										
LSD for interaction years x forecrop (P < 0.05 – 8.99, P < 0.01 – 11.0)										

Table 5. TKW after lucerne and spring barley forecrops and cultivation intensity in the years 1991, 1995–2001 (g)

Cultivation intensity	Forecrop lucerne								Average	%
	1991	1995	1996	1997	1998	1999	200	2001		
ES	356	47.1	45.8	43.8	46.4	49.6	40.6	46.3	44.4	100.0
ACS	342	47.6	37.3	45.6	44.8	51.0	40.1	45.9	43.3	97.5
CS	340	47.2	37.7	45.5	46.0	50.8	42.5	46.1	43.7	98.4
$\bar{x}$	346	47.3	40.2	44.9	45.7	50.4	41.0	46.1	43.8	
LSD for the years ($P < 0.05 - 2.49$, $P < 0.01 - 3.29$)										
	Forecrop spring barley									
ES	34.5	47.8	47.1	45.1	45.9	48.3	43.5	47.4	44.9	100.0
ACS	34.5	48.9	45.3	43.9	45.5	49.7	44.0	49.4	45.1	100.4
CS	32.8	46.6	43.7	44.7	45.6	48.6	41.9	46.9	43.,8	97.6
$\bar{x}$	33.9	47.7	45.3	44.6	45.6	48.8	43.1	47.9	44.6	
LSD for cultivation intensity ($P < 0.05 - 1.12$, $P < 0.01 - 1.49$)										
LSD for the years ($P < 0.05 - 2.48$, $P < 0.01 - 3.11$)										
	Following lucerne and spring barley forecrop									
ES	35.1	47.5	46.5	44.5	46.2	49.0	42.5	46.9	44.7	100.0
ACS	34.4	48.3	41.3	44.8	45.1	50.4	42.1	47.7	44.2	99.0
CS	33.4	46.9	40.7	45.1	45.8	49.7	42.2	46.5	43.2	96.7
$\bar{x}$	34.3	47.5	42.8	44.8	45.7	49.7	42.1	47.0	44.2	
LSD for the years ($P < 0.05 - 2.30$, $P < 0.01 - 2.89$)										
LSD for forecrops ($P < 0.05 - 0.70$, $P < 0.01 - 0.97$)										
LSD for interaction years x forecrop ($P < 0.05 - 3.78$, $P < 0.01 - 4.66$)										

Table 6. The yield of winter wheat after lucerne and spring barley forecrops and different cultivation intensity in the years 1991, 1995–2001 ($t.ha^{-1}$)

Cultivation intensity	Forecrop lucerne								Average	%
	1991	1995	1996	1997	1998	1999	200	2001		
ES	6.56	7.12	8.42	7.14	5.52	7.57	6.96	6.48	6.97	100.0
ACS	6.45	7.11	8.02	5.07	5.90	7.01	5.73	7.07	6.54	93.8
CS	7.41	7.42	8.65	5.92	5.15	7.76	6.99	7.17	7.05	101.2
$\bar{x}$	6.80	7.21	8.36	6.04	5.52	7.44	6.56	6.90	6.85	
LSD for the years ($P < 0.05 - 1.47$, $P < 0.01 - 1.85$)										
	Forecrop spring barley									
ES	7.16	6.86	7.93	7.63	6.12	6.46	7.44	6.99	7.07	100.0
ACS	7.18	6.20	8.03	7.33	5.69	5.54	5.79	7.16	6.61	93.5
CS	6.63	7.04	9.21	7.74	6.05	6.59	7.89	6.86	7.25	102.5
$\bar{x}$	6.99	6.70	8.39	7.56	5.95	6.19	7.04	7.00	6.98	
LSD for variants ($P < 0.05 - 0.62$, $P < 0.01 - 0.82$)										
LSD for the years ($P < 0.05 - 1.38$, $P < 0.01 - 1.73$)										
	Following lucerne and spring barley forecrops									
ES	6.86	6.99	8.17	7.38	5.82	7.01	7.20	6.73	7.02	100.00
ACS	6.81	6.65	8.02	6.20	5.79	6.27	5.76	7.11	6.58	93.7
CS	7.02	7.23	8.93	6.83	5.60	7.17	7.44	7.01	7.15	101.85
$\bar{x}$	6.89	6.95	8.37	6.80	5.73	6.82	6.80	6.95	6.92	
LSD for intensity cultivation ($P < 0.05 - 0.40$, $P < 0.01 - 0.52$)										
LSD for the years ($P < 0.05 - 0.88$, $P < 0.01 - 1.10$)										
LSD for interaction years x forecrops ($P < 0.05 - 1.44$, $P < 0.01 - 1.78$)										

