YIELD FORMATION OF COMMON PEAS AND NUTRIENT UPTAKE

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Abstract: *During 2010-2012, the field trial of pea variety Xantos was established on Experimental site of SAU in Nitra (E 18º09', N 48º19') with altitude of 175 m. 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. 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 tested variety is medium early, semileafless type, with good plasticity to soil and climate condition. 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 supplemented with mineral fertilizer to the balance equilibrium level. Common pea (Pisum sativum L.) 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 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. Year condition of evaluated years differ significantly mainly in precipitation pattern. In 2012, the warmest (+1.5 °C above LTA) dry condition (87.8 °C of LTA) was noted. The wettest year was 2010 (61% above LTA). In 2011, the most suitable wheatear conditions were determined. The yield of pea was highly significantly influenced by year conditions and significantly by mineral fertilization treatments. The highest seed yield (2.11 t ha^{-1}) and straw (4.04 t ha^{-1}) was reached in 2011. The lowest yield of pea seeds (1.03 t ha^{-1}) and straw (1.79 t ha^{-1}) was noted in 2012. The close relationship between biomass production and fertilization and forecrop residues incorporation was determined (r=0.9592^{+++}). The highest nitrogen uptake was in 2011 (65.14 kg ha^{-1}) on mineral fertilization treatment with incorporation of forecrop aboveground biomass of maize. The phosphorus and potassium uptake was the highest in wet year (2010) also on mineral fertilization treatment with incorporation of forecrop aboveground biomass of maize. The lowest uptake of P and K was on the control treatments. The lowest total nutrient uptake was in 2012 due to lack of soil moisture and high temperature, thereby was limited function of the root system.*
Key words: *common pea, harvest residues, fertilization, nutrient, yield*

INTRODUCTION

Field pea is cultivated for its seeds that are rich in protein. The effect of pea cultivation on succeeding winter cereals and winter oilseed rape nitrogen nutrition is very important part of crop rotation. Post harvest residues and aboveground biomass are important part of nutrient cycles with positive influence on nutrient balance of crop rotation as a source of nutrient for next growing crops. Incorporation of cereals, legumes, oil crops straw and sugar beet post harvest residues in crop rotation in an average 10.2 kg N. 3.9 kg P_2O_5 a 24.5 kg K_2O is return into the soil per hectare (HLUŠEK ET AL., 2007).

As a legume, pea plant has the ability to symbiotically fix N_2. However, symbiotic N_2 fixation is very sensitive to environmental stresses that affect plant growth. KOVÁČIK (2001) states, that the proportion of symbiotically fixed nitrogen on the total nitrogen content of pea biomass is 50%. VANĚK, LOŽEK ET AL. (2013) recommend nitrogen fertilization of 40 kg ha^{-1} only on less fertile soils or inappropriate condition for biologic fixation. The interaction effect of phosphorus and bio-fertilizers is significant on number and dry weight of root nodules and seed yield (Bhat et al., 2013).

The inadequate fertilization regarding soil conditions and plant needs, can cause severe nutritional unbalances, manifested through the apparition of some characteristic plant phenotype symptoms which lead to a significant regression of production and quality (CIOBANU et al., 2007; ONDRIŠÍK et al., 2009) and the yield formation is very complex physiological process determined by many environmental factors (POSPIŠIL and CANDRÁKOVÁ. 2004). Yields of common peas are highly variable, they progress slowly as compared to non-leguminous crops and this could be inferred to nitrogen nutrition (HANÁČKOVÁ et al. 2010). Due to the acreage of common peas decreased in Slovakia from 9046 ha in 2010 to 3256 ha with an average yield 2.04 in 2013.

The aim of the research was to evaluated the influence of mineral fertilization and forecrop biomass incorporation on yield of common peas biomass with relationship to nutrient withdraw in specific agro climatic condition of south western Slovakia.

MATERIAL AND METHODS

The polyfactorial field trial was carrying out during 2010-2012 on Experimental site of Slovak Agricultural University in Nitra, in south-western Slovakia (E 18º09'. N 48º19') with altitude of 175 – 180 m above 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 growing season is 16.2°C. Agro-climatic sub-area is characterized as very dry. 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 forecrop for common pea 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. Tested variety of pea Xantos was realised from 2004. The tested variety is semileafless type, intermediate height with good resistance to lodging. Seed is green yellow, with average TKS of 259 g for food and feed purposes.

