Effects of method of cultivation on root density and grain and crop residue yields of sorghum

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Summary

IN THE SUBHUMID ZONE *of Nigeria, crop residues of cereals such as sorghum provide substantial amounts of fodder for cattle in the dry season. For cereal production, ridging is the traditional method of land cultivation in the zone. The study reported in this article was carried out in order to clarify the benefits associated with ridging and to determine whether these can be provided by other, less labour-intensive cultivation techniques.*

Increasing ridge height from 0 to 45 cm increased grain and crop residue yields. Root density, plant height and leaf area index (LAI) of sorghum also increased with increasing ridge height, and there was a positive correlation between root density and grain and crop residue yields. No significant differences in yields were found for ridge heights of over 30 cm. It is concluded that the main function of ridging on periodically waterlogged soils is to raise the root system above the fluctuating water table. This promotes root development and enhances the ability of roots to extract nutrients and moisture from the soil, thereby increasing yields.

Introduction

Farmers in the subhumid zone of Nigeria traditionally grow crops on ridges. The importance of this cultural practice for cropping has been demonstrated especially on soils that are periodically subjected to a perched water table (Mohamed-Saleem et al, 1985). The benefits associated with ridging include prevention of waterlogging, increased water infiltration and concentration of nutrients in and around the rooting zone (Kowal and Stockinger, 1973). Its main disadvantage is that it is labour intensive. In a study carried out in ILCA's case study area in Abet, ridging was found to account for 31% of the total time spent on cropping maize on natural fallows (Tarawali et al, 1986). Farmers maximise returns for the labour spent on ridging by intercropping. Lack of labour at ridging time can limit the area cultivated by a farmer (Powell, 1986).

The main objective of the work reported in this article was to determine the effect of ridge height on crop production and to ascertain the benefits associated with ridging.

Methods

The study was conducted in Abet (9° 40' N, 8°10' E, mean annual rainfall 1300 mm) during the 1985 wet season. Sorghum (variety SK5912) was used as the test crop, since it is one of the major crops in the zone and provides a substantial amount of fodder for cattle during the dry season. The treatments consisted of six land preparation methods, each replicated four times in a randomised complete block design.

1. Flat, undisturbed seedbed

2. Flat seedbed, surface disturbed with hand hoe

3. 15–cm ridge height

4. 30-cm ridge height (open ridges[1])

5. 30–cm ridge height (tied ridges[2])

6. 45–cm ridge height

[1] Open ridges are ridges opened at both ends.

[2] Tied ridges are adjacent ridges joined at the ends and in the middle by subsidiary ridges, thereby forming furrows.

The plot size was 10 m x 5 m, and each row was 10 m long. Sorghum was planted at a spacing of 0.30 m within and 1 m between rows. Compound fertilizer was applied to each plot at a rate of 60 kg N, 60 kg P and 60 kg K/ha at the time of planting, and an additional 60 kg N/ha was applied in the form of urea 6 weeks later. The plots were weeded twice by locally hired labourers using traditional hoes. In December, the panicles from each ridge were harvested separately and threshed to determine grain yield at 15% moisture. The crop residues were cut and dried at 60°C for 48 hours to estimate dry-matter yield.

The heights of eight randomly selected plants/treatment were measured in October. The length (1) and breadth (b) of the leaves of these plants were also measured to determine leaf area and leaf area index (leaf area per unit area of land). Leaf area =1 × b × 0.75 (correction factor).

Studies to determine root density, were carried out during the course of the experiment. Five soil-root core samples per treatment were taken using a bucket auger (7 cm diameter, 15 cm height). All samples were taken along the rows, at distances of 5 and 15 cm away from randomly selected plants. The roots were washed in slowly running water and dried at 60° to determine dry weights. The data collected were analysed using ANOVA and linear regression.

Results

Table 1 shows that grain and crop residue yields of sorghum increased with increasing ridge height. There were significant differences between yields on the flat land and on the 30- and 45-cm ridges but not between those on the 30-and 45-cm ridges No significant differences were found between yields on the two flat seedbeds or between those on the tied and open 30-cm ridges, nor were there any differences in grain yield between the flat treatments and the 15-cm ridge.

Table 1. *Effects of method of cultivation on grain and crop residue yields of sorghum, Abet, 1985.*

Method	Grain yield (kg/ha)	Crop residue yield (kg/ha)
Flat, undisturbed	1724	3666
Flat, disturbed	1827	4301
15-cm ridge	2023	5243
30-cm ridge (open)	2338	5294
30-cm ridge (tied)	2190	5317
45-cm ridge	2246	5453
LSD (0.05)	400	1163

Root density of sorghum increased with ridge height (Figure 1) for cores taken 5 and 15 cm from the plants. However, the density of roots was less in cores taken 15 cm from the plants. Figure 2 shows that there was a positive correlation between root density and grain and crop residue yields.

