THE INFLUENCE OF RIDGING ON SWEETPOTATO PRODUCTION UNDER DRYLAND CONDITIONS

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ABSTRACT

Sweetpotato production may provide an option to diversify cropping systems in northern Namibia and provide additional food to households. A 1996 survey on root crop production found that sweetpotatoes are mostly planted on flat soils under dryland conditions in northern Namibia. Since the start of the sweetpotato variety evaluation programme, farmers have queried the production of sweetpotatoes on ridges versus on the flat under dryland conditions. No recommendations were known on the production of sweetpotatoes under dryland conditions on relatively sandy soils as they occur in northern Namibia. In the experiment conducted to evaluate the effects of soil type and soil arrangement on the performance of different varieties, it was found that sweetpotatoes perform better in loamy soil than sandy soil. Also, all varieties should be planted on ridges rather than on the flat in loamy *sand* to obtain a higher tuber yield and a more pleasant tuber shape. If high-potential varieties, that can induce a large number of tubers, are however planted on sand, they should be planted on the flat rather than on a ridge to ensure that fewer tubers are induced of which most can mature to marketable size. Lower-potential varieties that induce fewer tubers should generally be planted on ridges in sand and loamy sand. Although the marketable tuber yield does not differ significantly between ridged and flat soil arrangement in sand for these varieties, the number of tubers that reach maturity can be increased when planted on a ridge in sand.

INTRODUCTION

In the northern regions of Namibia an average annual rainfall of >400 mm allows mixed farming systems with livestock and seasonal crop production. The staple food crop, pearl millet, is the only crop perceived to thrive well in the mainly sandy soils with relatively low and erratic rainfall. The need to find other crops suitable for the area, to diversify the current farming system, is therefore evident. Sweetpotato is an important crop in Africa because it requires few inputs, plantings can produce a crop within four months of establishment, the production per unit area is among the highest of the major starch staple food crops and it can withstand drought better than some of the cereal crops.

The Namibian Root Crops Research Project was initiated in 1994, started its first fieldwork in late 1995 and conducted a baseline survey in 1996. This survey, conducted in the Kavango and Caprivi regions, revealed that a minority of farmers in those regions currently produce sweetpotatoes. It was found that sweetpotatoes are mainly planted on flat soils under dryland conditions.

Production expansion was limited due to the lack of planting materials of suitable varieties and therefore selection, multiplication and distribution of improved varieties has taken place every season since 1996. At various occasions during this process, farmers queried the production of sweetpotatoes on ridges versus on the flat under dryland conditions.

In their leaflet on the cultivation of the sweetpotato, Coertze *et al.* (1994) stated that the yield and quality of sweetpotatoes grown on ridges is higher than when grown on the flat. Reasons for the better performance on ridges is attributed to better drainage in the root zone and a better ability of the tubers to grow in the looser soil, than in the more compact flat soil. It is therefore generally recommended to grow sweetpotatoes on ridges. These recommendations are however made for areas with heavy soils where crops are irrigated.

No recommendations are known on the production of sweetpotatoes under dryland conditions on relatively sandy soils as they occur in northern Namibia. This project was initiated following on repeated queries from farmers who participated in on-farm evaluation of improved sweetpotato varieties and farmers' days on the issue. The main concerns are whether soil in ridges dries out faster than the flat and whether the advantage of better aeration on ridges is also applicable when sweetpotatoes are grown under dryland conditions in sandy soils.

In the absence of sophisticated soil moisture determination apparatus, the trials were designed in a rather simplistic fashion, i.e. the performance of the crop was evaluated under the different conditions under review. The variables of concern are soil type, soil arrangement and variety. Although most soils in northern Namibia are classified as sand, there are differences in terms of clay and silt content. Soil with relatively high clay content was chosen as 'loamy sand' and almost pure sand was chosen as 'sand'. Soil arrangement refers to soils ridged or left flat before planting. As there are a number of sweetpotato varieties with different characteristics that are currently recommended, they were evaluated as another variable in the experiment.

