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THE EFFECT OF SOWING METHOD AND SEEDING RATE ON YIELD AND QUALITY OF SAINFOIN (*ONOBRYCHIS SATIVA* L.) FORAGE

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Two-factorial small-plot trial with sainfoin (*Onobrychis sativa* L.) cv. Makedonka was carried out at Rimski Šančevi (slightly calcareous chernozem) in the years 1995–1997. Row-to-row spacing (150 and 250 mm) and seeding rates (120, 140, 160, and 180 kg.ha^{-1} of seed, i.e. single-seed fruits/pods) were the factors A and B. The green forage yield, dry matter and crude protein contents were determined. The highest annual yield (with four cuttings per year) was obtained in the second year (72.0 t.ha^{-1}), followed by the third (60.0 t.ha^{-1}) and then first (50.0 t.ha^{-1}). Looking at all three trial years (1995–1997) taken together, a statistically significant coefficient of correlation (r = 0.81) was found between the seeding rate and green forage yield. The smallest yield was obtained with the seeding rate of 120 kg.ha^{-1}, while all the other, increased rates gave balanced yields (variation range of 1.8 t ha^{-1}). These results support the use of the 140 kg.ha^{-1} seeding rate and 250 mm row-to-row spacing. The crude protein yields exhibited a similar trend as green mass yields.

sainfoin (*Onobrychis sativa*); row spacing; seeding rate; yield; crude protein

INTRODUCTION

Sainfoin (*Onobrychis sativa* L.) is a perennial forage legume characterized by a high competition index. This crop's competitiveness is manifested both in its competition for vegetative space with other crop species (when grown in a mixed crop) and competition within the species itself (when grown in a pure crop). All this is particularly pronounced when sainfoin is grown in a dense stand. Thin stands, on the other hand, result in yield losses, so it is of particular importance to determine optimum row-to-row spacing and seeding rate as this is a prerequisite for a high, stable, and profitable sainfoin production.

Recommendations found in the literature for these two parameters cover a wide range of values – from 125 to 350 mm for row-to-row spacing and from 70 kg ha^{-1} to 360 kg ha^{-1} for seeding rate (depending on whether seeds or single-seed pods are used for sowing). According to some authors, sainfoin produces the largest hay yields when the row-to-row spacing values are lower, namely 150 mm (Ćupina et al., 1993), 180 mm (Spedding, Diekmahns, 1972), and 200 mm (Ivanovski et al., 1998). This is consistent with reports from the literature that state that the highest yields of green mass in legumes are obtained with dense stands ranging between 150 and 250 mm (Ćupina et al., 1997; Ivanova-Bandžo, Fidanoski, 1973). Onoffrii and Tomazoni (1989) report that the largest sainfoin hay yields are produced by a row-to-row spacing of 200–300 mm. Depending on whether the seed or fruit (a single-seeded pod) are used for sowing, different seeding rates are recommended in the literature: 55–65 $kg.ha^{-1}$ of seed (Spedding, Diekmahns, 1972); 79 and 105 $kg.ha^{-1}$ of seed (Ivanovski et al., 1998); 50–70 $kg.ha^{-1}$ of seed and 140–170 $kg.ha^{-1}$ of fruit (Onoffrii, Tomazoni, 1989); and 150 $kg.ha^{-1}$ of fruit (Ćupina et al., 1993). In practice, however, it is the fruit that is most often used for sowing, since under favorable conditions the seed germinates and emerges from the fruit coating unimpeded. In sainfoin, therefore, what is botanically the fruit actually represents the seed in agricultural terms. The seeding rate in this crop species is significantly affected by agroecological growing conditions.

The objective of our three-year study was to contribute to the solution of the aforementioned problems by monitoring the effects of different row-to-row spacing and seeding rates on yields of green forage and raw protein during the first three years in the exploitation of a sainfoin crop.

MATERIAL AND METHODS

Our two-factorial small-plot trial was carried out on a slightly calcareous chernozem soil at the Rimski Šančevi Experiment Field of the Institute of Field and Vegetable Crops in Novi Sad using a randomized block design with four replications:

Factor A – row-to-row spacing of 150 and 250 mm;

Factor B – seeding rates of 120, 140, 160, and 180 $kg.ha^{-1}$ of seed, i.e. single-seed fruits/pods.

