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POTENTIAL ROLE OF NATIVE BUSH IN THE CHACO FOR MITIGATION OF DRYLAND SALINITY IN GRASSLAND

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Abstract

There is a zone of some 3.000.000 ha with an elevated dryland salinity risk in the Paraguayan Chaco due to a shallow saline ground water table. Evidence is shown of the crucial role native bush seems to play in keeping the water table at a low level and reducing therefore the risk of soil salinisation. In this paper a planned field experiment is outlined to define the tolerable level of deforestation and pasture establishment for a sylvopastoral production system in the Chacoan zone prone to dryland salinity.

Keywords: Deforestation, thornbush, osmotic potential, sylvopastoral system, Paraguay

Introduction

The Paraguayan Chaco is an alluvial plain with sediments from the Andes. It is a semi-arid to sub-humid region of approximately 250.000 km^2 with 500-1200 mm rainfall/year (mainly summer incidence). The undisturbed natural vegetation is predominantly a drought-deciduous thornshrub thicket. In the more humid eastern part of the Chaco, the landscape is characterised by a mosaic of thornbush and temporarily waterlogged edaphic grasslands (“water camps”). The dominant soil type in the Chaco is a fertile Luvisol with increasing conductivity in depth. Soils of the water camps are typical Gleysols.

From northeast to southwest, right across the Paraguayan Chaco, there is a belt of 50-75 km width and about 500 km length with a shallow, saline ground water table (Wiens, 1996). This is a transition zone between the semi-arid Central Chaco and the sub-humid Bajo Chaco. In this zone, the water table has such a high level (sometimes <150 cm) that dryland salinity may occur due to capillary ascension and salt outcrops at the soil surface (“discharge areas” of ground water), particularly in and around lagoons and water camps (Wiebe-Harder, 1999). In contrast, in the “recharge areas” in the northwestern part of the Chaco, close to the Andes, the water table remains in considerable depth (>30 m). The large-distance ground water flow rate from northwest to southeast is very low (<1 m yr^{-1}; Hoyer, 1993).

The problem

Since the 1960’s, native bush is successively cleared in order to establish pastures with *Cenchrus ciliaris* (buffel grass), *Panicum maximum* (panic) cv. Gatton and other grasses. In the Paraguayan Chaco, the annual rate of bush clearing has reached approx. 100.000 ha. In this way extensive production systems predominantly based on bush browsing are increasingly replaced by semi-intensive ranching on man-made grasslands with cow-calf systems and steer fattening. Nowadays more than 1 million ha of sown grassland has been established in the Central Chaco. Man-made grasslands are successively extending towards the aforementioned transition zone prone to dryland salinity.

When bush is cleared for pasture establishment, the water table rises and the saline ground water is diluted. For example, under grassland a water table rise by 8 cm and a reduction of electrical conductivity by 34% have been measured on average over four months, in comparison with adjacent bush (Nitsch, 1994). This is due to the reduced transpiration (lower leaf area index), reduced rooting depth, and hence increased infiltration rate of rainwater in grassland as compared to bushland. Therefore capillary ascension of saline groundwater (though diluted) and soil surface salinisation are more frequent in pastureland than in bushland (Bennett, 1998).

Although the dynamics of salts in the soil are not yet clearly understood, field observations at sites with a shallow water table suggest that a few centimetres of difference of the mean depth of the water table may cause a grassland either to grow vigorously or to die off (mostly during wet years) due to soil salinisation. On the other hand, during a sequence of drier years, when the ground water table is lowered and salts are leached from the soil surface, a spontaneous rehabilitation of salt affected areas has been observed (Glatzle, 1999).

The presumed role of native bush

Most of the Chacoan native woody species such as *Prosopis ruscifolia*, *Bulnesia sarmientoi*, *Ruprechtia triflora*, *Zizyphus mistol* or *Tabebuia nodosa* are capable of producing tremendously high suction capacities (up to >50 bar) as measured by Mitlöhner (1995) with a Scholander device, enabling them to absorb water from a rather saline environment: Water absorption should be possible from a solution with an electrical conductivity of up to 65 mS cm^{-1}. This suggests that native bush, whose rooting depth easily reaches the ground water level in areas prone to salinity, is able to re-lower rapidly the water table, re-concentrating the ground water up to a maximum salinity level, after the water table had risen and the ground water had been diluted following a rain water infiltration event. Due to its very high suction force, Chacoan bush seems to keep the ground water at a low level, playing a crucial role for the mitigation or avoidance of soil salinisation and degradation of productive land resources.

