THE YIELD PRODUCTION OF PEA AS AFFECTED BY TILLAGE SYSTEMS AND FERTILIZATION GROWING IN SOUTH-WESTERN SLOVAKIA

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Abstract: *During 2008-2010, the field trial with pea variety Dunaj was carried out after wheat forecrop each year. The experimental site of Slovak Agricultural University in Nitra is located in south-western Slovakia (E 18º09', N 48º19') with altitude of 175 m above MSL. 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.There were three tillage treatments (O1-medium deep ploughing to 0.24 m, O2-shallow ploughing to 0.15 m, O3-disc tools to 0.12 m and fertilization treatments H1-control treatment, H2-inorganic fertilizers (P and K on yield 3 t ha^{-1}), H3-inorganic fertilizers and incorporation of forecrop residues. Grain yield of pea was highly significantly influenced by the year, tillage and fertilization. The highest seed yield of 4.27 t ha^{-1} was in the wet year 2010. Lack of humidity supported only 2.15 t ha^{-1} in 2009. Mouldboard ploughing has created significantly the most suitable condition with average yield in shallow ploughing (3.01 tha^{-1}) and in medium deep ploughing treatment (2.98 t ha^{-1}). Fertilization treatments significantly influenced the yield by application of inorganic fertilizer (3.08 t ha^{-1}) and by combination of inorganic fertilizers and incorporation of forecrop residues (2.99 t ha^{-1}) with comparison to control treatment (2.74 t ha^{-1}).On the base of correlation analysis the highly significant direct relationship between yield and number of pods per plant (r=0.77^{++}), and TSW (r=0.60^{++}) was determined. Year condition related to the plant density of crop (r=0.43^{++}) and number of pods per plant (r=0.51^{++}). No relationship between fertilization treatment and yield component was found. Indirect relationship between plant density and number of pods per plant (r=-0.33^{++}) and TSW (r=-0.64^{++}) respectively was determined, but plant density and number of seeds per pod revealed high relationship (r=0.59^{++}). Indirect relationship between number of pods and number of seeds per pod (-0.52^{++}) and between number of seeds per pod and TSW (r=-0.83^{++}) was also determined.*

Keywords: *common pea, soil tillage, fertilization, yield, seed composition*

INTRODUCTION

The nature of agriculture and farming practices in any particular location are strongly influenced by the long-term mean climate state. The experience and infrastructure of local farming are generally appropriate to particular types of farming and to a particular group of crops which are known to be productive under the current climate (GORNALL et al., 2010).

Pulses are an important group of agricultural crops, not only in terms of agronomic, but also have an important role in the diet of humans and animals. Nevertheless growing area steadily declined in Slovakia and is now moving at 6000-8000 ha. Irregular rainfall pattern is getting more frequent. Common pea is grown on an area of around 4,000 hectares with an average seed yield up to 2.0 t ha^{-1} (JAMBOROVÁ, 2014).

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).

The suitable tillage technology can help to stabilize the canopy of pea. According KOVÁČ et al. (2005) conventional tillage treatment with interaction of crops created the better soil moisture condition after a cropping of common peas with comparison to no till technology. Tillage research and the impact of tillage on field pea is very important part por improving sustainability of production. . However, there is no published research describing the impact of replacing CT with RT on field pea performance in agro-ecoregion of south-western Slovakia. Introduction of a pea to improving soil organic matter recommends KOVÁČ et. al. (2014) and field pea is a good crop, especially in crop rotation with prevailing cereals. A second argument is the value of these crops as food, because of the high content of essential amino acids, protein from beans of lentils and chickpeas and their high digestibility (NIȚĂ et al., 2011),

The aim of the experiment was to verify the suitable tillage methods, fertilization practices and benefit of forecrop residues to the yield production of field pea growing under the climatic conditions in south-western Slovakia.

MATERIAL AND METHODS

The polyfactorial field trial of common pea was established on Experimental site of Slovak Agricultural University in Nitra during 2008-2010. Experimental site is located 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 20 m^2 (10 x 2 m), in four replications. Maize as a forecrop was used. There were three tillage treatments (O1-medium deep ploughing to 0.24 m, O2-shallow ploughing to the 0.15 m, O3-disc tools to the 0.12 m and fertilization treatments H1-control treatment, H2-inorganic fertilizers (P and K on yield level of 3 t ha^{-1}), H3-inorganic fertilizers and incorporation of forecrop residues.

