

WEED INTERFERENCE WITH *Lupinus albus* CROP

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SUMMARY

A comparative analysis of the growth of *Lupinus albus* grown in stands in mixture with annual weeds and in stands without weeds (with herbicide) was carried out on a field trial with two large plots. The measurements taken at every two weeks include some parameters which characterize the growth of above ground *L. albus* individual plants (height, number of leaves, number of plants/unit area, total dried weight and their components and leaf area). At the same intervals the above ground dried weight of weed species was determined. Logistic curves were fitted to primary values and to growth parameters. The annual weeds were highly dominated by *Medicago nigra*, *Melilotus segetalis*, *Papaver rhoeas*, *Phalaris brachystachis* + *P. coerulescens*, *Raphanus raphanistrum* and *Sinapis arvensis*. Leaf area, relative growth rate (RGR), leaf area ratio, number of *L. albus* plants/unit area, harvest index (HI), crop growth rate (CGR), leaf area index (LAI) in stands without weeds (with herbicide) were significantly higher than in stands in mixture with weeds.

RESUMO

No sentido de avaliar a concorrência exercida pelas infestantes no desenvolvimento da cultura do tremoceiro, realizou-se um ensaio de campo em duas grandes parcelas, uma com tratamento herbicida e outra infestada (sem herbicida). Quinzenalmente efectuaram-

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se colheitas destrutivas da parte aérea das infestantes para determinação das matérias secas por espécie e de 15 plantas de *L. albus* para análise de crescimento com determinações das matérias secas, contagem do número de folhas e vagens, área foliar e altura. Foram ajustadas curvas logísticas aos valores primários e aos parâmetros de crescimento. As infestantes mais importantes pela sua biomassa foram *Medicago nigra*, *Melilotus segetalis*, *Papaver rhoeas*, *Phalaris brachystachis* + *P. coerulescens*, *Raphanus raphanistrum* e *Sinapis arvensis*. Os valores de área foliar, taxa relativa de crescimento RGR, razão de área foliar (LAR), número de plantas de tremço/unidade de área, índice de colheita (HI), taxa de crescimento da cultura (CGR) e índice de área foliar (LAI) na parcela com herbicida foram significativamente mais elevados relativamente à parcela infestada.

INTRODUCTION

The main cause of crop loss is the crop-weed interference, which includes competition and allelopathy (Moreira, 1979). Plants of different species in a field compete with each other for growth-limiting resources like water and nutrients. In autumn sowing *Lupinus albus* the growth rate is slow from the beginning of vegetative stage, this is due probably to low temperatures (Pate *et al.* 1985). Thus *Lupinus albus* appeared sensitive to weed competition.

Estimating losses from weeds in *Lupinus* spp. was from 25-100% of yield losses (Alonso, 1983), in the case of *Lupinus luteus* cvs "Refusa" and "Milfontes" had yield reduction of 31% and 64% respectively (Gaspar & Moreira, 1993).

In studies of crop-weed interference, one method of examining the interaction is to follow the accumulation of dry matter by serial destructive harvesting throughout the growing season of the annual crop. The advantage of this methodology is the possibility of direct comparison of the weed and crop dry matter accumulation per unit area along the time. For the study of the interference effects between the natural flora and crop, a field trial was carried out, where the data were collected by the classical methodology of growth analysis. Within the weed flora, the relative importance of individual species can be assessed by recording their contribution to the total weed dry matter at the different sampling dates. This methodology is based on primary values such as total dry matter of the plant, dry matter of different parts (root, stems, leaves, flowers, fruits and seeds), leaf area and plant height.

This paper aims at analysing the weed flora interference in *Lupinus albus* crop with representative evaluation under field conditions.

MATERIALS AND METHODS

The above mentioned experiment was conducted during the year 1990/91, from 14 November to 18 June at a research farm, Instituto Superior Agronomia, Lisboa, Portugal. Rainfall during the growing station was 583,3 mm and mean air temperature was 14°C.

The soil is a vertisol (Vertisols, FAO) having pH 6,7 and 2,5 % organic matter with C/N = 10. Fertilizer and soil insecticide was broadcast prior to seeding at the rate of 36 kg/ha P and 1,25 kg/ha chlorpyrifos-ethyl. Seeding were made in rows with the french variety «Ares» in order to obtain a density 25 plants/m².

