THE INFLUENCE OF AGRO-ECOLOGICAL CONDITIONS ON COMMON PEA YIELD

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Abstract: *A field stationary experiment was carried out during years 2005 - 2007 at the Experimental base of the Slovak University of Agriculture in Dolná Malanta. The long-term average annual temperature of the site is 9.7° C and 16.6° C during the vegetation period. The average rainfall is 561 mm, including 323 mm during the vegetation period. Agro-climatic sub-area is characterized as very dry. Soil subtype was classified as Haplic Luvisol on proluvial sediments with loess. Main aim of this study was the evaluation of yield and yield components (the number of plants per unit area, number of pods per plant, number of seeds in the pod, and thousand of kernels weight) of common pea variety Dunaj grown under different soil tillage and fertilization treatments. Tillage treatments were as follows: O1 - conventional tillage (to the depth of 0.25 m), O2 - reduced tillage (to the depth of 0.18 m), O3 - minimized tillage (to the depth of 0.10 m). The fertilization treatments: 0 - no fertilization; PH – balance fertilization to design yield; PZ – balance fertilization with incorporation of forecrop residues after harvest. Nutrients were added on the base of balance method according to nutrient content in soil on yield level of 3 t ha^{-1} pea seeds. From the results achieved in this study we can conclude that pea yield was statistically highly significantly affected by the climatic conditions during years (the highest yield 4.48 t ha^{-1} was reached in 2006), significantly by soil tillage (3.76 t ha^{-1} in O3 treatment) and fertilization (3.85 t ha^{-1} in PZ treatment). The lowest yield (2.82 t ha^{-1}) was reached during the growing season in year 2007, characteristic by the lack of moisture and high temperatures. The proportion of seeds on overall pea phytomass was around 50 %, resulting in the ratio of seeds to straw 1:1.*

Key words: *common pea, soil cultivation, fertilization, seeds yield*

INTRODUCTION

Rational agricultural production provides non-deficit humus balance, where the main role play crop residues (LEON and VELÁZQUEZ, 2002; TUDOR et al., 2009). Decomposed and mineralised organic matter provides mineral nutrients for plants (TOBIAŠOVÁ and ŠIMANSKÝ, 2009, TOBIAŠOVÁ, 2010). Increasing of fresh organic matter content in soil causes a raise of its biological activity, which accelerates the process of organic matter mineralization (FECENKO et al., 2000). The keeping of high soil biological activity provides maintaining of favourable rate between mineralization and humification processes (SOTÁKOVÁ, 1982). Not only microbes, but also various soil zoocoenoses are important at organic matter decomposition and mineralization (PETŘVALSKÝ et al., 2004; PORHAJAŠOVÁ et al., 2005).

Important yield forming factor is water. Pea seed for germination needs to absorb 96 – 105% water of its weight. For seeds yield is important the size of assimilation area since establishment of the first pod. Ideal leaf area is 6 m^2 per 1 m^2 of land (PETR, 1980; PETR, 1987). Pea has the greatest demand for water during flowering, pods and seeds production. Water deficit leads to increased blossom drop and decrease of seeds development (KOSTREJ, 1998).

At present, farmers try to use different methods of basic and pre-sowing soil tillage in terms of costs saving. Used equipment significantly affects the overall energy balance of the work process (NOZDROVICKÝ, 1994). HORÁK et al. (2005) found statistically significant

reduction of fuel consumption in energy-saving technologies compared with traditional.

The aim was on the basis of results obtained in years 2005-2007 to determine the impact of moisture and temperature on yield of common pea cultivated by different soil tillage systems in interaction with the fertilizers and forecrop residues incorporation.