The sainfoin variety Makedonka was used and the trial plot size was 5 m^2. The sowing was done on April 5, 1995 and the study covered the first three years of sainfoin life (1995, 1996, and 1997). The usual crop tending measures were applied during the growing seasons.

At technological maturity, the green forage yield was determined ($t.ha^{-1}$) and samples for determining dry matter and crude protein contents (both expressed as percentage) were taken. The raw protein yield ($t.ha^{-1}$) was determined based on the dry matter yield and nitrogen content.

Statistical data analysis was performed by the analysis of variance (ANOVA) using regression and correlation.

Weather conditions during the trial

As shown in Table I the sums of precipitation and mean daily temperatures during the study years were higher than the long-term average.

RESULTS AND DISCUSSION

Green forage yields

During the trial years, our sainfoin produced high green forage yields, confirming that the species has a high biological potential (Ćupina et al., 1993). As shown in Table II, the highest annual yield (with four cuttings per year) was obtained in the second year (72.0 $t.ha^{-1}$), followed by the third (60.0 $t.ha^{-1}$) and then first (50.0 $t.ha^{-1}$). Such results were definitely influenced by the weather conditions during the trial years, most notably by the sum and distribution of precipitation (Table I).

In 1995, the 150 cm row-to-row spacing produced a higher annual green forage yield (52.3 $t.ha^{-1}$) than the 250 mm one (48.1 $t.ha^{-1}$) regardless of the seeding rate used. The differences were not significant, however. Looking at Factor B (seeding rate) relative to both variants of Factor A, the lowest annual yield was recorded in the 120 $kg.ha^{-1}$ treatment, while in all the other ones the yields were balanced, i.e. there were no statistically significant differences between them. In all of the treatments, the largest yield was recorded in the first cutting, while the second and third cuttings produced yields that were balanced and less than half as high.

In the second year of study (1996), the 250 mm treatments gave an average yield of 75.0 $t.ha^{-1}$, which was 6.2 $t.ha^{-1}$ more than in the 150 mm ones. In this case too, however, the difference was not statistically significant. At 150 mm spacing, similar to the year before, the lowest yield was obtained with the lowest seeding rate (120 $kg.ha^{-1}$), while the other rates gave balanced and considerably higher yields. A similar trend was found in the 250 mm treatments as well, only in this case the 180 $kg.ha^{-1}$ rate produced a somewhat higher yield 83.7 $t.ha^{-1}$. The differences between the forage yield from the 120 $kg.ha^{-1}$ treatment and those from the other treatments were highly significant, while the differences between the treatment with 180 $kg.ha^{-1}$ and the ones with 140 and 160 kg ha-1 were significant. On average, the highest yield of green forage was achieved in the third cutting (24.7 $t.ha^{-1}$), followed by the first (22.6 $t.ha^{-1}$), while the second and fourth cuttings gave almost identical yields (12.4 and 12.5 $t.ha^{-1}$, respectively).

I. Mean daily temperatures (°C) and monthly precipitation (mm) during the first three years (1995–1997) of sainfoin growing

Month	Parameter	Year			Long-term average
		1995	1996	1997	
I	°C	0	–0.8	–1.4	–1.3
	mm	69.0	47.0	42.9	39.0
II	°C	6.2	–2.2	3.2	0.8
	mm	57.0	32.0	46.6	43.0
III	°C	6.1	2.8	5.7	5.0
	mm	41.0	29.0	36.3	35.0
IV	°C	11.5	11.6	7.5	11.6
	mm	0	20.0	75.3	47.0
V	°C	15.8	18.2	14.2	16.4
	mm	83.0	93.0	18.0	57.0
VI	°C	19.2	20.5	20.8	19.8
	mm	103.5	78.0	84.7	81.0
VII	°C	23.1	19.9	20.0	21.5
	mm	5.0	55.0	128.3	63.0
VIII	°C	20.9	21.0	20.1	21.8
	mm	73.0	113.0	124.6	47.0
IX	°C	16.2	13.0	16.0	17.1
	mm	96.0	99.2	30.3	35.0
X	°C	12.9	14.2	9.4	6.6
	mm	1.0	59.0	85.0	33.0
XI	°C	3.4	6.5	7.2	6.6
	mm	36.3	90.0	141.0	56.0
XII	°C	2.0	4.3	3.2	1.4
	mm	63.0	64.0	76.0	61.0
Average	°C	11.4	11.5	12.1	11.0
Total	mm	627.0	779.0	889.0	597.0

