PRECIPITATION AND TEMPERATURE EFFECTS UPON GRAIN YIELD OF FIELD PEA

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Abstract: Investigation of influences of precipitation and temperatures on grain yield of 8 genotypes of field pea was conducted in conditions of east Croatia. Locations, genotypes and interaction between them had highly significant effect on grain yield. Rainfall from February to May and rainfall during the pea vegetation were in very high positive correlation with average yield of pea, whilst temperatures in May and Jun were in negative correlation. Semigley soil type provided higher average yield than eutric cambisol in 2005.

Keywords: field pea, grain yield, precipitation, temperature

Introduction

Temperature and precipitation are among main factors that influence crop yields. Knowing the effect of a.m. factors on specific crop and cultivar helps in bringing decisions during the production process. Investigations of Borbély et al. (2007), Nagy (2007) and Hoffmann et al. (2007) showed that different crops have different needs upon precipitation and its distribution over the crop year while Borbély et al., (2007) and Hoffmann et al. (2007) emphasize the importance of soil water reserve as well. According to Lesznyák et al. (2007) in environment with 185 mm of natural rainfall during the pea vegetation, irrigation of 60 mm can increase grain yield of some cultivars for 89 to 751 kg ha^{-1}. Payne et al. (2000) reported that both winter precipitation and precipitation during the vegetation had highly significant positive effect on dry pea yield, while the effect of precipitation during the vegetation was stronger than of winter precipitation. The same authors point out that the sum of maximum daily temperatures above 25.6 °C during the reproductive phases of crop had negative effect on yield. The aim of this research was to investigate the influences of precipitation and temperature on field pea grain yield in conditions of east Croatia.

Materials and methods

Seven new field pea genotypes and variety Baccara as a standard were included in investigation. The trial was seeded as a random block design in 3 repetitions, in Osijek (eutric cambisol, pH 6.22 in water) in 2005, 2006 and 2007 year and in Nova Gradiška (semigley, pH 6.4 in water) in 2005 year. Dimensions of basic plot were 1 m × 5 m. Seeding stand was 120 seeds per square meter. Seeding dates in Osijek were 2nd April 2005, 30th March 2006, and 12th March 2007, and in Nova Gradiška 2nd April 2005. Harvest dates in Osijek were 30th Jun 2005, 5th July 2006, and 18th Jun 2007, and in Nova Gradiška 12th July 2005. Analysis of variance for grain yield as a split-plot design with location as a main factor and genotype as a subfactor, and correlation analysis between precipitation, temperatures and average location yields were performed using SAS/STAT software, version 8.

Results and discussion

Winter precipitation preceding the pea vegetation and precipitation and temperatures during the pea vegetation period differed among 4 locations in the conducted research (Table 1 and Table 2).

Table 1. Amount of precipitation preceding and during the pea vegetation (mm)

	Location			
Period	Osijek 2007	Osijek 2006	Osijek 2005	Nova Gradiška 2005
November-January	90.2	146.0	192.6	146.6
February	46.5	48.3	66.2	58.5
March	76.0	52.5	54.0	56.4
April	0.0	86.8	55.3	78.4
May	56.1	78.6	54.1	54.6
Jun	33.3	78	110.2	48.3
November-seeding	177.1	242.8	312.8	261.5
Seeding-harvest	114.9	261.3	219.6	253.6

Table 2. Temperatures during the pea vegetation (°C)

		Location			
	Period	Osijek 2007	Osijek 2006	Osijek 2005	Nova Gradiška 2005
Average month temperature (*until harvest)	April	13.3	12.7	11.5	11.2
	May	18.2	16.2	17.0	16.1
	Jun	21.5 *	20.1	19.5	18.9
Average of max. daily temperatures (*until harvest)	April	21.1	18,7	17.3	17.7
	May	24.8	22.2	22.7	22.5
	Jun	28.2 *	25.5	25.2	25.7
Sum of max. daily temp. above 25.6°C	10thMay-harvest	96.1	110.6	81.7	94.6
	May-15th Jun	86.9	18.3	43.7	47.8

Grain yields of field pea were highly significantly influenced by location, genotype and interaction between genotype and location (Table 3).

Table 3. Analysis of variance for grain yield of field pea

Source of variation	DF	SS	MS	F Value	Pr > F
Location	3	101.7886305	33.9295435	92.79 **	<0.0001
Genotype	7	8.3369278	1.1909897	3.26 **	0.0051
Genotype × Location	21	21.0661757	1.0031512	2.74 **	0.0010
Error	64	23.4026440	0.3656663		

All 4 locations differed significantly in average yield. The highest average yield among locations, of 4.8869 t ha^{-1} was achieved in Osijek 2006 while the location Osijek 2007 had the least average yield of 2.2070 t ha^{-1}. The highest average grain yield of 4.1210 kg ha^{-1} over 4 locations was achieved with new genotype G-07-3 . It did not differ significantly from the rest 6 new genotypes. Standard genotype differed significantly

against others only, with the least average yield of 3.0742 t ha^{-1} over 4 locations (Table 4).

