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INTERSPECIES RELATIONS AND YIELD OF DIFFERENT FIELD PEA/OATS MIXTURES

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ABSTRACT

The experiment was conducted in order to examine biological interaction, yield and variation of certain morphological traits in mixture with field pea as main and oats as supporting crop. Experiment included two trials, each conducted in the spring of 2015 and 2016. Each trial with two factors, the factor of the mixture (100: 15% - field pea: oats; 100: 30% field pea: oats), intercropped as additive series and two controls (100% field pea; 100% oats) and the second factor, the develpoment stage(I phase – flowering phase of field pea; II phase – seed formation of field pea). Beside the botanical share and yield of fresh weight and dry matter, plant height and number of internodes were also examined. Based on the obtained results it have been concluded that oats is highly competitive. In both years oats showed high competitiveness although it was in lower share in sowing rate. Fresh weight and dry matter yield exceed the yield of individually grown crops in 2015 (fresh matter yield – I mowing phase: field pea – 17.3 t ha^{-1}; oats – 16.2 t ha^{-1}; 100:15% - 21.7 t ha^{-1}; 100:30% – 21.2 t ha^{-1}) and 2016 (fresh matter yield – I mowing phase: field pea – 16.21 t ha^{-1}; oats – 21.3 t ha^{-1}; 100:15% - 22.9 t ha^{-1}; 100:30% – 20.95 t ha^{-1}). It have been concluded that mixtures with higher share of oats form higher dry matter yield, while the yield of fresh weight was not significantly different between the mixtures.Plant height and number of internodes in field pea have higher values when they are in a mixture than in single crop.

INTRODUCTION

Domestication and cultivation of field pea (*Pisum sativum L.*) for human consumption is as old as agriculture itself and it is assumed that the use of pea in the diet of domestic animals took place in parallel. Archeological evidence suggest that cultivation started 10 000 years BC in area of Middle East (Baldev, 1988; Zohary*et al*., 2000). Since then pea have been used for various purposes, and today we recognize several subspecies of cultivated pea. Most important subspecies for producing quality forage is *Pisum sativum ssp. arvense* (field pea). Field pea seed can be used for making high-quality concentrate, and whole plant for forage. Whatever the case, there are many benefits of using field pea in diet of domestic animals, especially ruminants. The digestibility of the grain is very high, and it contains up to 28% of high-quality proteins (Mikić *et al*., 2006) and most minerals (Acikgoz*et al*., 1985). One of the advantages of growing pea is the possibility of applying grains in the diet without thermal treatment (Marohnić, 2006; Mikić *et al*., 2006). Pea straw has around 12% of total protein in dry weight and can be used as animal feed or as litter in livestock buildings. Compared to some other annual legumes, forage pea is characterized by favorable content of certain amino acids (Mihailović*et al*., 2010). This plant has agro-

technical significance as well. The quantities of nitrogen that remain in the soil for the next crop, after the cultivation of pea, range from 45 to 63 kg ha^{-1} N (Stevenson *et al*., 1997). Therefore, the need for nitrogen fertilizer is reduced as well as the risk of environment pollution (Huss-Danell*et al*., 2007).

Advantages of growing pea in mixture with oats, compared to individually grown crops, are numerous. A large number of papers have examined this issue and *Fabaceae* x *Poaceae* in general. Advantages are reflected in increased forage and grain yield (Krga*et al*., 2016; Jensen, 1996), higher N content in the fodder (Cowell *et al*., 1989; Droushiotis, 1989), better forage quality (Chapko*et al*., 2013; Carr *et al*., 1997), more favorable impact on soil (Lazaridou *et al*., 2006), prevention to some diseases in animals (Lacefield*et al*., 1997), decreased lodging, etc.

Animal husbandry in Serbia is facing a delay.Inadequate agricultural policies and practices have led to a reduction in livestock.One of the conditions to improve livestock on the territory of Serbia is to improve the production of animal feed rich in protein. The production of high yield forage rich in protein can reduce the need to import expensive protein feeds while providing a balanced meal and thus reduce the overall input in livestock. Goal of this study was to examine differences in yield, botanical share and other morphological parameters affected by different sowing rates and mowing phase, while looking back on main characteristics for these mixtures.

MATERIAL AND METHOD

The experiment was carried out in the vicinity of Belgrade(44° 50' 18.9" latitude, 20° 17' 0.6" longitude, 66 m elevation) at the Institute for Animal Husbandry. The paper examine two trials, each conducted in the spring of 2015 and 2016. Each trial included two factors. First factor wastype of mixture (100% field pea: 15% oats; 100% field pea: 30% oats) with two control treatment (100% field pea; 100% oats), with 100% sowing rate of 155 kg $ha^{-1}$for both species; and second factor, mowing phase (I phase – flowering phase of field pea; II phase – seed formation of field pea).

