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Phosphorus fertilization and seeding rate effects on sulla (*Hedysarum coronarium* L) forage production

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Summary - A pluriannual experiment was conducted in a hilly area of southern Italy with the aim of evaluating the response of sulla to phosphorus fertilization and seeding rate. Two different fields both maintained for two productive cycles were sown to study the effects of three fertilizers - 50, 100 and 150 kg ha^{-1} of P_2O_5, respectively and a non fertilized control, in a factorial combination with three seeding rates - 25, 50 and 75 kg ha^{-1} of seed respectively. Variations in dry weight and leaf area per plant as a result of the experimental factors were observed as the growing season progressed: the values of both traits increased significantly with the amount of P-fertilizer supplied to the soil and with the reduction in seeding rate. The supply of P-fertilizer up to 100 Kg ha^{-1} of P_2O_5 resulted in significant increases in dry matter yield compared to the non fertilized control, in particular in the later growth phase of the meadow. The use of the highest quantity of seed in almost all cases showed higher productive levels compared with those of the other treatments, mainly at the final sampling performed at the bloom stage.

Key-words: forage, phosphorus fertilization, seeding rate, sulla

Résumé: *Une expérience pluriannuelle a été menée dans une localité de colline du sud de l'Italie aufin d'évaluer la réponse de la sulla à la fertilisation phosphatée et à la densité de semis. L'effet de trois traitements de fertilisation phosphatée, respectivement 50, 100 et 150 kg ha^{-1} de P_2O_5, et un contrôle sans engrais, en combinaison factorielle avec trois traitements de densité de semis, respectivement 25, 50 et 75 kg ha^{-1} de semence, ont été étudiés dans deux différents champs expérimentaux maintenus pour deux cycles de prodution. Pendant que le cycle de végétation avançait, des variations du poids sec et de la surface foliaire ont été remarquées, par effet des facteurs expérimentaux, dans chaque plante: les valeurs des deux caractéres ont augmenté de façon significative avec l'augmentation de l'apport de l'engrais phosphaté dans le sol et avec la diminution de la densité de semis. L'application de l'engrais phosphaté jusqu'à 100 Kg ha^{-1} de P_2O_5 a causé des augmentation significatives du rendement en matière sèche par rapport au contrôle sans engrais, en particulier dans la phase plus tardif de la croissance de la prairie. L'utilisation d'une quantité plus élevée de semence a mis en évidence presque toujours des niveaux de production plus élevés par rapport à ceux des autres traitements, surtout au moment du dernier prélèvement effectué au début de la floraison.*

Mots-clés: *densité de semis, fertilisation phosphatée, fourrage, sulla*

Introduction

The farming systems to valorize the Mediterranean marginal areas are based on sylviculture and pastoralism when conditions are the worse, or based on artificial grasslands in the less difficult areas where marginality is an effect of socio-economic rather than natural factors (Cavallero and Ciotti, 1991). In the latter environments, the tendency to simplify the cropping systems has led to problems in the grassland management. In the regions of southern Italy, often characterised by slope and clayey soils, sulla represented one of the traditional crops for rotations with wheat as well as the ideal choice for fulfilment of productive and protective functions (Talamucci, 1998). Actually, the presence of this legume in the cropping systems of southern Italy is subordinated to the prospect of the increase and the stability of production. A contribution in this sense can be provided by the appropriate combination of a

number of cultural practices, among which P-fertilization and seeding rate are considered to be of particular interest. Information on the first aspect is limited. With regard to seeding rate, available experimental references have often shown contrasting effects on the productive behaviour of the crop (Di Prima *et al.*, 1975; Restuccia, 1975). The objective of this experiment was to study the response of sulla to variations of the above-mentioned factors.

Materials and methods

The trial was conducted in Gallina (38° 10' Lat. N., 15° 45' Long. E., 232 m a.s.l.), a hilly area of southern Italy. The climate of the trial site is semi-arid Mediterranean. The soil type where the experiment took place is sandy clay loam, slightly acidic, non-calcareous, with a low total nitrogen, available phosphorus and organic matter content, and moderately supplied by exchangeable potassium. Two experimental fields were established, each lasting for a period of two years: the first was sown on 10 December 1991; the second on 17 December 1992. Three P-fertilization treatments were compared: 50, 100 and 150 kg ha^{-1} of P_2O_5 as single super phosphate respectively and a non fertilized control (P_0), in a factorial combination with three seeding rate treatments: 25, 50 and 75 kg ha^{-1} of seed respectively. The treatments were arranged in the trial area according to a randomised split-plot design with three replicates. The P-fertilization factor was ascribed to the main plot and the seeding rate factor was ascribed to the sub-plot. The latter, with an area of 36 m^2 (6 x 6 m) consisted of 30 rows spaced 20 cm apart. Dehulled seeds of the local genotype of sulla, "Catanese" (purity 98%, capability of germinating 93%), found in the Catania plain in Sicily were used in the experiment. Weeds were periodically eliminated by hand. During each growing season a series of plant samples were collected on undisturbed sampling areas of 400 cm^2 (20 x 20 cm) until the bloom stage. The plant population was also determined at the bloom stage. The leaf area and dry weight of the sampled plants was measured.