In the third study year (1997), looking at both spacing treatments put together, the highest green forage yield (average of three cuttings) was attained with 140 kg of seed per hectare (74.2 and 60.8 t.ha^{-1}, respectively). At 150 mm spacing, where the average yield was higher by 8.1 t.ha^{-1} compared to 250 mm (not significant statistically), the 120 kg.ha^{-1} seeding rate produced a higher biomass yield (67.0 t.ha^{-1}) than the 160 and 180 kg.ha^{-1} ones, which stood in contrast to the first two years of study.

II. Forage yield of sainfoin (t.ha^{-1}) during the first three years of growing (1995–1997) depending on row spacing and applied seeding rate

Row spacing (mm)	Seeding rate (kg.ha^{-1})	1995				1996					1997			
		cutting			total	cutting				total	cutting			total
		I	II	III		I	II	III	IV		I	II	III	
150	120	26.4	10.1	8.1	44.6	18.0	9.7	20.2	10.5	58.4	40.2	13.6	13.1	67.0
	140	29.8	11.0	13.4	54.2	25.4	11.4	23.2	11.5	71.2	43.5	16.4	14.3	74.2
	160	30.5	11.5	12.8	54.8	23.4	11.6	24.5	12.7	72.2	32.0	15.5	13.9	61.4
	180	31.2	12.2	12.2	55.6	24.6	11.7	24.7	12.4	73.4	29.5	11.7	12.8	54.1
Average		29.5	11.2	11.6	52.3	22.8	11.1	23.2	11.8	68.8	36.3	14.3	13.5	64.2
250	120	22.1	11.8	8.8	42.7	18.3	12.0	20.1	11.0	61.4	23.0	11.2	10.2	44.4
	140	24.0	13.3	10.6	47.9	21.3	14.6	28.2	12.8	76.9	36.7	13.2	10.9	60.8
	160	25.8	14.0	10.9	50.7	24.1	13.8	28.2	14.6	77.7	34.2	11.7	11.1	57.4
	180	24.8	13.9	12.5	50.9	26.0	14.7	28.5	14.5	83.7	36.2	13.5	10.8	60.6
Average		24.1	13.3	10.7	48.1	22.4	13.8	26.3	13.2	75.0	32.6	12.4	10.8	55.8
Average 150 and 250		26.8	12.2	11.1	50.2	22.6	12.4	24.7	12.5	72.0	34.4	13.4	12.2	60.0
LSD	A 1%	2.1	1.2	1.9	9.2	4.6	1.1	3.7	1.4	16.3	13.5	10.8	10.2	20.8
	5%	1.5	0.9	1.4	5.0	3.4	0.8	2.7	1.1	14.3	7.4	5.9	5.6	16.7
	B 1%	3.0	1.7	2.7	3.9	6.5	1.6	5.2	2.0	8.2	6.6	3.2	2.6	7.6
	5%	2.2	1.2	2.0	3.1	4.7	1.2	3.8	1.5	6.0	4.8	2.3	1.9	5.6
	AB 1%	4.2	2.3	3.9	4.1	9.1	2.3	7.3	2.0	11.6	13.2	9.0	1.3	11.6
	5%	3.1	1.7	2.8	3.0	6.7	1.7	5.4	2.1	8.5	8.2	5.3	4.8	8.5

Looking at all three trial years (1995–1997) taken together, a statistically significant coefficient of correlation ($r = 0.81$) was found between the seeding rate and green forage yield. The smallest yield was obtained with the seeding rate of 120 $kg.ha^{-1}$, while all the other increased rates gave balanced yields (variation range of 1.8 $t.ha^{-1}$), which is of particular importance in view of sainfoin's small genetic potential and low economic viability of its production. These results support the use of the 140 $kg.ha^{-1}$ seeding rate and 250 mm row-to-row spacing.

