Biotechnology in Animal Husbandry 27 (4), p 1523-1530 , 2011 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 633.2
DOI: 10.2298/BAH1104523P

STAND DENSITY EFFECTS ON BIRDSFOOT TREFOIL HERBAGE YIELD GROWN FOR COMBINED USAGE

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Original scientific paper

Abstract: Birdsfoot trefoil grown for seed (cv. Bokor) was examined in agroecological conditions of Western Serbia during period 2007-2009. The goal was to determine herbage yield which could be achieved growing seed crop, using different interrow spacing (12.5, 25 and 50 cm) and various seeding rates (2, 4 and 8 kg ha^{-1}). The highest hay yield was obtained in the third production year at the narrowest spacing and using the highest seeding rate (5.26 t ha^{-1}). Total hay production during 3 years using birdsfoot trefoil seed crop for herbage yield ranged from 9.11 to 14.83 t ha^{-1} depending on row spacing and from 10.74 to 13.2 t ha^{-1} depending on seeding rate. The highest stand density (8 kg ha^{-1} seeding rate and 12.5 cm interrow spacing) produced the highest herbage yield of birdsfoot trefoil in the combined usage (for forage and seed production).

Key words: birdsfoot trefoil, row spacing, seeding rate, herbage yield

Introduction

Birdsfoot trefoil (*Lotus corniculatus* L.) belongs to perennial legumes which is the special group of plants important for forage production. It takes the most important place in grass-legume mixtures for establishing artificial grasslands in the hilly-mountainous regions of Serbia. As pure crop, it is grown locally only on small areas.

It may grow in very different agroecological conditions, on almost all types of soil, with very wide range of pH value, from 4 to 9 *(Marvin, 2004)*. On soils of lower quality, birdsfoot trefoil has ignificant role in providing protein component in forage. However, in favourable conditions of soil and climate, it considerably falls behind the yield of alfalfa *(Gotlin and Čižek, 1955)*. During vegetation period it could be cut for herbage biomass three times, and under favourable conditions even four times. Average yield of biomass (green fodder) ranges from 35-40 t ha^{-1}, and of hay 8-10 t ha^{-1} *(Vučković, 2004)*. Some studies suggest that it is possible to

achieve the yields of pure birdsfoot trefoil hay of 6-14 t ha^{-1}, and in the mixture with grasses 10-17 t ha^{-1} *(Bullard and Crawford, 1995)*.

Birdsfoot trefoil has good palatability, it contains high percentage of protein and it is easily digestible for cattle, sheep and horses *(Sareen, 2004)*. The hay of birdsfoot trefoil is of excellent quality, with high content of crude protein *(Halling et al., 2002)* and plenty of B-carotene and vitamin C. Quality of forage does not change with development stages so fast as it is the case with other legumes. It contains 19.68-25.75% crude protein and only 18.38-24.20% of crude cellulose in the flowering stage *(Ocokoljić et al., 1978)*. While studying morphological and nutritional characteristics of wild populations of birdsfoot trefoil, *Vučković et al. (2007)* concluded that Serbian populations are more superior according to their chemical characteristics and nutritional values as compared to populations from other parts of the world. Presence of condensed tannins in the leaves and stem prevents bloating of ruminants, so that birdsfoot trefoil does not cause bloating of cattle while grazing *(Beuselinck and Grant, 1995)*. By comparing birdsfoot trefoil and alfalfa, grazed by sheep and lambs, *Douglas et al. (1995)* established greater production of wool in sheep and weight in lambs, when using birdsfoot trefoil in their nutrition. Recent studies have shown that sheep that have used the hay of birdsfoot trefoil in their diet have less problems with parasitic infections *(Marley et al, 2002)*. Strongly developed root system of birdsfoot trefoil binds well and protects soil against erosion. Considering the fact that the process of biological fixation of nitrogen takes place indirectly, through symbiotic bacteria, birdsfoot trefoil takes significant place in sustainable agricultural and organic production *(Tomić, 2007)*.

