Root characteristics of *Lotus corniculatus* L. and *Bromus inermis* L. grown on eroded rangeland in a semi-arid area of South Bulgaria

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ABSTRACT

The supportive role of plant roots for slope stabilization is identified. Nevertheless, information on root characteristics and their effects in controlling soil erosion are scarce. The main task of this study was to evaluate site effects (slope, soil parameters, fertilization) on root characteristics and thus in return to identify of the erosion-reducing potential of two cover crops in semi-arid conditions of South Bulgaria. To achieve this, root morphology and density distribution, biomass production of a mixture of Bird's-foot trefoil and Bromegrass grown on gentle (6^o) and steep slopes (12^o), and relevant soil characteristics were measured. The experiment included plots without and with 11 different rates of NPK fertilization. In was observed that the effect of the fertilization on shoot and root development was stronger on the gentle than on the steep slope. The shoot: root mass ratios were higher for the steep slope and for treatments without or minor rate of fertilization. On these plots, less root biomass occurred in the topsoil due to root relocation in deeper soil depths. Compared to mass, root length and surface area densities did not consistently increased with increasing the NPK fertilization rate. Extra Ca applications, however, apparently supported the root elongation. No significant differences in mean root diameters were found between the treatments, except of the highest N applications, affecting primarily the growth of the main roots rather than their branches. A high erosion-reducing potential of the topsoil roots was estimated in all treatments on both slopes.
KEYWORDS: Rangeland, Slope, Soil fertility, Cover crops, Root morphology, Erosion-reducing potential

INTRODUCTION

Water erosion has been recognized as a major soil degradation process in Bulgaria. This is of special relevance for rangelands in semi-arid areas characterized with long periods of drought combined with intensive rainfalls in summer. Without proper land management, they remain unprotected having high vulnerability to erosion (Rousseva et al. 2006). The important role of roots for soil resistance against erosion have been identified as they contribute to aggregate building and stability, increasing infiltration rate, etc. At the same time, data on root morphological characteristics and their effects in controlling soil erosion are still scarce. For slope stabilization, deep rooting systems are preferable, but concerning surface protection against water erosion, a dense lateral-spreading root systems seems to be more effective (Gyssels et al. 2005). The main task of this study was to evaluate site effects (slope, soil physical parameters, fertilization) on root characteristics and thus in return to identify of the erosion-reducing potential of two crops having different above and belowground habits.

METHODS AND MATERIAL

The study was conducted at an experimental field of "N. Pushkarov" Institute of Soil Science, situated in the Sakar mountain region, Southeast Bulgaria on two positions: a gentle slope of 6^o and on a steep slope of 12^o. The climate is continental-Mediterranean characterized by mild winter and hot summer with typical long periods of drought. The soil was classified as Chromic Luvisol, sandy clay loam, having acidified surface layer due to carbonate leaching down. A leguminous, *Lotus corniculatus L.*, and a grass, *Bromus innermis, L.*, were grown in proportion 40 to 60 %. The experiment consisted of 20 m^2 plots without and with 11 different rates of NPK fertilization in 4

replications. Plant and soil observations were carried out continuously. Topsoil roots were sampled by digging soil-monoliths of 20 x 20 x 30 cm (depth) at the end of experiment at the end of August. Roots were washed out from the soil in situ over a set of sieves. Representative root samples per treatment, mix of the 4 replicates, were taken and treated to measure their geometrical parameters using image analysis systems following Himmelbauer et al. (2004). Rest of the roots were oven dried (60^{o}C) for root mass evaluation. An erosion-reducing potential of the topsoil roots was estimated using two equations proposed by De Baets et al. (2007).

RESULTS AND DISCUSSIONS

Results showed rather unfavorable growth conditions, especially on the steep slope position, *i.e.* pH of 4.9, bulk density of 1.6 g cm^{-3}, and hydraulic conductivity of 2 to 3 cm d^{-1}. Measured soil parameters were averaged per slope position and thus valid for all variants. The shoot: (topsoil) root mass ratios were higher for the steep slope and for the variants without or with minor rate of fertilization due to root relocation in deeper soil depths (Fig. 1). Compared to root mass, root length and surface area densities did not consistently increased with increasing the NPK fertilization rate. Extra Ca applications, however, apparently supported the root elongation. No significant differences in the mean root diameter were found between the treatments, except for the highest N rates affecting primarily the growth of the main roots rather than their branches. Concerning both positions, just the root length density differed considerably and was higher on the gentle than on the steep slope (Fig. 1). A high resistance against erosion of the topsoil roots was evaluated in all treatments on both slopes, since the soil erodibility values derived from the density of roots with a certain diameter were fare below 0.01. The obtained results here are highly valuable, since comparative root data in relation to soil erosion are rare.