MATERIAL AND METHODS

A field stationary experiment was carried out in years 2005-2007 at the Experimental base of the Slovak University of Agriculture in Dolná Malanta. The long-term average annual temperature of the site is 9.7°C and 16.6°C during the vegetation period. The average rainfall is 561 mm, including 323 mm during the vegetation period. Altitude of the site is 175 m. Agro-climatic sub-area is characterized as very dry (ŠIŠKA and ČIMO, 2006). Soil subtype was classified as Haplic Luvisol on proluvial sediments with loess, and soil pH was 6.0 i.e. slightly acidic. The experiment was configured as long strips with vertically segmented plots. The size of plot was 30 m^2 (10 x 3 m), in four replications.

Forecrop was winter wheat as advised by HANÁČKOVÁ and SLAMKA (2004). The variety of common pea used in experiment was Danube.

The tillage treatments were as follows: O1 – conventional tillage (to the depth of 0.25 m), O2 –reduced tillage (to the depth of 0.18 m), O3 –minimized tillage (to the depth of 0.1 m).

Treatments of fertilization: 0 - no fertilization, PH - balance fertilization by mineral fertilizers to design yield, PZ – balance fertilization by mineral fertilizers to design yield with incorporation of forecrop residues after harvest.

Sowing periods: April 6, 2005; April 6, 2006; March 16, 2007.

Dates of harvest: July 15, 2005; July 18, 2006; June 29, 2007.

Nutrients were added on the base of balance method according to nutrient content in soil on yield level of 3 t ha^{-1} pea seeds under the normative nutrients withdrawing per 1 ton of crop: 63 kg N, P 7.4 kg, 37.4 kg K (FECENKO and LOŽEK, 2000).

RESULTS AND DISCUSSIONS

Years 2005-2007 distinguished with great disproportions in rainfall. Compared to normal (multi annual averages in years 1951-1980), the year 2005 was characteristic by lack of rainfall in March, but in April the normal was exceeded for 35.7 mm. In June, the lack of moisture was 38.5 mm. Relative equal moisture for common pea was during the growing season in year 2006. The year 2007 was characterized by lack of rainfall in spring. After sowing there was a drought, which lasted for three weeks. In May a surplus of rainfall was 44.1 mm compared to normal, but did not compensate the absence of water. Examined years distinguished also by temperature differences. The biggest difference was in year 2007, when temperature exceeded normal values throughout the whole pea growing season. These conditions were reflected in the yield and yield components of common pea (Table 1).

MATHE-GASPAR et al. (2005) studied pea cultivation in Hungary and found that soil and weather are the main environmental factors influencing pea yield. The effect of soil and weather can not be separated because the pea is sensitive to weather. But weather has greater influence than soil and the degree of impact depends on the pea variety.

Lack of moisture in the spring 2007 influenced mainly the number of plants per unit area (Table 2). From the sown seeds remained only half, and the average number of plants per m^2 was 52. In years 2005 and 2006 the number of plants was 90 per m^2.

Important yield components are the number of pods per plant, number of seeds in the pod, and thousand of kernels weight (TKW). Number of pods per plant was the highest in year 2006 (6.69 pc.).

Table 1

Moisture and temperature conditions in years 2005-2007

Year	Month												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
	Rainfall (mm)												
1951-80	31	32	33	43	55	70	64	58	37	41	54	43	561
2005	36.4	58.3	3.4	78.7	60.9	31.5	59.0	94.5	47.1	12.1	43.2	113.2	638
2006	57.4	39.0	35.2	48.1	95.6	63.9	23.7	84.0	12.7	15.3	24.4	7.8	507
2007	56.2	46.1	59.1	0.3	109.1	39.5	35.8	78.9	91.2	31.6	50.2	19.0	617
	Temperature (°C)												
1951-80	-1.7	0.5	4.7	10.1	14.8	18.3	19.7	19.2	15.4	10.1	4.9	0.5	9.7
2005	-0.1	-2.7	2.7	11.0	15.2	18.0	20.7	19.1	16.3	10.5	4.1	0.4	9.6
2006	-4.1	-1.6	3.5	11.4	14.0	19.2	22.6	16.7	16.6	12.2	7.5	3.2	10.1
2007	1.5	4.6	7.9	12.5	17.2	21.2	22.4	21.2	13.7	9.9	3.6	-1.1	11.2