Experimental plan was completely randomized block design. The trials were carried out on calcareous type of soil (chernozem-soil known for its natural quality), in natural water conditions (no irrigation), without fertilizers. Both trials were harvested at the flowering phase of field pea, and seed formation stage. Beside botanical share and yield of fresh and dry matter, height and number of internodes were examined. The experiment was set up in four repetitions with elemental plots of 8 m^2 with a row spacing 20 cm. Autumn tillage was done at depth of 25 cm, followed by a fine seedbed preparation and land rolling after sowing. The botanical share of field pea and oats in the mixture is determined by sampling and separating mixtures on 1 m^2. The dry matter is formed on the basis of 1 kg of fresh matter, which was dried in an oven at a temperature of 60° C. Ten plants sample was taken for the analysis of morphological characteristics.Climatic factors and chemical analysis of soil were examined, presented and interpreted. Experimental findings were analyzed by the method of variance analysis (ANOVA) for two-factorial plan, and the significant differences were determined by LSD test.For statistical analysis program Statistica Version 8.0 was used.The results are presented in tables.

Climatic factors: The vegetation period of spring crops had a sufficient amount of precipitation (391.4 mm) with a regular schedule, 46 mm more than in the referenced period. Mean monthly temperatures were higher, and the average for the six months of cultivation (I-VI) was 12.1° C, one degree higher than in the referenced period. Compared to the previous decades, 2015 is considered to be extremely warm with a special focus on the month of July, which is considered to be one of the hottest months in the history of measurements, however, mowing of spring trial was completed in mid-June, so the crop

avoided this extreme period, confirming the thesis that the pea with its short vegetation avoids summer high temperatures and drought.

The climatic period for second trial (2016) had significantly higher values than values in referenced period and vegetation period in 2015. Total precipitation for second trial (I-VI) was 170.4 mm higher than values in referenced period and 124.4 mm higher then values in 2015. Average temperature was 1.6° C higher than the values in referenced period. Based on the displayed results it can be concluded that the climatic values for both trials were slightly higher than average in terms of temperature and visibly higher in terms of monthly precipitations.

Table 1.

Monthly precipitation (mm) and average temperatures (C°), spring experiment

Year	*Month*												-
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**I-VI**
	Monthly precipitation - mm												*Sum*
1992-2013	**50.1**	**46**	**41.1**	**53.6**	**58.1**	**96.5**	65.7	59.2	63.2	53.5	51.8	65	345.4
2015	**37.3**	**62.5**	**136**	**35.1**	**87.6**	**32.9**	10.3	49.5	101.4	71.8	63.4	3.8	391.4
2016	**48.1**	**43.3**	**144**	**55**	**75.4**	**150**	-	-	-	-	-	-	515.8
	Average monthly temperature – C°												*Average*
1992-2013	**1.7**	**3.3**	**7.9**	**13.6**	**18.2**	**21.8**	23.6	23.3	18.2	13.1	7.7	2.8	11.1
2015	**3.1**	**4.9**	**9.0**	**13.1**	**19.2**	**23.5**	27.3	26.0	20.0	12.4	9.2	4.3	12.1
2016	**2.1**	**8.8**	**9.1**	**15.2**	**17.8**	**23.2**	-	-	-	-	-	-	12.7

II-VI – Climatic period significant to spring crop; **IX-V** Climatic period significant to winter crop

Soil features: Based on the chemical analysis of the soil, compared to the optimal values that are characteristic for soil type Chernozem, it can be concluded that the soil had average humus content (2.36 %), average to high content of the total (0.22%) and decent content of nitrate nitrogen (28 ppm). High phosphorus content have been confirmed (34.91 ppm) and the average potassium content (141 ppm). pH value in KCl 5,69 was also in appropriate range for tested species. If we take into account the medium-fine soil on which trials were carried out, without the use of fertilizers, it can be concluded that the crop, in terms of soil factors, had favorable conditions for growth and development, but not for expressing their full potential.

RESULTS AND DISCUSSIONS

Based on visual observations,larger quantity of weeds have been observed in single grown crops, while field pea and oats combinations are characterized by good competitive ability against weeds. This is consistent with a number of other researches (Weiner *et al*., 2001; 2010, Kristensen *et al*., 2010), thus it can be concluded that the higher crop density reduced weed presence.

