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in

Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.).
Sustainable Mediterranean grasslands and their multi-functions

Zaragoza : CIHEAM / FAO / ENMP / SPPF
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79

2008
pages 215-218

Sustainable management of fodder crops by compost application

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SUMMARY – This research study started in the autumn of 2004, and is still in progress, and was carried out in Foggia (southern Italy). The aim of this study was to evaluate the effects of organic compost coming from agro-industrial and farming residues on the productive and qualitative performances of three fodder crops: subterranean clover (*Trifolium subterraneum* L.), proteic pea (*Pisum arvense* L.) and Italian ryegrass (*Lolium multiflorum* Lam.). On elementary plots of 270 m^2 each, laid out following a split-plot experimental design with three replications, the following fertilizing strategies were compared: (i) mineral fertilization (MIN), with chemical fertilizers; (ii) organic fertilization (ORG), with on-farm compost; and (iii) organic-mineral fertilization (MIX), with a commercial product. In the first two years of the trial (2005-06), the ORG fertilizer was able to achieve the best responses in both clover and pea crops, followed by the MIN treatment, while the significantly higher Italian ryegrass production was obtained with the MIX treatment.

Keywords: Fodder crops, on-farm compost, yielding capability, quality.

RESUME *– "Gestion durable des cultures fourragères avec l'application de compost". La recherche, menée depuis l'automne 2004, est encore en cours dans un milieu méditerranéen (Foggia, Sud de l'Italie). L'objectif de l'expérience était d'évaluer les effets d'un compost organique obtenu en employant les déchets des exploitations agricoles, sur la production et la qualité de trois cultures fourragères: trèfle souterrain (*Trifolium subterraneum *L.), pois protéique (*Pisum arvense *L.) et ray-grass d'Italie (*Lolium multiflorum *Lam.). Trois stratégies de fertilisation : (i) minérale (MIN), avec superphosphate pour les espèces légumineuses et sulfate ammoniacal pour la graminée ; (ii) organique (ORG), avec déchets agricoles ; et (iii) organique-minéral (MIX), avec un produit commercial, ont été comparées dans des parcelles de 270 m^2 chacune. Les résultats obtenus dans les deux premières années d'étude (2005 et 2006) ont montré la supériorité du traitement ORG, capable d'assurer les meilleures productions pour le trèfle et le pois, alors que la production la plus intéressante de ray-grass d'Italie a été obtenue avec le traitement MIX.*

Mots-clés : *Cultures fourragères, compost d'exploitation agricole, production, qualité.*

Introduction

Environmental, social and economical reasons have pointed out that in agriculture is not still possible to pursue a continuous increase of profits by applying conventional agronomical practices and intensive cropping systems, that have caused the progressive worsening of environmental conditions. In this situation, the conservative agro-techniques, as the application of organic biomasses and the introduction of leguminous crops, could partly contribute to the reduction of those problems.

Referring to the mineral fertilization, in particular to the nitrogen (N) one, its excessive and/or incorrect application could result, under Mediterranean conditions, in possible phenomena of fertility deterioration. Conversely, organic amendments could increase soil fertility and play an important role in sustainable agricultural production. In fact, the soil application of compost offers many benefits, by sustaining soil fertility (Sikola and Yakovchenko, 1996), improving soil chemical, physical, hydrological and biological characteristics (Celik *et al*., 2004) and reducing ecological risks resulting from nitrate losses and water contamination (Janzen *et al*., 2003).

Several experiments have been conducted on the application of different composts on different crops (Maiorana *et al*., 2005; Montemurro *et al*., 2006), but there is still a lack of information on the environmental impact and the agronomic value of these organic materials in fodder crops grown in Mediterranean conditions.

As a consequence, the Research Unit for Cropping Systems in Dry Environments has been carrying out a research for evaluating the potential of composting on-farm agro-industrial waste materials (olive pomace, sheep manure and pruning residues) into a farm resource. Therefore, the objective of this field experiment is to study the effects of different ways of fertilization on the productive and qualitative responses of three fodder crops and the most important soil parameters.

In this paper only the quantitative and qualitative performances of fodder crops are reported.

