Biotechnology in Animal Husbandry 26 (spec.issue), p 285-291, 2010 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 633.361

EFFECT OF GENOTYPE AND CROP DENSITY ON SAINFOIN (*Onobrychis vicifolia* Scop.) FORAGE YIELD

B. Ćupina[1], L. Marinković[2], Dj. Krstić[1], A. Mikić[3], S. Antanasović[2], P. Erić[1]

[1]Faculty of Agriculture, Novi Sad, Republic of Serbia
[2]DOO Matica, Čenej, Republic of Serbia
[3]Institute of Field and Vegetable Crops, Novi Sad, Republic of Serbia
Corresponding author: cupinab@polj.uns.ac.rs
Original scientific paper

Abstract: Sainfoin has a small potential for seed yields and that often limits its wider cultivation. Sainfoin is, also, a highly competitive species in both mixtures and pure stand and that makes the research on different stand densities especially important. Four year (2004-2008) field trial was carried out as a three–factor random block design. The Factor A was cultivar, genotype (Makedonka and EG Norm), the Factor B row spacing (15, 25 and 30 cm) and the Factor C seed rate (80, 120 i 160 kg ha^{-1}). The paper presents the total annual forage yields (t ha^{-1}) during all four trial years. The achieved forage yields are in accordance with the environment and sainfoin life. The influence of cultivar is not crucial for satisfactory green forage yields in sainfoin. In all four trial years, regardless of cultivar and seeding rates, the highest green forage yields were achieved in dense stand (15 cm), followed by 25 cm and finally by 35 cm. the highest green forage yields were at a seed rate of 120 kg ha^{-1}. For the widely present dual-purpose cultivation, that is, for forage and seed, the most reliable production of both forage and seed production is at a seed rate of 80 kg ha^{-1} and at a row spacing of 25 cm.

Key words: sainfoin, crop density, seeding rate, forage yield

Introduction

Sainfoin (*Onobrychis viciifolia* Scop.) may be a potential replacement for lucerne (*Medicago sativa* L.) in the agro-ecological conditions of Vojvodina due to its productive and quality traits. Being cultivated mainly in non-irrigated farming systems, lucerne often produces yields much lower than its biological potential. In the conditions of Vojvodina, there is a lack of precipitations of about 250 mm for the successful forage production *(Bošnjak, 1991)*. The research so far points that sainfoin is well tolerant to drought, as well as that it has a considerable growth rate in arid conditions too *(Ćupina et al., 1993; Ćupina et al., 1999)*. Sainfoin has a

small potential for seed yields and that often limits its wider cultivation. Along with this, sainfoin is a highly competitive species in both mixtures and pure stand and that makes the research on different stand densities especially important. The results of various trials in semi-arid conditions, with sainfoin grown for both forage and seed, reveal that, in all trial years and in most cuts, sainfoin produces the highest forage yield at the lowest row spacing, while the highest seed yields are at a seed rate of 100 do 150 kg ha^{-1} *(Vučković et al., 1996)*. Depending on the cultivation purpose, forage or seed, there is row spacing from 12.5 cm to 35 cm and seed rates from 70 kg ha^{-1} to even 360 kg ha^{-1}. It should be remembered that the main reason for high seed rates in sainfoin is the sowing of a one-seed pod *(Ivanova-Bandžo, 1973)*. *Spedding and Dikmans (1972)*, *Ćupina et al. (1993)* and *Ivanovski et al.,* (*1998*) emphasize that the highest forage yields in sainfoin are produced in a dense stand, that is, at small row spacing. By decreasing seed rate, by regulating seed quantity and row spacing, yields of both forage and seed are affected. The seeding rates higher than 160 kg ha^{-1} may lead to a decrease in forage yields as a consequence of higher competitiveness between plants, as well as to a decreased stand density. *Ćupina and Erić (1999)* point out that the highest green forage yields are achieved at a seed rate of 140 kg ha^{-1} and row spacing of 25 cm. They also point that seed rate does not significantly affect the yields of both forage and seed, meaning that satisfactory yields are possible at a lower seed rate and that the seed rates needs to be adjusted according to the genetic potential for seed yield and thus contribute to the production reliability. Being aware of all that was said, this paper is aimed at assessing the impact of genotype, row spacing and seed rate to forage yields in sainfoin, since the sainfoin production could be more reliable if the adequate genotype is assessed for the agro-ecological conditions of Vojvodina and if the optimal seed rates are determined.

