Effects of intraspecific competition on growth and seed yield of contrasting sulla genotypes

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Abstract

Sulla (*Hedysarum coronarium* L.) is a short-lived perennial legume native to the Mediterranean basin, where it is grown extensively as a 2-year forage crop. Seed is often obtained as a secondary product from second-year crops established to produce forage. Very little information is available on seed yield capacity in the first year of the crop cycle and on the influence of agronomical techniques on the reproductive process. The present study aimed to evaluate the effect of intraspecific competition on dry matter accumulation (both in epigeic organs and in taproots) and seed production in the first year of a crop cycle for two contrasting genotypes. Two field trials were carried out in a Mediterranean environment during the 2003/2004 and 2004/2005 growing seasons. The experiment was set up as a split-plot design with four replications. The treatments were as follows: 1) genotype: Gangi or Resuttano (both originated from inside Sicily but differed in terms of growth rate during the 2 years of the cycle); and 2) intraspecific competition realized by means of two plant densities: 100 and 600 plants m^{-2}. The results showed that in the first year of the cycle, the two landraces had very different behavior: Resuttano tended to accumulate C reserves in taproots, whereas Gangi used the photoassimilates mainly for epigeic growth and the gamic reproduction process. As a result, Gangi produced about 550 kg ha^{-1} seed, whereas Resuttano had a negligible seed yield. The increase in intraspecific competition increased above- and belowground biomass at the beginning of flowering irrespective of genotype but had no effect on crop growth or seed yield at maturity.

Introduction

Sulla (*Hedysarum coronarium* L., syn. *Sulla coronaria* [L.] Medik.) is a short-lived perennial legume native to the Mediterranean basin (Talamucci, 1998), where it is grown extensively as a 2-year forage crop for grazing and/or hay or silage production. The species plays a key role in cereal-based systems of semi-arid regions, particularly in organic and low-input agriculture. It is commonly used to enhance the productivity and sustainability of farming systems (e.g., to supply nitrogen and to maintain soil organic matter). Recently there has been a newfound interest in sulla both in traditional and in nontraditional areas because of its excellent adaptability to marginal and drought-prone environments (Borreani *et al*., 2003; Annichiarico *et al*., 2008). Moreover, it has several non-agricultural uses; for example, it is planted for soil protection (Watson, 1982) and revegetation of disturbed lands (Flores *et al*., 1997) as well as for honey production and landscape architecture (Talamucci, 1998). Seed is often obtained as a secondary product from stands established to produce forage. Usually seed is harvested from second-year crops and from selected areas where more vigorous plants and fewer weeds are found (Stringi & Amato, 1998). Very little information is available on seed yield capacity in the first year of the crop cycle and on the influence of agronomical techniques on the reproductive process. The present study aimed to evaluate the effect of intraspecific competition on dry matter accumulation (both in epigeic organs and in taproots) and seed production in the first year of the crop cycle for two contrasting genotypes.

Materials and Methods

Two field trials were carried out during the 2003/2004 and 2004/2005 growing seasons in a Mediterranean environment (37°30'N – 13°31'E; 178 m a.s.l., Sicily, Italy) on a deep, well-structured soil classified as a Vertic Haploxerert. The treatments were as follows: 1) genotype: Gangi and Resuttano; and 2) intraspecific competition realized by means of two plant densities: 100 and 600 plants/m^2. The two landraces, both originating from inside Sicily, differed in terms of productivity (aboveground biomass and seed) in the first year of the cycle and regrowth capacity after the summer stasis (Amato *et al*., 2007). The experiment was set up as a split-plot design with four replications, with genotype as the main plots and intraspecific competition as sub-plots. Sub-plots were 7.0 × 4.5 m (18 rows, 0.25 m apart and 7 m long). Before sowing, 69 kg P_2O_5 ha^{-1} was applied. Plots were hand-sown on 7 January 2004 and 10 January 2005. Sulla was seeded at double rate (200 and 1200 seeds/m^2, respectively for 100 and 600 plants/m^2) and hand-thinned 20 days after emergence to obtain the desired plant densities. All plots were hand-weeded. Within each sub-plot three 1.25 × 0.75 m areas were randomly chosen for destructive plant samplings at the beginning of flowering (which was similar for the two landraces; i.e., in the first days of May), after 30 days (which coincided with the end of flowering for Gangi, the last to stop flowering), and at maturity. At each stage, number of plants, plant height, total aboveground biomass, botanical fractions (leaves, stems, and racemes), and taproot biomass (layer 0–20 cm) were recorded. At the beginning of flowering, leaf area was measured with a LI-COR 3100C leaf area meter on a 50-g subsample of leaves per plot. In the remaining plot area, seed yield and seed yield components were recorded at maturity. Analysis of variance on the combined 2-year data set was performed according to the experimental design. Data analysis was performed using SAS version 9.1 (SAS Institute, 2004). Year was treated as a random factor, whereas all other factors were treated as fixed.