METHODS

Trials to investigate the effect of ridging on sweetpotato production under dryland conditions were conducted at Mahenene and Mashare Research Stations. The trials were planted on 17 December 1999 at Mashare Research Station and on 6 January 2000 at Mahenene Research Station. The trial layout followed a three-factorial design with three replications. The main blocks were soil type (sandy and loamy sand), the sub-blocks were soil arrangement (ridged and flat) and the sub-sub-blocks were variety (the five most popular varieties). Each sub-sub-block consisted of an 18m long row (60 plants). Tip cuttings were spaced at 0.30m between plants and 1.2m between rows. Guard rows were planted at the ends of both main blocks. Soil samples were taken and analysed for each main block. Rainfall during the 1999/2000 season at the two research stations is shown in Table 1.

Table 1. Rainfall during the 1999/2000 season at Mahenene and Mashare Research Stations

Month	Mahenene	Mashare
October 1999	1.9	26.3
November 1999	122.7	17.1
December 1999 (before planting)	200.8	63.7
December 1999 (after planting)		83.7
January 2000 (before planting)	20.8	274.7
January 2000 (after planting)	25.7	
February 2000	37.7	79.9
March 2000	128.0	225.0
April 2000	28.4	0.0
May 2000	30.6	0.0
Total	**596.6**	**770.4**

Before planting, 2:3:2 (22) fertilizer was broadcasted at 300 kg/ha at both sites. A potassium nitrate sidedressing was applied once at 200 kg/ha, six weeks after planting. The trial at Mashare Research Station was harvested at approximately four months after planting on 19 April 2000. Due to the dry period in January and February, followed by heavy rains in March, the trial at Mahenene Research Station was harvested approximately 5.5 months after planting on 27 June 2000.

Data on establishment and yield performance (roots per plant, marketable tuber yield and percentage unmarketable tubers) was analyzed using Microsoft Excel and Statistica MANOVA.

RESULTS

Soil analysis:

The description of soil samples, taken from the main blocks of the different soil types, is shown in Table 2. Although both samples are described as sand, the clay percentage of the 'loamy sand' blocks are higher than those of the 'sand' blocks from both sites.

Table 2. Soil analysis of the main blocks (Agricultural Laboratory)

Block	Texture	%	%	%
Mahenene sand	Sand	3.6	3.8	92.6
Mahenene loamy	Sand	7.0	6.0	87.0
Mashare sand	Sand	0.7	2.7	96.6
Mashare loamy sand	Sand	6.1	2.3	91.6

Establishment of sweetpotato cuttings:

Table 3 shows the ANOVA parameters for all the variables and interactions between them for establishment of sweetpotato cuttings. P is highlighted where differences between the treatments or their interactions are statistically different.

Table 3. Summary of all effects for percentage establishment at Mahenene and Mashare Research Stations (statistically significant effects at $\alpha = 0.05$ are highlighted)

Mahenene			Mashare		
Effect	**F**	**P**	**Effect**	**F**	**P**
Variety	12.221	**0.001**	Variety	122.592	**0.000**
Arrangement	2.301	0.137	Arrangement	19.279	**0.001**
Soil type	0.009	0.925	Soil type	5.052	**0.030**
Variety x arrangement	0.262	0.901	Variety x arrangement	2.038	0.107
Variety x soil type	0.487	0.746	Variety x soil type	7.900	**0.001**
Arrangement x soil type	4.755	**0.035**	Arrangement x soil type	0.699	0.408
Variety x arrangement			Variety x arrangement		

Table 4. Percentage establishment of different sweetpotato varieties, soil arrangements and soil types evaluated at Mahenene and Mashare Research Stations (different letters indicate significant differences between the values)

	Mahenene	Mashare
Variety		
Ribbok	98.889[a]	
Japon TS	98.056[a]	95.417[a]
Xushu 18	97.361[a]	94.028[a]
Brondal		91.806[a]
Mafutha	96.389[a]	71.806[b]
LM 88.014	87.639[b]	36.111[c]
Arrangement		
Ridged	96.556[a]	82.500[a]
Flat	94.778[a]	73.167[b]
Soil type		
Sandy	95.722[a]	75.444[a]
Loamy-sand	95.611[a]	80.222[b]

Roots harvested per plant:

Table 5 shows that there are significant differences between the number of roots harvested from different varieties, different soil arrangements and different soil types. There are however no significant effects of interactions of the variables on the number of roots per plant.

