Soil water regime under rotational fallow and alternating hedgerows on an Ultisol in southern Cameroon

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Received 28 May 2003; accepted in revised form 8 March 2004

Key words: Alley cropping, Gliricidia sepium, Leucaena leucocephala, Natural fallow, Nutrient cycling, Planted fallow

Abstract

Soil moisture depletion during dry seasons by planted hedgerows to lower levels than under natural fallow, would reduce drainage and nutrient losses in the following rainy season when food crops are grown. The volumetric water content of the 0–150 cm soil profile was measured under planted hedgerows (alternating Leucaena leucocephala and Gliricidia sepium) and natural fallow, both either annually cropped to sole maize or in a two-year crop/two-year fallow rotation, in the humid forest zone (annual rainfall 1700 mm) of southern Cameroon during the 1995–1996 and 1996–1997 dry seasons. Hedgerows were cut to 0.05 m height, largely eliminating trees’ water consumption during cropping phases. Differences in total soil water content at 0–150 cm depth, between systems, occurred only in the early phases of the 1996–1997 dry season. In both dry seasons, differences between systems in water content were found in some soil layers, all within 0–60 cm depth, yet, without consistent advantage of any system in exploiting the topsoil water resources. Soil water content was lower under L. leucocephala than G. sepium at 20–40 cm depth only. Below 60 cm depth, no differences in water regimes between systems were found. Under southern Cameroonian conditions it is unlikely that any of the systems has an advantage in accessing or recovering water and thus, if available, nutrients from the sub-soil. None of the systems examined was capable of delaying drainage and thus it appears unlikely that downward displacement of nutrients is delayed after the start of the rains.

Introduction

Hedgerow intercropping or alley cropping has been shown to enable continuous food crop production on relatively fertile Alfisols in south-western Nigeria. However, on less fertile Ultisols and Oxisols, hedgerow intercropping does not generally increase yields. Such examples as well as cases of crop yield losses can be found in Kang et al. (1995). Due to low adoption rates of alley cropping for continuous food production on Ultisols and Oxisols in southern Cameroon (Kamenge and Degrande 2002), fallow phases were introduced. Such fallow phases give hedgerows time to produce biomass and accumulate nutrients.

The often quoted advantages of hedgerow systems and alley cropping: nutrient uptake from weathering, deep soil layers, and interception and
recovery of nutrients displaced downward with percolating leachate have rarely been proven and quantified (Sanchez 1995). There is little or no doubt about the potential contribution to sustained soil fertility and crop production of such processes, their quantification, however, appears prohibitively complicated and expensive. Measurements of soil water tensions or contents do not allow a quantitative assessment of such processes. However, they can detect if such processes occur and whether these are likely to contribute to nutrient cycling in different fallow and cropping systems.

Under rainfall conditions as in southern Cameroon and the larger part of the humid forest zone of the Congo basin, research on soil water regimes is less concerned with water deficiency and the consequent crop yield loss. Here, excessive rains contribute to nutrient leaching and displacement, especially early in the cropping phase, when crops have a low water consumption and a limited root system. Retention of nutrients in the topsoil is important because recycling of nutrients within the 0–1 m topsoil is the more efficient approach in retaining soil fertility than recovering nutrients from deeper soil layers (Lehmann et al. 2001).

The dry seasons are crucial for both the natural fallow species and planted hedgerows to produce biomass and accumulate nutrients, which will be returned to the surface soil when the vegetation is slashed and mulched or burned. The magnitude and pattern of water withdrawal from a soil profile, especially below the rooting depth of food crops indicates the ability of a fallow or hedgerow species to access sub-soil water and nutrients, and thus its potential to reduce water and nutrient losses to the whole system and movement out of the rooting zone of the food crops. Here the trees were pruned to 0.05 m, thus could not contribute to water and nutrient uptake during cropping phases. The only process by which this hedgerow system could reduce drainage and leaching in the early phases of maize growth, would be the reduction of the soil water content below levels attained in natural fallow, before the start of the rains. Wallace (1996) reported that greater water withdrawal by tree roots and the water uptake of ‘out of the cropping season water’ may alter drainage patterns. If a larger proportion of the soil water is withdrawn during the dry season in any system, more rainfall would be required before drainage starts in that system. As a consequence the residence time of the soil solution would be increased and crops would have more time to withdraw nutrients. Seyfried and Rao (1991) showed that in a perennial mixed cropping system with trees, the solute residence time was increased compared to a monocrop without trees, contributing to reduced leaching losses in the system with trees.

In this experiment volumetric water contents were measured in a profile of 0–150 cm depths over two dry seasons to determine if hedgerow systems withdraw more soil water than natural fallow. Our hypotheses were:

1. Hedgerow systems, irrespective of fallow or cropping phase, withdraw more water from the soil than natural fallow in the same phase.
2. Patterns of water withdrawal are different between hedgerow systems and natural fallow systems, with more water withdrawn from deeper layers in hedgerow systems.
3. Hedgerow systems under fallow, withdraw more water from the soil than pruned and cropped hedgerow systems.
4. Different hedgerow species have different water regimes.
5. In the interrow space, less water is withdrawn than under the hedgerows.

Materials and methods

The trial was established in 1988 at the Minkoameyos research station of the Institute of Agricultural Research for Development (IRAD) in Yaoundé, Cameroon. The site is situated at 3°52’ N and 11°26’ E and 813 m altitude. The 10 years average annual rainfall is 1692 mm. The rainfall pattern is bimodal. Rains usually start in March and end in early July (1st cropping season), followed by a short dry season of 6–8 weeks, then recommence in September and stop at the end of November (2nd cropping season). Mean air temperature ranges from 19.2 to 28.6 °C. The soil is a Ferric Acrisol with no pronounced profile differentiation. The site is a well-drained sandy clay soil in the top 30 m layer.

The experiment was a randomised complete block design with five replicates out of which three were used for the investigation of water dynamics.