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Long term dominance of annual legume species after P application in a Mediterranean rangeland

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Summary - The herbaceous vegetation in *Sarcopoterium spinosum* dwarf-shrub communities is the main source of forage for beef cows that graze the range. Changes in the botanical composition of the sward of such a community growing on phosphorus-deficient terra rossa soil overlying hard limestone were studied over a 11-year period. The site was protected from grazing during the growing season in winter but was grazed by cattle in summer. Phosphate fertiliser, applied once only in 1988 at two rates (4.5-9.0 g P m⁻²), led to the dominance of annual legume species throughout the experiment. Legume dominance was reduced only in two years when there was very little rain at the beginning of the rainy season. The prolonged response of the herbaceous sward patches to a single P application appeared to be caused by the gradual release of phosphate from the applied fertilizer, by recycling through the ungrazed vegetation and seeds, and also by the summer grazing system that facilitated recycling of the phosphorus consumed in by the cows in the supplementary feed. The continuing dominance of the legume species is remarkable considering experience in other situations. It may have been related to low N-fixing ability of the associated rhizobia.

Key-words: legumes, P application, plant community dynamics, range improvement

Résumé - La végétation herbacée dans une communauté de buissons xérophytiques de *Sarcopoterium spinosum* est la principale ressource fourragère de ces espaces pâturés par du bétail viandeux. Des changements dans la composition botanique de la végétation d'une telle communauté, croissant sur un sol de type terra rossa déficient en phosphore (P) et recouvrant une couche dure de limon, ont été étudiés sur une période de 11 ans. Le site était protégé du pâturage pendant la saison de croissance en hiver mais ouvert au bétail en été. Une fertilisation de Phosphate appliquée une seule fois en 1988 en deux traitements différents (4.5 et 9.0 g/m²) a entraîné la dominance d'espèces légumineuses annuelles tout au long de l'expérience. La dominance légumineuse a été réduite seulement au cours de deux années, et ce lorsque les précipitations en début de saison ont été faibles. La réponse prolongée de la végétation herbacée à une application unique de P semble être causée par la libération graduelle du fertilisant phosphaté, par le recyclage via les plantes et semences non pâturées et également par le système de pâturage estival qui facilite le recyclage du P consommé par les vaches dans la complémentation alimentaire. La dominance continue des espèces légumineuses est remarquable considérant l'expérience en d'autres situations. Cela pourrait être relié à une faible capacité de fixation de l'azote par les rhizobium associés.

Mots-clés: légumineuses, application de P, dynamique d'une communauté de plantes, amélioration des pâturages

Introduction

Dwarf-shrub communities, dominated by prickly burnet (*Sarcopoterium spinosum* (L.) Spach.), cover large areas of hilly rangeland in eastern Mediterranean regions. Pasture and animal production in these areas is poor because of the sparse cover of herbaceous vegetation. On terra rossa and brown rendzina soils, herbaceous primary production is low mainly because of phosphorus deficiency. It has been shown that despite the degraded appearance of these rangelands they can be rehabilitated and converted to much more productive pasture.

Stability of conversion in the long run depends to a large degree on the resilience of the shrubs and the vigor of the herbaceous sward. But there are very few long term studies on this aspect of vegetation manipulation in Mediterranean dwarf-shrub eco-systems. Understanding of the influence on the vegetation of habitat conditions and anthropogenic interventions is essential for rational management of these areas for forage production, fire control and recreational values. The main objective of the present study was to determine the long term effects of phosphorus nutrition on the composition of the herbaceous vegetation growing in patches between *Sarcopoterium spinosum* shrubs.

Materials and Methods

Experimental site: The experimental site was near En Yaaqov, 15 km east of the Mediterranean coast, in western Galilee, Israel (long. 35°15'E; lat. 33°01'N; alt. 500 m). The climate is typically Mediterranean; average seasonal precipitation is 797 mm but with large inter- and intra-seasonal variation. The rainy season, and with it the growing season of the herbaceous vegetation, begins in October-November and ends in April-May; during the summer months (June to September) there is little or no rain. During the 11 years of the study annual rainfall varied between 569 and 1328 mm.

Experimental design: The treatments included a control (P0) with no manipulative treatment, and two P priming treatments; P1 with 4.5 g P/m² and P2 with 9.0 g P/m². P was applied only once at the beginning of the experiment. In all P treatments, enriched (25% P₂O₅) superphosphate was spread evenly by hand on the soil surface in the autumn of 1988 after the fire and just before the 1988/89 rainfall season. Each treatment was implemented on 10x10 m plots and replicated five times in randomised blocks.

Botanical composition was determined at the peak of the growing season before seed dispersion in each of five 25 x 25 cm sample quadrats in each plot. The relative cover of grass, legumes and forbs was estimated visually as the average composition of the five samples in each plot.

Results

A single application of phosphorus fertilizer had a large and persistent effect on the botanical composition of the herbaceous vegetation. Indigenous annual legume species constituted only 10 - 20% of the herbaceous vegetation at the beginning of the experiment in the unfertilized treatment. Following P fertilizer application, annual legumes dominated the botanical composition of the sward year after year in this experiment falling below 40% only in 1994 (Fig. 1). There were two major deviations, from this pattern, one in 1991 and another in 1994. These were relatively dry years (613 mm and 628 mm annual rainfall) with very little rainfall in the beginning of the season (Fig. 2). In the P0 treatments, grasses dominated together with forbs, especially in the earlier years; as time went by, the annual legume cover increased slowly but steadily. During the first three years there was a general reduction in the cover of forb species and a complementary increase in the cover of grasses.

