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Growth and Multiplication Ability of *Musa* Species Using the Whole-Corm Technique

Victor Edward Mshani[1*] • Moses Kwapata[2] • James Bokosi[2] • Weston Mwase[2] • Joyce Njoloma[2] • Moses Maliro[2]

[1] Bvumbwe Agricultural Research Station, P.O. Box 5748, Limbe, Malawi
[2] University of Malawi, Bunda College, P.O. Box 219, Lilongwe, Malawi

Corresponding author: * vmshani@yahoo.co.uk

ABSTRACT

A split-split-plot design experiment was carried out during the winter to specifically determine the most suitable developmental stage for corm extraction to optimize the multiplication rate, identify the most suitable substrate and also establish the multiplication rates of the banana genomes using the whole-corm technique. The genetic constitution of the banana cultivar has an effect on the performance of different genotypes as triploid cultivars "Kabuthu" (AAA) and "Ngwewo" (AAB) showed superiority in all the parameters. Overall, triploids were superior seconded by tetraploids and then lastly diploids. There was also an inverse relationship between the number of roots and the number of days to regeneration. Corms obtained from fruiting banana plants produced plantlets much faster and were superior in most aspects as compared to corms from suckers and followers. The type of substrate had no significant effect on the performance of the different banana genomes.

Keywords: corm, cultivar, genotypes, ploidy level, substrate

INTRODUCTION

Importance and production of bananas

Bananas (family Musaceae), one of the largest herbs in the world, is the fourth most important global food crop, coming after rice, wheat, and maize (Frison and Sharrock 1998; Schinzl 2003). *Musa* species has been a staple of the human diet since the dawn of recorded history as nearly 400 million people in the tropics depend on them as a food source. This is because of the ease and stability of production and the highly nutritious nature of the fruit.

Bananas and plantains are cultivated in over 100 countries throughout the tropical and sub-tropical regions of the world covering a total area of approximately 10 million ha. The vast majority of producers are small-scale farmers growing the crop either for home consumption or for local markets (Frison and Sharrock 1998). World banana and plantain production is estimated at about 103 million tons per year of which around 30 million tons are produced in Africa. Malawi produces an estimated 93,000 tons of bananas with plantains being put at 200,000 tons (FAOSTAT 2005).

Shortage of planting material

A common limiting factor to large-scale production of bananas and plantains and or expansion of existing plantations is the difficulty in obtaining planting material (Baiyeri and Aba 2005), due to poor suckering ability of 8 to 12 suckers in 12 to 15 months (Adelaja 1995) and hence inadequate to meet the needs of medium to large-scale production at the recommended population of 1,600-2,500 plants/ha.

It is also a major cause for the spread of pests and disease from infested to clean areas. This has led to the wide spread of three common banana diseases in Malawi namely; Banana Bunchy Top Virus, Fusarium Wilt and Black Sigatoka and also the prevalence of pests such as root knot nematode, burrowing nematodes and also banana weevils. In addition to this, it has been reported that the planting materials obtained are largely unselected hence their yields are unpredictable and also the banana plants give smaller bunches (Adelaja 1995).

Other propagation technologies such as Whole-corm and Split-corm have been tested at research stations in Malawi using sawdust as the substrate and the giant Cavendish 'Williams' (AAA) as the only test cultivar. These have provided better solutions to the existing banana production constraints despite the knowledge gaps which have been identified with time. This has proven detrimental to the expansion of the banana fields in Malawi as new banana orchards are established with planting materials obtained from orchards belonging to friends and relatives which is mostly diseased and unselected and hence drastically limiting the expansion of banana plantations.

This study was therefore aimed at optimizing the whole-corm technique by identifying alternative substrate materials to sawdust; determine the optimal developmental stage of *Musa Spp.* for corm extraction to maximize the multiplication rate; identify the most appropriate banana genotypes for this technique and also establish the variation in multiplication rates among nine banana genotypes using the whole corm technique.

MATERIALS AND METHODS

Whole corm technique is a method of propagating species of the genus *Musa*. It involves cutting the pseudostem from the corm at any stage of development and then removing the roots and leaf sheaths to expose the buds. These corms can be planted in any type of substrate to germinate. The resulting offshoots produced are detached from the corm using a sharp knife and they can either be planted in polythene tubes or directly out-planted in the field depending on their size.