Figure 1. *Effect of ridge height on root density of sorghum, Abet, 1985.*

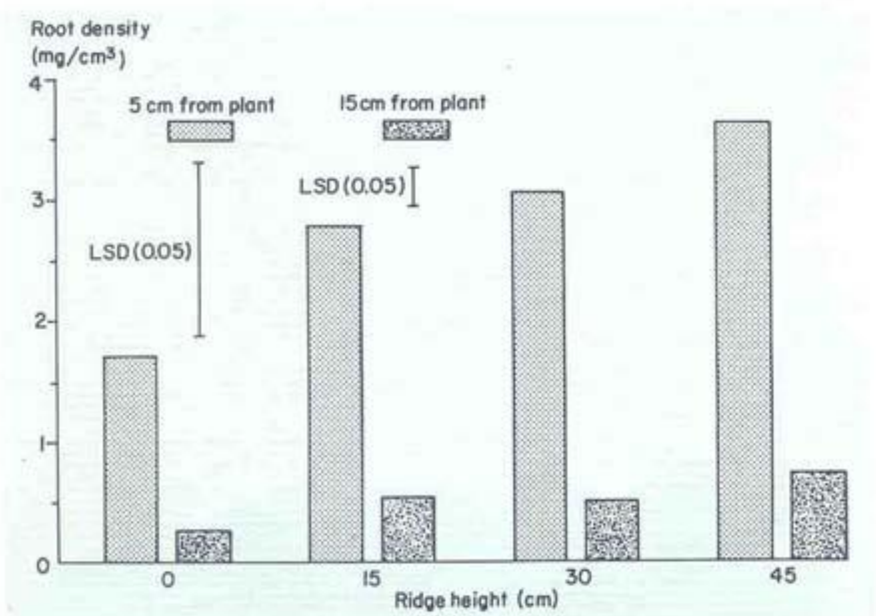
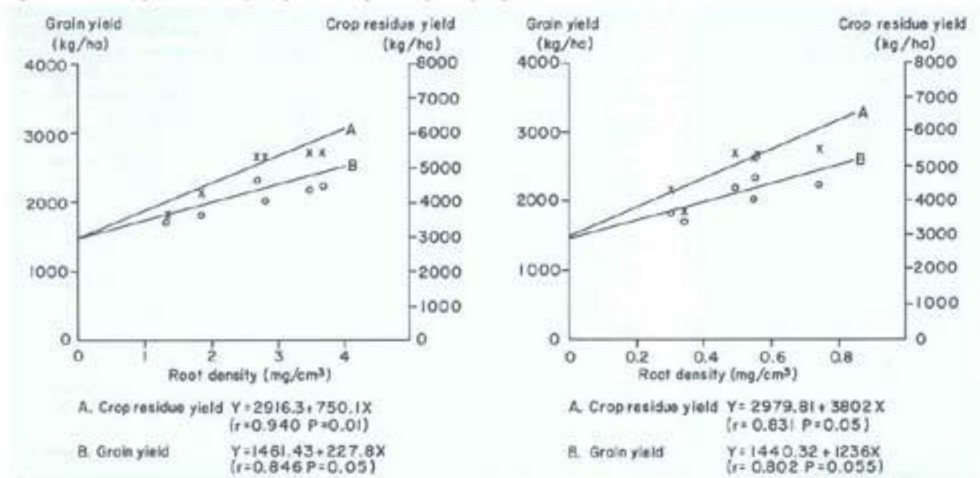


Figure 2. *Relationship between density and grain and crop residue yields of sorghum, Abet, 1985.*



Ridging affected the growth of sorghum. Plants grown on ridges were taller and had greater leaf area index than those grown on flat seedbeds (Table 2). While most of the roots of plants grown on the flat beds tended to concentrate in the top 15 cm of the soil, a substantial proportion of the roots of plants grown on ridges exploited depths below 15 cm, the proportion increasing with increasing ridge height (Table 3).

Table 2. *Effects of method of cultivation on plant height and leaf area index (LAI) of sorghum, Abet, 1985.*

Method	Plant height (cm)	LAI
Flat, undisturbed	124.5	0.82
Flat, disturbed	128.4	1.14
15-cm ridge	140.4	1.30
30-cm ridge (open)	144.0	1.45
30-cm ridge (tied)	147.1	1.37
45-cm ridge	148.9	1.43
LSD (0.05)	7.4	0.31

Table 3. *Effects of method of cultivation on root distribution)[1] of sorghum, Abet, 1985.*

Ridge height	Depth (cm):	5 cm from plant			15 cm from plant		
		0–15	15–30	30–45	0–15	15–30	10–45
Flat		96.5	2.8	0.7	75.6	22.3	2.1
15 cm		86.2	11.5	2.3	68.3	20.0	11.7
30 cm		83.5	14.6	1.9	59.1	34.9	9.0
45 cm		74.5	23.6	1.9	37.8	55.6	6.6

[1] Expressed as % of total at all depths.