Table 4. Average grain yields over genotypes and locations (t ha^{-1}) and least significant differences

	Average grain yields over locations				
Genotype	Osijek 2007	Osijek 2006	Osijek 2005	N. Gradiška 2005	Genotype avg.
G-07-1	2.385	5.107	3.613	4.292	3.8493
G-07-2	1.973	5.852	3.163	4.625	3.9036
G-07-3	2.426	5.832	3.380	4.846	4.1210
G-07-4	2.185	4.841	3.857	4.663	3.8862
G-07-5	2.230	5.299	3.537	4.175	3.8101
G-07-6	2.045	4.888	4.117	4.425	3.8687
G-07-7	2.139	4.864	4.233	4.775	4.0028
Standard	2.274	2.413	3.343	4.267	3.0742
Location average	2.207	4.887	3.655	4.509	3.8145
	LSD (p=0.05)	LSD (p=0.01)			
Location	0.3487	0.4634			
Genotipe	0.4932	0.6554			

Since the locations differed in weather conditions as well as in average yield, the correlation analysis was undertaken to discover the direction and strength of influences of precipitation and temperatures on average location pea yields.

Table 5. Correlation coefficients between precipitation and average yield of locations

Period	November-seeding	Seeding-harvest	November-harvest	February-May
Correlation coefficient	0.53721	0.98356	0.85213	0.99506
Level of significance	0.4628	0.0164	0.1479	0.0049

Observed precipitation was in positive correlation with average yields of locations. Precipitation during the period February to May was in very high correlation with average yield and had the highest positive correlation coefficient r = 0.99506. Precipitation during the period from seeding to harvest was in very high correlation with average yield too, with r = 0.98356 . The total winter and vegetation precipitation, from November to harvest was in high correlation (r = 0.85213) with yield but winter precipitation alone was in weak correlation (r = 0.53721) with average yields of locations (Table 5). These precipitation influences partly differed from Payne et al., (2000) because they found winter and during vegetation precipitation both had highly significant effect on pea yield, with winter precipitation having slightly less effect than precipitation during vegetation. In 2005 year the higher average yield was achieved in Nova Gradiška on semigley soil type than in Osijek on eutric cambisol, despite the higher total November to harvest (Table 1) precipitation in Osijek than in Nova Gradiška 2005, probably because of the soil type influence. Observed temperatures were in negative correlation with average pea yields of locations. Average month temperature of May and average of maximum daily temperatures of May were in very high negative correlation with yield, with correlation coefficients r = -0.98241 and r = -

0.96282, respectively. Since the seed setting occurs during May, this agrees with Jeuffroy et al. (1990) findings that elevated temperatures during the seed setting reduce the number of seeds per pod and consequently the yield. Sum of maximum daily temperatures above 25.6 °C from 10th May to harvest was in weak positive correlation, statistically insignificant, with yield (r = 0.39834) what disagrees with Payne et al. (2000) because of influence of extremely early harvest in Osijek 2007 and consequently low sum of temperatures connected with low yield. The sum of maximum daily temperatures above 25.6 °C from 1st May to 15th Jun was in very high negative correlation with yield (r = -0.92848). Correlation coefficients between yield and average month temperatures and average of maximum daily temperatures of Jun (r = -0.75067 and r = -0.83940, respectively) and April (r = -0.51488 and r = -0.70510, respectively) were relatively lower in comparison to correlations of May temperatures (Table 6).

Table 6. Correlation coefficients between temperatures and average yields of locations

	Average month temperatures			Average of max. daily temp.			Sum max. daily temp.>25.6°C	
Period	April	May	Jun	April	May	Jun	10thMay-harvest	1stMay-15th Jun
Correlation coef.	-0.51488	-0.98241	-0.75067	-0.70510	-0.96282	-0.83940	0.39834	-0.92848
Level of signif.	0.4851	0.0176	0.2493	0.2949	0.0372	0.1606	0.6017	0.0717

Conclusions

Conducted investigation of precipitation influences on average pea yields showed that precipitation from February to May was in highest positive correlation with average location yields (r = 0.99506). Precipitation during the pea vegetation was in very high correlation with average yield of location (r = 0.98356), whilst winter precipitation from November to seeding, which is being utilized by pea crop as reserve in soil, was in weaker positive correlation (r = 0.53721) with average yields. Semigley soil type provided higher average yield than eutric cambisol in 2005 year. Investigation of influence of temperatures showed that average May temperature and average of maximum daily temperatures of May were in very high negative correlation with average yields of locations (r = -0.98241 and r = -0.96282, respectively). The sum of maximum daily temperatures above 25.6 °C from 1st May to 15th Jun was also in very high negative correlation with yield (r = -0.92848).

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