ANALYZE OF DIFFERENT CROPPING SYSTEMS AND YEAR CONDITIONS ON GRAIN YIELDS AND THOUSAND-KERNEL WEIGHT OF PEA (*PISUM SATIVUM* L.)

Klimeková Marta, Zuzana Lehocká
Plant Production Research Centre – Research Institute of Plant Production, Bratislavská cesta 122, 921 68 Piešťany, Slovakia, klimekova@vurv.sk

Abstract: *In the 1998 - 2007 years we observed the effect of two different cropping systems (conventional and ecological) and year conditions on yield height and thousand-kernel weight of pea (Pisum sativum L.). The study was carried out in the stationary field experiment established in the year 1990 at Borovce near Piešťany town (western part of the Slovak Republic) on a loamy luvi-haplic Chernozem in the area with a continental climate. The experimental design consists in a split plot arrangement with four replications (during the years 1999-2002) eventually two replications (during the years 2003-2007). There were six crops in the crop rotation: maize for grain – spring barley – winter wheat - spring barley – pea - winter wheat. The model variety of pea was variety Olivin in the years 1998-2002 and Achat in the years 2003-2007. Both varieties are green seed varieties well-bread at the breeding station in Horná Streda, Slovakia. The average yield in the experiment was 2.71 t/ha during the years 1998-2007. The yields of pea were statistically significantly (** P<0.05) influenced by year and farming system. Within the years 1998-2007 the statistically higher (** P<0.05) yields were investigated in the conventional system than in the organic system. The more modern variety Achat (grown in the years 2003-2007) had higher yields than the variety Olivin (grown in the years 1998-2002). The difference represents 13.4 %. Thousand-kernel weight was statistically significantly influenced by year (** P<0.05). The farming system did not statistically significantly influence the values of TKW in the experiment.*

Key words: *pea, organic system, conventional system, thousand-kernel weight, year conditions*

INTRODUCTION

The organic agriculture is taking into consideration two aspects: the human being and the environment. It is based on the prohibition of using chemicals like pesticides, herbicides or chemical fertilizers. This will offer healthy and natural products, but also will protect the environment.

Grain legumes play a key role in cropping systems. In organic farming without livestock where the availability of nitrogen (N) is limited, they potentially constitute both a cash crop and a source of N incorporation into the system via N2 fixation.

Among grain legumes, peas (*Pisum sativum* L.) are very productive in temperate conditions. When cropped with adequate inputs, it can accumulate more than 300 kg $N.ha^{-1}$ in above-ground parts with about 70% of this amount being partitioned into grains (Jensen,

1987; Crozat et al., 1994). Without any N fertilizer application, 65–75% of the N accumulated by the pea crop is derived from biological nitrogen fixation (Jensen, 1997; Crozat et al., 1994). In organic cropping systems, these figures are of particular interest providing that the contribution of the crop to soil N balance remains positive (Schmidt et al., 1999; Hauggaard-Nielsen and Andersen, 2000).

The area of legumes growing in the Slovak Republic has been changing according to the inquiry but still the most important is pea production. In the table 1 we list the area and average yields of pea in the Slovak republic in the years 2002 – 2007.

Table 1:

Growing area (ha) and average yields (t/ha) of pea in the Slovak republic in the years 2002-2007

Year	2002	2003	2004	2005	2006	2007
Area (ha)	9,261	11,799	10,595	11,710	9,746	9,207
Yield (t/ha)	2.86	1.63	3.06	2.44	2.40	1.78

Source: Statistical office of the Slovak Republic (2008)

The aim of the paper was to evaluate the effect of the farming systems (conventional versus organic) and years conditions on the yields and thousand-kernel weight (TKW) of pea (Pisum sativum L.) in the continuous period of ten years.

MATERIAL AND METHOD

The study was carried out in the stationary field experiment established in the year 1990 at Borovce near Piešťany town (western part of the Slovak Republic) on a loamy luvi-haplic Chernozem with good content of available potassium, medium content of available phosphorus and high content of available magnesium. The area has a continental climate with the average annual temperature 9.2 0C (15.5 0C during the vegetation period) and mean annual precipitation 593 mm (358 mm during the vegetation period).