Material and Methods

A field trial was carried out at Čenej, near Novi Sad, in the unit of *Agricultural Production – Matica*, the section of *Agriculture*, of the company of Neoplanta Meat Industry, Novi Sad, as a three–factor random block design and with four replicates. The Factor A was cultivar, that is genotype (Makedonka and EG Norm), the Factor B row spacing (15, 25 and 30 cm) and the Factor C seed rate (80, 120 i 160 kg ha^{-1}). The trial was established on 23 April 2004, with wheat as a preceding crop. In the first year (2004), sainfoin was cut twice, on 10 July and 31 August. In the second year (2005), it was cut four times, on 25 May, 27 June, 11 August and 18 October. In the third year (2006), sainfoin was cut also four times, on 12 June, 11 July, 16 August and 29 September. In the fourth year (2007), it was cut four times again, on 5 May, 13 June, 25 July and 10 October. The paper

presents the total annual forage yields (t ha^{-1}) during all four trial years. Each time, the stand was cut in its stage of the technological maturity for forage production.

Soil conditions. The trial was conducted on a slightly carbonated chernozem soil, with its chemical properties shown in Table 1. The reaction of this soil is between neutral and acid, with a high $CaCO_3$ in the sowing layer. The $CaCO_3$ content increases together with the depth, unlike humus and total nitrogen. The soil was well provided with nitrogen in its active layer, that is, humus-accumulative part, while the content of both phosphorus (P_2O_5) and potassium (K_2O) was low, decreasing as the depth increases.

Table 1. Soil properties (Čenej)

Depth	$CaCO_3$	pH in H_2O	pH in KCl	Humus (%)	N (%)	mg/100 g soil	
						P_2O_5	K_2O
0-30	17.34	8.23	7.63	3.08	0.153	5.7	14.0
30-60	24.45	8.34	7.67	2.01	0.101	2.6	10.0
60-90	26.12	8.42	7.78	1.46	0.073	1.8	9.0
Pros. 0-90	22.64	8.33	7.69	2.18	0.109	3.37	11.0

Rainfall amount and distribution as well as monthly temperatures are presented in table 2. There were favourable weather conditions for crop establishment in the sowing year. In the second and fourth year of sainfoin life i.e. 2005 and 2007, deficit of precipitations in April effected yield in the first cutting.

Table 2. Amount of precipitation (mm) and mean monthly temperatures (^oC) for hydrological years (2004-2007)

Rainfall (mm)												
Year/ month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2004	46.5	22.6	20.5	100.2	105.6	123.4	70.5	47.0	42.7	70.5	117.0	35.5
2005	30.2	41.2	33.7	23.7	52.0	143.2	160.7	120.1	57.0	0	19.8	52.9
2006	44.0	12.3	68.7	73.9	89.8	106.7	15.2	129.6	9.0	13.4	9.3	27.2
2007	26.0	48.1	82.9	0	66.1	53.1	31.2	82.7	58.1	117.4	56.5	0
Long term avarage	36.7	31.1	51.5	49.5	78.4	106.6	69.4	94.9	41.7	50.3	50.7	28.9
Temperature (^oC)												
Year/ month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2004	-1	2.5	6.7	12.5	15.2	19.8	22	21.7	16.3	14.2	7	2.7
2005	0.3	-3.3	4.7	12.1	17	19.3	21.7	20.3	18	12.7	5.3	2.3
2006	-1.0	1.7	6.0	13.3	16.3	19.3	23.3	20.3	18.7	11.6	6	1.2
2007	6.2	5.8	8.9	13.4	18.6	22.0	23.2	22.6	14.6	10.9	3.9	0.1
Long term avarage	-0.6	1.6	6.2	11.4	16.8	19.9	21.2	21	16.9	10.4	8.4	2.5