The banana corm has "eyes", which have the ability to shoot and grow into a banana plant. Corms at three different stages of growth were used thus; corms from 14 months old bananas (fruiting), 8 months old (followers) and 2 months old (suckers). These

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Table 1 Effect of genotypes on the performance of *Musa spp.* using the whole-corm technique for 243 corms.

Cultivar	Growth parameters				
	Days to regeneration	No. of leaves	No. of shoots	No. of roots	Height (cm)
Kapeni	62.0 cde	3.67 bc	3.00 abcd	28.44 cd	9.11 ab
Kambani	72.5 e	2.93 a	2.41 ab	20.52 bc	7.19 a
Kabuthu	39.5 a	5.41 e	3.81 d	36.07 d	11.52 bc
Ngwewo	43.7 ab	4.48 d	5.63 e	34.67 d	15.48 d
Saba	53.2 bc	3.67 bc	3.41 cd	19.22 b	10.67 b
FHIA 02	66.3 de	3.33 ab	2.30 a	9.89 a	7.15 a
SH 3640	51.6 bc	4.22 cd	3.26 cd	22.00 bc	11.52 bc
TMBx5295/1	49.0 ab	3.78 bc	3.22 bcd	20.89 bc	13.96 cd
TMBx 1378	60.8 cd	3.26 ab	2.70 abc	14.00 ab	10.67 b
Mean	55.4	3.86	3.30	22.86	10.81
Lsd (0.05)	10.79	0.69	0.84	8.05	3.19
S.E	11.43	0.74	0.86	7.94	3.49
CV%	20.7	19.2	25.9	34.7	31.3

Means followed by different superscripts in the same column are significantly different at $P < 0.05$ using the LSD test

corms were obtained from 9 banana genotypes from the three ploidy levels hence diploids - 'Kapeni' (AA) and 'Kambani' (AB); triploids - 'Kabuthu' (AAA), 'Ngwewo' (AAB) and 'Saba' (ABB); tetraploids - 'FHIA 02' (AAAA), 'SH 3640' (AAAB), 'TMBx 5295/1' (AABB) and 'TMBx 1378' (ABBB).

Procedure

The corms were uprooted from the soil and physically inspected for damage by nematodes and weevils by checking for defects such as dark spots and tunnels. Corms were paired to minimize the chances of spreading soil pests. The corms were let to rest for 48 hours before planting to cure the injuries. To remove the apical dominance, a sharp knife was used to kill the growing points. Three quarters of the outer leaf sheath cover were carefully removed to expose the lateral dormant buds. After that, corms were planted in 15 cm deep wooden boxes, at a depth of 2 cm from the top surface with the appropriate substrate to germinate in the open. A uniform watering regime was monitored on substrates once in every 2 days.

Experimental design

A split-split-plot design experiment was layed down with three factors at different levels thus; 9 banana genotypes × 3 substrates × 3 corm types. The substrate was the main plot factor with the genotype and age as the sub plot and sub-sub plot factors respectively. This experiment was replicated three times hence giving a total of 243 plots.

Data collected

Data was collected both before and after planting the corms. Before planting the weight (kg) and circumference (cm) of the corm were measured. After planting, the following data was collected; the number of days to sucker emergency, the number of shoots per corm assessed after every two weeks up to a period of 3 months and the number of roots per corm after 3 months.

Data analysis

The analysis of variance (ANOVA) was done using the statistical package GenStat. Means were separated by the Least Significant Difference Test (LSD). Relationships between aerial and root characteristics were evaluated using correlation analysis on all parameters both on the corms before planting and on shoots after regeneration.

