YIELD FORMATION STRATEGIES OF COMMON PEAS

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Abstract: *During 2006-2008, the polyfactorial field trial of growing common peas (Pisum sativum L.) was established on Experimental site of Slovak Agricultural University in Nitra, in south-western Slovakia (E 18º09', N 48º19') with altitude of 175 m above Mean Sea Level. The location has continental warm and moderate arid climate with an average annual temperature of 9.07°C and average annual precipitation of 561 mm. The mean temperature during the growing season is 16.2°C. The soil type is Orthic Luvisol with a loamy texture, medium humus content of 1.95%-2.60% and a pH of 5.7. The Slovak variety of common pea Svit was tested. The tested variety is medium early, semi leafless type, with good plasticity to soil and climate conditions. Three fertilization treatments as follows: 0-without organic and inorganic fertilization, PH –mineral fertilizers calculated to the 4 t yield level, PR- incorporation of all above-ground plant material of forecrop (maize for corn) supplemented with mineral fertilizer to the balance equilibrium level. Common pea was growing after maize. In autumn, phosphorus and potassium fertilizers were applied. In spring, 20 kg ha^{-1} of mineral nitrogen as a starting dose was also applied. The influence of mineral fertilization and green manure treatments on creation of yield component, yield of seeds and yield of pea straw was evaluated. The yield of seeds was highly significantly influenced by year condition. The yield range from 2.82 t ha^{-1} in 2008 to 4.06 t ha $^{-1}$ in 2006. The same trends were noted in straw production, when the yield of straw was higher than seed production. Harvest index ranged from 0.79 to 0.96. The significantly higher yield was reached in mineral fertilization treatments (3.53 t ha^{-1}) and treatments with mineral fertilization with incorporation of all forecrop aboveground material (3.48 t ha^{-1}). Due to the nitrogen depression, forecrop residues treatments negatively affected the yield of pea (3.1 t ha^{-1}). The yield of seeds was highly significantly influenced by number of pots per plant and TSW. The significant direct relationship between pots number per plant and TSW was found. The highest TSW was in 2006 (265.85 g). Mineral fertilizers and forecrop residue incorporation positively influenced the number of seeds per pod.*

Key words**:** *common pea, crop residues, fertilization, yield, yield components*

INTRODUCTION

Formation of the economic yield of pulses is more intricate process than in other grain crops. The reasons are the first of all the small possibility of control of the number of lateral fruitful axes, the gradual and prolonged differentiation of generative organs, and mainly the significant dependence of the generative organs formation on external conditions. The following yield factors play the key role: 1. Number of plants (or fruitful axes) per unit of area. 2. Number of pods per plant or number of pods per 1 square meter. 3. Number of seeds in pod. 4. Seeds weight (ČERNÝ ET AL., 2012).Very important yield forming factor is water. The pea seed for germination needs to absorb 96% – 105% water of its weight. For seeds yield is very 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, 1987). Rational agricultural production provides non-deficit humus balance, where the main role plays crop residues (TUDOR ET AL., 2009). Decomposed and mineralized organic matter provides mineral nutrients for plants (TOBIAŠOVÁ AND ŠIMANSKÝ, 2009).

The aim of the research was to evaluate the influence of incorporation of forecrop biomass and mineral fertilization on yield, formation of yield component of seeds and straw in specific agro climatic conditions of South-western Slovakia.

MATERIAL AND METHODS

During 2006-2008, the polyfactorial field trial of growing common pea variety Svit was established on Experimental site of Slovak Agricultural University in Nitra, in south-western Slovakia (E 18º09', N 48º19') with altitude of 175 – 180 m above MSL (Mean Sea Level). The location has continental warm and moderate arid climate with an average annual temperature of 9.07°C an average annual precipitation of 561 mm. The mean temperature during the growing season is 16.2°C. Agro-climatic sub-area is characterized as very dry (ŠIŠKA AND ČIMO, 2006). The soil type is Orthic Luvisol with a loamy texture, medium humus content of 1.95%-2.60% and a pH of 5.7 (TOBIAŠOVÁ AND ŠIMANSKÝ, 2009).