Table 7. Variance analysis of winter wheat grain yield and its yield components following lucerne and barley

Source of variability	Sum of squares				d.f.	Statistically significant by			
	yield	No. of spikes m^{-2}	TKW	No. of grains in spike		yield	No. of spikes m^{-2}	TKW	No. of grains in spike
Cultivation intensity (A)	2.90	18.15	6.34	25.44	2	+ +	–	–	–
Year (B)	21.35	675.85	938.10	677.4	7	+ +	+ +	+ +	+ +
Forecrops (C)	0.17	4.49	8.41	27.45	1	–	–	+	–
A x B	4.6	101.36	43.12	53.20	14	–	+	–	–
A x C	0.03	3.56	6.29	0.69	2	–	–	–	–
B x C	6.75	26.66	4.69	153.0	7	+ +	–	+ +	+
Residuals	6.01	2.58	1.28	7.24	14	–	–	–	–

d.f. – degree of freedom

Table 8. The winter wheat yield, number of spikes for area and TKW after leguminous and different cultivation intensity in the years 1991–2001

Cultivation intensity	Grain yield / t ha^{-1}											$\bar{x}$	%
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
	L	H	H	H	L	L	L	H	H	H	H		
ES	6.56	5.66	6.45	7.92	7.12	8.42	7.14	5.56	6.71	7.99	658	691	100.0
ACS	6.45	6.00	6.72	7.92	7.11	8.02	5.07	5.89	7.39	6.18	652	666	96.4
CS	7.41	5.46	7.10	8.26	7.42	8.65	5.92	5.44	8.01	7.13	682	705	102.0
$\bar{x}$	6.80	5.71	6.76	8.03	7.21	8.36	6.04	5.63	7.37	7.10	664	687	
LSD for the years ($P < 0.05 - 1.50$, $P < 0.01 - 1.81$)													
Cultivation intensity	Number of spikes per square meter												
ES	374	378	577	617	648	630	684	486	314	613	669	544	1000
ACS	252	364	627	607	742	616	651	407	399	625	787	533	98.0
Cs	439	323	501	352	588	629	539	416	316	666	746	528	971
$\bar{x}$	355	355	568	625	661	625	625	436	343	633	734	541,	
LSD for the years ($P < 0.05 - 171$, $P < 0.01 - 207$)													
Treatment	TKW (g)												
ES	35.6	46.7	38.8	46.8	47.1	45.8	43.8	47.7	49.1	42.8	46.0	44.4	100.0
ACS	34.2	46.8	40.6	50.1	47.6	37.3	45.6	47.3	49.8	43.8	47.0	44.5	100.2
CS	34.0	47.9	40.1	50.8	47.2	37.7	45.5	45.8	51.0	43.2	46.3	44.5	100.2
$\bar{x}$	34.6	47.1	39.8	49.2	47.3	40.2	44.9	46.9	49.9	43.2	46.1	44.5	
LSD for the years ($P < 0.05 - 5.43$, $P < 0.01 - 6.58$)													

L – lucerne forecrop, H – peas forecrop, EC – ecological system, ACS – arable conventional system, CS – conventional system

DISCUSSION

One of the most important cash crop in the SR is winter wheat. The stand establishment of winter wheat plays a crucial role in the whole agronomic system. Stand density is regulated by agronomical practices (such as date of drilling, rate of sowing and rate of nitrogen). It depends mainly on weather conditions. On average 363 plants per square meter grew up after lucerne and spring barley – it represents 80.6% of emergence rate during our 8 years' experiment. Following the leguminous as a forecrop, approximately 365 plants per square meter grew up – it represents 81.1% of emergence rate during 11 years of experiment. The emergence rate ranged from 56.2% (in 1999) to 91.7% (in 2000). The variability of emergence rate was affected by the weather.

The stand density is significant for the beginning of qualitative yield components. If stands are over regular density because of rate of sowing or higher rate of nitrogen, the number of grains in spikes is reduced (Petr, 1983).