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.

Nutrients were added on the base of balance method according to nutrient content in soil on yield level of 4 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 et al., 2000). Due to the good phosphorus and potassium stocks in soil, replacing system was used. Dose of phosphorus in form of superphosphate (dose 25 kg ha^{-1} of P) and potassium in form of 40% potassium salt fertilizer (dose 112 kg ha^{-1} K) was also applied each year. In spring, 20 kg ha^{-1} of mineral nitrogen as a starting dose was also applied. Sowing periods was as follows: March 25, 2010; March 25, 2011 and March 22, 2012. Dates of harvest were as follows: July 19, 2010; July 6, 2007 and July 3, 2012. Sowing dose was 1.1 million germinable seeds per ha each year.

Table 1

Agrochemical soil analysis (Mehlich III), experimental site Dolná Malanta

Year	Content of available nutrients in soil (mg kg^{-1})				pH_{KCl}	Humus (%)
	P	K	Ca	Mg		
2010	88	305	1215	325	6.08	2.12
2011	82	253	1050	295	5.75	1.81
2012	75	280	1110	280	6.05	1.91

RESULTS AND DISCUSSION

The variety Xantos was evaluated for 2010-2012 growing period. The evaluated years differ in humidity and temperature condition (Figure 1 and 2). The year 2012 was the warmest and the wettest conditions were examined in 2010 (more than 61% of LTA (Tab. 2).

Table 2

Temperatures and rainfalls patterns in 2010-2012, experimental site Dolná Malanta

Year	Temperature (°C)	Differences from normal	Rainfall (mm)	% of normal
Long Term Average (1961-1990)	9.7	0	539.0	100
2010	9.9	+0.2	868.8	161.1
2011	10.4	+0.7	607.9	112.7
2012	11.2	+1.5	473.3	87.8

The year 2012 was warmest up to 1.5 C° with relation to LTA with great deficit of moisture - less than 87.8 %. Temperature in the initial period of growth, flowering phase and seed formation are crucial and should not exceed 25 C° (Hanáčková et al., 2010). The most suitable year for growing of peas was 2011.

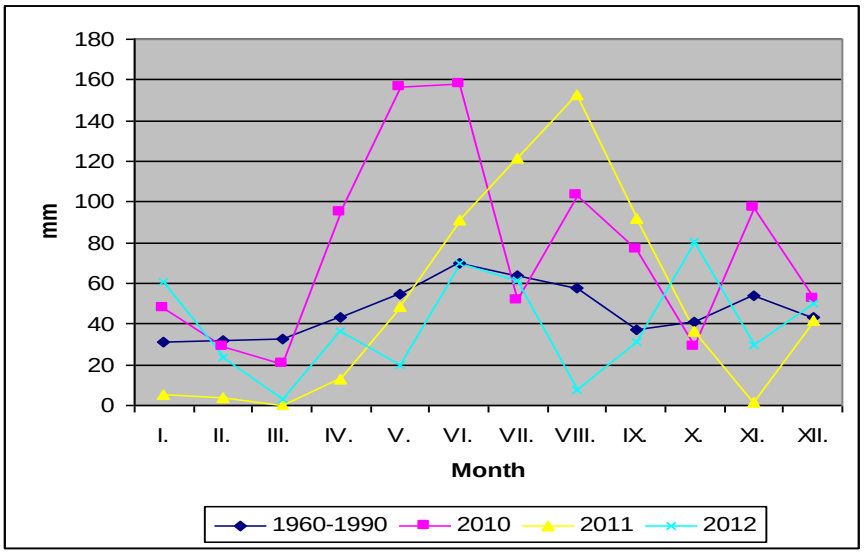

Figure 1: Weather conditions in years 2010-2012 – sum of precipitation (mm)

For yield formation the most important factor is precipitation pattern during creation of generative organs of peas (ČERNÝ et al., 2012) it is usually during Mai and first decade of June in Slovakia. It was confirmed by results in 2011. In spite of warmer condition in June (up to 1.8 C° of LTA) with sufficient normal dose of precipitation, temperature has no negative impact to the yield formation.

