Interactions between Plant, Soil, Water Erosion and Sediment Deposition at the Microscale in a Patchy Matorral

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Résumé
Les interactions entre plantes, sol, érosion hydrique et sédimentation ont été étudiées à microéchelle au sein d'un maquis méditerranéen à distribution spatiale discontinue (Valencia, Espagne). Trois espèces présentant des morphologies différentes (*Rosmarinus officinalis*, *Stipa tenacissima* et *Anthyllis cytisoides*) ont été sélectionnées afin de déterminer leur efficacité relative dans la réduction de l'érosion par saltation pluviale (*splash*), le ruissellement et le transport de sédiments par érosion inter-rigoles. L'influence des trois espèces sur les propriétés physiques et chimiques du sol a également été analysée à différentes distances des plantes. L'accumulation de sédiments dans le microenvironnement des plantes a été déterminée en analysant les formes microtopographiques associées aux plantes sur les pentes (monticules ou terraces). Le taux de splash est réduit de 90% sous *R. officinalis*, 83% sous *S. tenacissima* et 49% sous *A. cytisoides* par rapport à un sol nu. En ce qui concerne le volume de ruissellement et le transport de sédiments, les taux de réduction sont de 66%, 51% et 18% et de 94%, 88% et 30% respectivement pour les trois espèces dans le même ordre. Une modification plus accusée du sol a été constatée dans le microenvironnement de *R. officinalis* et *S. tenacissima*, par rapport à celui d'*A. cytisoides*. La hauteur des monticules associés aux plantes s'est avérée dépendante de l'espèce considérée (19.4, 14.6 et 4.3cm sous la canopée de *S. tenacissima*, *R. officinalis* et *A. cytisoides* respectivement). La morphologie des plantes (structure de la canopée, litière et rugosité des tiges) est déterminante pour la réponse des plantes aux différents processus.

Introduction
In the Mediterranean region, semi-natural shrubland communities (also called "*matorral*") often present a discountinuous cover with an alternation of vegetated spots and bare inter-plant areas. In such communities with a mosaic distribution of plants, interactions of individual plants with soil, splash erosion, runoff and sediment transport is relevant for the general processes that act at a larger scale.

Objectives
The objective was to determine the relative efficiency of three species with different morphologies (*Rosmarinus officinalis, Stipa tenacissima, Anthyllis cytisoides*) of a typical Mediterranean matorral of Eastern Spain (Valencia Province) in:
(1) the reduction of splash erosion,
(2) the reduction of interrill runoff and sediment yield,
(3) the modification of relevant soil properties,
(4) the net balance of splash/ soil loss by runoff/ sedimentation/ bioturbation
Implications of the results for erosion control at a larger scale (i.e. slope scale) are discussed.

Methods

(1) Soil detachment was measured under natural rainfall conditions by means of splash cups placed at different distances from the plant axis (2 inside cups below the plant canopy, 1 at the periphery of the canopy, and 4 ouside the canopy in the inter-plant area).

(2) Interrill runoff and sediment yield were measured in erosion microplots less than 1m2, containing each one single plant (or no plant for bare interplant area).

(3) Soil samples and soil properties measurements were taken at different distances from the plant axis (below, at the periphery and outside the plant canopy in the bare inter-plant area).

(4) Mounds reflect the net balance of different processes, i.e. splash, soil loss by runoff, sedimentation, bioturbation (Bochet *et al.*, 2000). A microprofilemeter (86x118cm) able to reproduce the soil surface microtopography in two dimensions was used to describe mound shape.