The area is classified as maize-barley growing region. The experimental design consists in a split plot arrangement with four replications (during the years 1999-2002) eventually two replications (during the years 2003-2007). There were six crops in the crop rotation: maize for grain – spring barley – winter wheat - spring barley – pea - winter wheat. The harvested area of one plot represented 75 m2 (3x25 m). The model variety of pea was variety Olivin in the years 1998-2002 and Achat in the years 2003-2007. Both varieties are green seed varieties well-bread at the breeding station in Horná Streda, Slovakia. The seeding rate represented 1.0 million of germinating seeds per one hectare.

In the conventional system we used ammonium nitrate with dolomite (total nitrogen content 27 %) in the dosage of 20 kg. The dosage of phosphorus and potassium was defined according to the actual content in the soil, recalculated for the

expected yield of 4 t/ha. The weed, diseases and pests regulation was realized upon the actual appearance of harmful factors by allowed chemical preparation, individually in each year.

The agro technical operations in organic system were realized in accordance with the Law NR SR No. 224/1998 as amended by the act No. 415/2002 (valid for the years 1998-2004) and the Law NR SR 421/2004 about organic farming (valid from 2004).

Experimental plots were harvested at full maturity and pea yields were recalculated at 15% of moisture content. Obtained results were evaluated by variance analysis, differences testing by Tukey test.

We investigated the effect of conventional and organic farming system and the effect of the growing year conditions on yields and thousand-kernel weight (TKW) of pea (Pisum sativum L.) in the years 1998 -2007.

RESULTS AND DISCUSSION

The average temperatures are listed in the table 2 and the average precipitations are listed in the table 3. During ten years trial period it was recorded that variability of pea yield and thousand-kernel weight (TKW) was statistically significantly affected by years in both farming systems (** $P<0.05$). Pea reacts stronger on the weather conditions (surplus or lack of moisture) than cereals. The highest demand for water is in the flowering stage. On the contrary the excessive amount of water in the ripening stage is harmful and has negative effect on the quality of seeds.

Table 2:

Average temperatures in the years 1998-2007 (^{o}C)

Month / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
January	1.44	-1.21	-3.59	-1.25	-4.02	-1.65	-3.06	-0.48	-4.82	3.47
February	3.63	-0.84	1.46	0.43	2.96	-1.06	1.28	-2.36	-2.51	4.32
March	3.53	6.59	4.06	4.73	7.06	5.17	4.42	3.01	2.10	7.65
April	12.02	11.61	12.81	7.72	11.08	9.94	11.65	11.45	11.53	11.32
May	15.24	15.81	15.79	15.43	18.69	18.73	14.05	15.62	14.75	16.50
June	19.48	18.43	18.16	15.38	19.85	22.26	17.94	18.18	18.99	20.36
July	20.68	21.23	16.88	19.21	22.82	21.67	20.06	20.44	22.96	21.28
August	20.10	18.85	20.58	20.11	22.36	22.92	20.70	19.12	17.31	20.60
September	15.27	18.65	13.63	11.94	15.55	15.88	15.01	16.41	17.21	12.78
October	10.81	0.85	11.95	11.15	9.19	7.98	12.22	10.89	12.38	8.64
November	1.67	2.63	6.98	0.93	7.55	6.66	5.20	3.68	7.43	2.76
December	-2.67	-1.85	0.27	-6.90	-1.51	0.88	0.96	-0.33	3.07	-1.00
Average	10.10	9.23	9.92	8.24	10.97	10.78	10.04	9.64	10.03	10.72

Table 3:

Average precipitations in the years 1998-2007 (mm)

