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Yield and quality of alfalfa as affected by water irrigation and phosphorus levels

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SUMMARY – A three-year research (1996-1998) was carried out in a hilly area of Southern Italy (Apulia region) on two species of *Medicago sativa* L. (an Italian alfalfa and the Spanish Mielga). The objective of this study was to evaluate the effects determined on these forage crops by two water irrigation levels (non-irrigated and 300 m^3/ha, at 35% of available water) and by two phosphoric fertilizer doses (75 and 150 kg P_2O_5/ha). The results obtained during the trial period pointed out the good yielding ability of the Italian alfalfa, while Mielga showed the best qualitative characteristics of forage. Water levels did not affect any parameter, probably because of good winter rainfalls, which levelled the effects of irrigation. At last, the lowest dose of phosphoric fertilizer assured the best qualitative responses, with differences almost always significant to analysis of variance.

Key words: Irrigation regimes, phosphorus fertilization, *Medicago sativa*, mielga.

RESUME – *"Effets de l'irrigation et du niveau de phosphore sur la production et la qualité du fourrage de luzerne". L'étude a été menée dans une localité de collines du sud de l'Italie pendant trois années (1996-1998) sur deux espèces de luzerne (*Medicago sativa *L.), une italienne (cv. Garisenda) et une spontanée espagnole (Mielga). Ces espèces ont été soumises à deux niveaux d'irrigation (pas irrigué et irrigation avec 300* m^3*/ha, alors que l'eau disponible dans le sol atteingnait 35%) et deux doses de fumure phosphorique (75 et 150 kg/ha de* P_2O_5*). Les résultats obtenus pendant la période d'essai ont montré la bonne productivité de la luzerne italienne et la supériorité de la Mielga pour les caractéristiques qualitatives. Les volumes d'irrigation n'ont pas exercé une influence sur les paramètres testés. Quant aux effets du phosphore, la meilleure réponse a été obtenue avec 75 kg/ha de* P_2O_5*, avec des différences souvent significatives à l'analyse statistique.*

Mots-clés : *Irrigation, fumure phosphorique,* Medicago sativa*, mielga.*

Introduction

Forage crops and livestock husbandry are two productive systems greatly linked between each other. In fact, only the availability of choice forage can warrant the quality and healthfulness of animal productions, also in the light of the latest events relating to the BSE. In this context, the role of forage legumes is very important, because of their high forage quality and feeding value.

In South Italy, *Medicago sativa* L. is one of the main forage crops, due to its good adaptation and yielding capacities. Nevertheless, a large part of Southern environments devoted to fodder crops are characterized by summer drought, poorly fertile soils (shallow and mostly clay), with low forage productions, both in yield and in quality. Therefore, the knowledge of suitable agronomic techniques can be useful.

For this purpose, since 1982 the Experimental Research Institute have carried out several studies (Rizzo and De Giorgio, 1982; De Giorgio *et al*., 1991; Rizzo *et al*., 1991).

This research is aimed to compare two perennial populations of *Medicago* and to determine which effect different water irrigation levels and phosphoric fertilization doses had on green forage and dry matter yields and on forage quality.

Materials and methods

The experiment was established in the autumn of 1995 and ended in 1998 at Rutigliano (41º01'N, 4º39'E), a hilly area of South Italy, on the Experimental Farm of the Institute.

The soil, whose physico-chemical characteristics are shown in Table 1, is classified as Rhodoxeralf Lithic Ruptic (Soil Taxonomy-USDA).

Table 1. Physico-chemical soil characteristics of experimental field

Shells	5.1%
Fine soil	94.9%
Coarse sand	2.7%
Fine sand	20.8%
Clay	51.0%
Silt	20.4%
pH	7.3%
Total N	0.132%
Organic matter	2.35%
Available P (as P_2O_5)	49 ppm
Exchangeable K (as K_2O)	711 ppm

The climate is "accentuated thermo-mediterranean" (UNESCO-FAO classification), with large inter- and intra-seasonal variations.