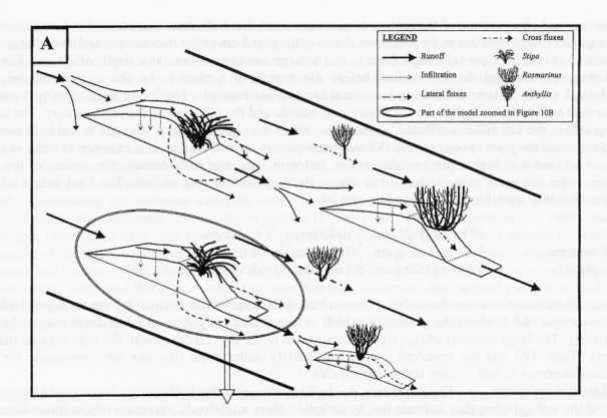
Results and Discussion

The three species interacted in different ways with the soil and the geomorphological processes studied, according to their morphologies (Table 1).

Table 1. Comparative data of cumulative interrill soil loss and splashed sediment (after a 2 years period), bulk density and soil organic matter content under the three species and in the inter-plant areas. Data with the same superscript (within each measured variable) do not differ significantly from one another.

	Rosmarinus	*Stipa*	*Anthyllis*	*Bare interplant area*
Cumulative soil loss (g/m^2)	133.0 ± 77.1 a	280.1 ±159.9 a	1635.7 ± 396.1 b	2344.1 ± 565.7 c
Cumulative splash (g/cup)	3.1 ± 2.0 a	5.3 ± 2.2 a	15..9 ± 6.1 b	31.1 ± 7.3 c
Bulk density (g/cm^3)	0.91 ± 0.14 a	0.89 ± 0.13 a	1.09 ± 0.16 ab	1.27 ± 0.16 b
Organic matter content (%)	5.07 ± 1.77 a	2.74 ± 0.84 b	2.42 ± 0.85 b	0.72 ± 0.38 c
Mound height (cm)	14.6 ± 6.4b	19.4 ± 7.9 a	4.3 ± 3.1	-
Canopy cover (%)	45 - 100	70 - 98	15 - 85	0
Litter cover (%)	40-100	-	3-30	0

Anthyllis cytisoides, a perennial summer-deciduous shrub with a lower canopy and litter cover, was the less efficient in reducing water erosion processes and in improving the soil surrounding characteristics. As a consequence, the mound height associated with *Anthyllis* shrubs was lower. The two other species, with a much denser canopy (*Stipa, Rosmarinus*) and litter (*Rosmarinus*) covers, and a high stem roughness at the soil surface interacted more efficiently with the surrounding soil, erosion and sedimentation processes.



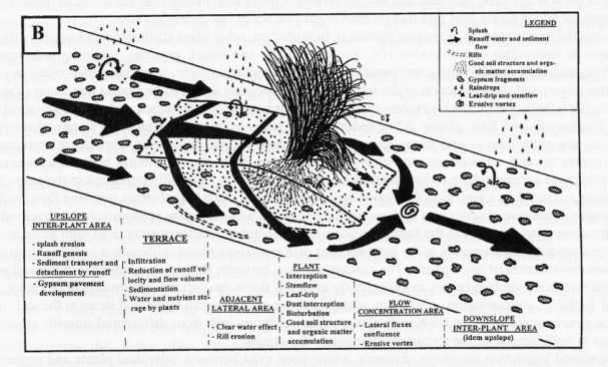


Figure 1. Model of the various processes taking part in the development of mound-plant systems (A) at the slope scale and (B) at the individual plant scale (after Bochet *et al*., 2000).

Conclusions

In semiarid shrublands with a patchy distribution, inter-plant areas with high rates of runoff and sediment transport act as water and nutrient suppliers for the plants (Fig. 1A). Species able to intercept the runoff flow and improve soil properties relevant to water infiltration are advantaged in these kind of ecosystems (Fig. 1B). Among the selected species, *Stipa tenacissima* (and to a lesser degree *Rosmarinus officinalis*) is the best adapted to such environments: the high terraces that form upslope from the tussocks make plant self-alimentation easier on slopes and increase the probabilities of survival in water-stressed conditions (adaptative strategy).

Reference list

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