THE INFLUENCE OF INTENSITY OF TREE THINNING ON THE REDISTRIBUTION OF SOIL WATER IN SOUTHERN AFRICAN MOPANI VELD

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ABSTRACT

The investigation was conducted on a densely wooded area in the Mopani veld of South Africa. Six plots were subjected to different intensities of tree thinning, ranging from a totally cleared plot (0 %) to plots thinned to the equivalent of 10%, 20%, 35%, 50% and 75% of the leaf biomass of a control plot (100%). Soil water measurements were taken at six different depths to a depth of 825 mm. The infiltration of rain water and redistribution within the soil profile exhibited marked differences between experimental plots. The soil water was predominantly held at a very shallow depth (<450 mm). Increased infiltration in plots with a low tree density occurred and was associated with the establishment of grasses. No stratification of soil water between the topsoil and subsoil could be established which means that the *C. mopane* trees and grasses are in direct competition for soil water in the upper soil layers.

KEYWORDS

Colophospermum mopane, grass-tree competition, infiltration, runoff

INTRODUCTION

Water is the main driving force of semi-arid ecosystems (Snyman and Fouché, 1991), and the suppressive effect of an increase in woody plant density on herbaceous production is largely through competition for soil water (Dye and Spear, 1982). The southern African Mopani veld, dominated by the tree species *Colophospermum mopane* Kirk ex J. Léonard (Kirk ex Benth), is a water limiting ecosystem, and high tree densities is considered a major factor contributing towards the low grazing capacity of this veld type (Gammon, 1984). The selective removal of woody plants would invariably influence the soil water regime and the objective of this study was to determine the influence of intensity of tree thinning on the redistribution of soil water.

MATERIAL AND METHODS

The study was conducted in the Northern Province of South Africa on a site located at 29°12'E, 22°19'S, 560 m above sea level. The vegetation is described as Mopani veld (Acocks, 1988) and the most important grass species are *Enneapogon cenchroides*, *Aristida adscensionis*, *Brachiaria deflexa*, *Cenchrus ciliaris* and *Digitaria eriantha*.

The rainy season usually extends from October to March inclusive, but rainfall is irregularly distributed and unpredictable. Mean long-term seasonal rainfall (July-June) for the period 1966/67 to 1989/90 was 376 mm (SE ±27.6, range 140-620 mm). The area is known for its high summer temperatures and moderate to warm winter temperatures. The underlying geology is mainly sandstone, and the soil is sandy (80% sand, 8% silt, 12% clay) with an effective depth of more than 1.2 m.

The study area consisted of six, 1.17 ha plots (180 m x 65 m), differing tree densities. The control plot was left undisturbed (referred to as the 100 % plot), and the others thinned to the approximate equivalents of 75 %, 50†%, 35 %, 20 %, and 10 % of the tree biomass of that of the 100 % plot (2 711 trees ha^{-1}). Herbaceous plants were almost completely absent in the control plot.

Thinning was completed during 1989 and a study of the soil water was conducted during the 1990/91 (440 mm rain) and 1991/92 (214 mm rain) seasons (July - June) with the aid of a neutron water meter (CPN model 503 DR). Ten seamless galvanised access tubes were randomly allocated to each experimental plot (total of 70 tubes). They measured 1.2 m, and were installed to a depth of 1.0 m.

Soil water measurements were conducted at six different depths zones: 75 mm (0-150 mm), 225 mm (>150-300 mm), 375 mm (>300-450 mm), 525 mm (>450-600 mm), 675 mm (>600-750 mm) and 825 mm (>750-900 mm). Individual readings with the neutron water meter were taken at a count rate of 15 seconds. Measurements were normally taken on 3 to 5 successive days after such an event, whereafter the measurements were taken with increasing intervals. Daily rainfall data were recorded with standard rain gauges placed at the four corners of the experimental area.

Calibration of the neutron water meter was conducted on a representative site next to the study area in accordance with the guidelines given by Karsten and Haasbroek (1973), Van der Westhuizen *et al*. (1981), and Snyman *et al*. (1987).

The soil bulk density was determined for each soil depth zone to enable the calculation of the percentage volumetric soil water (θV). The soil water content, expressed as θV, was calculated for each soil depth zone. These values were calculated as the mean of the ten measuring sites within each plot and plotted over time.

RESULTS AND DISCUSSION

Tree thinning resulted in marked increases in grass production and grass cover (Smit, 1994). As a consequence of the difference in grass cover the infiltration of rain water and redistribution within the soil profile also exhibit marked differences between experimental plots. The results displayed a linear response between the extremes of total clearing (0 % plot) and the control (100 % plot). Subsequently the results of the soil water redistibution are presented for these extremes only (Figure 1 - 0 % plot and Figure 2 - 100 % plot). Figures 1 and 2 represent the full duration of the soil water study (542 days), days when no soil water measurements were taken inclusive. It must therefore be noted that the true soil water content of those days not measured will be masked by the straight lines that joined known data values, and that these graphs must serve as a measure of comparison between plots.