Discussion

The dependence of species composition on resource availability was clearly illustrated in the response of the annual herbaceous vegetation to P enrichment. It favoured the legume species by two different pathways. The first was the response to the P fertiliser that maintained legume dominance for at least 11 years even though it was applied only once at the beginning of the experiment. The other pathway was the gradual increase in legume cover

in the P0 treatment that was most probably a response to the P imported by the grazing animals during the summer when they were fed P-rich poultry litter as a nitrogen supplement.

Such dominance in Mediterranean swards is uncommon. Dominance in one year and the consequent N enrichment of the soil is commonly followed by increase of non-legume nitrophilous species. The reasons for the persistent dominance of leguminous species in this experiment is not clear. The following hypotheses can be postulated:

1. A large seed stock of legume species was established in the first two years in response to P enrichment and that was maintained and enlarged in subsequent years both by new seed crops and long term viability, reinforced by the presence of hard-coated seeds. Abundant germination and consequent competitive pressure could then have suppressed the non-leguminous species.

2. The P supply was maintained by recycling of the P taken up by the vegetation through the residual ungrazed litter and the seeds as well as through the droppings of the grazing animals.

3. The supplementation of P by the grazing animals that were fed P-rich poultry litter supplements added an annual exogenous increment to the available store of P in the soil.

4. The N-fixing efficiency of the rhizobia on the legumes was low and as consequence there was very little 'surplus' nitrogen to favour growth of grass and other nitrophilous species.

These hypotheses are, of course, speculative but indicate that the continued dominance of the legume component under such conditions deserves more study.

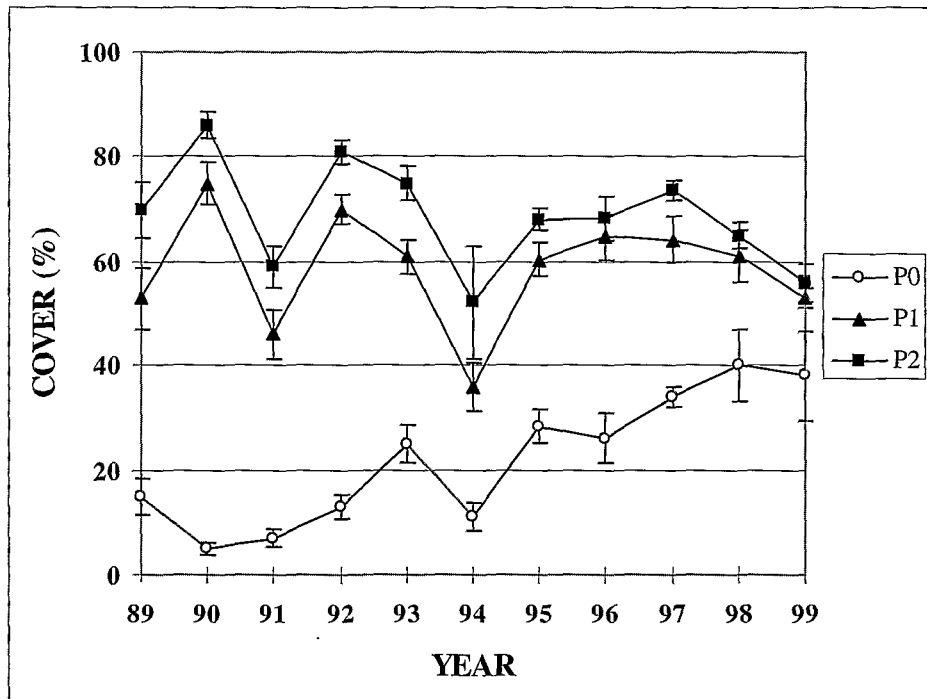


Figure 1. Sequential change in the cover of the legumes in the experimental treatments.

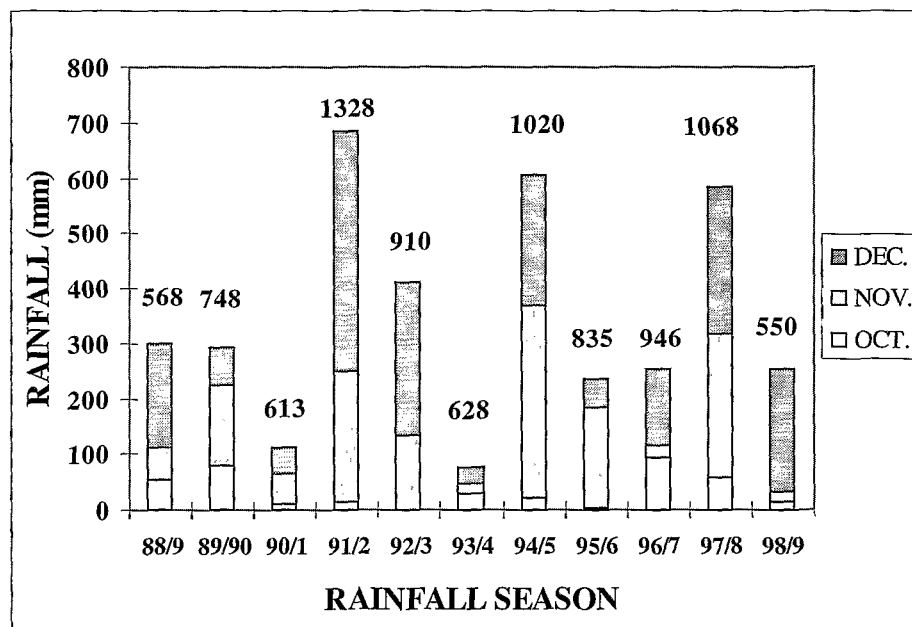


Figure 2. Rainfall at the beginning of the seasons between 1988/9-1998/9 in the experimental site near En Yaaqov (The number above the column is for the total annual rainfall).