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Utjecaj oborina na prinos sjemena ozimog stočnog graška

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THE INFLUENCE OF PRECIPITATION ON FORAGE PEA SEED YIELDS

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SUMMARY

Field pea (Pisum arvense L.), also known as Austrian winter pea, is increasingly being planted in Croatia and its surrounding to produce high-quality roughage. The main characteristics of the variety are short vegetation, high forage yields and excellent forage quality that is reflected in the high protein production. Seed production of peas is a very complex process. In agricultural production the yield is under the influence of plant genetic potential and environmental factors, especially of the precipitation amount during the growing season. Seed production of forage pea variety 'Osječki zeleni' along with the climatic conditions for a nine-year period (2004–2012) were analysed. The analyses showed large variability in yields, germination and 1000 grain weight as well as oscillations in the amounts of precipitation during the growing period of winter peas in the analysed years. Pearson's correlation coefficient analysis showed a lack of relation between yield, germination and 1000 grain weight. There was no correlation observed between the tested parameters and the total amount of precipitation during the growing period. Thus it can be concluded that the observed parameters were substantially influenced by other environmental factors.

Key-words: forage pea, seed production, precipitation, variety, correlation

INTRODUCTION

The forage pea (*Pisum arvense* L.) is becoming more interesting legume in the Republic of Croatia and worldwide. There are few advantages of forage pea primarily due to its protein-rich and high green mass yield, low financial investments and low technological requirements in forage production (Uher et al., 2007; Togay et al., 2008; Yildirim et al., 2008; Čupić et al., 2013; Ates et al., 2014). The other significant trait of forage pea production is early abandonment of fields (during May in temperate northern hemisfere) opening up the possibility of the second sowing and the year-round coverage of arable land, thus, maximizing the arable land usage. Also, forage pea leaves off significant quantities of organic matter and nitrogen in the soil for the subsequent crop (Annicchiarico and Iannucci, 2008; Erman et al., 2009; Liu et al., 2011; Samarappuli et al., 2014). Forage pea is almost "organically" produced since there is no need to use pesticides in the production and the use of mineral fertilizers is brought down to a minimum (Agafonova et al., 2011; Piotrowska-Dlugosz and Wilczewski, 2014).

The demand for forage peas has significantly increased in the past ten years, during which a large number of family farms invested significant resources into building dairy farms. Feeding dairy cows based on haylage forage pea can increase production and quality of milk (Čupić et al., 2010).

Sufficient quantities of seeds need to be produced for the expanding forage pea area. Forage pea seed production is more complex and uncertain than forage production, which is confirmed by the results of Tekeli and Ates (2003), Türk et al. (2011) and Tan et al. (2012). Difficulties in forage pea seed production are the first and foremost conditioned by plant height and stem structure. Plants of variety 'Osječki zeleni' are about 190 cm tall at the harvest time and lodge under the weight of their pods making harvesting significantly harder and increases seed loss. According to Kumar et al. (2013)

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plant height and stem thickness are morphological properties, genetically inherited, depending on crop variety and environmental factors. They are negatively correlated with seed yield. An analysis was carried out regarding the effect of precipitation on seed yield in the production of the forage pea seed of the variety 'Osječki zeleni' in the period from 2004 till 2012 at the Agricultural Institute Osijek.