Materials and methods

The research, still in progress, started in the autumn 2004 at Foggia (Southern Italy, 41° 27' lat. N, 3° 04' long. E, 90 m above sea level) on a cereal-livestock farm, typical of the trial area.

The soil of the experimental field is a silty-clay Vertisol of alluvial origin, classified as Typic Chromoxerert, Fine, Mesic by Taxonomy USDA.

The climate is "accentuated thermomediterranean" (UNESCO-FAO classification), with rains concentrated mainly in the winter months.

On crops of subterranean clover (*Trifolium subterraneum* L., cv. Antas), proteic pea (*Pisum arvense* L., cv. Eiffel) and Italian ryegrass (*Lolium multiflorum* Lam., cv. Elunaria), the following three fertilizing strategies were studied: (i) mineral fertilization (MIN), with 100 and 80 kg P_2O_5 ha^{-1} (as superphosphate) for subterranean clover and proteic pea, respectively, and with 100 kg N ha^{-1} (as ammonium sulphate) for Italian ryegrass; (ii) organic fertilization (ORG), with an on-farm compost; and (iii) organic-mineral fertilization (MIX), with a commercial product. The treatments 2 and 3 were applied in such quantity to supply crops the same amounts of P_2O_5 and N of mineral fertilization.

The experimental design was a split-plot, assigning the level of split to each fodder crop, with three replications and elementary plots of 270 m^2.

At harvesting, on a surface of 60 m^2, fresh weight, dry weight and plants height of subterranean clover and Italian ryegrass, the grain yield of proteic pea and the protein contents of the three crops were determined.

Statistical analysis of variance was carried out using the SAS procedures (SAS Institute, 1998). Differences among the means were analyzed at the $P \leq 0.05$ probability level applying the Least Significant Difference (LSD) and the Duncan Multiple Range Test (DMRT) for two and more than two means comparison, respectively.

Results and discussion

The weather during the two-year trial period was characterized by total annual rainfall higher than the long-term averages 1952-2004 in the first year (2005, 617 mm *vs* 554 mm) and similar to that in the second one (2006, 562 mm *vs* 554 mm). The average monthly temperatures were 15.1°C in 2005 and 15.5°C in 2006 *vs* 15.5°C of the long-term period.

The best green forage and dry matter productions of subterranean clover and Italian ryegrass were obtained in the driest year (2006), however characterized by a better rains distribution during the crops cropping cycle, with differences almost always statistically significant (1.82 t ha^{-1} and 3.50 t of dry matter in the two crops, respectively, vs. 1.45 t ha^{-1} and 3.19 t recorded in the first trial year, Tables 1 and 3). In subterranean clover this behaviour could be also depended on the capability of the perennial leguminous crops to achieve the best productions in the years following the sowing, probably due to the increase of total seasonal amount of N_2 fixed, that generally increases with each additional year of plants cultivation, as found in alfalfa by Kelner *et al*. (1997). On the contrary, proteic pea (Table 2) achieved the significantly best grains yield in the rainiest 2005 (3.25 t ha^{-1} vs. 1.29 t). No difference in protein content of both subterranean clover and Italian ryegrass was observed between the years (Tables 1 and 3), while proteic pea showed the significantly highest values (30.30%, Table 2) in the least productive year (2006), thus confirming the inverse relation that often links the quantitative and qualitative characteristics of the production.

Table 1. Effect of years and fertilizing treatments on the quanti-qualitative parameters of subterranean clover

	Green forage (t ha^{-1})	Dry matter (%)	Dry matter (t ha^{-1})	Protein content (%)
Years				
2005	4.36 b	33.33 a	1.45 b	10.16
2006	6.62 a	27.43 b	1.82 a	10.90
Treatments				
MIN	5.43 ab	31.86	1.73 a	10.79
ORG	6.58 a	28.66	1.89 a	10.24
MIX	4.47 b	30.61	1.37 b	10.56

Values with different letters in the columns are significantly different at P≤0.05 (LSD test and DMRT).