RESULTS AND DISCUSSION

Genotypes

The results in **Table 1** show that there were significant differences ($P < 0.05$) between the 9 banana genotypes in all the measured parameters indicating that the genomic composition and the ploidy level of the *Musa spp*. has an influence on the size of different parts (Blomme *et al.* 2000). 'Kabuthu', a triploid AAA dwarf Cavendish cultivar produced shoots much earlier (about 6 weeks) followed by 'Ngwewo' (AAB) and 'TMBx 5295/1' (AABB). 'Kabuthu' and 'Ngwewo' (AAB) also had the highest number of roots (36.07 and 34.67, respectively) and leaves (5.41 and 4.48, respectively) after 12 weeks. Triploid cultivars 'Ngwewo' (5.63), 'Kabuthu' (3.81) and 'Saba' (3.41) gave the highest number of suckers after 3 months with 'FHIA 02' (AAAA) and 'Kambani' (AB) showing the lowest multiplication rates though they belong to different ploidy groups.

The lower multiplication rates obtained can be attributed to the apical dominance as shoots were let to grow after regeneration. The low temperature levels during the study period might have had a negative effect as well on both the development and growth of *Musa.* Blomme *et al.* (2006) working with a Cavendish variety 'Williams' discovered that the root growth was slower at lower temperatures as the root extension was nearly 3cm per day at 25°C, below 0.5 cm per day at 15°C and ceased at 11.5°C. This entails that the slow root development had an effect on the growth of all other aerial appendages.

This work was done during winter period, which falls between the months of May to August in Malawi, which was characterized by very low temperatures averaging 17°C while the optimum temperature for *Musa* growth and reproduction is 25°C, a temperature only reached in the summer months of September to December This was manifested by the presence of dark or black spots on their leaves, which is an indication of chilling or cold injury (**Fig. 1**).

Fig. 1 Symptoms of chilling or cold injury.

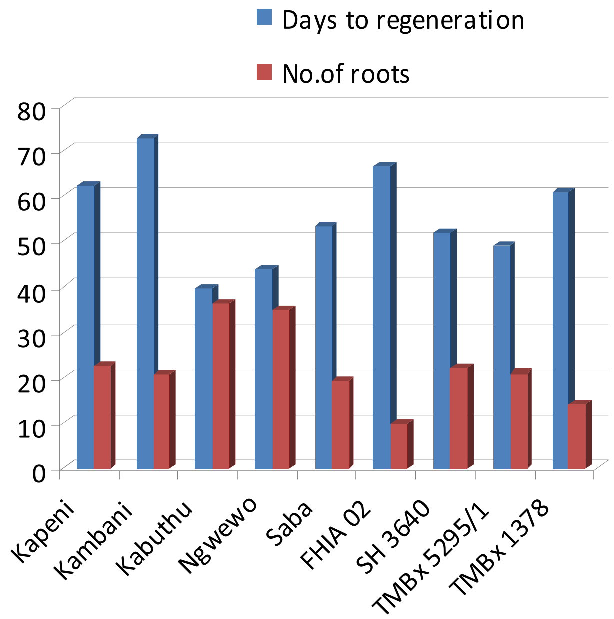

Fig. 2 Number of days to regeneration and number of roots.

The two diploid cultivars, 'Kambani' (AB) and 'Kapeni' (AA) took the longest period (72.5 and 62 days respectively) to produce shoots. The former had the least number of leaves (2.93) followed by 'TMBx 1378' (ABBB) with 3.26 and 'FHIA 02' (AAAA) with 3.33. 'FHIA 02' also performed poorly both in terms of the number of roots developed (9.89) and the number of days (66.3) taken to produce shoots.

Fig. 2 shows that there is an inverse relationship between the number of roots produced and the number of days to regeneration as evidenced by the high number of roots for the cultivars 'Kabuthu' and 'Ngwewo' with relatively fewer corresponding number of days to regeneration.

Corm age

Corms obtained from fruiting banana plants produced plantlets much faster (48.1 days) than those from follower and sucker plants (**Table 2**). They also showed superiority in other parameters such as the number of leaves, number of shoots and number of roots produced per corm after 3 months. The banana (*Musa* spp.) root system is important for plant anchorage and the uptake of nutrients and water and thus strongly influences growth (Sebuwufu *et al.* 2004). This study showed that corms from fruiting plants produced more roots which led to the production of more suckers.

This agrees with Blomme *et al.* (2006) who studied the *in vivo* growth of shoots and root system for a Cavendish cultivar 'Williams' (AAA) and concluded that more suckers per mat were observed from larger corms, which could also explain the higher number of roots.