The weather during the three-year trial was characterized by annual rainfall (627.2, 613.1 and 663.2 mm, respectively in 1996-1997-1998) always higher than the long-term average 1977-1995 (606.2 mm), even if the rains were unevenly distributed in each year, being concentrated in the winter months. On the contrary, the average monthly temperatures were almost always similar to those of the long-term averages, except in the third year, in which temperatures have been consistently higher.

On two populations of *Medicago sativa* L., an Italian alfalfa (cv. Garisenda) and a Spanish alfalfa (Mielga), were studied:

(i) *Two water irrigation levels not irrigated*, with 1 or 2 water supplies only in the warmest July and August months, and *300 m^3/ha* of water application at 35% of available water in the soil, with 2-4 waterings in each season, according to the climatic pattern. Besides, both treatments were irrigated with 300 m^3/ha at the sowing-time, to aid germination and seedling development and to ensure plants establishment.

(ii) *Two phosphoric fertilizer doses, 75 and 150 kg P_2O_5/ha*, pre-plant incorporated in the soil in summer of the first trial year, at the time of main ploughing, and in the autumn of 1996 and 1997, as top dressing.

Sowing was performed in the last ten days of November 1995 with 30 kg/ha of seeds, in elementary plots of 6 m^2, with a row-spacing of 20 cm.

All treatments were arranged in a randomized design, with three replicates.

In each year, the first mowing was carried out at the full-bloom stage; the following cuttings were made when plants reached, on the average, about 40 cm height.

Italian alfalfa was harvested twice in 1996, five times in 1997 and four in 1998. In Spanish Mielga, three harvests were taken in the first year, four in the second and third years.

On samples collected from each plot and dried at 70ºC for 48 h the following chemical determinations were made: crude protein (multiplying total N-Kjeldahl by 6.25), crude fat (Soxlet), ash (samples dried at 550ºC), neutral-detergent fibre (Van Soest and Robertson, 1980), Forage Unit of milk and meat (Demarquilly *et al.*, 1978).

Data obtained during the trial period were analysed according to ANOVA procedure (SAS Institute, 1998). Differences among mean values were performed with the SNK test.

Results and discussion

The results obtained during the trial period are given in Table 2. The best yielding responses (green forage and dry matter) were obtained in the second and third year, with statistically significant differences in comparison with those of 1996; it confirms the ability of legumes to achieve the best yields in the years following sowing, also because of higher cuttings number, as related before. On the contrary, the effects of weather (rains) were very scanty. For the forage quality, it is difficult to determine a trend; when yields were poor (1996), there were the highest crude protein and fat contents, and then of milk and meat forage units. On the whole, the best yields/quality balance has been obtained in the last year (1998).

Table 2. Effects of experimental treatments on quanti-qualitative parameters of production

	Green forage (t/ha)	Dry matter (t/ha)	Crude protein (%)	Crude fat (%)	Ash (%)	NDF (%)	Milk Forage Unit (/ t d.m.)	Meat Forage Unit (/ t d.m.)
Years								
1996	15.84 b	5.18 b	17.45 a	3.51 a	11.40	37.43 c	8.62 a	7.81 a
1997	50.18 a	12.66 a	15.37 c	3.36 c	11.38	41.10 a	8.20 c	7.35 c
1998	41.48 a	12.00 a	16.61 b	3.45 b	11.39	38.89 b	8.45 b	7.63 b
Species								
Italian alfalfa	40.50 a	10.82 a	15.81 b	3.39 b	11.39	40.23 a	8.27 b	7.44 b
Mielga alfalfa	31.17 b	9.07 b	17.16 a	3.48 a	11.40	38.04 b	8.56 a	7.74 a
Water levels								
Dry conditions	34.50	9.71	16.37	3.43	11.39	39.26	8.40	7.55
300 m^3/ha	37.17	10.18	16.59	3.45	11.39	39.00	8.45	7.60
P_2O_5 levels								
75 kg/ha	34.99	9.74	16.85 a	3.46 a	11.39	38.55	8.49 a	7.68 a
150 kg/ha	36.68	10.15	16.11 b	3.41 b	11.39	39.69	8.34 b	7.49 b

[a,b,c]Values with different letters in the columns are significantly different at P ≤ 0.05 (Student-Newman-Keuls test).