DISCUSSION

Establishment of sweetpotato cuttings:

Table 3 shows that there are significant differences between the % establishment of different varieties. At both trial sites the variety LM 88.014 shows significantly lower establishment than the other varieties. Low establishment of this variety has also been observed previously in variety evaluation trials.

It is further shown that at Mashare the establishment of all varieties was significantly better on ridges than on the flat and also significantly better in loamy sand than in sand. However, the differences between establishment in different soil arrangements and soil types were not significant at Mahenene.

Table 5. Summary of all effects for number of roots per plant at Mahenene and Mashare Research Stations (statistically significant effects at a = 0.05 are highlighted)

Mahenene			Mashare		
Effect	**F**	**P**	**Effect**	**F**	**P**
Variety	8.406	**0.001**	Variety	11.150	**0.001**
Arrangement	11.988	**0.001**	Arrangement	27.655	**0.001**
Soil type	13.246	**0.001**	Soil type	117.955	**0.000**
Variety x arrangement	1.274	0.298	Variety x arrangement	1.789	0.151
Variety x soil type	1.987	0.117	Variety x soil type	1.903	0.129
Arrangement x soil type	1.295	0.262	Arrangement x soil type	2.266	0.140
Variety x arrangement			Variety x arrangement		

Table 6. Differences in roots per plant between different sweetpotato varieties, soil arrangements and soil types evaluated at Mahenene and Mashare Research Stations (different letters indicate significant differences between the values)

	Mahenene	Mashare
Variety		
Xushu 18	1.612[bc]	3.571[a]
Japon TS	1.169[c]	3.134[ab]
LM 88.014	2.373[ab]	2.541[bc]
Brondal		2.095[c]
Mafutha	2.201[abc]	2.061[c]
Ribbok	3.239[a]	
Arrangement		
Ridged	2.541[a]	3.151[a]
Flat	1.697[b]	2.210[b]
Soil type		
Sandy	1.676[b]	1.708[b]
Loamy-sand	2.563[a]	3.652[a]

Figure 1 shows the significant effect of the interaction between variety and soil type on establishment at Mashare. Whereas the soil type had no effect on the establishment of the varieties Xushu 18, Japon TS, Brondal and Mafutha, the establishment of LM 88.014 was significantly better in loamy sand than in sand.

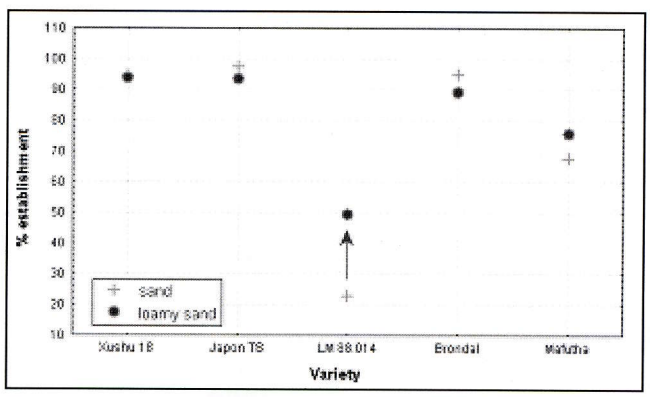

Fig. 1. Significant effect on the percentage establishment of the interaction between soil type and sweetpotato variety. The variety LM 88.014 showed significantly better establishment in loamy sand than in sand at Mashare Research Station.

Marketable tuber yield:

Table 7 shows that all three variables individually, as well as interactions between the variables, have significant effects on marketable tuber yield.