Serial destructive harvesting was made every 15 days, the first 22 days after seeding (DAS). Weed samples were collected randomly with the help of 0,25 m² quadrat which we used through 16 places (in total 4 m²) of each plot and date. In the same area, 15 plants of a *L. albus* were collected. The measurements include some parameters which characterize the growth of above ground *L. albus* individual plants (height, number of leaves, number of plants/unit area, total dried weight and their components and leaf area) and above ground dried weight of weed species.

Mathematical functions were fitted to experimental data in the sense of description of the relationship between the data and the time (along the growing season). With this methodology small deviations from the overall trend are «smoothed» often making the results less erratic. Equations were estimated by using a computer method very common in software of algorithm, with the finding of — Gauss-Newton (Myers, 1986). The programmes were made in GENSTAT5, directive FITNONLINEAR (Lane *et al*, 1987). Two logistic models were fitted to the data of each treatment (with weeds — S/HERB and herbicide application — C/HERB) describing in appropriate way growth attributes (RGR, dry matter accumulation). To determine whether there were significant effects on the parameters associated with each model, the residual mean squares associated with models fit to each treatment separately — full model — was compared to the residual mean square associated with a single model fit to the entire data set across treatments — reduced model.

RESULTS AND DISCUSSION

The fitness of regression curves was only to the 180 DAS, because we can not adapt the shape of the logistic function to the senescence phase after that time.

Individual level:

There are significant differences between the full model and the reduced model, thus as we can see in tables 1,2 and 3, TDM (total dry matter accumulation) and parameter B (growth rate) are higher in C/HERB despite the similarity of the asymptotic value. TDM is minor in S/HERB at individual level like in high densities, however the average number of *L. albus* plants per m² is higher in C/HERB (22.6 to 18.3), then the higher density effect is due in S/HERB to weeds. This agrees with Hakansson (1983).

The evolution of total leaf area was different between treatments. The asymptote of the model fitted to C/HERB data had a higher value than the asymptote of the model S/HERB, however the point of inflexion was earlier in S/HERB. Barradas (1991) has found in different densities of *L. albus* crop for the parameter B values from 0,042 (16,8

plants/m²) to 0,052 (10,5 plants/m²); for the parameter C values from 160 DAS (10,5 plants/m²) to 167 DAS (39 plants/m²) that were earlier than our values (170 DAS in C/HERB and 186 DAS in S/HERB).

The models adjusted to the height evolution are different, although having two parameters in common the point of inflexion was earlier in S/HERB.

Table 1

Regression parameters, point of inflexion (C_I) and (R^2) of the model $Y = A/(1+C \times e^{-B \times DAS})$, for total dry matter accumulation (TDM), total leaf area (AREA) and plant height (HEIGHT) in *Lupinus albus* crop

Quadro 1

Parametros da regressão, ponto de inflexão (C_I) e coeficiente de determinação (R^2), do modelo $Y = A/(1+C \times e^{-B \times DAS})$, para a evolução da matéria seca total (TDM) área foliar (AREA) e altura da planta (HEIGHT) de *Lupinus albus*

			Regression parameters		C	Point of inflexion (C_I)	R^2
			A	B			
Primary	with weeds	TDM	122.70	0.04	3599.00	186	85.50
		AREA	815.10	0.08	20213.00	118	74.00
		HEIGHT	131.63	0.03	61.60	134	94.80
values	with herbicide	TDM	124.50	0.06	51849.00	170	88.00
		AREA	1547.00	0.08	43958.00	134	74.40
		HEIGHT	139.70	0.03	49.46	143	93.00

Table 2

Comparison of full and reduced models of total dry matter accumulation, total leaf area and plant height models

Quadro 2

Somas de quadrados dos erros dos modelos conjunto, separados e separados com parâmetros comuns

		① Single model		② Separated models			③ Separated models with common parameters			
		SQE	g.l.	SQE _A	SQE _B	SQE _A + SQE _B	g.l.	SQE	g.l.	n.º p.c.
Primary	TDM	21703.00	357	5436.00	10254.00	15690.00	354	15690.00	355	2
values	AREA	2907×10 ⁴	357	6533880	16445460	22979694	354	—	—	—
	HEIGHT	22499.00	357	9906.00	11754.00	21660.00	354	21680.00	355	2
<i>(L. albus</i> + weeds.) / m ²		23174.00	21	1578.00	1664.00	3242.00	18	—	—	—

Table 3
Tests for significant differences between models

Quadro 3
Testes para avaliação das diferenças significativas entre modelos

		Gallant test			F test		
		① vs ②	① vs ③	③ vs ②	① vs ②	① vs ③	③ vs ②
Primary values	TDM	***	***	ns	***	***	***
	AREA	***	—	—	***	—	—
	HEIGHT	***	***	ns	***	***	ns
<i>(L. albus + weeds) / m²</i>		***	—	—	***	—	—

** Significant at $\alpha = 0.05$

*** Significant at $\alpha = 0.01$

ns Not significant.