Referring to species, Mielga showed forage and dry matter productions lower than those of Italian alfalfa, but a higher ratio dry matter-green forage and better qualitative parameters, thus confirming the interesting responses showed in a previous research carried out in the same trial environment (Maiorana *et al*., 2000).

Unlike what was found by Halim *et al*. (1989), forage quality did not improve in response to water-deficit stress; in fact, all qualitative parameters were almost similar in both water levels.

Green forage and dry matter yields and neutral-detergent concentration rose with increasing P_2O_5 fertilizer rates spread before planting, even if the differences were not significant in analysis of variance. This was in accordance with work reported by Walworth and Sumner (1990) for dry matter and by Sanderson (1993) for neutral-detergent fibre. Crude protein and fat contents and forage units of milk and meat were, instead, significantly higher with the lowest P rate (75 kg P_2O_5/ha).

The effect of "years   crops" interaction on green forage and dry matter productions, reported in Fig. 1 (A and B, respectively), points out that for these parameters the highest values were obtained in 1997 and then decreased, while Mielga always increased its productions, showing a better persistency over time.

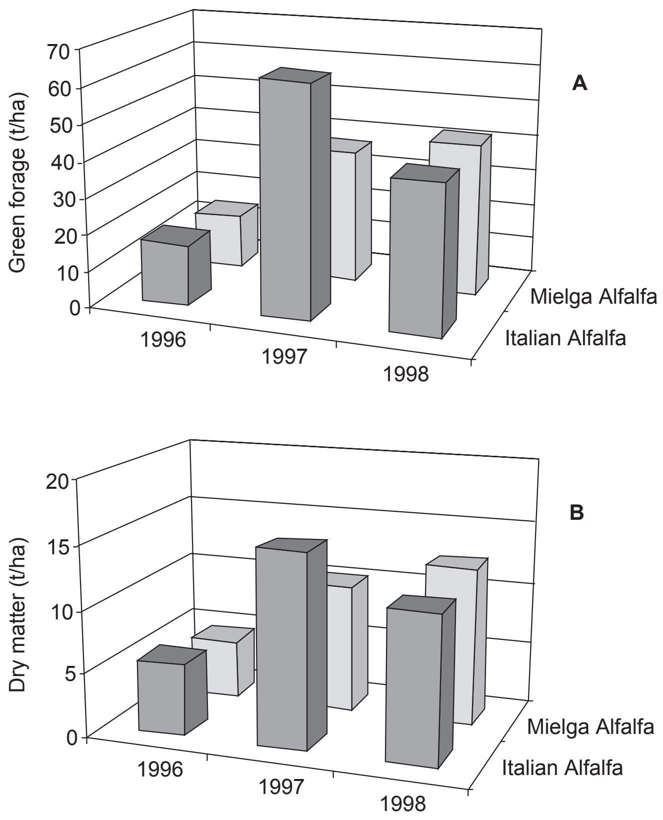

Fig. 1. Effect of "years crops" interaction on green forage and dry matter productions.

Conclusions

The results obtained from this research during the three-year period have pointed out:

(i) Mielga is well-adapted to the soils and to the climatic conditions of the trial environment, providing good responses, above all for qualitative parameters of forage.

(ii) The least differences observed in the quantitative parameters of production and determined by the watered treatment are not counterbalanced by the highest costs of production.

(iii) The small and not statistically significant decreases in forage and dry matter yields obtained with the rate of 75 kg P_2O_5/ha were greatly outweighed by the significative increase of forage quality.

In our trial environment it is, thus, possible to achieve good results, from the point of view of both forage and dry matter yield and quality, with the less intensive treatments, i.e. in dry conditions and with the lowest P_2O_5 fertilization.

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