MATERIAL AND METHODS

Forage pea seed production of the variety 'Osječki zeleni' in the period from 2004 till 2012 was carried out at the Agricultural Institute Osijek. During all the production years, 120 kg ha^{-1} of peas and 50 kg ha^{-1} of the wheat variety 'Žitarka' were sown in a mixture. The wheat variety used has a relatively low and strong stem and it was sown in order to mitigate the lodging of pea plants and to facilitate easier seed harvesting. In the analysed years, a mixture of forage peas and wheat was sown by a grain combine cereal seeder (with row spacing of 13 cm) with a rototiller, in succession after wheat or barley. The sowing was carried out directly after ploughing, in a single pass, between 15th October and 1st November. The soil where plants were sown was *Eutric Cambisol*, also known as brown soil, of a slightly acid to neutral reaction (pH in KCl 6.4–7.0) with over 30 mg 100 g^{-1} P_2O_5 and K_2O soil having about 2% of humus. 200 kg ha^{-1} of NPK mineral fertilizer with a concentration of 7:20:30 and 50–100 kg ha^{-1} of UREA were added to the experiment prior to sowing. The harvest was carried out with a combine harvester in the period between 25th June and 10th July, depending on climate conditions, i.e. when grain humidity was below 13%. The quantity of natural seeds (a compound of peas and wheat) was determined by weighing after the harvest. The weight of processed seeds and the yield of pure field pea seeds per hectare were determined after processing. The 1000 grain weight, germination energy and germination were determined using a pure seed sample. Seed processing as well as seed quality analyses were carried out in the processing facility and laboratory of the Seed Production Department at the Agricultural Institute Osijek.

Pearson's correlation coefficient analysis was performed by statistical program CropStat version 7.2 (IRRI, 2009) and phenotypic correlation between the investigated traits was calculated. The climate conditions: average monthly air temperatures and precipitation during forage pea vegetation and the long-term average (1971–2000) are presented in Tables 1 and 2.

Table 1. Mean monthly temperatures (°C) during the growing season for the observed years and for long-term period (LTA, 1971–2000) at the location Osijek, Croatia

Tablica 1. Srednja mjesečna temperatura zraka (^{0}C) tijekom vegetacije u promatranim godinama i višegodišnji prosjek za Osijek (VP, 1971.-2000. godine)

Month *Mjesec*	Year/*Godina*									LTA *VP*
	2004	2005	2006	2007	2008	2009	2010	2011	2012	
March/*Ožujak*	5.9	4.1	5.4	8.5	7.5	6.8	6.8	6.4	6.2	6.4
April/*Travanj*	12.0	11.5	12.7	13.3	12.5	14.6	12.4	13.2	11.5	11.2
May/*Svibanj*	15.4	17.0	16.2	18.3	18.1	18.3	16.5	16.7	16.5	16.7
June/*Lipanj*	19.8	19.5	20.1	22.3	21.5	19.2	20.4	20.7	19.8	19.6

Table 2. Monthly rainfall during the growing season (mm) for the observed years and for long-term period (LTA, 1971–2000) at the location Osijek, Croatia

Tablica 2. Mjesečna količina oborina tijekom vegetacije (mm) u promatranim godinama i višegodišnji prosjek za Osijek (VP, 1971.-2000. godine)

Year/ Month *Godina /Mjesec*	March *Ožujak*	April *Travanj*	May *Svibanj*	June *Lipanj*	Total *Suma*
2004	29.6	122.0	63.3	88.4	303.3
2005	54.0	55.3	50.5	110.2	270.0
2006	52.5	86.8	78.6	78.0	295.9
2007	76.0	2.9	56.1	33.3	168.3
2008	82.4	48.8	66.9	76.3	274.4
2009	26.5	18.7	39.4	62.8	147.4
2010	22.2	71.1	120.8	234.0	448.1
2011	37.2	19.9	80.1	50.2	187.4
2012	45.0	58.8	69.1	83.0	255.9
LTA/*VP*	40.5	51.0	59.2	82.0	232.7

RESULTS AND DISCUSSION

When observing the mean monthly temperature (Table 1) during the vegetation period throughout the analysed years of forage pea seed production, considerable deviation from the long-term average can be noticed. Temperatures were slightly higher than the long-term average during most months and years what did not contribute to the growth and development of the forage pea as it performs better in colder and wet conditions. Air temperature deviations were in range of +/–2°C from the long-term average. Larger deviations from the long-term average, particularly between production years, were noted in monthly precipitation (Table 2). During the vegetation period (March–June) the amount of precipitation by year varied from 147.4 to 448.1 mm, whereas the long-term average was 232.7 mm. Even larger deviations from the long-term average occurred in monthly precipitation, and therefore it was assumed that the major forage pea seed yield variations (Table 3) occurred due to the deviations of precipitation. Climate change, especially precipitation and temperature regimes, have a direct, often adverse, influence on the quantity and quality of field crop yields (Kovačević et al., 2013).