Forage species have utmost importance in the development of cattle breeding in hilly-mountainous region. One of conditions for faster expansion of this species is providing of sufficient quantity of high-quality seeds. There are favourable conditions in Western Serbia for seed production of this forage legume *(Petrović, 2011)*. Crops intended for seed production make certain quantity of forage. Due to variation of seed yields, and its price at the market, there is an issue of possible increase of birdsfoot trefoil profitability, by combined use, where certain yield of forage is made, in addition to seed production. The aim of our studies was to establish the quantity of forage that can be obtained by growing the birdsfoot trefoil crops for combined use, when establishing on various interrow spacings and with various seeding rates.

Materials and Methods

The field experiment was carried out in Western Serbia, near the city of Šabac, in the period 2007-2009. Seeding of birdsfoot trefoil (cv."Bokor") was carried out in spring 2007 in the completely randomized block design in four replications, with the basic plot of 10 m^2 (2x5m). The way of seeding (factor A) with three interrow spaces (12.5, 25 and 50 cm) and the amount of seeds for

seeding (factor B) with three seeding rates (8, 4 and 2 kg ha^{-1}) were tested. In the first experimental year, the seed was obtained from the first cutting, and then the production of forage was measured from the second and the third, while in the second and the third year of birdsfoot trefoil life, the second cutting was used for seeds, and the first and the third one was used for forage. The yield of green biomass was established in the stage of bud emergence early stage of flowering, from each plot. After drying of biomass and establishment of drying factor, the yield of dry material per hectare was established. Obtained data were processed in variation-statistical way, by variance analysis, and evaluation of significant differences were established by LSD test.

Agro-ecological conditions. The soil on which the experiment was carried out belongs to pseudogley. According to results of chemical analysis (Table 1) the soil is carbonate-free, in the humus ploughland horizon of acid reaction, with decreasing acidity trend in parallel with increasing depth. It belongs to low and low slightly humus soil, poor in total nitrogen. The soil is poor in terms of contents of easily available phosphorus, and it is medium rich in easily available potassium.

Table 1. Chemical properties of soil

Depth (cm)	pH		Humus (%)	Total N (%)	Content in mg/100g of soil	
	H_2O	nKCl			P_2O_5	K_2O
0-30	5,45	4,50	1,84	0,092	8,2	15,0
30-50	5,80	4,73	1,61	0,088	6,1	13,1
50-70	6,15	4,97	0,85	0,064	5,0	13,7

Table 2. Precipitation and mean monthly temperatures for experimental period

Month	Temperatures (^{0}C)				Precipitation (mm)			
	2007	2008	2009	1977-2006	2007	2008	2009	1977-2006
I	5,2	1,9	-1,5	- 0,2	40,2	27,6	42,1	38,2
II	5,8	4,3	2,4	1,6	49,5	5,4	30,5	34,3
III	8,6	7,6	7,4	6,5	40,3	57,4	38,2	39,2
IV	13,0	12,9	14,3	11,3	0,0	52,4	12,0	49,5
V	18,5	18,3	18,4	16,8	49,0	42,4	44,1	55,3
VI	22,0	21,5	19,5	19,7	65,2	58,1	81,3	85,5
VII	22,6	21,7	22,3	21,2	38,7	61,0	24,0	62,5
VIII	22,3	21,4	22,6	20,8	42,5	22,7	42,3	56,9
IX	14,3	15,3	15,0	16,4	73,4	76,4	70,1	49,3
X	10,4	12,9	11,2	11,6	68,0	12,6	77,3	50,8
XI	3,7	7,9	5,1	5,5	62,6	48,8	80,0	52,6
XII	0,3	3,7	0,5	1,1	32,2	66,2	47,0	44,4
Total					561,6	531,0	588,9	618,5
Average	12,2	12,5	11,4	11,0				

Based on data of weather station in Sremska Mitrovica (Table 2), it is seen that average air temperatures in the experimental years were higher than the several years' average. All experimental years had even sums of precipitation, but somewhat lower as compared to the several years' average. Due to higher temperatures and lower precipitation, short periods of drought in 2007 and 2009 occurred in April and July, and in 2008 in August and October.