Table 2

Number of plants per m^2 in years 2005-2007

Soil cultivation	Fertilization treatments	Number of plants per m^2			**Average**
		2005	**2006**	**2007**	
O1	0	89	92	51	77
	PH	92	95	45	77
	PZ	91	95	51	79
	x	**91**	**94**	**49**	**78**
O2	0	91	95	56	81
	PH	92	82	59	78
	PZ	93	88	51	77
	x	**92**	**88**	**55**	**78**
O3	0	87	83	51	74
	PH	91	89	51	77
	PZ	89	79	53	74
	x	**89**	**84**	**52**	**75**
Average total		**91**	**89**	**52**	**77**

Between years 2005 (6.30 pc.) and 2007 (6.37 pc.) the difference was small. Soil cultivation influenced the number of pods mainly in years 2006 and 2007, but differently. In year 2006, the highest number of pods was formed under reduced tillage, and the lowest under conventional. In year 2007, the highest number of pods was formed under conventional tillage and the lowest under minimized. Fertilization treatments did not have definite influence on the number of pods (Table 3).

Table 3

Number of pods per plant in years 2005-2007

Soil cultivation	Fertilization treatments	Number of pods per plant			
		2005	**2006**	**2007**	Average
O1	0	4.92	6.33	7.23	6.16
	PH	6.46	5.25	7.13	6.28
	PZ	7.80	6.13	7.25	7.06
	x	**6.39**	**5.90**	**7.20**	**6.50**
O2	0	6.24	9.20	5.80	7.08
	PH	6.28	7.23	6.46	6.66
	PZ	6.50	6.27	6.79	6.52
	x	**6.34**	**7.57**	**6.35**	**6.75**
O3	0	7.06	6.68	5.71	6.48
	PH	6.40	7.00	5.63	6.34
	PZ	5.03	6.15	5.32	5.50
	x	**6.16**	**6.61**	**5.55**	**6.11**
Average total		**6.30**	**6.69**	**6.37**	**6.45**

In years 2005 and 2006, the most seeds in the pod were formed under conventional soil tillage, and in year 2007 under reduced. On average, the most seeds in the pod were in year 2006 (3.72 pc.) and the least in 2005 (2.96 pc.).

Table 4

Number of seeds per pod in years 2005-2007

Soil cultivation	Fertilization treatments	Number of seeds per pod			
		2005	**2006**	**2007**	Average
O1	0	3.19	3.87	3.56	3.54
	PH	2.92	3.86	3.35	3.38
	PZ	3.18	3.69	3.53	3.47
	x	**3.10**	**3.81**	**3.48**	**3.46**
O2	0	2.68	3.55	3.46	3.23
	PH	3.09	3.35	4.11	3.52
	PZ	2.95	3.66	3.26	3.29
	x	**2.91**	**3.52**	**3.61**	**3.35**
O3	0	2.72	3.86	3.33	3.30
	PH	2.83	3.78	3.33	3.31
	PZ	3.06	3.86	3.32	3.38
	x	**2.87**	**3.83**	**3.29**	**3.33**
Average total		**2.96**	**3.72**	**3.46**	**3.38**

Despite adverse conditions in 2007, TKW was the highest (274.56 g) just in that year. This was mainly due to fewer plants, when lower number of pods per plant and lower number of seeds in the pod caused the energy concentration in the seeds weight. Nevertheless, the overall yield of pea seeds was the lowest. TKW was positively influenced by fertilization and minimized soil tillage.