In the first (2015) experimental year, in both phases, there was a significantly higher yield of fresh and dry matter in mixtures than in individually grown crops (Table 2). There were no significant differences between mixtures. Mowing phases were different only for dry matter yield, where the yield in the second phase (5.26 t ha^{-1}) was significantly higher than in the first phase (3.58 t ha^{-1}). Field pea and oats share did not considerably change depending on the mixture, however the percentage of oats ishigher despite a lower share in sowing rates.Sowing rates should be taken into account, since oats is visibly competitive species. With the advancing of vegetation, percentage of field pea in mixture is increasing (54% I phase); (62% IIphase). Plant height and number of internodes can be seen as indicator of yield.With the increase of these values it is expected that the yield will increase as well. In the second phase, these features manifested higher values in mixture 100:30%.

Height of plants in this mixture was significantly higher than the height in a mixture of 100:15% or single grown crops. Number of internodes have same values in both mixtures, and significantly lower in single grown pea compared to mixtures. As expected, these values were significantly higher in second mowing phase compared to the first (phase I – height 73.4; number of internodes 14.2; phase II - height 97.9; number of internodes 17.4). Oats plant height did not vary for both phases.Number of internodes varied only in the second phase and was higher in the mixtures in relation to the pure crops.Height was significantly higher in the second mowing stage (75 cm) then in the first (55 cm).

Table 2.

Botanical share, yield and morphological characteristics of field pea and oats in mixture (2015)

Mixture and mowing phase	*Fresh weight t ha^{-1}*	*Dry matter t ha^{-1}*	*Field pea share (%)*	*Oats share (%)*	*Plant height - field pea (cm)*	*Number of internodes - field pea*	*Plant height – oats (cm)*	*Number of internodes - oats*
I Mowing phase								
Field pea 100%	17.7^{b}	2.84^{b}	0	100	76.3	13.6	-	-
Oats 100%	16.2^{b}	3.27^{ab}	100	0	-	-	52.6	3.75
100%:15%	21.7^{a}	3.6^{ab}	51	49	70.2	14.3	55.3	3.5
100%:30%	21.2^{a}	4.45^{a}	57	43	73.7	14.5	57.1	3.75
F test	**	**	ns	ns	ns	ns	ns	ns
II Mowing phase								
Field pea 100%	19,8^{b}	4.56^{bc}	0	100	87.7^{b}	14.5^{b}	-	-
Oats 100%	14.4^{c}	5.25^{ab}	100	0	-	-	73.9	3.4^{b}
100%:15%	23.2^{a}	6.4^{a}	60	40	97.4^{b}	18.4^{a}	75.6	4^{a}
100%:30%	22.1^{ab}	6.32^{a}	64	36	108.6^{a}	19.2^{a}	77.2	4^{a}
F test	**	**	ns	ns	**	**	ns	*
Phase								
I	19.6	3.58^{b}	54^{b}	46^{a}	73.4^{b}	14.2^{b}	55^{b}	3.7
II	20.3	5.26^{a}	62^{a}	38^{b}	97.9^{a}	17.4^{a}	75^{a}	3.8
F test	ns	*	*	*	**	**	**	ns

100%:15% - *field pea:oats* sowing rate; **100%:30%** - *field pea:oats;* **I mowing phase** – *flowering stage of field pea*; **II mowing phase** – *seed formation of field pea*; **F test** – *least significant differences*; **ns** –*non significant*

In second trial (2016), fresh and dry matter was lowest in single grown field pea for both mowing phases. Oats exhibited different trend in the second trial than in the first, and in terms of yield parried (phase I: field pea – 16,21 t ha^{-1}; oats – 21,3 t ha^{-1}, 100:15% - 22,9 t ha^{-1}; 100:30% - 20,95 t ha^{-1}) or it had significantly higher yield compared to single grown pea or in mixtures (phase II: field pea – 12,1 t ha^{-1}; oats – 22,1 t ha^{-1}, 100:15% -14,6 t ha^{-1}; 100:30% - 14,75 t ha^{-1}). However, in terms of dry weight, mixtures and single grown oats, in both phases had no significant difference although it is visible that oats (Field pea 100% - 2,84 t ha^{-1}; Oats 100% - 3,27 t ha^{-1}) still have higher DM yield than single grown field pea.Field pea and oats share did not significantly changed depending on the mixture and phase. The share of oats in total yield is still high although it had lower share in sowing rate. Plant height of field pea had not significantly changed depending on mixture, but there were changes dependent on mowing phase. Plants had significantly higher values in second phase (I – 110.8 cm; II – 127.5 cm). Number of internodes of field pea had significantly higher values in the mixture compared to single grown pea, and these values also varied depending on the phase.

Overall experiment have shown that yield of fresh and dry matter are stable in first mowing phase and intercropping these two species intercroped affected yield. Dry matter content tend to increase with maturity of crop, but due to lower quality (Dear *et al*., 2005), digestibility and increased differences in yield in later vegetation, harvest should not be delayed, so optimal harvest should be around stage of flowering.