Table 3. Production of forage pea seeds at the Agricultural Institute Osijek for the observed years

Tablica 3. Proizvodnja sjemena ozimog stočnog graška na Poljoprivrednom institutu Osijek po godinama

Year *Godina*	Area sown *Površina sjetve* ha	Totally produced *Ukupno proizvedeno kg*	Total processed pea *Ukupno dorađeno* kg	Utilization % *Iskorištenje* %	Germination % *Klijavost* %	1000 seed weight *Težina 1000 zrna g*	Yield *Prinos* kg ha^{-1}
2004	8	10500	9170	87.3	91	105	1146
2005	9	11715	10280	87.7	85	116	1142
2006	10	21520	18215	84.6	95	104	1821
2007	16	31200	23980	76.9	86	106	1498
2008	15	37980	30750	80.0	84	89	2050
2009	20	45800	27960	61.0	83	117	1398
2010	15	31500	24300	77.1	93	91	1600
2011	23	65840	56470	85.8	91	111	2455
2012	12	36660	29040	86.3	83	108	2420

To verify the assumption, Pearson's correlation coefficient analysis was carried out in order to test the correlations between the seed yield, 1000 grain weight and seed germination of the forage pea variety 'Osječki zeleni' and precipitation by the analysed years and months. Table 3 shows that the sown area for the production of higher forage pea was between 8 and 23 hectares with a constant growing trend.

In 2012, 12 ha of the variety 'Osječki zeleni' were sown along with 10 ha of a new variety with a coiling tendril and very early growth named 'Letin'. Due to its coiling tendril and plant interconnections, the new variety 'Letin' is not susceptible to lodging and can be sown without a supporting plant, i.e. cereal, both as forage as well as a seed crop. Forage pea seed yield varied considerably during the observed 9-year period ranging from 1142 to 2455 kg ha^{-1}. Tekeli and Ates (2003) obtained similar yields while testing five lines of field pea seed yield over three years. In their research, seed yield varied from 1602 to 2590 kg ha^{-1} with plant heights between 107 and 124 cm and precipitation quantities ranging from 314 to 513 mm for the entire vegetation (November–October). Muehlbauer (1998) recorded that forage pea seed yield of two varieties averaged between 2071 kg ha^{-1} in 1994 and 3327 kg ha^{-1} in 1995. Hatam and Amanullah (2002) tested 13 field pea genotypes with heights ranging from 115 to 190 cm and got considerably lower seed yields (49 to 1000 kg ha^{-1}) whereby the 190 cm genotype yielded only 67 kg ha^{-1} of seeds. Tan et al. (2014) obtained low amounts of yield of 886 to 1404 kg ha^{-1} in a two year investigation with three rowing spaces having different amounts of seed in sowing of local ecotypes of winter forage pea. Effectiveness during the processing is shown by the percentage of pure processed pea seeds relative to the produced natural quantity (underneath the harvester) which consisted of pea seeds, wheat grains, mechanical contaminants and other compounds. During the pea seed processing it is possible to separate all admixtures and impurities which create disposable waste (wastage) or black waste ranging from 0.7 to 12.8% whereas 5.6 to 26.2% is of usable or white waste obtained from natural seeds. White "waste" mostly consists of wheat grains, pea seed breakage, etc., and wheat grains can be completely separated during further processing meaning that approx. 100–500 kg ha^{-1} of wheat can be produced along with the pea seeds (Table 4).

Table 4. Losses during processing of forage pea seeds of the variety 'Osječki zeleni' for the observed years

Tablica 4. Gubitci tijekom dorade ozimog stočnog graška (Osječki zeleni) po promatranim godinama

Year *Godina*	Waste/*Otpad*		Unusable Waste/*Rastur*	
	kg	%	kg	%
2004	590	5.6	740	7.1
2005	1360	11.6	76	0.7
2006	2210	10.3	1095	5.1
2007	5400	17.3	1820	5.8
2008	4750	12.5	2480	7.5
2009	11980	26.2	5860	12.8
2010	5740	18.2	1460	9.6
2011	7015	10.5	2355	3.7
2012	3400	10.1	1220	3.6

Murray and Swensen (1985) found out that field peas for seed production should be sown as a joint crop with a cereal, having gained a pea grain yield increase of 27% by sowing 25% of wheat along with peas in comparison to sowing only peas. By analysing the precipitation influence on pea seed yield, germination and 1000 grain weight for the variety 'Osječki zeleni' from 2004 till 2012, it was found out that the seed yield and germination were not in correlation with the amount of precipitation. However the precipitation quantity negatively affected the 1000 grain weight (Table 5).