Mineral 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). Date of sowing and harvest was as follows: 26.3.2008 - 5.7.2008; 3.4.2009 - 16.7.2009 and 23.3.2010 - 15.7.2010. One million of germinating seeds of Slovak variety Dunaj was applied to the depth of 0.05 m with interrow spacing of 0.125 m.

Data were subjected to statistical analyses by using Statgraphic 5 software.

RESULTS AND DISCUSSION

It is common knowledge that leguminous plants are characterized by specific traits including, among others, high dependency of pod setting and pod dropping on weather conditions. In addition, their yielding is influenced by co-effects of weather and agro technical conditions; therefore the variability of yielding may be high and difficult to predict (DORÉ et al., 1998).

Other important environmental factors are water and temperature. The course of the temperature and rainfall is shown in Table 1.

Water supply of the soil in the period of January and February is very important. In 2008, dose of rainfall in March (62.7 mm) compensate the lack of precipitation during February (20.2 mm) according to WMO climate normal.

The same scenario was noted in 2010, when precipitation in April was higher up to 47 mm above climate normal which compensate the lack of precipitation in March. Year 2010 can be characterized as wet. The higher lack of precipitation was noted in April and May in 2009.

Table 1

Rainfall (mm) a temperature (°C) in spring months in years 2008 - 2010

Year	Rainfall (mm)							
	January	February	March	April	May	June	July	Summary
1961-1990	31.0	32.0	30.0	39.0	58.0	66.0	52.0	308.0
2008	30.0	20.2	62.7	36.3	55.4	862	90.0	380.8
2009	41.7	57.3	53.6	10.1	38.1	794	69.8	350.0
2010	48.2	28.8	24.2	86.0	158.0	1313	68.9	545.4
	Temperature (°C)							
1961-1990	-1.7	0.7	4.0	10.4	15.1	18.0	19.8	9.5
2008	1.4	3.5	5.5	11.0	16.0	19.9	20.4	11.1
2009	-1.3	1.2	5.5	14.0	15.5	17.1	20.6	10.4
2010	-2.9	0.2	5.3	10.6	15.2	20.1	22.9	10.2

The temperature curve was normal during evaluated years except April in 2009 which was extraordinary warm (14.0 °C). The impact of weather fluctuation of evaluated years to yield production of peas is demonstrated in Table 2. Average yield of seeds differ significantly between evaluated year conditions. The sufficient amount of precipitation support the yield potential of Dunaj variety and very high yield was received (more than twice). Evidence of relationship between seed yield and yield of straw is evident in 2010.

Productivity of plants is determined by multiple factors that directly affect one another, therefore yield variability may be high and difficult to predict. Most often, however, a lower crop yield is achieved in the no-tillage system than in the ploughing system (WOŹNIAK, 2013).There is no significant difference between conventional tillage (O_1) and reduce tillage (O_2, O_3). This is not with concordance to result of HANÁČKOVÁ et al. (2010), who received best results under conventional tillage. Shallow ploughing to the 0.15 m (O_2) significantly created better soil condition with comparison to O3-disc tools to the 0.12 m (Table 2).

Fertilization treatments also significantly influence the yield of seeds and straw. Application of mineral fertilizers and their combination with incorporation of forecrop residues significantly increase the yield of seeds up to 0.25 -0.34 t ha^{-1} or expressed in relative units 10.7% - 12.4%.

Table 2

Yield differences of seed and straw between the levels of examined experimental factors. Tukey test Yield of seeds: P 0.05 = 0.1715, P 0.01 = 0.2171. Yield of straw: P 0.05 = 0.1713, P 0.01 = 0.2191

Factors		Yield of seeds (t ha^{-1})	Yield of straw (t ha^{-1})
Year	2008	2.40b	2.03a
	2009	2.15a	2.82b
	2010	4.27c	5.54c
Soil cultivation	O1	2.98ab	3.51b
	O2	3.01b	3.60b
	O3	2.82a	3.28a
Fertilization treatments	H1	2.74a	3.21a
	H2	3.08b	3.57b
	H3	2.99b	3.61b

The means followed by the same letter are not significantly different at P 0.01< probability level

KOVAC, NOZDROVICKÝ, MACAK, et al. (2010) demonstrates the benefits of minimization technology also on the economy of crops, including pea.

