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in

Delgado I. (ed.), Lloveras J. (ed.).
Quality in lucerne and medics for animal production

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 45

2001
pages 141-143

Effect of nitrogen fertilisation on alfalfa (*Medicago sativa* L.) regrowth and production

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SUMMARY – Alfalfa remobilises the N reserves accumulated in the roots for regrowth after harvest in greenhouse conditions. This effect was studied in field conditions in order to know if 50 kg/ha of supplementary nitrogen fertilisation after each harvest could avoid removing N reserves in the roots or increase the shooting after cutting. Results showed an increase of dry matter yield (18.7%) and crude protein content (11.3%) in the whole plant due to N fertilisation, but no differences (P > 0.05) were observed in shooting after cutting. Dry matter yield and crude protein content in the roots decreased in N non-fertilised plants.

Key words: *Medicago sativa* L., dry matter yield, crude protein, N reserves.

RESUME – *"L'effet de la fertilisation azotée sur la production et la repousse de la luzerne (*Medicago sativa *L.)". La luzerne utilise les réserves azotées accumulées dans les racines pour la repousse après la récolte en conditions de serre. Cet effet a été étudié en conditions de champ afin de savoir si un apport d'azote après chaque coupe, de 50 kg/ha, pouvait éviter la réduction des réserves azotées des racines ou augmenter la repousse après la coupe. Les résultats ont montré une augmentation du rendement en matière sèche (18,7%) et de la teneur en protéines (11,3%) chez la plante entière en réponse à la fertilisation azotée, mais on n'a pas observé de différences (P > 0,05) pour les repousses après la coupe. Le poids des racines et leur teneur en matière azotée ont diminué chez les plantes non fertilisées.*

Mots-clés : Medicago sativa *L., rendement en matière sèche, matière azotée, réserves azotées.*

Introduction

Alfalfa (*Medicago sativa* L.) is a leguminous crop that does not generally need nitrogen fertilisation due to its ability to assimilate atmospheric N_2 by biological fixation associated to microsymbiont *Rhizobium meliloti*. However in a review some authors (Hannaway and Shuler, 1993) suggest that a small application of N fertiliser at establishment increases yields in the seeding year when soils are low in N or organic matter or when there are relatively cool temperatures.

Studying the time course of N_2 fixation in alfalfa, some researches showed that N_2 fixation decreased immediately after cut and remained low for 10 to 14 days. As result, alfalfa removes the N reserves accumulated in the taproots for shooting after harvest (Kim *et al.,* 1991; Lemaire *et al.,* 1992; Barber *et al*., 1996). On the other hand an increase in the N concentration of the roots has been observed when N fertilisation was applied after harvest (Barber *et al*., 1996).

The purpose of this work was to determine in field conditions the effect of the supplemental nitrogen fertilisation on alfalfa after harvest by quantifying the N partitioning between leaves, stems, crowns and roots has been observed along their regrowth.

Material and methods

Aragón alfalfa cultivar was seeded in October 1998 in Zaragoza (Spain). Alfalfa was established in box-plots of 35 cm diameter and 50 cm high at a density of 200 plants/m^2 (22 plants/box-plot). Box-plots were refilled with soil from irrigated fields where alfalfa is part of the rotation but where alfalfa has not been seeded in the last four years. Soil fertility analysis showed the following: loam texture, pH of 8.18, organic matter contents of 1.97%, exchangeable P = 8.72 ppm (Olsen method), exchangeable K = 124.0 ppm and EC_e of 0.54 dS/m.

Two treatments were applied in 1999: 0 and 50 kg of N/ha as ammonium nitrate after each harvest. Box-plots were irrigated to field capacity when needed. The first three cuts that were harvested at 50% bloom and 5 cm height were not controlled.

Recordings were taken during the 4th and 5th growth periods. The time course of growing was followed by emptying and sampling three complete box-plots, twice a week (3-4 days) making a total of eight sampling dates in each growth period.