Table 5

Thousand of kernels weight in grams in years 2005-2007

Soil cultivation	Fertilization treatments	TKW - Thousand of kernels weight (grams)			
		2005	**2006**	**2007**	Average
O1	0	228.20	254.50	269.50	250.73
	PH	236.50	248.73	269.50	251.58
	PZ	241.00	243.32	268.70	251.01
	x	**235.23**	**248.85**	**269.23**	**251.10**
O2	0	234.90	263.41	264.10	254.14
	PH	233.90	248.06	269.30	250.42
	PZ	243.80	246.84	278.80	256.48
	x	**237.53**	**252.77**	**270.73**	**253.68**
O3	0	233.20	246.84	283.70	254.58
	PH	239.40	265.57	294.60	266.52
	PZ	246.60	255.32	272.80	258.24
	x	**239.73**	**255.91**	**283.70**	**259.78**
Average total		**237.50**	**252.51**	**274.56**	**254.85**

Agro-ecological conditions significantly affect the yield level. For common pea was the best year 2006, when a maximum yield (4.50 t ha^{-1}) was reached. Lack of moisture and high air temperature in year 2007 negatively influenced the yield of pea seeds (2.82 t ha^{-1}), which was the lowest from all evaluated years. The yield is significantly affected mainly by limiting factors, i.e. excessive deficit or surplus of water and extreme temperatures (HÁJEK and STŘÍDA, 1974).

Beside statistically highly significant effect of year, the yield of pea seeds was significantly influenced by soil tillage and fertilization (Table 6). The lowest yield was reached under conventional tillage system and in the treatment without use of fertilizers and forecrop residues. In the experiments of ŠARIKOVÁ and HNÁT (2005), ŽÁK et al. (2002) a higher yield of common pea was achieved under conventional soil tillage. KOVÁČ (2003) stated that minimized tillage can be used in good soil-climatic conditions for most crops.

Table 6

The influence of year, soil cultivation and fertilization on common pea yield (ANOVA, Statgraphics Plus)

Factor/yield t ha^{-1}	Year		
	2005 3.73 b	**2006** 4.48 c	**2007** 2.82 a
	Soil cultivation		
	O1 3.53 a	**O2** 3.74 b	**O3** 3.76 b
	fertilization		
	0 3.38 a	**PH** 3.80 b	**PZ** 3.85 b

Seeds yield is also related to the production of aboveground phytomass. The proportion of seeds yield on the total phytomass was expressed as harvest index, which was in all examined years relatively balanced (Table 7). The proportion of seeds from the overall phytomass was 42 to 49 %. Under conventional and reduced soil tillage was the highest harvest index at treatments with mineral fertilizers, and under minimized tillage at treatment with mineral fertilizers in combination with incorporated forecrop residues.

Table 7

Harvest index in years 2005-2007

Soil cultivation	Fertilization treatments	Harvest index			
		2005	**2006**	**2007**	**Average**
O1	0	0.49	0.39	0.43	0.44
	PH	0.48	0.46	0.55	0.50
	PZ	0.49	0.38	0.47	0.45
	x	**0.49**	**0.41**	**0.48**	**0.46**
O2	0	0.47	0.33	0.49	0.43
	PH	0.46	0.43	0.50	0.46
	PZ	0.44	0.43	0.46	0.44
	x	**0.46**	**0.40**	**0.48**	**0.45**
O3	0	0.48	0.44	0.47	0.46
	PH	0.50	0.43	0.49	0.47
	PZ	0.49	0.47	0.52	0.49
	x	**0.49**	**0.45**	**0.50**	**0.48**
Average total		**0.48**	**0.42**	**0.49**	**0.46**

CONCLUSIONS

Based on the results achieved by growing of common pea variety Dunaj in years 2005 to 2007 we can conclude that for high yield of seeds and total phytomass are important regular distribution of rainfall and adequate temperature throughout the whole growing season. The yield of pea seeds was statistically highly significantly affected by tillage system. The highest yield was achieved under minimized tillage (3.76 t ha^{-1}) and in the treatment with mineral fertilizers in combination with incorporated forecrop residues (3.85 t ha^{-1}). The proportion of seeds on overall pea phytomass was around 50 %, resulting in the ratio of seeds to straw 1:1.

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