According POSPIŠIL et al. (2014) the high energy efficiency was determined in reduce tillage of common peas.

The influence of fertilization treatments in different tillage system during 2008-2010 is demonstrated in Figure 1.

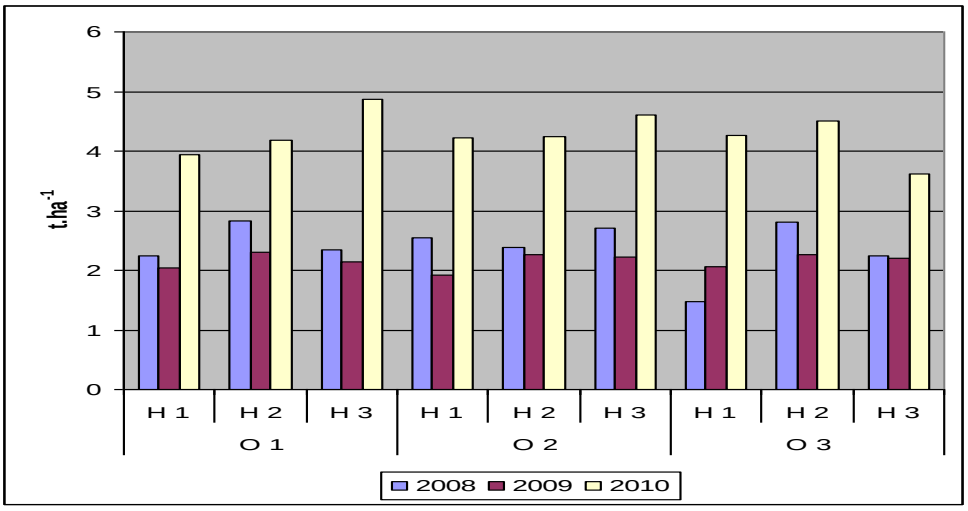

Figure 1 The yield of pea seeds during 2008-2010

The yield of seeds is influence by key yield components. Number of plants per square meter is dependent on number of germinated seeds. Pea seeds need about 90% water by weight of seeds (POSPIŠIL and CANDRÁKOVÁ, 2004). The sufficient amount of accessible water for pea seeds is crucial for establishment of high density stand.

Table 3

The yield components of common pea variety growing under different tillage in 2008-2010

Year	Treatments	Number of plants per square m	Number of pods per plant	Number of seeds per pods	TKW
2008	O1	75	3,77	4,42	247,54
	O2	68	4,32	4,98	246,05
	O3	70	3,95	4,12	245,71
	$\bar{x}$	**71**	**4,01**	**4,51**	**246,43**
2009	O1	95	3,40	6,49	151,56
	O2	90	3,61	6,15	144,40
	O3	92	3,81	6,82	144,60
	$\bar{x}$	**92**	**3,61**	**6,49**	**146,85**
2010	O1	88	6,39	3,03	287,12
	O2	92	6,10	3,06	277,19
	O3	87	5,64	3,25	282,84
	$\bar{x}$	**89**	**6,04**	**3,11**	**282,84**
Total average		**84**	**4,55**	**4,70**	**225,22**

The better humid condition was in 2010 which reflect higher parameters of yield components and the significantly higher yield of pea seeds.

The parameters of yield components as influence by tillage treatments and fertilization treatments are in Table 3 and Table 4.

Tillage conditions differentiated plant number per 1 m^2. Number of seeds per plant was very similar in 2008 and 2010 in narrow interval 18.01 - 18.80. In spite of 23.42 seeds per plant and 92 plants per square meter, the year conditions of 2009 were not suitable for development of seed and 146.85 g of TSW was determined.

