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in

Molina Alcaide E. (ed.), Ben Salem H. (ed.), Biala K. (ed.), Morand-Fehr P. (ed.). Sustainable grazing, nutritional utilization and quality of sheep and goat products

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 67

2005
pages 81-86

Yield and quality of mixed winter fodder crops in Mediterranean environment

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SUMMARY – The aim of the two-year research is to evaluate, in temporary grasslands, forage mixtures able to ensure grazing during winter months and a good re-growth capacity after the grazing period and to study cutting times and to investigate the plant nutritional status. On plots of 8 m^2 each, laid out in a split-plot design with three blocks, ten mixtures of annual grasses (oat, Italian rye-grass) and legumes (crimson clover, sea clover, Egyptian clover, burr medic, vetch) and two harvest times (HT1 = at the first opened flower of clovers or burr medic; HT2 = at 100% of flowering of clovers or burr medic) have been compared. The trial has given good results from HT2 and, in both harvesting times, from the mixtures "oat, Egyptian clover, common vetch" and "oat, crimson clover, common vetch", whether for winter cut for animal grazing, or for overall mean yields.
mean yields.

Key words: Forage mixtures, grasses, legumes, harvest times, production, quality.

RESUMÉ *– "Production et qualité des mélanges des cultures fourragères dans un milieu méditerranéen". L'objectif de cette recherche, menée à Rutigliano (Sud de l'Italie) pendant deux années (2001-2002), était d'évaluer différents mélanges de cultures fourragères, capables d'assurer le pâturage pendant l'hiver et ayant une bonne capacité de repousser après la période de pâturage. On vise aussi à étudier les époques de fauche et l'état de nutrition des plantes aux stades précoces. Dix mélanges de graminacées (avoine des prés, ray-grass d'Italie) et légumineuses annuelles (trèfle incarnat, trèfle maritimum, trèfle d'Alexandrie, luzerne polymorphe, vesce) et deux époques de fauche (EF1 = première fleur ouverte pour les trèfles ou la luzerne polymorphe ; EF2 = 100% de floraison des trèfles ou de la luzerne polymorphe) ont été comparées. Les résultats obtenus ont montré la supériorité des mélanges "avoine des prés, trèfle d'Alexandrie, vesce" et "avoine des prés, trèfle incarnat, vesce" et de la fauche EF2.*

Mots-clés : *Mélanges, graminacées, légumineuses, époques de fauchée, productions, qualité*.

Introduction

Under the semi-arid conditions of South Italy, one of the most important factors limiting crops production is the lack of rains during the summer period. This situation is harder for fodder crops, usually not irrigated, because of the high costs of water. As a consequence, their productions are satisfactory in spring but very poor in summer.

In Southern Italy, the major part of fodder production consists of mixed temporary grasslands with autumn-winter cycle (Istat, 1995) used for hay production. Nevertheless, in some areas of the Apulia Region, the winter grazing of grasslands (December-March) is also widespread (Corleto *et al*., 2001). In the light of these considerations, the improvement of fodder crops should be aimed not only for a quantitative and qualitative increase of productions, but also for their better distribution during the year.

Another very interesting aspect for forage crops, not much investigated till now especially in semi-arid conditions, is the nitrogen fertilisation of grasses. In fact, an improper use of this element could induce a high incidence of production costs and higher risks of groundwater pollution (Giardini, 1989). For this purpose, the control of plants nitrogen nutritional status may be a useful tool for optimising N fertilisation. Among the proposed methodologies for monitoring the nutritional status, the nitrate content and the leaf N status are increasingly applied (Reeves *et al*., 1993; Montemurro *et al*., 2001), because they provide useful indications on N plants demand. Therefore, using these non-destructive techniques, it is possible to bring the plant nitrogen status to the optimal level.

On this matter, the Agronomic Research Institute of Bary has carried out a two-year research on temporary grasslands of annual grasses mixtures and legumes characterised by different cropping cycle, with the objective to: (i) test forage mixtures able to ensure the winter grazing and a good re-growth capacity during the driest months of the year, after grazing; (ii) evaluate their quantitative and qualitative performances; (iii) study the influence of cutting times; and (iv) investigate the nutritional status of plants.

Materials and methods

The research has been carried out at Rutigliano (41° 01' N, 4° 39' E), a hilly area of Southern Italy, in the years 2000 and 2001. The climate is "accentuated thermomediterranean" (UNESCO-FAO classification). Particularly, the weather during the trial period was characterised by annual average temperatures consistently higher (over 18.0 °C in both trial years) than the long-term average (1977-1999, 15.5 °C). On the contrary, the annual rainfall was always lower than the long-term average (355 and 445 mm, respectively for 2000 and 2001, vs 611 mm). The soil is classified as Rhodoxeralf Lithic Ruptic (Soil Taxonomy-USDA).