Growth parameters

The evolution of RGR (fig. 1) and LAR (fig. 2) values in C/HERB are superior than in S/HERB, the quantity of limited resources available for *L. albus* plants of the treatment C/HERB is higher. The maximum value of LAR was at 118 DAS, from that time on the values of the two treatments converge.

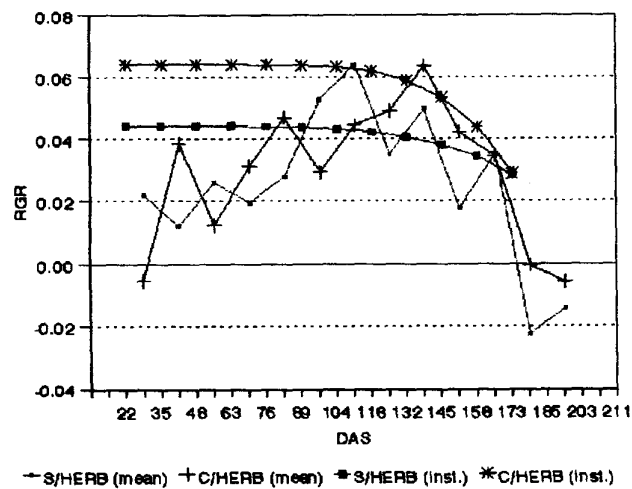


FIGURA 1 — Relative growth rate (RGR) evolution, mean and instantaneous values in both treatments (C/HERB and S/HERB).

FIGURA 1 — Evolução da taxa relativa de crescimento (RGR) média e instantânea nas duas modalidades (C/HERB e S/HERB).

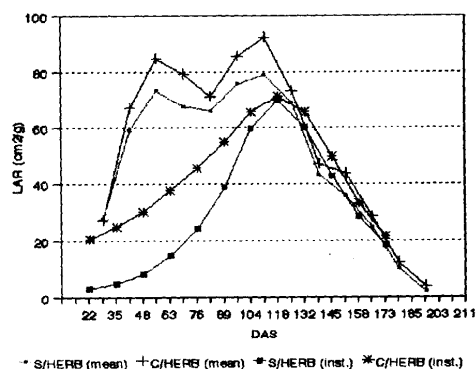


FIGURA 2 — Leaf area ratio (LAR) evolution in both treatments (S/HERB and C/HERB). Mean and instantaneous values.

FIGURA 2 — Evolução da razão de área foliar (LAR), nas duas modalidades (S/HERB e C/HERB). Valores médios e instantâneos.

Population level

The stress of the proximity of neighbour plants can reflect in higher level of mortality, affecting the growth with reduction of growth rates and delaying the ripeness (Harper, 1977 and Hakansson, 1988). This can explain the inferior number of *L. albus* plants in S/HERB. We did not find differences in phenological stages between treatments.

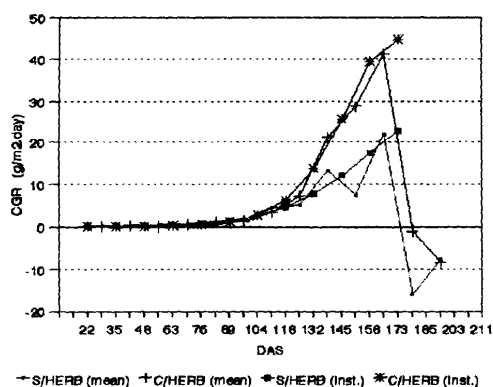


FIGURA 3 — Crop growth rate (CGR) evolution in both treatments (S/HERB and C/HERB). Mean and instantaneous values.

FIGURA 3 — Evolução da taxa de crescimento da cultura (CGR) para as duas modalidades (S/HERB e C/HERB). Valores médios e instantâneos.

The harvest indexes (HI) are 46.2 and 49.6 % for S/HERB and C/HERB respectively. These values are relatively high, the differences between treatments draw the different developmental condition of the growth of the two populations.

The community indicators, CGR (fig. 3) and LAI (fig. 4) are superior in C/HERB. There is a delay of 15 days between CGR curves of the two treatments, the maximum value of C/HERB is 15 days earlier and two folds (approximately) the maximum value of S/HERB. The LAI asymptote value of S/HERB (1.5) is minor and earlier than in C/HERB (4.5). We consider therefore this fact is due to a higher density and the superior values recorded in the evolution of total leaf area in the population of the treatment C/HERB.