Whole plants from each box-plot were transferred to the laboratory for leaf/stem and root/crown separations. Dry matter yield (DMY) of fractions was assessed by drying at 60ºC for 48 hours and crude protein (CP) content of the samples was determined by Kjheldhal procedure (AOAC, 1990).

Box-plots were arranged in a randomized complete block design with three replications. For the analysis of N there were 32 treatment combinations (two N treatments eight sampling dates two harvests). The data was subjected to ANOVA (SAS, 1998) and the variation was partitioned into replicate, N treatments sampling dates, harvest effects, and their interactions. Where F-tests were significant at $P \leq 0.05$, LSDs were calculated.

Results and discussion

Results are presented in Tables 1 and 2. N fertilisation did not affect the height of the alfalfa plants or the number of shoots per plant but the plots receiving N fertilisation increase the DMY and CP in leaves, stems, crowns and roots. The effects were similar in both (4th and 5th) cuts (Table 1).

Table 1. Effects of the N fertilisation and order of harvest on plant height, dry matter yield (DMY) and crude protein (CP) in alfalfa trials

	Height (cm)	Shoots (no.)	Leaves		Stems		Roots		Crown	
			DMY (g/plot)	CP (%)	DMY (g/plot)	CP (%)	DMY (g/plot)	CP (%)	DMY (g/plot)	CP (%)
	Significance									
Growth period	***	NS	NS	***	NS	***	*	NS	***	***
N fertilisation	NS	NS	**	NS	*	*	**	**	*	*
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Average									
Growth period										
Fourth cut	35.3	4.5	16.2	32.9	10.9	15.6	52.1	14	19.5	11.7
Fifth cut	39	4.6	15.7	34.6	11.5	15.8	57.4	14	25.8	10.8
N fertilisation										
0 N/ha	36.7	4.4	14.8	33.4	10.3	14.5	50.2	12.5	20.3	10.3
50 N/ha	37.6	4.7	17.1	34	12.1	16.9	59.3	15.5	25	12.3

The study of the time course of DMY and CP content in the plant fraction, shows their decrease in roots from harvest to 10 or 14 days after cut, mainly in non fertilised plots, but they increased again up to next harvest (Table 2).

Height plant was not significantly affected by N fertilisation but DMY increased 18.7% and CP 11.3% in the whole plant. It was attributed to the high N fertilisation (150 kg/ha that received the crop during the first fourth harvest and 200 kg/ha on the first fifth harvest). A root weight and CP reduction were observed in non fertilised plots. This DMY and CP decrease could be due to the utilisation of N reserves of the roots in non fertilised plots (Lemaire *et al*., 1992; Barber *et al*., 1996). Further research is needed to study the effects of N fertilisation on the persistence of plants.

Table 2. Plant height, dry matter yield (DMY) and crude protein (CP) of alfalfa (g/plot) by arrangement of box-plots, 0 or 50 N/ha fertilised, in two growth periods (4th and 5th harvest)