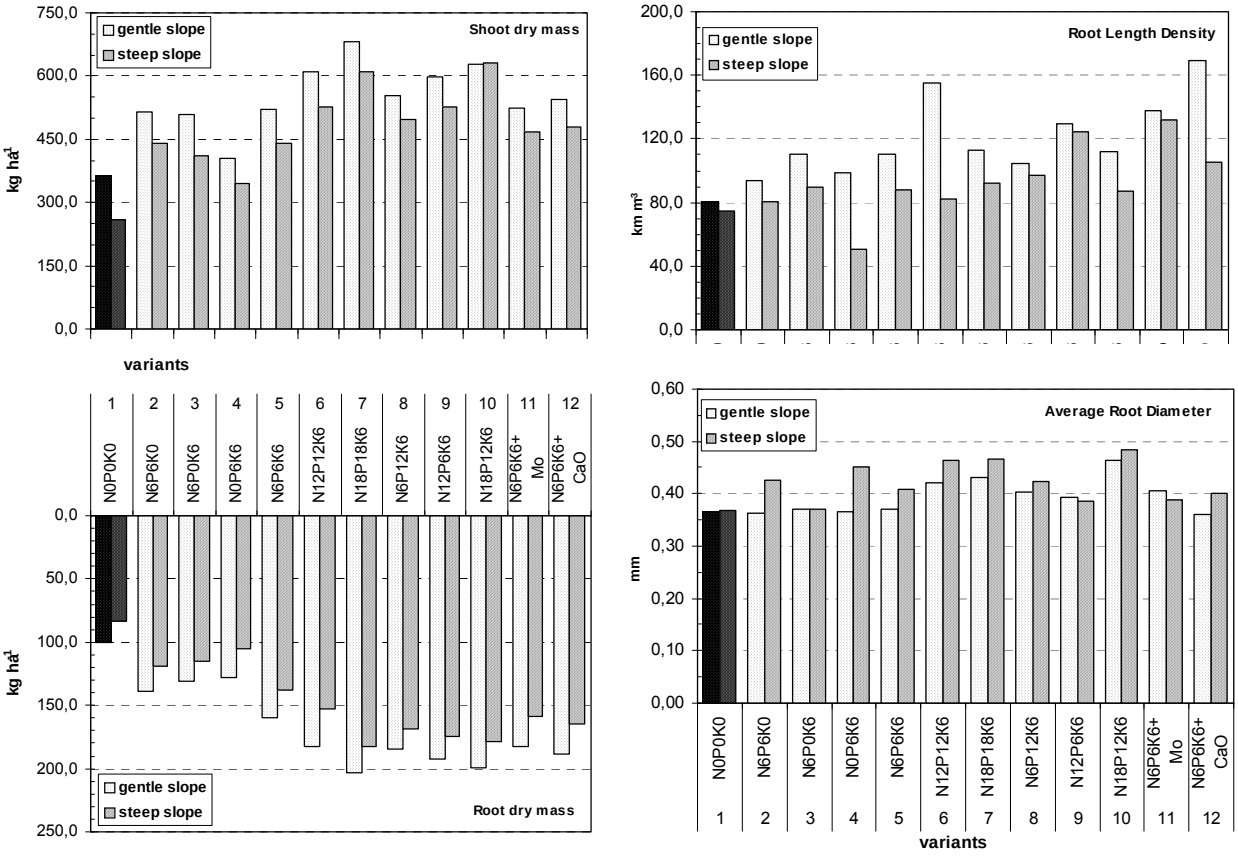

Figure 1. Shoot and root biomass, root length density and average diameter measured in the topsoil of 30 cm in all variants of fertilization on gentle and steep slope positions.

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