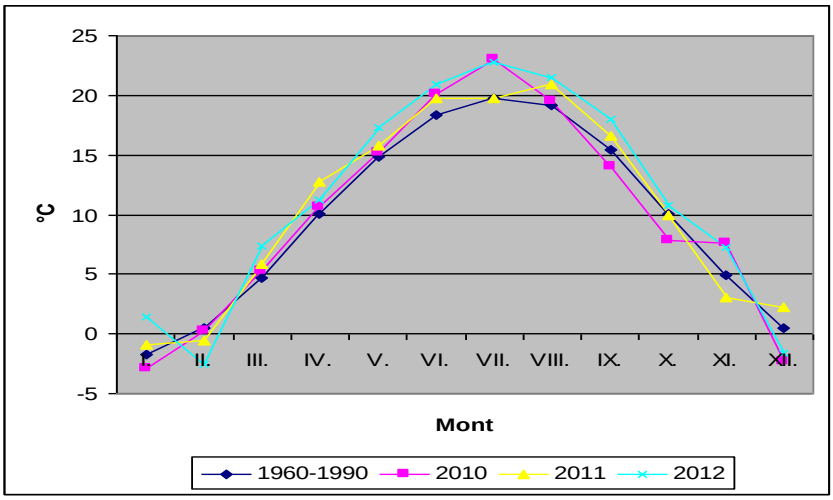

Figure 2: Weather conditions in years 2010-2012 – temperature (°C)

In 2011, the highest average yield of seeds (2.11 t ha $^{-1}$) and straw (4.04 $^{-1}$) was reached (Tab. 3). Conversely, humidity in May 2012 was only 33% of normal level and even at normal humidity in June did not replace mentioned deficit. Yield of seeds (1.03 t ha $^{-1}$) and straw (1.79 t ha $^{-1}$) was significantly the lowest in 2012.

Table 3

Yield of seeds and straw of common peas variety Xantos, 2010-2012

Year	Treatment	Seed yield		Yield of straw	
		t.ha^{-1}	rel. %	t.ha^{-1}	rel. %
2010	0	1.30	100.0	3.71	100.0
	PH	1.76	135.3	4.11	110.8
	PZ	2.14	113.8	4.06	103.5
	PH + PZ	2.19	168.4	2.72	73.3
	$\bar{x}$	1.85	-	3.65	-
2011	0	1.88	100.0	3.92	100.0
	PH	2.05	109.0	3.93	100.2
	PZ	2.14	113.8	4.06	103.5
	PH + PZ	2.38	126.6	4.23	107.9
	$\bar{x}$	2.11	-	4.04	-
2012	0	0.91	100.0	1.88	100.0
	PH	1.14	125.2	1.94	103.1
	PZ	1.13	124.1	1.84	97.8
	PH + PZ	0.95	104.4	1.49	79.2
	$\bar{x}$	1.03	-	1.79	-
Average years	0	1.36	100.0	3.17	100.0
	PH	1.65	121.3	3.33	105.0
	PZ	1.68	123.5	3.11	98.1
	PH + PZ	1.84	135.2	2.81	88.6
	$\bar{x}$	1.66	-	3.16	-

0 - unfertilized control; PH - mineral fertilizers; PZ - post-harvest residues; PH+PZ – mineral fertilizers + biomass of forecrop

The significant influence of year condition on yield of seeds and yield of straw was noted. The fertilization treatments have also significant influence on evaluated parameters of seed and straw yield. According average value of three evaluated years the highest yield was reached after application of mineral fertilization with incorporation of all forecrop maize biomass (1.84 t ha^{-1}) with less level of straw production (2.81 t ha^{-1}). In this evaluated period also incorporation of all forecrop biomass support higher yield of peas (nitrogen depression was not occur). The positive significant influence was noted also in mineral nitrogen fertilization treatments with comparison to zero treatments (Tab. 4). This is with concordance with result of ŠARIKOVÁ (2005).