On plots of 8 m^2 each, laid out in a split-plot design with three blocks, the following treatments have been studied:

(i) *Ten mixtures of annual grasses and legumes:*

1 = Oat (cv. Argentina) + crimson clover (cv. Ungherese) + common vetch (cv. Catarina);
2 = Italian rye-grass (cv. Asso) + crimson clover (cv. Ungherese) + vetch (cv. Catarina);
3 = Oat (cv. Tropicale) + crimson clover (cv. USA) + vetch (cv. Mirabella);
4 = Italian rye-grass (cv. Asso) + crimson clover (cv. USA) + vetch (cv. Mirabella);
5 = Oat (cv. Tropicale) + sea clover (cv. Commerciale) + vetch (cv. Catarina);
6 = Italian rye-grass (cv. Asso) + sea clover (cv. Commerciale) + vetch (cv. Catarina);
7 = Oat (cv. Tropicale) + Egyptian clover (cv. Sacromonte) + vetch (cv. Catarina);
8 = Italian rye-grass (cv. Asso) + Egyptian clover (cv. Sacromonte) + vetch (cv. Catarina);
9 = Oat (cv. Argentina) + burr medic (cv. Anglona) + vetch (cv. Mirabella);
10 = Italian rye-grass (cv. Asso) + burr medic (cv. Anglona) + vetch (cv. Mirabella).

(ii) *Two harvest times:*

HT1, at the first opened flower of clovers or burr medic;
HT2, at 100% flowering of clovers or burr medic.

Both harvesting times were submitted to a winter early cutting (in February), simulating grazing, on average at 10 cm of plant height.

Seed doses changed according to 1000 seeds weight and were 120 kg/ha in mixtures with oat (30% oat, 20% clovers or burr medic and 50% common vetch) and 100 kg/ha in the ones with Italian rye-grass (30% Italian rye-grass, 20% clovers or burr medic and 50% common vetch).

Sowing was established on November 2000 and 2001, with a 18 cm row spacing. In each trial year, all the experimental plots received 100 kg P_2O_5/ha, at the time of main soil ploughing, and 50 kg N/ha as a top dressing, after the winter mowing.

During plant cropping cycle, plant nutritional status was also determined by means of the leaves green index (SPAD chlorophyll meter, Minolta 502) and the nitrate content of the basal part of the stalk (Nitracheck, MERCK), only in HT2 treatment. Total nitrogen content of plants was determined by Fison CHN elemental analyser (EA 1108) and total N uptake was calculated.

At harvesting, the green forage yield was determined and two samples were taken in each elementary plot for the dry matter content determination (after oven-drying at 105 °C till constant weight) and for the qualitative analyses (crude protein and neutral-detergent fibre, NDF), after oven-drying at 80 °C.

At last, the nitrogen use efficiency (NUE) was calculated as the ratio between yield and total nitrogen uptake (Montemurro *et al*., 2002).

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

Results and discussion

Table 1 shows the results obtained during the trial period, as mean values of years 2000 and 2001. With reference to mixtures, green forage yields ranged from 41.42 t/ha of mixture 4 (Italian rye-grass, crimson clover, vetch) to 55.81 t/ha of mixture 7 (oat, Egyptian clover, vetch), statistically the best; the production of mixture 3 (oat, crimson clover, vetch) appeared very good too (53.26 t/ha). The remaining mixtures showed values only slightly lower than 50 t/ha (about 47 - 49 tons of green forage per hectare), except treatments 2 and 6 and the above-mentioned mixture 4.

Table 1. Effect of treatments on yield, quality and nitrogen status of plants

	Green forage (t/ha)	Dry matter (t/ha)	Protein content (%)	N content (%)	N uptake (kg/ha)	NUE* (t/kg)	NDF** content (%)
Mixtures							
1	49.08 bc	9.85	18.53 ab	2.97 ab	274.75 ac	0.170 ab	35.61 ab
2	43.88 c	9.09	18.27 ab	2.92 ab	250.35 bd	0.170 ab	36.05 ab
3	53.26 ab	9.55	18.42 ab	2.95 ab	272.11 ac	0.189 a	35.80 ab
4	41.42 c	8.81	16.96 ab	2.71 ab	222.48 d	0.181 ab	38.29 ab
5	49.18 bc	8.78	19.12 a	3.06 a	264.70 ad	0.183 ab	34.60 b
6	42.54 c	9.25	15.93 b	2.55 b	230.41 cd	0.182 ab	40.04 a
7	55.81 a	10.27	19.07 a	3.05 a	304.95 a	0.178 ab	34.69 b
8	47.47 bc	9.94	18.55 ab	2.97 ab	273.05 ac	0.168 ab	35.57 ab
9	48.47 bc	9.35	19.49 a	3.12 a	285.94 ab	0.164 b	33.98 b
10	47.18 bc	10.08	17.44 ab	2.79 ab	273.21 ac	0.173 ab	37.47 ab
Harvest times							
HT1	44.82 b	9.14 b	17.85	2.86	256.79 b	0.172 b	36.77
HT2	50.83 a	9.85 a	18.51	2.96	273.60 a	0.180 a	35.65

Values with different letters in columns are significantly different at $P \leq 0.05$ (SNK test).
*NUE = Nitrogen use efficiency.
**NDF = Neutral-detergent fibre.

