Field Performance of Cassava *(Manihot esculenta Crantz)* Established from Tissue Culture-derived Plantlets and Conventional Stem Cuttings

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Abstract

This study was conducted to compare the growth, yield and agronomic root tuber characteristics of two cassava (Manihot esculenta Crantz*) cultivars ("Thail 1" and "I93/0170") established from tissue culture plantlets (TCPs) and conventional stem cuttings (CSCs). Results indicated that cassava established from the TCPs significantly ($p \leq 0.05$) grew faster and produced more basal branches than that established from the CSCs. Cultivar Thail 1 established from the TCPs and CSCs produced 8 and 3 basal branches of 100 and 78cm long while cv. 193/0170 established from the TCPs and CSCs produced 4 and one basal branch(es) of 54 and 33cm long, respectively. Moreover, cassava established from the TCPs significantly ($p \leq 0.05$) produced higher yield of longer marketable root tubers than that established from the CSCs. Cultivar Thail 1 established from the TCPs and CSCs produced 26 and 21t/ha of marketable root tubers of 34.2 and 25cm long while cv. I93/0170 established from the TCPs and CSCs produced 13 and 9t/ha marketable root tuber yield of 38.2 and 30cm long, respectively. Although the use of the TCPs is recommended for increasing the productivity of longer cassava root tubers, cost-benefit studies are required.*

Keywords: Tissue culture-derived plantlets, Field plant growth, Yield, Root tuber characteristics, Cassava

Introduction

Cassava (*Manihot esculenta* Crantz) is a tropical crop grown in the lowlands of Asia, Africa and South America for its thickened and tuberose roots. It produces more calories per unit of land than any other crop in the world, except sugarcane (CIAT, 1980). It is a staple food for around 500 million people (Cock, 1985), and is grown and eaten by small-scale farmers living in areas with poor soils and unfavourable climate (Roca *et al.*, 1992; Lynam, 1993). Although it is mainly eaten for its starch, its leaves provide vitamins and proteins. Cassava can also be processed into a variety of products for food and industrial uses (Henry *et al.*, 1995).

Cassava is conventionally propagated through stem cuttings derived from field-grown plants. However, planting materials especially of elite cultivars are usually insufficient since one plant can hardly produce 30 stem cuttings per year (Konan *et al.*, 1996). *In vitro* propagation has the potential to increase the multiplication rate (Smith *et al.*, 1986; Konan *et al.*, 1996). For example, one nodal plantlet can theoretically produce about one million cassava plantlets with four nodes per year (Konan *et al.*, 1996). Moreover, *in vitro* propagation, in particular meristem culture, leads to production of disease-free planting materials (Khartha and Gamborg, 1975). Despite the advantages of tissue culture technology in ensuring mass production of disease-free plantlets, little information is available on growth and yield performance under field conditions of cassava established from the tissue culture plantlets. The objective of this study was to investigate the effect on plant growth, marketable yield and agronomic characteristics of root tubers of field- grown cassava established from tissue culture plantlets.

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Materials and methods

Tissue culture plantlets (TCPs) of two cassava cultivars "Thail 1" and "I93/0170" were produced from single node cuttings of meristem-regenerated plantlets at the Vegetable and Ornamental Plant Institute Laboratory in the Republic of South Africa. The nodal cuttings were cultured in 4.42 g/l MS medium (Murashige and Skoog, 1962) supplemented with 2μM $CuSO_4$ and 2.0 % sucrose, solidified with 0.085% agar at pH of 5.8 (Taylor and Henshaw, 1993). The plantlets were hardened-off at the age of 1.5 months. The hardening-off involved pricking the plantlets in one-litre containers filled with commercial compost, and raising them for 2.5 months in a greenhouse with temperatures maintained at 26-30°C and relative humidity above 50%. Conventional stem cuttings (CSCs) of 15cm long and four nodes from field-grown cassava plants of the same cultivars as above were used as a control.

The land was sub-soiled, ploughed and then thoroughly harrowed. The hardened-off TCPs and CSCs were planted in the field at a spacing of 100 x 100cm. The set-up of the experiment was 2 x 2 factorial combination superimposed on a Randomised Completely Block Design with four treatment combinations each with 12 plants, and replicated four times. The treatment combinations were (i) TCPs of cv. Thail 1 (ii) TCPs of cv. I93/0170 (iii) CSCs of cv. Thail 1 and (iv) CSCs of cv. I93/0170. The experimental plots were surrounded by guard row cassava cv. MCOL 22. The experiment was conducted once during spring with monthly average temperatures of 15-18°C and summer with monthly average temperatures of ranging from 20 to 32°C. These were the only favourable seasons for tropical crops like cassava, which is affected by low temperatures during winter. The crop was irrigated during dry spell in summer.

Harvesting was performed when the crop was eight months old. Data collected included length, number of branches and internodes at two branching levels (Figure 1), marketable yield (fresh and dry weight, and number of root tubers) and agronomic characteristics (diameter and length) of root tubers. The analysis of variance and mean separation were respectively performed based on the General Linear Models Procedure and Duncan's Multiple Range Test using a SAS (1990) statistical package.