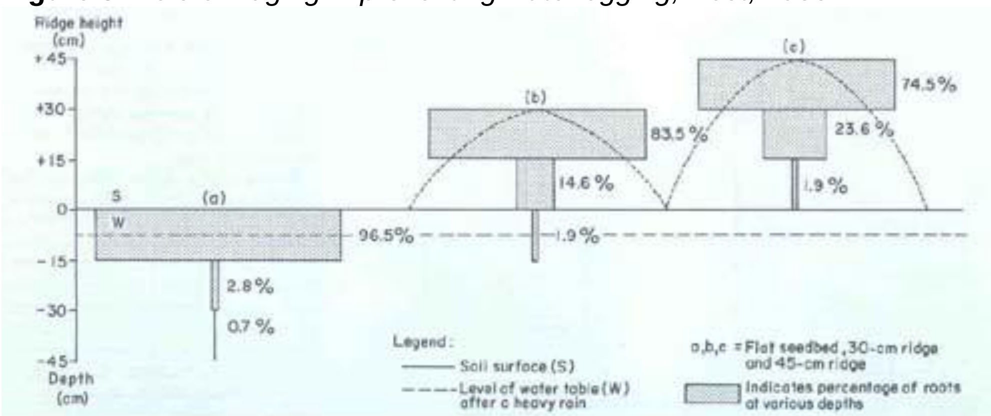
Discussion

The increase in grain and crop residue yields with increasing ridge height (Table 1) confirms that ridging improves crop production on ferruginous soils, where the compact structure and hardpan near the surface may hinder root growth and moisture infiltration (Bennet et al, 1979). The increase in root density with ridging observed in this study suggests that more nutrients and moisture can be extracted from the soil by roots of plants growing on ridges, thereby increasing yields.

Plants growing on ridges had a larger proportion of their roots in the soil layers below 15 cm than those gown on flat beds (Table 3). Penetrometer readings in similar situations in the Kurmin Biri case study area increased sharply at the 15 to 25 cm soil depths, indicating difficulties for root growth on flat seedbeds (Vine et a1,1985).s

Ridging appears to be particularly advantageous for soils with a periodically perched water table. In Abet, Mohamed-Saleem (unpublished data) observed that the water table was 7 to 15 cm below the soil surface for more than 48 hours following heavy rains in August. Roots submerged during these periods will asphyxiate, and this leads to poor development. The role of ridging in relation to this phenomenon is demonstrated by Figure 3. In the event of waterlogging, about 53% of the roots of plants growing on a flat bed will be affected, as compared with 0.9% on 30-cm ridges and none on the 45-cm ridges.

Figure 3. *Role of ridging in preventing waterlogging, Abet, 1985.*



The grain and crop residue yields of sorghum on the 45-cm ridges were not significantly different from those on the 30-cm ridges. This indicates that 30 cm is a satisfactory ridge height for cropping in the subhumid zone of Nigeria. The increase in grain and crop residue yields with increasing ridge height suggests that other, less labour-intensive methods of cultivation, such as *in situ* disturbance of soil, cannot be substituted for ridging.

Earlier studies carried out in the Kunmin Biri case study area (Mohamed-Saleem et al, 1985) indicated that planting sorghum on 30-cm ridges resulted in a yield increase of 600 kg/ha over planting on flat seedbeds. Although a similar yield margin was recorded in this study, the overall yield reported here for each treatment was approximately 1 t/ha greater than that recorded at Kurmin Biri. Three factors may have contributed to the differences in yields recorded in the two studies. Firstly, the site at Abet had been under continuous cultivation for 2 or 3 years, and the residual effects of fertilizer applied previously may have influenced the yield. Secondly, the fertilizer rate used for the experiments conducted in Kurmin Biri was lower than that used in the present study. Finally, rainfall during the 1985 growing season was 300 mm higher and better distributed than in the previous 3 years.

Ridging after a legume fallow requires less labour than tilling a soil after a natural fallow (Tarawali et al, 1986). This has an important implication in the subhumid zone of Nigeria, where ILCA is presently encouraging farmers and agropastoralists to try legume-based cropping within fodder banks (concentrated units of stylosanthes pasture for dry-season supplementation of cattle). The lower labour requirements for tilling a fodder bank would be attractive to farmers.

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