It was also found out that the seed yield, germination and 1000 grain weight were not in correlation with the amount of monthly precipitation. The differences in seed yields for the analysed production years are probably the result of variation in crop lodging and the insufficient quality of the technical solutions during harvesting. Harvesting severely lodged crops was shown to be technically extremely complex, particularly due to the lodge pea plants which were 2 m long. If harvesting is conducted in a way that the harvester/scythe goes underneath the crops, it leads to plant evulsion, plants being knocked down, pod cracking and large seed loss. The harvester must go "over the crops" when harvesting severely lodged crops or in the direction of lodging, respectively. In that way the scythe reaps the smaller part of the plant and a great number of pods remain on the field unmown. In this case the seed loss is great as well. Therefore, the cereal is extremely important in forage pea seed production since it prevents the pea plants from complete lodging and thus enable for an easier and more efficient harvest with lower seed losses.

Table 5. Correlation coefficients between studied parameters

Tablica 5. Pearsonova korelacija ispitivanih parametara

	Yield Prinos	1000 seed weight Težina 1000 zrna	Germination Klijavost
Precipitation/*Oborine*	-0.12	-0.66*	0.53
Yield/*Prinos*		-0.20	-0.02
1000 seed weight *Težina 1000 zrna*			-0.30

*– correlation is significant at the 0.05 level

CONCLUSION

The conducted analysis of precipitation influence on seed yield, germination and 1000 grain weight throughout a nine-year production period for the forage pea variety 'Osječki zeleni' at the Agricultural Institute Osijek showed the great variation in yield and germination being not in correlation with the amount of precipitation. The yield variation of forage pea seeds was probably influenced by the level of crop lodging and the insufficient quality of the technical solutions during the harvesting process. The 1000 grain weight and the amount of precipitation were in a significantly negative correlation.

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UTJECAJ OBORINA NA PRINOS SJEMENA OZIMOG STOČNOG GRAŠKA

SAŽETAK

Ozimi stočni grašak (Pisum arvense), poznat i kao Austrian winter peas, sve se više sije u Hrvatskoj i njenom okruženju za proizvodnju kvalitetne voluminozne krme. Osnovne značajke te kulture su kratka vegetacija, visoki prinosi mase i odlična kakvoća, koja se ogleda kroz visoku produkciju bjelančevina. Sjemenska proizvodnja ozimoga stočnoga graška vrlo je složena, a time i neizvjesna, najviše radi same građe i visine stabljike. U poljoprivrednoj proizvodnji ostvarivanje većega ili manjega prinosa, osim genetike sijane sorte ili hibrida, najčešće se povezuje s okolinskim uvjetima tijekom vegetacije, a prije svih s količinom oborina. Stoga je napravljena analiza sjemenske proizvodnje ozimoga stočnoga graška, sorte Osječki zeleni, na površinama Poljoprivrednog instituta Osijek za devetogodišnje razdoblje (2004.-2012. godina) i klimatskih prilika te je utvrđeno veliko variranje, kako u prinosu, klijavosti i masi 1000 sjemenki, tako i u količini oborina tijekom vegetacijskoga perioda ozimoga graška u analiziranim godinama. Korelacijska analiza, po Pearsonu, pokazala je nepostojanje veze između prinosa, klijavosti i mase 1000 sjemena te analiziranih parametara i ukupne količine oborina u vegetacijskome periodu graška, iz čega se može zaključiti da su promatrani parametri pod znatnim utjecajem drugih čimbenika.

Ključne riječi: ozimi stočni grašak, prinos sjemena, oborine, sorta, korelacije

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