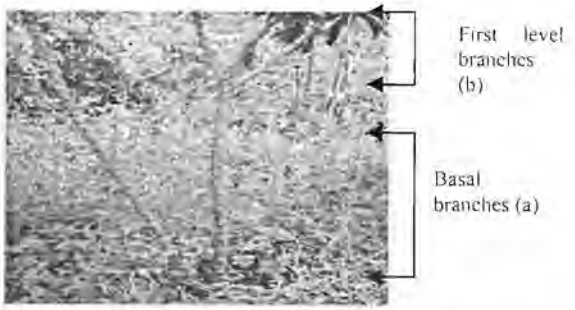

Figure 1: Basal and first level branches of cassava cv. Thail 1 established from the conventional stem cuttings.

Results and discussion

Plant growth

Results indicated that cassava established from the TCPs significantly ($p \leq 0.05$) produced more and longer basal branches with longer internodes than that established from the CSCs (Table 1). Cultivar Thail 1 established from the TCPs and CSCs produced 8 and 3 basal branches of 100 and 78cm long while cv. 193/0170 established from the TCPs and CSCs produced 4 and one basal branch (es) of 54 and 33cm long, respectively. Longer basal branches with longer internodes implies that cassava established from the TCPs had initially faster growth than that established from the CSCs. Similar findings have been reported in many crops established from TCPs including banana (Ramcharan *et al.*, 1987). Tissue culture plantlets grow faster partly because they are initially free from diseases and planted in the field with adequate foliage and root systems whereas CSCs form leaves and roots later after being planted (Vuylsteke and Ortiz, 1996). Moreover, the initial establishment (sprouting and subsequent growth of sprouts) of cassava established from the CSCs depends largely on the food reserves contained in the cuttings. Howeler (2000) observed that single node and thin (small amount of food reserves) cuttings resulted in reduction of cassava growth and root tuber yield.

Table 1: Number and length of branches of cassava cv. Thail 1 and cv. I93/0170 established from the tissue culture plantlets and conventional stem cuttings

Treatment combination	Number of branches		Branch length (cm)		Internode length (cm)	
	Basal branch	Ist level branch	Basal branch	Ist level branch	Basal branch	Ist level branch
TCPs of cv. Thail 1	8^{c}	3^{a}	100^{d}	102^{b}	4.0^{b}	4^{a}
CSCs of cv. Thail 1	3^{b}	3^{a}	78^{c}	99^{b}	2.0^{a}	4^{a}
TCPs of cv. I93/0170	4^{b}	2^{a}	54^{b}	85^{a}	4.0^{b}	4^{a}
CSCs of cv. I93/0170	1^{a}	3^{a}	33^{a}	86^{a}	1.5^{a}	3^{a}

a, b, c, d = numbers in a column bearing the same letters are not significantly ($p \leq 0.05$) different according to the Duncan's Multiple Range Test.

Table 2: Root tuber marketable yield of cassava cv. Thail 1 and cv. I93/0170 established from the tissue culture plantlets and conventional stem cuttings

Treatment combination	Fresh weight yield (t/ha)	Dry weight yield (t/ha)	Number of tubers (000/ha)	Root tuber diameter (cm)	Root tuber length (cm)
TCPs of cv. Thail 1	26^{d}	9.0^{d}	121^{b}	3.6^{b}	34.2^{b}
CSCs of cv. Thail 1	21^{c}	7.5^{c}	120^{b}	3.7^{b}	25.0^{a}
TCPs of cv. I93/0170	13^{b}	4.0^{b}	80^{a}	2.6^{a}	38.2^{b}
CSCs of cv. I93/0170	9^{a}	3.0^{a}	80^{a}	2.4^{a}	30.0^{a}

a, b, c, d = numbers in a column bearing the same letters are not significantly ($p \leq 0.05$) different according to the Duncan's Multiple Range Test.

Marketable yield of cassava root tubers

Cassava established from the TCPs produced significantly ($p \leq 0.05$) higher marketable yield of root tubers than that established from the CSTs (Table 2). Cultivar Thail 1 established from the TCPs and CSTs produced root tuber yield of 26 and 21t/ha while cv. I93/0170 established from the TCPs and CSCs produced root tuber yield of 13 and 9t/ha, respectively. Similarly, marketable dry weight yield of root tubers varied in the same trend as the marketable fresh weight yield. Higher marketable yields have also been reported in a number crops established from TCPs including banana, wheat, oats and maize (Lee *et al*., 1988; Carver and Johnson, 1989; Dahleen *et al*., 1991; Lee, 2003). However, the root tuber yield of cassava established from the TCPs recorded in this study is lower than the maximum reported before from cassava established from the CSCs, which is 36kg/ha depending on cultivars, environmental conditions and crop management (COSCA Tanzania, 1996; Howeler, 2000).

Agronomic characteristics of root tubers

For each cultivar, cassava established from the TCPs significantly ($P \leq 0.05$) produced longer root tubers than that established from the CSCs (Table 2). Cultivar Thail 1 established from the TCPs and CSCs produced root tubers which were 34.2 and 25cm long while cv. I93/0170 established from the TCPs and CSCs produced root tubers with 38.2 and 30.0cm long, respectively. The longer root tubers of cassava established from the TCPs could partly be linked to the increased plant height. Raimbault (1991) reported that plant root length and girth are directly proportional to those of the branches.

Conclusion

Establishing cassava using the TCPs can lead to a faster initial plant growth, resulting in higher yield of longer marketable root tubers. The high yield obtained from the TCP cassava is due to faster initial plant establishment. Such results have also been reported in first crop yield of several tissue culture-derived crops in comparison to subsequent ratoon crop yields. Further studies are required to evaluate the cost-

benefit and field performance of cassava TCPs in marginal and heavily disease-infected areas.

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