In 2010 and 2011, the highest seed yield was reached after application of mineral nitrogen fertilizers together with incorporation of all forecrop biomass, but conversely in year condition of 2012 the yield of seeds was less than in treatments with mineral nitrogen fertilization (PH) or incorporation of forecrop biomass (PZ).

Table 4

Yield differences of seed and straw between the levels of examined experimental factors (LSD test at the P 0.05 level of significance)

Factor	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})
Yield	P 0.05 = 0.0672	P 0.05 = 0.2255
2010	1.84b	3.65b
2011	2.11c	4.03c
2012	1.03a	1.78a
Fertilization	P 0.05 = 0.0553	P 0.05 = 0.2604
0	1.36a	3.17ab
PH	1.65b	3.33b
PZ	1.81c	3.32b
PH+PZ	1.84c	2.81a

In spring, 20 kg ha^{-1} of mineral nitrogen as a starting dose was also applied in our treatments. According results of eight application terms of nitrogen fertilization at the different development stage of common peas, there is now evidence of different influence of these application terms on yield of common peas (SOUZA et al., 2008). The yield is strongly dependent from nutrient uptake. Uptake of nutrients is dependent on soil nutrient resources, nutrients resources from mineral fertilizers, soil ecological factors and interference influence between nutrient uptake and plant uptake capacity.

The direct phytomass production and nutrient uptake is documented by linear regression graph (Figure 3) with high determination coefficient R^2 – 0.921 in PH +PZ treatments.

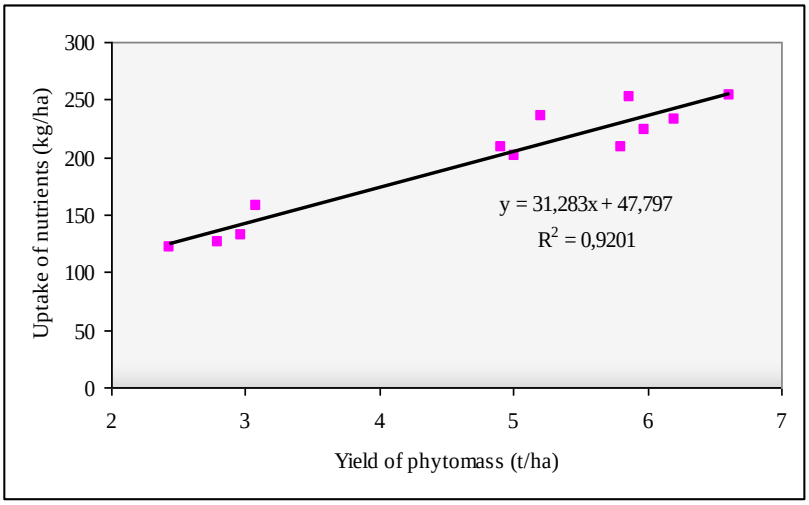

Figure 3: Relationship of the seed phytomass yield and uptake of nutrients in PH+PZ treatment

The nutrient balance was influence by nutrients uptake of peas biomass of and management of aboveground biomass (removing or incorporation).

The highest nitrogen uptake was noted on zero treatment and the lowest uptake was noted on treatment with nitrogen fertilization together with incorporation of all biomass production of maize as a forecrop – PH +PZ treatment (tab. 5).

The highest uptake of phosphorus, potassium and calcium was reached on fertilization treatment. High level uptake of magnesium was noted on the mineral nitrogen fertilization and zero treatments both.

According (FECENKO and LOŽEK et al., 2000), pea seeds under the normative nutrients withdrawing per 1 ton of crop 63 kg N, 7.4 kg P, 37.4 kg K, 25 kg Ca and 3.6 kg Mg.

We determined lesser uptake of some nutrient on the level 46.8 kg N; 6.01 kg P; and 23.5 kg ha Ca. Uptake of potassium (38.4 kg K) and magnesium (6.5 Mg) was higher than normative uptake.