Month / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
January	12.1	12.4	34.0	13.2	18.8	40.9	50.6	39.9	56.1	53.1
February	0.7	36.4	29.5	19.1	42.7	9.4	27.4	51.6	30.1	36.2
March	14.3	20.4	79.0	67.0	20.8	0.9	49.4	7.0	25.3	56.0
April	35.0	48.3	9.7	31.8	27.8	16.5	14.4	91.2	52.7	0.0
May	19.1	27.4	35.9	30.1	50.4	8.7	15.5	33.5	66.5	58.9
June	46.1	118.4	39.1	43.0	95.3	33.9	72.9	33.7	136.2	55.7
July	38.5	87.0	69.1	118.5	67.6	63.3	15.9	96.9	0.5	33.8
August	22.1	36.3	20.8	10.0	71.7	16.0	44.6	98.8	83.7	93.6
September	167.4	36.6	42.9	114.7	34.5	19.3	38.9	42.3	0.0	109.6
October	140.0	20.1	26.9	11.7	58.2	57.9	61.4	10.2	30.0	34.0
November	25.4	39.2	82.4	30.0	61.9	34.5	46.5	48.0	49.4	36.2
December	20.8	46.8	55.2	43.3	44.9	30.6	33.3	69.5	13.3	32.0
Sum	541.5	529.3	524.5	532.4	594.6	331.9	470.8	622.6	543.8	599.1

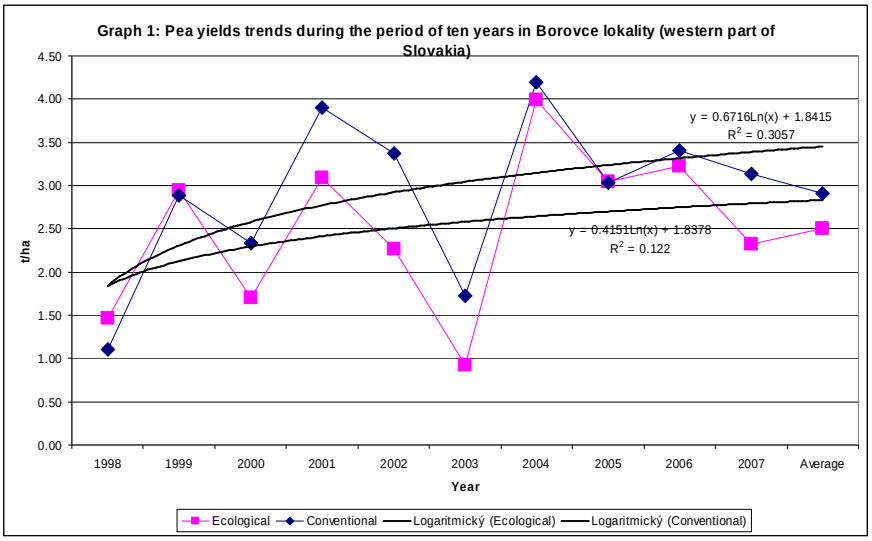
The average yield in the experiment was 2.71 t/ha. The average yield in organic system (2.91 t/ha) was statistically lower (** $P<0.05$) than the average yield in the conventional system (2.91 t/ha). In both systems the highest yields were obtained in the year 2004 (3.99 t/ha in organic system and 4.20 t/ha in conventional system). This year the yields were statistically significantly higher compared with the other nine years (besides the year 2002). There were lower yields of pea in the conventional system in the years 1998, 1999 and 2005. These years were characterized by low precipitation in May. In another tested years the yields were higher in the conventional system than in the organic one, but the statistically significantly differences were only in the year 2002. For this climatic conditions pea is also very valuable forecrop for different reasons. It might improve the soil structure and could be a source of N incorporation into the system via N2 fixation. For example Lehocka (2007) investigated that higher yields of winter wheat were after pea (5.82 t/ha) compared with yields after alfalfa (5.61 t/ha). In both systems there was the positive, increasing trend in the yields of pea within the period of ten years while the experiment was running (Graph 1).