The experiment was designed as long strips with vertically segmented plots. The size of plot was 30 m^2 (10 x 3 m), in four replications. Maize as a fore crop was used, after harvest of forecrop mouldboard ploughing to the depth 0.25 m and phosphorus and potassium mineral fertilizers were applied. For seedbed preparation harrow and combinator were used. The Slovak variety of common pea Svit was tested. The tested variety is medium early, semi leafless type, intermediate height (0.75-0.95 m) with good plasticity to soil and climate condition. Seed is spherical, yellow, and medium in volume, TSW of 210-250 g.

Three fertilization treatments as follows: 0-without organic and inorganic fertilization, PH – mineral fertilizers calculated to the 4 t yield level, PR- incorporation of all above-ground plant material of fore crop (maize for corn) supplemented with mineral fertilizer to the balance equilibrium level.

Nutrients were added on the base of balance method according to nutrient content in soil on yield level of 4 t ha^{-1} seeds under the normative nutrients withdrawing per 1 ton of crop: 63.0 kg N, 7.4 kg P, 37.4 kg K (FECENKO AND LOŽEK, 2000). Due to the good phosphorus and potassium stocks in soil, replacing system was used. In spring, 20 kg ha^{-1} of mineral nitrogen as a starting dose was also applied. Sowing periods was as follows: April 7, 2006; March 15, 2007 and February 28, 2008. Dates of harvest were as follows: July 17, 2006; June 27, 2007 and July 3, 2008. Sowing dose was 1.1 million germinable seeds ha^{-1} $year^{-1}$. ANOVA analyzes were carried out with Stat graphic software.

RESULTS AND DISCUSSIONS

The period 2006-2008 was distinguished by a great disproportion in rainfall (Fig. 1 and 2). Compared to normal (multi annual averages in period 1961-1990), the year 2006 have been characterized by normal temperature and precipitation excluding warm April and very wet May. Year 2007 was very specific in warm and extraordinary warm spring months. Extraordinary wet March was followed by extraordinary dry April and very wet May. Summer period have been characterized by a low quantity of precipitations in June and July.

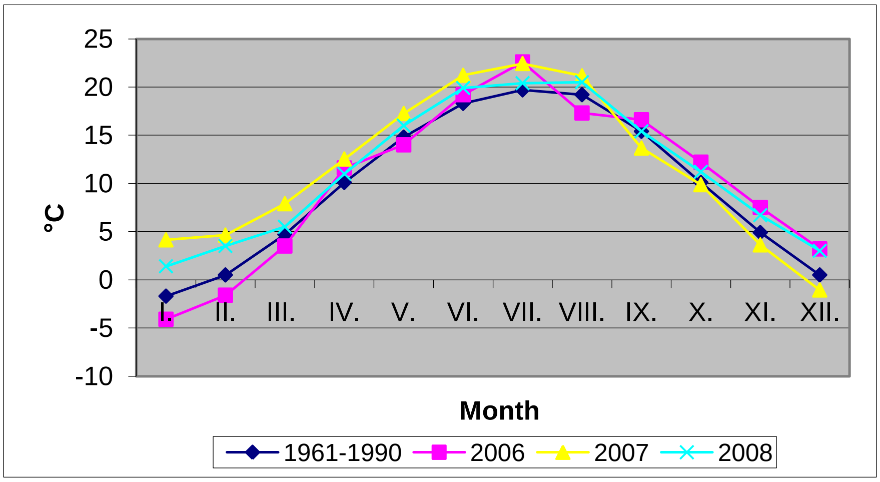

Figure 1: Temperature condition in years 2006-2008 at experimental site.

In 2008 was normal in temperature with warm June. Extraordinary wet March was followed by wet June and very wet July.