Crude protein yield

Sainfoin dry matter is characterized by a high crude protein content that most often ranges between 17 and 25% (Spedding, Diekmahns, 1972). In the present study, the raw protein content varied according to the year and cutting, ranging from 19.77% (2nd cutting, 1997) to 21.01% (2nd cutting, 1995 and 1996). Due to a small range of variation of dry matter and crude protein contents between the various cuttings, the raw protein yields exhibited a similar trend as green mass yields (Table III). This is further supported by the fact that a highly significant coefficient of correlation was observed between the green mass yield and seeding rate used ($r = 0.90$).

CONCLUSION

On the basis of the obtained results the following conclusions can be drawn. The highest annual yield (with four cuttings per year) was obtained in the second year (72.0 $t.ha^{-1}$), followed by the third (60.0 $t.ha^{-1}$) and then first (50.0 $t.ha^{-1}$).

Looking at all three trial years (1995–1997) taken together, a statistically significant coefficient of correlation ($r = 0.81$) was found between the seeding rate and green forage yield. The smallest yield was obtained with the seeding rate of 120 $kg.ha^{-1}$, while all the other, increased rates gave balanced yields (variation range of 1.8 t ha^{-1}), which is of particular importance in view of sainfoin's small genetic potential and low economic viability of its production. These results support the use of the 140 $kg.ha^{-1}$ seeding rate and 250 mm row-to-row spacing.

Due to a small range of variation of dry matter and crude protein contents between the various cuttings, the crude protein yields exhibited a similar trend as green mass yields.

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ĆUPINA, B. - ERIĆ, P. (Zemědělská fakulta, Institut polních plodin a zeleniny, Novi Sad, Jugoslávie):

Vliv způsobu setí a výsevku na výnos a kvalitu píce vičence ligrusu.

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Dvoufaktorový pokus, uspořádaný metodou znáhodněných bloků se čtyřmi opakováními, s vičencem ligrusem (*Onobrychis sativa* L.) odrůdy Makedonka byl založen 5. 4. 1995 na mírně vápenaté černozemi na pokusné stanici Rimski Šančevi Institutu polních plodin a zeleniny v Novém Sadu. V letech 1995–1997 byl sledován vliv rozteče řádků 150 a 250 mm (faktor A) a výsevku 120, 140, 160, a 180 kg.ha^{-1} jednosemenných plodů (faktor B). Byl sledován výnos zelené hmoty (t.ha^{-1}), obsah a výnos hrubého proteinu (t.ha^{-1}). Výsledky byly statisticky vyhodnoceny programem ANOVA s použitím regresní a korelační analýzy. Nejvyšší roční výnosy čerstvé hmoty byly dosaženy (při čtyřsečném využití) ve druhém roce vegetace (72,0 t.ha^{-1}). Ve třetím roce byl výnos čerstvé hmoty v průměru 60,0 t.ha^{-1} a v prvním roce 50.0 t.ha^{-1} (tab. II). V průměru let 1995–1997 byl statisticky průkazný rozdíl (korelační koeficient r = 0,81) mezi výsevkem a výnosem čerstvé hmoty. Nejnižšího výnosu bylo dosaženo při výsevku 120 kg.ha^{-1}, při vyšších výsevcích byly výnosy úměrné. Na základě těchto výsledků se ukazuje jako nejvhodnější výsevek 140 kg.ha^{-1} a rozteč řádků 250 mm. Vzhledem k malé variabilitě obsahu sušiny a dusíkatých látek mezi jednotlivými sečemi vykazoval výnos dusíkatých látek podobný trend jako výnos čerstvé hmoty (tab. III).

vičenec ligrus (*Onobrychis sativa*); rozteč řádků; výsevek; výnos; dusíkaté látky

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