Table 4:

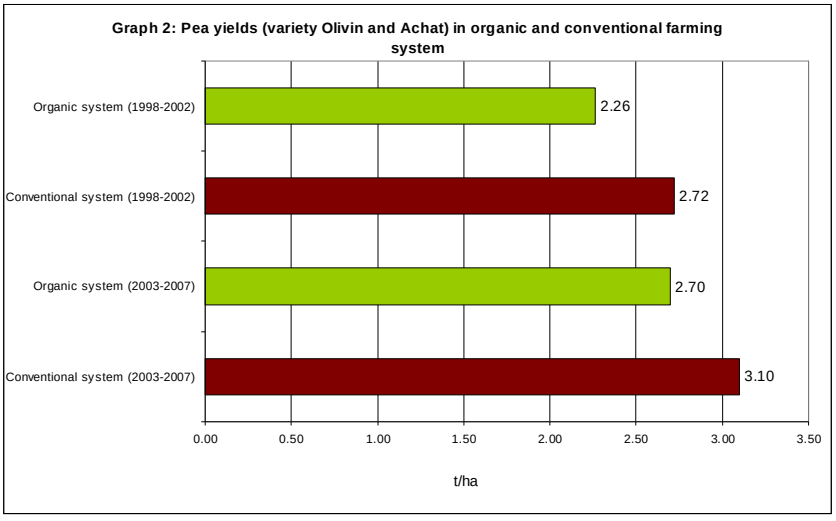
Yields of pea (t/ha) in the years 1998-2007
in organic and conventional farming system

System / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Ecological	1.47	2.94	1.70	3.09	2.27	0.93	3.99	3.04	3.23	2.32	**2.50**
Conventional	1.10	2.89	2.34	3.90	3.37	1.72	4.20	3.03	3.41	3.14	**2.91**
Average	1.29	2.92	2.02	3.49	2.82	1.33	4.09	3.04	3.32	2.74	**2.71**

LSD 0.05 system 0.19
LSD 0.05 year 0.69



In the years 1998-2002 the model variety was Olivin and the average yield in the experiment represented 2.51 t/ha. In the years 2003-2007 the model variety was Achat and the average yield within the experiment was 2.90 t/ha. The variety Achat had in average higher yields than Olivin (15.5 % difference). Achat is more modern variety, semi leafless type. In the organic system the yields increased at 17.9 % at Achat variety and in the conventional system the increase represented 14.0 %. The yield increasing was caused by the better stand closing and better competitiveness against weeds. Hansel (2007) suggests reducing weeds problems in the pea stands by using vine varieties. This was also confirmed in our experiment and the vine variety reduced weeds infestation in the experiment. The differences of varieties in term of the reached yields could be explained mainly by the differences in standing ability of varieties in the specific climatic conditions of Borovce locality.



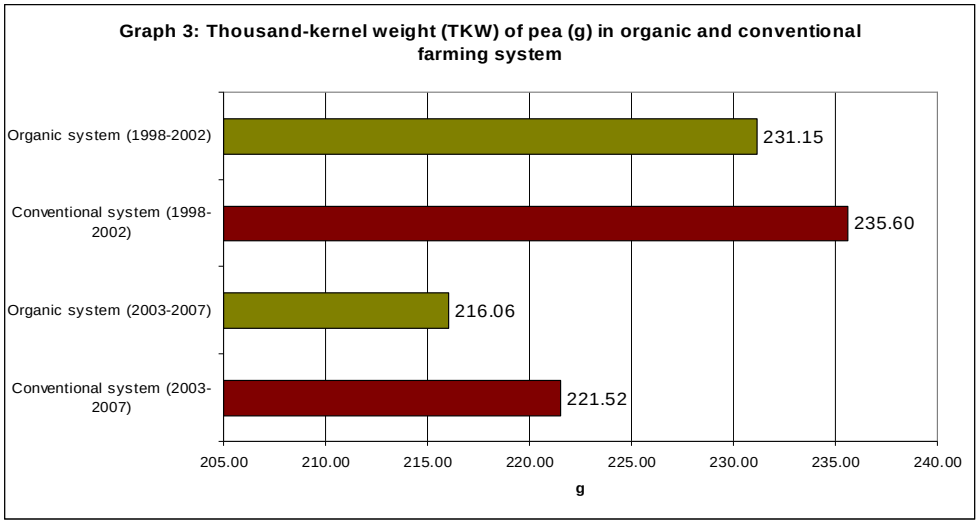
Thousand-kernel weight (TKW) is a genetically conditioned characteristic. The results of TKW in the years 1998 – 2007 are listed in the table 5.

