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in

Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.).
Sustainable Mediterranean grasslands and their multi-functions

Zaragoza : CIHEAM / FAO / ENMP / SPPF

Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79

2008

pages 483-486

Article available on line / Article disponible en ligne à l'adresse :

<http://om.ciheam.org/article.php?IDPDF=800702>

To cite this article / Pour citer cet article

Sulas L., Ledda M. **Sulla (*Hedysarum coronarium* L.) seed production at different sowing rates.** In : Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.). *Sustainable Mediterranean grasslands and their multi-functions*. Zaragoza : CIHEAM / FAO / ENMP / SPPF, 2008. p. 483-486 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79)



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Sulla (*Hedysarum coronarium* L.) seed production at different sowing rates

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SUMMARY – Sulla is a short-lived perennial legume native to the Mediterranean basin and grown as a rainfed forage crop in many countries on clay and calcareous soils. This legume has a remarkable N-fixation ability and can play an important role for forage production, due to its moderate condensed tannin content, and/or multifunctional agriculture (organic agriculture, environment protection, honey production, landscape embellishment, etc.). The objective of this research was to study, during a biennial cycle, the effect of different sowing rates (10, 20 and 30 kg/ha of seed) on sulla seed production and components in order to identify optimal plant density. The different seed rates showed a temporary effect in plant density and no significant effects on seed production compared to the age of the sulla stand.

Key words: Legume, sowing, seed, yield, components, stand age.

RESUME – "Production de graines pour le sainfoin d'Espagne (*Hedysarum coronarium* L.) à différentes doses de semis". Le sainfoin d'Espagne (*Hedysarum coronarium* L.) est une légumineuse pérenne originaire du bassin méditerranéen et elle est cultivée sans irrigation comme fourrage dans les terrains calcaires et argileux. Cette légumineuse est très apte pour la fixation de l'azote, et elle est très utile pour la production de fourrage, qui a une teneur modérée en tannins condensés, et pour l'agriculture multifonctionnelle (agriculture biologique, protection du milieu, production de miel, pour embellir le paysage, etc.). L'objectif de ce travail a été l'étude, pendant deux ans, de l'effet de trois différentes doses de semis (10, 20 et 30 kg ha⁻¹) sur la production de graines et leurs composantes, pour l'identification de la densité optimale de plantes. Les différentes doses de semis ont montré un effet temporaire sur la densité des plantes et des effets non significatifs sur la production de graines en comparaison à l'âge de la prairie.

Mots-clés : Légumineuse, semis, graines, production, composantes, âge de la culture.

Introduction

Sulla is a short lived perennial legume originated from the Mediterranean basin, where it is grown as forage crop in many countries (Algeria, Greece, Italy, Portugal, Spain, Tunisia, etc.). In Italy, sulla has been grown since 1860 and has been the most important forage legume in semi-arid environments with clay and calcareous soils (Sulas, 2006). Sulla was introduced into New Zealand for soil protection aims since 1950 (Watson, 1982), and recently, for its favourable characteristics (moderate condensed tannin content) is considered as a plant to support grazing by ruminant and to prevent bloating (Borreani *et al.*, 2003) and also as a possible option to reduce methane emissions into the atmosphere from dairy cows farming (Woodward *et al.*, 2002).

A proof of the renewed interest on sulla are the new varieties suitable for medium to high rainfall (i.e. 450 mm) areas of Australia that are currently being released (Yates *et al.*, 2006).

Therefore this legume can play an important role for both forage production and possible alternative uses within the context of the multifunctional agriculture. For these reasons, its seed production should be regarded not only in terms of yield, seed price and EU subsidies, but also for the consequent benefits arising from the sulla crop: soil fertility improvement, N fixation ability, soil and environment protection role, honey production, landscape embellishment, etc.

In Italy, previous experiments focused on the effects of different sowing methods (broadcast sowing, pocket drilling and row seeding) and seed types (hulled and dehulled seed, i.e. hull present and hull removed) on the forage production (Di Prima *et al.*, 1975) that was increased at high sowing

rates. Information about the sowing rate influence on seed production is still scarce. On the other hand, the low yield coupled with the high loment dehulling costs after harvesting have determined a high seed price for this leguminous plant.

The objective of this research was to study, during a biennial cycle of the sulla crop (i.e. year of sowing or first year crop plus subsequent year or second year crop) the effect of different sowing rates on the seed production and its components in order to identify the optimal plant density.

Materials and methods

The experiment was carried out in North-Sardinia (Italy) on flat clay-loam calcareous soil, pH 7.5 with low N and P₂O₅ content and adequate K₂O content, during the biennium 2002-2004. The climate of the area is semi-arid Mediterranean with a mild winter and an average annual rainfall of 547 mm. In Autumn 2002, plots of the Italian commercial variety 'Grimaldi' were established at three different seeding rates: SR 10, SR 20 and SR 30 kg ha⁻¹ of viable seed using the same row spacing of 40 cm. A randomized block design with three replicates was adopted and each plot size was 15 m² (5 x 3). Before sowing fertilization was applied at a rate of 100 kg ha⁻¹ of P₂O₅.

The following measurements were made on sampling areas: seedlings establishment, plant density trend (no. m⁻²), actual seed yield and its components (number of stems per plant, racemes per stem, loment per raceme, articles per loment, seeds per article and 1,000 seed weight). A combine plot harvester was used on the whole plots. Plant survival and seedling re-establishment were recorded at the beginning of the second year crop.

The data have been subjected to analysis of variance (ANOVA) and differences among the averages evaluated by means of LSD_{0.05}.