Roots harvested per plant:

The number of roots harvested per plant was influenced by variety, soil arrangement and soil type at both sites. There were no significant effects of interactions between the three variables on the number of roots per plant.

Table 7. Summary of all effects for marketable yield at Mahenene and Mashare Research Stations (statistically significant effects at a = 0.05 are highlighted)

Mahenene			Mashare		
Effect	**F**	**P**	**Effect**	**F**	**P**
Variety	4.167	**0.007**	Variety	10.219	**0.001**
Arrangement	2.391	0.131	Arrangement	24.219	**0.001**
Soil type	58.866	**0.000**	Soil type	332.756	**0.000**
Variety x arrangement	0.471	0.757	Variety x arrangement	0.3065	0.872
Variety x soil type	2.221	0.086	Variety x soil type	6.591	**0.001**
Arrangement x soil type	5.537	**0.024**	Arrangement x soil type	8.055	**0.007**
Variety x arrangement			Variety x arrangement		

The ranking of varieties differs slightly between the sites, which may occur when the performance of the different varieties is at the highest possible level.

At both sites the number of roots per plant was higher in ridges than on the flat. The number of roots per plant was also higher in loamy-sand than in sand at both sites.

Marketable tuber yield:

Not only variety, soil arrangement and soil type individually had significant effects on the marketable tuber yield, but also the interactions between these variables (Table 7).

Table 8 shows the marketable yields at Mashare were generally higher than at Mahenene. This may be attributed to the less favourable rainfall conditions through the season at Mahenene.

Table 8. Differences in marketable yield (ton/ha) between different sweetpotato varieties, soil arrangements and soil types evaluated at Mahenene and Mashare Research Stations (different letters indicate significant differences between the values)

	Mahenene	**Mashare**
Variety		
Brondal		10.702[a]
Japon TS	3.458[ab]	9.549[a]
Xushu 18	2.391[b]	8.077[ab]
Mafutha	3.320[ab]	6.071[bc]
LM 88.014	4.830[a]	4.711[c]
Ribbok	4.743[a]	
Arrangement		
Ridged	4.094[a]	9.493[a]
Flat	3.403[a]	6.151[b]
Soil type		
Sandy	2.035[b]	1.628[b]
Loamy-sand	5.462[a]	14.016[a]

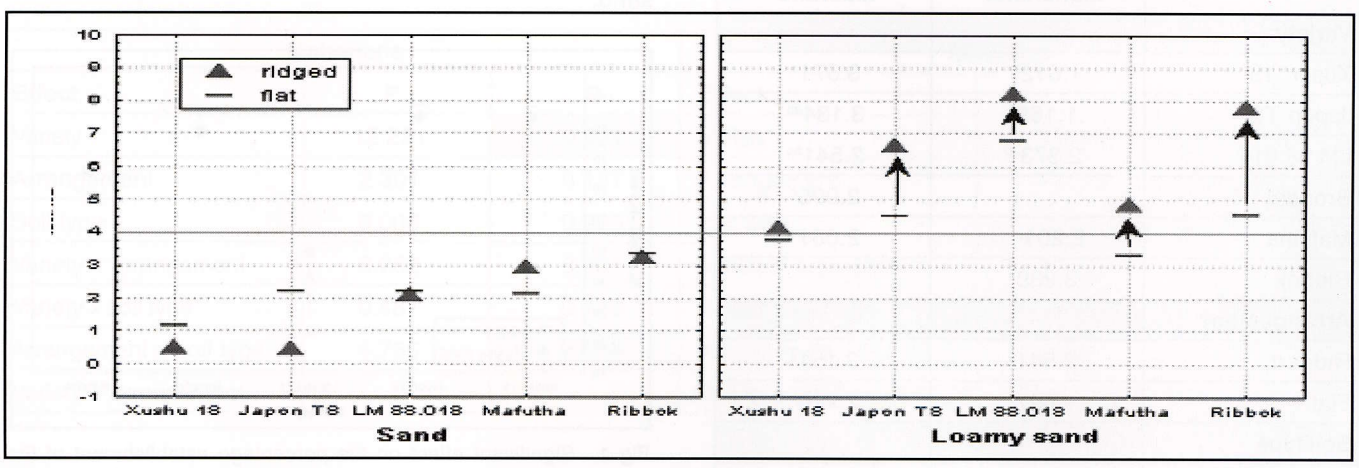

Fig. 2. Effects of the three-way interaction between variety, soil arrangement and soil type on marketable sweetpotato tuber yield at Mahenene Research Station.