Table 4

The yield components of pea variety growing under different fertilization treatments in 2008-2010

Year	Treatments	Number of plants per ha	Number of pods per plant	Number of seeds per pods	TSW
2008	H1	69	3.90	4.03	243.03
	H2	68	4.32	4.98	246.05
	H3	69	4.18	4.89	250.02
	$\bar{x}$	**69**	**4.13**	**4.63**	**246.37**
2009	H1	87	3.51	6.01	146.86
	H2	96	3.70	6.94	146.23
	H3	91	3.48	6.51	144.46
	$\bar{x}$	**91**	**3.56**	**6.49**	**145.85**
2010	H1	88	5.68	3.07	283.05
	H2	89	6.08	3.07	279.79
	H3	90	6.37	3.20	284.31
	$\bar{x}$	**89**	**6.04**	**3.11**	**282.38**
Total average		**83**	**4.58**	**4.74**	**224.87**

Significantly indirect relationship between number of pods per plant and number of plants per ha (-0.33^{++}) and between TSW and number of plants per ha was determined (-0.64^{++}). Number of seeds per pods has indirect relationship to number of pods per plant and TSW. Very important positive relationship (0.6039^{++}) between yield of seeds and TSW was also confirmed (Table 5).

Table 5

Correlation relationship between factors 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	0.0508	0.7750^{++}	-0.4097^{++}	0.6039^{++}
Year	0.4376^{++}	0.5106^{++}	-0.0165	0.0638
Soil cultivation	-0.2210^{+}	0.2011	0.0074	0.0107
fertilization	0.0779	0.1098	0.1684	0.0317
Number of plants per ha	-	-0.3346^{++}	0.5979^{++}	-0.6418^{++}
Number of pods per plant	-	-	-0.5245^{++}	0.6723^{++}
Number of seeds per pods	-	-	-	-0.8328^{++}

Level of significance: P 0.05 = 0.22; P 0.01 = 0.28

On the base of correlation analysis the highly significant direct relationship between yield and number of pods per plant ($r=0.77^{++}$), and TSW ($r=0.60^{++}$) was determined. Year condition related to the plant density of crop ($r=0.43^{++}$) and number of pods per plant

($r=0.51^{++}$). No relationship between fertilization treatment and yield component was found. Indirect relationship between plant density and number of pods per plant ($r=0.33^{++}$) and TSW ($r=-0.64^{++}$) respectively but plant density and number of seeds per pod revealed high relationship ($r=0.59^{++}$). Indirect relationship between number of pods and number of seeds per pod (-0.52^{++}) and between number of seeds per pod and TSW ($r=-0.83^{++}$) was also determined.

The obtained results demonstrate the strong influence of environmental conditions. It is necessary to find most suitable local methods of cultivation.

CONCLUSIONS

The yield of seeds was significantly influenced by year conditions. The highest yield of 4.27 t ha^{-1} was noted in wet year of 2010. Lack of humidity supported only 2.15 t ha^{-1} in 2009.

Mouldboard ploughing has created significantly the most suitable condition with average yield in shallow ploughing (3.01 tha^{-1}) and in medium deep ploughing treatment (2.98 t ha^{-1}).

Fertilization treatments significantly influenced the yield by application of inorganic fertilizer (3.08 t ha^{-1}) and by combination of inorganic fertilizers and incorporation of forecrop residues (2.99 t ha^{-1}) with comparison to control treatment (2.74 t ha^{-1}).

The highly significant direct relationship between yield and number of pods per plant ($r=0.77^{++}$), and TSW ($r=0.60^{++}$) was determined. Year condition related to the plant density of crop ($r=0.43^{++}$) and number of pods per plant ($r=0.51^{++}$). No relationship between fertilization treatment and yield component was found. Indirect relationship between plant density and number of pods per plant ($r=-0.33^{++}$) and TSW ($r=-0.64^{++}$) respectively but plant density and number of seeds per pod revealed high relationship ($r=0.59^{++}$). Indirect relationship between number of pods and number of seeds per pod (-0.52^{++}) and between number of seeds per pod and TSW ($r=-0.83^{++}$) was also determined.

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