Results and Discussion

The achieved forage yields are in accordance with the environment (Table 3a and 3b) and years of life of sainfoin. The highest average forage yield was in the second year (62.0 t ha^{-1}). The average forage yield in the fourth year was 54.1 t ha^{-1}, in the third year it was 43.7 t ha^{-1}, while in the first year it was lowest (27.7 t ha^{-1}). It is indicative that that precipitation sum in the summer months in 2005 was above the long-term average, especially in June, July and September, while the temperatures in these months were either average ones or slightly below the long-term average. In 2007, the precipitation sum was the same as that of the long-term average and it is a good distribution of the precipitations that resulted in high green forage yields in this year. Regarding the cultivar, that is, the Factor A, in 2004 the cultivar EG Norm had higher green forage yield for 2.2 t ha^{-1}, while in the second year (2005) the cultivar Makedonka had higher green forage yield for 0.8 t ha^{-1}. In the third year, the difference in green forage yields between the two cultivars of 1.7 t ha^{-1} was not significant. In the fourth year, the cultivar Makedonka had higher green forage yield for 2.0 t ha^{-1} with no significance. These results show that the influence of cultivar is not crucial for high green forage yields in sainfoin. In all four trial years, regardless of cultivar and seeding rates, the highest green forage yields were achieved in dense stand (15 cm), followed by 25 cm and finally by 35 cm. The lowest green forage yield at a row spacing of 15 cm was produced in the first year (2004) in the cultivar EG Norm at a seed rate of 80 kg ha^{-1} (29.8 t ha^{-1}). The highest average green forage yield was in the second year (2005), at a row spacing f 15 cm and in the cultivar Makedonka, what was higher for 13.9 t ha^{-1} in comparison to the yield at a row spacing of 25 cm. This difference was significant and offers the basis for recommending a dense stand for green forage production. In all trial years, the highest green forage yields were at a seed rate of 120 kg ha^{-1}. In the first year (2004), regardless of cultivar, the highest green forage yield (28.5 t ha^{-1}) was at a seed rate of 120 kg ha^{-1} and was not significantly higher in comparison to the other seed rates. The difference between this seed rate and the seed rate of 160 kg ha^{-1} was only 0.6 t ha^{-1}. Somewhat higher difference (1.9 t ha^{-1}) was in comparison to the seed rate of 80 kg ha^{-1}, although it was not significant as well. In the second year (2005), the highest green forage yield (63.7 t ha^{-1}) was at a seed rate of 120 kg ha^{-1}, what was only 0.2 tha^{-1} higher in comparison to the green forage yield at a seed rate of 80 kg ha^{-1}, with no significant difference in both this and the comparison to the green forage yield at a seed rate of 160 kg ha^{-1}. In the third year (2006), the highest green forage yield (46.7 t ha^{-1}) was achieved at a seed rate of 120 kg ha^{-1}, not significantly higher in comparison to the green forage yield at a seed rate of 80 kg ha^{-1}, but significantly higher than the green forage yield at a seed rate of 160 kg ha^{-1}. The same trend in both cultivars was obvious in the fourth year (2007): the highest green forage yield (57.7 t ha^{-1}) was at a seed rate of 120 kg

ha^{-1}, significantly higher in comparison to the green forage yield at a seed rate of 160 kg ha^{-1} and not significantly higher than the green forage yield at a seed rate of 80 kg ha^{-1}, with a difference of 3.4 t ha^{-1}.

Table 3a Effect of genotype, row spacing and seeding rate on sainfoin forage yield

Year		2004				2005			
		Seeding rate							
Variety	Row spacing (cm)	80	120	160	Average	80	120	160	Average
Makedonka	15	30.6	29.7	30.6	30.3	79.2	75.8	67.1	74.1
	25	27.6	26.5	26.6	26.9	60.1	60.7	60	60.2
	35	19.1	23.1	25.4	22.6	49.1	55.1	54.7	53
	Average	25.8	26.5	27.5	26.6	62.8	63.8	60.6	62.4
EG Norm	15	29.8	33.2	30.9	31.3	74.4	73.4	65.5	71.1
	25	28.6	30.3	28.1	29.0	60.6	60.7	56.8	59.4
	35	23.8	28.3	25.8	26.0	57.6	56.5	48.9	54.3
	Average	27.4	30.6	28.2	28.8	64.2	63.5	57.1	61.6
Average		26.6	28.5	27.9	27.7	63.5	63.7	58.8	62.0

LSD $_{0.05}$	A	B	C	AB	AC	BC	ABC
2004	3.673	1.551	2.046	2.86	3.102	3.17	4.692
2005	12.88	4.58	6.11	9.93	10.23	9.44	14.44

Table 3b Effect of genotype, row spacing and seeding rate on sainfoin forage yield

Year		2006				2007			
		Seeding rate							
Variety	Row spacing (cm)	80	120	160	Average	80	120	160	Average
Makedonka	15	49.8	54.8	47.8	50.8	66.8	72.1	60.1	66.3
	25	41.4	44.7	42.2	42.8	51.9	57.0	52.0	53.6
	35	36.7	32.8	35.6	35.0	46.5	47.1	42.4	45.3
	Average	42.6	44.1	41.9	42.9	55.1	58.7	51.5	55.1
EG Norm	15	51.5	58.3	49.8	53.2	66.0	69.7	60.8	65.5
	25	41.4	46.5	38.9	42.3	49.0	51.3	48.6	49.7
	35	37.7	43.2	33.9	38.2	45.3	48.9	38.2	44.1
	Average	43.5	49.3	40.9	44.6	53.5	56.6	49.2	53.1
Average		43.1	46.7	41.4	43.7	54.3	57.7	50.4	54.1