The ranking of varieties differs slightly between the two sites. The ranking may not be a good reflection of the varieties' performance due to the interaction effects with the other variables. At Mashare all plots on ridges performed better than on the flat, while there was no significant difference between ridged and flat soil arrangement at Mahenene. At both sites the marketable tuber yield was higher on the loamy sand than on the sand.

Figures 2 and 3 show the effects of the interaction between sweetpotato variety, soil arrangement and soil type. At both sites it is evident that most varieties performed significantly better when planted on a ridge in loamy sand. In sand there was no significant difference in marketable tuber yield between ridged and flat planting for most varieties.

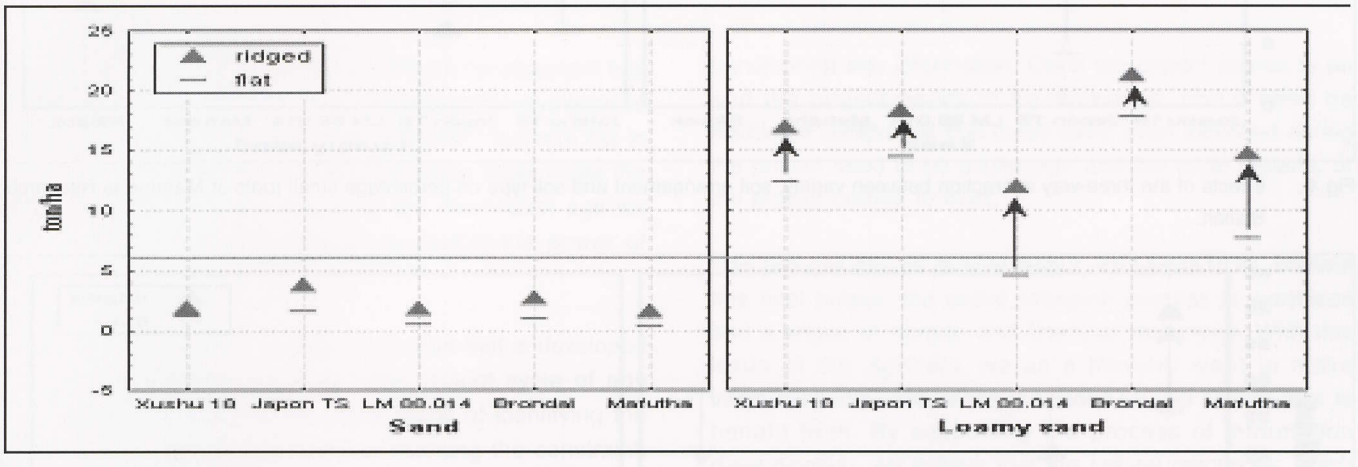

Fig. 3. Effects of the three-way interaction between variety, soil arrangement and soil type on marketable sweetpotato tuber yield at Mashare Research Station.

Fig. 4. Difference in growth of sweetpotato cuttings at one month after planting in sand (left) and loamy-sand (right) at Mahenene Research Station.

Fig. 5. Tuber yield of the variety Xushu 18 at Mashare Research Station on sand (left) and on loamy sand ridged (center) and loamy sand flat (right). Note the correspondence to figure 3, where yields on sand are lower than on loamy sand and yields on ridges in loamy sand are higher than on flat loamy sand.