Fluctuations in the daily soil water content were the largest in the topsoil (0-150 mm) and these fluctuations decreased as soil depth increased. In general, very little soil water reached the soil layers beyond 450 mm. Only in the 0 % plot did the soil water content of the >450-900 mm soil zone show marked increases associated with specific rainfall events (Figure 1b). In relation to increasing *C. mopane* densities, soil water penetration occurred to shallower depths. As can be seen from Figure 2 the soil water content of the 100 % plot at depths >300 mm showed very little change, demonstrating the poor infiltration and redistribution of soil water into the soil profile of this plot. Since very little, if any, soil water appeared to be available in deeper soil layers, the shallow, extensive horizontal spread of the *C. mopane* roots (Smit, 1994) proved to be essential for the survival of *C. mopane*.

These results confirmed the occurrence of high rainwater runoff losses expected in plots with a poor grass cover, compared to those plots with some grass cover. In addition, it presents evidence suggesting that soil water extraction within the 0-300 mm soil zone by the roots of the *C. mopane* trees occurred at a rate fast enough to prevent soil water from reaching deeper soil layers. In the grass only plot (0% plot) some water did manage to reach deeper soil layers, but the considerable difference between the water content of the >300-450 mm and the >450-600 mm soil zones (Figure 1) indicates that grasses predominantly utilise water within the top 450 mm.

In view of the theory proposed by Walker *et al.* (1981) that stratification of soil water between the topsoil and subsoil may lower competition between woody plants and grasses (since woody plants presumably have exclusive use of subsoil water) it is significant to note that no such spatial separation of soil water existed in the study area. This would invariably mean that the *C. mopane* trees and grasses are in direct competition for soil water and that the *C. mopane* trees at high densities utilise the available soil water to such an extent as to prevent the establishment or survival of grasses.

REFERENCES

Acocks, J.P.H. 1988. Veld types of South Africa. 3rd edition. Memoirs of the Botanical Survey of South Africa 57.

Dye P.J. and Spear P.T. 1982. The effects of bush clearing and rainfall variability on grass yield and composition in south-west Zimbabwe. Zim. J. agric. Res. **20**: 103-118.

Gammon D.M. 1984. Effects of bush clearing, stocking rates and grazing systems on vegetation and cattle gains. Meat Board Focus, May/June.

Karsten J.H.M. and Haasbroek F.J. 1973. A new method of calibrating a neutron mois-ture meter and a correction for the effect of soil bulk density. Agrochemophysica **5**: 35-40.

Smit G.N. 1994. The influence of intensity of tree thinning on Mopani veld. Ph.D-thesis, University of Pretoria, Pretoria.

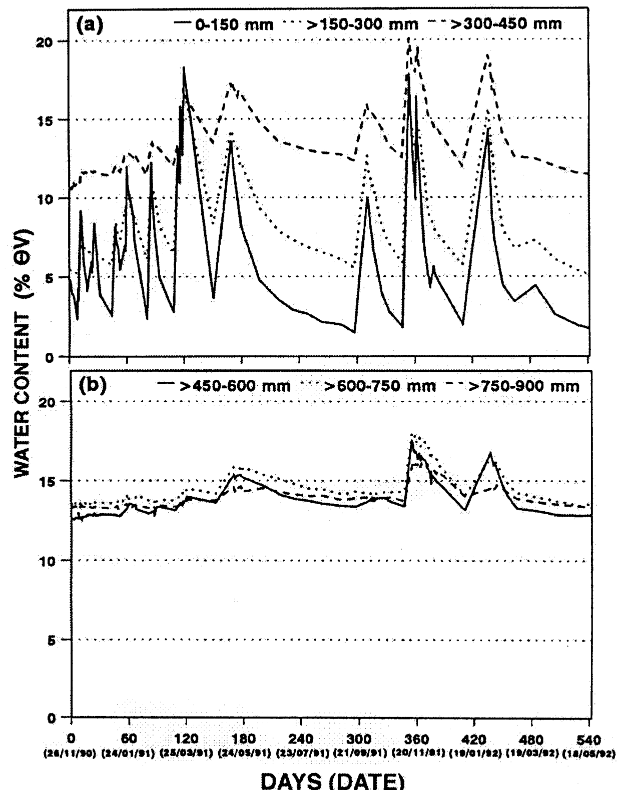
Snyman H.A., Venter W.D., Van Rensburg W.L.J. and Opperman D.P.J. 1987. Ranking of grass species according to visible wilting order and rate of recovery in the central Orange Free State. J. Grassl. Soc. South. Afr. **4**: 78-81.

Van der Westhuizen M., Bristow K.L., Van der Bank D.J. and Naudé G.R. 1981. Evaluation of a gamma-attenuation soil water meter and a neutron-scattering meter for measuring topsoil water content. Agrochemophysica **13**: 25-29.

Walker B.H., Ludwig D., Holling C.S. and Peterman R.M. 1981. Stability of semi-arid savanna grazing systems. J. Ecol. **69**: 473-498.

Figure 1

Soil water redistribution in the soil profile of the 0 % (totally cleared) plot: (a) soil depth zones 0-450 mm, and (b) soil depth



zones >450-900 mm.

Figure 2

Soil water redistribution in the soil profile of the 100 % (control) plot: (a)soil depth zones 0-450 mm, and (b)soil depth zones >450-900 Cm.