Table 2. Effect of years and fertilizing treatments on the quanti-qualitative parameters of proteic pea

	1st pod height (cm)	Grain yield* (t ha^{-1})	1000 seeds weight* (g)	Protein content (%)
Years				
2005	46.79	3.25 a	245.36 b	23.03 b
2006	44.45	1.29 b	279.12 a	30.30 a
Treatments				
MIN	45.30	2.24 ab	262.38 ab	25.15
ORG	46.66	2.47 a	269.71 a	27.66
MIX	44.89	2.10 b	254.64 b	27.17

*At the 13% of moisture.
Values with different letters in the columns are significantly different at P≤0.05 (LSD test and DMRT).

Table 3. Effect of years and fertilizing treatments on the quanti-qualitative parameters of Italian rye-grass

	Green forage (t ha^{-1})	Dry matter (t ha^{-1})	Plant height (cm)	Protein content (%)
Years				
2005	10.45	3.19 b	72.93 b	9.64
2006	11.05	3.50 a	94.30 a	9.38
Treatments				
MIN	10.21 b	3.16 b	83.65 b	9.20 ab
ORG	9.18 b	2.86 b	76.65 c	8.87 b
MIX	12.87 a	4.02 a	90.55 a	10.46 a

Values with different letters in the columns are significantly different at P≤0.05 (LSD test and DMRT).

With reference to the fertilizing strategies, it is particularly interesting that their effects have shown clear and significant differences in a great part of the three fodder crops parameters. In fact, in subterranean clover (Table 1) and proteic pea (Table 2) the best dry matter (1.89 t ha^{-1}) and grain (2.47 t ha^{-1}) productions were obtained with the ORG treatment, even if without significant differences in comparison with MIN fertilization (1.73 and 2.24 t ha^{-1} for the two crops, respectively). Regarding the protein content, the values always showed clear similarities, with values never statistically significant among the three experimental fertilizing treatments applied in both crops, indicating that this important qualitative parameter is more linked with the genetic characteristics than the agronomic practices, i.e. the N fertilization, as found in other crop by Maiorana *et al*. (2005).

The effectiveness of the on-farm compost (ORG) was also confirmed by the highest production of green forage in subterranean clover and by the best 1000 seeds weight in proteic pea, with differences always significant in respect to the MIX treatment. On the whole, these findings pointed

out that the organic materials can be considered a good N source for fodder crops production, in accordance with Sullivan *et al*. (2003) and Montemurro *et al*. (2004), also because these materials ensure to rizobium better substrate conditions. Furthermore, the on-farm compost, applied on the fodder crops tested one month before sowing, did not damage the early vigour, coverage degree and growth of plants, confirming the results found by Murillo *et al*. (1997). The main effects of fertilizing treatments on the most important parameters of Italian ryegrass (Table 3) showed that, unlike what found in the other two crops, the MIX fertilizer was able to ensure the significantly highest green forage yield (12.87 t ha^{-1}), dry matter production (4.02 t ha^{-1}), plants height (90.55 cm) and protein content (10.46%). The superiority of the MIX treatment could be depended on its capability to release the organic N during the entire cropping cycle of Italian ryegrass, which needs more N supply than the leguminous crops tested. Therefore, these findings indicate the effectiveness of the partial substitution of the mineral N with the organic one. This fertilizing strategy is particularly useful in Mediterranean environments, in which the amendment functions of a fertilizer could be more important than its mineral N content, because of the high N mineralization rate and, consequently, the reduction of organic matter. On the contrary, the total substitution of mineral N with organic N is unfavourable, since the worst performance were always obtained with the ORG fertilizing, as found in other crops in the same environment (Montemurro *et al*, 2005), even if green forage productions, dry matter yields and protein content did not statistically differ from the MIN fertilizing. This behaviour was probably due to the inability of the on-farm compost to satisfy the highest N needs of a grass crop as the Italian ryegrass.

Conclusions

The results obtained so far have shown, on the one hand, that the on-farm compost provided either the best green forage production and dry matter yield, or good protein content in subterranean clover and proteic pea; on the other hand, that it achieved the worst performances in Italian rye-grass, but similar to those obtained with the MIN treatment. Its application also enabled satisfactory clover persistence over time, as that ensured by MIN and MIX treatments.

On the whole, the findings of this research pointed out that the application of organic compost in environments characterized by semiarid conditions seems to be a useful agricultural practice. At the same time, its use could aid the farmers to arrange the best nutrient management plans, with the possibility to apply organic amendments.

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