In a semi-arid climatic zone such as the Chaco, where annual potential evapotranspiration exceeds 2000 mm (more than twice the annual rainfall), native xerophytic bush could obviously transpire much more water if transpiration was not limited by soil water availability (drought and high tension) and/or by high concentration of salts in the soil solution (high osmotic potential). It is assumed therefore that even a reduced bush density could fulfil in an associated pasture its ground-water-regulatory-function, transpiring rapidly excess rainwater in the soil, as long as the rooting system reaches most of the soil volume. Since native bush has little pastoral value, and some bush clearing is necessary to reduce competition for light, water and nutrients in order to successfully establish a pasture, a sylvopastoral system should constitute the compromise of producing beef while keeping the risk of dryland salinity at a tolerable level in areas with a shallow water table.

Experimental approach

On the basis of this hypothesis, a field experiment will be carried out in order to define the permissible extent of bush clearing and pasture establishment in the transition zone prone to salinisation: At two representative water camps susceptible to dryland salinity, a strip of bush, 50 m wide, will be cleared along the gradient towards the centre of the water camp and planted with Estrella grass (*Cynodon nlemfuensis*). Perpendicularly to this strip, three lines with a series of boreholes for ground water observation are installed from inside the bush right across the grass strip. Each line has to follow more or less the same depth of the water table (about 100 cm, 150 cm and 200 cm, measured at the end of the dry season). Weekly observations will provide information on the level and the amplitude of the water table and the variation of the ground water salinity as affected by rainfall and by the distance from the edge of the bush. In the centre of the pasture strip and inside the bush, conductivity sensors and tensiometers shall be installed permanently at a variety of depths from the soil surface to ground water level in order to observe the dynamics of soil salinity and humidity along the soil profile. Furthermore the suction power of the dominating woody species growing at the edge and inside the bush shall be measured, at various degrees of soil humidity, with an Scholander device.

On the basis of the data observed it is expected to better understand the ground water and salt dynamics in the soil and to be able to assess up to which approximate distance from the edge of native bushland and at which mean depth of the water table pasture establishment is safe – in other words, up to which distance from the edge of the bush the roots are capable of regulating the water table and preventing salinity. This knowledge should provide a sound basis to define the critical level of the water table, when deforestation has to be avoided completely (or native bush allowed to re-grow), to design a sylvopastoral production system (permissible pattern and proportion of bush clearing), and to define the limits of sustainable production in areas prone to salinisation.

References

Bennett, B. (1998). Dealing with dryland salinity. Ecos **96**: 9-21.

Glatzle, A. (1999). Compendio para el Manejo de Pasturas en el Chaco. Edición El Lector, Asunción.

Hoyer, M. von (1993). Hidroquímica del agua subterránea en el área urbana de Filadelfia (Chaco Boreal/Paraguay). Dirección de Recursos Hídricos, Filadelfia (unpublished report).

Mitlöhner R. (1995). Standortcharakterisierung durch pflanzliche Saugspannung und potentiellen osmotischen Druck im Chaco Central, Paraguay. Universität Göttingen (unpublished report).

Nitsch, M. (1994). Versalzungsgefährdung von Böden im östlichen Zentralchaco als Folge nicht angepaßter Rodungsmaßnahmen. BGR, Hannover (unpublished report).

Wiebe-Harder, S. (1999). Landnutzung und Bodenversalzung im Chaco von Paraguay. Universität Halle (unpublished report).

Wiens, F. (1996). Evaluación económica del uso de la tierra al Este de Loma Plata, Chaco Central – Oriental: Problemas de salinización en suelos de monte en una zona de transición. Asunción (unpublished report).