The data were analysed separately for each year and sampling, according to the ANOVA model of the experimental design adopted and the comparison of the mean values was performed with the LSD test at $P \leq 0.05$. Since the interaction between the studied factors was rarely significant, the results were presented in terms of main effects.

Results and discussion

Meteorological conditions

The mean air temperature in winter passed from 8.5 to 6.5, from 12.3 to 9.6 °C and from 13.5 to 11.8 °C in 1991-92, 1992-93 and 1993-94 respectively. Temperature in spring increased up to 18.3, 21.0 and 19.0 °C respectively at the end of May. The rainfall in the same period during the three years was 240.2, 353.1 and 340.2 mm.

First productive cycle (1991-92 and 1992-93)

The duration of the period between the emergence of the plants, occurring in January, and the bloom stage, which took place in May, was approximately five months in both years of the first productive cycle of the meadow.

From March onwards there were almost continuous significant variations both in the dry weight, leaf area per plant and the dry matter yield as a result of the P-fertilization (Fig. 1). Dry matter yield at the final sampling significantly increased from 3.2 to 4.7 t ha^{-1} from P_0 to P_{100} in 1991-92 and, from 3.2 to 4.3 t ha^{-1} from P_0 to P_{50} in 1992-93. The plant population in the two years varied from 230 and 210 plants m^{-2} of P_0 to 281 and 293 plants m^{-2} of P_{150} respectively.

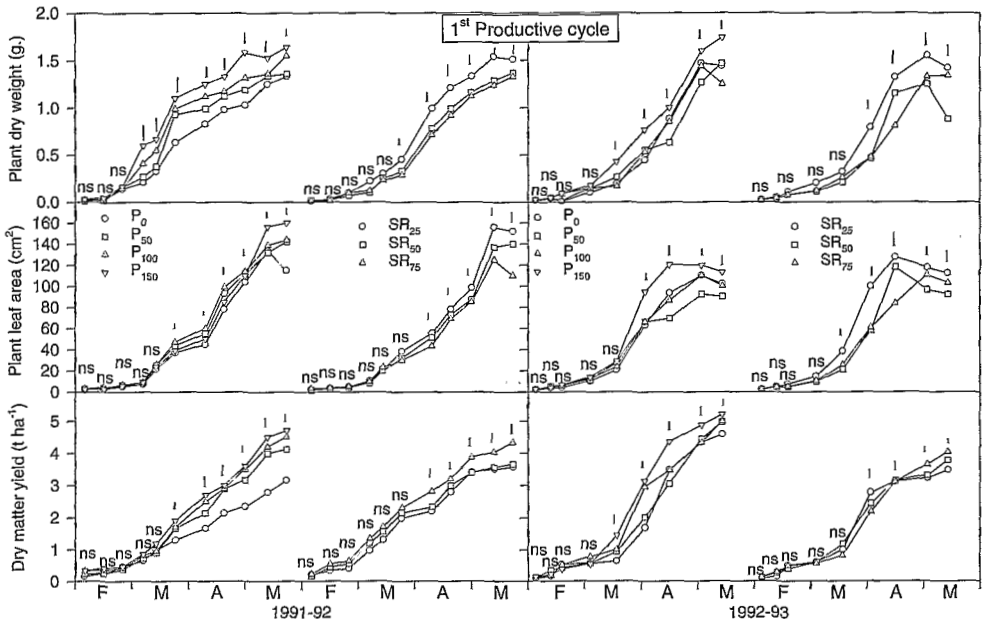

Fig. 1 - Changes in plant dry weight and leaf area, and dry matter yield of sulla in relation to P-fertilization (left) and seeding rate (right) during 1991-92 and 1992-93 (first productive cycle). Vertical bars indicate LSD P≤0.05.

The seeding rate also led to significant variations in the studied traits. The use of the lowest quantity of seed resulted, from April onwards, in dry weight and leaf area values which were almost always statistically higher than those of other treatments. On the other hand, a significantly higher productive level was observed with the highest quantity of seed, also from April onwards, in 1991-92, and only at the later two samplings in 1992-93. At the final sampling the dry matter yield was 3.6 t ha^{-1} on average of SR_{25} and SR_{50}, in both years, and 4.0 and 4.3 t ha^{-1} for SR_{75} in 1991-92 and 1992-93 respectively. The plant population was 232, 261 and 328 plants m^{-2} and 246, 305 and 341 plants m^{-2}, respectively, for SR_{25}, SR_{50} and SR_{75} in the two years.