The stand density of wheat is also regulated by auto regulation ability. The key component of wheat yield is usually the number of spikes per area. The scientific knowledge and the practice confirms, that the yield of cereals increases with the number of spikes per area and depends mainly on the stand density and external envi-

Table 9. Variance of analysis of winter wheat grain yields and its yield components following leguminous in the years 1991–2001

Source of variability	Sum of squares				d.f.	Statistically significant at			
	yield	No. of spikes m^{-2}	TKW	No. of grains in spike		yield	No. of spikes m^{-2}	TKW	No. of grains in spike
Cultivation intensity	0.88	3.352	3.81	0.018	2	–	–	–	–
Year	22.94	60.464	644.9	606.8	10	++	++	++	++
Residual	0.25	3.370	3.39	8.33	20	–	–	–	–

Table 10. Relation between yield of winter wheat, yield components after leguminous forecrops and rainfall during January–May, in the years 1991–2001

Y	*X*	*r*
Grain yield	rainfall (I.–V.)	0.775^{++}
Number of spikes per m^{-2}	rainfall (I.–V.)	0.524
TKW	rainfall (I.–XII.)	0.633+

LSD $P < 0.05$ – 0.602, $P < 0.01$ – 0.734

ronmental conditions (nutrition and weather conditions). It is also supported by the results of our experiment when the variability of the number of spike per area was significantly affected by years (high significance) and also by the interaction the cultivation intensity x years (significantly).

Our knowledge partially corresponding with conclusions of Karabínová and Andraščík (1987) who stated, that nitrogen fertilisation had a positive influence on increasing number of spikes per area from 14.41% up to 15.86% when compared to the control treatment (without fertilisation). Our results are also compatible with findings of Petr et al. (1998, in: Faměra et al., 2001) who stated, that N fertilisation caused marked changes in the structure of wheat stands – higher number of spikes per area unit and higher productivity of spike.

The important knowledge for the systems of winter wheat growing are particular yield components that are interrelated and also how the effect of change of one of them affects the production and accumulation potential of growing. The yield stability of wheat depends on the compensation ability of plants. There are genotype differences in the general compensation ability for certain organs. According to Bláha et al. (2003), abiotic stress factors affect significantly yielding traits, root traits and seed traits. Sensitivity of winter wheat cultivars to abiotic stressess is a very important trait in plant production.

The farm yield is given by the function of number of grains per area (the number of spikes per square meter x the number of grain per spike) and weight of TKV. They represent the wheat accumulation potential. Karabínová and Andraščík (1987) ascertained the statistically highly significant influence of fertilisers on grain yield within the range of 17.9 to 19.3 with the yield realised in particular through the number of grains per square meter. The relation between the sources and sink of assimilates in the period of wheat flowering till its maturity affect the grain weight. In conditions of our experiment it was approximately from the last decade of May to the end of June or starting the first decade of July. According to Kábrt (1979) environmental conditions exerted their influence on the total yield as well as on the stalk height, heading term and grain size. Temperature and precipitation are responsible for about 50% of the variability of the yield in separate years.

Kábrt (1977) underlined importance of sum of daily temperatures for the growing of winter wheat. According this the sum of the average positive daily temperatures for the growing season of winter wheat is in close relation to the level of the yield. In 18-year tests series, the greatest yields were obtained when the sum of temperatures for the whole growing season was 2230 °C.

TKW of winter wheat was significantly affected by weather conditions, forecrop and the interaction of weather x forecrop. The influence of fertilisation on TKW was insignificant. Also Vidovič (2001) and Rückschloss, Jamriška (2001) made the conclusion, that fertilisation had small influence on TKW.

Our results showed that applicability value of forecrop for winter wheat was different. The value involved all direct effects manifested by a preceding crop on winter wheat. It depended on weather conditions, length of vegetation period of a forecrop (lucerne contrast spring barley), the amounts and quality of root and aboveground post harvest residues (spring barley and lucerne), amount of soil water reserve, manuring and fertilisation, yield level of the preceding crop and applied cultural practices. Indirect applicability value implied the cumulative effects of all preceding crops and it depended on the frequency of growing of crop in rotation and the proportion among small cereals and row crops in rotation. Our results corresponded with those of the authors Molnár (1999), Kováč et al. (2003) and others. It followed from our results that the differences of direct forecrop value of lucerne expressed as the grain yield without mineral fertilisation (treatment ES; 6.97 $t.ha^{-1}$) and the manured winter wheat following spring barley without mineral fertilisation (treatment ES; 7.07 $t.ha^{-1}$) were approximately identical. The similar results regarding yield of winter wheat following red clover and potatoes manured with FYM were published by Špaldon (1985), Vrkoč et al. (2002) and others.