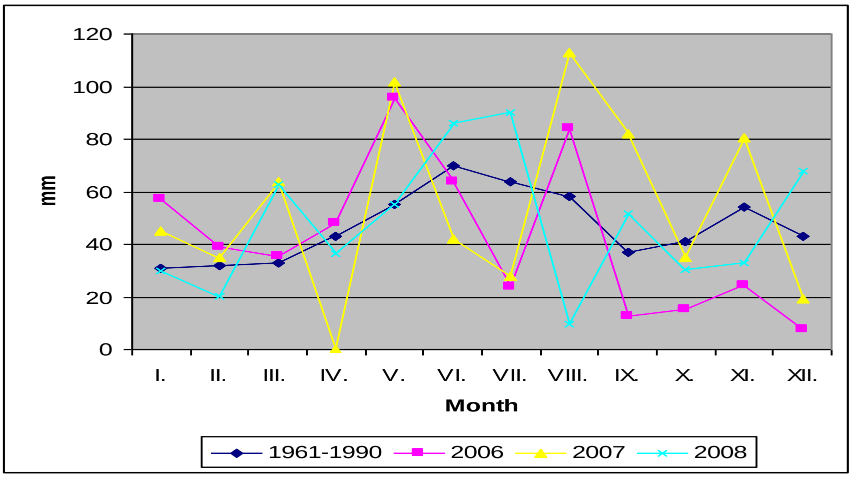

Figure 2: Precipitation scenarios during 2006-2008

The number of plants – fruitful axes per unit area depends on the number of emerged plants and on their branching intensity. The number of plants as well as the number of branches are reduced by unfavourable factors (weather, interplant competition, diseases) in course of vegetation (ČERNÝ ET AL., 2012). Numbers of pods per unit area were stable in all evaluated years. The average number of pods per plant was significantly highest in 2006 (Tab. 1) and lower in 2008 (Tab. 3). Number of seeds per pod was relatively stable too. TSW vary between years from 227.87 g in 2008 to 265.85 in 2006.

The moisture conditions in spring influenced negatively TSW. Pulses are extremely sensitive to agro climatic conditions during formation or generative organs, flowering and ripening (JAVOR AND SUROVČÍK, 2001). The influence of agro climatic conditions and fertilization was also confirmed by MARTON (2008), in average year conditions

they received yield of 2.4 t ha^{-1} in zero treatments, but in treatments without fertilization the yield decreased up to 54% in dry years. The same decreasing was noted also in very wet year condition up to 41.7% but only 25.8 in fertilized plots. The yield components of common peasvariety Svit are shown in tables 1-3.

Table 1

The yield components of common peas variety Svit in 2006

Treatments	Average number (pcs.)			TSW (g)	Yield (t ha^{-1})		Harvest Index
	Plants / m^2	pods / plant	seeds / pod		seeds	straw	
0	90	4.51	3.69	269.41	3.99	4.06	0.98
PH	75	5.91	3.73	258.85	4.29	4.53	0.95
average	83	5.21	3.71	264.13	4,14	4.30	0.96
PZ	84	4.89	3.33	268.08	3.67	4.16	0.88
PH+PZ	91	5.06	3.54	267.07	4.42	4.57	0.97
average	88	4.98	3.44	267,58	4.05	4.37	0.92
0, PZ	87	4.70	3.51	268,75	3,83	4.11	0.93
PH, PH+PZ	83	5.49	3.64	262.96	4.36	4.55	0.96
average	85	5.09	3.57	265.85	4.09	4.33	0.94

The exemplary reaction of peas to humidity and temperature was noted in 2007 (Tab. 2). The precipitation regime and temperature in early spring months was compensating by very wet condition in May. TSW with comparison to 2008 results was higher by 7.77 g which contributed to an increase in seed yield of 0.29 t ha^{-1} in 2007 compared with 2008.