On the whole, these results point out the highest yielding ability of mixtures containing oat (about 15%, on average) than the ones with Italian rye-grass. Differences among mixtures appear less evident and not significant for dry matter yields, for which the best responses have been obtained sometimes also with mixtures containing Italian rye-grass, i.e. the 8th and the 10th, with 9.94 and 10.08 t/ha of dry matter, respectively. It is very interesting to observe that the productive superiority of mixtures 3 and 7 repeated itself (results not reported) in each year of trial, whether in both harvesting times, or in the winter cutting for simulating the animal grazing.

Besides, several mixtures showed a fairly good ability to produce green forage also during the warmest and the driest months, above all mixtures 7 and 8.

Protein contents of the mixtures tested showed significant differences only between mixtures 5, 7, 9 and mixture 6; this last one, constituted by Italian rye-grass, sea clover and vetch, reached the worse protein content (15,93%), lower than 17% the mean value of the best three mixtures (5, 7, 9), always exceeding values of 19%.

Since the differences of protein content among mixtures 5, 7, 9 are statistically not significant the presence of sea clover, Egyptian clover or burr medic in the mixtures appears not to be very important. The protein content of other mixtures reached a value of 18% on average, statistically not different from the mixtures having the highest (5, 7, 9) and the lowest (6) values. Even for protein content, it would seem preferable to introduce oat in the mixtures instead Italian rye-grass, even if the differences are slight. Nitrogen content showed trends similar to those of protein. The maximum value of nitrogen uptake (about 305 kg N/ha) has been observed in mixture 7 (oat, Egyptian clover, vetch); it resulted statistically different in mixtures 2, 4, 6, (with Italian rye-grass), but not different from mixtures 1, 3, 5, 9 (without Italian rye-grass) and 8, 10 (with Italian rye-grass). Therefore, N uptake appeared less influenced for the presence of Italian rye-grass, in comparison with protein and nitrogen contents. Nitrogen use efficiency (NUE) was very similar in the ten mixtures, without a clear effect caused by fodder crops they included. In fact, the two mixtures that showed the highest (3) and the lowest NUE (9) contained oat and vetch and it is very hard to attribute a higher NUE (+34 kg/ha green forage/kg N absorbed) to the presence of crimson clover instead of that of burr medic.

Concerning the neutral-detergent fibre content (NDF), this parameter showed a behaviour exactly contrary to those of protein; in fact, mixture 6 reached the highest NDF values (40%), mixtures 5, 7, 9 the lowest ones. The findings observed for NDF contents of mixtures tested show that Italian rye-grass can contribute to increase NDF percentages.

Among harvesting times (Table 1), the one carried out at 100% of legumes flowering (HT2) showed results significantly higher than those of HT1, not only for green forage and dry matter production, but also for N uptake and nitrogen use efficiency (NUE). Besides, with HT2 treatment have been carried out three mowing (including the winter one) in 2000 and four in 2001; with the earliest harvest time (HT1), four and five, respectively.

To investigate nitrogen nutritional status, some samples of the ten mixtures have been analysed with the “SPAD method“, which measures the green index of leaves, strongly correlated with chlorophyll content in plant leaves, in its turn depending on the nitrogen nutritional status of the crop (Yadava, 1986; Schepers *et al*., 1992). Another important parameter correlated to nitrogen nutritional status of the plants is nitrate level. High amounts of nitrate in fodder crops may negatively affect animal health, because of the reduction of nitrate to nitrite, a precursor of harmful compounds (Maynard *et al*., 1976). SPAD readings (Table 2) pointed out different mixtures behaviour: the first group, including all the mixtures with oat (1, 3, 5, 7, 9), was characterised by a better nitrogen status than that with Italian rye-grass.