Second productive cycle (1992-93 and 1993-94)

The time between the vegetative resumption and the bloom stage was approximately six and a half months in the first year and five months in the second year of the second productive cycle. The crop resumed vegetative activity late in October in both years. However, as a result of the different climatic conditions experienced by the plants, soil cover occurred at the start and the end of November respectively in the two years and the bloom stage was reached in the middle of May and at the end of April.

Markedly higher values were evidenced for all the studied traits compared to the first productive cycle, with the exception of the plant population (Fig. 2).

In both years the increase in the quantity of P-fertilizer distributed to the soil resulted in a tendential increase in dry weight, leaf area per plant and dry matter yield which, as observed in the first productive cycle, became more evident as the growing season progressed. The dry matter yield values of the three P-fertilization treatments were similar, on average 7.5 and 7.4 t ha^{-1} in the two years, whereas they were found to be significantly higher in both years than those of the non fertilized control, 5.3 and 6.0 t ha^{-1}. The plant population varied from 73 (P_0) to 91 plants m^{-2} (P_{50}) in the first year and from 65 (P_{150}) to 95 plants m^{-2} (P_0) in the second year.

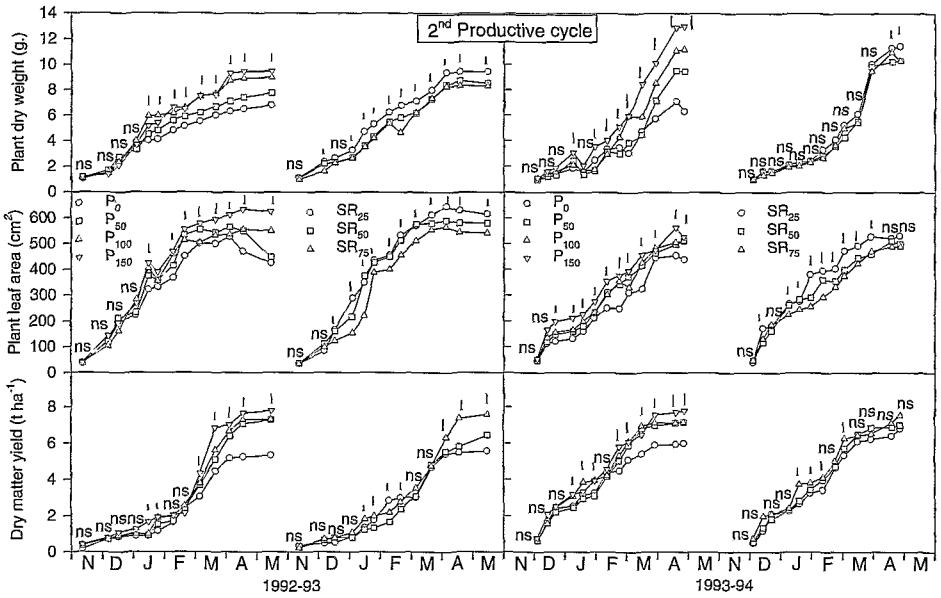

Fig. 2 - Changes in plant dry weight and leaf area, and dry matter yield of sulla in relation to P-fertilization (left) and seeding rate (right) during 1992-93 and 1993-94 (second productive cycle). Vertical bars indicate LSD P≤0.05.

The influence of seeding rate on the variations in dry weight and leaf area per plant was less marked, compared to the first productive cycle because of the modest regrowth capacity of sulla. However, the treatment SR_{25} showed tendentially higher values of dry weight per plant in the first year only and of leaf area in both years. In the first year significant increases in the dry matter yield occurred in the later phase of the productive cycle with the increase in seeding rate. In particular, the yields of the final sampling were 5.6, 6.4 and 7.6 t ha^{-1} respectively for SR_{25}, SR_{50} and SR_{75}. In the second year on the other hand, no significant difference emerged among the three seeding rates which produced, on average, 7.1 t ha^{-1} of dry matter. With the increase in seeding rate the plant population increased from 53 to 74 and to 88 plants m^{-2} in the first year and from 60 to 65 and to 71 plants m^{-2} in the second one.

Conclusions

Under the environmental conditions of the experimental site, sulla reached its highest dry weight and maximum leaf area between April and May in both productive cycles. The studied factors induced variations of both traits of the plant: in particular, as the growing season advanced, appreciably higher values were observed with the increase in the supply of P-fertilizer to the soil and the decrease in the seeding rate. The use of reduced quantities of P-fertilizer resulted in significant increases in dry matter yield compared to the non fertilized control, especially at the final sampling taken at the bloom stage. No further cases of productive increases emerged from the supply of the highest quantity of P-fertilizer. These results provide confirmation of the ability of the species to exploit modest energy inputs. The variation in seeding rate showed contrasting effects in the different years on the dry matter yield. However, the productive level of the final sampling was almost always higher with the use of the highest quantity of seed.

The growth of sulla and the dry matter yields of each sampling also highlight the prospects for diversifying the management system of the meadow both by means of grazing in the autumn-winter period, mainly during the second productive cycle, and with haymaking in spring.

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