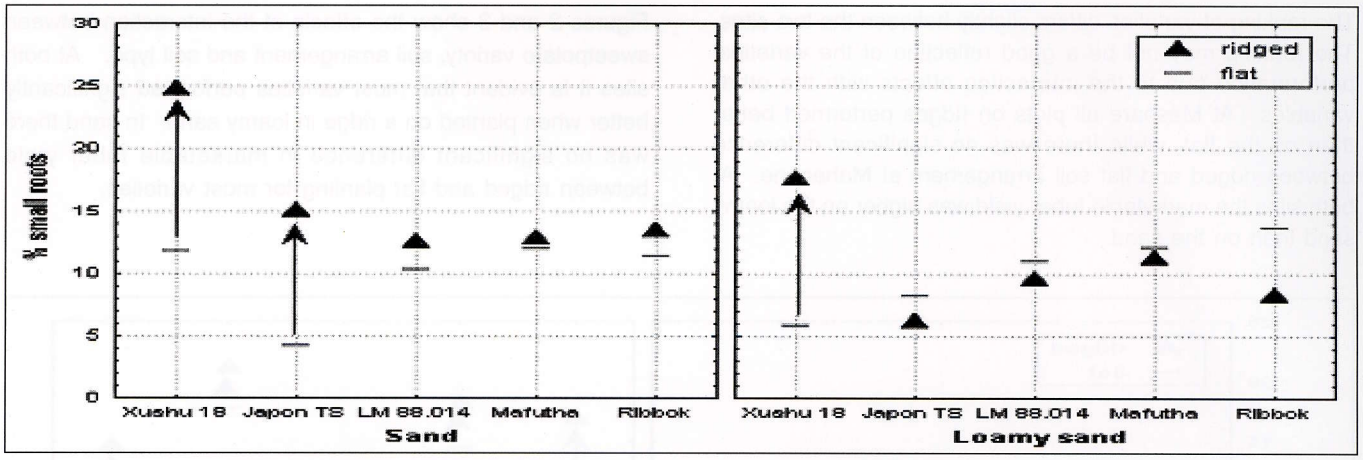

Fig. 6. Effects of the three-way interaction between variety, soil arrangement and soil type on percentage small roots at Mahenene Research Station.

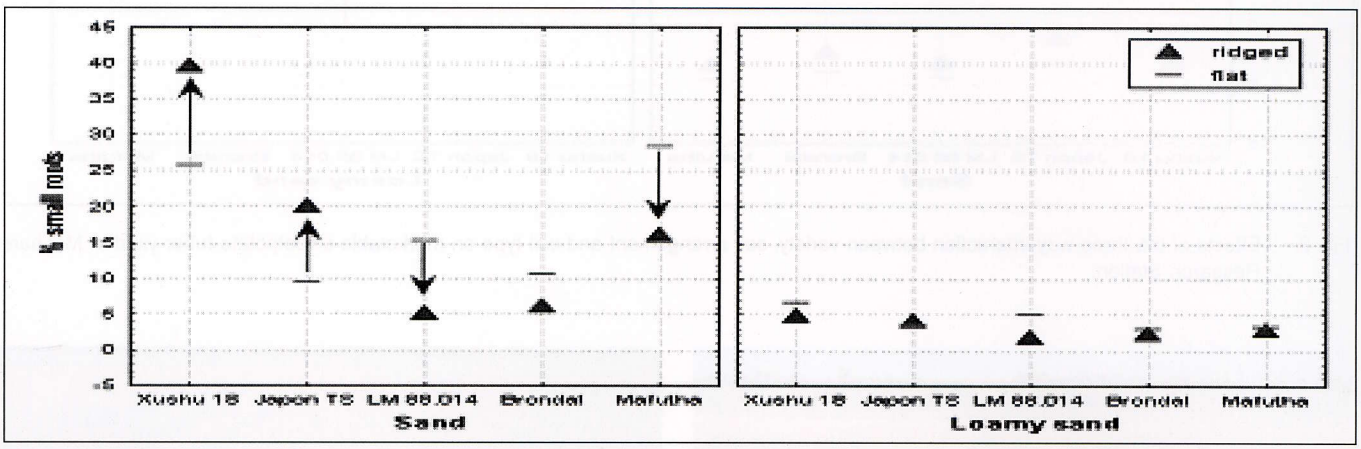

Fig. 7. Effects of the three-way interaction between variety, soil arrangement and soil type on percentage small roots at Mashare Research Station.