Cut	Days	Height (cm)		DMY leaf (g)		DMY stem (g)		DMY root (g)		DMY crown (g)		CP leaves (%)		CP stem (%)		CP root (%)		CP crown (%)	
		0	50	0	50	0	50	0	50	0	50	0	50	0	50	0	50	0	50
4th	0 (cut)	42.3	48.3	21.2	21.5	16.2	20.1	50.7	55.6	17.4	18.2	26.9	27.8	12.9	14.9	14.3	15.4	12.6	13.3
	3	9.7	9.7	4.1	4.4	1.7	2.1	53.5	61.7	15.6	15.2	–	–	–	21.0	12.8	14.9	11.7	13.1
	7	22.0	24.3	7.0	8.2	3.0	4.3	35.8	48.7	14.6	17.7	39.4	42.9	25.2	26.9	12.7	16.0	10.6	12.7
	10	37.0	36.7	14.6	16.1	9.5	9.4	40.6	43.5	17.5	20.3	36.9	39.4	17.8	20.7	10.9	14.5	9.6	13.4
	14	36.7	40.7	12.9	17.7	8.9	11.9	33.3	50.8	15.8	19.5	31.9	33.8	14.2	17.5	12.6	15.2	11.4	13.6
	17	38.3	40.7	17.7	20.7	12.3	14.1	51.7	56.8	20.3	23.4	30.2	31.6	12.3	14.0	13.3	15.6	10.6	12.8
	21	41.7	43.7	17.3	21.0	12.8	13.9	49.9	60.9	20.7	24.5	28.5	30.9	10.8	12.9	12.9	15.6	10.1	12.9
	24	47.7	41.3	22.5	25.1	14.1	15.5	53.8	72.2	20.5	24.6	28.5	28.9	10.0	11.4	13.3	16.1	10.9	12.4
	28	46.3	48.0	23.1	26.7	19.0	22.2	57.9	62.7	19.0	23.2	29.6	27.9	9.7	9.2	13.1	14.9	9.9	10.5
Significance		***	***	***	***	***	***	*	*	NS	**	***	***	***	***	**	NS	*	**
LSD† (5%)		6.15	5.00	4.08	4.85	2.93	3.57	14.04	15.52	5.31	4.87	1.54	1.66	2.18	2.59	1.18	1.41	1.01	1.16
5th	0 (cut)	46.3	48.0	23.1	26.7	19.0	22.2	57.9	62.7	19.0	23.2	29.6	27.9	9.7	9.2	13.1	14.9	9.9	10.5
	3	7.0	9.3	1.5	2.0	0.8	0.6	58.4	73.3	20.2	25.4	–	–	–	–	13.2	16.8	11.1	13.3
	7	23.0	20.7	5.3	7.2	2.5	2.1	52.6	62.3	20.1	24.9	41.9	–	18.4	30.9	12.9	16.1	10.2	12.4
	10	34.3	39.0	10.2	14.1	6.1	9.3	38.8	53.6	19.2	26.5	38.3	41.7	20.1	24.2	11.0	15.0	7.7	9.6
	14	43.0	43.0	13.0	17.1	7.2	13.3	37.0	52.6	19.1	25.1	35.9	38.1	17.5	20.3	11.4	15.4	8.2	–
	17	45.7	50.3	17.5	20.7	12.7	16.7	51.6	47.8	22.4	26.0	33.6	34.7	14.1	15.5	12.4	16.0	9.7	12.0
	21	49.0	50.7	20.2	23.7	15.0	18.7	62.7	64.1	25.1	43.3	32.4	32.2	12.5	13.2	12.4	15.7	9.9	11.7
	24	52.7	51.7	21.1	22.4	15.4	17.7	56.2	69.1	27.1	31.2	31.7	31.1	11.4	12.2	12.4	14.7	10.5	11.5
	28	52.7	52.3	28.8	25.8	23.6	22.4	70.2	67.9	27.5	29.7	29.3	28.5	11.2	11.2	12.5	15.4	10.7	12.5
Significance		***	***	***	***	***	***	**	NS	**	NS	***	***	***	***	***	NS	***	*
LSD† (5%)		4.66	3.37	3.60	4.64	2.28	4.73	12.98	21.60	5.67	16.61	2.11	2,25	2.29	2.20	0.98	2.28	2.14	2.16

†LSD = Least Significant Diference.

*P < 0.05, **P < 0.01, ***P < 0.001, NS = P > 0.05.

Conclusions

Alfalfa fertilised with 150 and 200 kg N/ha increased the total plant DMY and CP percentages by 18.7% and 11.3%, respectively. N fertilisation did not affect the alfalfa regrowth height but reduced the weight and CP content of roots in non N fertilised plots.

Acknowledgements

This study has been financed by INIA (Spanish Institute for Agricultural Research) project (SC98-043-C2-1).

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