Table 5

Nutrient uptake of 1 tone of seeds of peas variety Xantos including adequate amount of straw, during 2010-2012 at Dolná Malanta experimental site

Treatment	N	P	K	Ca	Mg
	kg t^{-1}				
0	50.7	6.3	40.7	26.4	6.8
PH	47.8	6.5	41.1	25.8	6.8
PZ	45.6	5.6	39.0	22.7	6.2
PH + PZ	43.1	5.6	32.7	19.0	6.0
Average	46.8	6.01	38.4	23.5	6.5

Nutrient uptake by pea seeds differs by year and treatment (tab. 6). The highest nitrogen uptake was on PH+PZ treatments on the level of 65.14 kg ha^{-1} in 2011. The highest uptake of P and K was noted in wet year 2010 also on PH +PZ treatments with comparison to low uptake of nutrient at the zero treatment.

The lowest total uptake of N, P, K nutrients was noted on PH+PZ treatment in 2012. Main reason was higher temperature and insufficient amount of available soil moisture which restricted function of plants root.

Table 6

Nutrient uptake of 1 tone of seeds of peas variety Xantos, during 2010-2012 at Dolná Malanta experimental site

Treatment	Year	Nutrient uptake (kg ha^{-1})									
		seed					biomass				
		N	P	K	Ca	Mg	N	P	K	Ca	Mg
0	2010	32.88	5.52	14.38	3.47	3.00	74.67	9.43	64.06	43.44	9.43
	2011	49.85	6.48	15.19	3.87	4.09	77.76	8.19	63.85	45.98	12.33
	2012	31.48	5.61	13.37	0.66	1.42	54.49	8.27	38.30	18.50	6.11
$\bar{x}$		38.07	5.87	14.31	2.67	2.84	68.97	8.63	55.40	35.97	9.29
PH	2010	43.75	8.16	19.34	4.66	3.08	84.84	13.16	85.84	57.28	10.46
	2011	55.11	7.18	16.84	5.45	4.83	84.61	9.01	66.35	48.88	14.89
	2012	36.35	6.99	16.79	0.89	1.72	67.21	9.89	51.17	21.33	8.43
$\bar{x}$		45.07	7.44	17.66	3.67	3,21	78.89	10.69	67.79	42.50	10.23
PZ	2010	45.89	7.95	18.91	4.08	4.73	80.33	12.18	81.20	52.37	9.96
	2011	59.09	6.75	16.42	4.93	7.07	77.76	8.19	63.85	45.98	12.33
	2012	38.61	4.80	16.50	0.64	1.67	60.32	7.58	43.85	14.50	5.50
$\bar{x}$		47.86	6.50	17.28	3.22	4.49	77.80	9.32	62.97	37.62	9.26
PH+PZ	2010	57.81	9.92	24.57	5.03	6.09	86.16	12.77	62.52	34.13	12.26
	2011	65.14	8.38	20.01	5.49	5.20	96.55	10.37	76.88	55.18	14.89
	2012	31.21	5.69	14.00	0.78	1.56	55.07	7.68	37.87	15.50	6.01
$\bar{x}$		51.39	5.00	19.53	3.77	4.,28	79.26	10.27	59.09	34.94	11.02
Average		45.60	6.20	17.19	3.33	3.71	74.98	9,73	61.31	37.76	10.20

CONCLUSIONS

According three year field study of common peas variety Xantos we can conclude the main results as follows:

The yield of pea was highly significantly influenced by year conditions and significantly by mineral fertilization treatments. The highest seed yield (2.11 t ha^{-1}) and straw (4.04 t ha^{-1}) was reached in 2011. The lowest yield of pea seeds (1.03 t ha^{-1}) and straw (1.79 t ha^{-1}) was noted in 2012. The close relationship between biomass production and fertilization and forecrop residues incorporation was determined (r=0.9592^{+++}). The highest nitrogen uptake was in 2011 (65.14 kg ha^{-1}) on mineral fertilization treatment with incorporation of forecrop aboveground biomass of maize. The phosphorus and potassium uptake was the highest in wet year (2010) also on mineral fertilization treatment with incorporation of forecrop aboveground biomass of maize. The lowest uptake of P and K was on the control treatments. The lowest total nutrient uptake was in 2012 due to lack of soil moisture and high temperature, thereby was limited function of the root system.

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of agrienvironmental indicators of sustainability and production capability of agroecosystem by diversification of crop rotation pattern in changing climate.

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