Table 2. Comparison among some nitrogen status indicators of plants (in HT2 harvest time)

Mixtures	SPAD	Nitrate content (mg/kg)	N content (%)	N uptake (kg/ha)	NUE* (t/kg)
1	46.62 a	142.90 d	3.16	302.01 ab	0.168 ab
2	44.58 ab	163.60 d	2.59	240.06 b	0.188 a
3	47.23 a	179.00 d	3.10	284.99 ab	0.194 a
4	42.56 bc	258.40 c	2.80	229.11 b	0.184 ab
5	47.71 a	198.00 cd	3.19	273.06 ab	0.186 a
6	40.94 c	988.20 a	2.65	234.77 b	0.179 ab
7	47.26 a	404.90 b	3.05	316.12 a	0.186 a
8	42.44 bc	207.80 c	2.82	264.61 ab	0.179 ab
9	46.06 a	316.10 b	3.35	317.48 a	0.160 b
10	41.53 bc	440.80 b	2.92	273.75 ab	0.171 ab

Values with different letters in columns are significantly different at $P \leq 0.05$ (SNK test).
*NUE = Nitrogen use efficiency.

Nitrate concentration in fodder crops stalk, on the contrary, was very high only in mixture 6 (Italian rye-grass + sea clover + vetch) and it was statistically different from the three mixtures groups that followed this trend: 6 > 7, 9, 10 > 4, 5, 8 > 1, 2, 3. The mixture containing the highest nitrate level showed a very low N content and, as a consequence, also NUE was low, because of a nitrate accumulation. The high nitrate content of mixture 6 probably depended on some environmental factors (temperature and water availability) and on peculiar botanical characteristics of the mixture, both influencing the transformation processes of nitrates into organic nitrogen.

Finally, also the observation on N uptake of the same samples provided a partial explanation of the previous findings: i.e., N uptake of mixture 6 is lower than N uptake of mixtures 7 and 9 (contrarily to the nitrate content).

Conclusions

The results obtained from this research during the two-year trial period have shown that:

(i) The mixture "oat + Egyptian clover + vetch" was the best. Moreover, together with the mixture "oat + crimson clover + vetch", ensured the highest yielding ability in both harvesting times and in the cuttings that simulate animal grazing, with a following good re-growth capacity and good protein content.

(ii) The harvesting time carried out at 100% of clover or burr medic flowering gave the best results in all the mixtures.

(iii) The mixtures containing oat provided productive and qualitative performances slightly better than those with Italian rye-grass.

(iv) In fodder crops, direct measurements of leaves chlorophyll content and stalks nitrate levels are useful indicators of nitrogen nutritional status, because, in our experimental conditions, they show a very strict correlation with yield, protein and N uptake. Consequently, using these methods to monitor N nutritional status during plants cropping cycle, accurate yield previsions could be made.

On the whole, these results can be considered appreciable not only in terms of yield and forage quality, but of mowing number, above all considering the unfavourable climatic pattern in the two years of trial, very critical in consequence of scanty rainfall, which was even below the poor values recorded in the long-term reference period.

Acknowledgements

Authors gratefully acknowledge M. Scazzarriello for valuable advice on technical assistance.

References

Corleto, A., Cazzato, E., Annese, V., Di Francia, A. and Proto, V. (2001). Prospettive di miglioramento agronomico degli erbai autunno-primaverili nei territori delle Comunità montane "Monti Dauni Meridionali", "Ufita" e "Vulture". In: *Il miglioramento delle risorse foraggere nei territori delle Comunità montane "Monti Dauni Meridionali", "Ufita" e "Vulture"*, pp. 22-56.

Giardini, L. (1989). Aspetti agronomici e fisiologici della concimazione azotata in relazione con l'ambiente. *Riv. di Agron.,* 23 (1): 3-22.

Istat (1995). Statistiche dell'agricoltura (1993).

Maynard, D.N., Barker, A.V., Minutti, P.L. and Peck, N.H. (1976). Nitrate accumulation in vegetables. *Adv. Agron.,* 28, 71-118.

Montemurro, F., Convertini, G. and Ferri, D. (2001). Previsione dello stato nutrizionale e dell'efficienza della nutrizione azotata in colture meridionali mediante test rapidi su nitrati e clorofilla. *Bollettino della S.I.S.S.,* 50 (4): 961-973.

Montemurro, F., Maiorana, M., Convertini, G. and Ferri, D. (2002). N-use efficiency, yield and quality in the maize-winter barley rotation. *Agrochimica,* 46 (3,4), 146-154.

Reeves, D.W., Mask, P.L., Wood, C.W. and Delaney, D.P. (1993). Determination of wheat nitrogen status with a hand-held chlorophyll meter: Influence of management practices. *J. of Plant Nutr.,* 16 (5), 781-796.

SAS Institute Inc. (1998). User's Guide, Version 6.12 SAS/STAT, Cary, USA.

Schepers, J.S., Francis, D.D., Vigil, N. and Below, F.W. (1992). Comparison of corn leaf nitrogen concentration and chlorophyll meter reading. *Commun. Soil Sci. Plant Anal.,* 23 (17 & 30): 2173-2187.

Yadava, U.L. (1986). A rapid and non-destructive method to determine chlorophyll in intact leaves. *HortScience,* 21 (6): 1449-1450.