Percentage small (unmarketable) tubers:

In Table 9 it is shown that all three variables and their interactions had an effect on the percentage small tubers.

The variety Xushu 18 had the highest percentage small tubers, an observation that has already been made in variety evaluation trails.

At Mahenene a significantly higher percentage of small tubers was found in ridges than on the flat. This may be due to higher numbers of roots formed in the ridges than on the flat, which could not all mature, due to the irregular rainfall.

At both sites the percentage small roots was higher in sand than in loamy sand. This may be due to the lower water holding capacity of the sand, which impairs maturation of the induced tubers.

In Figures 6 and 7 it is shown that the percentage small tubers of most varieties does not differ significantly between the ridged and flat arrangement in loamy sand. In the sand however, the varieties Xushu 18 and Japon TS had a higher percentage small tubers on the ridge than on the flat. Both varieties induced more tubers on the ridge, which could not mature due to the low water holding capacity of the sand. At Mashare the percentage small tubers was lower on the ridge than on the flat for the varieties LM 88.014 and Mafutha. This indicates that the tubers of both varieties matured faster in the ridge than on the flat.

Percentage small (unmarketable) tubers:

Table 9. Summary of all effects for percentage small sweetpotato tubers at Mahenene and Mashare Research Stations (statistically significant effects at a = 0.05 are highlighted)

Mahenene			Mashare		
Effect	**F**	**P**	**Effect**	**F**	**P**
Variety	2.794	**0.040**	Variety	12.909	**0.000**
Arrangement	6.809	**0.013**	Arrangement	0.314	0.578
Soil type	4.236	**0.047**	Soil type	103.252	**0.000**
Variety x arrangement	4.068	**0.008**	Variety x arrangement	4.124	**0.007**
Variety x soil type	0.695	0.600	Variety x soil type	8.618	**0.001**
Arrangement x soil type	4.931	**0.033**	Arrangement x soil type	0.051	0.822
Variety x arrangement			Variety x arrangement		

Table 10. Differences in percentage small tubers between different sweetpotato varieties, soil arrangements and soil types evaluated at Mahenene and Mashare Research Stations (different letters indicate significant differences between the values)

	Mahenene	Mashare
Variety		
Brondal	5.538[a]	
LM 88.014	10.869[ab]	6.782[ab]
Japon TS	8.404[a]	9.277[ab]
Mafutha	12.027[ab]	12.661[b]
Xushu 18	15.005[b]	19.231[c]
Ribbok	11.711[ab]	
Arrangement		
Ridged	13.183[b]	10.313[a]
Flat	10.023[a]	11.083[a]
Soil type		
Sandy	12.849[b]	17.679[b]
Loamy-sand	10.357[a]	3.717[a]

RECOMMENDATION

The above indicates that sweetpotatoes perform better in loamy sand than in sand. Also, all varieties should be planted on ridges rather than on the flat in loamy sand, to obtain a higher tuber yield and a more pleasant tuber shape.

If varieties with high potential, i.e. those that can induce a large number of tubers, such as Xushu 18 and Japon TS, are however planted on sand, they should be planted on the flat rather than on a ridge, to ensure that fewer tubers are induced of which most can mature to marketable size.

Varieties with lower potential that induce fewer tubers, such as Mafutha, Brondal and Ribbok, should generally be planted on ridges in sand and loamy sand. Although the marketable tuber yield does not differ significantly between ridged and flat soil arrangement in sand, the number of tubers that reach maturity can be increased when planted on a ridge in sand.

ACKNOWLEDGEMENTS

The analysis of the soil samples was kindly performed by the Agricultural Laboratory. Assistance and support was given by Mrs. Renette Krommenhoek on trial design, layout and statistical analysis.

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