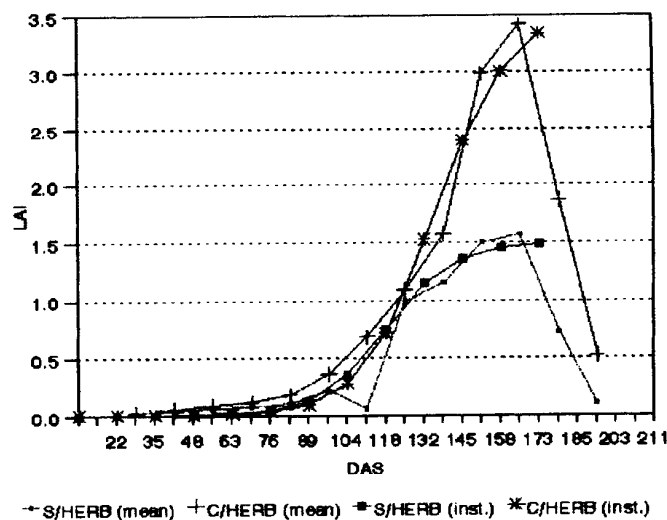


FIGURA 4 — Leaf area index (LAI) evolution in both treatments (S/HERB and C/HERB). Mean and instantaneous values.

FIGURA 4 — Evolução do índice de área foliar (LAI) para as duas modalidades (S/HERB e C/HERB). Valores médios e instantâneos.

Total biomass per unit of area

Total biomass per unit of area is calculated as the sum of the mean values of above ground dry matter both *L. albus* plants and weeds present per unit of area. The statistical treatment procedures is similar to that described for *L. albus* plants. Table 4 shows the values founded in the two treatments (C/HERB and S/HERB) and table 3 the tests of significant differences.

Table 4
Regression parameters, point of inflexion (C_I) and R^2 of the model
 $Y = A / (1 + C \times e^{-B \times DAS})$, for total dry matter accumulation.
Mean values per unit of area (m^2)

Quadro 4
Parâmetros da regressão do modelo $Y = A / (1 + C \times e^{-B \times DAS})$,
para a evolução da matéria seca total, ponto de inflexão (C_I) e coeficiente de
determinação (R^2). Valores médios e por unidade de área (m^2)

		Regression parameters			Point of inflexion (C_I)	R^2
		A	B	C		
Total dry weight of	S/HERB	4053.00	0.05	4723.00	184	99.90
<i>L. albus</i> +weeds	C/HERB	2964.00	0.06	55813.00	170	99.90
Total dry weight of	S/HERB	1558.00	0.05	62.72	177	99.6
6 main weeds	C/HERB	3.47	0.07	280.00	78	94.9
Total dry weight of	S/HERB	49.22	0.12	3.49×10^8	162	98.9
minor species	C/HERB *	—	—	—	—	—

* Not converged

There are significant differences between the models fitted to the two treatments. In S/HERB model the asymptote value is higher but the growth rate is retarded (fig. 5) thus promoting the advance in the point of inflexion. But the senescence was simultaneous in the two situations (C/HERB and S/HERB), that means that there is no advantage for the S/HERB situation. In the treatment C/HERB the contribution for the total biomass per unit of area is due principally to the *Lupinus albus* plants, and from 173 DAS more than 50 % is due to the pods. In S/HERB treatment from 76 DAS less than 70% is due to *L. albus* plants; six group of weed species of the are responsible for the main 30%.

In C/HERB treatment until 104 DAS the six groups of species are predominantly in the weed flora, however the contribution for the total biomass per unit of area was negligible. It is important to underline the contribution for the total biomass of *L. albus* plants in C/HERB treatment because it is 100% until 89 DAS, which corresponds to herbicide period persistence (herbicide applied cyanazine). Herbicide treatment exhibited a good control to the six groups of the species.

