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Interaction between water and nutrient supply under semi-arid conditions

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Introduction

In many semi-arid areas of the subtropics, deeply weathered soils dominate with low nutrient content or availability. Especially low phosphorus availability is a common problem [1].

In such areas it is often difficult to identify the major growth limiting factor as it might vary from year to year, depending on which of the mechanisms linking water and nutrient availability and requirement for plant growth will dominate. In this paper some of the important mechanisms are discussed in detail.

Effect of increasing nutrient availability on plant water balance

A very important relationship between nutrient supply and plant water balance is the increase in shoot size due to improved nutritional status and thereby the increase in water requirement of the crop. If this enhanced water requirement cannot be met due to climatic

conditions well fertilized plants will have lower seed or grain yield, despite promotion of vegetative growth during the early growth stages.

Not only water requirement of a crop can be altered by changing the nutritional status but also the capacity of the crop for water uptake, which is closely related to root growth. Low amounts of fertilizer application generally enhance root growth, while higher amounts of fertilizer have no effect on root growth or even inhibit it (figure 1).

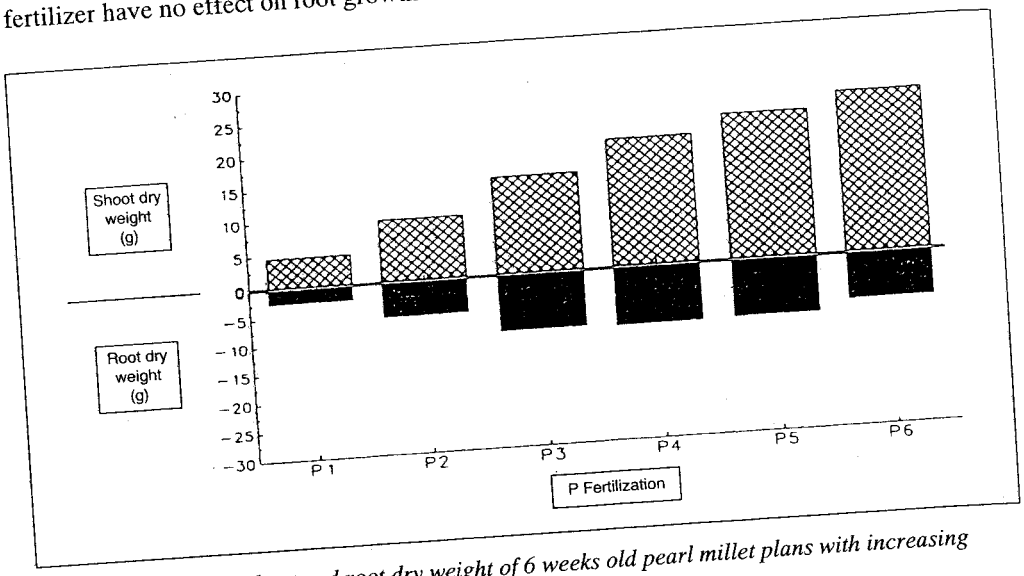

Figure 1. *Change of shoot and root dry weight of 6 weeks old pearl millet plans with increasing levels of P fertilization [g/pot].*

Not only root mass, but also specific root surface area can be affected by the mineral nutrient concentration in the soil. For example phosphorus is known to favour growth of fine roots. Root surface area can be important for water uptake once soil hydraulic conductivity, which reflects soil resistance to water movement, becomes the limiting factor for water uptake.

P deficiency also decreases hydraulic conductivity of the roots [2], which is an essential component of the equation for water flux according to the Ohm's law analogy.

Carbohydrate partitioning between root and shoot, which reflects to some extend the ratio between capacity for water uptake and water requirement of a crop, can be altered substantially due to changes in nutrient availability.

As an adaptation to low nutrient availability plants do not only form a more intensive root system relative to the shoot, but also a number of mechanisms can be induced which increase the availability of nutrients in the rhizosphere. For example plants can change the rhizosphere pH by release of H^+, HCO_3^- or organic acids. They can change the redox potential by release of reductants like phenols or by formation of aerenchyma. Other possibilities are the release of complexing agents like phytosiderophores, or of ectoenzymes like phosphatase. Under stress conditions such as nutrient deficiencies, root exudation may account for up to 30 % of the total dry matter production [3]. Increased