Table 2

The yield components of common peas variety Svit in 2007

Treatments	Average number (pcs.)			TSW (g)	Yield (t ha^{-1})		Harvest index
	plants /m^2	pods / plant	seeds/ pod		seeds	straw	
0	79	4,26	3,59	238,66	2,88	3,22	0,89
PH	84	4,64	3,52	237,25	3,23	3,49	0,93
average	**82**	**4,45**	**3,56**	**237,96**	**3,06**	**3,36**	**0,91**
PZ	87	4,63	3,35	229,88	3,09	3,35	0,92
PH+PZ	85	4,42	3,69	236,78	3,24	3,82	0,85
average	**86**	**4,53**	**3,52**	**233,33**	**3,17**	**3,59**	**0,89**
0, PZ	83	4,45	3,47	234,27	2,99	3,29	0,91
PH, PH+PZ	85	4,53	3,61	237,02	3,24	3,66	0,89
average	**84**	**4,49**	**3,54**	**235,64**	**3,11**	**3,47**	**0,90**

The proportion of seeds yield on the total biomass was expressed as harvest index, which was relatively balanced in all over the years we have studied .

Table 3

The yield components of common peas variety Svit in 2008

Treatments	Average number (pcs.)			TSW (g)	Yield (t ha^{-1})		Harvest index
	Plants / m^2	pods/ plant	seeds / pod		seeds	straw	
0	93	4.24	3.25	220.72	2.83	3.76	0.75
PH	91	4.65	2,98	244.10	3.09	3.76	0.82
average	**92**	**4,45**	**3.12**	**232.41**	**2.96**	**3.76**	**0.79**
PZ	81	3.86	3.70	226.15	2.56	2.85	0.90
PH+PZ	79	3,87	4.20	220.51	2.80	3,40	0.82
average	**80**	**3.87**	**3.95**	**223.33**	**2,88**	**3.13**	**0.86**
0, PZ	87	4,05	3.48	223.44	2.70	3.31	0.83
PH, PH+PZ	85	4.26	3.59	232.31	2.95	3.58	0.82
average	**86**	**4.16**	**3.53**	**227.87**	**2.82**	**3.44**	**0.82**

Significant direct relationship between yield and number of pods per plant and TSW was determined by correlating coefficients. Between number of plants per hectare and number of seeds per pods was noted a negative correlation. Very important relationship between number of pods per plants and TSW documented significance of weather condition during formation of yield component and its influence on yield of peas. Significant relationship of fertilization treatments was noted only between numbers of seeds per pod (Tab. 4).

Table 4

Correlation between yield of seeds and yield components of common pea

Components	Number of plants per ha	Number of pods per plant	Number of seeds per pods	TSW
Yield of seeds	0.1305	0.7936^{++}	-0.0987	0,8604^{++}
Ferilization (PZ PH)	-0.1261	-0.0560	0.3594^{+}	-0.0594
Number of plants per ha	-	-0.1100	-0.5739^{++}	0.1268
Number of pods per plant			-0.2054	0.6755^{++}
Number of seeds per pods				-0.1320

Level of significance: P 0.05 = 0.33; P 0.01 = 0.42

ZUK-GOLASZEWSKA AND WIERZBOWSKA (2006) also confirm influence of fertilization on high of pea plants, number of pods and number of seeds per pods. The influence of mineral fertilization and incorporation of forecrop biomass was noted in different way. The lower seed yield (3.1 t ha^{-1}) and lower yield of straw (3.45 t ha^{-1}) was in treatments with incorporation of forecrop plant biomass without mineral fertilization. Due to the immobilization of nitrogen via biomass residue the yield of seeds was negatively influenced.

The significantly higher yield of seeds and yield of peas straw was reached on treatment with incorporation of maize biomass together with mineral fertilizers. Yield of straw and seeds in treatments with mineral fertilization treatments (PH) and mineral fertilization with incorporation of fore crop biomass (PH+PZ) was on the same level.

Crop straw in all years exceeded seed yield, as demonstrated by harvest index from 0.82 to 0.94. The yield of straw and seeds is documented in figure 3.