Table 3.

Botanical share, yield and morphological characteristics of field pea and oats in mixture (2016)

Mixture and mowing phase	*Fresh weight t ha^{-1}*	*Dry matter t ha^{-1}*	*Field pea share (%)*	*Oats share (%)*	*Plant height - field pea (cm)*	*Number of internodes - field pea*	*Plant height – oats (cm)*	*Number of internodes - oats*
I Mowing phase								
Field pea 100%	16.21^{b}	2.33^{b}	100	0	109.2	14.6^{b}	-	-
Oats 100%	21.3^{ab}	4.49^{a}	0	100	-	-	69.6^{a}	4.8^{a}
100%:15%	22.9^{a}	4.6^{a}	63.5	36.5	112.1	16.2^{a}	67.5^{ab}	3.7^{b}
100%:30%	20.95^{ab}	4.63^{a}	62.9	37.1	111	15.73^{a}	63.5^{b}	3.7^{b}
F test	*	**	ns	ns	ns	**	*	**
II Mowing phase								
Field pea 100%	12.1^{b}	2.4^{b}	100	0	131.5	14.8^{b}	-	-
Oats 100%	22.1^{a}	5.82^{a}	0	100	-	-	72.7^{a}	3.2^{b}
100%:15%	14.6^{b}	4.66^{a}	71.4	28.6	132.9	17.4^{a}	69.3^{ab}	3.6^{a}
100%:30%	14.75^{b}	4.62^{a}	65.5	34.5	124.6	15.9^{b}	67.4^{b}	3.2^{b}
F test	**	**	ns	ns	ns	**	*	*
Phase								
I	20.3^{a}	4.01	63.2	36.8	110.8^{b}	15.5	66.9	66.9
II	15.85^{b}	4.38	68.5	31.5	127.5^{a}	16	69.7	69.7
F test	**	ns	ns	ns	**	ns	ns	ns

100%:15% - *field pea:oats* sowing rate; **100%:30%** - *field pea:oats;* **I mowing phase** – *flowering stage of field pea*; **II mowing phase** – *seed formation of field peas*; **F test** – *least significant differences*; **ns** –*non significant*

Dear *et al*. (2005) have concluded that crude protein content in field pea/oats mixture is lower when mowing phase is delayed. In mowing phase I (booting phase of oats), crude protein content was 11%, second mowing phase (anthesis stage of oats) 9.4% and in phase III (milk stage of oats), 6.9%. It is useful to mention that almost all legume species provide best quality forage in earliest stages of maturity such as flowering stage, weather annual or perennial, single or intercropped, and this is supported by vast scientific data (Llovers, 2001; Wiersma *et al*., 1998; Hintz*et al*., 1991).

Both years have shown same trend in terms of field pea:oats competitiveness and it have been concluded that oats is highly competitive even though it had lower share in sowing rate and mixture also tend to increase plant height and number of internodes.

CONCLUSIONS

Based on the obtained results there were higher levels of rainfall during the growing season as well as mild temperatures and average soil quality.

Oats is highly competitive and because of that characteristic, preparing of mixtures in terms of sowing rate should be done with precaution and oats share in sowing rate should not exceed 15%.

Plant height and number of internodes of field pea were significantly higher in the mixture than in controls (2015 - phase I: field pea -13,6 cm; 100:15% - 14,3 cm; 100:30% - 14,5 cm); (2016 - phase I: field pea -14,6 cm; 100:15% - 16,2 cm; 100:30% - 15,73 cm). These values indicate that field peaplants tend to grow longer when in mixture.

Dry matter increase as the share of oats in the mixture increases, but due to its competitiveness, the share of oats in sowing rate should not exceed 15%.

The average yield of fresh and dry matter was significantly higher in the mixture compared to pure crops (2015 - phase I: field pea - 2.84 t ha^{-1}; oats - 3.27 t ha^{-1}; 100: 15% - 3.6 t ha^{-1}; 100: 30% - 4.45 t ha^{-1});(2016 - phase I: field pea - 2:33 t ha^{-1}; oats - 4.49 t ha^{-1}; 100: 15% - 4.6 t ha^{-1}; 100: 30% - 4.63 t ha^{-1}).The differences between the mixtures

themselves were not significant.Average dry matter yield was higher in the second phase, however, forage tend to lose its quality and good chemical composition with later maturity of crop, thus later mowing is not recommended, also, according to the results, the second phase is prone to large variations in terms of yield. After analysis of the obtained results, first mowing phase (flowering stage of field pea) is more reliable in terms of stable yield and quality.

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