Results and Discussion

In all experimental years (Table 3), the way of seeding and seeding rate had high influence on the yield of hay per cuts. With increase of width of interrow space, the average yield of hay decreased, so that the highest yields were achieved at the minimum spacing of 12.5 cm. With decrease of seeding rate, the average yield of forage decreased so that the highest yields were established on the variant with the highest seeding rate of 8 kg ha^{-1}, i.e. the highest density of crops.

Table 3 Effect of interrow spacing and seeding rate on birdsfoot trefoil herbage yield (DM) in two herbage cuts during seed production (2007-2009)

	Herbage yield (t ha^{-1})					
	2007		2008		2009	
Interrow spacing A	II cut	III cut	I cut	III cut	I cut	III cut
12.5 cm	1.75[a]*	0.87[a]	4.47[a]	1.18[a]	5.02[a]	1.54[a]
25 cm	1.61[b]	0.67[b]	3.53[b]	0.96[b]	4.11[b]	1.10[b]
50 cm	1.51[c]	0.50[c]	2.48[c]	0.59[c]	3.24[c]	0.79[c]
LSD 0.05	*0.046*	*0.045*	*0.11*	0.059	*0.17*	*0.042*
Seeding rate B						
8 kg ha^{-1}	1.80[a]	0.85[a]	3.75[a]	1.07[a]	4.43[a]	1.30[a]
4 kg ha^{-1}	1.69[b]	0.67[b]	3.51[b]	0.91[b]	4.04[b]	1.14[b]
2 kg ha^{-1}	1.38[c]	0.51[c]	3.22[c]	0.75[c]	3.89[b]	0.99[c]
LSD 0.05	*0.046*	*0.045*	*0.11*	0.059	*0.17*	*0.042*
Average	1.62	0.68	3.49	0.91	4.12	1.14

*Means in columns followed by the same letter are not significantly different by Fisher's protected LSD values (P=0.05)

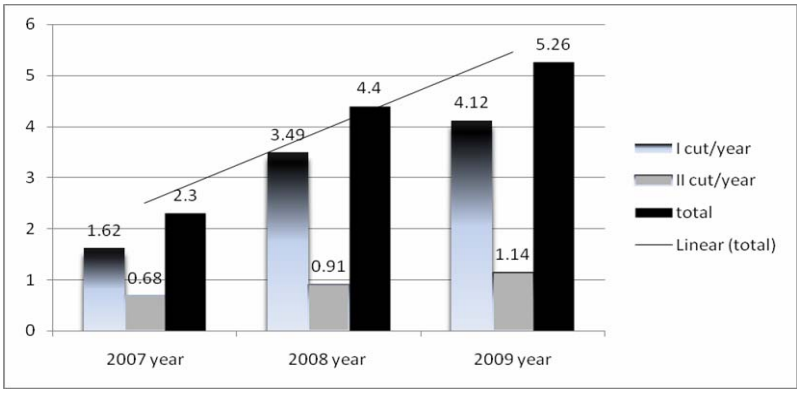

Figure 1. Herbage yield of birdsfoot trefoil during seed production, t ha^{-1} (2007-2009)

By observing forage yields per cuts, earlier cuts were higher than the later ones, which is as expected (Figure 1). Total production of hay per experimental years differed to significant extent. In the year of establishment, total hay production was 2.30 t ha^{-1}, in the second year it was 4.40 t ha^{-1}, and in the third year it was 5.26 t ha^{-1}. Production of forage was directly dependant on the age of crops and it increased with years of crop use. The birdsfoot trefoil crop was in the third year of production in 2009 with considerably developed plants, so that it achieved higher yield of forage per hectare as compared with the first and the second experimental year. This is the reason why in 2009 the highest annual hay yield (6.56 t ha^{-1}) was achieved at the narrowest interrow spacing (12.5 cm) and of 5.73 t ha^{-1} by using the highest seeding rate (8 kg ha^{-1}). Total hay production in the three-year period of using birdsfoot trefoil crop ranged from 9.11 to 14.83 ha^{-1} depending on the interrow spacing and from 10.74 to 13.2 ha^{-1} depending on the seeding rate.