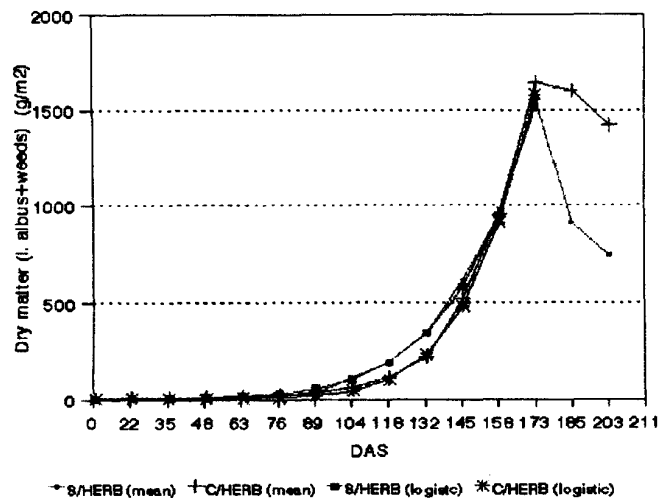


FIGURA 5 — Dry matter accumulation of *L. albus* + weeds aerial parts per unit of area, in both treatments (S/HERB and C/HERB).

FIGURA 5 — Evolução da acumulação da matéria seca, da parte aérea de todas as plantas numa unidade de área, nas duas modalidades (S/HERB e C/HERB).

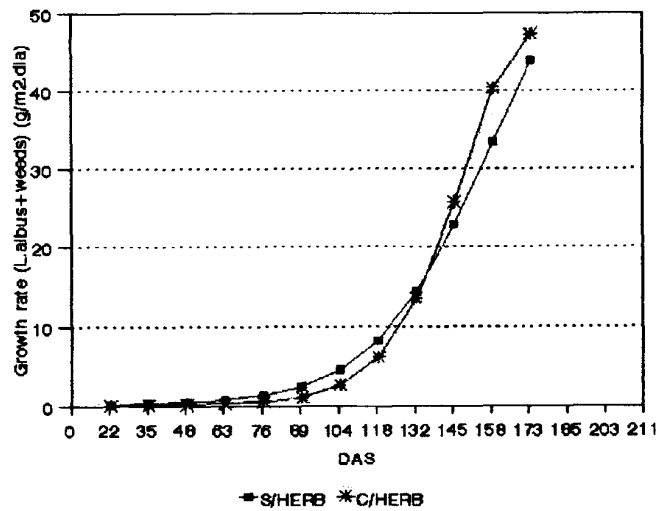


FIGURA 6 — Instantaneous growth rates of total above ground biomass (dry weight of *L. albus* + dry weight of weeds) per unit of area in both treatments.

FIGURA 6 — Taxa de crescimento instantânea da biomassa total da parte aérea (matéria seca de trevoceiro + matéria seca das infestantes) produzida por unidade de área nas duas modalidades, ao longo do ciclo cultural.

Table 5
Regression parameters, point of inflexion (C_I) and R^2 of the model
 $Y = A / (1 + C \times e^{-B \times DAS})$, for total dry matter accumulation/unit of area (m^2)

Quadro 5
Parâmetros da regressão do modelo $Y = A / (1 + C \times e^{-B \times DAS})$, para a evolução da
matéria seca total, ponto de inflexão (C_I) e coeficiente de determinação R^2
para as seis principais infestantes. Valores médios e por unidade de área (m^2)

		Regression parameters			Point of inflexion (C_I)	R^2
		A	B	C		
<i>Medicago nigra</i> *	S/HERB	109.20	0.10	14.89×10 ⁶	158	99.60
	C/HERB	1.72	0.05	691.00	133	92.2
<i>Melilotus segetalis</i>	S/HERB	85.66	0.12	70.75×10 ⁶	145	99.60
	C/HERB	1.57	0.05	265.00	117	97.30
<i>Papaver rhoeas</i>	S/HERB	72.61	0.07	16.04×10 ³	147	97.20
	C/HERB	1.33	0.05	68.60	91	96.60
<i>P. brachystachys</i> +	S/HERB	238.70	0.10	66.06×10 ⁵	155	99.30
<i>P. coerulescens</i>	C/HERB	1.65	0.06	727.00	112	93.90
<i>R. raphanistrum ssp. raphanistrum</i>	S/HERB	114.40	0.04	412.00	156	90.50
	C/HERB	1.37	0.10	12930.00	90	98.30
<i>Sinapis arvensis</i>	S/HERB	89233.00	0.06	17.84×10 ⁶	272	89.90
	C/HERB	1.64	0.04	66.20	104	91.00

* With restriction at 170 DAS.

The models fitted for the six groups of species in the two situations (table 5) show that the parameters A and B, except for *Rapahanus raphanistrum ssp. raphanistrum*, had higher values in S/HERB situation. The parameter B, except for *Rapahanus raphanistrum ssp. raphanistrum*, in C/HERB situation had a higher value than in the model MST and the model of accumulation of total biomass per unit of area. The point of inflexion was earlier in the models of the six groups of the species of the situation C/HERB.

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