The high number of roots showed its positive influence on other growth parameters such as the sucker height. In all parameters, corms obtained from follower suckers performed second best while corms from suckers were the least performers. This entails that the age of the corm had a significant influence on the performance of these corms because flowered plants develop lateral buds more rapidly (Bakelana-ba-Kufimfuta 2000). This can be explained by the fact that old corms have ripe buds and enough nutritional reserves that enhance their development as opposed to the other two types which had a smaller surface area to accommodate a bigger number of buds which were undeveloped. This is the case because corms obtained from fruiting *Musa* plants had the biggest circumference area (43.27 cm^2) and also had the largest average weight of 2.72 kg.

Rajan and Markose (1998), doing similar work, found that planting corms weighing 8 kg of cv. 'Giant Cavendish' performed much better in most growth parameters than 3 kg, 3.5 kg and 5 kg corms. They concluded that big and old banana corms had sufficient food reserves to help them develop appendages much faster and also of bigger size.

Substrate type

Results from **Table 3** indicate that the type of substrate had no effect on the performance of the different banana genotypes as regards any of the characters measured. Though differences were observed in various parameters, they were not significantly different at ($P < 0.05$). This entails that depending on availability, any of the three substrate types such as sand, sawdust and loam soil can be used without foregoing any opportunity cost in using an alternative one (**Fig. 3**).

Baiyeri and Aba (2005) had similar findings when they worked with various Cavendish (AAA) and plantain (AAB) genotypes. They concluded that ricehull and sawdust had similar effects on most sucker plantlets initiation parameters measured on the five genotypes used 'Pita 22' (4x), 'Pita 25' (4x), 'FHIA 17' (4x), 'Agbagba' (3x) and 'Nsuka local' (3x) as there was no significant effect from the initiation media on the growth parameters. They discovered that root formation by the corm and number of plantlets excised over time were similar in both media types, although corms planted in ricehull showed higher values in most cases.

Table 2 The overall effect of corm age on the performance of *Musa* spp. using the whole-corm technique for 243 corms.

Corm age	Growth parameters						
	Circum (cm)	**Corm wt (kg)**	**Days to regeneration**	**No. of leaves**	**No. of shoots**	**No. of roots**	**Height (cm)**
Sucker	18.46 a	0.62 a	63.8 b	3.28 a	2.85 a	14.20 a	6.84 a
Follower	31.67 b	1.42 b	54.4 ab	3.95 b	3.28 ab	22.43 b	11.74 b
Fruiting	43.27 c	2.72 c	48.1 a	4.35 b	3.78 b	31.94 c	13.84 b
Lsd (0.05)	2.14	0.25	6.64	0.44	0.50	3.63	2.30
CV%	22.2	51.3	20.6	19.2	25.9	34.7	32.3
S.E	6.90	0.81	11.43	0.74	0.86	7.94	2.30

Means followed by different superscripts in the same column are significantly different at $P < 0.05$ using the LSD test

Table 3 The overall effect of the type of substrate on the performance of *Musa* spp. using the whole-corm technique for 243 corms.

Substrate	Growth parameters						
	Days to regeneration	**Number of leaves**	**Number of shoots**	**Number of roots**	**Girth (mm)**	**Height (cm)**	**Leaf area (cm^2)**
Sand	57.1	3.78	3.41	22.49	7.25	10.54	238
Sawdust	55.3	3.90	3.10	22.22	7.41	10.31	240
Loam soil	53.9	3.90	3.41	23.85	7.44	11.57	285
Lsd (0.05)	6.30	0.41	0.47	4.39	0.97	1.91	61.4
CV%	20.8	19.4	25.8	35.2	24.0	32.3	44.3
S.E	11.53	0.75	0.85	8.04	1.77	3.50	112.5

Fig. 3 Banana suckers from different substrates.

Table 4 Correlations between characters.