Our results from soil fertility field in Trnava hilly country (the Danubian Lowland) in the years 1991–2001 indicated, that the yields of winter wheat following leguminous forecrops depended more on weather (significantly) than on intensity cultivation (insignificantly). On the base of variance analysis according to the calculated sum of squares the influence share of the weather on grain yield represented 92.8%.

According to Bujnovský et al. (1998) the reduction of yield in the ecological system compared to the conventional one used to be an the average lower by 10–30%. The crop production was assumed to be approximately 20% lower than in conventional system in the Swedish ecological system (Aerberg et al., 1996). Similar results were obtained in Poland (Duer, Kus, 1998). Our level of winter wheat grain yields after leguminous forecrop in the period of 11 years showed that appropriate yields of winter wheat were achieved in the ecological system. The difference between the conventional growing (7.05 $t.ha^{-1}$) and ecological one (6.91 $t.ha^{-1}$) was not statistically significant. According to Lacko-Bartošová et al. (1998), the integrated wheat growing system gave significantly higher yield (6.01) than did the ecological one (5.59 $t.ha^{-1}$). In a long-term stationary experiment established in 1957 with winter wheat growing for 11 years Rückschloss and Jamriška (2001) found out that the analysed years had greater source of variability of the grain yields than fertilisation.

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Received for publication on May 13, 2003
Accepted for publication on December 16, 2003

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Vplyv predplodiny, intenzity pestovania a počasia na úrodu ozimnej pšenice (*Triticum aestivum* L.) a úrodotvorné prvky.

Scientia Agric. Bohem., *35*, 2004: 12–20.

Cieľom práce bolo v dlhodobom v poľnom stacionárnom pokuse založenom v roku 1990 na úrodnej černozemi hnedozemnej Podunajskej nížiny (v SR) analyzovať vplyv predplodín a intenzity pestovania pšenice letnej f. ozimnej na úrodu a jej štruktúru. Poľný pokus sa nachádzal v ochrannom pásme podzemnej vody v Borovciach pri Piešťanoch, v kukuričnej výrobnej oblasti. Pšenica sa pestovala v dvoch šesťhonových osevných postupoch. Skúšali sa tri predplodiny pšenice (lucerna siata, jačmeň siaty jarný a bôbovité – lucerna siata + hrach siaty) a rôzna intenzita jej pestovania (ES – ekologický systém bez priemyselných hnojív a pesticídov, ACS – konvenčný systém bez živočíšnej výroby so zaorávkou pozberových zvyškov predplodín a CS – konvenčný systém s využitím maštaľného hnoja a priemyselných hnojív). Všetky varianty pokusu sa jedenkrát vápnili mletým vápencom v dávke 3 $t.ha^{-1}$ počas každej rotácie. Z výsledkov vyplynulo, že analyzované roky a intenzita pestovania boli väčším zdrojom variability úrod ako predplodina (lucerna, jarný jačmeň). Ozimná pšenica úrodou a prvkami úrodnosti reagovala na podmienky jednotlivých ročníkov, na intenzitu pestovania a predplodinu. Intenzitu pôsobenia týchto faktorov pri úrode, hmotnosti tisíc zŕn a počet zŕn v klase dokumentujú aj signifikantné interakcie počasia a predplodiny. Pri počte klasov boli okrem počasia signifikantným zdrojom premenlivosti interakcie intenzita pestovania x počasie. Podiel vplyvu faktorov pokusu pri úrode, počte klasov na jednotku plochy, TKV a počte zŕn v klase bol pri faktore intenzity pestovania 9,53 % – 2,59 % – 0,67 % a 3,45 %, pri počasí 70,16 % – 96,4 % – 98,32 % a 91,85 %, resp. pri predplodine 0,56 % – 0,64 % –0,88 % a 3,72 %. Variabilita úrody zrna pšenice pestovanej po leguminóznych predplodinách, za obdobie 1991 až 2001, bola viac ovplyvnená počasím (vysoko preukazne) ako intenzitou pestovania (nepreukazne).

pšenica letná f. ozimná; intenzita pestovania; predplodina; úroda zrna; štruktúra úrody; IFOAM

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