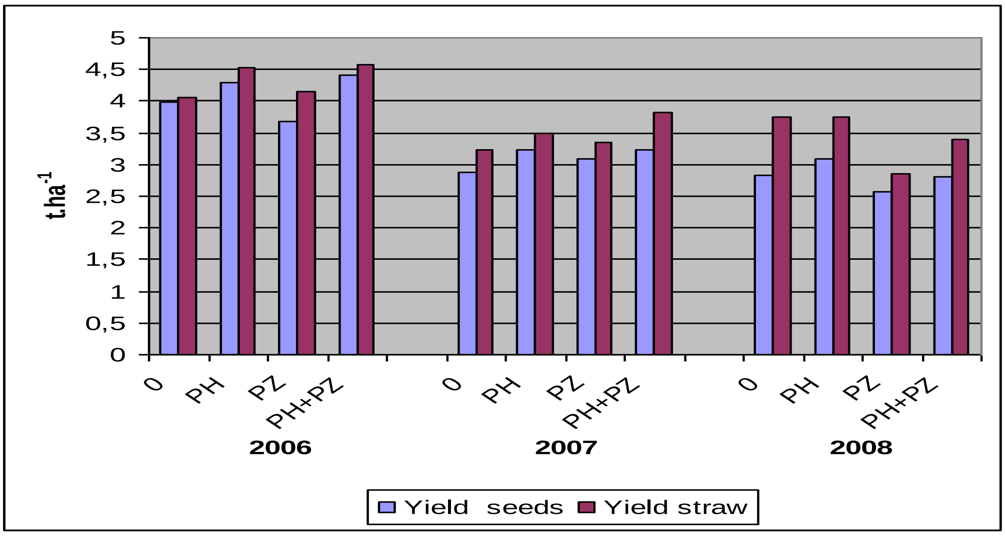

Figure 3: The yield of pea seeds and straw during 2006-2007

According ANOVA results (Table 5) yield of seeds was significantly influenced by the climatic conditions of each year . The higher peas yield of 4.09 t ha^{-1} was noted in 2006 in spite of lower yield of 2.82 t ha^{-1} in 2008. A significant effect of yield of peas straw was observed in 2006. In 2007 – 2008 we don't observe a significant effect of straw yield .

Table 5

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

Factor	Yield of seeds (t ha^{-1})	Yield of straw (t ha^{-1})
Year	P 0.05 = 0.0936	P 0.05 = 0.0643
2006	4.09c	4.33b
2007	3.11b	3.47a
2008	2.82a	3.44a
Fertilization treatments	P 0.05 = 0.1081	P 0.05 = 0.0743
0	3.23b	3.68b
PH	3.53c	3.92c
PZ	3.10a	3.45a
PH+PZ	3.48c	3.93c

The means followed by the same letter are not significantly different at P 0.05< probability level

The significantly higher yield was reached in mineral fertilization treatments (3.53 t ha^{-1}) and with a combination with forecrop biomass incorporation (3.48 t ha^{-1}) respectively. Incorporation of maize biomass without supplement of nitrogen mineral fertilization decreases significantly the yield of seed due to nitrogen depression (3.1 t ha^{-1}). According KADAR ET AL. (2003) dose of nitrogen more than 100 kg ha^{-1} decreased the yield. Phosphorus is important in early growing stages. Influence of nitrogen and potassium is dominant during ripening period.

CONCLUSIONS

The yield of seeds was significantly influenced by year climatic conditions. The highest yield of 4.09 t ha^{-1} was noted in 2006 in spite of lower yield of 2.82 t ha^{-1} in 2008. The same tendency was noted by yield of straw, but yield of straw was higher than yield of pea seeds. The proportion of seeds yield on the total biomass was expressed as harvest index, which was in range 0.79-0.96.

The significantly higher yield was reached in mineral fertilization treatments (3.53 t ha^{-1}) and mineral fertilization with a combination of forecrop biomass incorporation (3.48 t ha^{-1}) respectively. Incorporation of maize biomass without supplement of nitrogen mineral fertilization significantly decreases the yield of seed due to nitrogen depression (3.1 t ha^{-1}).

Significant direct relationship between yield and number of pods per plant and TSW, and negative correlation between number of plants per hectare and number of seeds per pods was noted. Very important relationship between number of pods per plants and TSW documented significance of weather condition during formation of yield component and its influence on yield of peas.

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