Results and discussion

The total annual rainfall from September 2002 to August 2003 was about 520 mm, mainly concentrated from September to January while rainfall from February to June was half than climatic values (100 vs 194 mm). This trend delayed seedling establishment and development and affected plant reproductive activity in late spring. In the second year, total rain exceeded 800 mm, but a complete absence of rainfall was recorded in May and June.

Seedling establishment and plant density

After the emergence, 25, 30 and 60 seedlings m⁻² were recorded respectively in SR 10, SR 20 and SR 30 and only the last value significantly differed from remaining ones. A progressive reduction in plant number was recorded during the season. Plant density at the end of spring differed in both years (Table 1), being significantly higher in the first year compared to the second one, without significantly differences among treatments. A progressive reduction in plant number is an usual trend for the sulla crop but, in this experiment, it was probably stressed by the unfavourable weather in winter. At the beginning of the second year crop, the number of new seedlings m⁻², originated from seed left in field (unharvested), resulted 20 in SR 10 and 13 and 11, in SR 20 and SR 30 respectively.

Seed production and its components

In the sowing year, stems number (Table 1) was slight high in SR 10 presumably due to the reduced competition among plants within the row compared to SR 20 and SR 30. In the subsequent year an overall increase of stems per plant was observed in all treatments as a consequence of the more prolonged growth period for the already rooted plants during the second year crop.

On average the number of racemes per stem ranged from about 5 to 10 respectively in the first and second year crop, it also being affected mainly by the difference in the duration of the growth period.

Table 1. Spring plant densities and seed yield components in the biennium

S.R.	10	20	30		10	20	30	
Year	Plants (no. m ⁻²)			Avg	Stems per plant (no.)			Avg
1 st	16.0	19.0	24.0	19.7 ^a	9.0	6.0	6.0	7.0 ^b
2 nd	10.0	10.0	8.0	9.3 ^b	10.0	10.0	12.0	10.7 ^a
Avg	13.0 ^a	14.5 ^a	16.0 ^a		9.5 ^a	8.0 ^a	9.0 ^a	
Year	Racemes per stem (no.)			Avg	Loments per stem (no.)			Avg
1 st	6.0	5.0	5.0	5.3 ^b	14.0	14.0	14.0	14.0 ^b
2 nd	11.0	10.0	9.0	10.0 ^a	26.0	27.0	28.0	27.0 ^a
Avg	8.5 ^a	7.5 ^a	7.0 ^a		20.0 ^a	20.5 ^a	21.0 ^a	

Means with the same letters do not differ significantly at $P \leq 0.05$ level.

The loments per stem increased from 14 to 27 in the second year crop, as a result of more racemes per stem and loments per raceme.

The articles per loment (Table 2) were very similar among treatments, while were significantly lower in the first than in the second year crop.

Table 2. Seed yield components and actual seed yield in the biennium

S.R.	10	20	30		10	20	30	
Year	Articles per loment (no.)			Avg	Seed per article (no.)			Avg
1 st	2.87	2.65	2.87	2.80 ^b	0.57	0.55	0.61	0.58 ^b
2 nd	3.30	3.27	3.40	3.32 ^a	0.78	0.83	0.84	0.82 ^a
Avg	3.09 ^a	2.96 ^a	3.13 ^a		0.68 ^a	0.69 ^a	0.73 ^a	
Year	1,000 seed weight (g)				Actual seed yield (kg ha ⁻¹)			
1 st	5.34	5.41	5.25	5.33 ^a	124	64	117	102 ^b
2 nd	4.45	4.03	4.12	4.20 ^b	317	317	260	298 ^a
Avg	4.90 ^a	4.72 ^a	4.69 ^a		220 ^a	190 ^a	188 ^a	

Means with the same letters do not differ significantly at $P \leq 0.05$ level.

The seeds per article increased from 0.58 (first year) to 0.82 respectively (second year crop) without significant differences among treatments, while the 1,000 seed weight decreased in the second year when number of seeds produced per m² was higher.

Actual seed yield of the second year, resulted three times higher as a result of variations in seed yield components.

The unfavourable weather in the first winter, with a delayed seedling establishment and development, caused a strong reduction of plant density in all treatments. Consequently, no significant differences among sowing rates were found. Moreover, the dry spring has probably reduced the seed yield. The number of survived plants was very similar in all treatments at the beginning of the second year crop. On the other hand, these findings have confirmed the results of previous researches, where a progressive reduction in plant density was shown from the emergence to harvest (D. Gianbalvo, pers. comm.; Sulas *et al.*, 2000). No significant differences among sowing rates were found also by Douglas and Foote (1985) in New Zealand, indicating that there was a little advantage in increasing seed rates.

An overall increase in seed production from the first to the second year of the sulla crop has been reported also by Martinello and Ciola (1994) and for this reason seed production is usually performed in the second year crop.

As evidenced in a previous research, aimed at the study of variations in phytomass components and forage production during a biennial cycle of sulla (Sulas *et al.*, 2000), this experiment has pointed out that: (i) seed yield components are influenced in a similar way by the stand age; and (ii) higher seeding rates caused an only temporary increase in plant density. Therefore, comparisons among results from different authors should be done considering not a single generic year of seed production, but the entire biennial cycle of the sulla crop.

Even if seed losses after first year harvest were able to regenerate seedlings in the subsequent year, these new plants were subjected to the strong competition from the one year older plants and consequently their contribution to the seed production proved to be negligible.

Conclusions

The results showed that different seed rates led to similar seed yields in both years of sowing and the subsequent most productive year of the same sulla crop. At the beginning of second year, even at low values of about 10 survived plants m² new seedlings had not effects on seed production.

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