	Circum (cm)	Corm weight	Days to regeneration	Stem girth	Sucker height	No. of leaves	No. of roots	No. of shoots	Leaf area
Circum									
Weight	0.79*								
Days	-0.18	-0.20							
Girth	0.29	0.32	-0.85						
Height	0.26	0.32	-0.79	0.89*					
Leaves	0.16	0.18	-0.82	0.83*	0.74*				
Roots	0.39	0.41	-0.55	0.53*	0.50*	0.55*			
Shoots	0.22	0.25	-0.46	0.44	0.41	0.45	0.56*		
LA	0.25	0.26	-0.77	0.86*	0.91*	0.72*	0.46	0.35	

*Correlations significant at the 0.01 level (2-tailed)

Correlations

Correlation was carried out between parameters measured on the corm before planting and the resulting appendages after planting.

Table 4 shows that there are positive relationships between various parameters which were evaluated using correlation analysis, which revealed that there is a positive correlation between factors measured on the corm before planting. This is true for the circumference of the corm and its actual weight, which gave a correlation factor of 0.79, which means that an increase in corm circumference leads to an increase in corm weight.

After 12 weeks of growing the corms, stem girth was found to be highly correlated to the height of the sucker, number of leaves and number of roots. A normal plant tries to balance itself such that as it grows in height it has to build the required stem girth to support itself and at the same time, develop enough roots for both mechanical support and nutrient uptake.

An increase in height creates a larger surface area for more leaves to develop and be supported. This was portrayed in a high positive correlation (0.86) between stem girth and leaf area. The latter was highly correlated (0.91) to stem height. This agrees with Blomme *et al.* (2001) who worked with 27 banana genotypes in Nigeria and found that an increase in leaf area stimulated the development of roots. They pointed out that the pseudostem is made up of leaf sheathes and hence reflects the number of leaves and plant vigour.

Plant pseudostem circumference will thus reflect shoot growth and is an important determinant of root vigour. The size of the tallest sucker contributed positively to the extent of the mat root system.

There is also some correlation (0.56) between shoot and root numbers. In addition to that, the number of roots was also correlated to the number of leaves. This is the case because shoots above ground initially depend on the support from roots underground for the supply of water, nutrients and even anchorage. When they grow, they develop leaves which have the ability to manufacture food but even roots play a vital role for their development and survival.

There was a strong negative correlation between the number of days to regeneration with such characters as sucker stem girth (-0.85), sucker height (-0.79), number of leaves (-0.82), number of roots (-0.55) and the leaf area (-0.77). This entails that an increase in the duration the corms took to produce shoots led to lower values in the corresponding measurements. The opposite is also true such that the quicker the corms (decrease in regeneration duration) produced suckers there was an increase in the corresponding characters because they had more time for development and growth.

CONCLUSIONS

The genetic constitution of a banana cultivar has an effect on the performance of different genomes during vegetative propagation. Triploid cultivars 'Kabuthu' (AAA) and 'Ngwewo' (AAB) showed superiority in most of the parameters such as the number of roots and leaves and plantlet height. In addition, the two cultivars were the first to produce shoots.

'TMBx 1378' (ABBB) and 'Kambani' (AB) gave the lowest multiplication rates though they belong to different ploidy groups. Triploids 'Kabuthu' and 'Ngwewo' had very big stem girths followed by tetraploids 'SH 3640' (AAAB), 'TMBx 5295/1' and 'TMBx 1378'.

Overall, triploids recorded higher values in most of the parameters measured, seconded by tetraploids and then lastly diploids. Genetically, tetraploids were supposed to perform better than triploids and diploids but findings from this study proved otherwise. This can be accrued to the fact that tetraploid cultivars have just been recently introduced in the country unlike the triploids which have been grown for a very long time and hence have been acclimatized and are considered as local cultivars in most cases.

There was also an inverse relationship between the number of roots and the number of days to regeneration. This is the case because the development of more roots made it possible for the corms to produce shoots much more quickly because roots were available to support such kind of activities.

Corms obtained from fruiting banana plants produced plantlets much faster and were superior in most aspects as compared to corms from followers and suckers. This is the case because corms from fruiting bananas have a bigger circumference and hence more buds which benefit from the high food reserves to support the initial growth development of shoots. In addition to that, the type of substrate had no significant effect on the performance of the different banana genotypes as shoots wee dependent on nutrients from the corm and not the substrate. Shoots emanating from the corm are fully attached to it during its developmental stages which may take up to six months in most *Musa* spp.

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