In previous studies of impact that the way of seeding and seeding rate make on the yield of birdsfoot trefoil crop, the authors point out the advantage of narrow row seeding compared with wide row seeding. So, *Miladinović (1964)* obtained the highest yield of hay yield on the shortest interrow space of 30 cm, which in the first cutting was 5.42 t ha^{-1} of hay. *Gatarić (1988)* achieved the highest average hay yield of 5.92 t ha^{-1}, in the first cut by denser seeding, i.e. by broadcast seeding with 20 kg ha^{-1} of seeds. In the studies of *Balan et al. (2002)* the average yields of dry matter of tested genotypes of birdsfoot trefoil ranged from 5.4 to 5.8 t ha^{-1}. Forage yields obtained in the third year of our experiments on the minimum rows and at the highest seeding rate, match the previously mentioned data from literature.

By growing birdsfoot trefoil on eroded soil *Mijatović (1975)* obtained the hay yield of 6.8 t ha^{-1}. According to *Ocokoljić et al. (1975)*, in the dry climate conditions of Serbian lowland region the average yield of birdsfoot trefoil hay of

11.9 t ha^{-1} could be achieved. By testing variability of productive features and quality of forage of selected birdsfoot trefoil genotypes, *Radović et al. (2007)* obtained the average hay yield of 11.34 t ha^{-1} of hay. The same authors point out that high results are the consequences of increased arability of soil on which testing was carried out. The same authors pointed out that high results are the consequence of soil arability on which the tests were carried out and that the yields of dry matter on the soil of lower quality, on which growing of birdsfoot trefoil is cost-effective, are considerably.

Birdsfoot trefoil can achieve good yields in seed production *(Petrović, 2011)*, so in combination with two cuts, considerable yield can be achieved for forage. The highest yields of forage in the densest crop establishment do not match the highest seed yield in three-year production, but they have the highest potential in combined use.

Conclusion

Birdsfoot trefoil is intended for seed production, and signficant amounts of biomass are achieved in addition to seed production. During three years trial the forage yield of birdsfoot trefoil was considerably changing depending on the tested factors. Production of forage was directly dependent on the age of crops, i.e. plant development, size of vegetation area and on the quantity of precipitation during the year. The highest hay yields were achieved in the third year of growing on the narrowest interrow spacing of 12.5 cm (6.56 t ha^{-1}) and at the highest seeding rate of 8 kg ha^{-1} (5.73 t ha^{-1}). Total production of hay in the three-year period of using the seed crop of birdsfoot trefoil ranged from 9.11 to 14.83 ha^{-1} depending on the interrrow spacing and from 10.74 to 13.2 ha^{-1} depending on the seeding rate. Birdsfoot trefoil in combined use (for seed production and forage) has the highest potential at higher density of crop establishment (8 kg ha^{-1} and 12.5 cm interrow spacing).

Uticaj gustine zasnivanja na prinos krme žutog zvezdana gajenog za kombinovano korišćenje

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Rezime

Žuti zvezdan za proizvodnju semena, sorte Bokor, ispitivan je u agroekološkim uslovima zapadne Srbije, u periodu 2007-2009. godine. Ispitivana je količina biomase koja se može dobiti gajenjem žutog zvezdana za seme, pri

zasnivanju na različitom međurednom rastojanju (12,5, 25 i 50 cm) i sa različitom normom semena (2, 4 i 8 kg ha^{-1}). Najveći prinosi sena ostvareni su u trećoj godini gajenja useva na najužem međurednom rastojanju od 12,5 cm (6,56 t ha^{-1}) i pri najvećoj količini semena od 8 kg ha^{-1} (5,73 t ha^{-1}). Ukupna produkcija sena u trogodišnjem periodu korišćenja semenskog useva žutog zvezdana bila je od 9,11 do 14,83 ha^{-1} u zavisnosti od međurednog rastojanja i od 10,74 do 13,20 ha^{-1} u zavisnosti od setvene norme. Žuti zvezdan u kombinovanom korišćenju (za seme i krmu) je imao najveći potencijal za prinos krme pri većoj gustini zasnivanja (8 kg ha^{-1} i 12,5 cm međuredno rastojanje).

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Received 30 June 2011; accepted for publication 15 August 2011