Table 5

Thousand-kernel weight (TKW) of pea (g) in the years 1998-2007 in organic and conventional farming system

System / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Ecological	198.27	223.10	231.77	305.50	197.10	174.35	235.30	210.00	221.80	238.85	**223.61**
Conventional	211.97	223.40	229.12	295.25	218.25	204.70	242.70	209.50	214.25	236.45	**228.56**
Average	205.12	223.25	230.45	300.37	207.67	189.52	239.00	209.80	218.02	237.65	**226.09**

The average TKW in the experiment was 226.1 g and the difference between organic and conventional system was not statistically significant. Our results did not confirm the investigations of Hrachovinová et al. (2007) who discovered lower TKW of pea in the organic system than in the conventional one. The statistically significant differences were observed among the years. The highest TKW was in the year 2001 (305.5 g in the organic system and 295.25 g in the conventional system) and it was statistically significantly higher than in another tested years. The year 2003 was very specific one. During the vegetation period the sum of precipitation was very low (177.7 mm) and the temperatures were very high (the average temperature was 18.61 ^{0}C). This climatic conditions increased evapotranspiration and therefore TKW was statistically significantly lower in comparison with another years. The variety Olivin had higher TKW (233.38 g) than Achat variety (218.79 g).



CONCLUSIONS

- The yields of pea were statistically significantly (** P<0.05) influenced by year conditions and farming system.

- Within the years 1998-2007 the statistically higher (** $P<0.05$) yields were investigated in the conventional system than in the organic system.
- The more modern variety Achat (grown in the years 2003-2007) had higher yields than the variety Olivin (grown in the years 1998-2002).
- In the first years of experiment (1998-2002, variety Olivin) the average yield of pea was lower compared with the average yield of pea in the years 2003-2007 (variety Achat). The difference represents 13.4 %.
- Thousand-kernel weight was statistically significantly influenced by year (** $P<0.05$). The farming system did not statistically significantly influence the values of TKW in the experiment.

Acknowledgments. The results were obtained within the frame of the Project 2003 SP 27/028 OD 01/028.

REFERENCES

1. Corre-Hellou, G., Crozat, Y.: N2 fixation and N supply in organic pea (Pisum sativum L.) cropping systems as affected by weeds and peaweevil (Sitona lineatus L.) Euroepean Journal of Agronomy, Volume 22, Issue 4, May 2005, pp. 449-458
2. Hansel, M.: Anbau von Erbsen, Sommerweizen, und Gerste in Reinsaaten und in Gemengen. In: Zwischen Tradition und Globalisierung : Beiträge zur 9. Wissenschaftstagung Ökologischer Landbau - Band 2, Universität Hohenheim, 20.-23. März 2007 - Berlin: Verlag Dr. Köster, 2007. - ISBN 978-3-89574-640-6. p. 133-136.
3. Hrachovinová –Fachadas, J. et al. : Peas in cropping systems on organic farming and in conventional conditions. In: Ekologické zemědělství 2007 = Organic farming 2007 : sborník z konference, 6.-7.2.2007 Praha Suchdol. - 2007. - ISBN 80-213-1611-9. p. 124-126.
4. Jensen, E.S., 1987. Seasonal patterns of growth and nitrogen fixation in field-grown pea. Plant Soil 101, p. 29–37.
5. Jensen, E.S., 1997. The role of grain legume N2 fixation in the nitrogen cycling of temperate cropping systems. D.Sc. Thesis, Riso-R-885, Riso National Laboratory, Denmark.
6. Lehocká, Z.: Analýza účinkov systému, predplodiny a ročníka na úrodu zrna pšenice letnej f. ozimnej (Triticum aestivum L.) = Effect of farming system, forecrop and year conditions on grain yields of winter wheat (Triticum aestivum L.) In: Zborník vedeckých prác SCPV v Nitre Ústavu agroekológie v Michalovciach 23. - Michalovce: SCPV-ÚAe, 2007. ISBN 978-80-88872-70-2. p. 17-24.