LSD $_{0.05}$	A	B	C	AB	AC	BC	ABC
2006	7.839	4.186	3.829	6.477	6.284	6.506	9.476
2007	16.4	5.56	6.61	12.66	12.56	10.46	16.51

Considering seed rate, regardless of the significant differences in single years and depending on cultivar, the reliability of production should be taken into

account. In most cases, the differences in yield are not significant enough to justify higher seed rates than the most reliable ones. Regarding the genetic potential of sainfoin for seed yield, as well as the available quantities on the seed market, it is recommended to apply lower seed rates, that is, 80 kg ha^{-1}.

Conclusion

On the basis of the results obtained during four years, the following conclusions may be drawn:

The influence of cultivar is not crucial for satisfactory green forage yields in sainfoin. The most appropriate row spacing for green forage production in sainfoin is 15 cm, at a seed rate of 120 kg ha^{-1}. For the widely present dual-purpose cultivation, that is, for forage and seed, the most reliable production of both forage and seed production is at a seed rate of 80 kg ha^{-1} and at a row spacing of 25 cm.

Acknowledgement

Research was financed by the Ministry of Science and Technological Development, Republic of Serbia, project TR 20083.

Uticaj genotipa i gustine useva na prinos krme esparzete (*Onobrychis vicifolia* Scop.)

B. Ćupina, L. Marinković, Dj. Krstić, A. Mikić, S. Antanasović, P. Erić

Rezime

U agroekološkim uslovima Vojvodine izvršeno je četvorogodišnje ispitivanje (2004-2007) uticaja genotipa i gustine useva na prinos krme esparzete. Ispitivan je uticaj dve sorte (Makedonka i EG Norm), međurednog razmaka (15, 25 i 35 cm) i setvene norme (80, 100 i 120 kg ha^{-1}). Najveći prinos krme ostvaren je pri gustorednoj setvi na 15 cm sa količinom semena od 120 kg ha^{-1}. Ova setvena norma, međutim nije dala statistički značajnu razliku u prinosu zelene krme u odnosu na setvu sa normom od 80 kg ha^{-1} semena.

References

BOSNJAK DJ. (1993): Zalivni režim lucerke u agroekološkim uslovima Vojvodine. Zbornik radova, Institut za ratarstvo i povrtarstvo, V 19, 238-245.

ĆUPINA B., ERIĆ P., MIHAILOVIĆ V. (1993): Komparativno ispitivanje produktivnosti kvaliteta višegodišnjih leguminoza. Zbornik radova, Institut za ratarstvo i povrtarstvo, Novi Sad, 21, 525-534.

ĆUPINA B., ERIĆ P. (1999): The effect of sowing method and seeding rate on yield and quality of sainfoin (*Onobrychis sativa* L.) forage. Scientia Agriculturae Biohemica, 30, 107-114.

IVANOVA-BANDŽO K., FIDANOVSKI F. (1973): Vlijanieto na meguredvoto rastojanie vrz prinosot od esparzeta (Onobrychis sativa). Spisanie za zemjodelski prašanja, 4-6.

IVANOVSKI P., PRENTOVIK T., DIMOV Z. (1998): Effect of Sowing Rate on Sainfoin (Onobrychis sativa Lam.) Forage and Seed Yield. Proceeding of 2nd Balkan Symposium on Field Crops, Volume 2, Novi Sad, Yugoslavia, 473-475.

TOMIĆ Z., NEŠIĆ Z., KRNJAJA V., ŽUJOVIĆ M. (2005): Parametri produkcije i kvaliteta novih sorti višegodišnjih leguminoza za stočnu hranu. Biotechnology in Animal Husbandry, 21, 3-4, 89-96.

SPEDDING C.R.W., DIEKMAHNS E.C. (1972): Grasses and Legumes in British Agriculture. Commonwelth Agriculture Bureaux – Farnham Royal, Slough.

VUČKOVIĆ S., PAVEŠIĆ-POPOVIĆ J., GLAMOČLIJA Đ., BOŽIĆ M., ZARIĆ D., NEGOVANOVIĆ D., ĆUPINA B. (1996): Uticaj načina setve i đubrenja borom i cinkom na prinos lucerkine krme u prvom otkosu. Zbornik radova, Institut za ratarstvo i povrtarstvo, Novi Sad, 26, 211-219.

Received 15 December 2009; accepted for publication 15 April 2010