Results and Discussion

In both growing seasons, at the beginning of flowering low plant density was ~90 plants m^{-2}, whereas for high plant density the number of plants per unit area was half of that fixed (~300 plants/m^2). Plant density did not further vary by treatment until maturity. At the beginning of flowering, Gangi accumulated a higher average aboveground biomass than Resuttano (+25%; Table 1). However, Resuttano produced a leafier forage (leaf:stem ratio, 8.1 vs. 1.5) and had a similar leaf area index. The two landraces also differed considerably in terms of taproot dry matter accumulation, which was more than double in Resuttano than in Gangi. The increase in plant density led to an increase in both leaf area index and biomass yield (both above and below ground) irrespective of genotype. During the flowering period, both landraces showed a dramatic increase in total biomass, but in Gangi the increase was mainly due to an increase in aboveground biomass (from 6.50 to 10.26 t DM ha^{-1}), whereas in Resuttano most of the increase occurred in taproots (from 1.35 to 7.11 t DM ha^{-1}). At the end of the flowering stage, the average concentration of taproot water soluble carbohydrates (WSC) was slightly greater for Gangi than for Resuttano (149 vs. 138 g kg^{-1} DM, respectively), but because of the much greater taproot dry matter production, Resuttano had about a 5-fold greater amount of WSC than Gangi.

Table 1. Sulla seed crop parameters (LSR = leaf:stem ratio; LAI = leaf area index; ADM = aboveground dry matter; TDM = taproot dry matter; WSC = water soluble carbohydrates) at various growth stages as affected by genotype and plant density.

			Beginning of flowering				End of flowering				Maturity
Year	Genotype[†]	Plant density[‡]	LSR	LAI	ADM	TDM	ADM	TDM	Taproot WSC		Seed
					t/ha	t/ha	t/ha	t/ha	g/kg	g/m^2	kg/ha
2004	Gan.	100	0.89	4.01	7.46	0.61	11.85	1.58	150	24	590
		600	0.77	3.76	9.94	0.78	10.38	1.37	151	21	515
	Res.	100	3.70	4.29	5.65	1.61	6.83	7.02	138	97	73
		600	4.63	4.20	6.72	1.98	5.94	6.80	127	86	10
2005	Gan.	100	2.72	2.86	3.25	0.38	8.74	1.25	145	18	535
		600	1.59	4.36	5.35	0.55	10.05	1.44	148	21	547
	Res.	100	10.92	2.78	3.21	0.80	3.91	6.78	142	96	7
		600	13.15	4.31	5.25	1.01	4.67	7.85	144	113	1
Year (Yr)			***[§]	***	***	***	*	ns	ns	ns	ns
Genotype (G)			***	ns	**	***	***	***	*	***	***
Plant density (D)			ns	***	***	**	ns	ns	ns	ns	ns
Yr × G			**	ns	***	**	ns	ns	*	*	ns
Yr × D			ns	***	ns	ns	**	ns	ns	ns	ns
G × D			ns	ns	ns	ns	ns	ns	ns	ns	ns
Yr × G × D			ns	ns	ns	ns	ns	ns	ns	ns	ns

[†] Gan. = Gangi; Res. = Resuttano. [‡] 100 = 100 plants/m^2; 600 = 600 plants/m^2.
[§] *, **, ***, $P \leq 0.05$, 0.01, 0.001, respectively; ns, $P > 0.05$.

Intraspecific competition did not affect any trait either at the end of flowering or at seed maturity. In the interval between the end of flowering and maturity a further increase in taproot dry matter (~15% on average) was observed for both genotypes (data not shown).

The seed yield of Gangi was, on average, 547 kg ha^{-1} (with no significant difference between the two growing seasons), whereas Resuttano produced a negligible seed yield in both years.

This study reveals the very different behavior of two sulla genotypes during the first year of a 2-year crop cycle; these differences could be related to different population survival strategies. Our results show that the Resuttano landrace tends to accumulate C reserves in taproots, whereas the Gangi landrace uses the photoassimilates mainly for epigeic growth and the gamic reproduction process. Greater C and N reserves in the taproots of alfalfa allow for greater plant survival and faster regrowth (Dhont *et al*., 2002); it is likely that this is also the case for sulla. The present study shows that the possibility of producing sulla seed in the first year of a crop cycle depends strongly on genotype. Further research is needed to investigate the behavior of these contrasting genotypes during the second year of the crop cycle, particularly with regard to seed yield and regrowth rates after the summer stasis.

Acknowledgments This work was funded by the University of Palermo

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